New England Aster, one of our valuable native honey plants.
From a painting in water color by Mrs. Andrew Jansen.

IOWA
GEOLOGICAL SURVEY

Bulletin No. 7

HONEY PLANTS
OF IOWA

L. H. PAMMEL, Ph.D., D.Sc., and CHARLOTTE M. KING

WITH THE COLLABORATION OF

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DES MOINES
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LETTER OF TRANSMITTAL

IOWA GEOLOGICAL SURVEY

To Governor John Hammill and Members of the Geological Board:

GENTLEMEN: I submit herewith a manuscript entitled 'Honey Plants of Iowa' and recommend that it be published as Bulletin Number 7 of the biological series of the Iowa Geological Survey.

'Honey Plants of Iowa' has been prepared by Dr. L. H. Pammel and Miss Charlotte King with the assistance of several collaborators whose names appear on the title page of the bulletin. The authors have made an excellent scientific contribution of inestimable value to the fruit and agricultural interests of the state. Statements of appreciation have already been received from persons who are familiar with the content of the book. Professor F. B. Paddock of the department of Apiculture, Iowa State College, states "Beekeepers everywhere will be much interested in the publication of this wonderful work. Dr. Pammel has been engaged in this extensive painstaking effort for fifteen years. While it is entitled the 'Honey Plants of Iowa' yet the information will be of interest to beekeepers throughout the United States. Beekeepers are urged to order this book and also to see that it is among the books of their Public Libraries where it will be of service to everyone of the community." Dr. C. F. Curtiss, Director, Iowa Agricultural Experiment Station, has written "The work on 'The Honey Plants of Iowa' is, I believe, by far the most extensive contribution on this subject that has been made by any writers. Doctor Pammel and Miss King's wide experience and extensive research have enabled them to make this an exceedingly valuable work which I am sure will be of great service to the apiculture industry. I take pleasure in commending this work unreservedly."

The publication of the bulletin on the 'Honey Plants of Iowa' was made possible through an appropriation for this purpose made to the Iowa Geological Survey at the 1929 session of the legislature of Iowa.

Respectfully submitted,

GEORGE F. KAY,
State Geologist

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PREFACE

The beekeepers of Iowa some years ago requested that the Iowa Agricultural Experiment Station make an investigation of the honey plants of the state. This study was urged by Frank C. Pellett, who was then State Inspector of Apiaries in Iowa, and who is now connected with the editorial staff of the *American Bee Journal*. Subsequently F. B. Paddock, professor of beekeeping at the Iowa State College, suggested further studies and at the Iowa Beekeepers' Association assembled in Des Moines in 1927 urged the publication of the material in hand.

After some fifteen years of labor connected with the problem the material is now brought together in book form. The senior author's own interest in the matter of honey and honey plants goes back more than a half century, when as a young lad he had an apiary near La Crosse, Wisconsin.

The first publication issued by the senior author respecting honey plants contained a list of the honey plants of Iowa; in it the following statement is made:

"Mr. Frank C. Pellett, the State Inspector of Apiaries, estimates the honey production in Iowa at ten to twelve million pounds annually. He estimates, moreover, that the bees could gather \$5,000,000 worth more of honey that now goes to waste.

"Aside from honey production, bees and other insects are of great importance in the pollination of flowers. Without these insects, in many cases, seed and fruit will not form. They are, therefore, of inestimable value to the fruit and agricultural interests of the state. It has seemed wise to undertake an exhaustive study of the problem from many different angles. Professor C. F. Curtiss, Director of the Iowa Agricultural Experiment Station, has authorized the undertaking of a study of this problem. It will take time to do this work properly, since a great many questions are involved. In this work the Botanical Section will have coöperation on fruit blossoms and leguminous forage plants (alfalfa, etc.) with Dr. J. N. Martin and Prof. L. A. Kenoyer; and a number of assistants will, during this and succeeding seasons, work on the problems of honey plants, insects, nectar secretions, etc."

The average honey yield in Iowa is probably under-estimated. There is something like an area of 1,140,000 acres in sweet clover in the state in fields, pasture and meadows, along roadsides and along railway rights-of way. The average yield per acre, according to best estimates, is $7 per acre or about $7,980,000. Charles D. Reed of the Iowa Weather and Crop Service writes to us that there are 10,055,119 acres in pasture, including woodland pastures. We estimate that about one-half of this, or 5,027,559 acres, is in white clover. The average yield of white clover honey per acre is about $5, which would make $25,137,795, but, of course, there are not enough bees to take care of this honey crop. Mr. Reed further observes that not in many years have we had such a luxuriant growth of white clover as this year (1929). Its fragrance is in the air everywhere, and all over the state bees are gathering a great harvest of honey from it.

Frank Coverdale of Jackson county, who was one of the original strong advocates of the use of white sweet clover as a forage crop, and also as a valuable honey crop, reports an unusually fine yield in 1929, a large supply of honey coming from this plant. In the year 1929, he took off ten thousand pounds of honey from two hundred twenty stands of bees, much of it from white sweet clover.

A large number of honey plants are never visited by bees because no bees are kept near by. In the year 1927, to cite a single illustration, bees were abundant on one of our native dogwoods (*Cornus Amomum*) in the vicinity of Ames, and yet seven miles away no bees were observed though nectar was abundant in the flowers.

Another interesting illustration. In 1929 in the latter part of June bees were fairly common upon *Sambucus canadensis* in Des Moines, but at Ames on that same day there were no honey bees, nor were any observed at Boone, despite the fact that apiaries were near and the odor of the elder blooms was very pleasant.

There are few honey bees in Denison in Crawford county. Consequently much nectar goes to waste. Late in June, 1929, there was still an abundance of white clover, *Trifolium repens*, and white sweet clover, *Melilotus alba*, some yellow sweet clover, *Melilotus officinalis*, and many blooms of hoary vervain, *Verbena stricta*, and hollyhock, *Althaea rosea*, and the moss rose, *Portulaca grandiflora*, but not a single bee was observed through several hours of study of the honey plants of the county.

Certain plants are much more consistent honey yielders than others. The *Veronica spicata*, or blue speedwell, has consistently produced honey during the season of 1929 for more than four weeks and the same is true of one of the common red loosestrifes, *Lythrum Salicaria.* Apparently bees even prefer these plants to the white sweet clover and white clover.

When such plants as white clover and the yellow and white sweet clover are beyond their prime they are less visited by honey bees. But the blue speedwell and loosestrife are visited by honey bees during their entire blooming season. The same is true of the Japanese barberry.

The season and soil are important factors in honey production. For instance in 1929 we found no bees upon the common staghorn sumach, *Rhus typhina,* at Ames, though in some years bees are abundant upon this and *Rhus glabra,* especially in northeastern Iowa.

It seems best to treat the subject from the following standpoints: General Description, Habitat and Plant Association, Distribution, Season of Bloom, Field Observations of Visits of Honey Bees, Structure of Flower, Nectar Secretion, Yield of Nectar and Pollen.

The subject of pollination is discussed as this has an important relation to the production of seeds and fruit, and has a biological interest. Special sections will be devoted to Soils and Honey Plants of Iowa, Weather and Honey Production, Environmental Influences on Nectar Secretion, Relation of Bees to Clover and Seed Production, Relation of Bees to Fruiting in Cucurbits, Mid-summer Bee Plants, and to contributions by L. H. Pammel on Pollination of Interest to Beekeepers, Importance of Bees for Production of Fruit, Honey Plants on Rights-of-Way of Railroads and Roadsides, historical matter pertaining to pollination. The following discussions will be included also:

The Relation of Honey Plants to Soils, L. H. Pammel and C. M. King; The Structure of Some Nectar Glands of Iowa Honey Plants, Wm. S. Cook; The Honey Bee and the Production of Seed in Sweet Clover, Red Clover, and Alfalfa, J. N. Martin; Phenology of Honey Plants, C. M. King; Data on Honey Yields, O. W. Park; The Pollen Grains of Honey Plants, Charles Hoffman; Studies in Variation of Red Clover, Edna Pammel and Clarissa Clark; Studies on the Structure and Content of Pollen, F. P. Sipe; The Frequency of Visits to the Same Flower by Honey Bees, C. C. Lounsberry; historical matter on honey plants, L. H. Pammel and C. M. King.

We wish to express to Dr. C. F. Curtiss our appreciation for his great interest in the undertaking of the station project; to Mr.

KEY TO FAMILIES

By ADA HAYDEN

Division Spermatophyta (Seed Plants)

Subdiv. Gymnospermae: Seed plants in which the ovules (seeds) are not contained in an ovary.

Subdiv. Angiospermae: Seed plants in which the ovules (seeds) are contained in an ovary.

Class I Monocotyledoneae: Embryo with one cotyledon and the early leaves alternate; leaves mostly parallel-veined; parts of the flowers mostly in 3's and 6's; stem without annual layers or clear distinction of bark, wood and pith; in cross section the woody fibers appear to be scattered through the pith.

A. Plants with perianth absent or scalelike, flowers very small, irregular, green, in the axils of chaffy bracts (glumes) arranged in spikes or spikelets.

B. Stems hollow, round or flattened; leaf sheaths split; fruit a caryopsis .... Gramineae

BB. Stems solid, more or less triangular, leaf sheaths not split; fruit an achene .... Cyperaceae

AA. Perianth always present; flowers large and showy.

B. Perianth free from the ovary.

C. Calyx and corolla distinct........ Commelinaceae

CC. Calyx and corolla usually undifferentiated........ Liliaceae

BB. Perianth adnate to the ovary.

D. Stamens 1-2 grown together with the pistil; flowers irregular .... Orchidaceae

DD. Stamens 3-6; ovary inferior.
Stamens 6 .... Amaryllidaceae
Stamens 3 .... Iridaceae

Class II Dicotyledoneae: Embryo usually with 2 opposite cotyledons, early leaves usually alternate; leaves usually netted-veined; parts of flowers usually in 4's and 5's; stems having bark, wood and pith differentiated.

Sub-Class I. Including plants with petals absent or when present all united in one unit (Polypetalae and Apetalae).

A. Corolla none; calyx present or absent.

B. Flowers unisexual (monoecious or dioecious) one or both sexes in catkins or catkin-like heads.

C. Staminate and pistillate flowers both in catkins.
D. Fruit many-seeded; plant dioecious....................Salicaceae
DD. Fruit 1-seeded; plants usually monoecious.
E. Calyx evident; fruit succulent..................Urticaceae
EE. Calyx represented by scales; fruit dry......Betulaceae
CC. Staminate flowers in catkins; pistillate flowers single or few, surrounded by a cup or involucre which in fruit becomes a bur or cup; usually monoecious.
D. Leaves pinnate ....Juglandaceae
DD. Leave simple ....Fagaceae
CCC. Staminate flowers in compact racemose catkins; pistillate in globular heads; mostly dioecious......................Urticaceae
BB. Flowers not in catkins, unisexual or bisexual.
C. Cells of ovary (when simple) with 1-2 ovules.
D. Pistils or distinct carpels more than 1, often numerous; calyx present.
E. Stamens inserted on calyx; leaves with stipules........ Rosaceae
EE. Stamens inserted on receptacle............Ranunculaceae
DD. Pistil 1, simple or compound.
E. Ovary free from calyx or calyx tube (superior), the calyx sometimes absent.
F. Nodes sheathed by stipules..............Polygonaceae
FF. Nodes not sheathed by stipules.
G. Shrubs or trees.
H. Leaves alternate (or sometimes verticillate).
I. Locule or cell of ovary, 1 or 2.
J. Apetalous; ovary 1-celled, 1-ovuled Urticaceae
JJ. Corolla present; ovary 2-4-celled........ Rhamnaceae
II. Locules or cells of ovary usually more than 2.
J. Stamens opposite petals and of same number ....Rhamnaceae
JJ. Stamens alternate with petals (if present; or opposite sepals), of the same or of greater number.
K. Leaves compound; juice not milky; ovary 3-celled.................. Sapindaceae

KK. Leaves simple; juice usually milky; ovary 3-celled.................. Euphorbiaceae

HH. Leaves opposite.

I. Fruit a samara.

J. Samara 1-celled, single........Oleaceae

JJ. Samara 2-celled, double....Aceraceae

II. Fruit not a samara. Pod leathery and burlike ....Sapindaceae

GG. Herbaceous plants (at times somewhat woody).

H. Stigma (and styles) 1-3 or more. Fruit an achene ....Urticaceae

HH. Fruit not an achene.

I. Pistil a single-celled, 1-ovuled ovary.

J. Flowers subtended by scarious bracts ....Amaranthaceae

JJ. Flowers not subtended by scarious bracts.

K. Leaves alternate........................... Chenopodiaceae

KK. Leaves opposite..Caryophyllaceae

II. Pistil of 3 united carpels; flowers unisexual; juice milky..........Euphorbiaceae

EE. Ovary inferior, or at least submerged in the calyx tube.

F. Trees and shrubs.

G. Leaves and young shoots covered with scurfy scales (upper surface sometimes glabrous).... Elaeagnaceae

GG. Leaves and shoots not scurfy....Nyctaginaceae

FF. Herbs.

G. Flowers subtended by united calyxlike bracts Nyctaginaceae

GG. Flowers not subtended by calyxlike bracts.... Rosaceae

CC. Cells or ovary with many (3 or more) ovules.

D. Ovary superior.

E. Pistil 1.

F. Cells one in ovary; leaves compound................... Ranunculaceae

FF. Cells 2-many in ovary; leaves simple..Lythraceae

EE. Pistils two or more and separate........Ranunculaceae

AA. Corolla and calyx present.

B. Stamens more than 10, usually numerous or more than twice as many as petals.

C. Calyx tube adherent to a compound ovary (inferior).

D. Sepals or calyx lobes 2; ovary with central or basal placenta; herbs ....Portulacaceae

DD. Sepals or calyx lobes more than two; ovary various...... Rosaceae

CC. Calyx or calyx tube not joined to pistils or compound ovary (ovary usually superior).

D. Pistils 1, sometimes composed of 2 or more carpels and more than 1 style.

E. Ovary 1-celled.

F. Ovules 2; juice not milky........Rosaceae

FF. Ovules few to many.

G. Sepals 2 (rarely 3); herbs.

H. Juice milky or colored; flowers regular.... Portulacaceae

GG. Sepals 3, 4 or 5; herbs or woody plants.

H. Fruit elevated on short stem........ Capparidaceae

HH. Fruit not so borne........Ranunculaceae

EE. Ovary with 2 or more cells.

F. Stamens monadelphous; herbs and shrubs........ Malvaceae

FF. Stamens distinct; trees........Tiliaceae

DD. Pistils few to many.

E. Climbing plants ....Ranunculaceae

EE. Erect herbs and shrubs.

F. Filaments united into a tube........Malvaceae

FF. Filaments not united.

G. Leaves opposite ....Calycanthaceae

GG. Leaves alternate.

H. Stamens inserted on calyx........Rosaceae

HH. Stamens inserted on receptacle or disc...... Magnoliaceae

BB. Stamens definite, usually 5-10, or not more than twice as many as petals.

C. Calyx or its tube adherent to ovary or partly adherent (ovary inferior).

D. Cell or cells of ovary containing 1 ovule.

E. Stamens of same number as petals and opposite them .... Rhamnaceae

EE. Stamens not of same number as petals or if of same number, alternate with them.

F. Number of stamens 5 or 10.

G. Leaves simple .... Rosaceae

GG. Leaves compound .... Umbelliferae

FF. Number of stamens 2, 4 or 8.

G. Stigma and style 1; fruit small, fleshy........ Cornaceae

GG. Stigmas (and sometimes styles) more than 1 or else lobed; fruit not fleshy...... Onagraceae

DD. Cell or cells of ovary with few or many ovules.

E. Ovary 1-celled.

F. Sepals or calyx-lobes 2........ Portulacaceae

FF. Sepals or calyx-lobes more than 2.. Saxifragaceae

EE. Ovary with 2 or more cells.

F. Stamens attached on conspicuous disc which sometimes covers ovary........ Celastraceae

FF. Stamens attached to calyx or calyx-tube

G. Style 1 .... Onagraceae

GG. Style 2 or 3........ Saxifragaceae

CC. Calyx free from ovary or pistils (ovary or ovaries superior).

D. Pistils (separate ovaries) 2 or more, sometimes more or less united at base and then strongly lobed.

E. Stamens inserted on calyx.

F. Stipules absent .... Saxifragaceae

FF. Stipules present .... Rosaceae

EE. Stamens inserted on receptacle beneath ovary (hypogynous); seldom perigynous.

F. Leaves punctate with transparent dots (when held against light)........ Rutaceae

FF. Leaves not punctate.

G. Plants herbaceous.

H. Plants fleshy .... Crassulaceae

HH. Plants not fleshy.

I. Ovaries with styles and stigmas separate .... Ranunculaceae

II. Ovaries separate or joined into a lobed pistil, with 1 common style; lobes of ovary 5 .... Geraniaceae

GG. Plants woody. Leaves pinnate; leaflets not more than 5-7................................Ranunculaceae

DD. Pistil 1 (carpels sometimes more than 1 joined into one body).

E. Ovary 1-celled.

F. Placenta 1 and ovary 1-ovuled but pistil compound as shown by number of styles and stigmas.

G. Plants herbaceous ....Cruciferae

GG. Plants woody ....Anacardiaceae

FF. Placenta and stigma 1 (ovary simple).

G. Fruit a legume..................................Leguminosae

GG. Fruit a berry or capsule.........Berberidaceae

FFF. Placentae or stigmas or both, or cells more than 1 (ovary compound, of more than 1 carpel even though 1-celled); ovules 2 or more.

G. Corolla distinctly irregular.................Violaceae

GG. Corolla regular or nearly so.

H. Attachment of seeds not on walls (parietal) but at bottom (central) or suspended from top.

I. Tendril climbers ....Vitaceae

II. Plants without tendrils.

J. Stamens not attached to corolla or only at extreme base; not united; few.

K. Stamens inserted on rim or throat of calyx tube..Lythraceae

KK. Stamens inserted on top of calyx tube.

L. Leaves opposite.......................... Caryophyllaceae

LL. Leaves alternate, evergreen.... Ericaceae

JJ. Stamens attached to corolla; as many as corolla lobes or more, sometimes monadelphous.

K. Styles 5; ovary 1-celled with 1 ovule ....Plumbaginaceae

KK. Styles 1; ovary 2-celled with usually 2 ovules..............Oleaceae

HH. Attachment of ovules on side of ovary (parietal) in 2 or more placentae.

I. Stamens 6, of which 2 are short; herbs ..... Cruciferae

II. Stamens otherwise.

J. Leaves heathlike. Small trees........ Tamaricaceae

JJ. Leaves not heathlike.

K. Fruit and ovary on stem within corolla (stipitate) .... Capparidaceae

KK. Fruit and ovary not stipitate.... Saxifragaceae

EE. Ovary 2- or more- celled.

F. Corolla distinctly irregular.

G. Leaves digitate ....Sapindaceae

GG. Leaves simple.

H. Calyx not tubular; 1 sepal long-spurred.

I. Carpel (cells) with 1 ovule.................... Tropaeolaceae

II. Carpels with several ovules.................... Balsaminaceae

HH. Calyx tubular, somewhat saccate or oblique at base................................Lythraceae

FF. Corolla regular or nearly so.

G. Fruit a double samara......................Aceraceae

GG. Fruit a simple samara..........................Oleaceae

GGG. Fruit not a samara.

H. Petals 4; stamens 6 with 2 shorter............ Cruciferae

I. Flowers unisexual (monoecious or dioecious); juice milky..........Euphorbiaceae

II. Flowers bisexual and symmetrical.

J. Leaves digitate................Oxalidaceae

JJ. Leaves pinnate.

K. Plants herbaceous.

L. Not climbing....Saxifragaceae

LL. Tendril climbing...................... Sapindaceae

K. Plants woody.

L. Fruit an inflated bladdery pod ....Staphyleaceae

LL. Fruit not a bladdery pod...... Sapindaceae

JJJ. Leaves simple, sometimes lobed or cleft.

K. Carpels separating from below and joined above by styles; seeds without aril....Geraniaceae

KK. Carpels splitting from above; seeds with aril........Celastraceae

KKK. Carpels and seeds otherwise.

L. Leaves opposite or verticillate; calyx tubular or cup-like.

M. Petals attached to receptacle ....Caryophyllaceae

MM. Petals attached to calyx.... Lythraceae

LL. Leaves alternate; petals fugacious ....Linaceae

Sub-Class II. Including plants with corolla in 1 piece, the petals more or less united (Gamopetalae).

A. Ovary superior.

B. Stamens free or attached at base of corolla..............Ericaceae

BB. Stamens attached to tube of corolla.

C. Stamens opposite the lobes and as many in number or more.

D. Ovary 1-celled, 1-seeded; fruit an achene........................ Plumbaginaceae

DD. Ovary 1-celled, several-seeded; fruit a capsule.................. Primulaceae

CC. Stamens alternate with the lobes of the corolla and not more in number.

D. Ovaries 2 distinct, 1-celled.

E. Corolla convolute in bud; styles united..Apocynaceae

EE. Corolla valvate in bud; styles distinct........................ Asclepiadaceae

DD. Ovary 1, deeply lobed, the parts at maturity separating as nutlets.

Leaves alternate ....Boraginaceae

Leaves opposite ....Labiatae

EE. Style not deeply lobed.

F. Ovary 1-celled. Seeds 1; corolla scarious............ Plantaginaceae

Seeds several to many; corolla not scarious............ Hydrophyllaceae

FF. Ovary 2-10 celled.

G. Stamens fewer than the lobes of corolla, usually 2 or 4.

H. Leaves opposite, woody................Oleaceae

HH. Leaves alternate; herbaceous..Solanaceae

GG. Stamens same number as the lobes of the corolla.

H. Ovary 3-celled; corolla regular.................. Polemoniaceae

HH. Ovary 2- to 4-celled.

I. Corolla with imbricate lobes.

J. Cells 1- to 2-seeded, separating into 4 nutlets.

K. Corolla regular; stamens 5........ Boraginaceae

KK. Corolla irregular; or rarely regular; stamens 4; usually didynamous.

L. Ovary not lobed; style at apex ....Verbenaceae

LL. Ovary 4-lobed; style basal.... Labiatae

JJ. Cells usually with many ovules; united into a 2-celled ovary—rarely 1-celled or 1-seeded.

K. Stamens 5; flowers regular; fruit a capsule or berry............. Solanaceae

KK. Stamens 2-4; flowers irregular.

L. Ovary many-ovuled; placenta central; usually herbaceous.. Scrophulariaceae

LL. Placenta parietal, usually woody ....Bignoniaceae

II. Corolla with convolute lobes; ovary 2-celled; 2 seeds in each cell; stamens 5; 5-lobed corolla. Mostly twining............ Convolvulaceae

AA. Ovary inferior.

B. Herbs with tendrils..Cucurbitaceae

BB. Herbs and woody plants without tendrils.

C. Anthers separate.

D. Stamens free or nearly free from the corolla.

E. Stamens as many as the lobes of corolla; juice milky ....Campanulaceae

EE. Stamens usually twice as many as the lobes of the corolla; woody ....Ericaceae

DD. Stamens attached to the corolla.

E. Ovary 1-celled; flowers in compact involucrate heads ....Dipsaceae

EE. Ovary 2- to 5-celled;

F. Leaves without stipules; never whorled.. Caprifoliaceae

FF. Leaves with stipules (a stipular line joining opposite leaves) or whorled..Rubiaceae

CC. Anthers united into a tube around the style.

D. Flowers not arranged in a head; without involucre; fruit a capsule or berry..Lobeliaceae

DD. Flowers arranged in a head; with involucre; fruit an achene ....Compositae

KEY TO GENERA OF TREES AND SHRUBS

By ADA HAYDEN

I. Trees.

A. Leaves simple.

a. Leaves opposite, palmately veined.
Fruit a double samara............Acer

aa. Leaves alternate, pinnately veined.

b. Buds with one scale............Salix

bb. Buds with more than one scale.

c. Margin of leaf entire.

d. Apex of leaf truncate............Liriodendron

dd. Apex of leaf not truncate.

e. Leaves silvery scurfy............Elaeagnus

ee. Leaves otherwise.

f. Leaf scars in whorls of two large and one small scar.. Catalpa

ff. Leaf scars alternate.

g. Bundle scars scattered.

h. Leaves dotted with transparent spots; fruit an aggregate of dry pods............Magnolia

hh. Leaves not dotted with transparent spots; fruit an acorn............Quercus

gg. Bundle scars definite in number.

i. Leaf scars 3; fruit a legume............Cercis

ii. Leaf scars 5-7; fruit a fleshy berry....Asimina

cc. Margin of leaf not entire.

d. Outline of leaf oblong-lanceolate, coarsely serrate; fruit a nut enclosed in a spiny involucre............Castanea

dd. Outline of leaf obliquely ovate-cordate.

e. Sap milky, fruit fleshy............Morus

ee. Sap not milky.

f. Pith continuous, fruit a nutlet.

g. Cluster of nutlets winged; mature bark uniformly furrowed ....Tilia

gg. Cluster of nutlets wingless; mature bark warty........ Celtis

ff. Pith chambered; fruit a samara; mature bark furrowed ....Ulmus dd. Outline of leaf symmetrically ovate-cordate.

e. Bundle traces 3, subequal; the lower one the larger; fruit dry, borne in catkins.

f. Pith 3-sided, green.......................................Betula

ff. Pith 5-angled, brown.......................................Populus

fff. Pith roundish, pale.

g. Trunks with smooth fluted gray bark. Young twigs smooth ....Carpinus

gg. Trunks with brown scaly bark. Young twigs with glandular pubescence ....Ostrya

ee. Bundle traces 5, unequal; fruit fleshy.

f. Never spinose.

Pith somewhat 5-angled; old bark smooth; leaves not lobed ....Amelanchier

ff. Usually with axillary spines.

g. Pith rather small, roundish; fruit a pome.

Leaves usually lobed.......................................Crataegus

gg. Pith roundish or angled; fruit a drupe; disc-like glands on petiole.......................................Prunus

AA. Leaves compound.

a. Leaves opposite.

b. Leaves palmately veined.

c. Bundle traces 3 in 3 compound groups.

Fruit a leathery pod.......................................Aesculus

bb. Leaves pinnately veined.

c. Bundle traces numerous in ellipse-shaped or C-shaped arrangement.

Fruit a samara.......................................Fraxinus

cc. Bundle traces 3; Fruit a double samara..........Acer (Negundo)

aa. Leaves alternate.

d. Spinose, fruit a legume.

e. Spines located in axil of leaf or scattered on trunk............ Gleditsia

ee. Spines representing stipules.......................................Robinia

dd. Unarmed.

f. Twice-pinnate leaves.

Fruit a legume.......................................Gymnocladus

ff. Once pinnate leaves.

Fruit a legume; leaf scars C-shaped encircling bud...... Cladastris

g. Fruit a nut; leaf scars shield-shaped.

h. Pith chambered ....Juglans hh. Pith continuous broken at nodes....................Carya

gg. Fruit a pome; leaf scars linear or ⌴ shaped....Pyrus

II. Shrubs.

A. Vine habit.

a. Climbing without tendrils.

b. Leaves simple.

Margin serrate; fruit an orange-colored capsule bearing seeds enclosed in a pulpy scarlet aril..Celastrus

Margin entire; fruit a red or yellow berry..........................Lonicera

bb. Leaves once-pinnately compound.

Climbing with aerial rootlets. Flowers orange, trumpet-shaped...... Tecoma

aa. Climbing with tendrils.

c. Leaves palmately veined.

d. Leaves simple, 3- to 5-lobed; tendrils opposite the leaves, naked (without discs)..Vitis

dd. Leaves digitate with 5 (3-7) leaflets; climbing by tendrils bearing adhesive discs and with aerial roots................Psedera

cc. Leaves simple or pinnately compound.

Tendrils few, naked, located mostly in inflorescence in species of temperate zones..Cissus

B. Bush habit.

a. Leaves opposite.

b. Leaves silvery-scurfy. Stems somewhat thorny; fruit red, berry-like ....Shepherdia

bb. Leaves not scurfy.

c. Leaves compound.

d. Digitate with 3-7 leaflets.

Twigs quadrangular bearing accessory buds; fruit drupe-like becoming peppery aromatic....................................Vitex

dd. Once pinnate with serrate leaflets.

Twigs 6-8 or 10-sided, stout, bearing single axillary buds; fruit a berry borne in panicles................................Sambucus

cc. Leaves simple.

e. Buds superposed.

f. Leaf scars with 1 bundle trace; fruit not persistent, berry-like in axillary clusters..............................Lonicera

ff. Leaf scars with 3 bundle traces; fruit dry 2-celled capsules ....Forsythia

ee. Buds not superposed. Bundle traces 1.

f. Leaves serrate; pith pale, bark often with corky lenticels; fruit a pink leathery capsule with scarlet arilled seed ....Evonymus ff. Leaves entire or serrate; pith green; fruit a persistent brown capsule .... Syringa

fff. Leaves entire; pith light brown; leaf scars opposite or whorled; fruit consisting of a head of nutlets .... Cephalanthus

aa. Leaves alternate (Cornus in part).

b. Leaves entire.

c. Bundle traces 1.

d. Pith moderate, white, homogeneous; flowers (white) and fruit (black) in terminal panicles............................ Ligustrum

dd. Pith small, round, brownish, usually excavated; flowers (greenish-white to pink) and fruit (red or white) in axillary terminal spikes.. Symphoricarpos

• cc. Bundle traces 3.

d. Twigs aromatic.

Buds without evident scales; accessory buds present............ Calycanthus

dd. Twigs not aromatic. Buds solitary; or exceptionally superposed, with pair of valvate scales. Flowers polypetalous; fruit a two-seeded drupe.. Cornus

Flowers gamopetalous; fruit a one-seeded drupe.... Viburnum

cc. Bundle traces 3; without stipules.

d. Bark exfoliating· inflorescence terminal.

e. Pith pale, continuous; fruit persistent; capsules usually 3- to 5-celled... Philadelphus

ee. Pith paler and spongy or brown and excavated between nodes; fruit a persistent capsule usually 4-celled.... Deutzia

dd. Bark continuous; inflorescence axillary.

Fruit persistent, 2-valved capsules............................ Diervilla

bb. Leaves not entire.

c. Leaves compound.

d. Palmately.

Mostly prickly, leaf scars torn and irregularly shrivelled on the much raised persistent petiole base.

Fruit an aggregate of drupelets................................ Rubus

dd. Pinnately.

e. Even pinnate.

Abruptly pinnate or subdigitate with rather small, entire or mucronate leaflets and prolonged rachis.

Fruit a legume.. Caragana

ee. Odd pinnate.

f. Stems prickly.

g. Juice aromatic or pungently acrid; leaves pellucid-punctate.
Fruit a leathery capsule........................Zanthoxylum

gg. Juice not aromatic; leaves not pellucid-punctate.
Fruit a hip..Rosa

ff. Stems not prickly.

g. Leaves trifoliate.

h. Punctate with transparent dots; fruit a samara.... Ptelea

hh. Not punctate with transparent dots; fruit bladder-like, 3-celled ....Staphylea

gg. Leaves with more than 3 leaflets; not transparent-punctate.

h. With milky sometimes poisonous sap; bundle traces in 3 groups of 3, 5 or 9 single scars....Rhus

hh. Without milky juice; bundle scars 3.

i. Leaflets entire; fruit a follicle............Sorbaria

ii. Leaflets serrate; fruit a legume............Robinia

cc. Leaves simple.

d. Bud scales one.
Buds appressed, solitary, small oblong; capsular fruits borne in catkins ....Salix

dd. Bud scales more than one.

e. Bundle traces and leaf-scars absent; leaves minute, gray-green, awl- or scale-shaped..Tamarix

ee. Bundle trace 1.

f. Five-angled stems bearing spinescent twigs.
Buds small, fascicled or aggregate; fruit a berry...... Lycium

ff. Stems not spinescent.

g. Fruit a follicle with persistent calyx.
Shrubs low and little branched or else with wand-like branches ....Spiraea

gg. Fruit a berry.

h. Leaves resinous dotted..........................Gaylussacia

hh. Leaves not resinous dotted....................Vaccinium

eee. Bundle traces 3.

f. Leaves bearing conspicuous glands.

g. Glands black, on upper midrib of leaf; fruit a pome ....Pyrus (arbutifolia)

gg. Glands on petioles of leaf; fruit a drupe......Prunus

ff. Leaves not bearing conspicuous glands.

e. Spinose.

Branched leaf spines subtend short spurs which bear foliage leaves; fruit a berry.................................Berberis

ee. Not spinose.

f. Staminate catkins for the next season usually conspicuous in catkins.

g. Fruit a nut enclosed in leafy involucre..........Corylus

gg. Fruit a samara borne in catkins......................Betula

ggg. Fruit persistent in woody cones bearing nutlets........ Alnus

ff. Flowers and fruit not borne in catkins or cones.

g. Fruit fleshy.

Elongated acute buds with 5 exposed scales; fruit a red pome borne in racemes......Amelanchier

gg. Fruit dry.

h. Low growing shrubs.

Leaves very hairy; fruit a dry capsule in panicle or corymbs...............................Ceanothus

hh. Treelike shrubs.

Leaves smooth or pubescent; fruit a drupe........ Rhamnus

In the keys of trees, shrubs, and families we have eliminated purely technical terms in-so-far as is practicable. This, however, conforms in systematic usage with the basic concepts used in Dr. Asa Gray's "Manual of Botany," Seventh Edition; Dr. L. H. Bailey's "Cultivated Plants;" Dr. Wm. Trelease's "Plant Materials;" Dr. A. Rehder's "Trees and Shrubs" and Dr. N. L. Britton's "Manual of the Flora."

DESCRIPTIVE MANUAL

L. H. PAMMEL AND CHARLOTTE M. KING

SPERMATOPHYTA

Seed plants or flowering plants. Flowers with stamens or pistils or both. Pollen grains produced in a pollen sac. Reproduction by seeds.

GYMNOSPERMAE

Seed not enclosed in an ovary. Representative plants—the yews (*Taxus*), pines (*Pinus*), (Fig. 1), spruce (*Picea*), larch (*Larix*), fir (*Abies*), hemlock (*Tsuga*), arbor-vitæ (*Thuja*), red cedar (*Juniperus*). The white pine (*Pinus Strobus*) is a type.

None of the conifers furnish pollen for bees. However, Pellett is authority for the statement that honey-dew is reported upon pine trees, also on fir trees in Germany. So far as we know bees have never been observed on pines in the state of Iowa.

ANGIOSPERMAE

Plants with seeds enclosed in an ovary. Representative types—maize, wheat, rye, barley, plum, peach, sunflower.

MONOCOTYLEDONEAE

Plants with fibrovascular bundles distributed through the cellular tissue. Pith and annual rings absent. Leaves generally parallel-veined. Flowers borne on the plant in threes or sixes, never in fives. Embryo with a single cotyledon. Represented by maize or corn, lily, onion, yucca, sedge.

GRAMINEAE, GRASS FAMILY

Plants with round, hollow, jointed stems, narrow alternate leaves with a single sheath, and glumaceous flowers arranged in spikes or panicles.

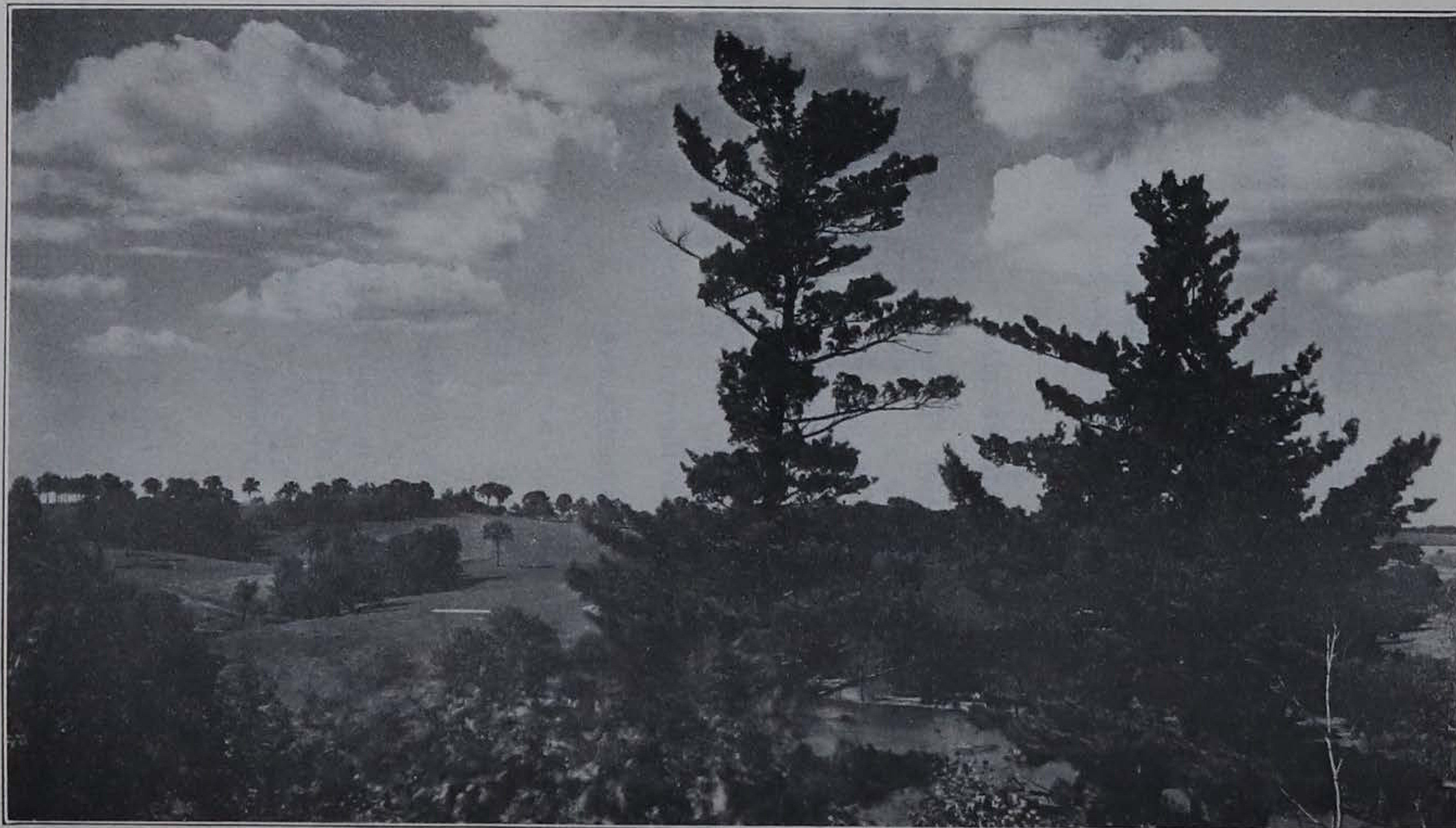


FIG. 1.—White pine (*Pinus Strobus*) in the Backbone Park in Delaware county. Plants of this type sometimes furnish honey-dew. *Bulletin Iowa State Parks.*

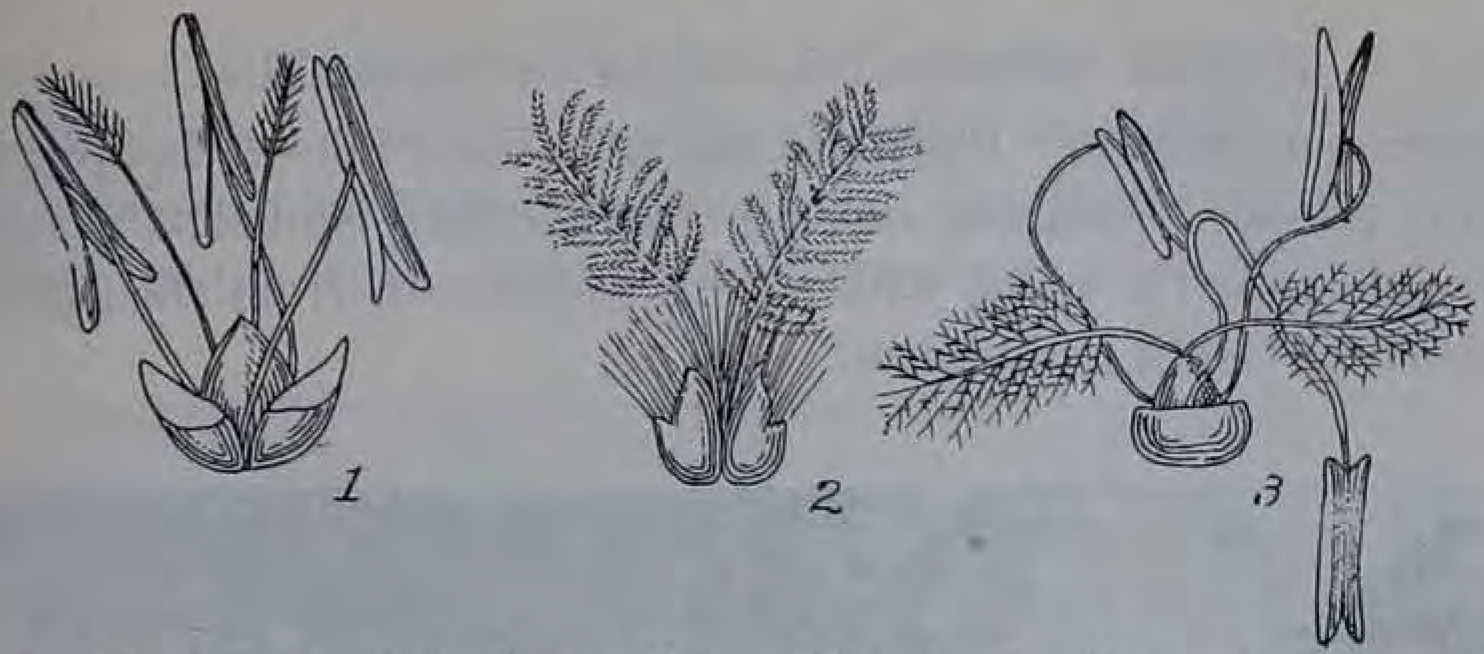
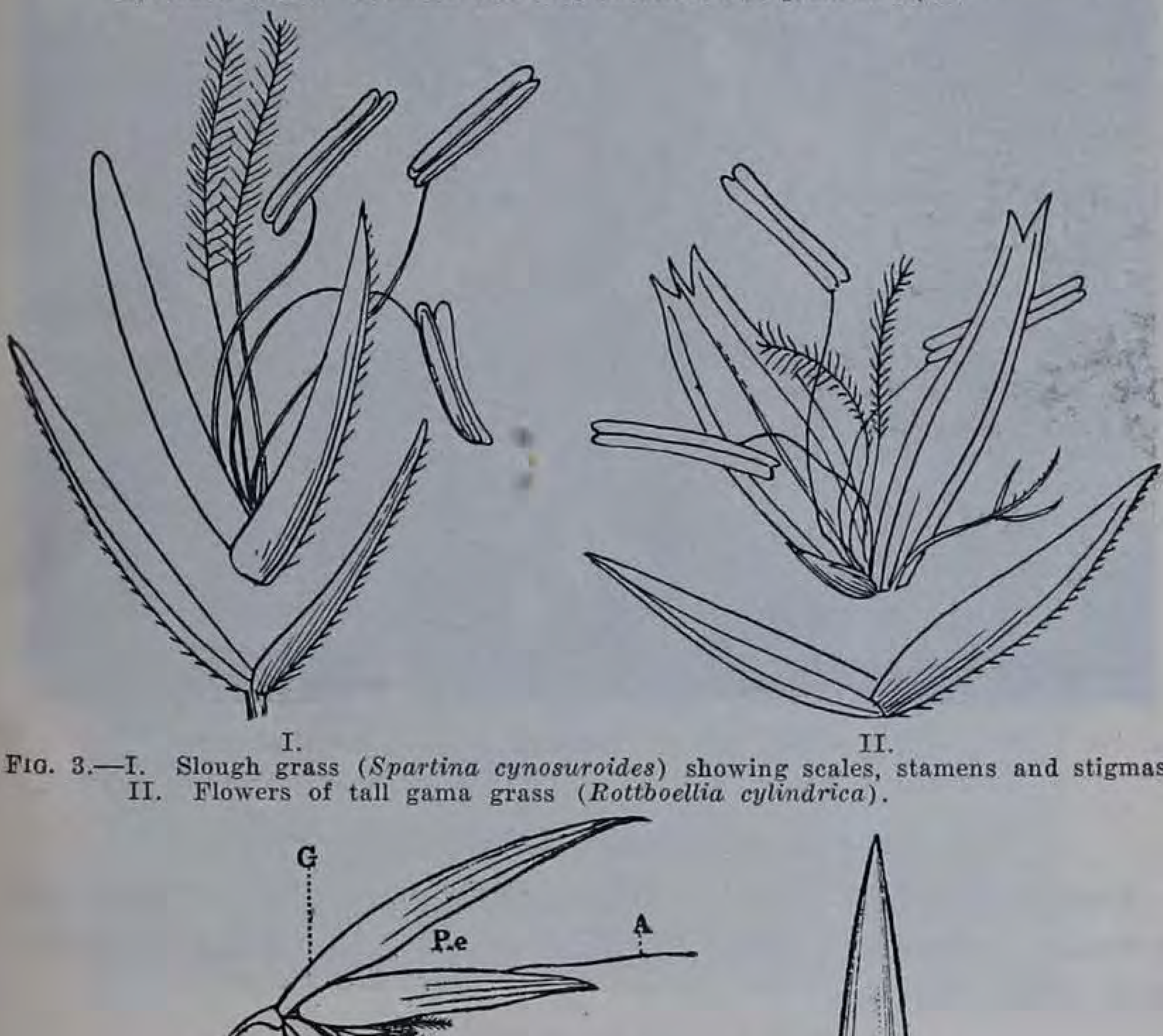


FIG. 2.—The structure of the flowers of three different types of grasses. Stamens shown next to the scales in Figure 1. Lodicules shown below. Figure 2. Common oats with the lodicules and the plumose stigmas. Figure 3. Melic Grass. Lodicules below. Stamens with long filaments and plumose style.



I. II.

FIG. 3.—I. Slough grass (*Spartina cynosuroides*) showing scales, stamens and stigmas. II. Flowers of tall gama grass (*Rottboellia cylindrica*).

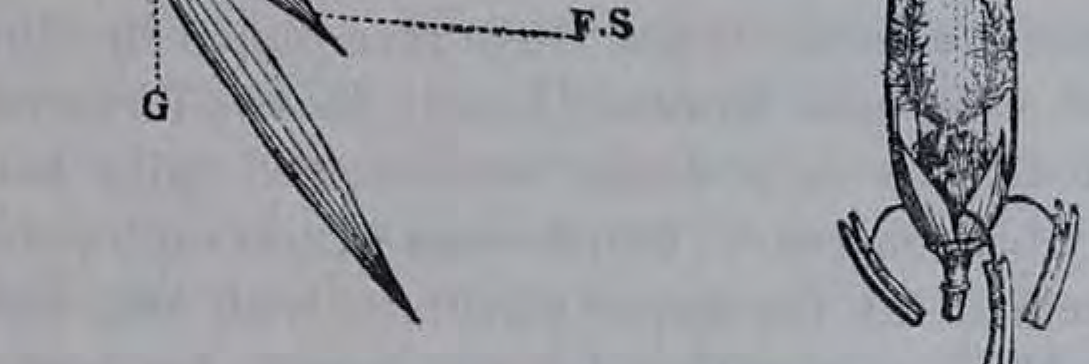


FIG. 4.—I. Flower of oats. G, empty glume; Pe, lemma bearing an awn A; pi, palea; FS, sterile flower. Between lemma and palea are pistil and stamens. II. Flower with lemma removed showing palea and the small bracts (lodicules) at the base of the pistil and stamens. *After Thomé.*

Zizania (Gronov.) L. Water or Indian Rice

Monoecious flowers. Pistillate and staminate flowers in spikelets in same panicle. Glumes, none in the pistillate spikelet. Lemma closely clasping the palea with a long hispid awn from the summit. Stamens 6. Grain cylindrical.

FIG. 5.—Indian rice (*Zizania palustris*). *Photo by C. M. King.*

Zizania palustris L. Wild Rice

Annual, 5 to 12 feet tall. Common in shallow water in lakes and streams. Abundant along the Mississippi. This plant furnishes some pollen for bees.

Zea Mays L. Indian Corn, Maize

Erect annual, of many types. Stem terminated by clustered slender spikes of staminate flowers (tassel) in two-flowered spikelets; the pistillate flowers in a dense, many-rowed spike borne upon a short axillary branch (ear); two flowers within each pair of glumes, the lower one neutral, the upper pistillate, with long style (silk).

Native to Mexico, possibly also to Central America and South

America. The great amount of corn cultivated in Iowa and in other states insures an abundant supply of pollen acceptable to bees.

The flowers of corn are monoecious; *i.e.* with both kinds of flowers growing on the same plant. The flowers are proterogynous (the

FIG. 6.—Indian corn, maize (*Zea Mays*).

pistils developing ahead of the stamens), and as in the entire group of grasses, are wind pollinated. The abundant yellow pollen grains are easily blown out from the versatile anthers. Each ovule of the pistillate flowers bears a threadlike style, the long "silk" threads of maize which are familiar to every one. The stigma is provided with plumose hairs, which serve the purpose of holding pollen grains. The lodicules when turgid open the flowers so that pollination can be brought about. See figure 7 for dehiscence.

The staminate flowers are visited for pollen by honey bees and other insects. The staminate corn flowers have a decided odor of cumarin.

FIG. 7.—Staminate flowers (tassel) of *Zea Mays*. *Photo by A. Hayden.*

As to the secretion of nectar, there may be a doubt. Some bee keepers claim that nectar is collected from corn, but our observations indicate pollen only.

Mr. Pellett calls attention to the statement of W. K. Morrison, who says that in tropical countries corn is a valuable honey plant. Honey-dew, also, is at times gathered by bees from the corn plant.

Zea Mays L. var. *rugosa* Bonif. Sweet Corn

The honey bee frequently visits the varieties of sweet corn, altogether for pollen. The condition of the weather seems to influence the visits of the bees.

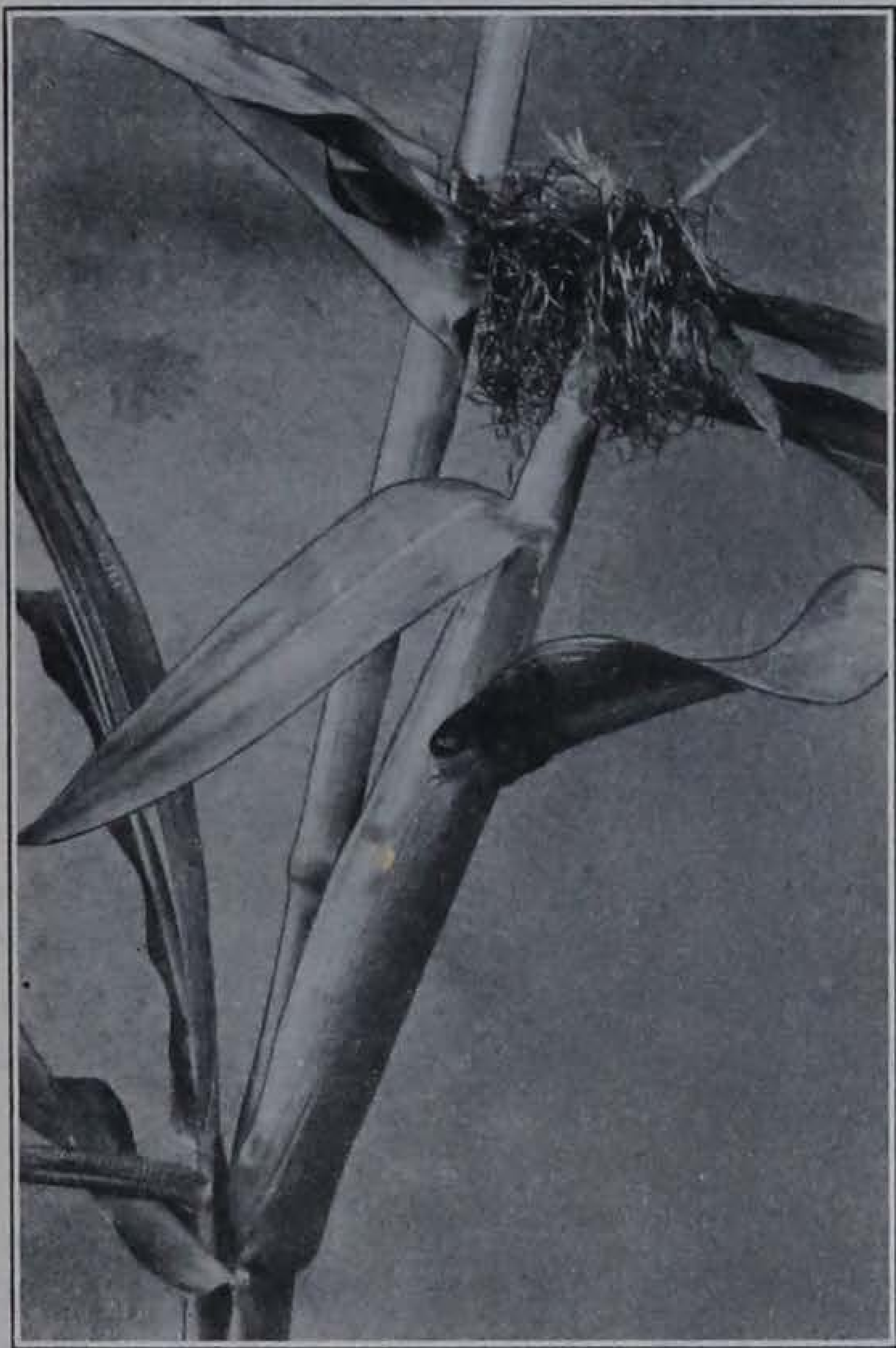


FIG. 8.—Pistillate flower of *Zea Mays*, showing styles (silks). *Photo by A. Hayden.*

HONEY BEE VISITS

Golden Bantam Sweet Corn

Ames,* July 23, 1927, 5 to 6 p.m. Dry, warm, some wind. Bees freely gathering this pollen. They preferred to work the lateral shoots of the corn tassel rather than the upright ones, as the anthers hung down and the bees were able to catch hold high up on the third or fourth anthers pendant from each flower and work their mandibles downward, forcing the pollen into their leg pockets. This took two to five seconds for each visit. (C.C.L.)

Bloomfield, July 25, 1927, 10:30 a.m. Bees abundant, getting pollen only.

* Localities of observation are for Iowa unless otherwise stated.

Two, two, three, one, three, two, one seconds in a flower. (L.H.P.)

Bloomington, August 25, 1927, 11 a.m. Bees on staminate flowers, two, two, three, three, two, one seconds. (L.H.P.)

Ames, July 15, 1929. Bees abundant on sweet corn. (Ada Hayden.)

Dana, July 17, 1929. Bees abundant on sweet corn. (A. Miller.)

Zea Mays L. var. *everta* Bailey. Rice Pop-corn

Ames, July 25, 1920, 9 a.m. On forty stalks in two minutes, three bees working.

July 26, 1920, 12 m. and 6 p.m. Bees at work.

July 27, 1920, 7:30 a.m. Dew, bright, clear. Bees abundant, every spike being visited. Bee passes from one stamen to another. Six, seven, two, five seconds in a flower.

8 a.m. Bright, clear. Four bees on one stalk in a minute. Time in flower — three, two, three, two, three, four, six seconds.

9 a.m. Clear. Six bees on one tassel at same time. Seconds in flower — two, three, three, two, three. (L.H.P.)

2 p.m. Clear, warm. Bees common. Three, three, three, six, four, eight seconds in a flower. Flowers strongly proterogynous.

Dana, July 20, 1929. Bees abundant. (A. Miller.)

Mount Pleasant, Sept. 8, 1929. Bees numerous, getting pollen. (S. M. Helmick.)

Cyperaceae, Sedge Family

Grasslike plants with fibrous roots, generally solid stems, sheaths closed. Flowers with three stamens. Fruit in an achene. Large number of species widely distributed in Iowa. Sedgês sometimes furnish pollen. Represented by the rush (*Cyperus*) and the sedge (*Carex*).

Commelinaceae, Spiderwort Family

Small family of herbs. Flowers perfect with six stamens, often irregular. Sepals three, green in color. Petals three. Last but a short time. Capsule two to three cells, several-seeded.

Tradescantia, Spiderwort

Regular flowers in umbels. Green sepals. Six stamens. Fertile. Filaments with hairs. Capsules two- to three-celled. Flowers last but a short time. Leaves long, slender, keeled.

Tradescantia bracteata Small. Spiderwort

Perennial, glandular-villous above. Bracts relatively large. Petals blue. Widely distributed in Iowa in sandy soil. Bees have been observed on this plant.

FIG. 9.—Spiderwort (*Tradescantia bracteata*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ledges (Boone county), Warren county (L. H. Pammel), Ames (C. R. Ball, E. D. Ball, B. Banks, S. W. Beyer, G. W. Carver, A. G. Hoopes, F. Rolfs, F. A. Sirrine), Armstrong (R. I. Cratty), Des Moines (H. Frankel), Fayette (B. Fink), Fort Dodge (F. W. Paige), High Lake (B. O. Wolden), Jewell Junction (F. C. Stewart), Kelley (P. Clayton), Marshalltown (C. C. Lounsberry), Pocahontas county (V. C. Fisk and L. H. Pammel).

Date of bloom, 1927, Ames, May 15.

LILIACEAE, LILY FAMILY

Herbs or occasionally woody plants; flowers regular; perianth of six parts frequently colored; stamens six, pistil one, ovary mainly three-celled. Fruit a pod or berry. Representatives—Solomon's seal, spikenard, hyacinth, lily, tulip, trillium, yucca, asparagus, onion. Green brier (*Smilax rotundifolia*), the only woody monocot native to Iowa.

Tulipa Gesneriana L. Common Tulip

Plants bulbous, small roots, simple stems, lanceolate leaves and a solitary bell-shaped flower.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Ames (Ruth Walker).

HONEY BEE VISITS

Ames, April 18, 1917. South side of Central Building, I.S.C. Bees and smaller Hymenoptera visiting flowers for nectar and pollen. (L.H.P.)

March 17, 1929, 4:30 p.m. Twenty-six seconds in a flower. I watched for several days. Did not see a bee. Today I found a single bee in a flower partly closed. It first gathered pollen and then crept up the style. It could not get out because of the smooth character of the petals. It fell back and finally I released it. (L.H.P.)

April 20, 1920. In sheltered spot three honey bees at work upon both red and yellow tulips in one minute. (L.H.P.)

April 20, 1920. (Red flowered variety). Three bees in one minute. Location sunny and protected. (L.H.P.)

Floral characters.—Knuth says: "Flowers feebly fragrant, very conspicuous by the vivid coloring of the perianth leaves. They are homogamous pollen flowers. The honey bee observed collecting pollen."

Blooming dates for Tulipa Gesneriana

Central Section

	Ames	Boone	Mt. Joy, Scott Co.	Mt. Joy
1892			4–27 early	late
1896			4–17 "	4–29 "
1898			4–24 "	5–24 "
1900			4–27 "	5–14 "
1921	4–1	4–20		
1922	4–20			
1923	4–30			
1924	4–20			
1927	4–20			

Uvularia L. Bellwort

Perennial from a rootstock with fleshy roots, forking above. Leaves oblong, perfoliate. Flowers yellowish, drooping. Perianth bell-shaped; stamens 6; pistil compound, 3-celled.

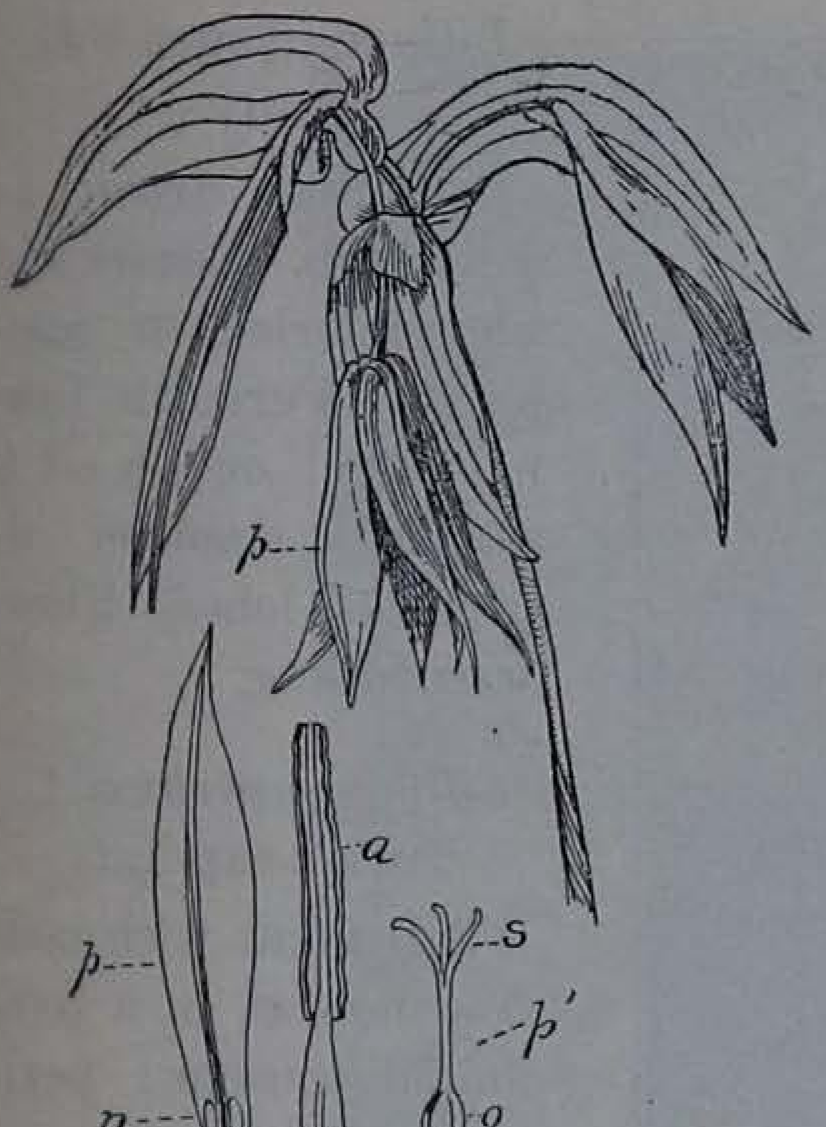


FIG. 10.—Bellwort (*Uvularia grandiflora*). p, perianth; n, nectar gland; p, pistil; s, three-cleft style; a, anther.

Uvularia grandiflora Sm.
Bellwort

Yellowish green plant. Stems naked above; leaves whitish-pubescent beneath; stamens exceeding the style.

Blooming date, 1925, Ames, April 10,
Lansing, May 1.
1926, Ames, April 26,
Lansing, May 3.

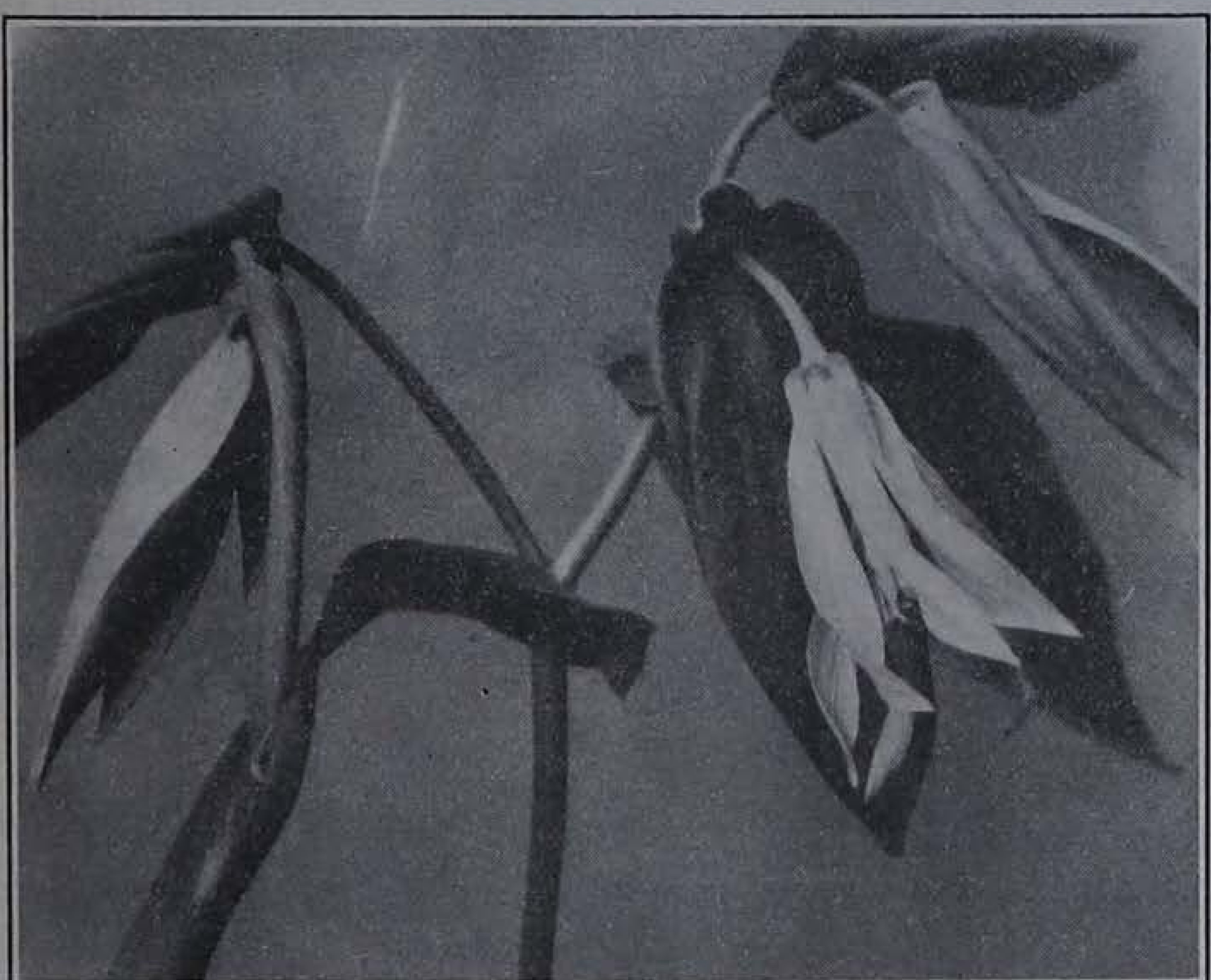


FIG. 11.—Bellwort (*Uvularia grandiflora*). *Photo by Ada Hayden.*

FIG. 12.—Turk's-cap lily (*Lilium superbum*). *Iowa State Park Bulletin.*

Lilium (Tourn.) L.
Lily

Perennial from a scaly bulb. Leaves sessile, whorled or scattered. Perianth funnel-form or bell-shaped; stamens 6; stigmas 3-lobed. Flowers nodding.

Lilium superbum L.
Turk's-cap Lily

Tall plant with nodding flowers in a pyramidal raceme; perianth divisions revolute, orange with dark purple spots. This is generally pollinated by night-flying insects, but occasionally honey bees are found on it.

Apis mellifica is reported in Europe on *Lilium candidum*. *Lilium philadelphicum* is the more common of the three native Iowa lilies. This has erect flowers, shaped something like a tulip; hence the early settlers called it "wild tulip."

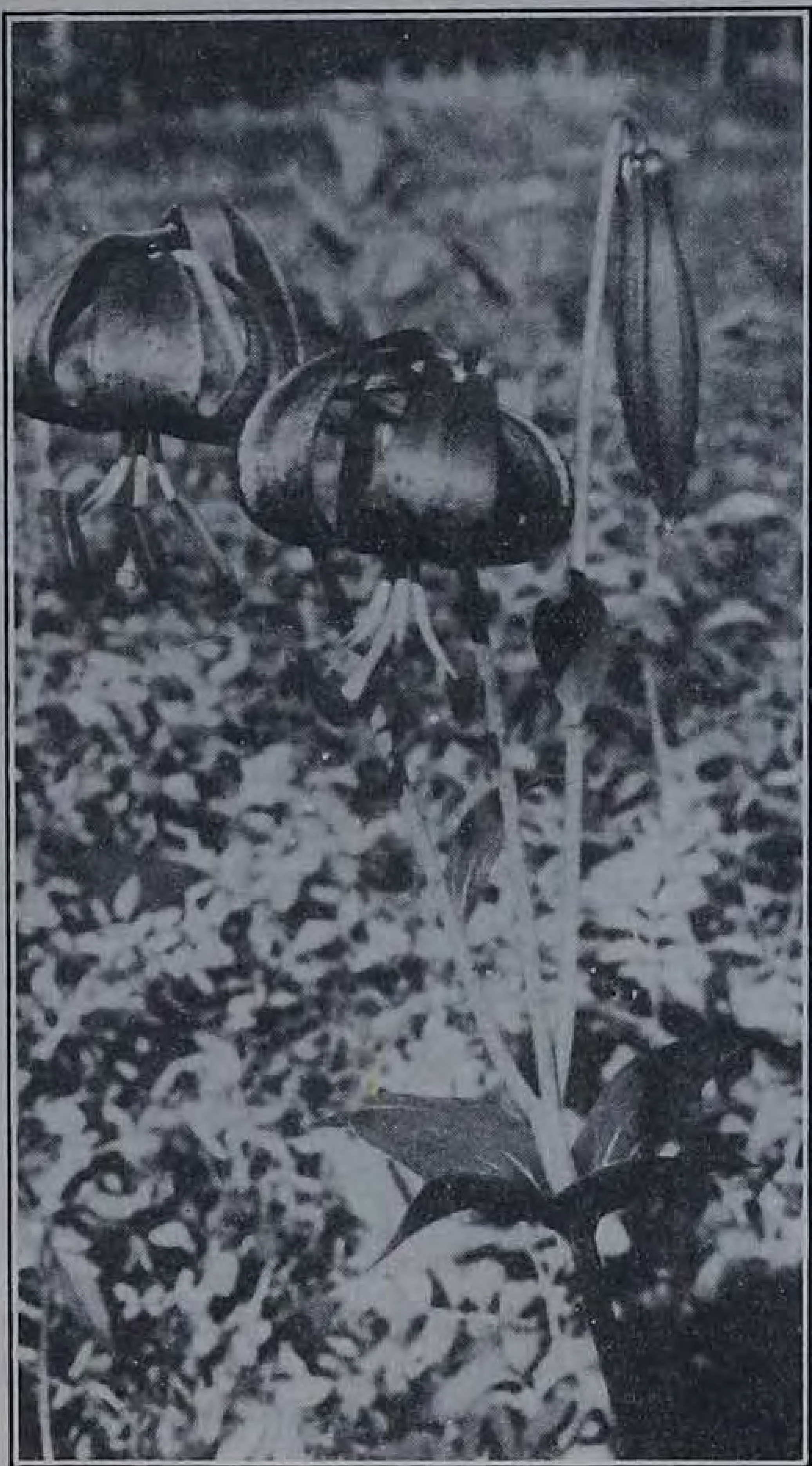


FIG. 13.—Turk's-cap lily. (*Lilium superbum*). *Photo by Ada Hayden.*

Allium (Tourn.) L. Onion

Leaves and stem from a coated bulb. Flowers in a simple umbel. Perianth of six colored sepals. Plant with pungent odor.

Allium Cepa L. Onion

The flowers of the onion, borne in an umbel, are white, the perianth of six sepals. The hollow leaves are much shorter than the inflated scape. All parts of the plant have a strong characteristic odor.

FIG. 14.—Field of onion in blossom. *From Iowa State Hort. Soc.*

The onion is believed to have had its origin in Persia. It is common in gardens and grown extensively in several sections of Iowa.

Mueller says: "Honey is secreted by the ovary in the three notches between the carpels." The flowers are visited by a few Hymenoptera and Diptera.

The flowers of the onion are often frequented by bees for nectar. Mr. Reppert of Burlington had some honey that had the odor and taste of onion. He removed his apiary to a sweet clover field where onion flowers were not accessible. This yielded an abundance of honey free from onion flavor and satisfied the bees.

Mr. Pellett says: "The onion yields freely, and the honey is said to be amber in color, with characteristic flavor which disappears after the honey is fully ripened."

HONEY BEE VISITS

Ames, June 27, 1927. Bees fairly common. Two, two, two, two, one, two seconds in a flower. (L.H.P.)

Allium canadense L. Wild Onion

Perennial herbs with bulb. Flowers in umbels, bulbiferous. Perianth, 6 divisions; capsule 3-celled. Common in the state.

FIG. 15.—Wild onion (*Allium canadense*). *Photo by C. M. King.*

Erythronium L. Dog's-Tooth Violet

A perennial rising from a deep scaly bulb. Leaves shiny, spotted. Lilylike flowers. Perianth of six divisions recurved; anthers six; capsule obovoid. Flowers in a scape, large, nodding.

FIG. 16.—Dog's-tooth violet (*Erythronium albidum*). *Photo by Ada Hayden.*

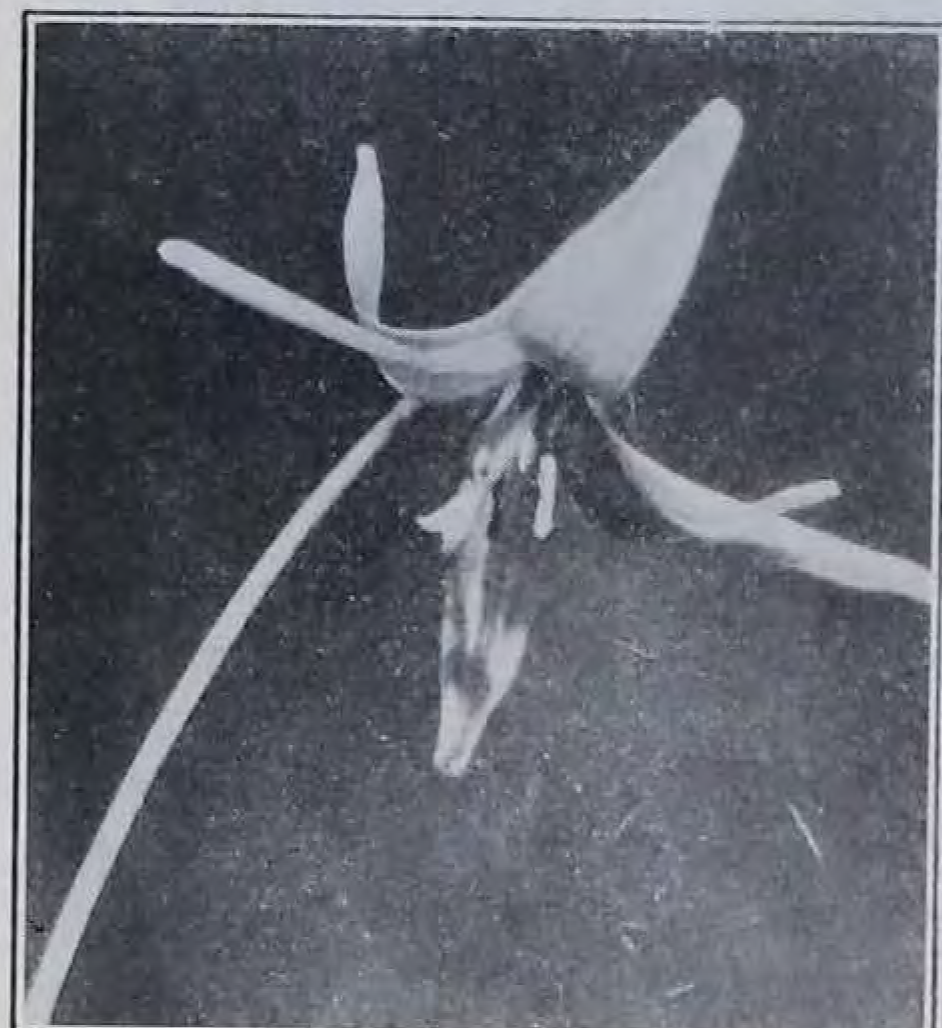


FIG. 17.—Dog's-tooth violet (*Erythronium albidum*). *Photo by Ada Hayden.*

Erythronium albidum

Nutt. White Dog's-Tooth Violet

Perennial with corm. Reproduced by subterraneous corm offshoots. Leaves elliptical, lanceolate, usually spotted. Flowers pinkish white. Widely distributed in North America. Associated with *Hepatica acutiloba, Sanguinaria canadensis, Anemone nemorosa.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Elkader, Guttenberg (R. Gmelin), Linn county, Osage (F. M. Tuttle), Ames (E. D. Ball, G. W. Carver, J. Dickey, F. Rolfs, P. H. Rolfs, R. Walker), Chickasaw county (W. D. Spiker), Decorah (H. Goddard, E. W. D. Holway), Denison (C. Blume), Des Moines (H. Frankel), Fayette (B. Fink), High Lake (B. O. Wolden), Iowa City (A. S. Hitchcock), Ledges (Boone county) (E.

Bissell, J. V. Ellis and L. H. Pammel), Peterson (L. H. Pammel), Sheldon (J. L. Mondabaugh).

General distribution in the United States:

Illinois—Chicago (Mason Bross); Indiana—Crawfordsville (W. H. Evans); Minnesota—Rochester (Mrs. N. E. Hansen); Nebraska—Ottawa (J. W. Huett); Wisconsin—Clay county (K. K. Mackenzie), Madison (L. H. Pammel).

HONEY BEE VISITS

Ames, April 29, 1928, 11:30 a.m. Clear, fairly common. Some bees gathering pollen, three, three, three seconds in a flower. (L.H.P.)

Date of bloom, Ames, April 22, 1926. Lansing, April 10, 1926.

Muscari (Tourn.) Mill. Grape Hyacinth

Small bulbous plants. Leaves narrow. Flowers in small racemose clusters. Three-angled pod.

Muscari Botryoides (L.) Mill.

A perennial plant. Slender scape with linear leaves. Flowers near top of scape. Blue in color. Commonly cultivated.

HONEY BEE VISITS

Ames, May 17, 1929, 9:30 a.m. Some bees. One, one, one, two, two, one seconds in a flower. (L.H.P.)

Yucca (Rupp.) L. Spanish Bayonet

Perianth with somewhat woody short stems. Leaves rigid, linear or sword-shaped. Flowers in an ample panicle, drooping, white. Perianth with six large whitish or greenish oval segments. Stamens 6; stigmas 3, sessile; capsule 3-celled or imperfectly 6-celled.

FIG. 18.—Flowers of *Yucca Whipplei*. Occasionally visited by bees as is our *Yucca glauca*. The flowers of our western Iowa species resemble the above. *After Kerner-Oliver.*

Yucca glauca Nutt.
Yucca or Spanish Bayonet

Leaves very stiff and pungent, filiferous on the margin. Raceme simple; flowers rather large. Stigmas green; capsule more or less 6-sided.

Common in western Iowa on bluffs and distributed westward.

Pellett reports this as visited by honey bees. It is, however, pollinated by a little *Pronuba*, the yucca moth.

Yucca filamentosa L.
Adam's Needle

Is commonly cultivated. Has a long rootstock. Leaves numerous, filiferous on the margin. Panicle densely flowered. Flowers large. Native to southern and southeastern United States.

Asparagus (Tourn.) L. Asparagus

Perennial herbs with branching stems and thick, matted rootstocks. Short threadlike or needle-like leaves, and small yellowish bell-shaped axillary flowers.

FIG. 19.—Asparagus (*Asparagus officinalis*). *Photo by Ada Hayden.*

Asparagus officinalis L. Garden Asparagus

A bushy garden plant with fleshy rootstocks, the so-called "leaves" consisting of thread-like branches, pale yellow flowers and red berries. Commonly grown throughout Iowa.

General distribution for the United States as shown by specimens in I.S.C. Herbarium:

Colorado—Fort Collins (J. H. Cowen); Missouri—Allenton (L. H. Pammel); South Carolina—Oconee county (two specimens, A. P. Anderson); South Dakota—Mount Vernon (B. Fink), Highmore (Quick); Virginia—Blacksburg (W. A. Murrill).

Mueller says: "Honey is secreted and lodged at the base of the corolla. The honey bee is a very abundant visitor, collecting both nectar and pollen."

HONEY BEE VISITS

Ames, July 2, 1927, 8 a.m. Bees gathering pollen freely. Two seconds in a flower. (C.M.K.)

FIG. 20.—Spikenard or False Solomon's seal (*Smilacina racemosa*). *Photo by Ada Hayden.*

Smilacina Desf. False Solomon's Seal

Perennial herbs with simple stems, thick rhizomes. Leaves alternate, simple, sessile. Flowers in racemes, white. Ovary 3-celled, two ovules in each cell.

Smilacina racemosa L. Desf. False Spikenard

Perennial, one and one-half feet tall. Somewhat downy. Numerous oblong, oval-lanceolate leaves. Flowers in a racemose panicle. Fruit red. In moist woods, general throughout the state.

Bees have been observed upon this plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eldora, Iowa City (south of), Lake Mills, Ledges, Madrid, Manchester, McGregor, Tete des Morts, Traer, Worth county (L. H. Pammel), Ames (G. W. Carver, Fred Rolfs), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson), Decorah (H. Goddard), Fort Dodge (F. W. Paige), Indianola, (H. Jaques, I. E. Melhus and L. H. Pammel), Rockford (C. L. Webster), West Union (E. Hancock and L. H. Pammel), Wild Cat Den (Muscatine county) (C. R. Ball).

General Distribution in the United States:

District of Columbia—Piney Branch Road (C. R. Ball and A. E. Paddock); Illinois—Aurora (Mr. Eldredge), Starved Rock (M. Heavenhill and L. H. Pammel); Kentucky—Bell county (T. H. Kearney); Louisiana—(T. L. Andrews); Massachusetts—(M. A. Day); Michigan—Mackinac Island, Whitehall (L. H. Pammel), ... (F. E. Wood); Minnesota—Anoka (R. I. Cratty), Brainerd (E. B. Watson), Star Island (Cass Lake) (P. S. McNutt and H. E. and L. H. Pammel), St. Paul (R. Gmelin); Missouri—St. Louis (H. Eggert, L. H. Pammel, F. K. R. and P. T. B.); New Hampshire—Coos county (A. H. Moore); New York—Fall Creek gorge (H. E. Summers), Poughkeepsie (Miss Shattuck), Six Mile gorge (H. E. Summers), White Plains (L. H. Pammel); Ohio—Cedar Point, Gambier (L. H. Pammel), Worthington (Asa Horr); Oregon—Hood river, Redmond (Kirk Whited); Pennsylvania—Gettysburg, Spruce creek (L. H. Pammel); Wisconsin—Holmen (L. H. Pammel), Neopit (C. H. Ineck and Wm. Nagel), Portland, Monroe county (C. M. King and D. Pammel).

FIG. 21.—Solomon's seal (*Polygonatum commutatum*). *Photo by Ada Hayden.*

Polygonatum (Tourn.) Hill. Solomon's Seal

Perennial herbs with simple stems from creeping knotted rootstocks. Flowers in axillary clusters, color white. Fruit blue.

Polygonatum commutatum (R. & S.) Dietr. Great Solomon's Seal

Smooth plant with stout stem; leaves ovate; flowers axillary; peduncles jointed; fruit blue. Common in woods. Associated with *Corylus americana*, *Ulmus fulva*, *Hepatica acutiloba*, *Anemone nemorosa*.

Bees frequently gather pollen from this plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Auburn, Bassett, Cedar Falls with *Celastrus scandens, Aster sagittifolius,* and *Apocynum androsaemifolium,* Cherokee, Clarksville, Dubuque, Lake Mills, McGregor, Palo Alto county, Saratoga, Sidney, Sioux City (L. H. Pammel), Ames (A. Hayden, E. R. Hodson, L. H. Pammel), Chickasaw county (W. D. Spiker), Clear Lake (R. I. Cratty), Creston (T. L. Andrews); Dakota City (F. C. Stewart), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Fraser (Botany Seminar), Goodell (G. B. MacDonald and L. H. Pammel), Kelley (Pearl Clayton), Laurens (F. W. Paige), Waterville (I. Stange), Winneshiek county (H. Goddard).

General distribution for the United States:

Illinois—Cheltenham Beach (L. H. Pammel); Kansas—Manhattan (D. G. Fairchild); Ohio—Cedar Point, Put-in-Bay (L. H. Pammel); Minnesota—Graceville (L. H. Pammel), Minneapolis, (R. I. Cratty); Missouri—Hogan (L. H. Pammel); New York—Ithaca (W. C. Muenscher and A. R. Bechtel, H. E. Summers); South Dakota—Sioux Falls (L. H. Pammel), Dell Rapids (N. E. Hansen); Wisconsin—Galesville, La Crosse (L. H. Pammel).

Date of bloom, 1927, Tabor, May 12.

Convallaria L. Lily-of-the-Valley

A perennial with bell-shaped flowers. Berry few-seeded, red.

Convallaria majalis L. Lily-of-the-Valley

A perennial herb. Perianth white. Six recurved lobes; six stamens; ovary three-celled. Commonly cultivated as an ornamental plant.

Bees occasionally visit this plant.

Date of bloom, Ames, April 22, 1927.

Melanthium L. Bunch-flower

Perennial plants, tall, leafy; from a thick rootstock. Flowers in open panicle, cream-colored or greenish. Perianth in six separate pieces; capsule ovoid, conical, 3-lobed.

Melanthium virginicum L. Bunch-flower

Rather tall leafy plant. Leaves linear. Perianth divisions flat, oblong or slightly hastate.

FIG. 22.—Bunch-flower (*Melanthium virginicum*). *Photo by C. M. King.*

Common throughout wet meadows of southern Iowa. Widely distributed in eastern North America.

Trillium L. Wake Robin

Perennial herbs with simple stems. Tuber-like rhizomes bearing a whorl of three leaves and a single flower with three green sepals and three petals. Sepals are persistent.

Kerner describes all species of *Trillium* as proterogynous, so that the flower is adapted to cross pollination.

Trillium nivale Riddell. Snow Trillium, Wake Robin

This small white trillium is found in rich wooded slopes in a number of localities in Iowa. It is frequented by honey bees. The height is from two to four inches; three oval obtuse leaves, three oblong, slightly wavy, white petals.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Decorah (E. W. D. Holway), Elkader (D. N. Gmelin).

General distribution for the United States:

Ohio—Columbus (W. A. Kellerman, E. J. Fulmer).

Blooming, Boone, April 1, 1924; Boone, March 22, 1925; Boone, March 21, 1926; Boone, March 17, 1927.

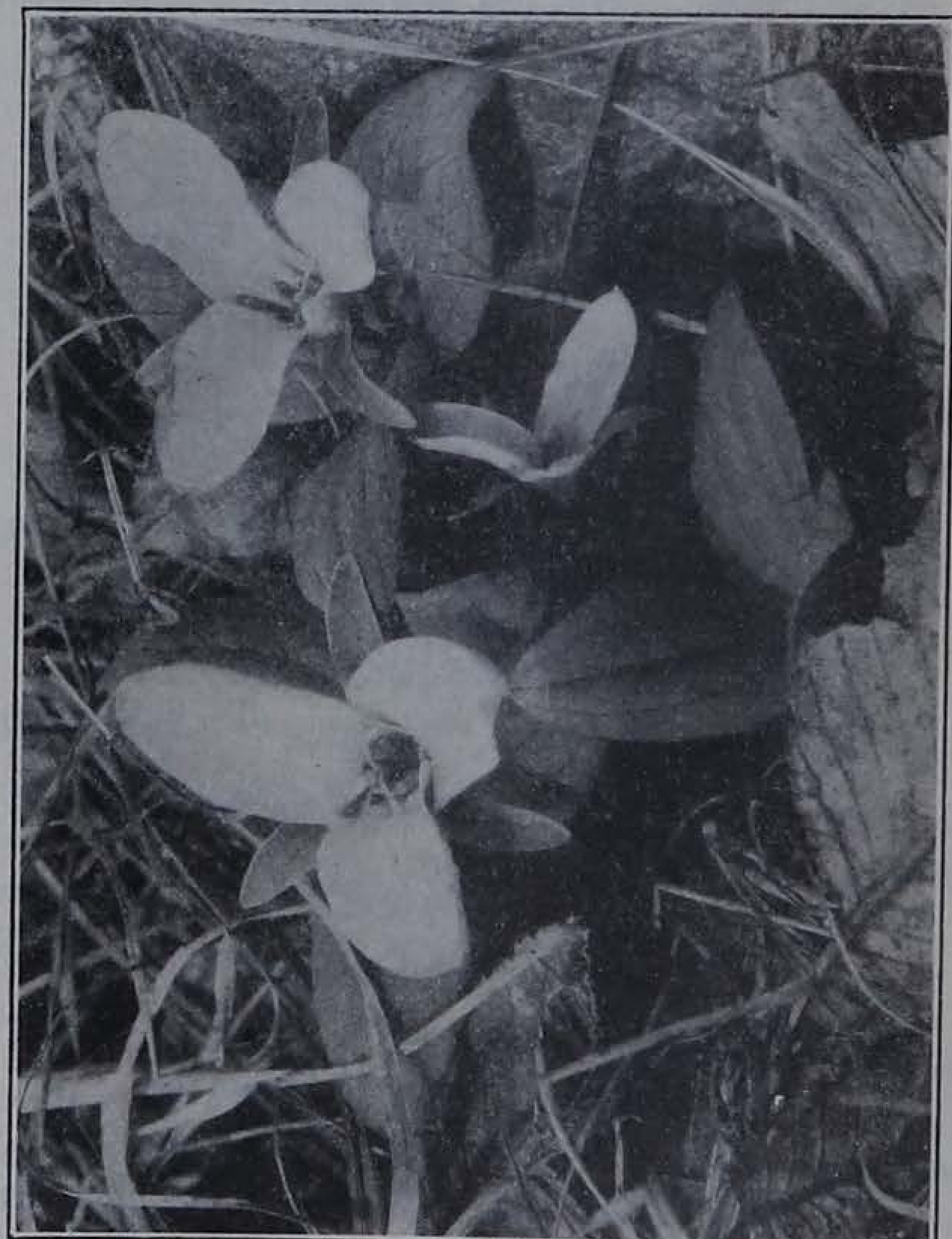


FIG. 23.—Wake robin (*Trillium nivale*). *Photo by Ada Hayden.*

HONEY BEE VISITS

Boone, April 12, 1927, 2 p.m. (season late). Clear, warm. Banks white with trilliums; fragrance distinct. Occasional bees and numerous other insects visiting the flowers. (L.H.P.)

Trillium grandiflorum (Michx.) Salisb. Large-flowered Trillium

Perennial herbs with leaves rhombic, ovate. Flowers with three green sepals. Petals oblanceolate, at first white, turning to rose color. Widely distributed in wet woods. Associated with *Anemone nemorosa, Dicentra Cucullaria.*

Hyacinthus orientalis L. Common Hyacinth

A genus with coated bulbs, narrow radical leaves, a simple leafless scape, with a raceme of handsome bell-shaped flowers.

This plant, with its racemes of white, pink or blue flowers, blooms in gardens in early spring. It may be grown out of doors with shelter in the latitude of Iowa.

The flower is attractive to bees and numerous other insects by reason of nectar secreted at the top of the ovary, as noted by Sprengel, and by juices about the perianth, as observed by Mueller.

Knuth says, "Bee flowers with juicy tissue at the base of the ovary, or with concealed nectar secreted there."

It is claimed by Knuth that the flower is not adapted to self-pollination, owing to the relative position of its parts.

HONEY BEE VISITS

Ames, April 12, 1914. South side Central Building, I. S. C. Three bees visiting one flower in three minutes, evidently for nectar. (L.H.P.)

April 14, 1914. South side Central Building. Bees visiting both tulips and hyacinths. (L. H. P.)

April 12, 1916. Campus. One bee visiting tulips and hyacinths.

April 18, 1917. South side Central Building. Tulips and hyacinths visited by bees, for nectar and pollen. Other smaller Hymenoptera present. (C.M.K.)

AMARYLLIDACEAE, AMARYLLIS FAMILY

FIG. 24.—Yellow star grass (*Hypoxis hirsuta*). *Photo by Ada Hayden.*

Hypoxis L. Star Grass

Perennial. A stemless, grasslike plant with linear leaves.

Hypoxis hirsuta (L.) Coville. Star Grass

Linear, grasslike leaves with yellow perianth. Plant associated with blue-eyed grass (*Sisyrinchium angustifolium*).

IRIDACEAE, IRIS FAMILY

Herbs with equitant leaves and regular or irregular perfect flowers of three petals and three petal-like sepals. Ovary 3-celled.

Iris (Tourn.) L. Fleur-de-Lis

Perennial with equitant leaves. Distinct perianth with long tube. Stamens distinct under the overarching petal-like stigmas. Capsules 3- to 6-angled. Flowers showy.

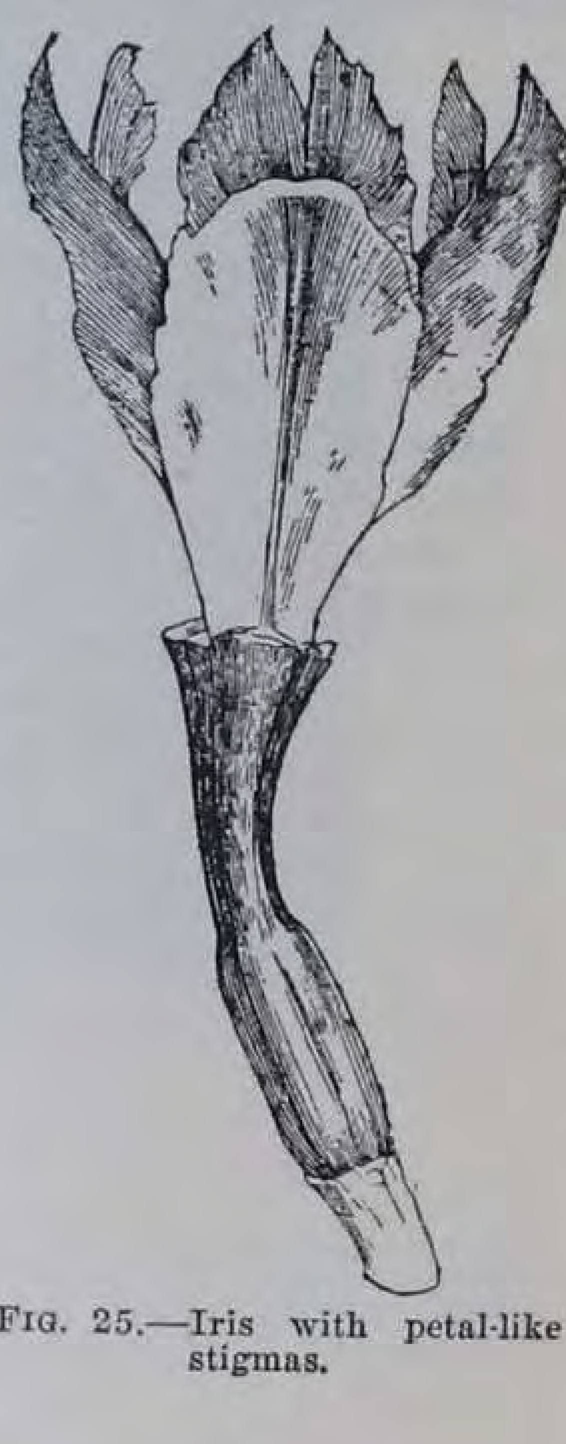


FIG. 25.—Iris with petal-like stigmas.

Iris versicolor L. Larger Blue Flag

Perennial with stout stems. Leaves somewhat glaucous. Flowers short pediceled, green to white. Tubes funnel-like. Wet places. Widely distributed.

Honey bees have been seen to gather the pollen. The nectar is inaccessible to them.

FIG. 26.—Larger blue flag (*Iris versicolor*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Missouri Valley (L. H. Pammel), Ames (C. R. Ball, A. S. Hitchcock, Royal Meeker), Chickasaw county (W. D. Spiker), Decorah (H. Goddard, E. W. D. Holway), Emmet county (R. I. Cratty), Fayette (B. Fink), Iowa City (A. S. Hitchcock), Pocahontas (V. Fisk and L. H. Pammel).

General distribution in the United States and Canada:

Illinois—Champaign (B. Fink); Michigan—Farwell (Ida Grillette); Minnesota—Coleraine (R. I. Cratty), St. Paul (R. Gmelin); Missouri—Jefferson City (L. H. Pammel); New Hampshire—Coos county (A. H. Moore); New Jersey—Pine Barrens (A. R. Bechtel and J. B. Brinton); New York—Ithaca (A. R. Bechtel and W. C. Muenscher, H. E. Summers), Niagara Falls (G. H. Frazier), St. Regis Falls (E. R. Hodson); Nova Scotia—(C. D. Howe and W. F. Lang); Ohio—Baltimore (Asa Horr); Pennsylvania—Sellersville (C. D. Fretz); Quebec—Isle due Havre (F. F. Marie-Victorin and Rolland-Germain); South Carolina—(G. McCarthy).

Iris germanica L. German Iris

Plant with thick, more or less branching rootstocks. Rather tall with stem bearing two-flowered terminal heads. Flower tinged with purple and more or less greenish on the lower part. Widely cultivated in numerous forms. It is visited by honey bees. Bees go to the flower largely for the pollen.

Knuth reports that it is visited by numerous individuals of *Apis mellifica*, which effect pollination. They usually crept out of the flower sideways after sucking nectar but in many cases, where the lateral entrance was narrow, backed out of the entrance. This, however, apparently caused them considerable trouble. The insects are attracted to the flower by both odor and nectar. The nectar guide in some of the species is in the form of a dark yellow patch.

Knuth says, "The only means of access is found between the three large sepals, which serve as platforms, and the three petaloid stylar branches situated above them. Each of these three entrances is divided into two separate tubes by the filaments, which are fused with the sepals. Visitors seeking nectar creep forward on the platform under the stylar branch, bending back the upper side of the little stigmatic lappet in doing so, and dusting it with pollen brought from another flower. In creeping further, the insect brushes against the anthers, which have dehisced downwards by two longitudinal slits, and dusts its back with fresh pollen. After having extracted nectar, it creeps out backwards, but is unable to brush against the upper sides of the stigmatic lobe again, as it has once more sprung upwards."

HONEY BEE VISITS

Ames, May 21, 1929, 8:30 a.m. Bees seven, twelve, eight seconds in a flower. Only a few bees. (L.H.P.)

1:30 p.m. Some bees. Ten, twelve, twelve seconds in a flower. (L.H.P.)

May 23, 1929, 8 a.m. Warm, westerly wind. Ten, twelve, four seconds in a flower. (L.H.P.)
May 30, 1929, 11 a.m. No bees. (L.H.P.)

Date of bloom, Ames, June 1, 1927.

Iris sibirica L. Asiatic Iris

A variable species growing in tufts, with linear leaves and small lilac-colored flowers.

HONEY BEE VISITS

Ames, May 30, 1929. Warm. Some honey bees. Ten, nine, ten seconds in a flower. (L.H.P.)

Sisyrinchium L. Blue-eyed Grass

Perennial with grasslike leaves. Flowers in small clusters. Sepals and petals alike.

Sisyrinchium angustifolium Mill. Narrow-leaved Blue-eyed Grass

An erect, ascending, glaucous herb. Stems winged. Spathes green or rarely purple. Flowers violet, rarely white. Sandy prairies. Associated with *Hypoxis hirsuta.*

Bees have been observed on this plant.

Date of bloom, Ames, May 12, 1926; May 12, 1927.

FIG. 27.—Blue-eyed grass (*Sisyrinchium angustifolium*).

FIG. 28.—Blue-eyed grass (*Sisyrinchium angustifolium*). *Photo by Ada Hayden*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Des Moines, Middle River, New Hampton, Winterset (L. H. Pammel), Ames (C. R. and E. D. Ball, B. Banks, S. W. Beyer, G. W. Carver, J. V. Ellis, H. Fausch, A. S. Hitchcock, F. Rolfs), Armstrong (F. W. Paige, R. I. Cratty), Charles City (J. C. Arthur), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson, T. J. Fitzpatrick), Decorah (F. R. Goddard), Fort Dodge (F. C. Stewart), High lake (B. O. Wolden), Iowa City (A. S. Hitchcock), Ledges (E. Bissel and L. H. Pammel), Muscatine (F. Reppert), Otho (F. W. Paige and L. H. Pammel).

General distribution in the United States:

Colorado—Crystal Park (F. E. and E. S. Clements), Larimer county, Laporte (L. H. Pammel), Tolland (L. A. Kenoyer); Idaho—Caribou mountain (George M. Armstrong and E. B. Payson), Warm creek (Miss Clearman); Illinois—Peoria (F. E. McDonald); Indiana—Wells county (Chas. C. Deam); Kansas—Wichita (T. L. Andrews); Massachusetts—Stockbridge (H. Kellogg); Minnesota—St. Cloud (R. Gmelin); Missouri—Gratiot (L. H. Pammel);

Nebraska—Belden (R. H. Hagelin); New Mexico—Cuba (A. D. Read); New York—McLean (A. R. Bechtel and W. C. Muenscher); Nevada—Hubbardston (E. F. Smith); Utah—Provo river (L. H. Pammel and E. M. Stanton); Wisconsin—La Crosse, Madison (L. H. Pammel); Wyoming—Laramie (I. C. Brownlie, E. E. Little, L. H. Pammel).

Gladiolus L.

Perennial, with coated bulb, mostly erect stem with large, showy flowers; red, purple, yellow, white. Funnel-shaped tubular corolla, the three upper larger than the three lower. Stamens, three; ovary 3-celled, many ovules. Many species in cultivation.

Gladiolus primulinus Baker

Flowers conspicuous; primrose or yellow; tube about one inch

FIG. 29.—Moccasin flower (*Cypripedium pubescens*). Showing a type of orchid. The inflated labellum and windows are at the upper end. *C. M. King.*

FIG. 30.—Large pink lady's slipper. (*Cypripedium hirsutum*). *Photo by Ada Hayden.*

long, much curved above. The three upper segments ovate or obovate acute, hooded. Three lower segments deflexed.

This and its hybrids are commonly cultivated.

HONEY BEE VISITS

Ames, July 21, 1928, 4:30 p.m. Bees twelve, eleven, six, eleven seconds in a flower. Gathering pollen. (L.H.P.)

August 4, 1928. One, four, one, two, four seconds in a flower. (L.H.P.)

ORCHIDACEAE, ORCHIS FAMILY

Herbs with irregular gynandrous flowers, perianth of six pieces adnate to the 1-celled ovary. Stamens 1-celled. Pollen generally in masses. Fruit a capsule. This is a large and interesting family. Among the genera which are visited by bees are the Orchis and Cypripedium.

The honey bee is reported on *Cypripedium pubescens.*

HONEY BEE VISITS

Des Moines. Mr. Steppan of Des Moines observed honey bees in the flower; also bumble bees. The latter could not get out though honey bees could. (L.H.P.)

DICOTYLEDONEAE

Exogenous plants. Stems formed of bark, wood and pith. Increase in size by the addition of an annual new layer on the outside next to the bark. Leaf netted-veined. Embryo with a pair of opposite cotyledons. Flowers on the plant in fives. Representative types—plum, pear, elm, cottonwood, willow, columbine, dandelion, sunflower and morning-glory.

SALICACEAE, WILLOW FAMILY

Dioecious trees or shrubs with both kinds of flowers borne in catkins. The fruit a pod bearing numerous seeds with downy silk.

Salix (Tourn.) L. Willow

Sterile flowers three to ten, stamens distinct or united, accompanied by one or two small glands. Fertile flowers with a small flat gland at the base of the ovary, stigmas short. Trees or shrubs with lanceolate leaves. Catkins frequently appearing before the leaves. Species largely insect pollinated and very freely hybridizing.

In the simple entomophilous willows the flower consists of a

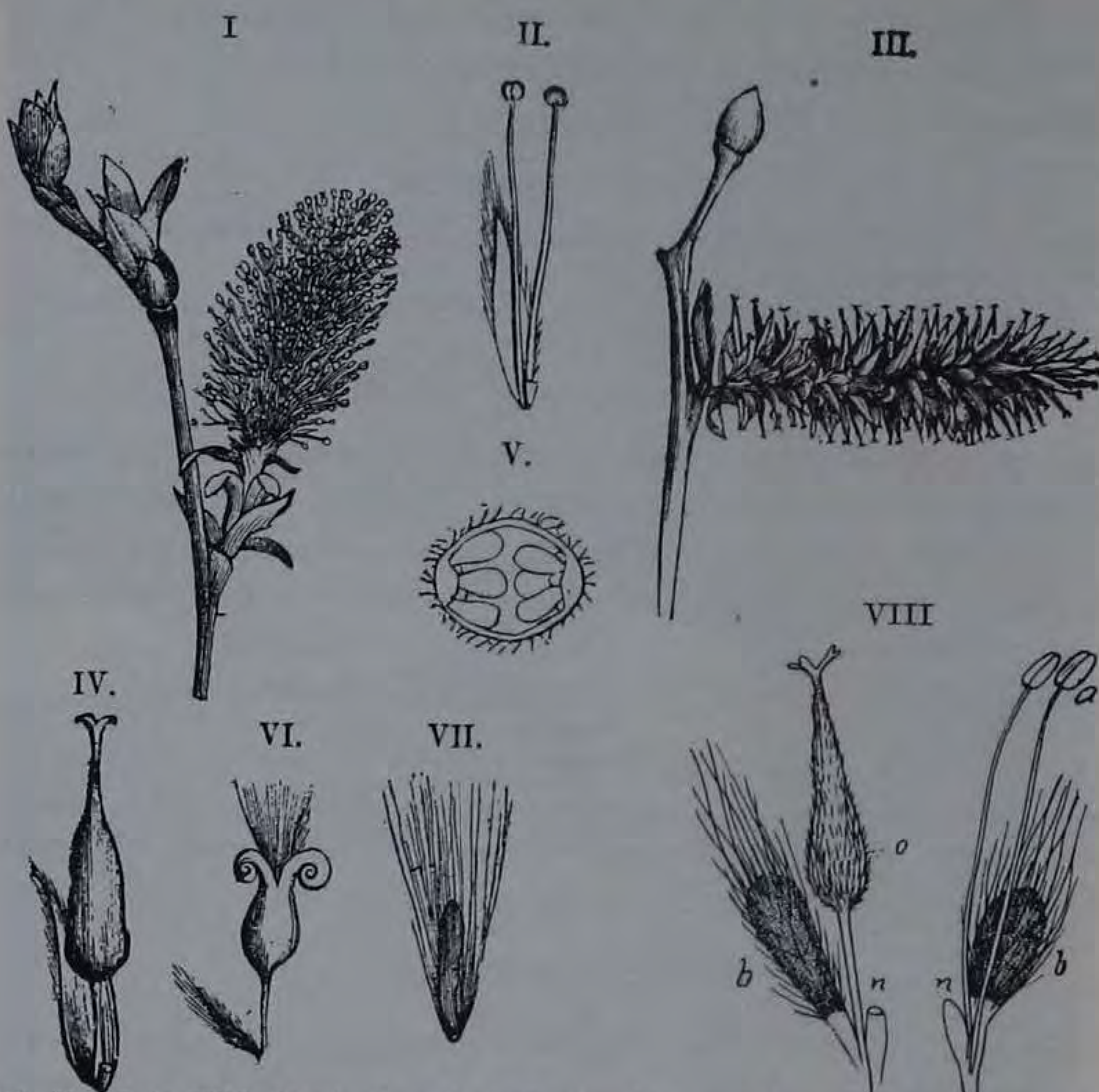


FIG. 31.—I to VIII, Staminate and pistillate catkins and flowers of the willow. II, Staminate flower, nectar gland shown at the base. IV, Pistillate flower, nectar gland shown at the base. *After Thomé.* VIII, (o) ovary; (b) bract; (a) stamens; (n) nectary. *C. M. King.*

small bract with one or more stamens at the inside, and one or two small nectar glands at the base by which nectar is secreted.

Knuth says, "Both the more conspicuous staminate flowers (which are therefore the first to be visited by insects) and the pistillate flowers secrete abundant nectar; they are consequently much sought by numerous insects, particularly bees, which bring about cross pollination and also lead to the formation of the numerous hybrids."

As insect visitors go from one species of willow to another indiscriminately, it is difficult to assign them to individual species.

Some of the willows are among the earliest of our spring flowers. *Salix discolor* and *S. rostrata* bloom before the leaves appear, at a time when the nights are cold and frosts frequent. They bloom too early in the northern states to yield surplus, but both pollen and nectar are supplied for early brood rearing.

"The early blooming willows are visited by large numbers of honey bees, for both pollen and nectar, and are of great value to the beekeeper."—ABC of Bee Culture.

Willows sometimes furnish nectar credited to dandelions.

HONEY BEE VISITS

Ames, April 22, 1916. Willows along creek in 'North Woods' visited by numerous flies and wild bees; some honey bees.

College Park, April 22, 1916. Willows visited by various Hymenoptera and flies, some bees.

Willows. S. amygdaloides and S. longifolia. O. W. Park, observer

Year	Time	Full bloom	Period of honey flow	Notes	Period worked by bees
1918	5/6			Pollen light yellow. An important source of early pollen in some of the localities. Some of the willows produce nectar also.	4/28
1922	4/20 5/8	4/28-5/5	4/29-5/5		4/29
1923	4/28	4/29-5/5			

All of the species of *Salix* are important as sources of nectar, which is found in both staminate and pistillate flowers.

In the case of *Salix humilis* (prairie willow) and of *Salix amydaloides* (peach-leaved willow) it has been observed that while bees are very busy about the staminate flowers, the pistillate flowers are visited almost entirely by flies.

In boggy regions *Salix rostrata* is important; in central Iowa *S. discolor*, *S. nigra* and *S. amygdaloides* are the important species, although *S. longifolia* has a long season. *Salix lucida* is a valuable honey producing plant and follows *S. rostrata* in bloom. It is a beautiful ornamental willow which should be planted more extensively.

Salix nigra Marsh. Black Willow

Grows from the size of a shrub to that of a tall tree. Leaves narrow, slender, finely serrulate, with short petiole and stipules. Stipules sometimes large, semicordate, pointed, persistent; or small

FIG. 32.—Black willow (*Salix nigra*). *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

ovate, deciduous. Fruiting aments 1 inch to $2\frac{1}{4}$ inches long, dense. Staminate catkins with a decided yellow color. Generally distributed in northeastern part of United States.

The black willow is common on alluvial banks of streams and along the borders of lakes. It frequently bends over into the water. It is more common southward than northward in this state, prefering soil of alluvial origin. It is associated with *Boltonia asteroides*, *Aster salicifolius*, *Aster novae angliae*, and *Thalictrum dasycarpum*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Anamosa, Atlantic, Belle Plaine, Boone (two specimens), Burlington, Cedar Falls, Centerville (two specimens), Clarinda, Clarksville, Delhi, Dillon, Fayette, Forest City, Hamburg (two specimens), Harvey, Indianola (three specimens), Keosauqua (three specimens), Lime Springs, Liscomb, Madison county, Marion county, McGregor, Moulton, Muscatine, New Albin (two specimens), Oakland, Rock Rapids, Saratoga, Stratford, Warren county, Webster City (two specimens), Yellow river (L. H. Pammel), Algona, Armstrong (R. I. Cratty), Charles City (Mrs. F. M. Tuttle, E. B. Watson), Council Bluffs (G. B. MacDonald and L. H. Pammel), Decatur county (T. J. Fitzpatrick), Decorah (E. W. D. Holway), Delaware county (I. T. Bode), Fraser (Botany Seminar), Mount Pleasant (H. E. Jaques), Oto (H. B. Clark), Salem (H. B. Clark and L. H. Pammel), Union (J. P. Anderson).

It has also been observed at the following additional places (L. H. Pammel): Ames, Clinton, Davenport, Des Moines, Dubuque, Eldora, Fairfield, Fort Dodge, Iowa City, Jefferson, Marshalltown, Mason City, Redfield.

General distribution in the United States:

Alabama—Birmingham, Montgomery (L. H. Pammel), Auburn (C. L. Pollard); California—Chica creek (C. R. Ball), Merced, Merced Falls (L. H. Pammel); Delaware—Carpenter's Station, Wilmington (William Canby); Illinois—Fountaindale (M. S. Bebb), Starved Rock (L. H. Pammel); Louisiana—Lake Pontchartrain (L. H. Pammel); Massachusetts—(Walter Dean); Michigan—Whitehall (L. H. Pammel); Minnesota—Taylor's Falls (H. E. and L. H. Pammel); Missouri—Creve Coeur lake (three specimens), St. Louis (L. H. Pammel); New York—Canandaigua (C. R. Ball), Ithaca (H. E. Summers); Ohio—Cedar Point, Huron (L. H. Pammel); Oklahoma—Muskogee (L. H. Pammel), Norman (W. T. Brown); Texas—Kerrville (two specimens, A. A. Heller), Texas Junction (C. R. Ball); Virginia—Mount Vernon (C. R. Ball); Virginia Beach (W. R. Maxon); Washington, D. C.—(Lester F. Ward), Hamilton Hill road (two specimens), Potomac flats (two specimens, C. R. Ball); Wisconsin—Bloomingdale, Galesville, St. Croix Falls, Trempeauleau bottoms (L. H. Pammel), La Crosse (Dora S. Pammel).

HONEY BEE VISITS

Ames, May 17, 1915. Clear, strong wind, three bees collecting pollen and honey; not so numerous as other Hymenoptera. Ten "wild bees" and five other insects present.

Each catkin with two hundred flowers. Staminate flowers decidedly yellow, odor pleasant.

Ames, Campus, May 23, 1929, 5:15 p.m. Clear, windy. Bees abundant. Two, two, one, two seconds in a flower. (L.H.P.)

May 24, 1929, 3 p.m. Warm. One, one, two, two, two, two seconds in a flower.

Blooming dates for Salix nigra

	Northern section	Central section
	Emmet Co.	Boone
1911	5–1	
1912	5–5	
1913	5–12	
1914		4–22
1915		4–23
1916		4–16
1917		5–5
1918		4–23
1919		4–13

Salix Wardi Bebb. Ward's Willow

This species is similar to the preceding. Lanceolate or ovate-lanceolate leaves with conspicuous veins; large stipules. Sometimes cultivated. Common south of this state. Flowers visited by honey bees.

Salix amygdaloides Anders. Peach-leaved Willow

A tree with lanceolate, long-pointed leaves, pale underneath, pedicels slender, stipules minute, soon falling, fertile aments becoming loose, 1 1/3 to 3 inches long.

The peach- or almond-leaved willow is a common willow along borders of streams. The preferred soil is usually of alluvial origin. It is associated with *Aster novae-angliae, Carex* spp., *Cyperus diandrus, Salix nigra, Salix longifolia, Aster Tradescanti.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Cedar Falls (two specimens), Clarinda, Dillon, Dubuque, Emmet county, Glenwood, Granite, Hamburg, Indianola, Jefferson, Keosauqua, Lake Mills, Lamont (two specimens), Lansing, Little Rock, Lost Island, Marion county (two specimens), Oakland, Palo Alto, Payne, Saratoga, Shell Rock, Stratford, Tama, Waterloo, Whiting (L. H. Pammel), Boone, Steamboat Rock (two specimens, W. D. Fitzwater), Missouri Valley, Spirit Lake (four specimens, P. A. Anderson), Postville (two specimens), Yellow river (O. Schultz), Decorah, West Bend (R. I. Cratty), Ames (C. E. Bessey, H. H. Hume, F. C. Stewart), Boone county (two specimens, J. V. Ellis), Charles City (C. L. Webster), Council Bluffs (H. B. Clark and L. H. Pammel), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Des Moines (A. MacCorkindale and Ira Welch), Fayette (two specimens, B. Fink), Forest City (A. L. Bakke and L. H. Pammel), Fort Dodge (F. Horton), Fraser (three specimens, Botany Seminar), Keokuk (P. H. Rolfs), Mount Pleasant (H. E. Jaques), Rockford (C. L. Webster), Sioux City (Mrs. H. J. Taylor).

It has also been observed (L. H. Pammel) at Algona, Altoona, Calmar, Centerville, Cherokee, Clear Lake, Clinton, Colfax, Cresco, Dakota City, Davenport, Decorah, Dexter, Fairfield, Fort Atkinson, Gilbert, Hamburg, Humboldt, Indianola, Lansing, Lehigh, Marquette, McGregor, Mitchellville, Muscatine, New Albin, Polk City, Redfield, Story City, Valley Junction.

General distribution in the United States and Canada:

Canada—Winnipeg (L. H. Pammel); Colorado—Fort Collins (C. S. Crandall), Golden (L. H. Pammel), Naturita (two specimens, Edwin Payson); Illinois—Cheltenham Beach, Fish lake, Galena, Savannah, Zehring (L. H. Pammel), Bowmanville (Frances C. Gates); Minnesota—Cass Lake, Ceylon, Graceville, Marshall, Rochester, Wadena (L. H. Pammel), Jackson county, Minneapolis (R. I. Cratty), Split Rock, Pipestone county (Carl A. Hansen), Star island (P. S. McNutt and H. E. and L. H. Pammel); Missouri—Bear Creek, Hannibal (Rev. Davis), Courtney (Kenneth K. Mackenzie); Nebraska—Lincoln county (F. G. Miller), Pine Ridge (J. C. Blumer); Nevada—Truckee Valley, Washoe county, (C. L. Brown) New Mexico—Mesilla Park (L. H. Pammel); New York—Canandaigua (C. R. Ball), Cascadilla creek (A. R. Bechtel and W. C. Muenscher), Ithaca (H. E. Summers); North Dakota—Wahpeton (L. H. Pammel); Ohio—Cedar Point (two specimens, L. H. Pammel); Oregon—Hood river (K. Whited), the Dalles (C. R. Ball); South Dakota—Brookings, Lake Poiret, Lake Tetonkeha, Little Missouri river, Peaceful Valley, Sioux Falls, Spring creek, Trent, Yankton (L. H. Pammel), Dell Rapids (N. E. Hansen); Utah—Farmington canyon (three specimens, L. H. Pammel), Salt Lake (R. E. Buchanan, C. P. Johnson, G. W. Lummis, L. H. Pammel); Wisconsin—Black river, Bluff Siding, Kilbourne, La Crosse (two specimens), La Crosse county, Madison, Mormon coulee, Shelby township (L. H. Pammel), St. Croix Falls (H. E. and L. H. Pammel).

Blooming dates for Salix amygdaloides

	Northern section	Central section			
	Emmet Co.	Ames	Cedar Rapids	Des Moines	Mt. Vernon
1907			4–28		
1908			4–26		
1914	5–9				
1915	4–27				
1918		4–27			
1919				5–3	4–26

HONEY BEE VISITS

Keosauqua, May 6, 1928, 10 a. m. Blooming period about half over. Some bees. Two, two, two, two, one, two seconds in a flower. (L.H.P.)

May 6, 1928, 12 m. Bees two, one, two, two seconds in a flower. (L.H.P.)

Jordan, May 12, 1929, 6:30 p. m. Two, two, two, two seconds in a flower. Staminate flowers. Only a few bees. Past its prime. (L.H.P.)

Elkhart, May 4, 1929, 12:30 p. m. Two, two, two, two, two seconds in a flower. Past its prime. (L.H.P.)

Sheffield, May 20, 1929, 3:00 p. m. One, two, two, two, two seconds in a flower. (L.H.P.)

Salix lucida Muhl. Shining Willow

Leaves ovate-lanceolate, pubescent when young, with rather stiff hairs; finally smooth, shining on both sides. Small stipules semicircular. Staminate catkins one-half inch to 1½ inches in length; the brownish or greenish capsules rounded at base. Small tree or shrub.

The shining willow is strictly a northern species. It occurs in peaty swamps or occasionally along streams influenced by spring waters in scattered areas in the Iowan and Wisconsin drift sheets.

It is associated with *Salix longifolia, Cirsium muticum, Populus tremuloides, Gentiana crinita.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park, Hanlontown, Postville, Saratoga (L. H. Pammel), Armstrong (R. I. Cratty), Delaware county (I. T. Bode), Fayette county (three specimens, B. Fink), Lawler (P. H. Rolfs).

Observed also (L. H. Pammel) at Forest City, Garner, Kossuth county, Lamotte, Lawler, New Albin, Strawberry Point, Wright county, Audubon (E. M. Cole and W. A. Hansen).

General distribution in the United States:

Michigan—St. Ignace, Muskegon, Powers, Whitehall (L. H. Pammel); Minnesota—Cass Lake (two specimens, H. E. and L. H. Pammel), Itasca State Park, Norway Beach, Wadena, Wyoming (L. H. Pammel); New York—Ithaca (three specimens, H. E. Summers), Oneida (Wm. R. Faxon); Ohio—Put-in-Bay, Sandusky (two specimens, L. H. Pammel); Wisconsin—Galesville, Holmen, Moose lake, Mormon coulee, tamarack swamp southeast of La Crosse (L. H. Pammel), Mercer (J. Clemens), St. Croix Falls (H. E. and L. H. Pammel).

HONEY BEE VISITS

Ames, April 28, 1928, 9 a. m. Heavy dew on ground. Clear. On the staminate flowers some bees and small Hymenoptera. Bees one, two, one, one, one seconds in a flower. (L.H.P.)

Salix alba L. White Willow

Leaves lanceolate to ovate-lanceolate. Silky pubescence on both sides. Ovate, deciduous stipules. This variety is planted as a windbreak and is widely distributed in the state. There are several different varieties. The variety *vitellina* (L.) Koch, with yellow or red branches is a beautiful tree with the old leaves glabrous and white beneath.

HONEY BEE VISITS

Ames, May 3, 1928, 1 p. m. Partly cloudy. Bees abundant on the staminate flowers. Two, two, two, two, two, one, two, one, two seconds in a flower.

Salix longifolia Muhl. Sand-bar Willow

Leaves one to six inches long, tapering at each end, nearly sessile, smooth and green on both sides, margins toothed. Stipules small, deciduous. Aments slender, often clustered. Small tree or shrub.

The sand bar willow is abundant on the shores of all the streams of Iowa, especially the Mississippi and the Missouri, Des Moines and Cedar; also along shores of lakes and ponds and where the top soil has been removed on gradings along railroads, where it is a good soil binder.

FIG. 33.—Sand-bar willow (*Salix longifolia*). *Photo by Ada Hayden.*

It is associated with *Lobelia cardinalis, L. siphilitica, Aster Tradescanti, Boltonia asteroides, Penthorum sedoides, Salix amygdaloides, S. nigra, S. discolor.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Auburn, Boone county, Cedar Falls (four specimens), Ceylon (two specimens), Fairfield, Greene county, Hamburg, Hanlontown, Harvey, Hawarden (two specimens), Keokuk (three specimens), Keosauqua (two specimens), Lake Mills (two specimens), Lamont, LeMars, Lime Springs, Liscomb, Little Rock, Lost Island lake, Madison county, Marion county, Mason City, New Albin, Okoboji (two specimens), Ottumwa, Postville, "Quarry" Ames, Rock Rapids, Steamboat Rock, Stratford, Summerset, Wall Lake, Waukon, Webster City (two specimens) (L. H. Pammel), Armstrong, West Bend (R. I. Cratty), Creston, Greenfield (F. C. Stewart), Dubuque county, Lee county (Paul Bartsch), Ames (three specimens, C. Bessey), Boone (H. Kellogg), Calamus (C. R. Ball), Chickasaw county (W. D. Spiker), Commerce (Mrs. H. Frankel, L. H. Pammel and Mrs. G. Rieman), Fayette (three specimens, B.

Fink), Fort Dodge (L. H. Pammel and E. H. Steffen), Fraser (two specimens, Botany Seminar), Garner (Miss W. Gilbert and L. H. Pammel), Grinnell (Vinnie Williams), High Bridge (two specimens, H. B. Clark and L. H. Pammel), Ledges (R. E. Buchanan, C. M. King and L. H. Pammel), Missouri Valley (H. E. and L. H. Pammel), Mount Pleasant (H. E. Jaques), Otho (H. B. Clark, F. W. Paige and L. H. Pammel), Rockford (G. B. MacDonald and L. H. Pammel), Shell Rock (E. S. Fyler), Sioux City (Rose S. Taylor), Spirit Lake (J. C. Austin and L. H. Pammel), Stanton (E. L. Morris), Tama county (F. A. Sirrine), Woodman's Hollow (F. W. Paige and L. H. Pammel), Yellow river (Ellison Orr, L. H. Pammel and D. O. Wilson).

This has also been observed (L. H. Pammel) at Algona, Arnold's Park, Burlington, Centerville, Cherokee, Clear Lake, Colfax, Cresco, Decorah, Dexter, Des Moines, Dubuque, Estherville, Fairfield, Forest City, Fort Atkinson, Iowa lake, Jefferson, Lake Okoboji, Mason City, New Albin, Pine Creek Hollow (Dubuque county).

General distribution in the United States:

Arkansas—Clear Fork, Prescott (L. H. Pammel); California—San Bernardino (two specimens, hairy type, L. H. Pammel); Colorado—Cache La Poudre, Salida (L. H. Pammel), Conejos river, Antonito, 7500 feet high (C. S. Crandall); Idaho—Sand Point (W. S. Dudgeon and L. H. Pammel); Indiana—Turkey Run State Park (L. H. Pammel); Michigan—Whitehall (L. H. Pammel); Maryland—Great Falls (three specimens, John R. Maxon); Minnesota—Lake City, Ortonville, Wadena (L. H. Pammel), Minneapolis, Turtle lake (R. I. Cratty), Brainerd (E. B. Watson), Cass Lake (L. H. Pammel and T. R. Truax), Minnehaha Falls (three specimens, H. E. and L. H. Pammel), Rochester (N. E. Hansen and L. H. Pammel), Star island (two specimens, H. E. and L. H. Pammel); Missouri—Allenton (G. W. Letterman); South Dakota—Brookings, Hartford Beach, Milbank, Sioux Falls (L. H. Pammel), Brookings (N. E. Hansen and L. H. P.), Big Sioux river (C. R. Ball); Nebraska—Halsey (J. C. Blumer), Wilcox (Joseph Clemens); Ohio—Cedar Point (two specimens, L. H. Pammel); Utah—Black's Fork at 7500 feet, Fuller's Ranch (two specimens, R. E. Buchanan, C. P. Johnson, G. M. Lummis, L. H. Pammel), White Rock (L. H. Pammel and E. M. Stanton); Wisconsin—La Crosse (L. H. Pammel).

HONEY BEE VISITS

Ames, May 26, 1923. Bees visiting staminate flowers for pollen. Two, two, two, one, two, one seconds in a flower. (L.H.P.)

Boone (Ledges valley), April 14, 1924. Clear, warm. Insects numerous about the flowers. No bees observed. (C.M.K.)

Ledges State Park, May 26, 1929, 3 p. m. Bees two, two, two, two, two seconds in a flower. (L.H.P.)

Keosauqua, May 6, 1928, 10 a. m. Bloom at height. Bees two, two, one, two, one, one seconds in a flower. (L.H.P.)

Salix cordata Muhl. Pussy Willow

A shrub or small tree. Glabrous branches, oblong-lanceolate leaves, which are sharply serrulate, green on both sides, somewhat paler beneath. Stipules roundish to ovate, usually large. Grows in marshy places. Freely visited by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Algona, Allamakee county, Anamosa, Auburn, Cedar Falls, Chariton, Cherokee, Clinton county, Coon Rapids, Dillon, Eldora, Gitchie Manitou Park, Granite, Greene, Hamburg, Hanlontown, Hawarden, Indianola, Jewell, Lansing, Little Sioux, Madison county, New Albin, Norwalk, Palisades (Linn county), Panora, Pisgah, Postville, Quarry, Rock Rapids, Saratoga, Spirit Lake, Stony Point, St. Olaf, Winnebago county (L. H. Pammel), Armstrong, West Bend (R. I. Cratty), Ames (C. R. Ball and L. H. Pammel, F. W. Faurot), Blue Grass (Minerva Benhoof), Chickasaw county (W. D. Spiker), Clear Lake (V. C. Fisk and L. H. Pammel), Commerce (Mrs. H. Frankel, L. H. Pammel, Mrs. G. Rieman), Council Bluffs (H. B. Clark), Decatur county (J. P. Anderson), Estherville (B. O. Wolden), Fayette (B. Fink), Fraser (Botany Seminar), Garner (Winifred Gilbert), Gilbert (S. W. Beyer and L. H. Pammel), Goodell (G. B. MacDonald), High Bridge (Boone county) (G. M. Lummis), Ledges (R. E. Buchanan), Little Rock (E. D. and W. N. Ball, L. H. Pammel), Mason City (C. H. McNider, J. H. Naylor and L. H. Pammel), Milford (H. S. Coe and L. H. Pammel), Missouri Valley (V. C. Fisk and L H. Pammel), Sioux City (L. H. Pammel and R. S. Taylor), Toledo (R. Beecraft and L. H. Pammel).

General distribution in the United States;

Michigan—Jefferson, Muskegon, Whitehall (L. H. Pammel); Minnesota—Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), Ceylon (L. H. Pammel); Nebraska—Halsted (J. C. Blumer); New York—Fall creek (Muenscher and Bechtel); Ohio—Cedar Point (L. H. Pammel); Pennsylvania—Tonawanda (L. H. Pammel); South Dakota—Brookings, Sioux Falls (L. H. Pammel); Wisconsin—La Crosse (L. H. Pammel).

Salix missouriensis Bebb.

Large shrub or tree. More or less pubescent twigs. Leaves lanceolate to ovate-oblong, somewhat glaucous beneath. More or less common in alluvial bottoms in western Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Council Bluffs (L. H. Pammel and H. B. Clark), Missouri Valley (L. H. and H. E. Pammel), Rolfe (L. H. Pammel), Sioux City (H. B. Clark).

General distribution in the United States:

Illinois—Kahokia (H. Eggert); Minnesota—Glenville (L. H. Pammel), Golden Valley (Mrs. Roy Westley); Missouri—Kansas City, Quindaco (K. K. Mackenzie); Nebraska—Foster, St. Helena (C. R. Ball); North Dakota—

Bismarck, Burleigh county, Dickinson county (C. R. Ball); South Dakota—Big Stone Lake (W. H. Over), Bonhomme, Sisseton (C. R. Ball), Roberts county (C. R. Ball and W. H. Over); Wisconsin—La Crosse (L. H. Pammel).

HONEY BEE VISITS

Freely visited by bees.

Sheffield, May 24, 1929, 3 p. m. Warm. Two, one, one, two, two, one seconds in a flower. (L.H.P.)

Salix discolor Muhl. Glaucous Willow, Pussy Willow

FIG. 34.—Pussy willow (*Salix discolor*). *Photo by Ada Hayden.*

Shrub or small tree, with lanceolate, bright green leaves, irregularly serrate, small stipules. The aments thick, cylindrical, 2½ inches long, appearing on the old wood, in early spring; scales clothed with long glossy hairs.

The pussy willow of Iowa occurs along streams and in upland moist springy places, especially on the Wisconsin and Iowan drift sheets where the soil is mixed with peat.

It is associated with *Pedicularis lanceolata, Scirpus atrovirens, Aster prenanthoides, A. novae-angliae, Thalictrum dasycarpum, Lobelia siphilitica.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Bluffton (two specimens), Clayton, Clear Lake, Clermont, Clinton, Dawson, Dubuque county (two specimens), Edgewood, Fairbanks, Fertile, Hanlontown, Hazleton, Indianola, Keosauqua, Lake Mills (four specimens), Lamont, Ledges (two specimens), Marion county, Mason City, Miller, Palisades (two specimens), Quarry, Sioux City, Sioux river, Stratford, Tama, Waterville, Webster City (two specimens), Winterset, Yellow river (L. H.

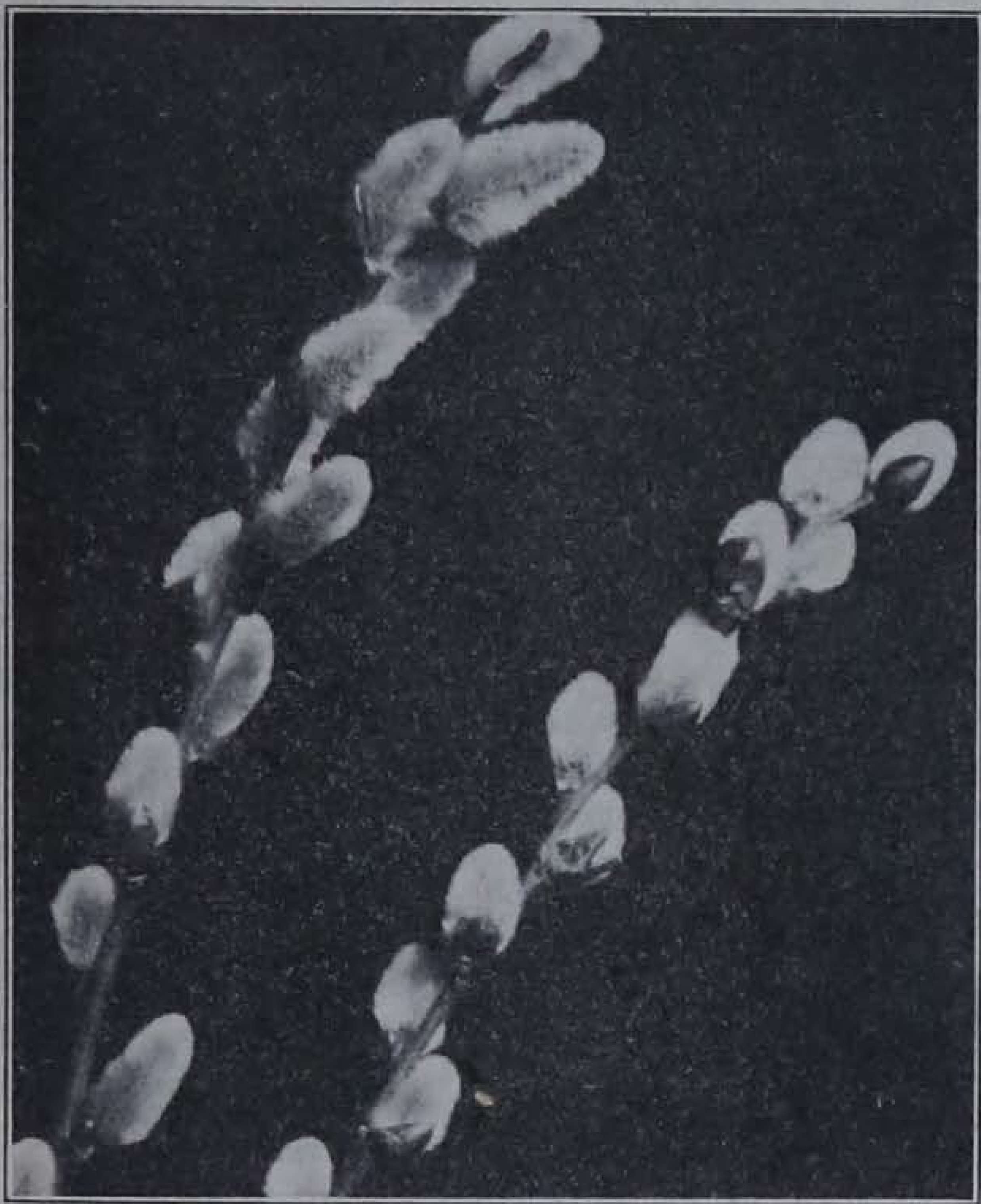


FIG. 35.—Pussy willow (*Salix discolor*). *Photo by Ada Hayden.*

Pammel), Ames (two specimens, F. A. Sirrine, P. H. Rolfs), Armstrong (R. I. Cratty), Fayette (B. Fink), Grundy Center (L. H. Pammel and B. B. Zimmerman), Pine Creek Hollow (two specimens, Fred Trenk and L. H. Pammel), Postville (four specimens, E. Orr, L. H. Pammel, D. O. Wilson), Rockford (Mr. and Mrs. F. A. Webster), Whitney (H. B. Clark and L. H. Pammel).

General distribution in the United States and Canada:

Colorado—Fort Collins (two specimens, L. H. Pammel); Illinois—Chicago, Galena (L. H. Pammel); Maine—Casco Bay, Harpswell Center (C. R. Ball); Michigan—Jackson, Muskegon, Whitehall (two specimens, L. H. Pammel), Creighton (Schoolcraft county, C. R. Ball), Houghton (L. H. Pammel and V. C. Fisk); Minnesota—Faribault, Leech Lake, Monticello, Ortonville (L. H. Pammel), Cass Lake, Cedar island, Duluth, Taylor's Falls (L. H. and H. E. Pammel), Big Stone Lake, Hiawatha Beach (C. R. Ball and W. H. Over), Crookston (Mrs. Roy Westley), Star Island (L. H. and H. E. Pammel and P. S. McNutt); New York—Fall Creek Bank (W. C. Muenscher and A. R. Bechtel), Ithaca (three specimens, H. E. Summers); Ohio—Castalia, Put-in-Bay (three specimens, L. H. Pammel); Pennsylvania—Tonawanda (L. H. Pammel); Wisconsin—La Crosse, La Crosse tamarack swamp (7 miles northeast of La Crosse) (L. H. Pammel), Eagle River (L. H. Pammel and V. C. Fisk), St. Croix Falls (L. H. and H. E. Pammel); Alberta, Canada—One mile northeast of Minburn (two specimens, C. R. Ball); Saskatchewan, Canada—Two miles west of Lashburn, thirteen miles west of Prince Albert (C. R. Ball).

Blooming dates for Salix discolor

	Northern Section		Central Section					Southern Section
	Lansing	Emmet Co.	Ames	Boone	Cedar Rapids	Iowa City	Iowa Falls	Cincinnati
1904							4–12	
1906						4–15		
1908					3–10			3–21
1910		3–25	3–22	3–20				
1911		4–17		4–1				
1912		4–12		4–6				
1913		4–18		3–16				
1914		4–18		4–20				
1915		4–15	4–1	4–5				
1916	3–27	4–28		4–1				
1917			3–18	4–2				
1918				4–23				
1919				3–9				
1920				3–12				
1921	3–21			3–6				
1922			3–28	3–26				
1923			4–18					
1924	4–9							
1925			4–1					
1926	4–10		4–8					
1927			4–4					

Honey production in Salix discolor, Pussy Willow. (O. W. Park.)

Year	Period of bloom		Full bloom	Period worked by bees
1919	3–26	4–26		4–12 to 4–25
1923	4–26	4–26		4–12 to 4–25

HONEY BEE VISITS

Ames, April 22, 1914. Along creek in North Woods. Numerous wild bees and flies. Several honey bees. (L.H.P.)

Ledges, Boone county, March 22, 1921, 2 to 4 p. m. Bright, warm. Bees very active in these willows. (C.M.K.)

Ames, April 6, 1922, 5:30 p. m. Clear. Bees numerous. One, two, one, two, one, one and one-half seconds in a flower. (L.H.P.)

April 15, 1922, 2 p. m. Sunshiny, light wind. Bees on pistillate flowers. One, two, three, one, two, three, two, two seconds in a flower. (L.H.P.)

Fort Dodge, April 30, 1922. Many wild bees on this willow. No honey bees. (L.H.P.)

Ames, April 14, 1924. Bees working freely in staminate flowers most of day. Pistillate flowers visited by bees and flies. (L.H.P.)

Salix petiolaris Sm.

Shrub with narrow lanceolate leaves, which are more or less tapering and finely serrate, silky when young. Stipules linear or rounded. This species grows in boggy places.

Freely visited by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cerro Gordo county, Clear Lake, Edgewood, Eldora, Fairbanks, Forest City, Garner, Kamrar, Lake Mills, Manchester, Mason City (Buffalo Slough), Miller, Rockford, Winnebago county (L. H. Pammel), Ames (C. E. Bessey, L. H. Pammel and C. R. Ball), Armstrong (F. W. Paige, R. I. Cratty), Chickasaw county (W. D. Spiker), Eldredge (Barnes and Miller), Hanlontown (A. C. McCorkindale and L. H. Pammel); Northwood (L. H. Pammel, Pratt, Edw. Johnson), Pilot Knob (Hancock county) (Winifred Gilbert and L. H. Pammel), Rice Lake (A. L. Bakke and L. H. Pammel), Van Horne (P. S. McNutt and L. H. Pammel).

General distribution in the United States and Canada:

Alberta—Clyde, North Dunseith (C. R. Ball); Manitoba—Winnipeg Beach (L. H. Pammel); Massachusetts—Milton (L. R. Churchill), Stockbridge (H. Kellogg); Michigan—Whitehall (L. H. Pammel); Minnesota—Cloquet, Emerson, Itasca State Park, Jackson, Moose Lake, Walker (L. H. Pammel), Anoka, Coleraine, Minneapolis (R. I. Cratty), Polk county, Schoolcraft county, Waterville (C. R. Ball), Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), Duluth (L. H. and H. E. Pammel), Garland (D. C. Poshusta), International Falls (H. Kellogg); Wildwood (Lois Pammel); New York—Erie county (C. R. Ball), Ithaca (H. E. Summers); Ohio—Buckeye lake, Cedar Point, Huron, Put-in-Bay (L. H. Pammel); Wisconsin—Alma, Galesville, Holmen, Muscoda, Mormon coulee, tamarack swamp (La Crosse), Wadena, Wauzeka (L. H. Pammel).

Salix humilis Marsh. Prairie Willow

A low shrub with narrow leaves, pubescent becoming glabrous above, below glaucous. Leaves oblanceolate or oblong-lanceolate, somewhat rugose, pubescent beneath, margin revolute. Stipules somewhat roundish. Common in prairies and borders of woods.

This species is freely visited by honey bees and is a valuable honey plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bloomfield, Bluffton, Centerville, Clear Lake, Clermont, Crescent, Delaware county, Dubuque county, Duck lake, Eddyville, Edgewood, Eldora, Gilbert, Guthrie Center, Iowa City, Jackson Junction, Lamont, Linn county, Little Sioux river, McGregor, Pilot Knob (Hancock county), Pilot Mound, Tama, Waukon Junction (L. H. Pammel), Pine creek (Hardin county) (C. M. King), Ames (C. M. King and A. E. Paddock, C. E. Bessey), Dayton (L. H. and H. E. Pammel, J. L. Seal), Decatur county (J. P. Anderson), Fayette (B. Fink), Fort Dodge (F. W. Paige), High lake (B. O. Wolden), Lamont (I. T. Bode), Ledges (L. H. Pammel, R. E. Buchanan, C. M. King), Mount Pleasant (H. E. Jaques), New Hampton (L. H. Pammel and W. D. Spiker), Osage (F. May Tuttle), Steamboat Rock (R. E. Buchanan), Worth county (L. H. Pammel, C. J. Pratt, Edwin Johnson).

General distribution for the United States:

Delaware—Wilmington (W. M. Canby); District of Columbia—Terra Cotta (C. R. Ball); Illinois—Fox (L. H. Pammel and M. Heavenhill); Maryland—Chevy Chase (C. R. Ball); Massachusetts—Stockbridge (H. Kellogg); Michigan—Glen lake, Lake Ontonagon (L. H. Pammel and V. C. Fisk), Antrim county (C. R. Ball), Whitehall (L. H. Pammel); Minnesota—Cass Lake, Clear Lake, Leech Lake, Minneapolis, Wadena, Wildwood (L. H. Pammel), International Falls (M. C. Ghostley), Star Island (L. H. Pammel and P. S. McNutt); Missouri—Greenwood (K. K. Mackenzie), Lee's Summit (B. F. Bush); Nebraska—Halsey (J. C. Blumer); New York—Ithaca (H. E. Summers); North Carolina—Biltmore Herbarium; Wisconsin—Coon Valley, Holmen, Kilbourne City, La Crosse, Madison, Muscoda, Rockton, Wauzeka (L. H. Pammel), Arlington (L. H. Pammel and V. C. Fisk), St. Croix Falls (L. H. and H. E. Pammel).

Salix tristis Ait. Dwarf Gray Willow

This species is closely related to the prairie willow (*Salix humilis*). Leaves are linear-oblanceolate with short petioles. The plant grows in somewhat sandy soil or on borders of thickets. It also is freely visited by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (C. E. Bessey), Decatur county (J. P. Anderson), Missouri Valley (L. H. and H. E. Pammel), Shelby county (T. J. and M. F. L. Fitzpatrick), Winneshiek county (H. Goddard).

General distribution in the United States:

District of Columbia—(G. McCarthy); Illinois—Bath, sand dunes (H. A. Gossard); Massachusetts—Stockbridge (H. Kellogg).

Salix rostrata Richards. Beaked Willow

Leaves elliptical to lanceolate, dull green, downy above, thin, finally rigid; stipules semicordate, toothed. The fertile catkins loosely flowered, one-half inch to $1\frac{1}{2}$ inches long. Pedicels slender, longer than scales. Small tree or shrub.

FIG. 36.—Peatbog willow, beaked willow (*Salix rostrata*), showing habitat. *Photo by Ada Hayden.*

The beaked willow occurs only on the Wisconsin and Iowan drift sheets in boggy places where peat is the main constituent. It is associated with *Cirsium muticum, Gentiana crinita, Carex filiformis, Parnassia caroliniana, Pedicularis lanceolata, Aster umbellatus, Salix pedicellaris, Phragmites communis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone county, Buffalo Slough (Mason City), Clarksville (two specimens), Dawson, Delaware county, Dubuque, Edgewood (two specimens), Fairbanks, Hanlontown, Lake Mills (two specimens), Lamont, Manchester, Marshalltown, Monticello, New Albin (two specimens), Pilot Knob (Hancock county), Pine Creek Hollow (Dubuque county), St. Olaf, Stratford, Wheelerwood (L. H. Pammel), Ames (C. E. Bessey, Mina Belle Lynch, F. A. Sirrine, two speci-

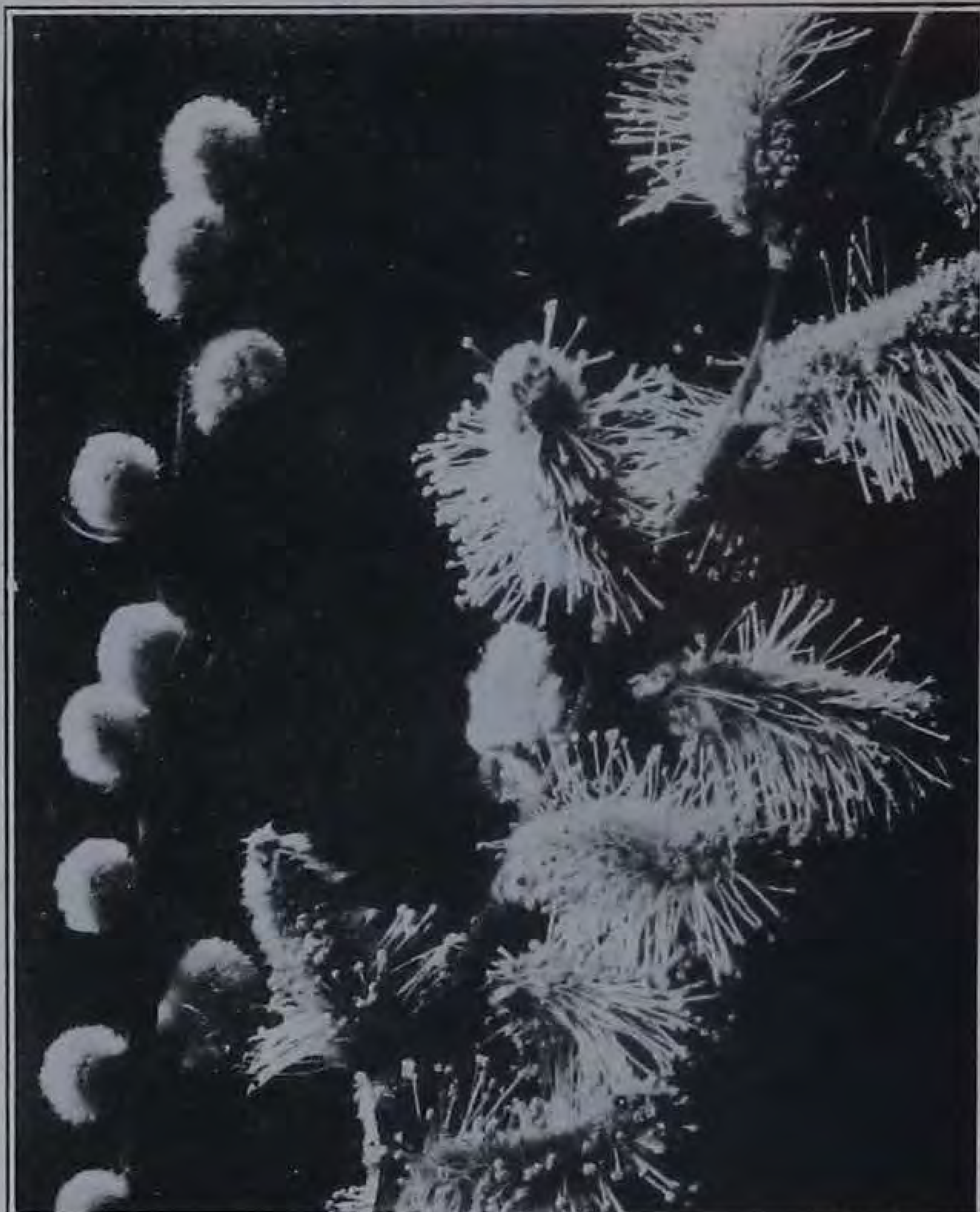


FIG. 37.—Beaked willow (*Salix rostrata*). *Photo by Ada Hayden.*

mens, F. C. Stewart), Armstrong (Emmet county) (R. I. Cratty), Decorah (E. W. D. Holway), Estherville (B. O. Wolden), Fayette (two specimens, B. Fink), New Hampton (three specimens, W. D. Spiker), Osage (F. M. Tuttle), Postville (two specimens, O. Schultz), Rockford (C. L. Webster), Webster county (L. H. Pammel and B. B. Zimmerman), West Union (L. H. Pammel and Emma Hancock), Yellow river (L. H. Pammel and Ellison Orr).

Observed also (L. H. Pammel) at Britt, Fertile, Forest City, Garner, Lamotte, Waukon.

General distribution for the United States and Canada:

Alberta—Ponok (C. R. Ball); Arizona—Mormon Lake (D. T. MacDougal); Colorado—Lookout Mountain (L. H. Pammel), Palmer Lake, 1908 (L. H. Pammel, L. V. Lee, Frank Raney, R. L. Barrett), Silver Plume, Rist Canon (C. S. Crandall), Ruckston (F. E. and C. S. Crandall); Idaho—Sand Point (L. H. Pammel and W. S. Dudgeon); Maine—Casco Bay, Harpswell Center (C. R. Ball); Michigan—Muskegon, Stambaugh, Whitehall (two specimens), White Head river (L H. Pammel and V. C. Fisk); Minnesota—Bemidji, Cannon Falls, Cloquet, Howard lake, Itasca lake, Itasca State Park, Norway

Beach (L. H. Pammel), Cass Lake (four specimens), Taeda island, Taylor's Falls (L. H. and H. E. Pammel), Backus (two specimens), Duluth (two specimens), Leech Lake, Walker (Ada Hayden), Wilmot, Wyoming (Mrs. Roy Westley), Brainerd (four specimens, E. B. Watson), Star island (L. H. and H. E. Pammel, P. S. McNutt), West Minneapolis (R. I. Cratty); Montana—(W. S. Dudgeon); New York—Ithaca (Muenscher and Bechtel); Saskatchewan—Paddockwood (C. R. Ball); South Dakota—Sisseton, Spring creek (L. H. Pammel); Utah—Echo, Farmington (three specimens, L. H. Pammel, C. P. Johnson, R. E. Buchanan, G. W. Lummis), Kamas (5900 feet) (L. H. Pammel, E. M. Stanton); Washington—Afton, Lincoln county (Edwin Payne and George M. Armstrong); Wisconsin—Alvin, Bloomingdale, Bruel river, Galesville, Holmen, La Crosse county, Madison, Mormon coulee, tamarack swamp northeast of La Crosse (L. H. Pammel), Mercer (Mrs. J. Clemens), St. Croix Falls (L. H. and H. E. Pammel); Wyoming—Laramie, Mammoth Hot Springs (Aven Nelson).

HONEY BEE VISITS

Bees observed (Iowa) 1927. (L.H.P.)

Ames, April 4, 1928, 8:30 a. m. Cloudy, warm. Bees very numerous, collecting pollen and nectar. One, two, two seconds in the flower. (L.H.P.)

Salix candida Flügge. Sage Willow, Hoary Willow

Low shrub. Oblong to linear-lanceolate leaves, downy above becoming smooth, lower surface covered with white tomentum, margin revolute. Capsule densely white-woolly. This species found in cold peat bogs in Iowa.

Associated with *Carex filiformis, Menyanthes trifoliata, Gentiana crinita, Eupatorium purpureum, Pedicularis lanceolata, Valeriana edulis.*

This species is freely visited by bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Hanlontown, Lake Mills, Worth county (L. H. Pammel), Clayton county, Postville (L. H. Pammel, E. Orr, D. O. Wilson), Estherville (B. O. Wolden), New Hampton (W. D. Spiker).

General distribution in the United States:

Illinois—Fountaindale (M. Bebb); Massachusetts—Bedford (G. G. Kennedy); Minnesota—Backus (A. Hayden), Cass Lake (L. H. Pammel), International Falls (Roy Westley), Minneapolis (R. I. Cratty), St. Cloud (R. Gmelin); Saskatchewan—Prince Albert (C. R. Ball); Vermont—Peachan (F. Blanchard); Wisconsin—Steven's Point (L. H. Pammel, V. C. Fisk), Mormon coulee (L. H. Pammel).

Populus (Tourn.) L. Poplar

Trees with broad heart-shaped leaves. Flowers form a cup-shaped disc. Stamens 8 to 30 or more; filaments distinct; stigmas 2 to 4;

catkins long and drooping, appearing before the leaves. Members of this genus are anemophilous.

The poplars are important for pollen, though Mr. Pellett reports some honey-dew from them also.

Populus tremuloides Michx. American Aspen, Quaking Aspen

Tree 6 to 20 feet high, with smooth greenish white bark; bud scales glabrous; leaves roundish heart-shaped, with sharp point and small regular teeth; petioles long, slender.

Light soils, Labrador to Alaska, south to Pennsylvania and Missouri. This tree is abundant in the woods and higher altitudes of the Rocky mountains.

FIG. 38.—Pistillate catkins of quaking aspen (*Populus tremuloides*). *Photo by S. G. F. Sheldon.*

The quaking aspen is common in partly drained peat bogs of Cerro Gordo, Winnebago, Fayette and Delaware counties and on slopes of clay hills; also in clay or peaty soil in isolated places of southeastern and central Iowa from Lucas to Van Buren counties. It is associated with *Salix rostrata, Aster sagittifolius, Anemone nemorosa* and *Festuca nutans*.

The aspen flowers early in Iowa, about the middle of April, at the time that small bees and honey bees are collecting nectar and pollen from the beaked willow (*Salix rostrata*).

Knuth said of a related species, *Populus tremula*, of Europe, "The male trees could be recognized and distinguished from the female ones at some distance by the loud buzzing of the insects."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Bellevue, Charles City, Clarion (two specimens), Clinton, Dubuque, Estherville (three specimens), Fairbanks, Forest City, Fraser, Garner, Greene, Johnson county, Keosauqua, Lake Mills, Lime Springs, Liscomb, Manchester, Marion county, Mason City, Moravia, Muscatine county, Okoboji (two specimens), Postville, Rockford, Strawberry Point, Traer, Waukon (L. H. Pammel), Delaware county, Lamont (I. T. Bode), Algona (two specimens, E. B. Watson), Cedar Falls (G. W. Carver), Colfax (F. P. Sipe), Decatur county (T. J. Fitzpatrick, J. P. Anderson), Decorah (E. W. D. Holway), Emmet county (R. I. Cratty), Fayette (B. Fink), Lansing (O. Schultz), Mount Pleasant (H. E. Jaques), Osage (Mrs. F. M. Tuttle), Slater (H. S. Fawcett), Webster City (two specimens, F. C. Stewart), West Liberty (L. H. Pammel and B. Shimek), Winterset near Pammel Park (L. H. Pammel).

It has also been observed (L. H. Pammel) at Boone, Clinton, Cresco, Decorah, Eldora, Forest City, Fort Dodge, Guthrie county (King State Park), Iowa Falls, Lehigh, Lyon county (north of Rock Rapids), Mason City, Pine Creek Hollow (Dubuque county), Spirit Lake, Steamboat Rock.

General distribution in the United States and Canada:

British Columbia—Crags (L. H. Pammel), Kamloops (L. H. Pammel, B. Athanasiou, A. L. Bakke, L. S. Park); California—Crane Flat, East of Patterson, Sierra Mountains, west fork Tuolumne, Yosemite region (L. H. Pammel), Yosemite Valley (L. H. Pammel and R. A. Needham); Canada—Banff, Calgary, Guelph (L. H. Pammel); Colorado—Arapahoe Mountain, Berthoud Pass, Camp Ouray, Crags, Forster, Lookout Mountain, North Cheyenne canyon, Norwood, Placerville, Rocky Mountain National Forest (L. H. Pammel, R. L. Barrett, F. L. Lee, L. V. Raney), Fort Collins, Cache La Poudre river (two specimens, L. H. Pammel and C. P. Johnson), Boulder Park (Ada Hayden), Breckenridge (J. P. Anderson), Chicken creek (C. F. Baker, F. S. Earl, S. M. Tracy), Minnehaha (F. E. and E. S. Clements), Rist Canon (J. H. Craven); Idaho—Sand Point (L. H. Pammel and H. S. Fawcett); Illinois—Cheltenham, Galena (L. H. Pammel); Massachusetts—Stockbridge (two specimens, Harriette Kellogg); Michigan—Gogebic, northern Michigan, St. Ignace (two specimens), Whitehall (two specimens, L. H. Pammel); Minnesota—Cannon Falls, Howard (near New Albin, Iowa), Itasca State Park (two specimens), Leech Lake, Minneapolis, Pike's Bay, Wadena, Walker (L. H. Pammel), Cass Lake, Star Island (L. H. and H. E. Pammel and P. S. McNutt), Anoka (R. I. Cratty), Brainerd (E. B. Watson), Duluth (L. H. and H. E. Pammel), Golden Valley (two specimens, Mrs. Roy Westley), International Falls (Harriette Kellogg); Montana—Wood's creek (L. H. Pammel and H. S. Fawcett); Montana and Idaho—Bitter Root Mountains, Warm Spring creek (L. H. Pammel); Nevada—Hunter creek (A. A. Heller); New York—Fall creek (W. C. Muenscher and A. R. Bechtel), "New York" (H.

E. Summers); Ohio—Cedar Point (L. H. Pammel); Oregon—Tomato creek (K. Whited); Utah—Middle Black Fork (L. H. Pammel, C. P. Johnson, G. W. Lummis, R. E. Buchanan), Ogden (L. H. Pammel and R. E. Blackwood); Wisconsin—Bangor, Coon Valley, Cloquet, Fond du Lac, Kilbourne, La Crosse (two specimens), Madison, Moose lake, Muscoda, Prairie du Chien, St. Croix Falls (two specimens), Viroqua, White Water State Park (L. H. Pammel), Platteville (L. H. Pammel and B. B. Zimmerman).

Blooming dates of Populus tremuloides

	Northern Section				Central Section									Southern Section			
	Lansing	Waukon	Forest City	Emmet Co.	Ames	Boone	Oskaloosa	Iowa City	Grinnell	Cedar Rapids	Marshalltown	Iowa Falls	Le Grand	Lamoni	Ottumwa	Creston	Garden Grove
1901					4-14												
1902											4-12		4-12				
1903																	
1904					4-17							4-21					
1905														3-24			
1906	4-15				4-17		4-8	4-14								4-6	
1907	3-28	4-5	4-7			3-21	3-22		3-23	3-20							3-24
1908									4-14	4-14							
1909	4-23																
1910						3-12											
1911	4-20			4-11		3-15									4-19		
1912	4-12					4-6											
1913				4-15		4-15											
1914	4-14			4-17		4-20											
1915				4-15													
1916						4-8											
1917						4-6			4-17 and 23								
1918																	
1919						4-20											
1920						4-17											
1921						4-17											
1922					3-30												
1923																	
1924	4-23																
1926						4-4											

Populus grandidentata Michx. Large-toothed Aspen

A tree, in some cases 50 or 60 feet in height, with grayish smooth bark. Scales of the buds woolly, with 5 or 6 divisions, slightly fringed; leaves ovate, margin with large, wavy teeth, at first woolly, finally smooth on both sides.

On clay or sandy slopes of hills of northeastern Iowa, sometimes forming pure stands.

It is associated with *Asarum canadense, Anemone nemorosa, Podophyllum peltatum* and *Polytrichum juniperinum.*

This plant furnishes some pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Clarksville, Colfax, Decorah, Delaware county (three specimens), Eldora, Hawley (two specimens), Lake Mills (two specimens), Lansing, Liscomb, Madrid, McGregor (two specimens), Monmouth, New Albin, Steamboat Rock (two specimens), Strawberry Point (L. H. Pammel), Algona (L. H. Pammel and Finley), Cedar Falls (G. W. Carver), Fayette (B. Fink), Fort Dodge (F. Hinton), Fraser (Botany Seminar), Hardin county (C. M. King), Johnson county (T. J. Fitzpatrick), Ledges (Boone county) (three specimens, C. M. King, J. V. Ellis, L. H. Pammel and A. F. Miller), Muscatine (Wild Cat Den) (F. Reppert), Postville (O. Schultz), Woodman's Hollow (Fort Dodge) (L. H. Pammel and F. W. Paige).

It has also been observed (L. H. Pammel) at Colfax, Cresco, Forest City, Fort Atkinson, Lehigh, Roberts, Waukon.

General distribution in the United States:

Arkansas—Burdette (Three States Lumber Company); Connecticut—New Haven (W. H. Mast); Illinois—Fox River (L. H. Pammel and Mark Heavenhill); Michigan—Ann Arbor (three specimens), Iron river, St. Ignace, Whitehall (L. H. Pammel); Minnesota—Cloquet, Lake City (L. H. Pammel), Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt), Brainerd (five specimens, E. B. Watson); New York—Fall creek (W. C. Muenscher and A. R. Bechtel), Ithaca (three specimens, H. E. Summers), Watkin's Glen (L. H. Pammel); Ohio—Cedar Point, Kelley's island, Put-in-Bay (L. H. Pammel); Pennsylvania—Tonawanda (L. H. Pammel); Wisconsin—Coon Valley, Holmen, Kilbourne City, Muscoda (two specimens, L. H. Pammel), Bloomingdale (C. M. King), Platteville (L. H. Pammel and B. B. Zimmerman), State line, Michigan and Wisconsin (L. H. Pammel and V. C. Fisk).

Populus deltoides Marsh. Cottonwood

Large trees 50 to 100 feet high, trunk 4 to 6 feet in diameter. Leaves broadly deltoid, margin crenate, acute, ovate or rarely cordate; petioles elongated. Stamens numerous; scales lacerate; capsules on slender pedicels.

Bees visit the flowers for pollen.

Date of bloom, 1925, Ames, April 6. 1926, Ames, April 20; Lansing, April 16. 1927, Ames, April 7.

FIG. 39.—Cottonwood (*Populus deltoides*). *Photo by Ada Hayden.*

Populus canadensis Moench. Carolina Poplar

This is a hybrid between the black poplar of Europe (*Populus nigra*) and *Populus deltoides* and is widely planted as a street tree. Ascending branches; leaves triangular-ovate, broad below, long-acuminate; catkins four to six inches long, pendant.

Another widely planted poplar is the Lombardy, a variety of *Populus nigra*. This is a staminate tree with a very narrow, tall, erect growth. The black poplar of Europe is but rarely cultivated.

Another commonly planted poplar of Iowa is the white poplar (*Populus alba* L.). This is a large, broad-headed, branched, suckering tree. Bark on young trunk white, but becoming darker. Leaves ovate to orbicular, white beneath; leaves on young shoots five-lobed. This species has become naturalized in many places in the state.

The *Populus Bolleana,* which is a variety of *alba,* is a fastigiate variety, with strongly lobed leaves. Another frequently grown tree is the *Populus candicans,* which resembles the balsam poplar. With an open, irregular top; resinous and aromatic buds; leaves broad. cordate.

Many of these species are visited by bees for pollen.

In bloom, Ames, April 6, 1925; April 20, 1926. Lansing, April 16, 1926.

JUGLANDACEAE, WALNUT FAMILY

Trees with alternate pinnate leaves and no stipules. Flowers monoecious; sterile or staminate in catkins with an irregular calyx, the pistillate solitary or in a small cluster with a three- to five-lobed calyx adhering to the ovary, which is one-ovuled. Fruit a dry drupe, with a hard and bony nutshell. Cotyledons fleshy and oily.

FIG. 40.—Black walnut (*Juglans nigra*). *Photo by Ada Hayden.*

Juglans L. Walnut

Staminate flowers with numerous stamens. Filaments free, short. Fertile flowers solitary or several. Four-toothed calyx and four small petals at the sinuses. Fruit indehiscent nut, mostly rough.

The plants of the two species are visited by honey bees for the pollen.

Juglans cinerea L. Butternut, White Walnut

Compound leaves of 7 to 17 leaflets, which are oblong-lanceolate,

FIG. 41.—Hickory (*Carya*). *Courtesy Iowa State Hort. Soc.*

downy beneath. Petioles with clammy hairs. Fruit deeply sculptured. Widely distributed in the state of Iowa.

Juglans nigra L. Black Walnut

Leaves of 11 to 17 leaflets, ovate-lanceolate, somewhat heart-shaped at the base, smooth above. Petioles minutely downy. Fruit somewhat spherical, rough. Widely distributed in the state.

Date of bloom, Ames, April 20, 1925; May 20, 1927. Lansing, May 8, 1927.

Carya Nutt. Hickory

Trees with monoecious flowers, stamens 3 to 10, filaments short. Fertile flowers 2 to 5 in a cluster, staminate flowers on a peduncle. Calyx 4-toothed, petals none. Fruit a nut with a dry shell. The nut is hard and bony, incompletely two-celled and at the base four-

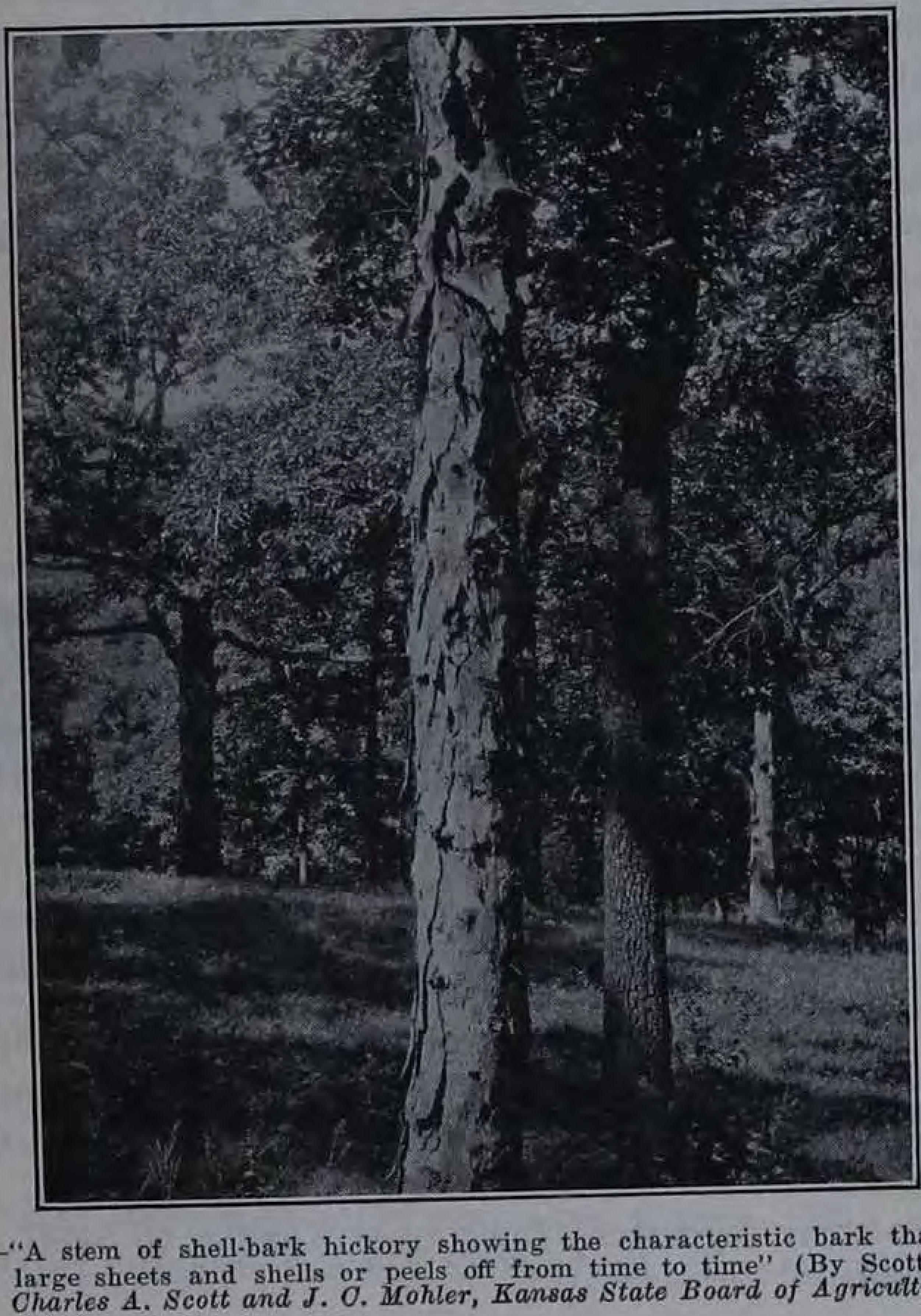


FIG. 42.—"A stem of shell-bark hickory showing the characteristic bark that loosens in large sheets and shells or peels off from time to time" (By Scott). *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

celled. The following species occur in the state and furnish both honey-dew and pollen.

Carya illinoensis (Wang.) K. Koch. Pecan

Large trees with few bud scales. Nut elongated, thin shells. Seeds sweet. Widely distributed in the Mississippi Valley, extending as far north as Green Island in Iowa.

Carya ovata (Mill.) K. Koch. Shell-bark or Shag-bark Hickory

Trunk bark shaggy, forming plates. Inner bud scales large and conspicuous. Compound leaves with 5 to 7 leaflets, minutely downy underneath when young. Sterile catkins in threes, pendant, fertile flowers few. Fruit a nut, white, hard and bony. Widely distributed in Iowa, especially common in eastern Iowa, extending westward to Sac county and southward to Fremont county, preferably on clay soils. Associated with the white oak.

Carya laciniosa (Michx f.) Loud. King Nut

Bark as in the preceding. Leaflets 7 to 9, somewhat downy beneath. Fruit ovoid; husk very thick; nut large. Grows in alluvial bottoms, in southeastern Iowa. Common near Centerville on Chariton river and eastward on the Fox and northward to southern Louisa county, along the Mississippi; also in Poweshiek county.

Carya alba (L.) K. Koch. Mocker Nut, White Heart

Bark close and tight fitting, rough, not shaggy. Young shoots tomentose. Leaflets 7 to 9, more or less lanceolate in outline, pointed. Husk hard and thick. Associated with *Quercus alba*, *Quercus rubra*, *Eupatorium urticaefolium* and *Smilacina racemosa*.

Not uncommon in eastern Iowa from Keokuk to Scott county. Upland woods.

FIG. 43.—Shag-bark hickory (*Carya ovata*). 1, Winter twig, x 1; 2, Portion of twig, enlarged; 3, Leaf, x 1/3; 4, Flowering branchlet, x 1/2; 5, Staminate flower, enlarged; 6, Pistillate flower, enlarged; 7, Fruit, x 1/2. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Carya cordiformis (Wang.) K. Koch. Bitter Nut or Swamp Hickory

Small trees with bark tight and close fitting. Bud scales in pairs; catkins pendant; leaves 7 to 11; fruit elliptical, bitter. As-

FIG. 44.—Mocker nut (*Carya alba*). 1, Winter twig, x 1; 2, Leaf, x 1/2; 3, Flowering branchlet, x 1/2; 4, Staminate flower, enlarged; 5, Pistillate flower, enlarged; 6, Fruit, x 1/2. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

sociated with *Quercus rubra, Carya ovata, Juglans cinerea, Populus deltoides, Ulmus americana, Solidago serotina.*

Common in eastern Iowa and extending westward to the Missouri river basin at Sioux City and in Fremont county.

FIG. 45.—Bitter nut (*Carya cordiformis*). 1, Winter twig, x 1; 2, Leaf, x 1/2; 3, Flowering branchlet, x 1/2; 4, Staminate flower, enlarged; 5, Pistillate flower, enlarged; 6, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Carya glabra (Mill.) Spach. Pignut or Broom Hickory

Trees with tight, close-fitting bark. Bud scales caducous; staminate catkins pendant; compound leaves 5 to 7, oblong or obovate-lanceolate. Nut with thick, bony shell, seed more or less bitter.

Rare in southeastern Iowa. Only a few localities reported.

BETULACEAE

Monoecious (rarely dioecious) trees or shrubs with alternate leaves. Sterile flowers in catkins, fertile flowers clustered, spiked or in catkins.

Corylus (Tourn.) L. Hazelnut

Sterile flowers in catkins; fertile flowers several, in a scaly bud. Stigmas two, long, red, slender.

Shrubs or small trees, flowering in early spring.

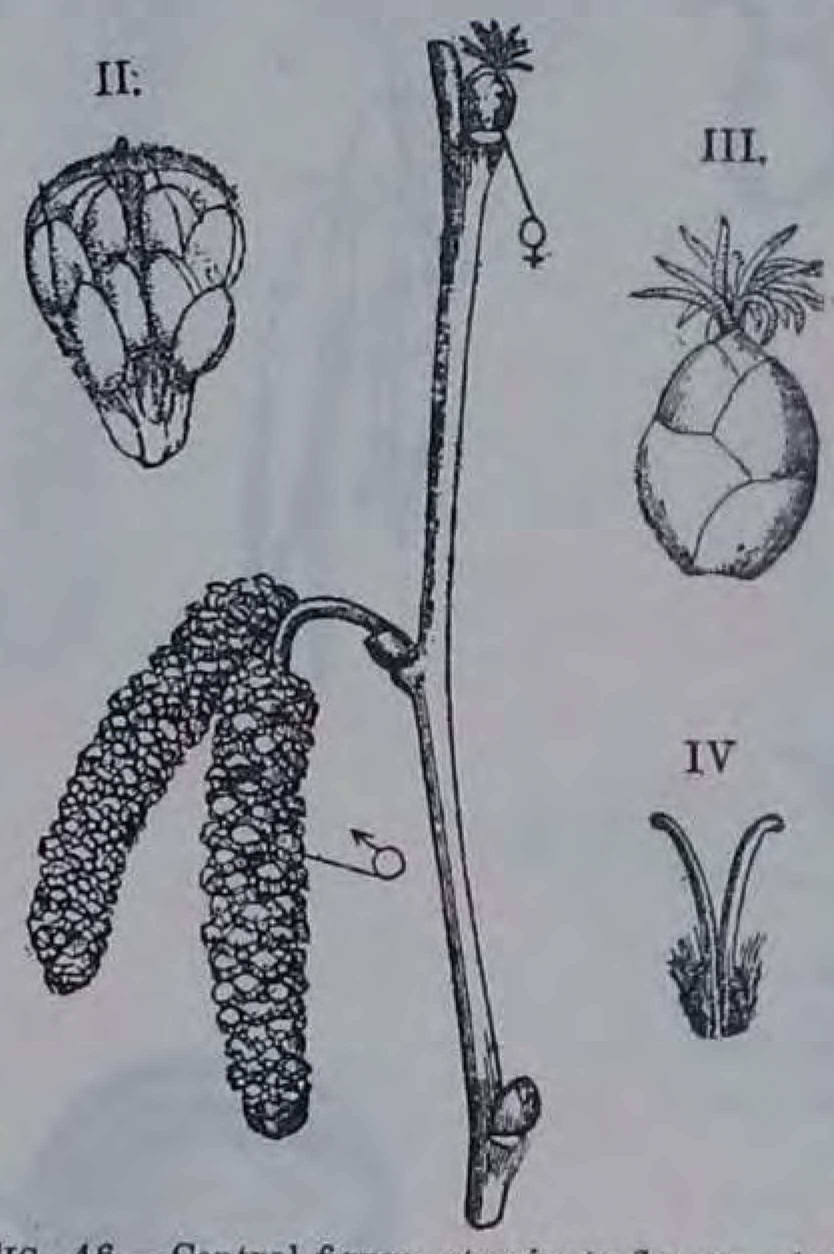


FIG. 46.—Central figure, staminate flowers of the hazel. Pistillate flowers shown in figures III and IV. *After Thomé.*

Corylus americana Walt. Hazelnut

In hazel the staminate catkins are pendulous; the pistils are contained in short erect inconspicuous cones. The staminate flower consists of eight half-stamens, with 1-celled anthers borne under large bracts. The hazel flowers appear early in April before the leaves are out. It is valuable to bees for pollen where there is a scarcity of early flowering plants.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Bellevue, Cedar Falls, Cherokee, Clarksville, Edgewood, Fairbanks, Farmington, Forest City, Glenwood, Greene, Jackson county, Lamont, Lansing, Liscomb, Mason City, Marshalltown, McGregor, Okoboji, Oskaloosa, Payne, Pilot Knob (Hancock county), Rochester, Saratoga, Shell Rock, Stratford, Waukon, Warren county (L. H. Pammel), Algona (E. B. Watson), Ames (two specimens, G. W. Carver), Boone county (J. C. Blumer, R. E. Buchanan, Lela Blaine, G. M. Lummis), Cedar Rapids (R. E. Buchanan), Colfax (P. Sipe), Decorah (E. W. D. Holway, R. I. Cratty), Fayette (B. Fink), Keokuk (P. H. Rolfs), Oto (H. B. Clark), Rockford (C. L. Webster), Salem (H. B. Clark and L. H. Pammel), Union (P. A. Anderson).

This plant has also been observed (L. H. Pammel) at the following places:

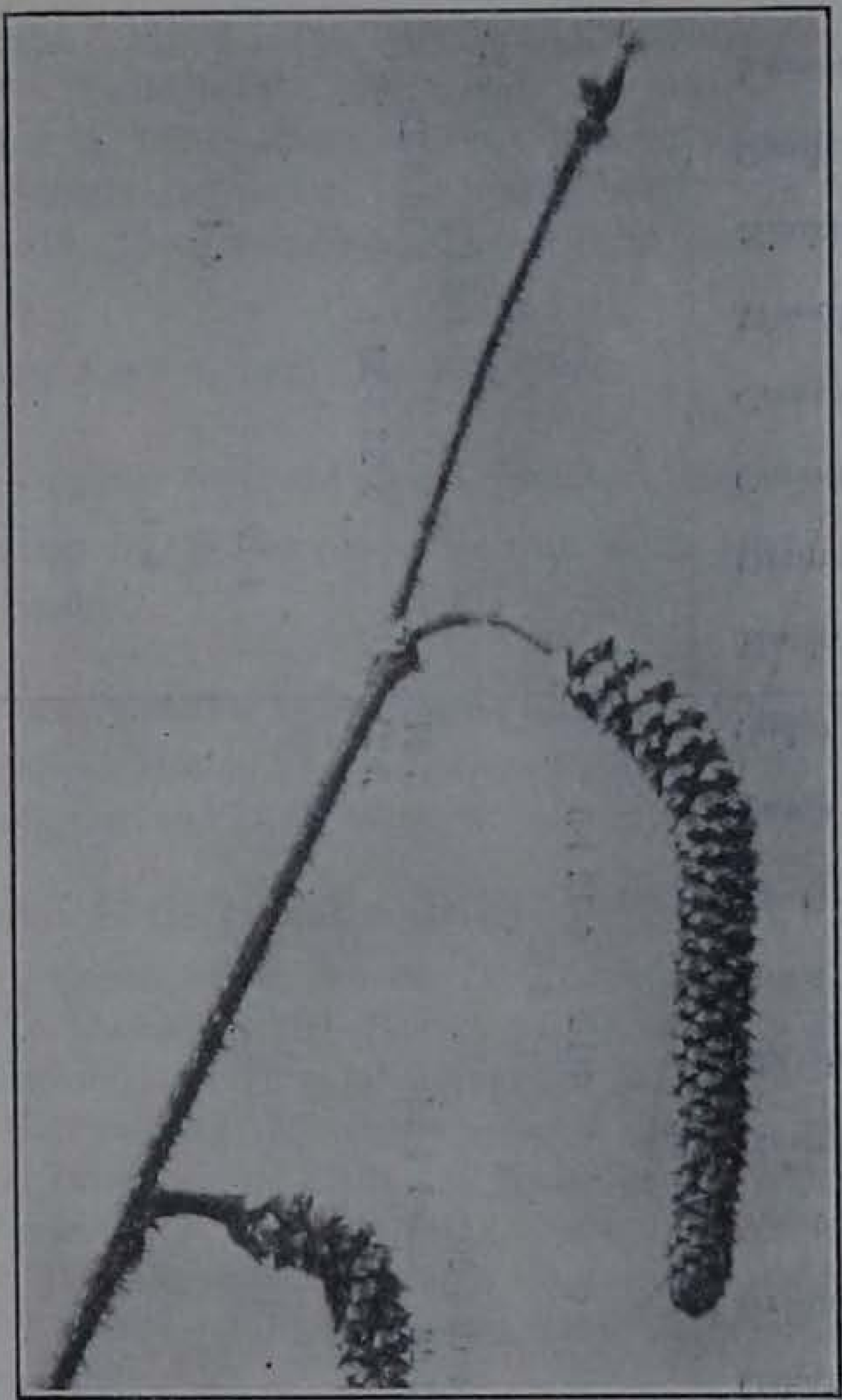


FIG. 47.—American hazelnut (*Corylus americana*). *Photo by Ada Hayden.*

Algona, Burlington, Centerville, Clinton, Cresco, Davenport, Decorah, DeWitt, Dexter, Dyersville, Fairfield, Farley, Fort Atkinson, Grinnell, Hamburg, Indianola, Jefferson, Keokuk, Lansing, Lehigh, Marquette, Moingona, Mount Pleasant, Muscatine, New Albin, New Vienna (Dubuque county), Pine Creek Hollow (Dubuque county), Polk City, Redfield, Shenandoah, Valley Junction.

General distribution in the United States:

Georgia—Habersham (John K. Small); Minnesota—Howard, Wadena, Wilmot (L. H. Pammel), Cass Lake, Norway Beach (L. H. and H. E. Pammel), Anoka, Minneapolis (R. I. Cratty), Backus (two specimens, Ada Hayden), St. Cloud (E. B. Watson); Missouri—Rolla, Rose Hill (L. H. Pammel), Rockport (A. O. Simonds); Nebraska—Blair (H. B. Clark); New York—Geneva (L. H. Pammel), Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Lancaster (Fairfield county) (Dr. Bigelow); Pennsylvania—Gettysburg (L. H. Pammel); South Carolina—Oconee county (A. P. Anderson); Wisconsin—Galesville, La Crosse (Lois and L. H. Pammel), Mercer (Mrs. Joseph Clemens).

Blooming dates for Corylus americana

	Northern Section					Central Section											Southern Section							
	Emmet Co.	Lansing	Waukon	Forest City	Ossian	Ames	Boone	Oskaloosa	Grinnell	West Union	Newton	Marshalltown	Iowa Falls	Le Grand	Tama Co.	Cedar Rapids	Harlan	Ottumwa	Cincinnati	Creston	Woodbine	Keokuk	Garden Grove	Lamoni
1896						4-9																		
1901						4-3																		
1902												4-12		4-12	4-5									
1904						4-2							4-6											
1905						3-15																		3-23
1906		4-20				4-6		4-12	4-20												4-8	4-2		
1907		3-31	3-25	4-3	3-15	3-26		3-22		5-1	4-26					3-21	3-23					3-16	3-23	
1908						3-13	4-3									3-21			3-23	3-23				
1909		4-1				5-1	4-20																	
1910	3-19						3-27																	
1911	3-23																	4-19						
1912	4-8	4-11				4-9																4-4		
1913	4-5																							
1914	4-13	4-17																						
1915	4-10					4-7																		
1916	4 -11					3-20																		
1919						4-7																		
1920						3-3 to 3-20																		
1921						3-24																		
1922						3-30																		
1923						4-15																		
1924						4-6																		
1926						4-6																		
1927						4-7																		

HONEY BEE VISITS

Ames, May 3, 1914. Eighteen to twenty bees visiting medium sized staminate shrub. No "wild bees". (L.A.K.)

College Park, May 3, 1916. Clear, warm. Ten to twenty bees on medium sized shrub, evidently for pollen. No "wild bees". (L.A.K.)

Ames, April 4, 1916. Bees bringing in much light yellow pollen from hazel. (Reese.)

Blooming, Ames, April 1, 1925; April 8, 1926.

Corylus rostrata Ait. Beaked Hazelnut

A form having ovate leaves; the nut with leafy involucre prolonged into a beak.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bluffton, Pine Creek Hollow (L. H. Pammel and Fred Trenk), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson).

General distribution in the United States:

Colorado—Fort Collins, Rist canyon (C. S. Crandall), Lookout mountain (L. H. Pammel); Massachusetts—Boston (J. G. Jack); Michigan—Gogebic (Mrs. Joseph Clemens), northern Michigan (L. H. Pammel and V. C. Fisk), Stambaugh (L. H. Pammel); Minnesota—Cass Lake (two specimens), Cloquet (L. H. Pammel), International Falls (H. S. Kellogg), Itasca State Park (L. H. and H. E. Pammel and P. S. McNutt); New York—Ithaca (W. C. Muenscher and A. R. Bechtel); South Dakota—Spearfish canyon (C. M. King); Virginia—Smythe county (two specimens, John K. Small); Wisconsin—La Crosse (L. H. Pammel).

Ostrya (Michx.) Scop. Hop Hornbeam

Slender birchlike trees with hard wood. Flowers appearing with the leaves, staminate flowers in catkins. Ovary and nut inclosed in an expanded closed bag. Leaves resemble the leaves of birch, veins straight.

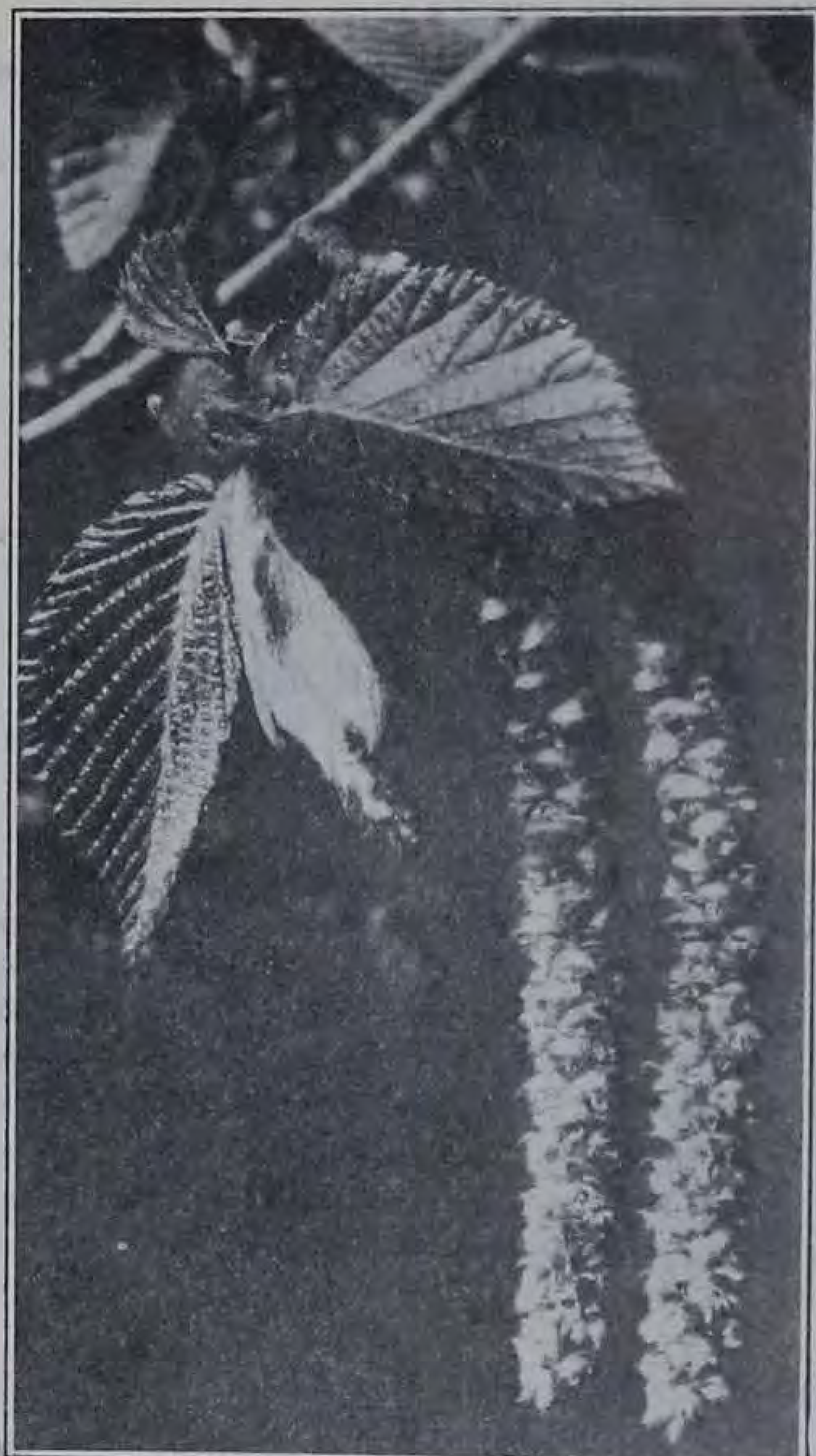


FIG. 48.—Hop hornbeam (*Ostrya virginiana*). *Photo by Ada Hayden.*

Ostrya virginiana (Mill) K. Koch. American Hop Tree, Hornbeam

A small tree with oblong leaves tapering to the point, sharply double serrate, downy on under side. The staminate catkins are pendulous, brownish yellow, appearing with the leaves. The pistillate flowers are in short catkins. The flowers are anemophilous, though the staminate flowers are occasionally visited for their abundant pollen by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Bellevue, Boone county, Cedar Falls, Cherokee, Clarksville, Decatur county, Decorah, Dubuque, Edgewood, Eldora, Estherville, Farmington, Greene, Hamburg, Harvey, Indianola, Jefferson, Keosauqua, Kossuth county, Lake Mills, Lake Okoboji, Lansing, Laurens, Little Sioux river, Lost Island lake, Lyons, Madison county, Madrid, Mahaska county, Manchester, Mason City, Marion county, McGregor, Missouri Valley, Montrose, Muscatine, Nashua, Petersen, Redfield, Rochester, Stratford, Warren county, Waterville, Webster City, Webster county, West Union, Winterset (L. H. Pammel), Alden (C. T. Stevens), Allamakee county (O. Schultz), Ames (Robert Combs and Fred Rolfs), Cedar Rapids (R. E. Buchanan), Charles City (E. M. Sherman), Colfax (P. Sipe), Columbus Junction (E. B. Watson), Council Bluffs (H. B. Clark and L. H. Pammel), Fayette (B. Fink), Fraser (Botany Seminar), Hardin county (C. M. King), Howard county, Osage (Mrs. F. M. Tuttle), Iowa lake (R. I. Cratty), Morning Sun (George Carver), Mount Pleasant (H. E. Jaques), Rockford (C. L. Webster), Shell Rock (E. J. Taylor), Sioux City (H. B. Clark), Union (P. A. Anderson), Waukon Junction (O. Schultz).

General distribution in the United States:

Alabama—Auburn (L. H. Pammel); Arkansas—Pine county (two specimens, L. H. Pammel); Connecticut—New Haven (W. H. Mast); Florida—Micanopy (L. H. Pammel); Illinois—Bluff lake near East St. Louis (four specimens), Cheltenham Beach, Galesburg (L. H. Pammel), Kankakee (R. I. Cratty), Rockford (L. H. Pammel, V. C. Fisk); Indiana—Turkey Run (two specimens, L. H. Pammel); Michigan—Ontonagon, Port Huron, Whitehall (two specimens, L. H. Pammel), Ironwood (Mrs. Joseph Clemens); Massachusetts—Adams (M. A. Day), Brimfield (H. E. Pammel), Stockbridge (four specimens, Harriette Kellogg); Minnesota—Cannon Falls, Cass Lake, Cloquet (two specimens), Graceville, Ortonville (two specimens), Porcupine Hill (L. H. Pammel and V. C. Fisk), Star island (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (R. Gmelin), Wildwood (Lois Pammel); Missouri—Columbia, Pilot Knob (L. H. Pammel), Rockport (A. O. Simonds); Nebraska—Blair (H. B. Clark); New York—Geneva, Goat Island, Palisade Park (L. H. Pammel), Ithaca (Muenscher and Bechtel); Ohio—Huron, Willard (two specimens, L. H. Pammel), Graceville (H. L. Jones), Pickerington (Asa Horr); South Dakota—Sisseton, Spring creek (L. H. Pammel); Wisconsin—Alma, Gilmore City, La Crosse, Prairie du Chien (L. H. Pammel), Platteville (L. H. Pammel and B. B. Zimmerman), State Road coulee (Lois and L. H. Pammel), St. Croix Falls (L. H. and H. E. Pammel).

Carpinus (Tourn.) L. Ironwood

Sterile flowers in catkins; fertile flowers several, spiked. Trees or tall shrubs with gray bark.

Carpinus caroliniana Walt. Blue Beech

Leaves ovate-oblong, pointed, finely serrate, smooth. Bractlets 3-lobed, halberd-shaped; staminate catkins pendulous; pistillate short, and erect stigmas reddish. The flowers are anemophilous. Honey bees occasionally visit the staminate flowers for pollen.

The blue beech is widely distributed in eastern Iowa but is not common elsewhere in the state.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Burlington, Centerville, Delaware county, Dubuque county, Ledges, Marshalltown, Strawberry Point, Waterville, Webster county, West Union (L. H. Pammel), Allamakee county (O. Schultz), Boone county (R. E. Buchanan), Fayette (B. Fink), Fraser (Botany Seminar), Mount Pleasant (H. E. Jaques), Muscatine (Paul Bartsch), Postville (O. Schultz), Steamboat Rock (C. M. King).

General distribution for the United States and Mexico:

Alabama—Montgomery (two specimens, L. H. Pammel); Arkansas—Hot Springs, Pine county (L. H. Pammel); Florida—Gainesville (L. H. Pammel); Georgia—Gordon (D. C. Poshusta); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Kentucky—Harlan county (T. H. Kearney, Jr.); Maryland—Baltimore (F. Trenk); Mexico—Vera Cruz (two specimens, C. G. Pringle); Minnesota—St. Charles (L. H. Pammel); Ohio—Cedar Point, Huron (two specimens, L. H. Pammel), Worthington (Asa Horr); Pennsylvania—Elk county (A. A. Heller), State College (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel), Syracuse (L. M. Underwood); South Carolina—Bradley (Davis), Oconee county (J. Anderson); Texas—Bowie county (A. A. and E. Heller), Kirbyville (E. R. Hodson); District of Columbia—Washington, Rock Creek Park (L. H. Pammel); Wisconsin—Kilbourne, Saint Croix (L. H. Pammel).

Date of bloom, Tabor, April 14, 1927.

Betula L. Birch

Trees or shrubs with somewhat resinous bark with conspicuous longitudinal lenticels. Sterile flowers in three-flowered cymes subtended by bractlets adnate to the base of the scale of the ament. Staminate aments long, pendulous, solitary or clustered; calyx 4- or 2-lobed. Pistillate catkins oblong or cylindrical, their scales closely imbricated, oblong-ovate, 3-lobed, light yellow or tinged with red; without calyx. Fruit a nut, winged.

We have three tree birches and one shrub in the state.

We have not observed any honey bees gathering pollen on the birches, but Pellett states that in some localities they are valuable for pollen.

Betula lutea Michx. Yellow or Gray Birch, Wintergreen Birch

With oblong-ovate cone which is nearly sessile, erect, leaves wedge-shaped or in some instances slightly heart-shaped at the base. Scales of the cone pubescent. Bark aromatic with the taste of wintergreen, separating into thin layers. This large tree in some cases attains a height of 100 feet and has a trunk three to four feet in diameter.

This species is not abundant in the state; grows on moist shady slopes.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bangor, Decorah, Dubuque county, Eldora, McGregor, Steamboat Rock, St. Olaf (L. H. Pammel), Allamakee county (O. C. Schultz), Edgewood (Howard Morey), Hardin county (C. M. King), Osage (F. May Tuttle).

Betula nigra L. River or Red Birch

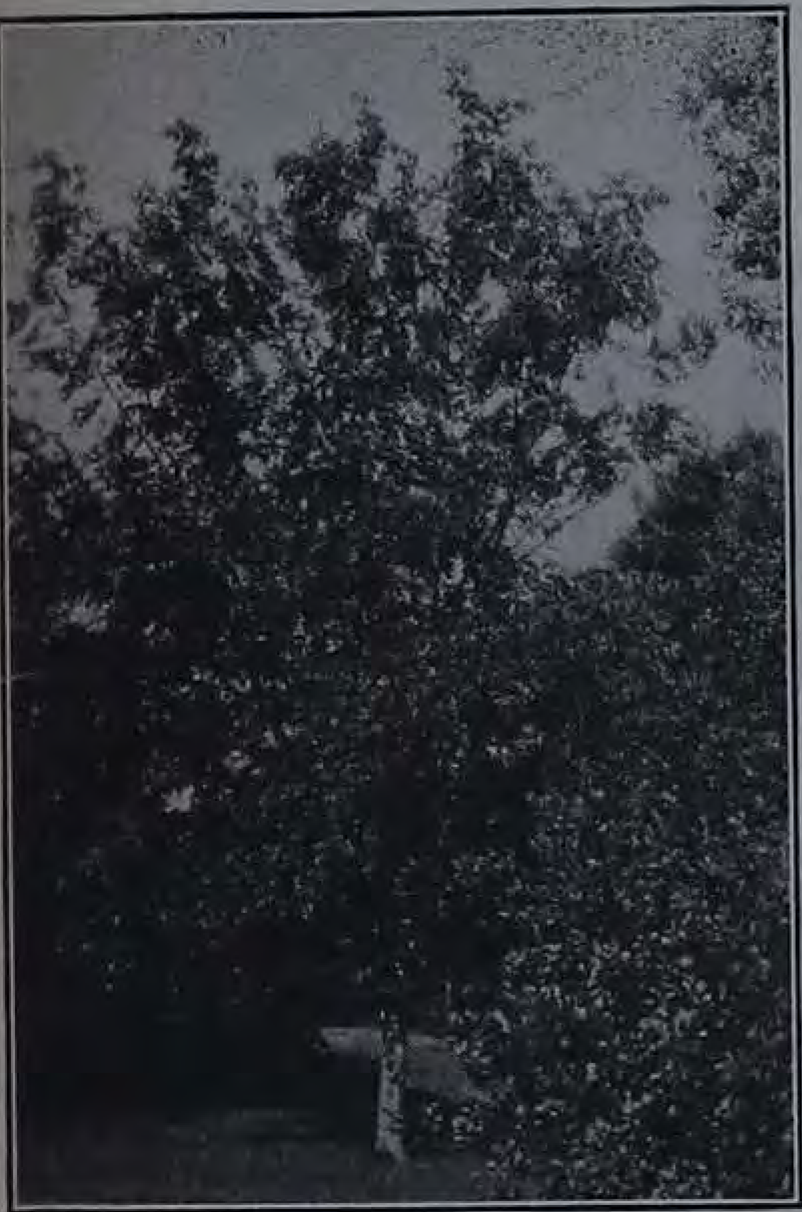


FIG. 49.—Red or river birch (*Betula nigra*). (By Gates.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Fairly good sized tree, 80 to 90 feet high and 2 to 3 feet in diameter. Slender branches. Leaves rhombic-ovate, acute, more or less wedge-shaped, doubly serrate, more or less glaucous, silky pubescent beneath. Bark reddish brown, separating into scales. This species is widely distributed in eastern Iowa along the larger streams, on Iowa river as far north as Marshalltown, along the Wapsipinicon, at New Albin on the Mississippi, on Des Moines river near Des Moines and on the streams of southeastern Iowa.

Date of bloom, Lansing, April 15, 1926.

Betula alba L. White Birch

Medium sized tree. Leaves ovate, taper pointed, green above, pale, glandular-dotted beneath, sharply double-serrate. Bark does not come off in layers. Cultivated as an ornamental plant and sometimes is an escape (Ames and Delaware county).

Betula papyrifera, Marsh. Canoe Birch, Paper Birch

Trees usually attaining a height of 60 to 70 feet and with a trunk 2 to 3 feet in diameter. The older bark is white, separating into layers, the younger branches dark orange with numerous lenticels at first pubescent, becoming smooth during the first winter, dull red in color. Leaves ovate, acute or acuminate, usually irregularly serrate, dark green above and paler beneath; somewhat pubescent. Staminate flowers in pendent clusters, pistillate flowers

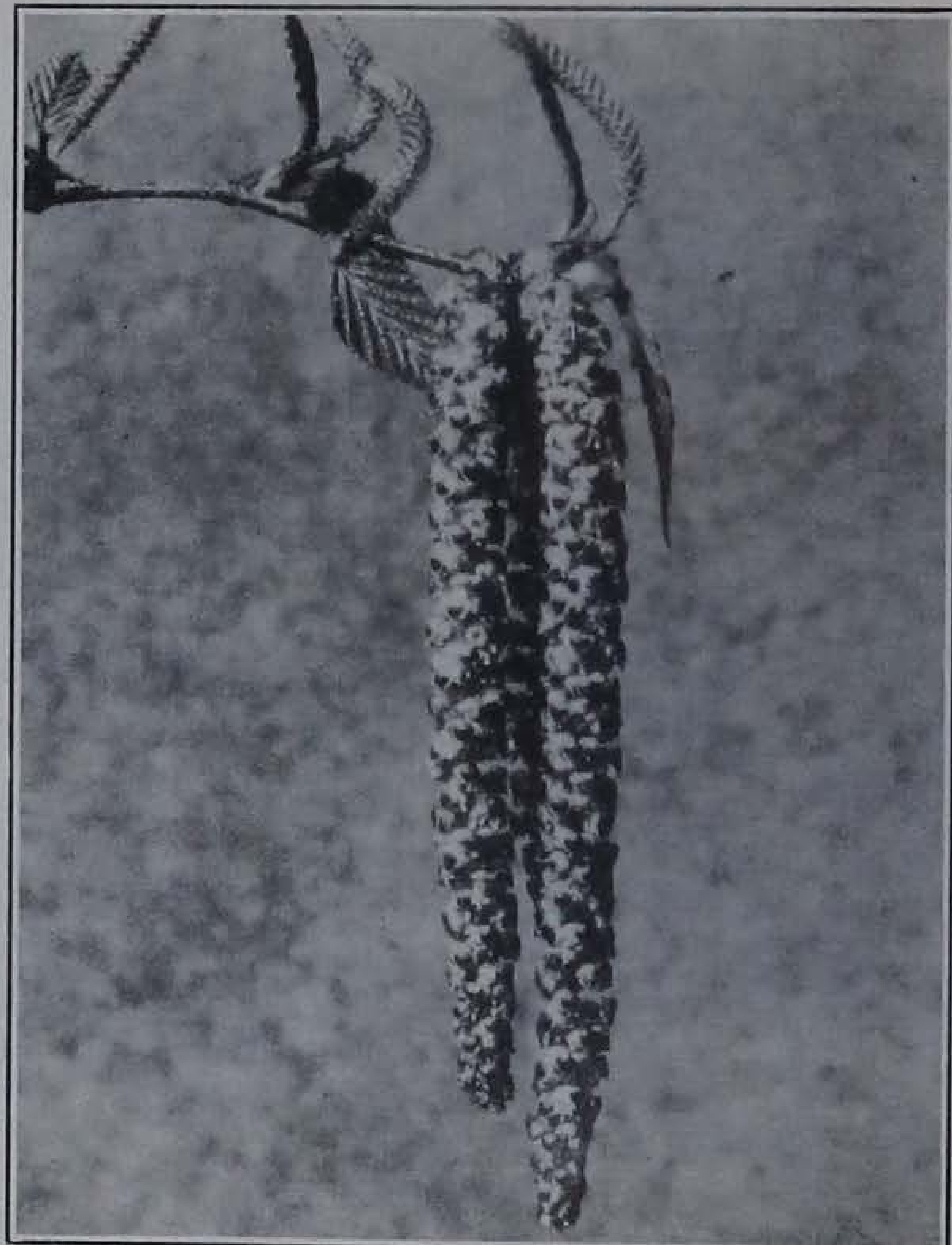


FIG. 50.—White birch (*Betula alba*). *Photo by Ada Hayden.*

an inch to 1¼ inches long, light green style. Stigmas bright red, cylindrical, smooth.

Date of bloom, 1925, Ames, May 2; Lansing, May 3. 1927, Ames, April 6.

Betula pumila L. Low or Swamp Birch

A small shrub from three to five feet in height, erect or ascending, not glandular. Leaves obovate, orbicular, or reniform, without resin, pale beneath. Found in peat bogs in Chickasaw county. Rare in the state.

Alnus (Tourn.) Hill. Alder

Trees and shrubs with astringent scaly bark. Leaves green above, paler beneath. Flowers in catkins appearing early in the spring. Staminate flowers with four or five bractlets. Calyx 3- to

5-lobed, and as many stamens. Fertile catkins ovoid or ellipsoid, becoming woody in the fruit.

Alnus incana (L.) Moench. Speckled or Hoary Alder

Shrubs or small trees with broadly elliptical to ovate leaves, mostly round at the base, the upper surface dark green, below paler color. Occurs in boggy places in northeast Iowa, extending as far south and southwest as Muscatine and Oelwein.

Probably visited by honey bees like the birches, though we have made no notes of visits in Iowa.

Fagaceae, Beech Family

Trees or shrubs with monoecious flowers. Leaves simple, alternate, straight-veined, stipules deciduous. Flowers in catkins. The staminate flowers pendent or erect, clustered; 4- to 8-lobed calyx; four to eight stamens. Pistillate flowers solitary or clustered, spikes or heads subtended by an involucre. Fruit a 1-seeded nut by abortion.

Castanea (Tourn.) Hill. Chestnut

Trees or shrubs with furrowed bark. Leaves ovate, acute, coarse-

Fig. 51.—American chestnut (*Castanea dentata*). *Photo by Ada Hayden.*

regular epidermis, in some provided with stomata and in some not. Below this epidermis are small 4- to 8-sided cells, differentiated from the surrounding tissue only by their granular cell contents and size. We may therefore define nectar glands as specialized tissue, which secretes a sweetish liquid (with few exceptions) called nectar.

In the following pages will be given a complete description of the nectar glands of the different flowers studied. They will be taken in the order in which they are given in the above outline.

Philadelphus coronarius L. Mock Orange

General.—This shrub is very common in Iowa and it is in full bloom by the middle of May. Its flowers secrete nectar very abundantly and when the material was collected it was noticed that the bees were very numerous about the flowers.

In the flower of this plant the nectar is half concealed. The ovary is inferior, the nectar gland being found as a disc which entirely covers the top of the ovary. The gland is slightly orange-colored and secretes nectar very abundantly.

Anatomy of the Gland.—A longitudinal section through the top of the ovary of *Philadelphus* shows the nectar gland to be a mass of granular tissue covering the entire apical surface. The gland is about 0.1 mm. in thickness. The glandular tissue consists of a single layer of epidermal cells and a variable number of layers of modified parenchymatous cells, which lie beneath the epidermal cells and which will henceforth be called the subepidermal cells. Below the subepidermal cells lies the ordinary unmodified parenchymatous tissue, which is characteristic of the flower parts. In this tissue are also found the fibro-vascular bundles. Their epidermal cells are somewhat columnar in shape, and have their outer walls more or less curved out. They are somewhat smaller in size than the subepidermal cells and their cell contents are also less granular. The cells of the subepidermal tissue contain a very granular protoplasm, although they are somewhat larger than the epidermal cells. The cells of the

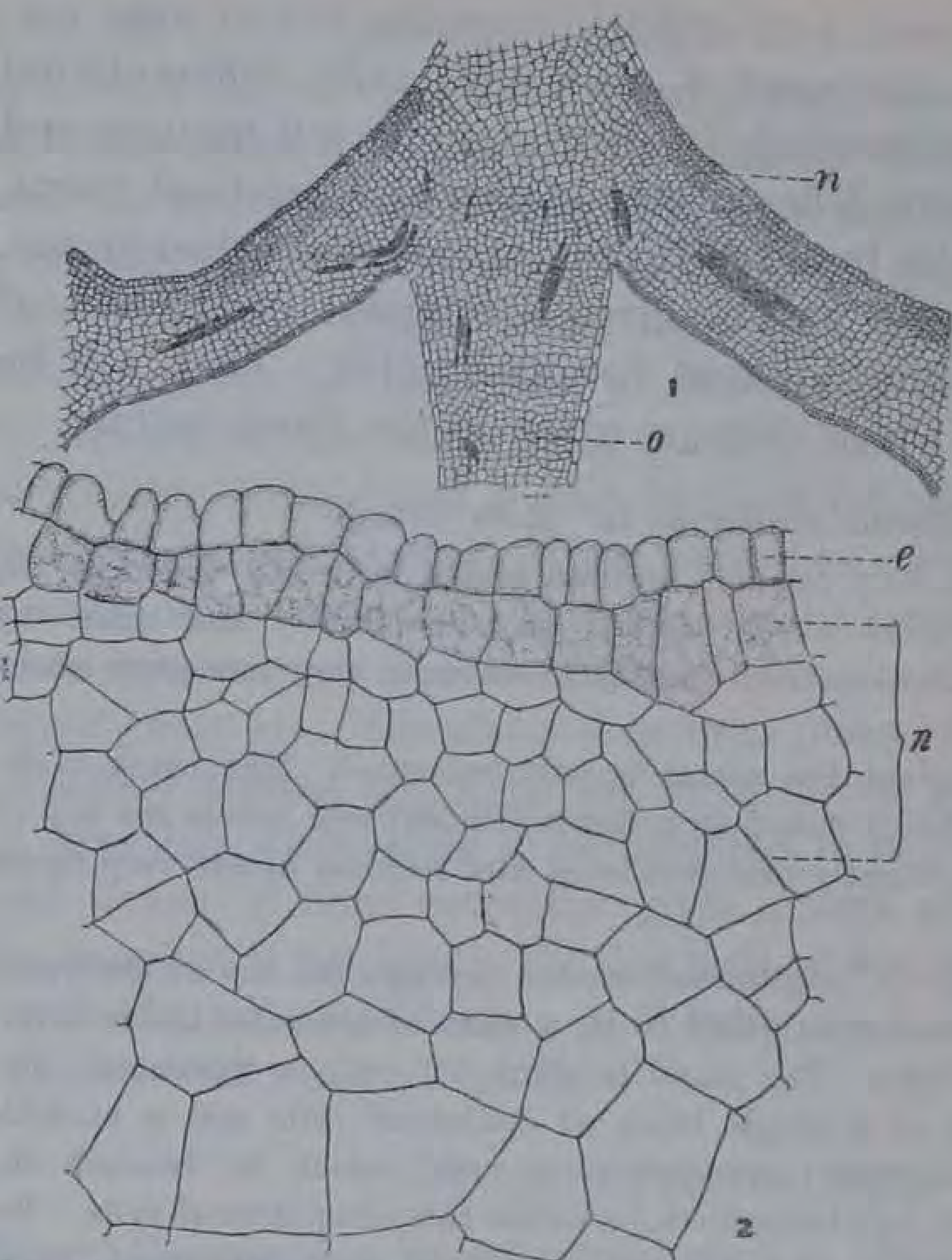


FIG. 553.—1. Longitudinal section through the ovary of *Philadelphus*, showing the position of the nectary. n, nectary tissue; o, cells of the ovary.
2. Part of a longitudinal section through the nectar tissue of *Philadelphus*. e, epidermis; n, nectar tissue (only first layer of cell protoplasm filled in).

subepidermal tissue contain a very granular protoplasm, although no large distinct granules are found. The cells are 4- to 8-sided and are smaller than the parenchymatous cells below them, although they are somewhat larger than the epidermal cells. The nectar tissue grades gradually into the parenchymatous tissue and it is difficult to tell where one stops and the other begins. But as a rule the subepidermal cells can be distinguished by their granular contents, their size and their shape. In the parenchymatous tissue are found the fibrovascular bundles, which run at right angles with the nectar tissue. They do not, however, extend up into the subepidermal cells, but are in very close proximity to them.

Pyrus communis L. Pear

General.—The pear is very common in the state of Iowa, and is no doubt one of the large sources of nectar in this state. It came into bloom this year (1922) about the latter part of April and was one of the earlier sources of nectar supply.

In the pear the receptacle comes up above the ovary, forming a cup-shaped depression on the top surface of the ovary. The lining of this entire cup is yellow and on it the nectar is secreted. The gland covers the entire lining of the cup, the face of which is somewhat furrowed, and in these furrows the nectar collects. The glandular tissue gradually grades into the tissue which goes to make up the stamens and top of the receptacle.

Anatomy of the Gland.—In the pear the nectar tissue is very distinct, being at least 0.2 mm. in depth. There is a distinct epidermis which stands out very

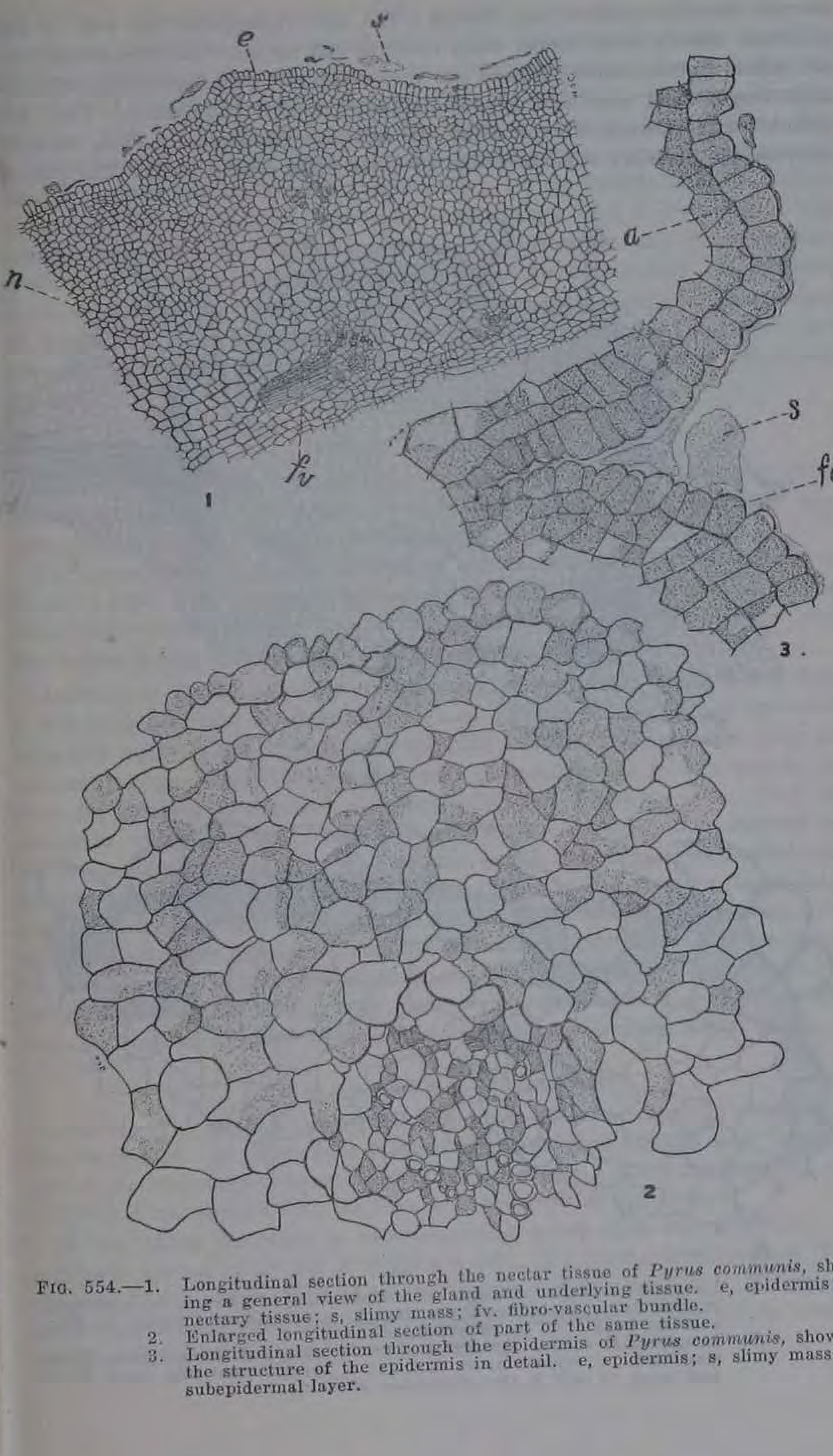


FIG. 554.—1. Longitudinal section through the nectar tissue of *Pyrus communis*, showing a general view of the gland and underlying tissue. e, epidermis; n, nectary tissue; s, slimy mass; fv. fibro-vascular bundle.
2. Enlarged longitudinal section of part of the same tissue.
3. Longitudinal section through the epidermis of *Pyrus communis*, showing the structure of the epidermis in detail. e, epidermis; s, slimy mass; a, subepidermal layer.

sharply from the surrounding tissues. The inner tangential cell wall of the epidermis takes a much deeper stain than the cell walls of the surrounding tissue, which feature makes it stand out very distinctly. The epidermal cells are much longer than wide and have a distinct granular protoplasm. They are provided with stomata through which the secretion takes place. These stomata resemble the ordinary stomata found in other parts of the plant. The guard-

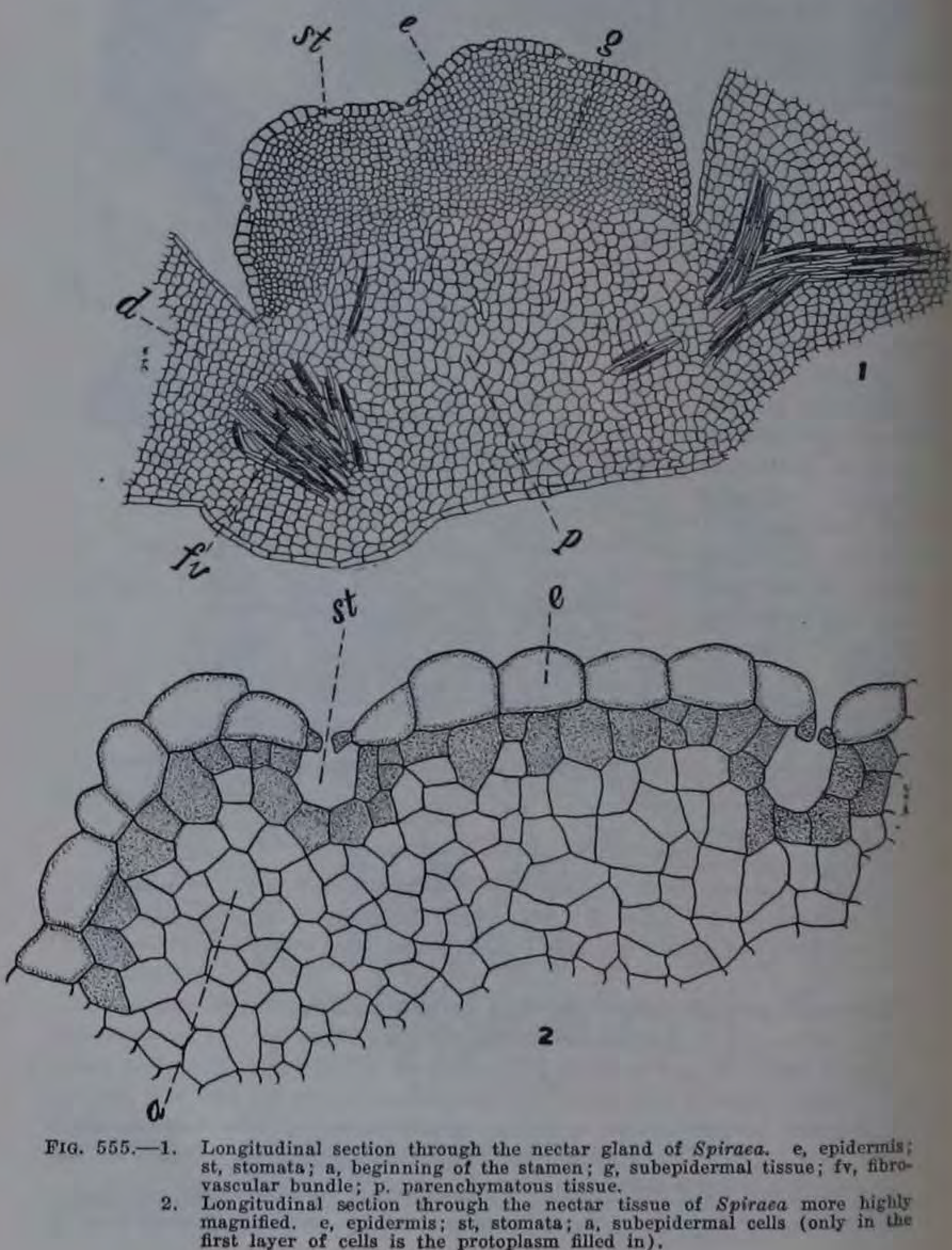


FIG. 555.—1. Longitudinal section through the nectar gland of *Spiraea*. e, epidermis; st, stomata; a, beginning of the stamen; g, subepidermal tissue; fv, fibrovascular bundle; p. parenchymatous tissue.
2. Longitudinal section through the nectar tissue of *Spiraea* more highly magnified. e, epidermis; st, stomata; a, subepidermal cells (only in the first layer of cells is the protoplasm filled in).

cells of the stomata have a very thick, granular protoplasm. Below the epidermis are found the subepidermal cells, which extend many layers in depth. They are practically the same size as the epidermal cells and are 4- to 8-sided, the common number of sides being six. The subepidermal cells are somewhat granular and grade gradually into the parenchymatous tissue below. The vascular bundles are very thick in the parenchymatous tissue, in some specimens even extending up into the nectar tissue. On the outside of the epidermis of the pear is found a slimy substance which always takes a deep stain. This collects above the epidermal cells as thin, irregular layers, and wherever there is a furrow in the epidermis it collects in large globular bodies. It probably is an excretory product of these cells and no doubt plays a part in the secretion of the nectar. The epidermal layer of the pear is somewhat furrowed and generally in these furrows are found the stomata, although this is not always the case.

Spiraea sp. Spiraea

General.—This plant is a cultivated shrub that is very extensively grown throughout the state. It seems to be a fair nectar yielder and bees were noticed upon it very regularly. It blooms about the middle of May.

The nectar gland in *Spiraea* consists of annular orange-yellow thickenings on the inner wall of the receptacle internal to the insertions of the stamens. These thickenings extend entirely around the receptacle and form a definite ring. The nectar is half concealed and is secreted abundantly.

Anatomy of the Gland.—The nectar gland of *Spiraea* is about 2 mm. deep, 4 mm. long and oval in shape. The gland consists of the regular epidermal cells and many layers of subepidermal cells below. The epidermal cells are somewhat larger than the epidermal cells of most nectar glands and do not have the granular protoplasm so characteristic of secreting cells. They are somewhat wider than long and are provided with stomata. The stomata are set somewhat deeply in the epidermis, the guard cells being richly filled with granular protoplasm. The secretion takes place through stomata, there being prominent intercellular spaces in the nectar tissue where they appear. The subepidermal tissue consists of small 4- to 8-sided cells filled with dense granular protoplasm. There is no distinct line of demarcation where they extend into the parenchymatous tissue. The parenchymatous tissue is well filled with vascular bundles, some of them extending nearly up into the nectar tissue.

Prunus virginiana L. Choke Cherry

General.—The common cherry is another one of Iowa's honey plants that is very important. It comes into blossom about the first of May and furnishes one of the important sources of early nectar supply. When the material was collected it was noticed that the bees were busy around the flowers.

In the cherry the ovary is superior, being borne upon the receptacle, the receptacle coming up around it to form a cup. The nectar tissue extends from the base of the ovary up to where the receptacle joins the calyx. This tissue has a deep orange color and secretes nectar abundantly. The cup is smooth and does not seem to be furrowed in any way.

Crataegus mollis (T. and G.) Scheele. Crataegus, Red Haw

General.—Crataegus is one of our early spring trees in Iowa. It is a rather large tree and blooms very abundantly. The trees also have a rather long blooming period and are worked on very hard by bees during this time.

In *Crataegus*, as in Cherry, the ovary is superior, the receptacle coming up around it to form a medium sized cup. On the wall of this cup the nectar is secreted. The lining of the receptacle is deeply furrowed and in these furrows the nectar collects. The nectar is half concealed and is somewhat protected from the weather by stamens bending over the cup. The secreting tissue extends up to the junction of the receptacle with the calyx.

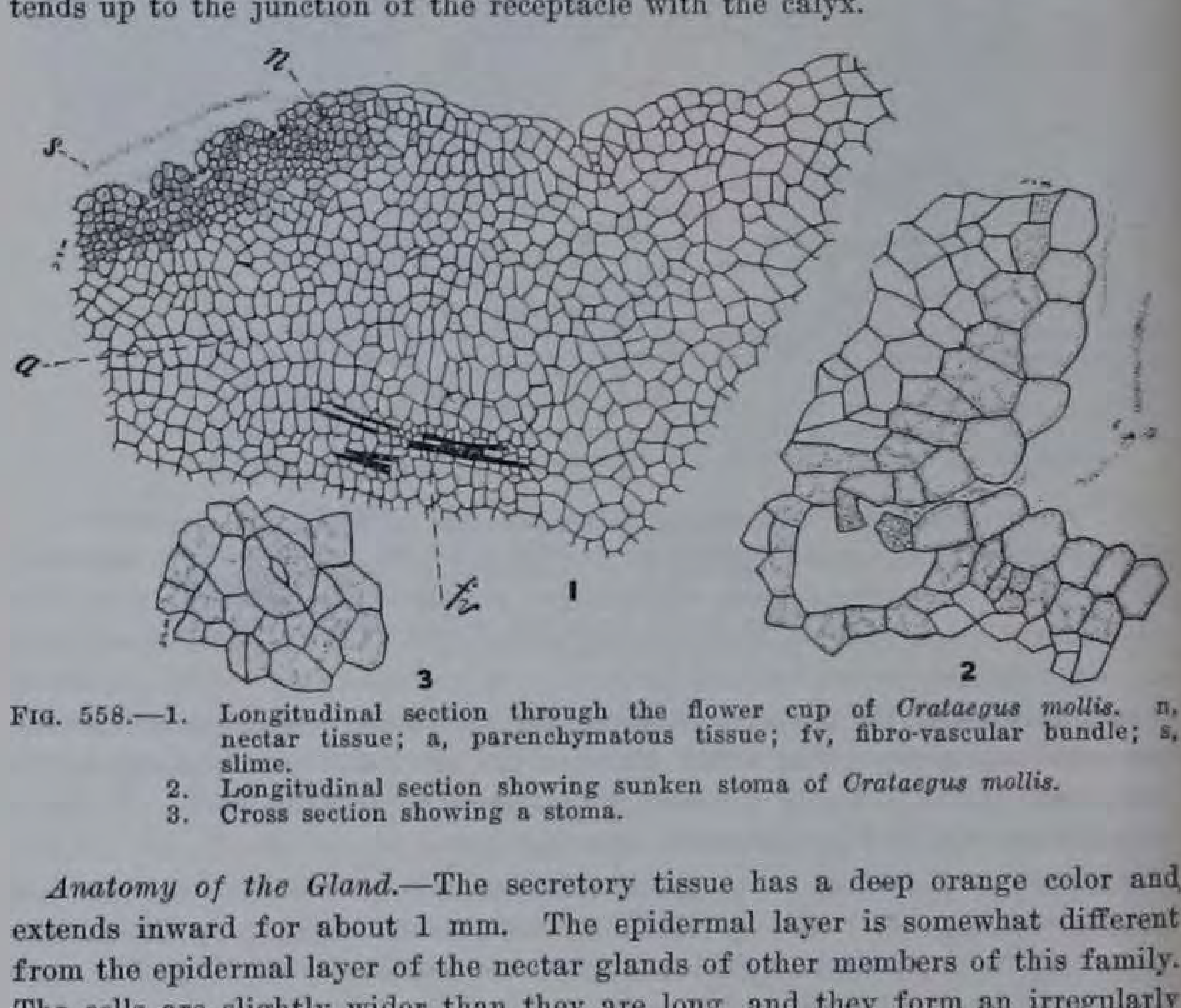


FIG. 558.—1. Longitudinal section through the flower cup of *Crataegus mollis*. n, nectar tissue; a, parenchymatous tissue; fv, fibro-vascular bundle; s, slime.
2. Longitudinal section showing sunken stoma of *Crataegus mollis*.
3. Cross section showing a stoma.

Anatomy of the Gland.—The secretory tissue has a deep orange color and extends inward for about 1 mm. The epidermal layer is somewhat different from the epidermal layer of the nectar glands of other members of this family. The cells are slightly wider than they are long, and they form an irregularly furrowed covering over the secreting tissues. At the bottom of these furrows stomata are generally found. The stomata are like ordinary stomata, but are set very deeply into the tissue. The guard cells are densely granular. On the outside of the epidermis is found a slimy mass, which is somewhat like that found in the pear but not so thick. The epidermal cells of the calyx are longer and are also thicker walled. They do not have the thick granular contents that the epidermal cells of the nectar tissue have. No stomata are present. The subepidermal tissue of the nectar glands is about six to eight layers of cells in thickness, and is quite distinct. Its cells are about the same size as the epidermal cells but more granular and much smaller than the parenchymatous cells of the tissue below. As usual they grade into the parenchymatous tissue and it is hard to tell the beginning of one and the ending of another. Vascular bundles are thick in the parenchymatous tissue.

Pyrus Malus L. Apple

General.—This year at Iowa State College the apple has proven one of our best early honey plants. The apple trees did not blossom until late in the season, hence the bees were able to work on them when the weather was warm.

In the apple the ovary is inferior, the receptacle coming up above the top of it. The receptacle forms with the calyx a cup-shaped depression on the top of the ovary. The lining of the cup-shaped receptacle forms the secreting surface. The nectar tissue extends all the way up to the place where the receptacle joins the calyx. The tissue has a deep orange-yellow color, a character typical of practically all nectar tissues.

Anatomy of the Gland.—In the apple we have the same kind of tissue that is characteristic of most of the members of this family that have been studied. The epidermal layer is more or less flat in outline, the cells being either long or wide. They are very granular and do not have any stomata present. The subepidermal layer consists of many layers of cells, which extend in for about 1 mm. There is no sharp line of demarcation between the subepidermal tissue and the parenchymatous tissue below. The fibro-vascular bundles do not come very close to the nectar tissue. There is a sharp line of demarcation between the epidermal cells of the nectar tissue and those of the calyx. The cells of the calyx are much larger and thicker walled. They do not have the granular contents that the others have. A large vascular bundle ends in close proximity to the subepidermal layer, but does not extend up into it.

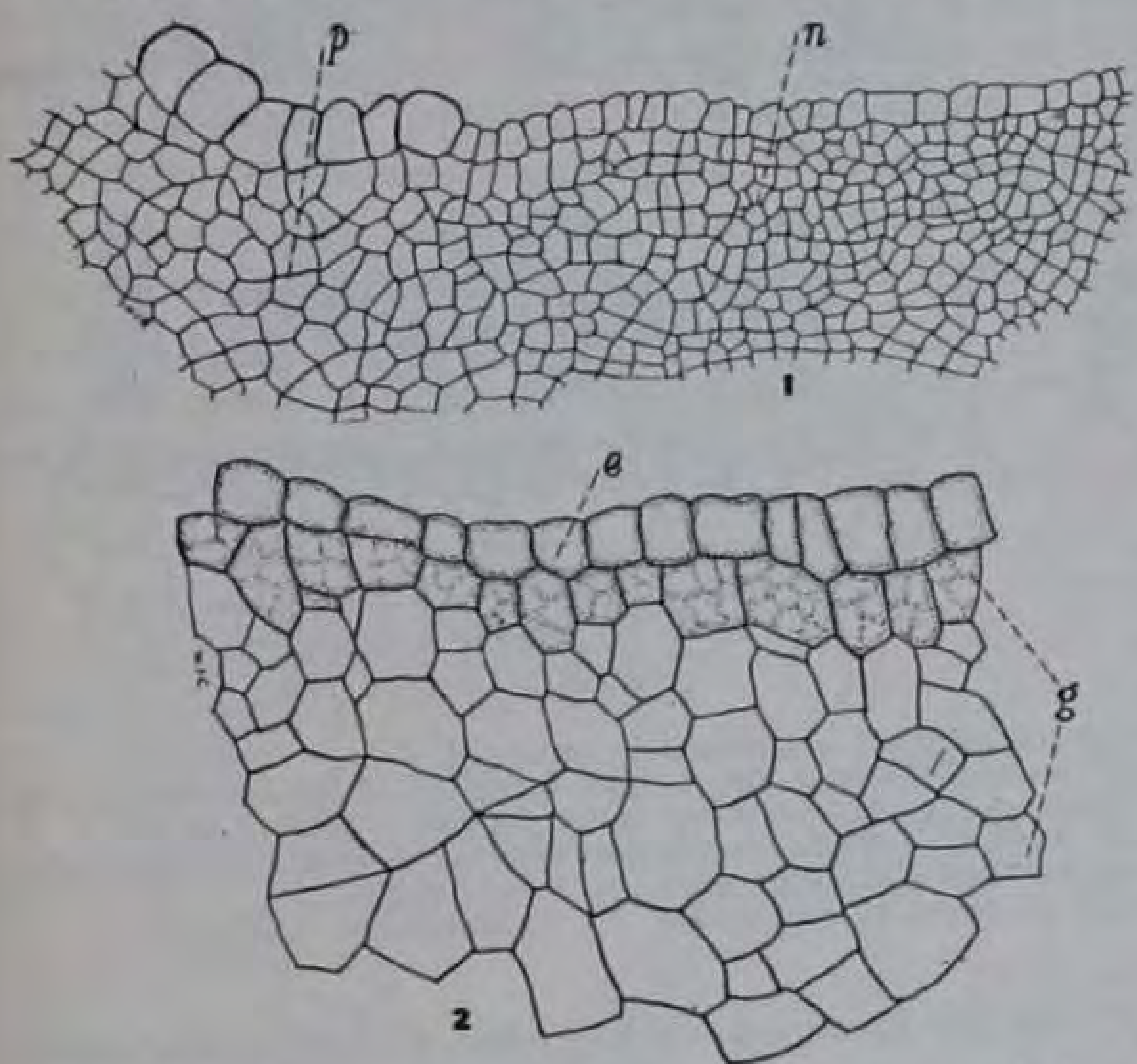


FIG. 559.—1. Longitudinal section through receptacle of *Pyrus Malus*. n, nectary tissue; p, parenchymatous tissue of the calyx.
2. Longitudinal section through the nectar tissue of *Pyrus Malus*. e, epidermis; g, subepidermal cells.

Tilia americana L. Basswood

General.—The basswood is also considered one of Iowa's greatest honey plants. Although not as abundant in the state as it was once, it still yields a good supply of nectar. This year the basswood was late, not blooming until after the first part of June but after coming into blossom it secreted nectar very abundantly. Bees were noticed on it from early morning until late in the evening, which indicated that they were getting a good supply of nectar. The blooming period lasts about three weeks.

In basswood, as the flowers are pendent, the nectar secreted by the hollowed sepals is protected from the rain. These sepals are filled with short hairs, which act as a protection for the nectar.

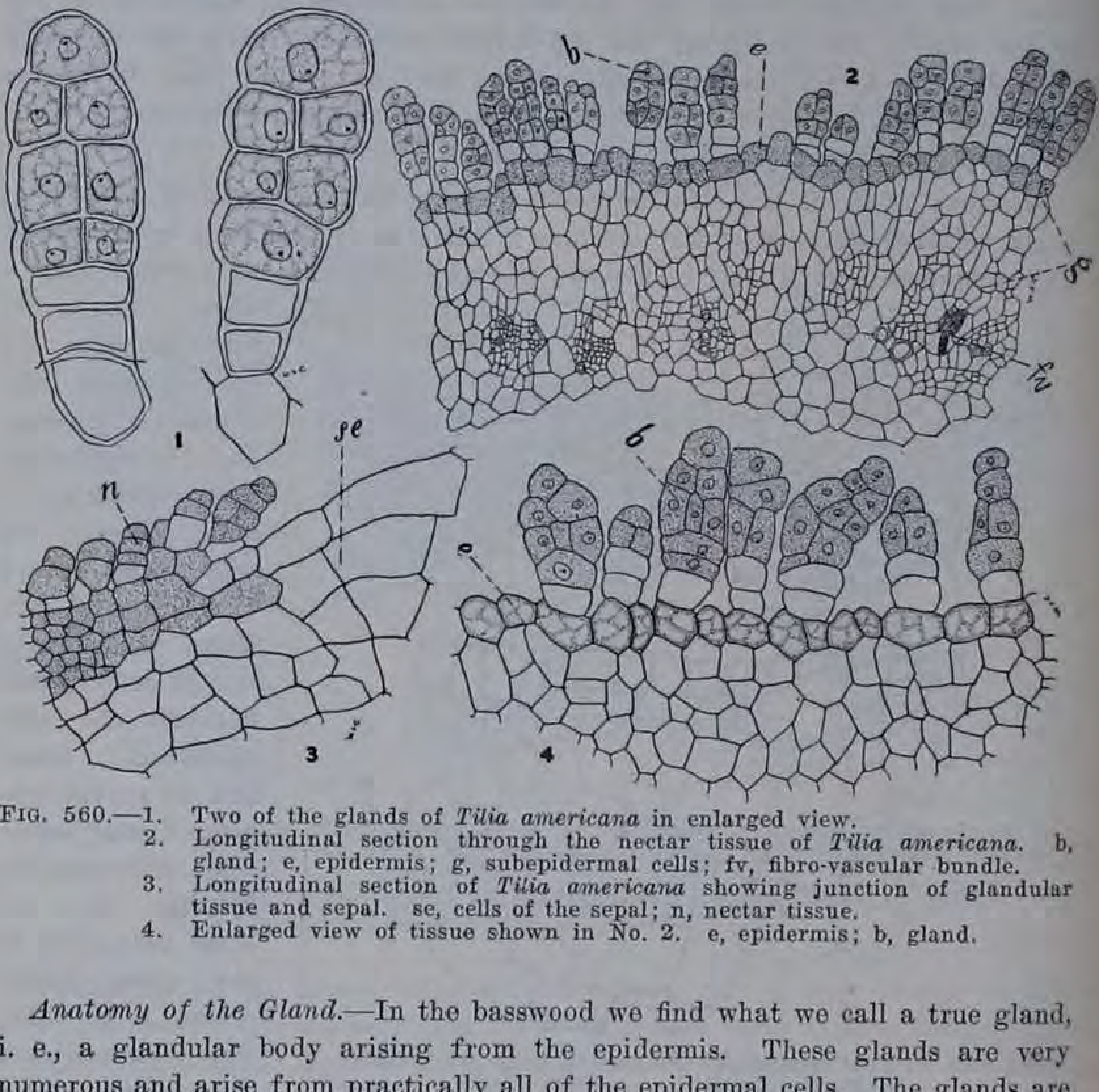


FIG. 560.—1. Two of the glands of *Tilia americana* in enlarged view.
2. Longitudinal section through the nectar tissue of *Tilia americana*. b, gland; e, epidermis; g, subepidermal cells; fv, fibro-vascular bundle.
3. Longitudinal section of *Tilia americana* showing junction of glandular tissue and sepal. se, cells of the sepal; n, nectar tissue.
4. Enlarged view of tissue shown in No. 2. e, epidermis; b, gland.

Anatomy of the Gland.—In the basswood we find what we call a true gland, i. e., a glandular body arising from the epidermis. These glands are very numerous and arise from practically all of the epidermal cells. The glands are much longer than they are wide and consist of, first, two stalked cells which rise from the epidermis and which do not contain granular protoplasm and nuclei. Above them is a large cell which is densely filled with protoplasm and contains a large nucleus. Above this large cell are two rows of two cells each, which have divided equally, and topping these cells is the cap-cell. All of these cells are filled with dense protoplasm and have prominent nuclei. The glands do not all contain the same number of cells, but this is the general plan. The epidermal cells from which the glands arise are fairly large and contain a dense granular protoplasm. Their outer walls are curved and they are longer than wide. Beneath the epidermal tissue are found the subepidermal cells, five or six layers in thickness. The cells are 4- to 8-sided and are distinctly granular. Below them the vascular bundles occur in the parenchymatous tissue. They are very abundant and some of them extend up into the nectar tissue

Petunia violacea Lindl. Petunia

General.—This flower, which is one of the cultivated varieties of Petunias, is not regarded as one of the honey plants in Iowa, and was not worked on with that in view. It was studied when the writer was just starting on his work and was used because it has a very prominent nectary.

The nectary glands of Petunia are located on opposite sides of the ovary at its base. They occur as rather large pyramidal mounds, and are easily seen with the naked eye. They have a deep yellow-orange color. Nectar is secreted very abundantly by the glands.

Anatomy of the Glands.—The nectar tissue is about 3 mm. deep, 4 to 6 mm. long and consists of the epidermal layer with many layers of the small subepidermal cells under it. The epidermal cells are larger than the cells beneath them but are not so distinctly granular. The epidermal cells are very irregular in shape, have their outer walls curved out somewhat and the epidermis is well provided with stomata. The stomata are borne on the surface and have a prominent stomatal chamber. The guard cells are distinctly granular. Secretion takes place through the stomata. The subepidermal cells are smaller than the epidermal cells and are also much more densely granular. They have very irregular shapes and do not have intercellular spaces. Below the subepidermal tissue is found the parenchymatous tissue of the slightly larger cells. A large vascular bundle is found in the tissue, extending nearly into the nectar tissue and running parallel with it.

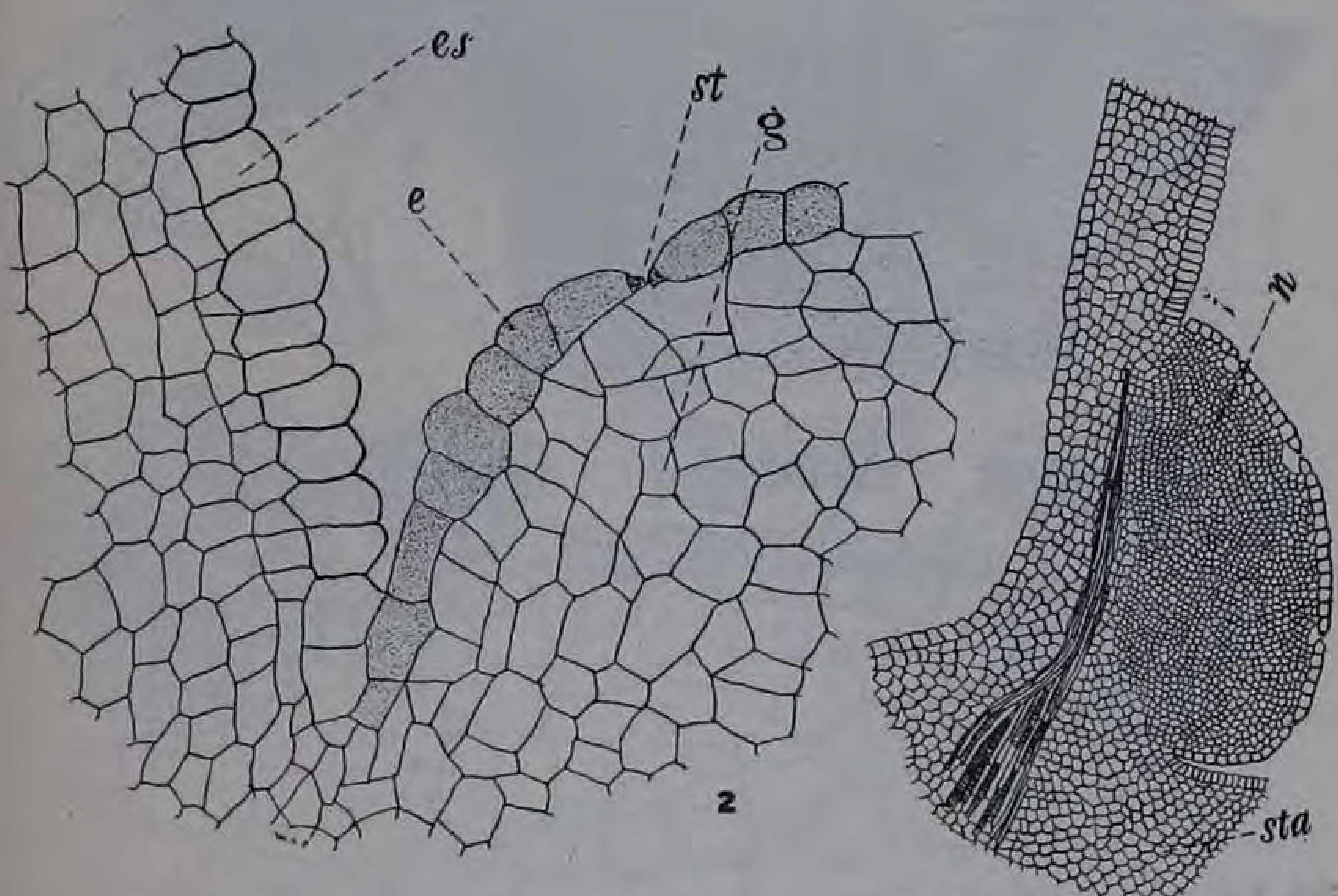


FIG. 561.—1. Longitudinal section through the nectar gland of *Petunia violacea*. n, nectar tissue; sta, cells of the stamen.
2. Enlarged view of a section of the glandular tissue showing the junction with the cells of the stamen. e, epidermis; st, stamen; es, epidermal layer of stamen; g, subepidermal cells (cells not filled in).

Catalpa bignonioides Walt. Catalpa

General.—The catalpa is a fairly large tree that is found over practically all of the state of Iowa. Its flowers are large and it secretes nectar abundantly, although the flowers last for only a few days.

In catalpa the nectar gland is located at the base of the corolla and at the base of the two stamens which rise from the corolla. The gland extends up for about 3 mm. on the stamens and corolla and is colored a light orange-yellow. The nectar is secreted abundantly and collects around the bottom of the ovary.

Anatomy of the Gland.—The nectary tissue extends into the corolla for about 1 mm. There is a distinct epidermis, which is plentifully supplied with large stalked glands. These glands rise from the epidermal cells and are somewhat fan-shaped. The gland consists of a large stalked cell, which does not have granular protoplasm and a nucleus. Above this stalked cell are found six to eight elongated cells which are arranged around the stalk cell in an irregular semicircle. These elongated cells are decidedly granular in appearance and have distinct nuclei. In cross section the glands consist of fifteen to eighteen cells, which are 3- to 6-sided. Secretion takes place through these glands. The

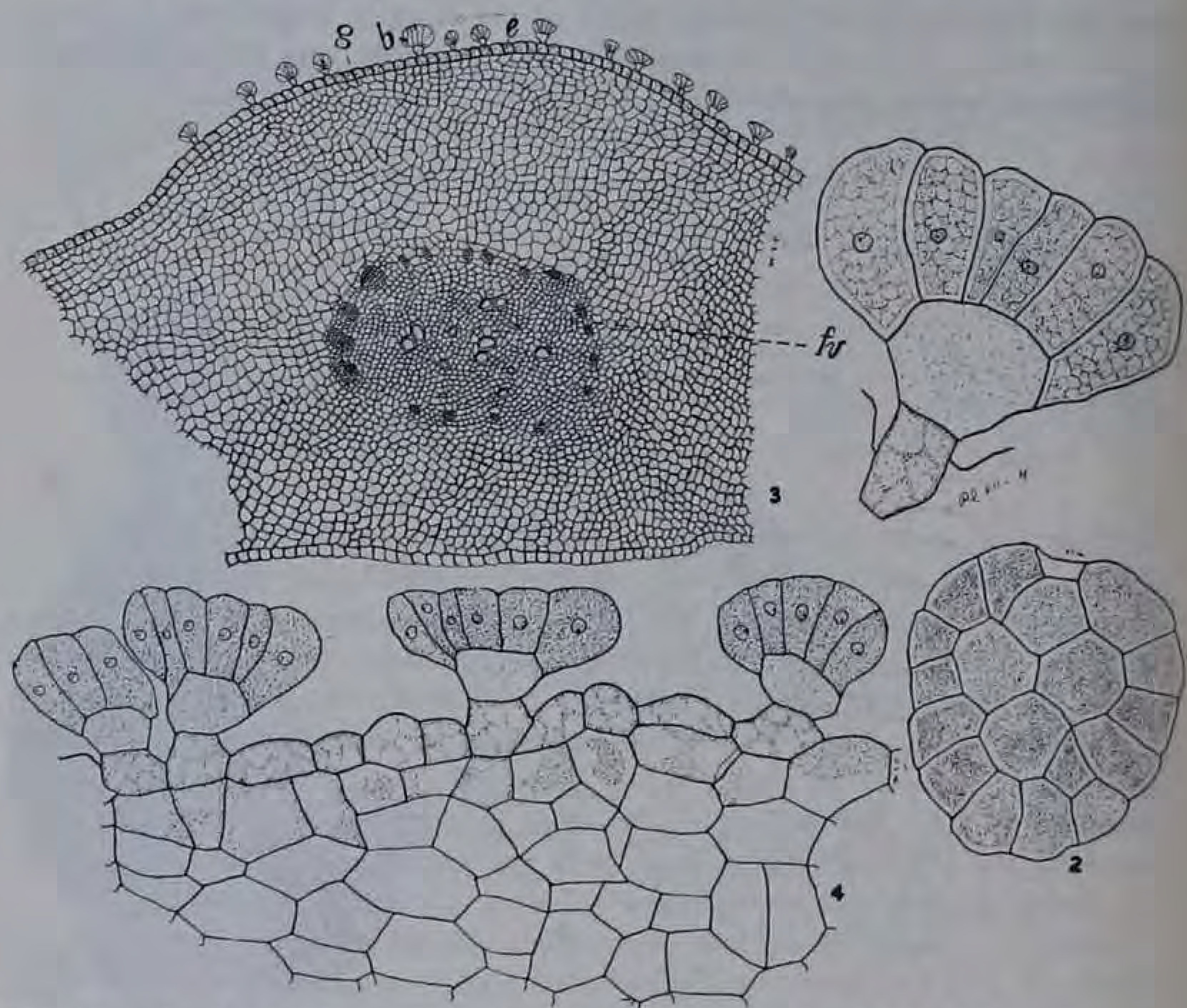


FIG. 562.—1. Longitudinal section through one of the glands of the *Catalpa*.
2. Cross section of the same gland.
3. Section through the base of the corolla of the *Catalpa*, showing the glands in longitudinal view. b, gland; e, epidermal layer; g, subepidermal layer; fv, fibro-vascular bundle.
4. Enlarged view of the glandular tissue of the *Catalpa*.

ly serrate, deciduous. Stipules linear-lanceolate. Flowers monoecious; the staminate clustered in long catkins, appearing with the unfolding of the leaves; the pistillate scattered or spicate at the base of the staminate catkins, 2 or 3 together or solitary. Calyx 6-lobed, abortive; stamens 5 to 12; involucre becoming spiny.

Visited by bees.

Castanea dentata (Marsh.) Borkh. Chestnut

A large tree with oblong lanceolate leaves. More or less freely cultivated in the state, but not quite hardy. Flowers visited by honey bees.

Quercus (Tourn.) L. Oak

Winter buds clustered at the ends of the branches, with chestnut brown scales, pubescent or smooth. Leaves lobed, dentate or entire. Flowers appear in early spring with the unfolding of the leaves; staminate yellowish green, solitary, in the axils of the bracts, or without bracts, in pendulous clustered aments; calyx bell-shaped, 4- to 7-lobed; stamens 4 to 6. Pistillate flowers solitary, subtended by a bract and 2 bractlets; calyx urn-shaped with a 6-lobed limb; ovary 3- to 5-celled, 2 ovules in each cell. Fruit a

FIG. 52.—White oak (*Quercus alba*). *Drawn by Ada Hayden.*

epidermal tissue is practically like others that have been studied but is perhaps somewhat more granular. There is no distinct subepidermal tissue, the cells below the epidermis being practically alike, except that one or two layers next to the epidermis are somewhat more granular. In the parenchymatous tissue are found large vascular bundles, which are spaced at regular intervals.

Lonicera tatarica L. Tartarian Honeysuckle

General.—This plant blooms in late May. It probably is not of great importance in this state for nectar, its corolla tube being slightly long for the bees to reach the nectar.

In *Lonicera* the gland is found on one side of the corolla. On one side of the flower the corolla is somewhat hollowed out, forming a kind of cup. Along the sides of this depression, which is fairly deep, is found the nectar tissue. This extends all along the bottom of the depression and for some distance out

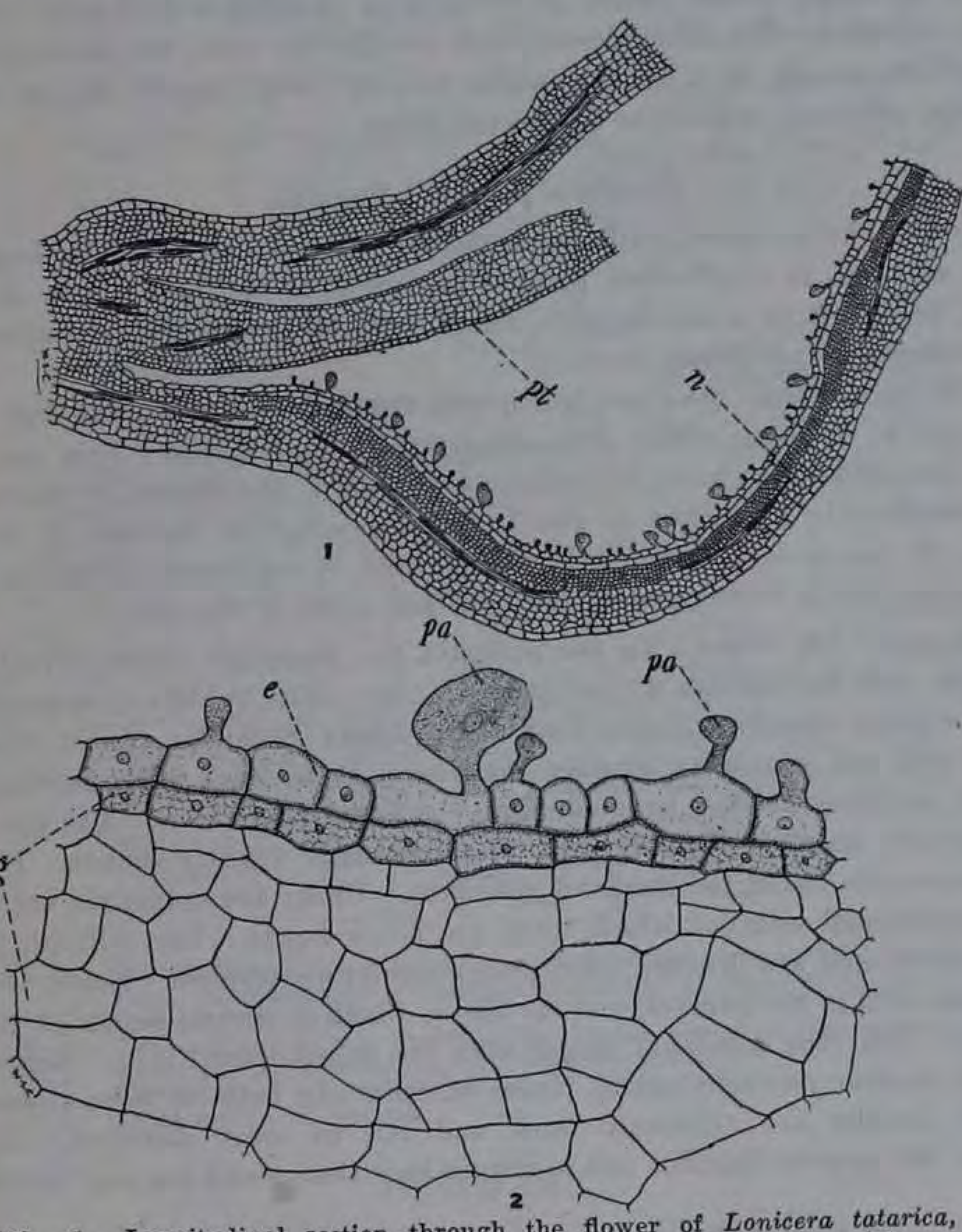


FIG. 563.—1. Longitudinal section through the flower of *Lonicera tatarica*, showing the position of the nectar gland. n, nectar tissue; pt, pistil.
2. Enlarged view of the nectar tissue. e, epidermis; pa, papilla; g, subepidermal cells.

of it up along the inside of the petal. The gland is well protected from rain by hairs which occur around it.

Anatomy of the Gland.—When we examine a section through the nectar tissue we find an epidermal layer covering the layer of subepidermal cells. All along on the epidermis rise little projections which have rounded knobs at the ends. At regular intervals arise larger projections which take on the character of glands, although there is no noticeable division into cells. Both the small projections and the larger ones are densely filled with a granular protoplasm. The larger projections contain nuclei. It is probable that the secretion takes place through the epidermal projections. There is no cross-wall between the epidermal cell and the projection. The ordinary epidermal cells are wider than they are long and are more or less flat on top, except where the projections arise. They have prominent nuclei, but are only slightly granular. Below the epidermis is found another layer of cells resembling the epidermal cells, which contain distinct nuclei and are distinctly granular. Below them is the subepidermal tissue, which consists of small 6- to 8-sided cells, distinctly granular. The subepidermal cells are divided from the parenchymatous cells of the corolla by a large vascular bundle, which extends all the way up the petal and runs parallel to the nectar tissue.

Cucurbita pepo L. Pumpkin

General—The pumpkin, while not being regarded as one of the leading honey plants of Iowa, is very widely planted in this state and is a source of nectar supply, especially as a late supply. The flowers secrete nectar very abundantly and are accessible to honey bees.

In the male flower (the one which was studied) the calyx and the corolla are united at the base, where they support a cup-shaped disc. This cup, about 3 mm. deep and 4 mm. wide, is completely covered by the column of stamens and is accessible only by means of two to four openings at the base of the filaments. It has a deep orange-yellow color and is sometimes completely filled with nectar, which is secreted at the base and sides of the cup.

Anatomy of the Gland.—In the pumpkin the glandular tissue is very deep, extending into the interior for at least 1½ mm. The epidermis is prominent, the cells being somewhat longer than the ordinary glandular tissue. The epidermal cells are somewhat broader than long, their outer walls curving only slightly, and they are less granular than the underlying tissue. The epidermis is plentifully supplied with stomata, which are only slightly sunken. Beneath the stomata are found the stomatal chambers. Under the epidermis are found the subepidermal cells, of which there are many layers. The cells are small, 4- to 6-sided, and are directly filled with granular protoplasm. Below the subepidermal cells is the parenchymatous tissue, which is several layers of cells in thickness, with cells somewhat larger than the subepidermal cells. Below this tissue is another parenchymatous tissue of cells. In both of these tissues the vascular bundles are extremely thick and run in every direction. In the pumpkin the vascular bundles end in the nectary tissues and are very abundant.

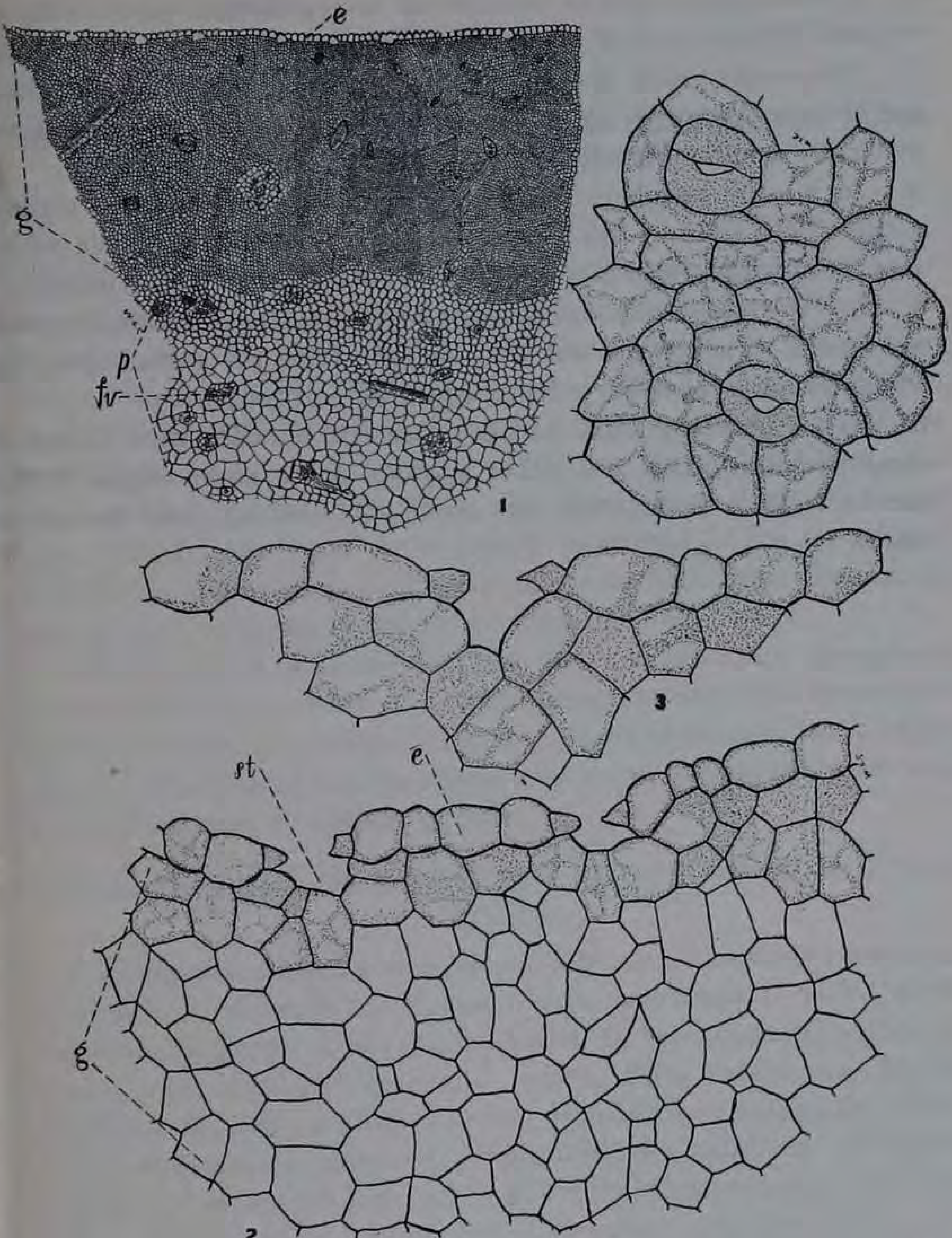


FIG. 564.—1. Longitudinal section through a part of the nectar tissue of *Cucurbita pepo*. e, epidermis; g, subepidermal cells; p, parenchymatous tissue; fv, fibro-vascular bundle.
2. Longitudinal section through the nectar tissue of *Cucurbita pepo*. e, epidermis; st, stomata; g, subepidermal tissue.
3. Longitudinal section of stomata.
4. Cross-section of stomata.

SUMMARY

1. In studying nectar glands we do not always find true stalked glands; in fact, they are the exception to the rule.

2. Nectar tissue always consists of an epidermal layer with or without stomata and of a subepidermal layer differing in thickness.
3. The nectar tissue is easily recognized by its smaller cells, which are always filled with a dense granular protoplasm. These cells are generally smaller than those of the surrounding ground tissue.
4. In all the members of the Rosaceae studied, no true stalked glands were found. An epidermal layer was found, under which was the subepidermal layer. Stomata may or may not be present.
5. In *Tilia americana* and *Catalpa bignonioides* true stalked glands are found. They stand out very sharply from the surrounding tissue and always have very dense, granular cell contents.
6. In all nectar glands studied, vascular bundles were found in close proximity and ran either parallel or at right angles to the nectar tissue. Sometimes they even extended up into the nectar tissue.

MIDSUMMER BEE PLANTS IN THE MISSISSIPPI ZONE OF CLAYTON COUNTY

ADA HAYDEN

With intent to determine (1) what plants were available to bees in late summer, (2) how these plants were located with reference to water reservoirs and (3) which of these plants were most valuable to the bee, some observations were made in Clayton county, Iowa, August 20 to September 9, 1919. The vicinities of McGregor, Beulah, Garnavillo, Guttenberg, Clayton, Prairie-du-Chien, and some of the adjacent islands of the Mississippi about McGregor were visited. Since the water supply is related to the topography and the distribution of plants is relative to both these factors, the geology and topography should be kept in mind.

While the west side of the river bears a luxuriant mesophytic forest, with only an occasional dry ridge or exposed peak bearing the prairie verdure, the weathered and exposed Wisconsin shore of the river in this vicinity bears a sparse and more xerophytic forest with a broad expanse of treeless prairie.

TYPICAL FLORA OF THE WEST SHORE OF MISSISSIPPI RIVER

Acer nigrum, A. saccharum, A. saccharinum, Fraxinus americana, F. viridis, F. nigra, F. americana, Ulmus americana, U. fulva, Celtis occidentalis, Carya ovata, Quercus alba, Q. acuminata, Q. rubra, Q. macrocarpa, Juglans cinerea, J. nigra, Tilia americana, Mitella diphylla, Hystrix patula, Lobelia siphilitica, Campanula americana, Osmorrhiza claytoni, Podophyllum peltatum, Hepatica acutiloba, Cystopteris fragilis, C. bulbifera, Camptosorus rhizophyllus, Asplenium Filix-femina, Pellea atropurpurea, Botrychium virginianum, Adiantum pedatum, Struthiopteris Germanica, Hydrastis canadensis, Actaea rubra, Panax quinquefolium, Arabis racemosa, Cypripedium pubescens, Caulophyllum thalictroides, Rhus typhina, Clematis virginiana, Hamamelis virginiana, Physocarpus opulifolius, Sicyos angulatus, Polymnia canadensis, Impatiens pallida, Impatiens biflora.

FLORA OF THE BLUFFS ON THE EAST SHORE OF MISSISSIPPI RIVER NEAR PRAIRIE DU CHIEN

Quercus velutina, Populus tremuloides, Betula papyrifera, Carya ovata, Ulmus fulva, Rhus glabra, Rhus Toxicodendron, Corylus americana, Vitis vulpina, Andropogon furcatus, A scoparius, Sorghastrum nutans, Sporobolus longifolius, Bouteloua curtipendula, B. hirsuta, Panicum Scribnerianum, Elymus robustus, Muhlenbergia mexicana.

PLANTS FREQUENTED BY HONEY BEES

Compositae
- Aster salicifolius
- Grindelia squarrosa
- Helenium autumnale
- Polymnia canadensis
- Solidago canadensis
- Solidago missouriensis
- Solidago rigida

Cucurbitaceae
- Sicyos angulata

Labiatae
- Lycopus americana
- Mentha canadensis
- Nepeta Cataria

Leguminosae
- Apios tuberosa

Polygonaceae
- Polygonum Muhlenbergii
- Polygonum pennsylvanicum

Ranunculaceae
- Clematis virginiana

Scrophulariaceae
- Scrophularia marilandica

The Bee Pastures.—The hills of the Iowa shore during the later part of August and early September showed only foliage traces of

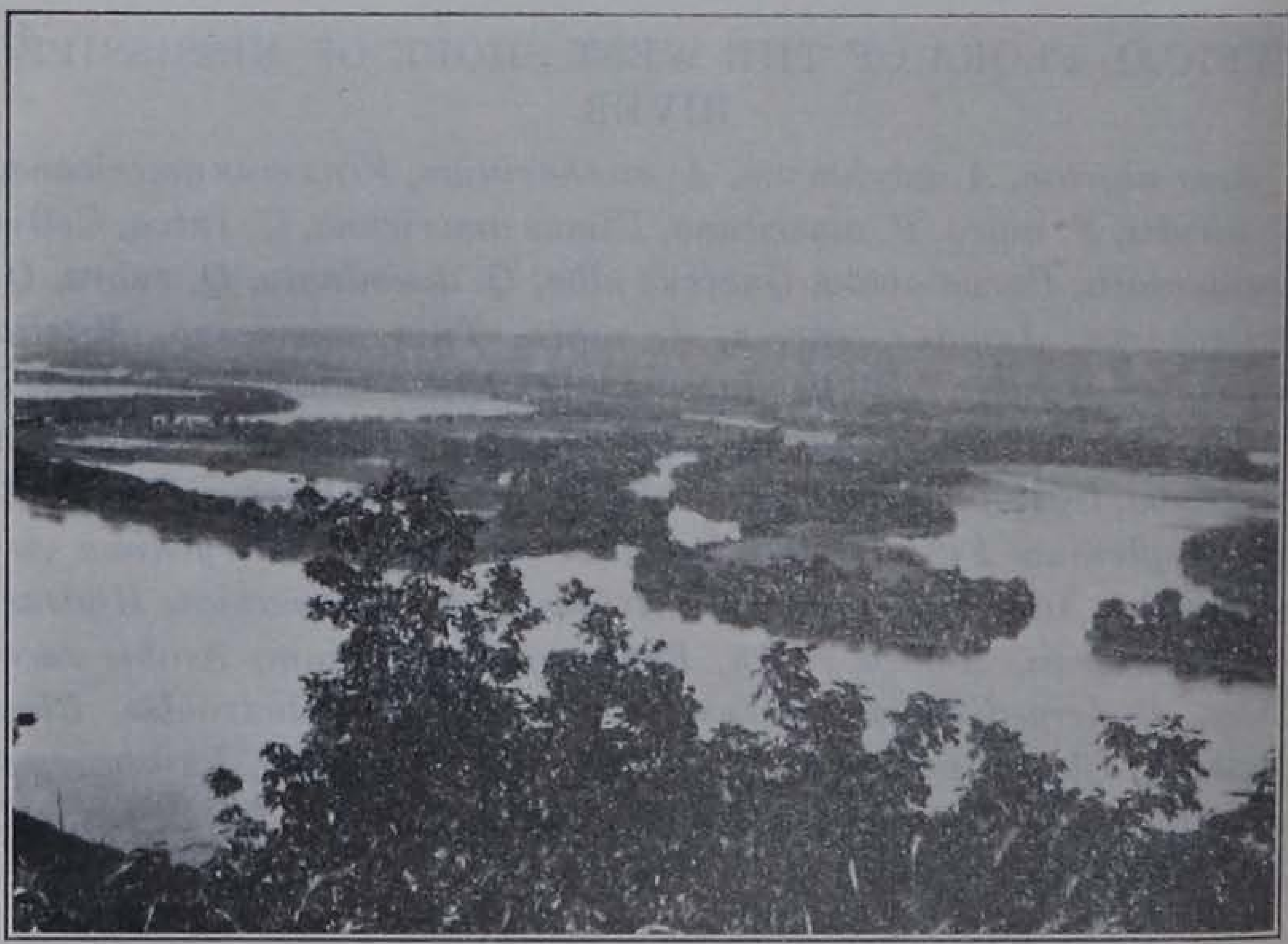


FIG. 565.—Bee pastures. Bergman's Island, Mississippi river. *Photo by Hayden.*

he profuse spring flora, as here and there the scarlet-berried ginseng or the blue-berried cohosh, with now and then along a rivulet or hedged about a spring, the jewel weed, spangled with orange or pale yellow cornucopias and encircled by bumble bees buzzing in and out. The only flowering plants were on the surfaces of the slopes exposed to the sun. *Clematis* or *Sicyos* vines lay on the bushes like great white blankets, here and at the damp base of the cliff or in the open spaces about the springs. *Polymnia* clumps stood out against the green tangle in cream-colored patches and along the railway banks ran the low white catnip colonies. Here small bumble bees and honey bees worked briskly in the morning and continuously on through the lengthening shadows of the afternoon, dipping their proboscides into the many-flowered heads, then moving with a whir to the next cluster, or, having filled their baskets with the pollen or their sacs with nectar, straight up from the flowers they circled and flew toward the distant hive. Not seldom the heavy laden worker beaten low from its high line of flight by treacherous currents met its death in the river.

The honey bee seems less efficient in its movement than the small bumble bee, which usually visits only fresh flowers and inserts its proboscis without experiment in the right groove, while the honey bee visits old dilapidated flowers as well as fresh ones, hovers sometimes before it makes a decision as to which flower to visit and occasionally finds difficulty in making entrance.

Again when a dull, warm, blue-haze-wrapt day blended the vivid colors in a soft mosaic scheme, a sudden shower drove the large bumble bee to shelter. Heels upward it clung to the under surface of a flower cluster, its black fur-coat protected from the drops; yet its small velvet-coated collaborator diligently and even more vigorously beseiged the trembling rain-pelted flowers. The honey bee laboriously persisted for nearly half an hour then somewhat reluctantly disappeared, as finally, but more slowly did the small bumble bee, leaving the soundly sleeping big bumble bee swinging in the steady drip under the rain-buffeted flowers.

SUMMARY

The abundance of limestone and sandstone products as constituents of the soil and the abundant water supply afford a desirable environment for a wide range of bee flora.

The light of the forest is sparse in the height of summer and

(Midsummer bee plants

Date	Hour	Locality	Name of plant	Wind
8/26/19	11:00-11:30 a.m.	McGregor, west side Mississippi river	Polymnia canadensis (Leafcup)	S.E.
8/28/19	1:00 p.m.	McGregor, west side Mississippi river	Polymnia canadensis (Leafcup)	S.E.
8/28/19	3:00 p.m.	McGregor, west side Mississippi river, foot of dry cliff	Sicyos angulatus (Wild cucumber)	S.E.
9/ 1/19	3:00- 4:00 p.m.	Prairie du Chien, Wis., east side Mississippi river	Sicyos angulatus (Wild cucumber)	S.E.
8/28/19	4:00- 4:30 p.m.	McGregor, west side Mississippi river, base of rocky cliff	Cirsium lanceolatum (Bull thistle)	S.E.
8/28/19	4:00- 4:30 p.m.	McGregor, west side Mississippi river	Clematis virginiana (White clematis)	S.E.
8/28/19	4:00 p.m.	McGregor, west side Mississippi river, foot of cliff	Nepeta Cataria (Catnip)	S.E.
8/28/19	11:00 a.m.	Beulah, near Bloody run	Linaria vulgaris (Toadflax)	S.E.
9/ 1/19	1:25 p.m.	Prairie du Chien, east side of Mississippi river flood plain	Physostegia virginiana (False dragon's head)	S.E.
9/ 1/19	1:25 p.m.	Prairie du Chien, east side of Mississippi river flood plain	Physostegia lanceolata (False turtle's head)	S.E.
9/ 1/19	2:30 p.m.	Prairie du Chien, east side of Mississippi river flood plain	Helenium autumnale (Sneezeweed)	S.E.
9/ 3/19	2:00 p.m.	Island in Mississippi river near McGregor	Helenium autumnale (Sneezeweed)	N.W.
9/ 2/19	4:00 p.m.	Prairie du Chien, flood plains	Grindelia squarrosa (gumweed)	S.E.
9/ 2/19	3:00 p.m.	Prairie du Chien	Aster salicifolius (Swamp aster)	S.E.
9/ 3/19	2:36 p.m.	Near Prairie du Chien, Bergman's island in Mississippi river	Mentha canadensis (Mint)	S.E.
9/ 4/19	12:30 p.m.	Bergman's island, E. of McGregor in Mississippi river	Polygonum pennsylvanicum (Knotweed)	S.
9/ 5/19	3:00 p.m.	Mouth of Yellow river	Solidago missouriensis	N.W.
9/ 9/19	1:00 p.m.	Oneida, sand	Solidago missouriensis	S.E.

of the Mississippi region)

Light	Soil	Habitat, exposure	Insect	Av. no. visits per 20 min.	Range in 20 min.	Other kinds of insect visitors.
				Over 2 sq. meters		
lear	Rocky, gravelly soil	Shady slope	Small bumble bee	17	14-21	
lear	Gravelly soil	Foot of dry, rocky cliff, east exp.	Small bumble bee	18	15-22	
lear	Gravelly soil	Foot of dry cliff, dense vegetation, shady east slope	Honey bee	15	15-18	Wasp, yellow jacket
lear	Rich loam, alluvial	Flood plain, moist, open all sides	Small bumble bee	14	11-17	Wasp, yellow jacket, honey bee
lear	Gravelly loam	Foot of dry rocky cliff, east exp.	Honey bee	21	15-25	Small bumble bee
lear	Gravelly loam	Foot of dry rocky cliff, dense vegetation, east exp.	Honey bee	15	15-18	Yellow jacket
lear	Gravelly loam	Foot of dry rocky cliff, east exp.	Large bumble bee	36	30-32	Honey bees
loudy, howers	Loam, alluvial	Flood plain, rocky limestone	Small bumble bee			
lear	Loam, alluvial	Flood plain, exposed all sides	Honey bee	36	31-47	Wasp, small bumble bee
lear	Loam, alluvial	Flood plain, exposed all sides	Honey bee	28	14-26	Wasp, small bumble bee
lear	Loam, alluvial	Flood plain, exposed all sides	Honey bee	24	20-33	Large bumble bee, small bumble bee
lear	Loam, alluvial	Flood plain, exposed all sides	Honey bee	35	35-46	
loudy	Loam	Dry bank near river	Small bumble bee	57	50-64	Honey bee, bumble bee
loudy	Alluvial	Swamp, flood plain	Honey bee	41	39-50	Small bumble bee, yellow jacket
loudy, howers	Alluvial	Swamp, edge of lakes on island	Honey bee	38	25-50	
lear	Alluvial	Edge of lakes on island	Honey bee	39	35-40	
lear	Alluvial	North bank of river	Honey bee	45	37-50	
Clear	Sandy loam	Railroad track	Honey bee	51	50-55	Wasp, fly, beetle

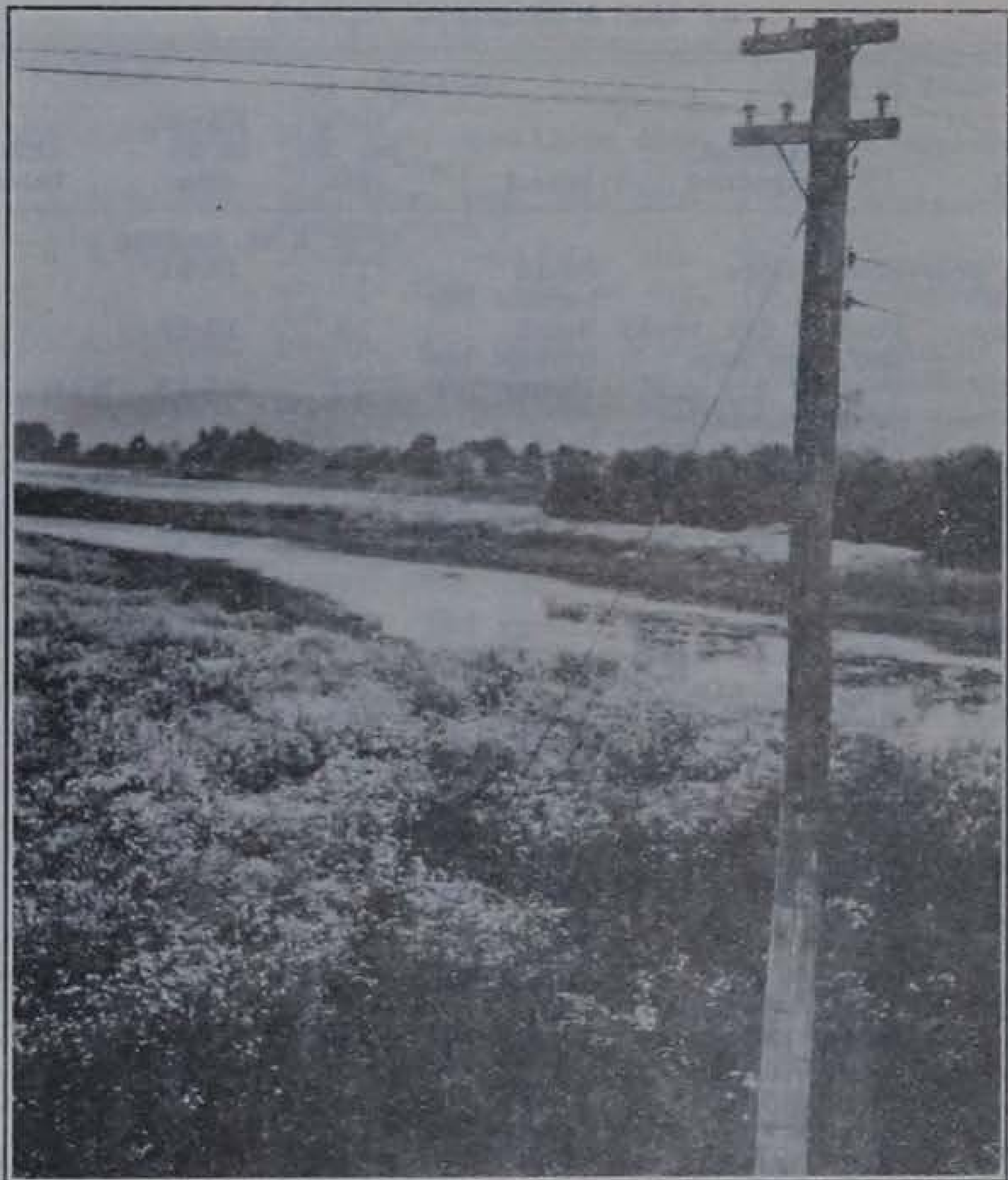


FIG. 566.—Bee pastures along Mississippi river. *Aster salicifolius.* *Photo by A. Hayden.*

though water is abundant in the deep interior, the flowering plants appeared in the greater light period of early spring and summer, hence the deep forest in midsummer affords few nectar-producing plants.

The open borders of the forest slopes and margins of open springs are the only habitats occupied by the flowering plants. These plants are principally deep-throated *Lobelia siphilitica*, *L. cardinalis*, *Impatiens biflora* and *I. pallida*, bumble bee and humming-bird pollinated plants.

The evenly watered, amply lighted, broad expanse of flood plain and island are the flower gardens of midsummer. The flowering plants are largely composites whose many-flowered heads, closely arranged in flat, corymbose panicles, afford an easily accessible surface and copious pollen as well as nectar.

A uniform water supply is essential to copious flower production, on which nectar flow is dependent. Since most midsummer flowers are found in the open forest or prairie, the factor of light may be regarded as quite as important as water.

FIG. 53.—White oak (*Quercus alba*). 1, Winter twig, x 2. 2, Leaf, x 1/2. 3, Flowering branchlet, x 1/2. 4, Staminate flower, enlarged. 5, Pistillate flower, enlarged. 6, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

nut covered or partly covered by a cup known as a cupule, 1-seeded by abortion.

A large genus of important trees.

The senior author has observed bees abundantly upon two of the oaks in Florida—*Quercus laurifolia*, and the live oak, *Quercus vir-*

STUDIES IN VARIATION OF RED CLOVER

EDNA C. PAMMEL AND CLARISSA CLARK

Variation in *Trifolium pratense* presents many interesting problems, some of which have been under consideration by the contributors to this paper.

General relationships between number of flowers in the head and number of seeds produced, the influence of soils and seasons, comparative dimensions of the flowers and of pollen grains were the particular features studied.

The present paper records work of Miss Edna Pammel in determination of variation in number of flowers in the heads of red clover from four different soil areas and the study of Miss Clark in variation in size of pollen grains; notes are included from the work of Miss Emma Wennholz and Miss Vera Mills in variation in number of clover flowers in heads miscellaneously collected, and from the study of Miss Mildred Walls upon variation in length of flower (stamen tube). Miss C. M. King rendered much assistance in arranging the materials of the paper.

A STUDY IN VARIATION IN NUMBER OF FLOWERS IN HEADS OF RED CLOVER

Countings were made from first, second and third crop clover on three different kinds of soil—alluvium, black loam and black loam underlain with gravel. All material was gathered in the vicinity of Ames, and only well developed heads were counted.

The following formulae from Davenport's Statistical Methods have been used in working out the mean index of variability, the coefficient of variability, and the probable error in each case.

$$A = \Sigma \frac{(v. f.)}{n}$$

where A = mean or average, m = sign of summation, v = magnitude of any class, f = frequency, or number of variates in that class, and n = total number of variates.

$$D = \sqrt{\Sigma \frac{(x^2.f)}{(\ n\ )}}$$

where D = index of variability, or the amount the group as a whole varies from the mean, x = amount of the deviation of any class from the mean, f = number of units in the class range, or in the present calculation, unity.

$$C = \frac{D}{a} .100 \text{ per cent}$$

where C = coefficient of variability. The 100 per cent is used to get the result into more convenient form, and is entirely arbitrary.

$$E_a = \frac{\pm .6745 \ \delta}{\sqrt{n}}$$

Where E_a = probable error of the mean.

$$E\delta = \frac{\pm .6745 \ \delta}{\sqrt{2n}}$$

where $E\delta$ = the probable error of the index of variability.

$$E_c = \pm .6745 \frac{C}{\sqrt{2n}} \left(1 + 2 \left[\frac{C}{100}\right]^2\right)^{1/2}$$

where E_c = the probable error of the coefficient of variety.

CONSTANTS FOR BLACK LOAM, FIRST CROP

n = 85	Total number of specimens
A = 71.1764	Mean average
δ = 21.7296	Index of variability
C = 30.52 per cent	Coefficient of variability
E_a = 1.5897	Probable error of mean
E = 1.1241	Probable error of index
E_c = 2.6018	Probable error of coefficient

CONSTANTS FOR BLACK LOAM, SECOND CROP

n = 133	E_a = 1.7343
A = 98.1127	$E\delta$ = 1.2263
δ = 29.6532	E_c = 2.179
C = 30.22 per cent	

CONSTANTS FOR BLACK LOAM UNDERLAIN WITH GRAVEL

n = 394	E_a = 98.57
A = 101.038	$E\delta$ = 0.6969
δ = 29.0086	E_c = 1.205
C = 28.71	

CONSTANTS FOR ALLUVIAL SOIL, THIRD CROP

n = 110	E_a = 1.0075
A = 68.7363	$E\delta$ = 0.7125
δ = 15.6697	E_c = 1.908
C = 22.70 per cent	

CONCLUSIONS

From the foregoing it may be seen that the second crop clover as more flowers in the head than the first crop clover, and that lack loam underlain with gravel is the best soil for the production f red clover.

An additional study was made* in the fall of 1910; the flowers f 98 heads were counted. The material was taken from various oils and localities in the neighborhood of Jefferson, Iowa, during period extending from June to September.

According to the results of this study, variation of clover heads etween fifty-three and sixty-eight flowers each is quite irregular, ut from sixty-eight to eighty-three it is very smooth; in fact this vith small breaks at eighty-three and again at eighty-eight reached o the central mode at ninety-eight. The drop, on the other hand, s much more irregular.

The range extended from fifty-three to one hundred forty-two lowers. The mean, as derived from the frequencies shown, is 90.44 lowers.

For the curve the magnitudes were grouped in eighteen classes, ach class being a group of 5 of the magnitudes. The mode is ound to lie at class 9 (the magnitude group 39 to 97 flowers).

CONSTANTS

$n = 983$	Number of heads
$A = 90.44$	Average
$\delta = 15.72$	Index of variability
$C = 17.38$	Coefficient of variability
$E_a = 0.502$	Probable error of mean
$E\delta = 0.354$	Probable error of index
$E_c = 0.0275196$	Probable error of coefficient

A STUDY OF THE VARIATION IN LENGTH OF FLOWERS (STAMEN TUBES) OF THE RED CLOVER†

A large collection of clover heads was gathered from the college campus; and from these 493 flowers were selected for the measurement.

CONSTANTS

$n = 493$	Number of flowers
$A = .8918$	Mean length
$\delta = .1494$	Index of variability
$C = .16751$	Coefficient of variability
$E_a = 0.0045306$	Probable error of mean
$E\delta = 2.9524$	Probable mean of index
$E_c = 0.041707$	Probable error of coefficient

* By Miss Wennholz and Miss Mills.

† From a study by Miss Mildred Walls.

SIZE OF POLLEN GRAINS OF RED CLOVER

A study of pollen grains was made from red clover blossoms gathered miscellaneously at Ames in October, 1910, to determine variations in width and length of grains. Four to six counts were made from each head. Measurements of 1,024 pollen grains were made with the micrometer scale, and curves were constructed using units of this scale; each unit represented 4 mu.

CONSTANTS FOR MEASUREMENTS OF WIDTH OF POLLEN GRAIN

$n = 1024$	$E_a = 0.27052$
$A = 56.1328$	$E\delta = 9.1731$
$\delta = 11.6156$	$E_c = 0.6119$
$C = 36.634$ per cent	

CONSTANTS FOR MEASUREMENTS OF LENGTH OF POLLEN GRAIN

$n = 1024$	$E_a = 0.27052$
$A = 56.1328$	$E\delta = 0.198$
$\delta = 13.32$	$E_c = 0.3727$
$C = 23.729$	

The average size was found to be 31.7 mu by 56.29 mu.

Both curves exhibit the more abrupt side in the direction of greater dimensions; the tendency therefore, so far as indicated by this study, is toward greater width and length of pollen grains.

A STUDY OF THE POLLEN AND PISTILS OF APPLES IN RELATION TO THE GERMINATION OF THE POLLEN

J. N. MARTIN AND L. E. YOCUM

The failure of a fruit tree to develop a normal amount of fruit may be due to a number of causes as stated by Kraus in volume VI of the Journal of Heredity. However, unless a plant develops fruit parthenocarpically, the development of fruit depends primarily upon how the pollen and pistil function relative to each other. As Kraus points out, fertilization by no means insures the development of fruit, for very commonly the fruit does not develop despite the fact that normal fertilization occurred; but, on the other hand, in the absence of fertilization, fruit seldom develops among apples.

It was thought that such investigations, i.e. content and behavior of pollen and stigma, might give some information concerning: (1) the effect of rainy weather during the blooming period on the setting of fruit; (2) the conditions of the stigma at the time horticulturists regard it as receptive; (3) the time at which artificial pollination can be done most successfully; and (4) whether or not the bagging of flowers practiced by horticulturists in experiments involving artificial pollination has any effect upon the results of pollination due to increasing the moisture content of the air about the flowers.

The apples included in the investigation were Ben Davis, Gano, Wealthy, Duchess, and Jonathan. The investigations extended over three consecutive seasons which differed considerably in the character of the weather as to rainfall and temperature during the blooming period.

Size and Shape of Pollen.—Excepting the slight bulging of the germ pores, apple pollen in the varieties studied is nearly globular when turgid. . . . Pollen shrinks so rapidly that under ordinary pollinating conditions, it is shrunken when it reaches the stigma. Examinations of pollinated stigmas showed them to be covered with pollen in the shrunken condition.

Content of the Pollen.—In the young bud, three or more days before the flowers opened, the pollen grains contained much starch.

The remaining tests were made on pollen from open flowers, and at this time there was no trace of starch, except in a very few apparently undeveloped grains.

From the tests it appears that the stored food of the pollen is present in the form of starch in the young bud but consists of proteins or amino acids, some pectic substances, and occasionally slight traces of sugar at the time of pollination. The constituents of the wall are cellulose and pectic substances.

Germination of the Pollen.—In germinating the pollen in solutions, chiefly cane sugar solutions were used, although other sugars were tried and found to be good.

About one-half c. c. of the various concentrations were spread over the bottoms of watch glasses and after the pollen, usually ranging from 50 to 200 grains in amount, was introduced, the watch glasses were sealed to prevent as far as possible changes in concentration resulting from evaporation.

The membranes used were pieces of beef's bladder and were about 1 cm. square. After being soaked 15 or 20 minutes in distilled water and then dried between two blotters, the membranes were put in watch glasses, pollen was spread on their surfaces and the watch glasses were sealed.

In a mass of pollen from the same flower as well as from different flowers there was such a wide variation in the requirements for germination, that no conclusions could be drawn except from the averages of a large number of tests.

A temperature of 22° to 25° C. was found most favorable for germination. The pollen of the five varieties was quite uniform in requirements, and average results obtained in the germination tests of any one variety are representative of those obtained for other varieties.

The average percentage of germination was highest in the 2½ per cent cane sugar solution. As the concentration increased up to 65 per cent, the per cent of germination decreased.

The fact that the pollen germinated to a considerable extent in distilled water suggested that the sugar solutions functioned in the germination of the pollen only in controlling the water supply.

The longest tubes obtained in any of the sugar solutions and on the membranes were about 2 millimeters. This limit in growth was attributed to the exhaustion of stored food in the pollen grain, and since no more growth was made in the sugar solution than on the membrane, it was again evident that the pollen tubes did not use the sugar as food. Even when grown on membranes soaked in sugar solutions, thus eliminating the feature of poor aeration, the tubes were no longer than on membranes soaked in distilled water. It is evident from the behavior of the pollen in water, in the sugar solutions, and on the moist membranes that germination depends only upon a water supply. . . .

In determining the most favorable solution for germination, it is obvious that it is essential to consider the time element.

Uniformity of Germination in the Five Varieties.—All of the five varieties, except Duchess, have been reported either partly or entirely self-sterile in the work of Lewis and Vincent. Self-sterility in some cases is known to be local, and these varieties may not be sterile in the orchard at Iowa State College. Nevertheless, it was thought worth while to investigate the uniformity of the water requirements of the five varieties by using membranes which had given a more even and a higher per cent of germination than the solutions. This was done by sowing the pollen of five varieties on a piece of membrane about 2 inches long and 1 inch wide, the pollen of each variety occupying a line running the full length of the membrane. The table below gives the results obtained:

Percentages of germination and growth of tubes of the pollen of the five varieties under similar conditions

Variety	Percentage of germ. at the end of 3 hrs.	Length of tubes
Duchess	90	½–1 mm.
Jonathan	92	½–1 mm.
Wealthy	85	½–1 mm.
Gano	90	½–1 mm.
Ben Davis	80	½–1 mm.

So little variation was shown that all five can be considered uniform in the water requirement for the germination of their pollen. It is, therefore, obvious that self-sterility, self-fertility and inter-fertility among these five varieties do not depend for the germination of their pollen upon a difference in the water requirement. Some pollinating experiments were carried on in the orchard to test out this assumption. For example Jonathan, reported as entirely self-sterile by the Oregon Agricultural Experiment Station, was self-pollinated and stigmas examined after 48 hours. On 20 stigmas examined 118 pollen grains were counted and 24 of the number had germinated, the number of germinations on a stigma ranging from 2 to 6. The results show that the pollen of the Jonathan can germinate on its own stigma and if this variety is self-sterile in the orchard of the Iowa State College the cause cannot be attributed to the inability of the pollen to germinate on the stigmas of the Jonathan.

The Effect of Age and Drying on the Germination of the Pollen. —In determining the effect of age and drying, pollen was taken from buds about two days previous to opening, from flowers in which the anthers were dehiscing, and from flowers which had been stored in paper bags in the laboratory. The averages of a number of germination tests of pollen from buds and open flowers were 75 and 87 per cent. The results show that pollen taken from flowers just previous to their opening or about the time the flowers are emasculated in pollinating experiments is about as good as pollen from anthers which are dehiscing. The pollen stored in the paper bags all died within 18 days and very little was found viable after 12 days' storage. It was also found that exposure to sugar solutions in which the pollen remained plasmolyzed soon resulted in death. More than 90 per cent were killed when exposed to a 70 per cent cane sugar solution for 72 hours.

IMPORTANCE OF HONEY BEES TO FRUIT PRODUCTION

L. H. PAMMEL AND C. M. KING

Most persons look at the honey bee largely from the standpoint of honey production. Valuable as this is, the greatest economic importance of bees and of many other insects is their value in carrying the pollen from one plant to another, thus securing cross-fertilization. While many plants are self-pollinated and self-fertilized, as in wheat, the majority are cross-pollinated and cross-fertilized, as in apple and clover.

S. A. Jones[1] says, "The fact that the most important work of the honey bee is not the production of honey, but the carrying of pollen from flower to flower, thus assisting in the fertilization of plants and assuring their fruitfulness, is not always appreciated. Growers of early cucumbers under glass find it necessary to install hives of bees in their hothouses to insure their crop. A rainy, cold spell during fruit bloom, keeping bees from flying, results in little fruit that season. Many people are not aware that they are thus dependent largely upon these busy and sometimes intrusive insects for the fruitfulness of their orchards and gardens. The work of the bees is important not only to the production of tree fruits, but to full seed or fruit production of a number of forages and grains, berries, and vining plants such as the squash and its relatives, not to mention many ornamental plants and trees. Many other varieties of bees than the honey-producing kind and a multitude of other insects assist in the work of transferring pollen from plant to plant, but the honey-bee is probably the most important single agent, certainly so in the case of fruit trees."

H. O. Hootman and G. H. Cale in an article "Busy Bees Bring Bending Branches" state: "It is impossible for the fruit-grower to over-estimate the importance of a knowledge of the pollination of fruit bloom. Without this knowledge, the selection of varieties for planting and their arrangement in the orchard cannot be intelligently practiced. The cultivation of self-sterile varieties must constantly be attended by disappointment and loss unless provision is made for cross-pollination to take place.

"In Virginia, Fletcher of the Agricultural Experiment Station reports that Bartlett or Kieffer pears in large blocks do not give satisfactory results. Out of 32 varieties of plums, Henderson in California found 25 to be self-sterile, 6 self-fertile and 1 doubtful."

It will be necessary first of all to have a clear understanding of fertilization in plants. Two kinds of organs are produced in flower-

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[1] U. S. Dept. of Agr. Bull., 685:1-61.

ing plants, stamens and pistils. Stamens are the male organs, which bear anthers in which pollen grains are produced; the pistil, which is the female organ, consists of the ovary containing ovules, the stigma receiving the pollen, and a slender connecting portion called the style.

The pollen grain falls upon the stigma and germinates, producing a pollen tube in which the male generative cells occur. This pollen tube passes down the style until it reaches the embryo sac of the ovule. The male generative cell fuses with the egg cell of the embryo sac and seed develops. In those plants habitually cross-fertilized the male generative cell has no influence on the egg cell of the same plant. In self-fertilized plants like wheat a cell in the pollen grain will fuse with the egg cell of the same plant.

Extended experiments were carried on by Charles Darwin[2] with many plants. He finds that in many plants, as in the morning-glory, cross-fertilization is decidedly advantageous. In his experiment he attributed 'the greater height, weight and fertility of the crossed plants' to their possessing 'greater innate constitutional vigor'.

The term self-fertile is applied to such as are close fertilized, and self-sterile to those in which pollen comes from some other plant. Some varieties of fruit will not fertilize other varieties of the same fruit; these are cross-sterile. Sometimes neither of the two varieties will fertilize the other; these are known as inter-sterile.

Some plants are always cross-fertilized, as in the willow, because the plants are dioecious, one plant being male and the other female. In monoecious plants like corn, there may be self-fertilization so far as the individual is concerned although the pollen comes from a different flower. In the corn plant the pollen generally comes from a different individual.

In this chapter we shall discuss briefly some of the different economic plants with reference to self- and cross-fertilization.

THE PEAR

M. B. Waite in an interesting series of experiments made some years ago indicated clearly the sterility of some varieties of the pear. Professor Waite[3] began his experiments on the pollination of pear flowers in 1890 and continued them until 1893.

He gives a description of the flower and then discusses in detail the methods

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2 The Effects of Cross- and Self-fertilization in the Vegetable Kingdom, 53.

3 Yearbook, U. S. Dep't. Agr., 1898, pp. 167-168.

giniana, at Cedar Keys. There were about as many as upon our spring flowers in Iowa.

Quercus alba L. White Oak

Large trees, some 100 feet in height, trunk three to four feet in diameter. Winter buds ovate, reddish brown. Bark light gray in color in the young trees, on older trees light gray with thin, depressed grayish scales. Leaves obovate to obovate-oblong, 7-lobed, bright red when unfolding, covered with soft pubescence. Staminate flowers in pendent catkins; pistillate, sessile. Fruit sessile or nearly so; acorn long; cup shallow.

Widely distributed, especially in eastern Iowa from New Albin to Keokuk and westward to the Des Moines river basin. Most com-

FIG. 54.—White oak (*Quercus alba*). *Photo by Ada Hayden.*

of securing cross-pollination and preventing insects from gaining entrance into the flower. He describes also the emasculation to secure cross-pollination. This was done by removing the stamens of all of the flowers. The pollinating was done by picking out freshly opened anthers from the flowers with a pair of small forceps and rubbing the pollen masses upon the stigmas. After the fruits were set they were counted.[4]

"The kinds classed as self-sterile, like Anjou and Bartlett, yielded a small percentage of fruit in favorable seasons with self-pollination where the trees were in good soil and were well pruned and well cultivated, while the sorts classed as self-fertile, like Angouleme, Seckel, and Kieffer, were almost self-sterile in unfavorable seasons. The question therefore arises as to whether pears which grow to such perfection in California, as Bartlett, Clapp's Favorite, and Clairgeau, do not find the climate of that state so favorable as to be self-fertile."

"Bad weather during flowering time has a decidedly injurious influence on fruitage by keeping away insect visitors and affecting the fecundation of the flowers, and, conversely, fine weather favors cross-pollination and the setting of the fruit."[5]

From an extended series of experiments at the Washington Experiment Station an article "Pollination of Deciduous Fruits" by W. A. Luce and O. M. Morris[6] was written.

Apparently in the state of Washington in 1928 orchards were largely planted with few varieties. This tendency in planting brings about a problem in pollination in "that it must be considered if serious trouble is to be avoided." In orchards where many varieties were planted there is abundant opportunity for cross-fertilization. Many self-pollination tests were made by these authors on apples, pears, sweet cherries, peaches and plums.

John H. Lovell[7] in an article "The Pollination of the Pear" discusses the importance of bees in carrying the pollen from one variety of pear to another and cites the investigation of M. B. Waite with the Bartlett pear in which the pollen came from another variety of the pear. Fruit set abundantly but where the pollen came from the Bartlett, very little fruit was set, showing the self-sterility of this variety. He also cites the case of an orchard of 22,000 pear trees of the Old Dominion Fruit company near Scotland, Virginia, on James river, where only a small yield was obtained. In one case where a few of Copp's Favorite were intermixed with the Bartlett the latter variety fruited abundantly.

Then he cites an experiment of S. W. Fletcher who made 8,275 pollinations of the Kieffer and 9,967 of the Bartlett. When the Bartlett was crossed with its own pollen one flower in 513 set fruit. When crossed with Kieffer one flower in 10 fruited. The same was true of the Lawrence and Duchess. The experiments with the Kieffer also showed that it was largely self-sterile. Then he quotes from the Michigan and West Virginia experiments. There was also a great difference in the size of the crossed and self-pollinated Kieffer pears.

4 Ibid., p. 173.
5 Ibid., p. 175.
6 Wash. Agr. Exp. Sta., Bull. 223, 1928.
7 American Fruit Growers Magazine, March, 1925, p. 10.

W. P. Tufts[8] in 1918 published the results of California experiments with the Bartlett pear which show that in most years the fruit crop is small when not cross-fertilized. A number of other varieties are known to be self-sterile, like the B. S. Fox and Comet; the Flemish Beauty and Howell are self-fertile. In the foothills of the Sierra mountains the Bosc and Anjou are good pollinators for the Bartlett.

Since the experiments of M. B. Waite many other experiments have been made. Hootman and Cale, in referring to light yields of pears in Michigan near Ann Arbor, state that the Huron Farms Corporation had a light yield of pears for several years. The following varieties provided ample cross-pollination; Bartletts, Kieffers, Sheldons, Lawrences and Flemish Beauties. At the beginning of blossoming, a yard of bees was placed near the orchard. At harvest time the yield of pears was nearly a thousand bushels while the largest crop in previous years had been 18 bushels.

Roy E. Marshall, Stanley Johnston, H. D. Hootman and H. M. Wells[9] experimented with pears and they conclude:

"Of all the varieties of pears tested, all but Flemish Beauty and Conference must be regarded as commercially self-sterile.

"Bartlett and Seckel are inter-sterile and should never be planted without the addition of a third pollinizing variety.

"Effective pollinizers among varieties of pears commonly grown in Michigan are Howell, Bosc, Conference and Flemish Beauty.

"The blooming seasons of varieties of pears overlap sufficiently in Michigan to provide adequate cross-pollination."

The following conclusions concerning pollination of pears were made by W. A. Luce and O. M. Morris.[10]

"Bartlett, Bosc, Anjou and Winter Nelis seem to be partially or entirely self-sterile in the Wenatchee District.

"The Flemish Beauty pear seems to be self-fertile.

"Anjou, Bosc, Flemish Beauty and Winter Nelis seem to be good pollinizers for Bartlett.

"The Anjou shows a strong tendency towards self-sterility. Bartlett, Bosc, Flemish Beauty and Winter Nelis are recommended as cross-pollinizers for it.

"The Bosc seems to be partially self-sterile, but is satisfactorily pollinized by Bartlett, Anjou, Flemish Beauty and Winter Nelis."

C. I. Lewis in "Orchard Management"[11] has this to say with regard to pollination of pears:

"While many of our varieties of pears are self-sterile, in Oregon, nevertheless, practically all are improved by crossing, and such varieties as Comice, which are absolutely sterile, must be crossed with other pears if good crops are to be realized. The Bartlett and d'Anjou intercrop very nicely, also Winter Nelis and Comice. Howell and Winter Nelis seem to go well with any varieties that bloom at the same time. We would not recommend the inter-

8 California Agrl. Exp. Sta., Bull. 307.

9 Mich. State College, Agr. Exp. Sta., Special Bulletin 188; 37.

10 Wash. Agr. Exp. Sta., Bull. 223; 5.

11 Oregon Agr. College, Exp. Sta. Bull. No. 111, pp. 81-82; 1911.

planting of the Bartlett and Bosc, as the crossing of the Bartlett by the Bosc has given us unsatisfactory results."

THE APPLE

Numerous experiments have been made with the apple. In his classic experiment Professor Waugh[12] found that large blocks of a single variety of fruit, no matter what variety, would not produce fruit. He found that of these varieties only three apples had set out of the 2,586 blossoms that he had covered: of these varieties the Baldwin, Esopus and Famuse set some fruit.

The senior author covered a large number of blossoms of Winesap apple to permit self-fertilization and even though the anthers in some cases were rubbed on the stigmas fruit did not set.

The inclement weather, rainy, cloudy and cold, in 1930, has interfered with the production of fruit of the apples and in most cases only one or two fruits have set.

A very important contribution is the paper "Pollination of Orchard Fruits in Michigan" by Roy E. Marshall, Stanley Johnston, H. D. Hootman, and H. M. Wells.[13]

After a series of experiments with the apple they arrived at the following conclusions:

"The standard varieties of apples for Michigan must be regarded as commercially self-sterile.

No cases of intersterility were found among the standard varieties of apples tested, although Baldwin and Rhode Island Greening proved to be unsatisfactory pollinizers for all varieties tested.

Effective pollinizers among the standard varieties of Michigan are Delicious, Steele, Red, Jonathan, Wealthy, Duchess, McIntosh, Grimes, and Northern Spy. The first two named are exceptionally good pollinizers.

The blooming seasons of any of the standard commercial varieties of apples overlap sufficiently in the average year to permit ample pollen transfer, though in some years an early blooming variety, like Duchess, does not overlap a late blooming one, like Northern Spy, sufficiently to provide adequate cross-pollination.

There should be not less than three varieties planted in an orchard if either Rhode Island Greening or Baldwin is to be included."

The most extensive early experiments were made by M. B. Waite[14], who writes in *"Pollination of Pomaceous Fruits"* as follows:

"Some of the flowers were emasculated with the scalpel and hand-pollinated by applying the open anthers to the pistils, while others were simply covered with bags made of paper, cheese cloth, or mosquito-net, from forty to sixty of the three kinds of bags being used on each tree. In a general way the re-

12 Rep. Vt. Agr. Experiment Sta. 13:362.

13 Agr. Exp. Sta. Mich. St. College, Special Bull. No. 188, p. 37.

14 Yearbook, U. S. Dep't. of Agr. 1898; p. 176, 177.

sults were similar to those obtained in the experiments with pears. The division of the varieties into self-fertile and self-sterile sorts was not nearly so well-marked.''

Professor Waite concluded: ''Crossing gave decidedly better results in all cases than self-pollination. The Baldwin, which was experimented upon freely, may be cited as a variety that comes as near being self-fertile as any, and yet even this is far from being entirely so, for in the best trees the percentage of fruit resulting from self-pollination was not more than one-fourth of that which resulted from crossing. Some of the Baldwin trees in fact seemed to be self-sterile, and trees of all the varieties occasionally set self-pollinated fruit.

''The practical conclusions drawn from the experiments with apples are the same as those from the work on pears. There are so many varieties of apples, and the conditions in different sections vary so much that different sets of varieties are planted in different regions. All the work here described was done at Rochester, Brockport, and Geneva, N. Y., and as the natural conditions in that region are very favorable to the apple, any tendency to self-fertility was probably pretty well brought out.''

W. A. Luce and O. M. Morris[15] reached the following conclusions from their experiments with apples:

''Most of the commercial varieties of apples commonly grown in Washington are partially or entirely self-sterile.

''The Winesap, Delicious, Stayman, and Arkansas Black are apparently self-sterile as grown in the Wenatchee district.

''The Delicious and Richared (Delicious) proved to be excellent pollinizers for the Winesap.

''The Winesap does not produce enough pollen to be valuable pollinizer for the Delicious or other varieties.

''Rome Beauty, Jonathan, and Winter Banana seem to be satisfactory pollinizers for both Winesap and Delicious.''

C. I. Lewis in ''Orchard Management''[16] has a few general remarks on the subject of pollination. Quoting him on the importance of cross-fertilization in different varieties of apples:

''Many of our commercial varieties of apples are evidently sterile, and we find that even some fertile varieties like the Yellow Newtown seem to be improved by crossing. Where two or three varieties are being grown we would recommend that such varieties be planted in oblong blocks, containing from two to six rows each. Where one wishes to plant a single variety that is to be pollinized every fifth tree in every third row would be ample. Where varieties bloom at the same time, fair results can generally be obtained by planting them together.''

Freeman S. Howlett[17] of the Ohio Agricultural Experiment Station, in a paper on ''Apple Varieties and Fruit Setting Factors'' states that studies made at the Ohio Agricultural Experiment Station prove that certain varieties of apple like the Baldwin, Delicious, Golden, Jonathan, Grimes, Nero, Northern Spy, Rome Beauty, Rhode Island Greening, Wealthy and others are not suffi-

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15 Wash. Agr. Exp. Sta., Bull. No. 223; 5, 1928.

16 Oregon Agr. Coll. Exp. Station, Bull. No. 111, pp. 81, 82; 1911.

17 American Fruit Growers' Magazine, March, 1927, p. 7.

ciently fruitful when self-pollinated. Some varieties like the Baldwin, Nero, Rhode Island Greening are of little value as pollinators for other varieties. Such varieties as Rome Beauty, Grimes Golden and Wealthy are effective pollinating varieties. The author calls attention to the position of the flower in the cluster as an important factor in pollination. The central flowers uniformly set more fruit than the lateral in such varieties as Stayman and Winesap and Arkansas Black. Other factors also must be considered in connection with fruit setting.

Mr. Ray Hutson,[18] in a paper on the honey bees as an agent in the pollination of pears, apples and cranberries, says that in the case of the Wealthy apple, out of 3,675 blossoms, 4.07 per cent set fruit, and without bees only 0.1 per cent. Out of 8,751 blossoms of the pear, 4.08 per cent set fruit; without bees 0.8 per cent. In the cranberry out of 2,385 blossoms 56 per cent; without bees 8.4 per cent. The other insect carriers also bear some relation to the percentage of fruit set.

H. D. Hootman and G. H. Cale[19] in an interesting article on "Busy Bees Bring Bending Branches" publish an item about a Northern Spy orchard as follows:

"Observations in several Michigan orchards indicated that lack of bees at blossom time have been partially responsible for the light crops produced. Honey bees played an important part in many orchards in 1928. Where bees were used for the first time, the fruit grower invariably underestimated the size of his crop.

"In the spring of 1927, there came to the senior author's attention a Northern Spy orchard, owned by O. W. Braman, located near Belding, Michigan, in which the yields from eleven acres had never been more than a thousand or fifteen hundred bushels in eight years. Practically all apples had been harvested near an old orchard of mixed varieties.

"In 1925, a yard of forty colonies of bees was put in the orchard, but this did not increase yields much. In 1927, "bouquets" of Ben Davis, Roxbury Russets and Tolman Sweet blossoms were put in tubs of water in the bee yard. About forty more half-barrel tubs were filled with bouquets and scattered through the south side of the orchard and buckets of bouquets were hung in the trees. Bouquets were placed about ten feet in front of the bees. What were the results? Bouquets plus bees did the trick. A 5,200 bushel crop was harvested.

"In another Northern Spy orchard near Portland, Michigan, only the trees on the outside row around the orchard and for several rows on the north where Jonathans and Baldwins joined were bearing satisfactorily. It was apparently a pollination problem, for the whole orchard had bloomed well. Arrangements were made with a beekeeper to distribute a truckload of bees in the orchard. Tubs of water were placed in front of the colonies and filled with bouquets of apple varieties known effectively to pollinate Northern Spies. The crop was 7000 bushels, the largest in 15 years.

"In the W. R. Roach Orchards, north of Hart, a twenty-acre block of Mc-

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18 Journ. Economic Entomology, 18:387; 1925.

19 A Practical Consideration of Fruit Pollination. American Bee Journal Publication.

Intosh had been producing light crops for a 22 year-old orchard. In 1927, the crop was 700 bushels and in other years it had been as high as 1600 bushels.

"Arrangements were made with C. J. Freeman, a beekeeper eighty miles away, to furnish 200 colonies of bees for the orchard in the blooming period. On May 18th, four truckloads of bees were distributed in a hundred and fifty acres of apples and cherries. Colonies were left there eleven days during which time the bees gathered three tons of honey.

"When blossoming time was over it appeared that the attempt to set a crop in the McIntosh orchard had been a failure as it was impossible to get enough bouquet material to keep the buckets in front of the colonies supplied with fresh branches. Further the bees had shown a preference for the cherry blossoms and worked them instead of the apples.

As the season advanced, however, red apples seemed to appear well distributed where they had not been seen earlier. As a result, some trees picked over twenty bushels and a total of 4,000 bushels was harvested."

Frank E. Pellett,[20] recognizing the importance of bees to secure cross-pollination, gives an account of the bee requirements in a large orchard of apples operated by Stark Brothers. Mr. Pellett says: "No longer do well informed fruit men plant orchards in solid blocks of one variety. Instead rows of other kinds are alternated at frequent intervals to secure cross-pollination. The Stark orchards are still young. The first trees planted were only nine years set.

"We found it hard to estimate the number of bees in single trees, as they moved about in such a way that one might count the same bee several times while missing others altogether. As nearly as we could tell, there were about a dozen bees working in each apple tree. This number should insure good cross-pollination, with a few hours of favoring weather. Mr. Lewis watched a single bee for a period of twenty minutes and found that it visited seventy-five flowers in trees of two different varieties. This is exactly what the arrangement of the orchard was designed to accomplish, for unless the bees pass from one variety to another, cross-pollination fails."

R. H. Kelty[21] has also under the title "Renting Bees for Use in Orchards" discussed this important subject.

The Community Fruit Tree Variety Trial Station at Rockwell City, Iowa, was established in April, 1916, by Robert E. Flickinger and George L. Brower.

In this trial planting, pollinators for the leading varieties of apples and pears were determined as follows:

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20 How the World's Best Known Fruit Growers Use Bees for Pollination. American Bee Journal Publication, November, 1929.

21 Bull. Mich. Agrl. Exp. Sta. 135.

APPLE VARIETIES

Varieties pollinated	*Best pollinators*
Baldwin	Northern Spy, Jonathan, Delicious
Delicious	Grimes, Jonathan, McIntosh
Duchess	Open, Grimes, McIntosh, Wealthy
Grimes	Jonathan, Delicious, Steele Red
Hyslop	Open, Duchess, Grimes
Jonathan	Open, Steele Red, Delicious
McIntosh	Delicious, Wealthy, Jonathan
Northern Spy	Wealthy, Duchess, McIntosh
R. I. Greening	McIntosh, Open, Grimes
Wealthy	Northern Spy, Open, McIntosh, Duchess
Steele Red	Delicious, Northern Spy, Open

PEAR VARIETIES

Anjou (Duchess) needs Conference or Seckel.
Bartlett needs Bosc, Conference, Flemish or Howell.
Bosc needs Howell, Bartlett or Flemish Beauty.
Clapp Favorite needs Howell.
Conference needs Bartlett, Bosc or Howell.
Flemish Beauty needs Bartlett or Seckel.
Howell needs Bartlett or Seckel.
Kieffer needs Bartlett (Lincoln), Howell or Garber.
Seckel needs Bosc, Flemish Beauty or Howell.

THE SOUR AND SWEET CHERRIES

Some work was also done by Marshall, Johnston, Hootman, and Wells[22] on the sour and sweet cherries.

"Varieties of sour cherries are generally regarded as self-fertile.

"All of the commercial varieties of sweet cherries are self-sterile.

"Bing, Lambert, and Napoleon are inter-sterile. The varieties commonly grown in Michigan, Windsor, Schmidt and Bing, are apparently interfertile.

"Varieties of sour cherries cannot be regarded as efficient pollinizers for varieties of sweet cherries."

The conclusions of W. A. Luce and O. M. Morris[23] concerning the pollination of cherries are as follows:

"The Bing, Napoleon (Royal Anne) and Lambert cherries are self-sterile and inter-sterile. Centennial, Black Tartarian and Black Republican are usually found to be satisfactory pollinizers for these three varieties.

"The Black Republican sometimes fails as a pollinizer for other varieties of sweet cherries. Only trees of known value for this purpose should be planted for pollinizers in new plantings.

"The sour cherries are commonly self-fertile."

Hootman and Cale[24] state in regard to cherries; "All sweet cherries are self-sterile. They bloom very early, often when insect flight is limited to short

22 Mich. State College, Agr. Exp. Sta., Special Bull. 188, p. 37.
23 Wash. Agr. Exp. Sta., Bull. No. 223, p. 5, 1928.
24 Busy Bees Bring Bending Branches, 16.

distances. Like pears they should not be planted over three or four rows of varieties together. The Schmidt Biggareau, Bing and Windsor are three good black sweets that will effectively pollinate each other. The Black Tartarian might be added. It is soft in flesh and ripens earlier than the Schmidt Bigarreau. Napoleon, Bing and Lambert are inter-sterile.''

THE PLUM

Marshall, Johnston, Hootman and Wells,[25] did some work on the plum and they conclude as follows:

''Some varieties of European plums produce fair to good crops when planted alone, but most of the varieties produce better crops when provision is made for cross-pollination. A few varieties are at least commercially self-sterile. There is no evidence of intersterility among the varieties of European plums tested.

''Burbank and Abundance (Japanese Plums) are self-sterile but the two varieties are dependable pollinizing varieties for each other. Burbank should always be interplanted with Abundance.

''The Blue Damson is self-fertile and produces satisfactory crops without cross-pollination.

''The varieties of European and Japanese plums are practically worthless as pollinizers for each other. There should be at least two varieties of the same species in a plum planting.

''The commercial fruit grower is almost entirely dependent on the common honey bee for the transfer of pollen from one variety to another.

''There are not enough bees in many orchards to insure the setting of a full crop of fruit in years when weather conditions are not favorable for maximum insect activity at blooming time.''

Luce and Morris[26] in speaking of the prunes and plums state:

''The Italian, French, and Sugar prunes are self-fertile. The Tragedy prune is self-sterile.

''The European plums and prunes that blossom at the same time are generally found to be inter-fertile.

''Self-sterility in Japanese plums is common. Beauty, Burbank, and Wickson are the most common effective pollinizers for Japanese varieties.

''Apricots are generally self-fertile.''

The bee is a most important agent in securing cross pollination in the plum.

The senior author made some experiments with several varieties of the American plum (*Prunus americana*) in 1929. A large number of plum flowers were covered with cheese cloth before they were open. In some cases the anthers were placed on the stigmas of the same flower with the result that no fruit set. In other words

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25 Mich. St. College, Agr. Exp. Sta., Special Bull. 188, pp. 37, 38.

26 Wash. Agr. Exp. Sta., Bull. 223, pp. 5-6, 1928.

he pollen must come from another plant. This pollen is largely arried by the honey bees.

Many experiments have been made recently. Professor Goff[27] vas the first botanist to point out that some flowers are imperfect. n the DeSoto plum he found that 107 out of 116 flowers had per-'ect pistils. In the wild gooseberry, 76 out of 123. Thirty-five lowers of the latter were without pistils.

Professor Waugh also did some work on the plum in Vermont.[28]

Professor U. P. Hedrick in "Plums of New York" makes this general comment on the fertility of plums:

"One of the discouragements in plum-growing is the uncertainty which attends the setting of the fruit in some varieties even though the trees bear an abundance of blossoms. Blooming, the prelude of fruiting, had little significance to the fruit-grower until the discovery was made that many varieties of several fruits were unable to fertilize themselves and that failures of fruit crops were often due to the planting of infertile varieties. Investigations as to the self-sterility of pears, plums and grapes have shown blossoming-time to be one of the most important life periods of these fruits. The knowledge obtained by workers in this field has to some degree modified the planting of all orchard-fruits and of none more than of the plums. Indeed, it is held by many that it is hardly safe to plant any excepting the Domestica and Insititia plums without provision for cross-pollination.

"A variety is in need of cross-pollination when the pollen from its own blossoms does not fecundate the ovules of the variety. There is a delicate and complicated procession during the process of fruit formation and the life of the fruit may be jeopardized by any one of a number of external or internal influences. These deleterious influences are most often unfavorable weather or defects in the reproductive organs of the plants themselves. Of the latter, in the plum there are several rather common ones which cause self-sterility, as impotency of pollen, insufficiency of pollen, defective pistils and difference in the time between the maturity of the pollen and the receptiveness of the stigmas.

"It is held that the main cause of the infertility in plums is impotency of pollen on the pistils of the same variety. The pollen may be produced in abundance, be perfect as regards appearance, and potent on the pistils of other varieties but wholly fail to fecundate the ovaries of the variety from which it came. The most marked examples of such impotency are to be found in the native plums, though the Triflora sorts are generally accredited with being largely self-sterile and the Domesticas somewhat so. The proof offered to show the impotency of plums is for the most part the records of fruit setting under covered blossoms. In this method of testing the impotency of pollen there are several sources of error and the figures given by experimenters

27 Wis. Agr. Exp. Sta. Rep. 1899:289, 1900:266. Garden and Forest 7:262. Wis. Agr. Exp. Sta. Rep. 1894:347, 1895:300. These data are brought together in L. H. Pammel's Ecology, 157.

28 Vt. Agr. Ex. Sta. Rep. 1897-1898:237. Vt. Agr. Exp. Sta. Rep. 13:359.

probably greatly exaggerate the infertility of plums, but since the experience of plum-growers generally affirms the results in some measure it is well to hold that the native plums at least should be so planted as to secure cross-pollination. It is doubtful if the Domestica and Triflora plums are self-sterile and yet the question is an open one as regards some varieties of these species.

"There is great difference in the quantity of pollen produced by the several groups of plums, but it is very doubtful if insufficiency of pollen is a factor of any considerable importance in the self-sterility of this fruit. Yet the matter is worth attention because of its bearing upon the selection of pollinizers. Of the several botanic groups, speaking somewhat generally, the Americanas and Nigras bear most pollen; the Munsoniana plums are abundant pollen bearers; the Trifloras seldom show a shortage but bear rather less than the others named; the Domesticas produce pollen abundantly; while the hybrid groups are the most capricious of all the plums in this respect, some varieties bearing much and others but little pollen. Probably the amount of pollen which the flowers of any tree produce is somewhat modified by the climate in which the tree is growing, by the weather and vigor of the tree.

"Waugh[29] and Goff[30] have shown that self-sterile plums often have abnormal pistils or pistils too weak for the development of fruits. Not infrequently flowers of the plum are without pistils, as occasionally, but less rarely, occurs with the stamens and petals. These abnormalities cannot be very general causes of self-sterility in plums, however, as varieties, or even trees, cannot often be found which are not fruitful if other varieties are growing near them. It is very doubtful if even so much as fifty per cent of abnormal flowers seriously jeopardize a plum crop as the trees bear, if they blossom at all, several times as many flowers as they can mature plums. But a high percentage of abnormal flowers nearly always indicates a general weakness in fruit-setting.

"Another cause often assigned for the failure of plums to set fruit is the difference in time of maturity of stamens and pistils. It is claimed that when these organs do not mature simultaneously the plums do not set unless pollen is supplied from some other source. The task of taking notes at blossoming time on more than three hundred varieties of plums on the grounds of this Station has given abundant opportunity to observe the comparative degrees of maturity of pistils and stamens in varieties of this fruit. In general the pistils mature first, often three or four days before the stamens. Rarely the pollen is disgorged before the stigmas are receptive. But stigmas remain receptive, weather conditions being favorable, for several days and the pollen from all anthers is not shed at once and is produced with such seeming prodigality as to almost insure the retaining of a sufficient amount to pollinate late-maturing stigmas. In view of these considerations, premature or retarded ripening of either pistils or stamens does not seem of great significance in the setting of the fruit.

"From the statements just made it may be seen that the main cause of the failures to set fruit when trees bloom freely must be ascribed to the failure

[29] Waugh, F. A., Vt. Agr. Exp. Sta. Bul., 53:51; 1896.

[30] Goff, E. S., Wis. Agr. Exp. Sta. Ann. Rpt., 18:302; 1901.

mon in eastern and northeastern Iowa. Prefers clay soil. Is frequently associated with the shag-bark hickory.

Date of bloom, Lansing, April 28, 1925; May 13, 1926.

Quercus stellata Wang. Post Oak

Tree in Iowa 30 to 40 feet high, trunk from 1 foot to 1½ feet in diameter. Winter buds ovate, obtuse, pubescent, light color. Bark whitish or tinged with brown; leaves oblong-obovate, 5- to 7-lobed, bright green and rough above, paler and pubescent beneath. Staminate flowers in pendent clusters, pistillate flowers with bright red stigmas. Fruit sessile or short stalked. Cup covers about one-third the length of the acorn. Scales of cup grayish and pubescent.

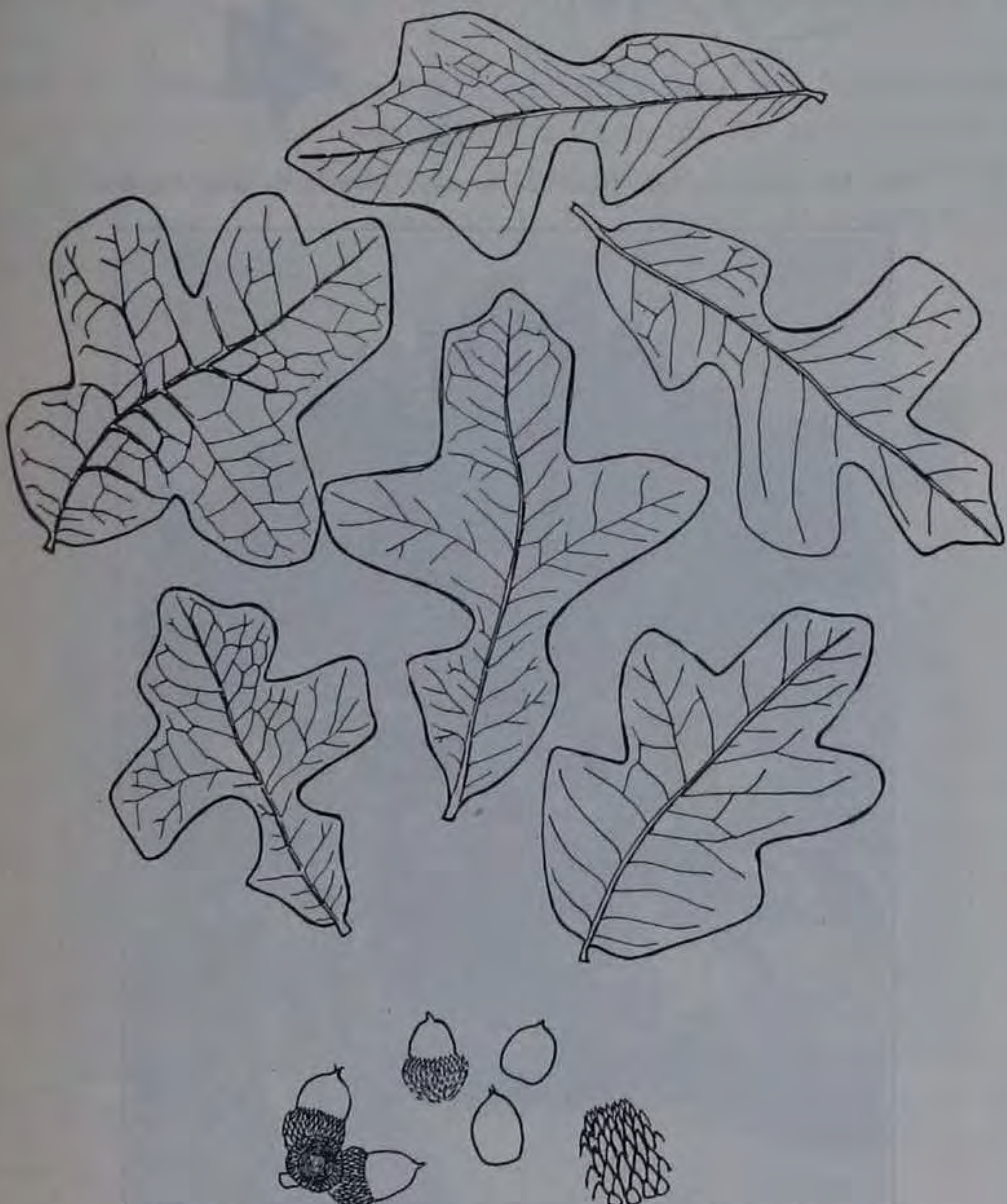

FIG. 55.—Post oak (*Quercus stellata*). *Drawn by Ada Hayden.*

of pollen to fertilize the pistils of the flowers of the same variety. The solution of the problem of self-sterility in the main, then, is to so plant that varieties will be mutually cross-fertilized. In the selection of varieties for such cross-pollination two factors must be considered, simultaneity of blossoming and sexual affinity.

"It is evident, if cross-fertilization is to play an important part in fruit-growing, in planting to secure it kinds must be chosen which come into blossom at the same time as those they are expected to fertilize. . . . .

"Varieties of plums seem to have sexual affinities. That is, some varieties will fertilize each other very well and some will not, even though they belong to the same species. There seems to be little definite knowledge as to the sexual affinities of plums and it is not, therefore, possible to lay down exact rules for the selection of pollinizers for individual varieties. In the current discussions of cross-pollination it is probable that the importance of "affinities" is overrated, and yet the subject is worthy of consideration. Waugh and Kerr have given this subject considerable attention for native and Japanese plums and have recommended a list of pollinizers for the several species.[31] The Domesticas and Insititias, the above writers hold, are best cross-pollinated by varieties from the same species if cross-pollination is essential.

"The subject cannot be closed without the expression of the opinion that the lack of cross-pollination as a cause of the uncertainties in the setting of fruit has been overestimated in the planting of plum orchards. This expression of doubt is made because there are serious disadvantages in the planting of mixed orchards of any fruit and the question as to whether these do not outweigh the advantages must ever be considered."

THE PEACH

The peach is generally recognized as self-fertile according to Marshall, Johnston, Hootman, and Wells.[32] Some varieties at least are self-sterile.

"The J. H. Hale peach is self-sterile and should never be planted in solid blocks. Other varieties of peaches that have produced unsatisfactory crops when self-pollinated are Late Crawford, Belle of Georgia, Greensboro, Red Bird Cling, Rochester, St. Johns, and Salway.

"South Haven is the most satisfactory of the four pollinizers tested for the J. H. Hale variety. Kalamazoo is also a satisfactory pollinating variety. Elberta and Banner are not entirely satisfactory."

The following conclusions concerning the pollination of peaches were made by Luce and Morris.[33]

"The varieties of peaches are generally self-fertile. The J. H. Hale is commonly self-sterile. This variety is inter-fertile with Elberta, Phillips, Cling and Slappy."

Hootman and Cale[34] state in regards to peaches:

"Most peach varieties are self-fertile. The J. H. Hale is self-sterile and should be inter-planted with other varieties. Elberta, South Haven, Kalamazoo

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31 Waugh, F. A., Plum Cult. 297-300. 1901.

32 Mich. Sta. College. Agr. Exp. Sta. Special Bull. 188, p. 37.

33 Wash. Agr. Exp. Sta., Bull. No. 223, p. 5, 1928.

34 Busy Bees Bring Bending Branches, p. 16.

and Banner will effectively pollinate the J. H. Hale, in well-mixed plantings with bees present.''

THE GRAPE

Bees and other insects are most important in connection with the pollination of the grape. The flowers are polygamo-dioecious, in which some plants have perfect flowers, others staminate with rudimentary ovary.

Professor Hedrick calling attention to the character of the flowers states:

''The most obvious characters which distinguish the grape vines of America from those of the old continent are: 1. The berries of all the American species and varieties that I have seen approach the figure of an oblate spheroid; that is, the poles are flattened, and the transverse diameter is longer than the polar; however, I have observed the Alexander's grape, and some of the bull or bullet grapes approach nearer to an oval or ellipsis which is the figure of all foreign or European grapes that I have seen; viz. a prolate spheroid. 2. Most of the American species and varieties have a glaucous and yellowish pubescence on the under surface of their leaves. 3. All that I have observed in the northern and eastern districts of the United States are *polygamous;* i. e. those vines which bear fruit (female) have hermaphrodite flowers (pentandria monogynia); but the males have only five stamina, without any female organ, and are always barren. One should suppose, from Walter so strongly marking this character as to induce him to place the Vitis in the class *Dioecia* where Linnaeus and the other European botanists had placed it in Pentandria (he himself being an European), that all the grape vines of the old continent are hermaphroditous and Pentandrian. I know not from my own observation whether the bull grape of Carolina is hermaphroditous or dioecious, and therefore rest satisfied with Walter's assertion.''

In Hedrick's ''Grapes of New York'' he quotes Dr. George Engelmann as follows:

''All the true grape-vines bear fertile flowers on one stock and sterile flowers on another separate stock, and are therefore called polygamous, or, not quite correctly, dioecious. The sterile plants bear male flowers with abortive pistils, so that while they never produce fruit themselves, they may assist in fertilizing the others; the fertile flowers, however, are hermaphrodites containing both organs—stamens and pistils—and are capable of ripening fruit without the assistance of the male plants. Real female flowers without any stamens do not seem ever to have been observed. Both forms, the male and the hermaphrodite, or if preferred those with sterile and those with complete flowers, are found mixed in their native localities of the wild plants, but of course only the fertile plants have been selected for cultivation, and thus it happens that to the cultivator only these are known; and as the grape-vine of the Old World has been in cultivation for thousands of years it has resulted that this hermaphrodite character of its flowers has been mistaken for a botanical peculiarity, by which it was to be distinguished not only from our

American grape-vines, but also from the wild grapes of the old world. But plants raised from the seeds of this as well as any other true grape-vine, generally furnish as many sterile as fertile specimens, while those propagated by layering or by cuttings of course, only continue the individual character of the mother-plant or stock.

"The fertile plants, however, are of two kinds: some are *perfect hermaphrodites* with long and straight stamens around the pistil, the others bear smaller stamens, shorter than the pistil, which soon bend downward and curve under it; these may be called *imperfect hermaphrodites,* approaching females, and they do not seem to be as fruitful as the perfect hermaphrodites, unless otherwise fertilized."

Professor S. A. Beach made two valuable contributions on this matter of sterility in grapes, one entitled "Self-fertility of the Grape"[35] and one on "Fertilizing Self-sterile Grapes."[36]

Professor Beach studied 169 varieties in regard to self-fertility. He grouped these into four classes as follows:

"Class 1 includes self-fertile varieties having perfect clusters or clusters varying from perfect to somewhat loose. Class 2 includes self-fertile varieties having clusters loose but marketable. Class 3 includes varieties which are so imperfectly self-fertile that the self-fertilized clusters are generally too loose to be marketable. Class 4 includes the self-sterile varieties. Whenever cross pollination has been prevented these have developed no fruit."

In class 1 and 2 marketable clusters from self-pollinated blossoms may be planted alone. Such varieties as the Bertha, Berckman's, Delaware, Clinton and Concord belong to the self-fertile class, while the Oneida, Jenison, Amber Queen and Herbert belong to the class in which pollen must come from other plants. Most of the sterility is due to the character of the short stamens but Professor Beach points out that some fruits will not set because of self-sterility.

"Long stamens are not a sure indication of self-fertility because some varieties which have long stamens are self-sterile.

"The most satisfactory explanation of the self-sterility which exists among grapes appears to be that there is a lack of affinity, in the self-sterile varieties, between the pollen and the pistils of the same variety."

In a second report[37] on the subject of self sterility of the grape he states that: "American grapes are either self-sterile or very imperfectly self-fertile. Such kinds, when they are self-pollinated only, either bear no fruit or produce more or less imperfectly filled clusters. In discussing the practical bearing of these discoveries upon the selection of varieties and arranging them in vineyards so as to get the best results in fruit production, attention was called to the fact that self-sterile varieties may produce well-filled clusters of fruit when the vines are located near enough to other kinds to make cross-fertilization possible.

"Twelve nearly or quite self-sterile varieties were treated with pollen from one or more of twenty-four varieties ranging from perfectly self-fertile to self-

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35 Geneva New York Agrl. Exp. Sta., Bull. 157:397.

36 Geneva New York Agrl. Exp. Sta., Bull. 169:331.

37 Geneva New York Agrl. Exp. Sta., Bull. 169:301.

sterile. . . . . The use of self-sterile varieties as pollinizers for other self-sterile varieties resulted in failure. Self-sterile varieties fertilized with varieties not strongly self-fertile produced clusters varying in compactness about as did the bunches of the pollinating variety. Self-fertile sorts, with rare exceptions, gave good results when used as fertilizers for either partially self-sterile or completely self-sterile varieties. From study of the effect of pollen from different varieties upon the same self-sterile variety, it seems probable that failure to set fruit may be due to several causes, such as dropping off of blossoms before they open or poor condition of the vine; but the most common cause is imperfect pollination due to impotent pollen.''

The most recent contribution on the subject is by Olav[38] Einset. While Concord and Rosaki gave a full set with their own pollen, Bakator, Brighton, Eclipse, Lindley and Pontiac were found to be completely self-unfruited.

Loose bunches are characteristic of these self-fruited grapes when they are left to open pollination, while compact clusters are obtained from hand pollination.

The data obtained indicate that the natural pollen carriers, viz., wind and insects, are not efficient in the case of the grape, and that artificial pollination is required to obtain maximum crops in the pollen-sterile varieties.

The self-sterile and imperfectly self-fertile grape varieties are: Lindley, Salem, Wyoming, Noah and Amber Queen.

In regard to fruitage Professor Beach says: ''An examination of the results shows that Amina gave scarcely any fruit when fertilized with the imperfectly self-fertile sorts Niagara, Worden and Catawba. Barry gave no fruit when pollinated with either Black Eagle or Hercules, but clusters which were open to cross-pollination in a mixed vineyard were well filled with fruit.''

Professor Beach[39] says further: ''In previous experiments varieties of grapes which are self-sterile or nearly so have shown about as little ability to fertilize other self-sterile sorts as they have for fertilizing themselves. In the tests here reported they have usually likewise failed to fertilize self-fertile varieties. Indications are seen, however, that the pollen in some instances, is not altogether impotent but that its own pistils are less congenial than those of some other varieties. Further investigation is needed to learn whether or not this self-sterility arises because the pollen is deficient in amount, or is not well developed, or is uncongenial to its own variety.''

N. C. Booth[40] has published some results on the potency of pollen grains of different varieties of cultivated grapes. This lack of potency is indicated by the difference in shape of the pollen grains. In some varieties potent and impotent pollen grains occur mixed in the same flower. ''It appears very certain that the capacity of the pollen for growth is in direct proportion to the number of self-fertile forms present and their conformity to the self-fertile type.'' Booth is of the opinion that it is possible that the grape developed from an older hermaphrodite form to forms that are essentially staminate and pistillate. All of the staminate flowers so-called which I have observed have small abortive pistils, which also conforms with the observations of Engelmann.

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38 New York State Agr. Exp. Sta., Technical Bull. 162, 13.

39 Bull. N. Y. Exp. Sta. Geneva, N. Y. 169.

40 Bull. N. Y. Exp. Sta. Geneva, N. Y. 224:298.

SWEET CLOVER

It is a well known fact that the production of clover seed is dependent on bees. Professor F. B. Paddock has published the following valuable note on this problem:

OUTSIDE INDUSTRIES DEPENDENT ON BEES

"Progress is being made toward the interrelation of beekeeping with other industries such as orcharding and clover seed production. In Iowa this year an abnormally poor set of clover seed has been reported in several areas accompanying reports of poor honey production. An outstanding example of this kind is along the Missouri River in the sweet clover belt, where much seed is usually produced, and where commercial honey production of Iowa is centered. This year the crop returns of honey were the lowest in the history of the region. During the fall considerable sweet clover was cut for seed, raked into windrows, but threshing was soon discontinued. In riding through the country, fields containing windrows of this undesirable material are mute evidence of seed and honey failure. It has been found in other states that the greatest amount of seed is produced in the presence of an abundance of bees but bees must be encouraged to work in fields by nectar flow conditions. Apparently this year in Iowa the climatic conditions were such that nectar was not produced by the plants and therefore did not attract the bees for pollination purposes.

BEES POLLINATE FRUITS

"There is an increased appreciation of the value of bees in pollinating fruits especially as a result of the work conducted in Michigan. A demand is being created for bees for use in pollinating orchards of nearly every kind of fruit. Pollination results have been printed by the Michigan Experiment Station as special bulletin number 188 entitled "Pollination of Orchard Fruits in Michigan."

"Another publication appears as Extension Bulletin No. 56 on the "Renting of Bees for Use In Orchards" by Professor Kelty, whose name is familiar to beekeepers in Iowa. Following closely is the booklet issued by Dadant and Sons entitled "Busy Bees Bring Bending Branches." These publications are all free upon request and every beekeeper should get the information which they contain. There is only one possible reason why this problem has not been felt more keenly in Iowa. The plantings of fruit are usually smaller than in other states and of a wider range of varieties. Furthermore there is a more general distribution of bees in this state than in most states, so that under natural conditions the bees are more readily available for pollination purposes.

"In the year 1929 sweet clover did not in some sections of the state secrete as much nectar as usual. Consequently bees were absent and a lighter crop of sweet clover seed resulted."[41]

H. S. Coe and J. N. Martin[42] found that sweet clover seldom produces a satisfactory quantity of seed when muggy or cloudy weather prevails. These

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41 Iowa Bee-Keepers' Bulletins, 1930, 1, p. 2.

42 Bull. U. S. Dep't. Agrl. 844.

authors find a direct connection between the insect pollinators and seed production and the results indicate that flowers fertilized by pollen transferred from another plant produce a higher percentage of pods than any other. In other words, cross-fertilization is essential in order to produce seed.

RED CLOVER

Regarding red clover seed production Westgate and Coe[43] state that "The work of Sirrine as well as that of Witte showed red clover to be self-sterile."

The authors of this paper found but two seeds from 643 heads which were allowed to mature under a screen cover, while Washburn says that only by the aid of bumble bees was he able to obtain seed.

A very comprehensive study on pollination of red clover was made by the authors.[44] They made a study of clover heads covered and not covered and seeds produced. In 1909 Mr. Lyle Clapper covered the first crop of 495 heads of red clover. Not a single seed was produced. Dr. Ada Hayden also covered a large number of heads. Out of 76 heads not a single seed was found. Of the second crop a large number of heads were covered by Miss Hayden and gathered in September. Out of 71 heads not one seed was found. One head contained two seeds.

Another experiment was conducted in which the clover heads were covered with tarlatan before any flowers opened and were kept covered, except while being worked, until mature. As soon as the flowers came into bloom they were self-pollinated by springing the keels of the flowers with toothpicks, care being taken to rub pollen upon each stigma. A separate toothpick was used for each head. In 1911 125 heads were self-pollinated and in 1912 170 heads. An average of 0.16 seed per head was obtained in 1911 and an average of 0.09 seed per head in 1912.

The results of this experiment show, as have previous experiments, that red-clover flowers must be cross-pollinated in order to set seed on a commercial basis. The amount of seed obtained is so small that it was probably the result of bees working through the tarlatan, although the cytological work reported upon in this paper shows that it is possible to have an occasional seed produced from self-pollination.

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43 Red clover seed production: Pollination studies. U. S. Dept. of Agr. Bull. 289: 3.

44 Proc. Ia. Acad. Sci., 18, p. 35.

THE SEED PRODUCTION OF CLOVER AND ALFALFA AS RELATED TO BEES

J. N. MARTIN

The production of seed in most plants depends upon the proper pollination of the flowers. Unless the flowers are pollinated fertilization in the ovules does not occur, and fertilization is the initiatory step in the process of seed development. Fertilization is the union of the sperms, the male nuclei of the pollen, with the egg and endosperm cell of the ovules. The ovules at time of fertilization are quite small, mere specks to naked eye. They are borne in cavities in the ovary, thus being enclosed by the ovary wall, which excludes the pollen from coming in direct contact with them. This necessitates the transmission of the sperms to the ovules by means of tubes which must traverse stigma, style and ovary. There are three processes involved: the pollen must be transferred to stigma; the pollen must develop a tube conveying the sperms from pollen grain on stigma to interior of ovules; and the sperms must fuse with the egg and endosperm of the ovule. The growth of the pollen tube and the fusion in the ovules depend upon a congeniality between pollen and pistil. In the absence of this congeniality pollination is of no avail. The requisite congeniality depends mainly upon the relationship of pollen and pistil, occurring most generally between pollen and pistils that are from different flowers, as in case of cross-pollination. In many cases the congeniality is best between pollen and pistils from different plants.

On account of their peculiar structure, the flowers of the legumes of the clover and alfalfa type require the assistance of insects in their pollination. The stamens form a tube which encloses the pistils with the anthers encircling the style a little below the stigma. The stigmatic surface is terminal and although the anthers may shed their pollen, the mere act of shedding does not transport the pollen to the stigma. Thus the anthers and stigma are so located in reference to each other as to prevent self-pollination. In some legumes, as for example the sweet pea, the stigma extends down the side of the pistil, and pollen has only to be shed from anther to reach the stigma, but such is not the case in the clovers and alfalfa. In these legumes the pollen reaches the stigma by showering down upon it after being thrown up by the flip of the pistil and stamens when the flower is tripped, or by being deposited on the stigma by a visiting insect. The keel (the boat-shaped structure of the flower) so thoroughly encloses stamens and pistil that pollen can neither escape from or enter a flower. In order for the pollen to escape and stigma to be exposed, it is necessary that the keel be pressed downward until pistil and stamens spring out of the keel. This is called tripping and is an adaptation to insect pollination. The springing of the stamens and pistil out of the keel during tripping accomplishes two things. First, it results in the sprinkling of the insect's body with pollen. Much of this pollen adheres to the insect's body and is carried to other flowers. Second, in the springing upward of the pistil stigma is brought in contact with the body of the insect and receives a deposit of the pollen adhering to the insect's body. Since the pollen

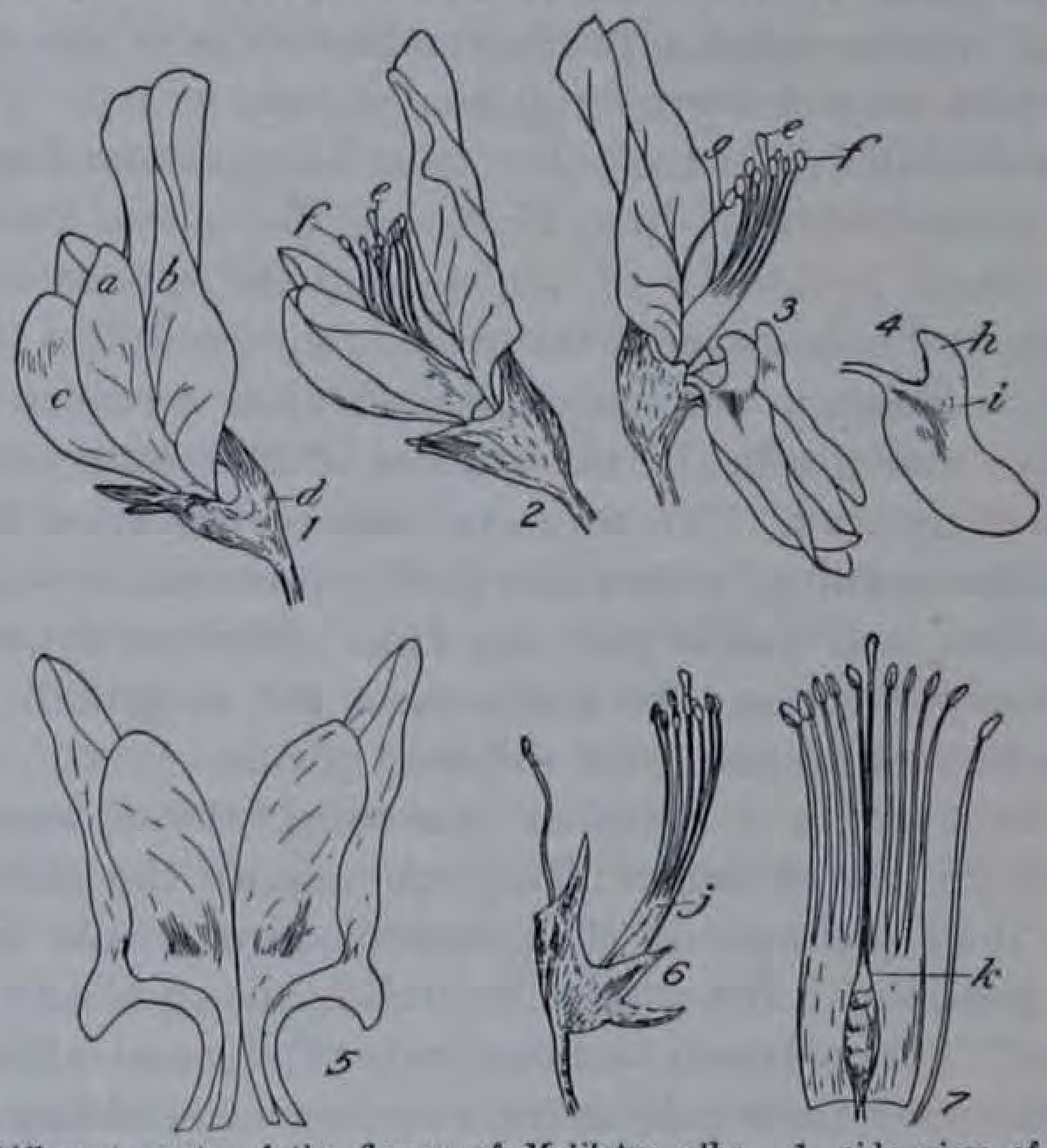

FIG. 567.—Different parts of the flower of *Melilotus alba*. 1, side view of the flower; 2, side view of the flower with the carina and alae slightly depressed; 3, side view of the flower, showing the carina and alae depressed sufficiently to expose the staminal tube and the tenth free stamen; 4, ala; 5, alae and carina spread apart to show their relative position and shape; 6, flower after the petals have been removed, showing in detail the calyx and staminal tube; 7, the staminal tube split open to show the relative size and position of the pistil. a, alae; b, vexillum; c, carina; d, calyx; e, stigma; b, anthers; g, tenth free stamen; h, digitate process of the superior basal angle of an ala; i, depression in the ala; j, staminal tube; k, pistil. *Drawn by Charlotte M. King.*

adhering to insects is usually the contribution of a number of flowers previously visited, the stigma generally receives from the insect pollen variously related. The accompanying figure shows the structure of the flower and its adaptation to insect pollination.

Bees visit clover and alfalfa flowers to obtain nectar or pollen. In either case they trip the flowers and thus pollinate the stigmas. Other insects to some extent trip clover and alfalfa flowers, but bees, especially bumble bees and honey bees, are the most important agents. The experiments described in the following pages were devised to procure an estimate of the importance of bees in the production of seed in the clovers and alfalfa.

Among the most important of the Legumes is the red clover. Whether or not cross-pollination is necessary for seed production and the comparative efficiency of bumble and honey bees as pollinators in red clover are two questions that have engaged the attention of a large number of investigators (see Bulletin 289, United States Department of Agriculture, 1915). Darwin's experiments showed that red clover, crimson clover, and white clover require cross-pollination. Later experiments by Frandsen, Lindhard, Wallace, and others of Europe also showed red clover to be self-sterile. On the other hand Armstrong in New Zealand, and McAlpine and some others in Europe report experiments showing that red clover is self-fertile. Experiments conducted by the U. S. Department of Agriculture show pretty conclusively that red clover requires cross-pollination. Heads enclosed in tarlatan and flowers self-pollinated produced an average of less than 16 seeds to 100 heads. These few seeds could have been the results of chance insect pollinations. It was also found that pollen from another flower in the same head or from a flower of another head on the same plant was not effective. Only when pollen and pistil were borne on separate plants was pollination effective.

As to the comparative importance of bumble bees and honey bees as pollinators of red clover, there is also a diversity of opinions. Those who do not believe that the honey bee is an important agent in the pollination of red clover call to the support of their argument the fact that the proboscis of the common bee is too short to reach the nectar in the red clover flower. The proboscis, which is about 6 millimeters in length, is on the average about 3.9 millimeters shorter than the corolla tube of the red clover flower. One must, however, take into account the fact that a copious secretion of nectar may fill the corolla tube to a height accessible to the honey bee. Even though nectar is not obtainable honey bees may visit the flowers for pollen. Experiments were conducted by the U. S. Department of Agriculture in which areas of red clover were enclosed in wire cages in which bees were placed. In cages containing only bumble bees an average of 30.4 seeds per head was harvested. In cages containing only honey bees an average of 37.2 seeds per head was harvested. The results show that the honey bee is able to pollinate red clover quite efficiently. Whether the bees visited the flowers for nectar as well as for pollen was not determined. The main trouble apparently is that the honey bees pass red clover by for other plants.

In some irrigated localities of the West where large yields of red clover seed are obtained and bumble bees are few, it is likely that honey bees do much of the pollinating. It may be a matter of being forced to work on red clover, other more desirable flowers not being available. In most parts of the United States, although the honey bee may be of considerable importance, the production of red clover seed depends chiefly upon the bumble bee. Varieties of red clover with shorter corolla tubes have been developed and it is claimed that honey bees are much more active on the flowers of these plants. The breeding of bees with longer proboscides has been suggested as another method of adjustment. Owing to the scarcity of bumble bees it is necessary that better service be obtained from the honey bee.

Sweet clover, although of less importance than red clover or alfalfa as a forage crop, is recognized as a valuable nectar producing plant. Just how necessary bees are in the production of sweet clover seed is not easily determined because sweet clover flowers are visited by so many kinds of insects. According to Darwin cross-pollination is necessary for a normal production of seed, while Kirchner and Kerner claim that cross-pollination is not essential. To get more light on these questions, the U. S. Department of Agriculture conducted a series of experiments, the results of which are reported in Bulletin 844, Bureau of Plant Industry.

In these experiments self-pollination gave a fair yield of seed but not so much as cross-pollination, showing that cross-pollination is most desirable but not absolutely necessary. Plants protected from all tripping agents produced very little seed, thus proving that the flowers must be tripped in order for pollination to occur. This

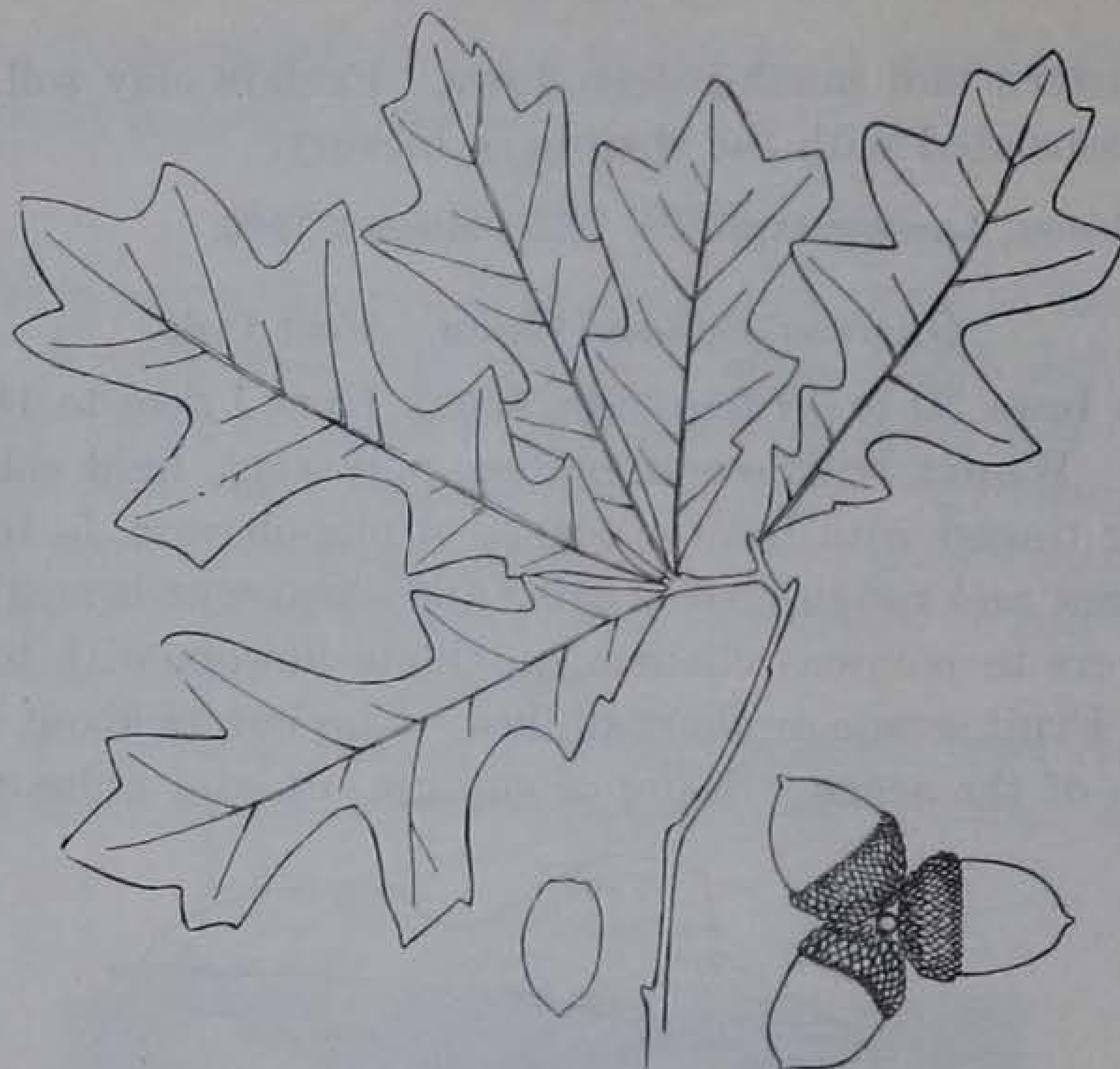

FIG. 56.—Overcup oak (*Quercus lyrata*). *Drawn by Ada Hayden.*

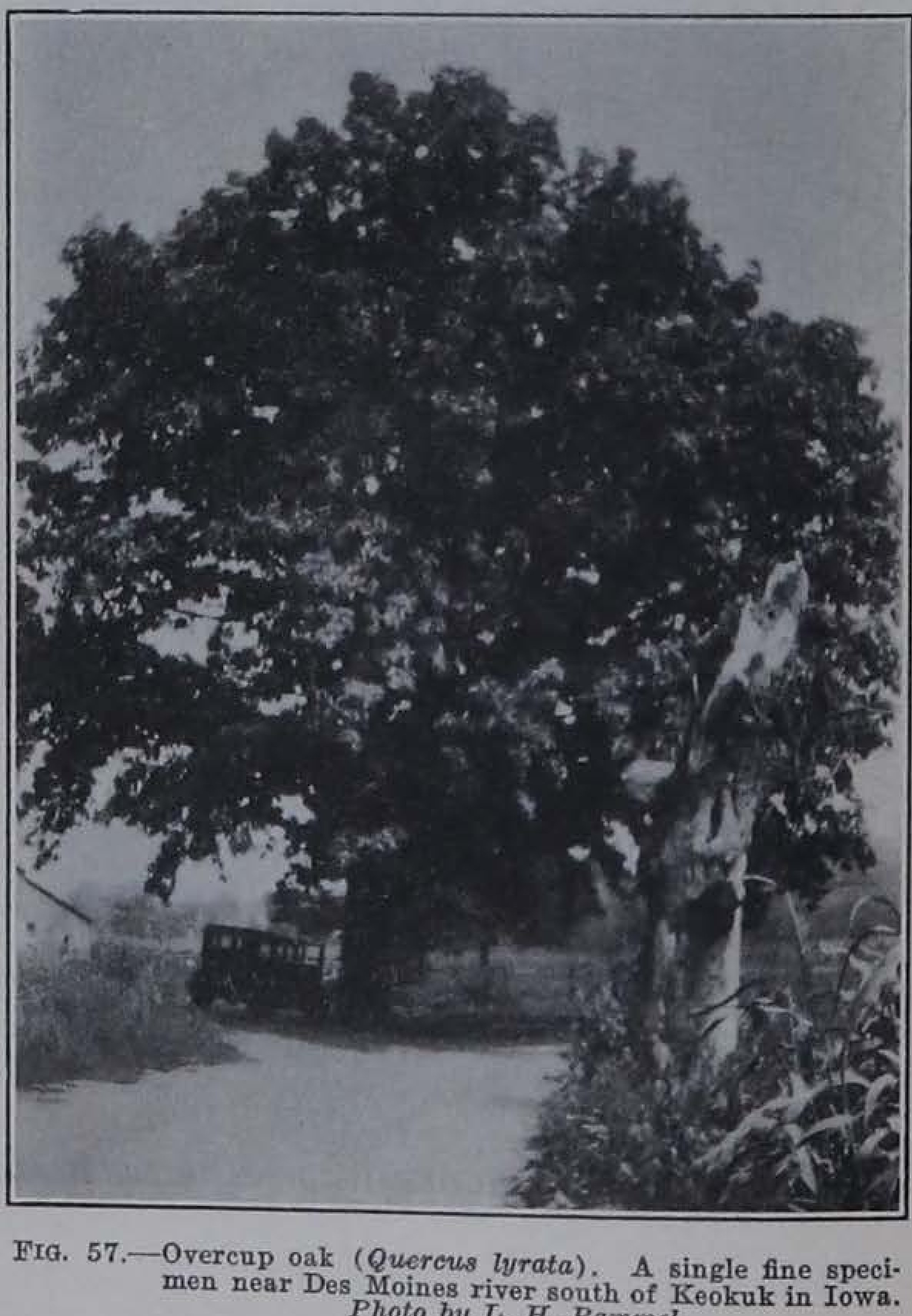

FIG. 57.—Overcup oak (*Quercus lyrata*). A single fine specimen near Des Moines river south of Keokuk in Iowa. *Photo by L. H. Pammel.*

establishes the importance of bees and other insects as tripping agents. Plants exposed to only night flying insects produced some seed but so little as to show that these insects are not important as pollinators. Plants exposed to only day flying insects produced approximately as much seed as plants exposed at all times. Plants enclosed in cages which excluded honey bees and all larger insects produced fair yields of seed, producing an average of 27.53 pods per raceme as compared with 28.23 pods per raceme on plants exposed to all insects. These results show that the small insects are efficient pollinators of sweet clover, but it is doubtful if the small insects are sufficiently numerous in fields of sweet clover to be depended upon. The conclusion as stated in the bulletin, is that the honey bee is the most efficient pollinator of sweet clover and is responsible for the pollination of more than half of the flowers in many localities.

In alfalfa, seed production is a matter of much concern because of the importance of the crop for forage. Production of seed by alfalfa is exceedingly variable, being much influenced by climatic factors. The best seed production occurs in the drier climates. There are numerous publications on questions relating to the pollination of alfalfa. A summary of these publications up to 1914 may be found in U. S. D. A. Bulletin 75. This bulletin also gives an account of the experiments of alfalfa seed production conducted by the U. S. D. A.

Self-pollination apparently is quite effective. There seems to be a wide variation among individual plants, some setting seed well when self-pollinated while others show a marked reduction over cross-pollination. A survey of the experiments warrants the conclusion that cross-pollination is most effective. Although alfalfa flowers, to some extent, set seed without being tripped, sometimes as many as five per cent or more of the flowers producing pods, tripping is essential for a normal production of seed. Carlson of Utah obtained excellent results from artificial tripping.

In the middle western and eastern parts of the United States honey bees apparently collect very little nectar from alfalfa. Piper and others state that the honey bee has difficulty in tripping the flowers and that most of the tripping is accomplished by bumble bees and other stronger insects.

According to Vansell and other investigators in the western states, alfalfa is a major source of nectar. Vansell describes six regions in California that lead in alfalfa honey production. Honey bees apparently must be able to reach the nectar in these localities, and most likely are important trippers of alfalfa. Vansell states that alfalfa constitutes one of the major sources of honey over much of the United States. This means that much of the pollination of alfalfa may be done by honey bees.

THE RELATION OF HONEY PLANTS TO SOILS

L. H. PAMMEL AND C. M. KING

It has long been recognized that certain environmental factors like temperature and other meteorological conditions, as well as soil, influence the secretion of nectar. In the case of the former, Dr. L. A. Kenoyer[1] in the compilation of weather records kept by Mr. Strong of Clarinda over a long period of years has shown that yield for a producing period seems to be closely correlated with both temperature range and rainfall. Moreover it has been shown by Dr. Kenoyer[2] that the more favorable the conditions for growth, the greater the amount of sugar secreted; and that the optimum condition for honey secretion is an alternation of low and high temperatures.

Soil is a contributing factor. The types of plants found in certain kinds of soils are an important consideration; for instance, the horse mint (*Monarda punctata*) is an excellent honey plant, one of the best for sandy soil. The common white clover is an excellent honey plant in the north; not only in the Wisconsin drift, but it is a most excellent honey plant in the nearly driftless area of Wisconsin and northeastern Iowa. It is also an excellent honey plant in the Iowan drift sheet, in part. It is not dependable as a honey plant in central Iowa, a region covered by the Wisconsin drift sheet. It is a shallow rooted plant and therefore the moisture necessary for making plant food is not at hand. On the other hand the two sweet clovers, the yellow and the white, are excellent honey plants in all parts of the state, in many different soil types. These are deep rooted plants. The blue vervain sometimes but not always yields an abundance of nectar, according to the amount of moisture available. This plant though a perennial, produces a root system that lies midway in depth between the shallow and deep systems of roots.

In northeastern Iowa, in Clayton, Allamakee and Winneshiek counties, as well as in western Wisconsin, certain goldenrods and asters are excellent honey plants. Some years ago Pammel had occa-

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1 See this volume, page 1110.

2 See this volume, page 1122.

sion to observe the honey flow in plants of western Wisconsin. The soil is a sandy loam. There were present several goldenrods (*Solidago nemoralis, S. rigida, S. canadensis, S. missouriensis, S. speciosa, S. ulmifolia*) and asters (*Aster multiflorus, A. laevis, A. novae-angliae, A. sericeus*). Every one of these species was visited by bees in great abundance. It is seldom that these species are visited by bees in central Iowa, although it is true that bottomland species of asters and goldenrods like *Aster Tradescantia, A. paniculata, A. salicifolius* are consistently visited by honey bees. Plants in such locations have an abundance of water easily available. There has been much published in recent years on soils and honey flow, but most of these publications overlook the other essential factors—root systems, soil moisture and climate—that go with soil types.

The American Bee Journal in several issues has discussed honey regions of various states. Under the topic "Honey Regions of Iowa," Frank C. Pellett[3] discusses the soil and climatic conditions and the sources of nectar. The author considers a few of the important plants, like white clover, alsike, sweet clover, basswood, buckbrush and asters. It is evident from his experience at Atlantic that though the white clover is abundant it does not always yield surplus. The same author discusses the same subject in American Honey Plants[4] under the heads topography, climate, rainfall and soils.

Myron H. Swenk[5] of Nebraska writes in substance that Nebraska is divided into the white clover region and the alfalfa region. The author publishes a list of the honey plants of these regions. The plants listed here are of interest as some are honey plants only under exceptional conditions. H. F. Wilson[6] in a discussion of the honey regions of Wisconsin notes that there are in the state many regions with varied topography. There are wide differences in nectar secretions of honey plants. Climate is also a factor. In Wisconsin there are six soil types. The sweet clover regions lie in southeastern Wisconsin; one region is noted because of the abundance of alsike clover.

Newton Boggs[7] discusses honey regions of Colorado. Colorado is a state where irrigation is practiced extensively. There are six irrigated regions; the South Platte, Arkansas Valley, San Luis Valley, Gunnison, Uncompahgre region and the northwestern section. These constitute the honey regions of the state.

Elmer G. Carr[8] states that distribution of bee plants in New Jersey depends mainly upon topography, that is, elevation.

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3 American Bee Journal, 52:453-455.

4 American Honey Plants, second edition, 171-174.

5 The Honey Regions and Honey Plants of Nebraska, American Bee Journal, 62:107-201.

6 American Bee Journal, 63:223-226, May, 1923.

7 American Bee Journal, 63:283-285, June, 1923.

8 The Honey Resources of New Jersey. American Bee Journal, 63:595-597, December, 1923.

B. J. Kindig,[9] in the Honey Resources of Michigan, finds that clovers grow best upon clays. The raspberry and fireweed flourish in the cutover lands. There is a valuable fall flow over the entire state from goldenrod, Spanish needles, blue verbena (Vervain) and aster. The fact that Michigan has a great variety of soils, resulting from its glaciation, accounts for the great variety of flowering plants, a distinct advantage to beekeeping.

J. H. Merrill[10] reports upon the honey plants of Kansas. He discusses the rainfall and temperature conditions, together with the soils and topography of the state. The great range of conditions accounts for a considerable range in the kinds of honey plants; alfalfa is common in irrigated lands and the Rocky Mountain bee plant is abundant in the western section, a region of considerable elevation. Basswood, clovers, fruits and dandelion characterize the northeast part; papaw and goldenrod characterize the southeastern portion; heart's-ease and fruit trees are valuable bee plants in the central portion.

Francis Jager[11] gives us an account of the honey regions of Minnesota. The surface is varied, the soil, a rich black loam with clay subsoil, is derived from the covering left by the last great glacier, which also spread down into Iowa. In the wake of the forest fires which have devastated such great areas of the coniferous woods over the northeastern half of the state have sprung up raspberry, cherry, alsike, fireweed, goldenrod and aster, making it a fine beekeeping region. The clearings of the Big Woods Region have opened up the country into pastures, fields and farms, where white clover, basswood, sweet clover, fruit trees, dandelion, goldenrod and asters flourish. The moisture and temperature of Minnesota favor the flow of nectar in the honey plants. In the prairie region of western Minnesota sweet clover is the most prominent honey plant.

Mr. Frank C. Pellett[12] finds in the Dakotas a promising outlook for sweet clover. He says, "Where we find a limestone soil, hot days and cool nights with a moderate amount of moisture there we find sweet clover yielding nectar freely."

E. F. Phillips and George S. DeMuth[13] in a bulletin on the Clover Region call attention to the distribution of clovers. The region most favorable to clovers lies within the area covered by the last glacier, northeastern Iowa being included in the best clover territory.

There is great variation in the amount of nectar secreted by these plants, according to soils, climatic conditions, etc. In general, the honey is best where soils are not acid, and where summer temperatures are relatively low. The plants thrive best and produce largest yield of nectar where there is abundant rain throughout the growing and blossoming period. In general alsike responds to the same conditions as white clover. Throughout the clover region are other plants valuable for nectar supply. Among them are wild red rasp-

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9 American Bee Journal, 62:545-547, December, 1922.

10 American Bee Journal, 62:7-10, January, 1922.

11 American Bee Journal, 63:65, February, 1923.

12 Beekeeping in North Dakota. American Bee Journal, 63:115-117, March, 1923.

13 Beekeeping in the Clover Region. U. S. Dept. of Agriculture, Farmers' Bul. 1215.

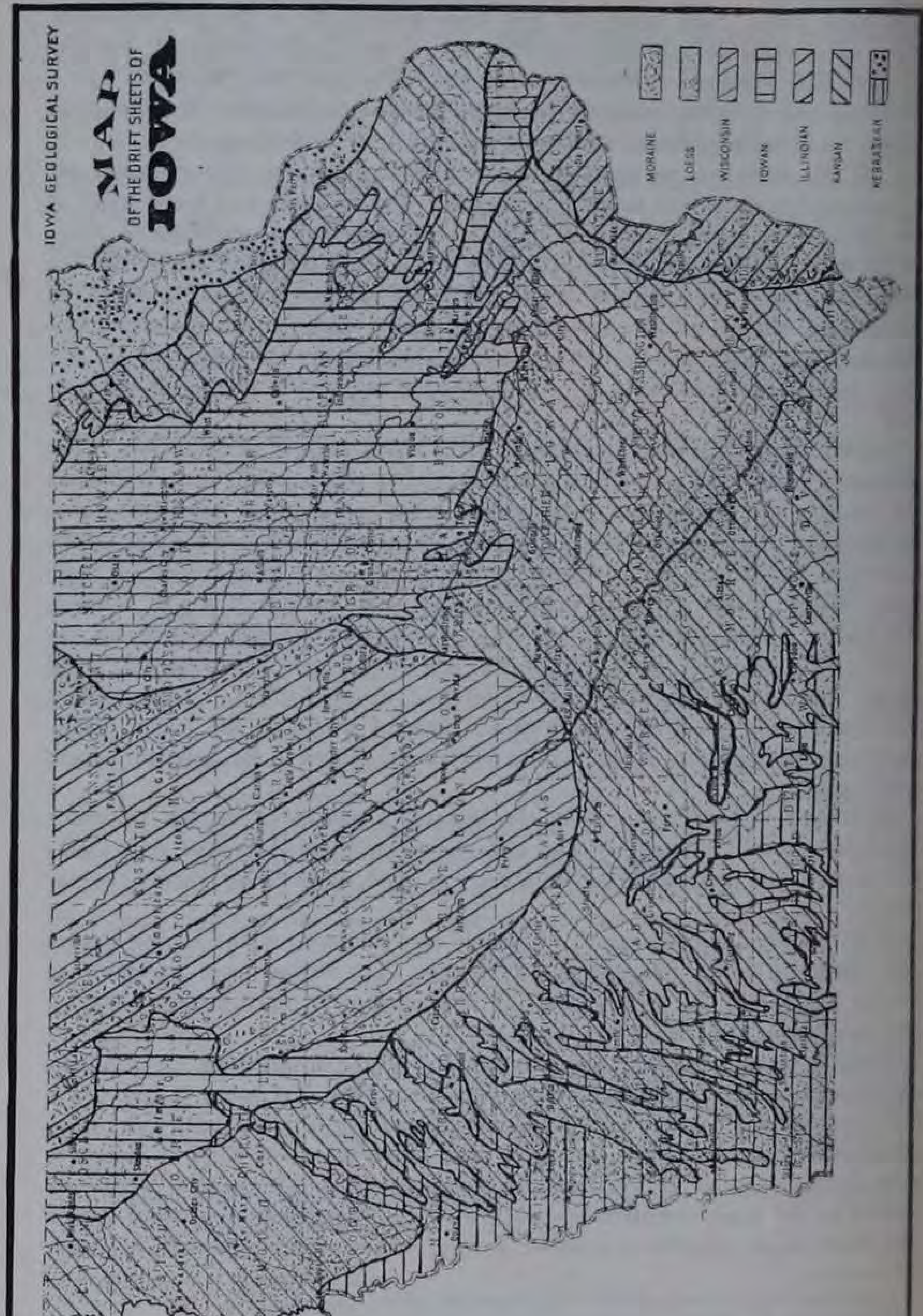

FIG. 568.—Map of Iowa showing the distribution of the drift sheets at the surface or under the loess. We are indebted to the Iowa Geological Survey for this fine map.

berry, fireweed (willow herb), Spanish needle, milkweed, sumac, buckwheat, maples, dandelion, basswood and white sweet clover.

DRIFT SHEETS OF IOWA

The geologists recognize that several glacial epochs occurred. Dr. James H. Lees[14] in his paper on the Des Moines River Valley says the first drift sheet, the Nebraskan, "has been found at different localities, in Fayette, Polk, Union and Harrison counties. The drift material is a very dark gray, almost black clay and is gummy and sticky. The Kansan, the second drift sheet, covers much of southern Iowa, from Lyon county south to the Missouri line and southeasterly through part of Cherokee, Sac, Carroll, Guthrie, southern Dallas and Polk counties, northeast to Jasper county, to Tama, Iowa, Johnson, Cedar, Washington, Henry and Lee counties. The till is a bluish pebbly clay, becoming yellow and even reddish on exposure."

"Associated with the Kansan drift sheet in different parts of Iowa are large bodies of gravel, some of them rusty and weathered. These are exposed at several localities along the Des Moines valley and are very common in other parts of Iowa. Overlying the Kansan drift at many points in the valley below Des Moines there is also a fine blue-gray or yellow silt known as loess. It is formed of the rock-flour from the glacial mill and seems to be related in origin of material largely to the drift, although it owes its present position to deposition by winds which brought it chiefly from the valley flats nearby. The loess is typically without pebbles, though locally it is sandy, especially in its basal portions. It is usually more or less calcareous, except when weathered, and is noted for its ability to maintain vertical walls."

"The third glacier, the Illinoian, extended as a little lobe into Iowa from Scott county to northern Lee county.

"The Iowan drift sheet extends from Worth county to Winneshiek, western Clayton to Delaware, Jones, Linn, Benton, Tama, Grundy and Franklin counties. The drift material contains boulders, sand and gravel. There is also a strip of Iowan drift west of the Wisconsin drift sheet from Sac to Osceola counties.

"The Wisconsin drift sheet extends as a broad lobe from Minnesota into Iowa, from Osceola county in the west, eastward to Worth and Cerro Gordo counties, south to Franklin, Hardin, Marshall, Polk, Dallas counties and north to Greene, Calhoun, Buena Vista, O'Brien and Osceola counties. It is the most recent of the glacial drift sheets and differs from the others in presenting along parts of its eastern and western margins ranges of knobs and mounds scattered promiscuously about or grouped compactly together in long series. This is the Altamont moraine, and a similar, though smaller, recessional series within the area of the drift sheet is known as the Gary moraine. The Wisconsin still has a typical topography. It has been but little modified by erosion, comparatively few streams cross its surface, and the terminal and recessional moraines doubtless are nearly as distinct as when first formed, while the ground moraine still retains its original features. Wide expanses of prairie stretch to the horizon, broken only by a shallow slough or deeper lake,

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14 Physical Features and Geologic History of Des Moines River Valley, Iowa Geological Survey Report 25:249-615, f. 39-53, Pl. 27-72.

or perhaps by a rare sag through which flows, more or less intermittently, a small stream carrying off the surplus rainfall.''

The white clover honey area is best developed in northeastern Iowa as indicated in two areas in this part of the state. See the map.

SOIL AREAS

The facts in the following discussion on the soil areas of the state have been taken largely from the reports on the soil survey of Iowa, made by the Iowa Agricultural Experiment Station.[15] They discuss the soil as to origin and character, enumerating the following types:

1. Geest, or soils resulting from the secular decay of indurated rocks.
2. Soils of fluviatile origin, or stream-made soil (alluvium).
3. Soils of aeolian origin, or wind-made soils (loess).
4. Soils of glacial origin, or ice-made soils (till).

The term ''geest'' is applied to soil which has accumulated at the surface in consequence of decomposition of rock.

The alluvial soils (fluviatile) include such soils as are deposited by streams; these may be divided into first bottom or present time deposit, and second bottom, a deposit chiefly of an earlier period.

Loess (æolian) is a fine-grained material deposited by the wind. Loess is generally light colored, buff and yellow or somewhat whitish. There are three areas of loess in Iowa, the Missouri loess in western Iowa, covering the territory from Lyon southeast to Guthrie and southwest to Taylor county; the southern Iowa loess from central Taylor county on the west, north to southeastern Guthrie county, thence east to Washington county, and southward to Lee; the Mississippi loess, covering in a general way the counties along Mississippi river, Allamakee, Winneshiek, Clayton, Jones, Cedar, Johnson, Iowa, parts of Tama, Marshall, Jasper, Poweshiek, Iowa, Johnson, Scott, Louisa, Henry, Des Moines and Lee counties.

SOILS OF GLACIAL ORIGIN

All of Iowa was at one time covered with ice sheets. In the melting of the ice a drift material was left. This drift, or till, is a stiff clay containing pebbles of various sizes and boulders. It is very thick, in some cases as much as five hundred feet. Soil is derived from this material.

DRIFT SHEETS AS RELATED TO SOIL AREAS

The Nebraskan.—This drift sheet originally covered the entire state. It lies under loess or alluvium in northeastern and western Iowa, but it has been observed in Fayette, Polk, Union, Harrison and other counties.

The Kansan.—This ice sheet pushed entirely across the state from the north into Missouri and Kansas. The evidence of the Kansan is pronounced in southern Iowa, where glacial boulders occur and where the soil is reddish or yellowish from the long continued changes to which it has been subjected.

The Illinoian.—This drift sheet invaded Iowa from Illinois. The Illinoian till is so completely buried under the Mississippi loess that it is rarely to be

15 Stevenson, W. H., Christie, G. I., Wilcox, O. W., The Principal Soil Areas of Iowa. Iowa Agricultural Experiment Station Bul. 82:372-394.

ound in situations where it can be cultivated and is not a factor in the assification of Iowa soils.

The Iowan.—This drift area east of the Wisconsin drift area extends from orth, Mitchell and Howard on the north to Marshall, Tama, Benton, Linn, ones and Clinton on the south. It came into Iowa from the north. A great any of the isolated swales left by the melted ice have been filled up or rained out by natural processes and a fair number of natural drainage lines re being developed. The excess of rainfall has therefore much greater opportunity of flowing away of its own accord than is the case in the area to e west; this of itself would serve to distinguish the two areas. But the ost obvious characteristic of the Iowan till, and the one which enables the asual observer to distinguish it from either of the others is the enormous ize of the granite boulders it contains.

The soils of the Iowan drift sheet do not differ very much from those of he Wisconsin. Peat bogs and alkali spots are very much rarer. As is to be exected in view of the greater age and better drainage of this drift sheet, there xist localities where leaching has been active.

Doctor Lees informs the senior author that the Iowa Geological Survey has ound in recent years that most of the Iowan drift area is covered with thin oess. Therefore this forms the real soil here as it does over the Nebraskan, Kansan and Illinoian drift areas, except of course where it has been eroded way, leaving the till at the surface.

The Wisconsin.—This is the youngest of the drift sheets. It covers in whole or in part the counties of Lyon, Osceola, Dickinson, Emmet, Kossuth, Winnebago, Worth, Cerro Gordo, Hancock, Palo Alto, Clay, O'Brien, Cherokee, Buena Vista, Pocahontas, Wright, Franklin, Hardin, Hamilton, Webster, Calhoun, Sac, Carroll, Greene, Boone, Story, Marshall, Polk, Dallas and Guthrie. It is, for the most part, in practically the same condition in which it was left after the enormous mass of ice which covered it melted away, except, of course, that it is now covered with vegetation. A few larger streams, such as Des Moines river, flow across it, but these rivers are so new that they have not had time to extend their tributaries very far back from their main channels. Nearly the whole territory is as yet a monotonous stretch of prairie, liberally dotted with undrained ponds, marshes, sloughs and lakes, many of which contain accumulations of unrotted peat. On both the eastern and western borders of the area are stretches of low hills which are the terminal moraines made by the ice sheet.

In consequence of the absence of natural drainage lines, the surface of much of this area is so marshy and water-logged that agriculture can be carried on only at a heavy disadvantage and frequent loss in seasons of excessive rainfall.

The soil of the area is principally a black loam, sandy in some places and clayey in others. It is generally rich in the elements of plant food and contains many boulders of various materials, including granite.

Summary.—It will be seen that the soils of the state may be roughly divided into two classes, drift soils and loess soils, and that further divisions may then be made into various drift and loess soils because of differences in period of formation, characteristics and general composition.

HONEY PLANTS AND SOILS

In this discussion of Iowa, selection of some characteristic area will be made for each of the principal soil types of the state. For *Missouri loess,* Pottawattamie county will be selected.[16]

The Marshall silt loam covers 68 per cent of the area. This is a black soil although sometimes with mottling of yellow. The topography is rolling or hilly, and much of the region was the original prairie. The Knox silt loam covers about 4.7 per cent of the county and this soil is light brown to buff in color. This is the soil type bordering on the Missouri lowlands, and it is characterized by the bluffs, which are from 100 to 150 feet high. There are many ravines and gulches. The Hancock silt loam is one of the terrace soils which belong to the second bottom rivers. It is a level type. It may have sand and is often alluvial.

Swamp and bottom land soils contain several types; especially the Wabash silt loam, which covers 13 per cent of the area of the county. This occurs in the overflowed bottoms of Walnut and Pigeon creeks. It is a dark brown to almost black mellow silt loam. This type is divided into the silt loam or alluvial and colluvial material along the minor streams and outer edges of the lowlands of nearly all of the larger streams. The other types need not be mentioned in this connection.

We may now consider some of the plants associated with these different types of soil, especially as related to honey plants.

The Knox silt loam contains many of the prairie types of species. The land is now of course largely cultivated. On this type of soil there are: Canada goldenrod (*Solidago canadensis*), smooth aster (*Aster laevis*), sunflowers (*Helianthus occidentalis, H. Maximiliani*), prairie clovers (*Petalostemum candidum, P. purpureum*), purple cone flower (*Brauneria purpurea*). The white and yellow sweet clovers do well and are common, also hog pea (*Astragalus caryocarpus*). Blazing star (*Liatris punctata*) and horse mint (*Monarda mollis*) also are found.

The Hancock series and the Wabash silt loam may be considered together. The more important plants are Maximilian's sunflower (*Helianthus Maximiliani*), common sunflower (*H. annuus*), golden-

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16 Stevenson, W. H., Brown, P. E., Hanson, H. P., and Reid, H. W., Soil Survey of Iowa, Pottawattamie County, 2:1-54, f. 1-11, 2 maps, 1918.

This species is common only in southeastern Iowa, occurring at Keosauqua, Keokuk and Farmington. Grows in rather thin soils. Sometimes found in islands in the prairies in southeastern Iowa. It never attains a large size in this state.

Quercus lyrata Walt. Swamp Post Oak, Overcup Oak

Large tree in some cases 100 feet high, 2 to 3 feet in diameter. Ovate winter buds with chestnut brown scales. Bark light gray with appressed grayish scales. Leaves obovate-oblong, 5- to 9-lobed, crowded to the end of the branch, white, tomentose beneath or smooth. The staminate flowers in groups in slender catkins, pistillate flowers sessile or short stalked, stigmas red. Fruit sessile or stalked, acorn nearly round. The cup covers the acorn beyond the middle.

Rare in this state. Reported by Shimek near the Amana colony in Iowa county. This distribution is quite unique and the find by Dr. Shimek is most interesting. It has been collected at Centerville by F. B. Trenk and at Keokuk by L. H. Pammel. It occurs in Illinois opposite Keokuk.

FIG. 58.—Staminate flowers of bur oak (*Quercus macrocarpa*). *Photo by S. G. F. Sheldon.*

rods (*Solidago canadensis, S. serotina*), asters (*Aster laevis, A. novae-angliae*). The Sarpy fine sand has snow-on-the-mountain (*Euphorbia marginata*), partridge pea (*Cassia Chamaecrista*), rattle-box (*Crotalaria sagittalis*).

The valleys and gullies are covered with trees and shrubs, as buckbrush (*Symphoricarpos occidentalis, S. orbiculatus*), basswood (*Tilia americana*), bur oak (*Quercus macrocarpa*), elms (*Ulmus americana* and *U. fulva*). Southward the papaw (*Asimina triloba*) and red bud (*Cercis canadensis*) and the quercitron oak (*Quercus velutina*) occur in sandy pockets.

For a typical *Wisconsin drift* area we have selected Buena Vista county, which was surveyed by the soils section of the Iowa Experiment Station and the U. S. Department of Agriculture.[17]

The Carrington loam covers 46 per cent of Buena Vista county and is a dark brown to black mellow loam with much gravel. The topography is a gently rolling prairie, in some places with steep slopes.

The Carrington silt loam occupies 27.8 per cent of the area of the county. The surface soil is a black silty clay loam; the topography is gently undulating to flat; before drainage, it was under water.

The Wabash silt loam is of the bottom land type and occurs in the bottoms of the streams, and in part is covered with trees. The silt clay occurs in the first bottoms of many of the smaller streams. Much soil is a light fluffy material with a great deal of organic matter. It is found in some of the old lake beds.

The plant types found in the Carrington loam in the original prairie condition included the blazing stars (*Liatris scariosa, L. pycnostachya*) and the hoary vervain (*Verbena stricta*), one of the most common plants in this area. Yellow and white sweet clover (*Melilotus officinalis, M. alba*) are common, also white and red clovers. The white clover does not yield much nectar, but the sweet clovers are always reliable.

On the steep slopes, especially, occur Pasque-flower (*Anemone patens* var. *Wolfgangiana*), wind flower (*Anemone cylindrica*), golden Alexanders (*Zizia aurea*). On the Wabash silt loam where trees are remaining, grow elms (*Ulmus americana*), cottonwood (*Populus deltoides*), willows (*Salix amygdaloides, S. nigra, S.*

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17 Stevenson, W. H., Brown, P. E., Forman, L. W., and Warren, H. W., Soil Survey of Iowa, Buena Vista County, 16:1-54, f. 1-11, 1 map.

fluviatilis); on the hills adjacent to streams on east and north slopes are such trees as the red oak (*Quercus rubra*), hard maple (*Acer saccharum*), basswood (*Tilia americana*), ironwood (*Ostrya virginiana*), with such rich woodland species as blue violet (*Viola cucullata*), goldenrod (*Solidago serotina*), blue aster (*Aster sagittifolius*). The alsike clover (*Trifolium hybridum*) grows in abundance where the area is drained. The peat soils contain gentians (*Gentiana quinqueflora*) and boneset (*Eupatorium perfoliatum*).

Another county in the *Wisconsin drift* is Winnebago county, quite unlike other counties as a whole, because it is in the region of an important moraine, the Altamont. The soils of this county are discussed by the Soil Survey[18] Report of Winnebago County. In this county the Wisconsin drift sheet has two drift soils, the Clarion and the Webster. The Clarion loam is the more extensive, covering 45 per cent of this county. It is a black friable fine-textured loam or silt loam and locally contains a gray calcareus material. There is some variation where the Clarion loam is covered with forest growth. The land is gently rolling and this phase of the Clarion covers about 26.9 per cent of the county. The surface part of this material is a dark brown to black loam with sand and gravel. The Webster loam has been described for another area of the terrace type. The Waukesha loam should be briefly discussed. It is a dark brown coarse textured loam or sandy loam. There is also some Fargo loam, a heavy black silty loam which sometimes is quite sticky. There is much muck, which has been described for Buena Vista county.

The prairie types of plants of the Clarion loam consist of blazing stars (*Liatris scariosa, L. pycnostachya*), thistle (*Cirsium iowense, C. discolor*), compass plant (*Silphium laciniatum*), purple coneflower (*Brauneria purpurea*), coreopsis (*Coreopsis palmata*), prairie coneflower (*Lepachys pinnata*), evening primrose (*Oenothera serrulata*), psoralea (*Psoralea argophylla*), prairie rose (*Rosa pratincola*), aster (*Aster umbellata, A. sagittifolius, A. laevis, A. azureus*), goldenrod (*Solidago serotina, S. missouriensis, S. latifolia, S. ulmifolia, S. nemoralis, S. rigida*), prairie clovers (*Petalostemum violaceum* and *P. candidum*), Joe Pye weed (*Eupatorium purpureum* var. *maculatum*). The following trees are found in this soil: the oaks (*Quercus ellipsoidalis, Q. alba, Q. nigra, Q.*

18 Stevenson, W. H., Brown, P. E., Forman, L. W., Baker, W. S., and Artis, S. H., Soil Survey of Iowa, Winnebago County, 23:1-60, f. 1-10, 1 map (1922).

macrocarpa), cherry (*Prunus serotina, P. pennsylvanica*), walnut (*Juglans nigra*), butternut (*J. cinerea*), prairie willow (*Salix humilis*), dogwoods (*Cornus alternifolia, C. asperifolia*), choke cherry (*Prunus virginiana*), plum (*Prunus americana*), wild crab (*Pyrus ioense*), haw (*Crataegus coccinea*), sugar maple (*Acer saccharum* var. *nigrum*), basswood (*Tilia americana*), slippery elm (*Ulmus fulva*), wild grape (*Vitis vulpina*), Virginia creeper (*Psedera quinquefolia*), sumac (*Rhus typhina, R. glabra*), hickory (*Carya ovata* and *C. cordiformis*).

Madison county lies on the northern edge of the exposure of the *Kansan drift sheet*.[19] The soils of the county are classified under five types—drift, loess, terrace, swamp and bottom land, and residual soils. The drift soils are the Shelby loam and Lindley loam.

The Shelby loam is discussed in another connection. The Lindley loam is a light grayish brown to brown loam underlain by a light brownish gritty sandy loam. It often contains coarse sand and lime nodules. There are three loess soils, the Tama, Clinton, and Grundy soils. These three soils cover about 63.7 per cent of the area of the county. The Tama silt loam is dark brown mellow soil with yellowish brown, compact, friable subsoil and rolling topography. The Clinton silt loam has been described elsewhere. The terrace soils are of four types, the Waukesha, Bremer, Jackson and Calhoun. The largest of the terrace types lies along Middle river. This soil is a dark brown mellow silt loam and the subsoil is a heavy silt loam. The Bremer silt loam is dark brown to black and friable and is high in organic matter. Its subsoil contains a good many iron concretions. The Jackson silt loam is light brown to grayish brown and its topography is gently rolling. The Calhoun silt loam has been described elsewhere. The swamp and bottom land type covers only a small part of the county. The Wabash has been described elsewhere. The topography is level. There are two types of residual soils, the Sogn silt loam and the Hagerstown. The former type is derived from the weathering of limestone, which occurs in the valleys of South and North rivers and of Cedar, Jones and Clanton creeks. The Hagerstown silt loam is also residual soil and is light red to reddish brown. It occurs on the Clanton near East Peru and on Cedar creek and North river. The Shelby loam on sandy ridges and knolls grows such plants as the oaks (*Quercus*

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19 Stevenson, W. H., Brown, P. E., Benton, F. H., and Forman, L. W., Soil Survey of Iowa, Madison County, 26:1-56, f. 1-10, 1 map.

velutina, Q. rubra), slippery elm (*Ulmus fulva*), ash (*Fraxinus americana*), hickory (*Carya ovata, Q. alba*), lopseed (*Phryma leptostachya*), goldenrod (*Solidago ulmifolia, S. latifolia*), sunflower (*Helianthus strumosus*), pennyroyal (*Hedeoma pulegioides*), sugar maple (*Acer saccharum* var. *nigrum*), basswood (*Tilia americana*).

The Lindley loam contains oaks (*Quercus rubra, Q. alba, Q. macrocarpa*), hawthorn (*Crataegus mollis, C. punctata*), sumac (*Rhus glabra*), wild grape (*Vitis vulpina*), hazelnut (*Corylus americana*), sunflower (*Helianthus strumosus*), pennyroyal (*Hedeoma pulegioides*), arrow-leaved aster (*Aster sagittifolius*).

The Tama silt loam type was originally prairie and where not cultivated contained such plants as bush clover (*Lespedeza capitata*), prairie sunflower (*Helianthus grosseserratus*), prairie clovers (*Petalostemum candidum, P. purpureum*), Indian plantain (*Cacalia tuberosa*), Iowa thistle (*Cirsium iowense*), blazing stars (*Liatris scariosa, L. pycnostachya*), milk vetch (*Astragalus canadensis*), Culver's root (*Veronica virginica*), butterfly-weed (*Asclepias tuberosa*), and psoralea (*Psoralea tenuiflora*).

The Clinton silt loam was originally forested and includes such plants as hickories (*Carya ovata, C. cordiformis*), slippery elm (*Ulmus fulva*), ash (*Fraxinus americana*), sunflower (*Helianthus strumosus*) and artichoke (*H. tuberosa*). Sweet clover (*Melilotus alba*) is common, also such weeds as catnip (*Nepeta Cataria*) and sticktight (*Bidens aristosa*).

The Waukesha silt loam contains white elm (*Ulmus americana*), hackberry (*Celtis occidentalis*) and sumac (*Rhus glabra*). The chief plants of the Wabash silt loam are hackberry (*Celtis occidentalis*), hard maple (*Acer saccharum* var. *nigrum*), oak (*Quercus rubra*), cottonwood (*Populus deltoides*), boxelder (*Acer Negundo*), sticktight (*Bidens aristosa, B. discoidea*), artichoke (*Helianthus tuberosus*), an introduced plant, but covering much of the waste soil and an excellent honey plant, and ironweeds (*Vernonia fasciculata, V. Baldwini*).

The soils of Henry county may be taken as an illustration of the *Kansan drift*, although a small part of the eastern part of the county is influenced by the Illinoian drift sheet.[20] The upper layer is of a reddish brown color, and the lower part is yellowish becoming bluish, which is the typical color of the clay.

[20] Stevenson, W. H., Brown, P. E., Forman, L. W., and Benton, F. H., Soil Survey of Iowa, Henry County, 15:1-60; f. 1-12, 1 map.

There are three typical soil types in the county: the loess, the terrace, swamps and bottomlands. The Grundy silt loam covers the largest area in the county, 39.4 per cent. It is dark brown to nearly black and at depth of 18 or 20 inches changes into a gray silty clay.

The Clinton silt loam, which covers about 25 per cent of the county, is found along streams, such as the Skunk, Big and Little Cedars, and originally was covered with timber; it is light brown to grayish brown, with rolling topography.

The Wabash silt loam is related to the Clinton. There is but little surface soil and this too was originally covered with forest. The Grundy silty clay loam is a black silty clay loam and grades into a plastic, tenacious, silty clay. It is locally known as "gumbo."

The Buckner is brownish to dark brown, a very fine sandy loam. There are four bottom land types: the Wabash silt loam, described elsewhere, the Genesee fine sandy loam, yellowish brown color, the Genesee silt loam and Wabash silty loam.

The Grundy type belongs to the prairie and orginally was covered with prairie plants but now is in agricultural crops. Here various clovers like the white clover (*Trifolium repens*), red clover (*T. pratense*) and sweet clovers (*Melilotus alba, M. officinalis*) grow well. The prairies are left along the right-of-way of railways and highways. The type of bee plants found here are meadow sunflower (*Helianthus grosseserratus*), asters (*Aster novae-angliae, A. laevis, A. multiflorus, A. salicifolius*), goldenrods (*Solidago rigida, S. canadensis, S. serotina*), wild rose (*Rosa pratincola*), pleurisy root (*Asclepias tuberosa*), wild vetch (*Astragalus canadensis*), horse mint (*Monarda mollis*), culver's root (*Veronica virginica*), meadow rue (*Thalictrum purpurascens*).

On the Clinton silt loam, which has its best development along the Skunk and Big and Little Cedar creeks, there are such trees as hard maple (*Acer saccharum* var. *nigrum*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), bur oak (*Quercus macrocarpa*), red oak (*Q. rubra*), white oak (*Q. alba*), shingle oak (*Q. imbricaria*), slippery elm (*Ulmus fulva*), some American elm (*U. americana*), prickly ash (*Xanthoxylum americanum*), buckbrush (*Symphoricarpos orbiculatus*), hazelnut (*Corylus americana*), hickory (*Carya ovata*), red bud (*Cercis canadensis*), hackberry (*Celtis occidentalis*). The herbaceous plants are asters (*Aster Drummondii, A. sagittifolium*), pennyroyal (*Pycnanthemum pilosum,* *Hedeoma pulegioides*), goldenrods (*Solidago ulmifolia, S. latifolia*), sunflowers (*Helianthus strumosus*).

The terrace soils contain such plants as bush clover (*Lespedeza capitata*), New Jersey tea (*Ceanothus ovatus*), anemone (*Anemone cylindrica*), cow vetch (*Astragalus canadensis*), and in the Buckner sandy loam, melons and cucumbers are grown. The partridge pea (*Cassia Chamaecrista*) and wild bean (*Strophostyles angulosa*) are common.

The Wabash silt loam and Genesee soils originally contained a fine growth of trees like the green ash (*Fraxinus lanceolata*), soft maple (*Acer saccharinum*), red bud (*Cercis canadensis*), honey locust (*Gleditsia triacanthos*), buckeye (*Aesculus glabra*), coffee bean (*Gymnocladus dioica*). Smartweed (*Polygonum virginianum*), crownbeard (*Verbesina helianthoides*) and aster (*Aster Tradescanti*) are abundant. Wild indigo (*Amorpha fruticosa*), buttonbush (*Cephalanthus occidentalis*) and dogwood (*Cornus Amomum*) are woody plants of the region.

Muscatine county may be selected as an area the topography of which was modified by the *Illinoian drift sheet*, and also because of the proximity to Mississippi river, where there are considerable deposits of sandy soil.

The report[21] of the soils section of the Iowa Agricultural Experiment Station on the survey of Muscatine county states that six of the soil types of this county are of the loess type, and these cover 64 per cent of the area. These types include Muscatine, Memphis, Lindley and Knox.

The Muscatine silt loam is the most important type. The surface soil is black to brownish tough, compact silty clay; the subsoil is brownish gray to finely mottled yellowish brown or gray compact silty loam. These soil types contain sand dunes with the characteristic depressions commonly called kettle holes and "blow outs." Some of these dunes attain a height of 50 feet. The Muscatine silt loam is found along small streams.

The Knox fine sandy loam has been described in another connection. There are twelve types of terrace soils, which belong to the Buckner, Calhoun and Bremer. The topography of the Buckner is quite level and the surface material is friable, black to dark gray to brownish in color.

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21 Stevenson, W. H., Brown, P. E., and Johnson, H. W., Soil Survey of Iowa, Soil Survey Report of Muscatine County, 3:1-64, f. 1-15; 1 map, 1918.

The plant life in Muscatine county is interesting. The Muscatine silt loam, which is the chief type, belongs to the original prairie where such plants as asters (*Aster multiflorus, A. laevis*), prairie sunflower (*Helianthus grosseserratus*), goldenrods (*Solidago rigida* and *S. canadensis*), blazing star (*Liatris pycnostachya*), cow vetch (*Astragalus canadensis*) were abundant.

The Memphis silt loam was originally largely forested with such trees as hickory (*Carya ovata, C. alba*), oaks (*Quercus alba, Q. rubra, Q. macrocarpa*), box elder (*Acer Negundo*), basswood (*Tilia americana*), and here also grew asters (*Aster Drummondii, A. sagittifolius*), sunflower (*Helianthus strumosus*), wild grape (*Vitis vulpina*), sumac (*Rhus glabra*), goldenrods (*Solidago ulmifolia, S. latifolia*), violets (*Viola pubescens* and *V. cucullata*), lopseed (*Phryma leptostachya*), button bush (*Cephalanthus occidentalis*).

The exceptional area on Pine creek contains the white pine (*Pinus Strobus*), dogwood (*Cornus circinata*), mountain mint (*Pycnanthemum muticum*), huckleberry (*Gaylussacia resinosa*). Melons and cucumbers are cultivated. The Knox fine sand was originally largely prairie except for small scattered groves of oak (*Quercus macrocarpa, Q. ellipsoidalis*). It contains prairie clover (*Petalostemum violaceum, P. candidum*), bush clover (*Lespedeza capitata*), horse mint (*Monarda mollis*), five-finger (*Potentilla canadensis*), bird-foot violet (*Viola pedata*), puccoons (*Lithospermum canescens, L. angustifolius*), false indigo (*Baptisia leucantha*), wild lupine (*Lupinus perennis*), sumac (*Rhus glabra, R. Toxicodendron*), New Jersey tea (*Ceanothus ovatus*), tickseed (*Coreopsis palmata*), blue aster (*Aster sericeus*), milkweed (*Asclepias verticillata*), sunflower (*Helianthus petiolaris*). Watermelons and cucumbers are commonly cultivated.

The plant life of the Buckner silt loam is not essentially different from that of the Memphis silt loam. The Buckner loam contains chiefly sedges and grasses and such other plants as ironweed (*Vernonia fasciculata*) and sticktights (*Bidens aristosa, B. discoidea*). The Buckner sand, which is extensively developed in Muscatine Island, contains such herbaceous plants as clammy-weed (*Polanisia trachysperma*), bird-foot violet (*Viola pedata*), wild lupine (*Lupinus perennis*), hoary vervain (*Lithospermum canescens*), bush clover (*Lespedeza capitata*), spurge (*Euphorbia corollata*), milk vetch (*Astragalus canadensis*), breweria (*Breweria Pickeringii*), beard-tongue (*Pentstemon grandiflorus*), sunflowers (*Helianthus *petiolaris, H. occidentalis*), hoary vervain (*Verbena stricta*), false dragon head (*Physostegia virginiana*).

The Wabash silty clay loam at the south end of the island is largely in Wapello county and contains such trees as soft maple (*Acer saccharinum*), ash (*Fraxinus lanceolata*), wild grape (*Vitis vulpina*), hickories (*Carya laciniosa, C. illinoensis*), and such plants as boltonia (*Boltonia asteroides*), ironweed (*Vernonia fasciculata*), frog fruit (*Lippia lanceolata*), monkey flower (*Mimulus ringens*), asters (*Aster Tradescanti, A. sericeus*), goldenrod (*Solidago serotina*), Spanish needles (*Bidens cernua, B. aristosa*), smartweeds (*Polygonum incarnata, P. Muhlenbergii*) and blue vervain (*Verbena hastata*).

Linn County.—The soils of the *Iowan drift sheet* in this county have been investigated by the soil survey of the Iowa Agricultural Experiment Station and are quite typical also for other counties in this drift sheet. The authors[22] of the bulletin quoted report twenty-seven soil types in Linn county. The topography of the county is generally rolling, especially near streams, although back of Cedar and Wapsipinicon rivers the county is somewhat flat. The ridges are covered with a fine loess material. The drift soils belong to the Carrington and Clyde series; of the former, the Carrington silt loam, a dark grayish brown or nearly black friable silt loam, covers nearly half of the county and its subsoil contains glacial pebbles and boulders, while large surface boulders also are a characteristic feature. The topography of this loam is gently rolling and the area was originally prairie. The Carrington loam has little sand and is a grayish brown fine loam. There is a little of the Carrington fine sandy loam, of a brown or dark grayish brown color. The Carrington very fine sandy loam is dark brown and is subject to erosion. The Clyde silt loam covers about seven per cent of the county; it is a black silty clay loam. The subsoil is heavy and compact. This also was originally prairie. The loess soils are the Clinton, Tama silt loam, Lindley silt loam and Lindley fine sandy loam, Lindley loam and Lindley fine sand and Lindley very fine sandy loam. Clinton silt loam covers about 8 per cent of the area of the county. This material is a brownish or yellowish brown clay. It is found in the high ridges along Cedar and Wapsipinicon rivers. The Tama silt loam lies in many small areas on

22 Stevenson, W. H., Brown, P. E., Benton, F. H., and Rowe, F. B., Soil Survey of Iowa, Linn County, 17:1-60; f. 1-11, 2 maps, 1920.

idges. The surface soil is dark brown and rather compact and riginally was covered with trees and shrubs. The Lindley fine and, as its name indicates, is a fine sand, in color light grayish rown. The Lindley very fine sandy loam occurs on steep slopes or idges, chiefly along Cedar river. Originally this area also was overed with forest trees.

The plant life of these different soil types differs greatly. The nuck, consisting of silty material and impervious subsoil, during he spring is often covered with water and contains the nodding martweed (*Polygonum incarnatum*), ironweed (*Vernonia fasciculata*), buttercup (*Ranunculus aquatilis, R. delphinifolius*). The Sarpy fine sand is for the most part forested with such trees as the ed haw (*Crataegus mollis, C. punctata, C. margaretta*), wild crab-apple (*Pyrus ioensis*), wild plum (*Prunus americana*), white elm (*Ulmus americana*), soft maple (*Acer saccharinum*), willows (*Salix nigra, S. amygdaloides*), cottonwood (*Populus deltoides*), ash (*Fraxinus lanceolata*), asters (*Aster salicifolius, A. Tradescanti*), smartweed (*Polygonum virginiana*). The Wabash silt loam contains such trees as the red haw (*Crataegus mollis, C. punctata*), soft maple (*Acer saccharinum*), box elder (*Acer Negundo*), white elm (*Ulmus americana*), ash (*Fraxinus lanceolata*), ironweed (*Vernonia fasciculata*), aster (*Aster Tradescanti*), artichoke (*Helianthus tuberosus*), smartweeds (*Polygonum virginianum, P. incarnatum, P. pennsylvanicum*), etc.

The Buckner fine sandy loam was in part at least originally covered with trees and there may be found oaks (*Quercus velutina, Q. ellipsoidalis, Q. alba, Q. rubra*), aspen (*Populus tremuloides*), willows (*Salix humilis, S. discolor*), wild cherry (*Prunus serotina, P. pennsylvanicum*), wild crab apple (*Pyrus ioensis*), hawthorn (*Crataegus Margaretta*), asters (*Aster multiflorus, A. laevis*), stiff goldenrod (*Solidago rigida*). In clearings, such plants as goldenrods (*Solidago ulmifolia, S. latifolia*) are present. The plant life of the Carrington silt loam was at one time in part a forest of such trees as basswood (*Tilia americana*), hickory (*Carya ovata, C. cordiformis*), oaks (*Quercus alba, Q. rubra*), hard maple (*Acer saccharum* var. *nigrum*), as well as sunflowers (*Helianthus strumosus*), asters (*Aster laevis, A. multiflorus*), wind flower (*Anemone caroliniana*), hepatica (*Hepatica acutiloba*). In the undrained portion of the Carrington silt loam grew bunch flower (*Melanthium virginicum*), goldenrods (*Solidago serotina*), asters (*Aster novae-

angliae, A. prenanthoides). Of the loess soils the Lindley was originally covered with hickory (*Carya ovata, C. cordiformis*), basswood (*Tilia americana*), oak (*Quercus ellipsoidalis, Q. velutina, Q. alba, Q. rubra, Q. macrocarpa*), elms (*Ulmus americana, U. fulva*), quaking aspen (*Populus tremuloides*), sunflower (*Helianthus strumosus*), violet (*Viola cucullata*), anemone (*Anemonella thalictroides*), aster (*Aster sagittifolius*), boneset (*Eupatorium ageratoides*), crownbeard (*Verbesina helianthoides*). The Tama silt loam along some of the rivers contains a typical prairie flora where it is not cultivated. The Clinton silt loam, once heavily timbered, contains such plants as white oak (*Quercus alba*), red oak (*Q. rubra*), basswood (*Tilia americana*), hickory (*Carya ovata*), American elm (*Ulmus americana*), slippery elm (*U. fulva*), sumac (*Rhus glabra*), wild grape (*Vitis vulpina*), asters (*Aster Drummondii, A. sagittifolius*), Joe Pye weed (*Eupatorium purpureum* var. *maculatum*), goldenrods (*Solidago ulmifolia, S. latifolia*), violets (*Viola cucullata, V. pubescens*).

Allamakee county, in the northeastern section of Iowa, is in the so-called *driftless area* of the state where drift is thin or absent. There are some striking topographic differences in this county as compared with drift areas. There is not much mantle of drift. Doctor Calvin[23] remarks that small boulders have been found; these are the remnants of the Nebraskan drift. The Cambrian system of rocks contains the Croixan sandstone, which is exposed in numerous places along Mississippi river and at some places is exposed for a height of 300 feet, as at New Albin. The Oneota limestone covers all of the bluffs. The St. Peter sandstone lies above the Oneota and is an arenaceous deposit. It occurs pure white as well as in the shades of yellow, red or brown.

Doctor Calvin, in speaking of the soils of Allamakee county, says, "The amount of residual, insoluble matter in the rocks of Allamakee county, taking the sandstones, shales and limestones all together, would probably, according to observations made by McGee, exceed half the bulk of the original beds."

The valleys contain a rich alluvial deposit. The plant life of the loess soil consists of a deciduous forest covering all of the north and east slopes of hills along the streams, including such trees as white, black, bur and red oaks (*Quercus alba, Q. velutina, Q. macrocarpa, Q. rubra*), large-toothed and quaking aspens (*Populus grandiden-*

23 Report of Iowa Geological Survey, 4:83.

Quercus macrocarpa Michx. Bur Oak

FIG. 59.—Bur oak (*Quercus macrocarpa*). *Drawn by Ada Hayden.*

Large trees, some of them over 100 feet high, trunk 4 to 6 feet in diameter. Winter buds broadly ovate, reddish brown scales, pubescent. Bark thin, deeply furrowed; light colored scales. Leaves obovate or oblong, deeply divided, 5- to 7-lobed, terminal lobe larger, margins crenate, bright green above and paler pubescent beneath. Staminate flowers in slender catkins, pistillate flowers sessile or stalked. Fruit solitary, sessile or stalked. The cup covers about one-half of the acorn, or in some specimens most of it. Scales grayish, pubescent, the outer scales long.

The most widely distributed and most common oak in the state. Occurs from New Albin to Keokuk and west to Hamburg and Lyon county. Some very large trees occurred in this state at one time. The most famous specimen is the Council Oak at Sioux City.

FIG. 60.—Bur oak (*Quercus macrocarpa* var. *olivaeformis*). *Drawn by C. M. King.*

Date of bloom, Ames, April 25, 1927.

ata, P. tremuloides), wild crab-apple (*Pyrus ioensis*), wild plum (*Prunus americana*), birch (*Betula papyrifera*), white ash (*Fraxnus americana*), white elm (*Ulmus americana*), slippery elm (*U. ulva*), corky bark elm (*U. racemosa*), basswood (*Tilia americana*), ervice berry (*Amelanchier canadensis*), sumac (*Rhus glabra* and *R. typhina*), wild grape (*Vitis vulpina*), box elder (*Acer Negundo*), hoke cherry (*Prunus virginiana*), black cherry (*P. serotina*), hard naple (*Acer saccharum* var. *nigrum*), hickories (*Carya ovata, C. ordiformis*), dogwoods (*Cornus circinata, C. alternifolia, C. asperiolia*).

In midsummer and autumn we find skullcap (*Scutellaria parviflora*), Joe Pye weed (*Eupatorium purpureum* var. *maculatum*), blue lobelia (*Lobelia siphilitica*), goldenrods (*Solidago ulmifolia, S. latifolia*), sunflower (*Helianthus strumosus*), aster (*Aster Drummondii, A. sagittifolius*), white snakeroot (*Eupatorium ageratoides*), avena (*Geum canadense*), selfheal (*Prunella vulgaris*), horse mint (*Monarda mollis*).

In the alluvial bottoms along the Mississippi are cottonwood (*Populus deltoides*), white elm (*Ulmus americana*), ash (*Fraxinus lanceolata*), oak (*Quercus platanoides*), willows (*Salix nigra, S. amygdaloides, S. fluviatilis*), asters (*Aster Tradescanti*), goldenrod (*Solidago serotina*), smartweeds (*Polygonum acre, P. Muhlenbergii*), Joe Pye weed (*Eupatorium purpureum*), mint (*Mentha canadensis*), hedge nettle (*Stachys aspera*), boneset (*Eupatorium perfoliatum*), false dragon's head (*Physostegia virginiana*).

The loess and prairie and cultivated fields lie on the divides between the stream courses; some of this at one time was covered with trees. The soil is a rich loam retentive of moisture. Somewhat similar areas occur in the adjoining counties of Clayton, Winneshiek, Jackson, Fayette and Dubuque. These prairies are covered with a rich growth of white clover (*Trifolium repens*) which is not equalled elsewhere in Iowa.

The plants of this region are alsike clover (*Trifolium hybridum*), yellow upright clover (*R. procumbens*), Culver's root (*Veronica virginica*), meadow sunflower (*Helianthus grosseserratus*), blue aster (*Aster laevis*), New England aster (*A. novae-angliae*), white aster (*A. multiflorus, A. salicifolius*), goldenrods (*Solidago rigida, S. serotina, S. canadensis*), blazing star (*Liatris pycnostachya, L. scariosa*), thistle (*Cirsium discolor*), meadow-rue (*Thalictrum pur-*

purascens), horse mint (*Monarda mollis*), rattle-snake master (*Eryngium yuccifolium*), milk vetch (*Astragalus canadensis*).

The terrace soils along the Mississippi and the larger streams are made up of a sandy soil which is locally quite coarse. The plant life here is a typical sandy prairie type consisting of bergamot (*Monarda punctata*), spurge (*Euphorbia corollata*), goldenrods (*Solidago missouriensis, S. nemoralis*), sunflower (*Helianthus occidentalis*), butterfly-weed (*Asclepias tuberosa*), milkweed (*Acerates* sp.); ground cherry (*Physalis lanceolata*), milkwort (*Polygala sanguinea*), skull cap (*Scutellaria parvula*), blue vervain (*Verbena stricta*).

HONEY CROP SOURCES OF IOWA

O. W. PARK

The following is a brief discussion of the honey and pollen ants of Iowa from the standpoint of the honey producer.

Primary Sources.—Honey crops are produced with considerable gularity in Iowa from the following plants: (1) white clover, ?) white sweet clover, (3) basswood, (4) heart's-ease (*Polygonum*),) Spanish needle (*Bidens*) and (6) buckbrush (*Symphoricarpos*). he order of their importance varies from year to year but white veet clover has ranked first almost continuously during the last velve or fifteen years. Prior to that time white clover was condered the best honey-producing plant in the state. It still ranks rst in certain sections, notably in the northern tier of counties and, or the state as a whole, it probably ranks second in importance. he other four plants of this group may be said approximately to e for third place but, considering average conditions for a series f years, it is believed their relative importance is fairly well reprented by the order in which they are named above.

These sources may be referred to as (1) early and (2) late. Vhite clover, white sweet clover and basswood yield during June nd July, while heart's-ease, Spanish needle and buckbrush yield uring August and September. All three of the early sources proluce high quality honey of very light color and mild flavor. The hree late sources produce honeys which range from light to dark mber and from fairly mild to rather strong flavors. The greater art of the annual Iowa honey crop usually is produced from the arly sources. This is a fortunate situation because of the better lemand and higher prices obtained for light colored and mild lavored honeys.

Primary honey plants of Iowa, in approximate order of blooming

		Ranking according to honey produced: quantity	quality
Trifolium repens	white clover	2	1
Melilotus alba	white sweet clover	1	2
Tilia americana	basswood	3	3
Polygonum	heart's-ease	4	6
Bidens	Spanish needle	5	5
Symphoricarpos orbiculatus	Buckbrush, coral berry, Indian currant	6	4

Secondary Sources.—Secondary honey sources comprise two groups as follows: (1) Those which normally produce considerable nectar, frequently are important locally, and would be of major importance if generally abundant; and (2) those which are generally abundant but which yield a honey crop only occasionally.

Secondary honey plants of Iowa, in approximate order of blooming

Taraxacum	dandelion
Trifolium hybridum	alsike
Melilotus officinalis	yellow sweet clover
Trifolium pratense	red clover
Asclepias syriaca	milkweed
Fagopyrum esculentum	buckwheat
Melilotus alba (annual)	Hubam

Minor Sources.—Honey plants not mentioned in the preceding lists are considered minor sources as far as the state crop is concerned, but certain ones may be of considerable importance locally. A complete list of the minor honey plants of the state would be out of place in a brief resumé such as this is intended to be. On the other hand this summary would scarcely be complete without at least a partial list of the nectar and pollen plants which contribute so much to the honey crop, indirectly, through their timely stimulation of brood rearing and by filling in between more important honey flows.

Minor honey plants of Iowa, in approximate order of blooming

Acer saccharinum	silver maple
Salix	willow
Acer Negundo	box elder
Prunus	wild cherry
Prunus	plum
Pyrus	pear
Pyrus Malus	apple
Acer saccharum var. *nigrum*	hard maple
Prunus	tame cherry
Crataegus	hawthorn
Berberis	barberry
Cercis canadensis	red bud
Pyrus ioensis	wild crab apple
Lonicera	Tartarian honeysuckle
Gleditsia triacanthos	honey locust
Robinia Pseudo-Acacia	black locust
Brassica campestris	wild mustard
Symphoricarpos racemosus	snowberry
Elaegnus angustifolia	Russian wild olive
Catalpa sp.	catalpa
Rubus sp.	raspberry
Ligustrum sp.	privet
Nepeta Cataria	catnip
Monarda sp.	horse mint, wild bergamot
Solidago sp.	goldenrod
Aster sp.	aster

Plants valuable for pollen only, in approximate order of blooming

Ulmus sp.	elms
Populus sp.	poplar, cottonwood
Quercus sp.	oaks
Rosa sp.	roses
Zea Mays	corn
Ambrosia sp.	ragweed

BLOOMING SEASON OF IOWA HONEY PLANTS

C. M. KING

Iowa lies between latitude 40° 30′ and 43° 30′. The altitude ranges from 475 feet in southeast Iowa to nearly 1700 feet in northwest Iowa. There is an annual rainfall of about 32 inches fairly well distributed through the growing season and over the state, the greatest precipitation being usually in the southeastern part. The average temperature for the year is 49 degrees, mean daily maximum 59 degrees, mean daily minimum 39 degrees. Iowa is located in a rich agricultural section of the country, once largely prairie country, now diversified by timber regions and groves along the streams. The conditions favor a general distribution of a wide variety of honey plants.

The Iowa year affords possibility of about 215 days of bloom available to the hive bee. The first bloom comes in March, on trees with flowers preceding the leaves and fitted for wind pollination. Low growing plants next appear in protected places. Bloom increases rapidly with the lengthening days. Frequently we note different representatives of a family blooming about the same general time, as in the case of the Ranunculaceae, saxifrages, crucifers, Rosaceae, which come in the earlier part of the summer, followed by the pinks and Leguminosae; later comes species of *Polygonum* and finally the composites.

In late spring appears the dandelion bloom which although an introduced plant, may be pictured as brightening fields and waysides the state over. About June 1 clovers begin their extended bloom. In early July the basswood contributes in many sections of the state.

The flowers of the second half of the season are more numerous in kind and amount and sources for the bee are more varied than are those of the first half. In the southern half of the state *Symphoricarpos* continues to yield for a prolonged period.

In August *Polygonums* come into bloom and composites begin. Their contribution lasts about six weeks and closes the season. Both native and introduced plants and orchard and crop plants furnish a generous proportion of honey.

A record of the blooming time of Iowa plants shows a continuous succession of bloom throughout the season. Bloom begins two or three weeks earlier in the southern part of the state than in the northern part, moving northward about a degree each week. The order of bloom of flowers of particular importance to the bee, that is, of those which yield surplus, is as follows: Early trees (mostly native), dandelion (introduced), clovers (introduced), basswood (native), *Polygonums* (native), asters and goldenrod (native). Tiding over the intervals between the main sources of supply is a continuous succession of scores of honey-yielding plants available for daily needs of the hive. No part of the state is without a liberal distribution of honey plants in both kind and amount, so that bee-keeping may be carried on successfully in any locality in Iowa.

At present there are extensive areas of unused nectar-yielding plants where many colonies of bees might be established. Bloom is sufficient so that production of honey could readily be increased beyond the point where it would meet the demands of the state.

Important honey crop sources of Iowa[1] *(Listed in approximate order of flowering)*

2. Dandelion
3. Alsike
2. Yellow sweet clover
1. White clover
3. Red clover
1. Sweet clover
1. Basswood
2. Milkweed
1. Heart's-ease
1. Spanish needle
1. Buckbrush
2. Buckwheat
2. Hubam

1. Yields a honey crop with considerable regularity.
2. Yields surplus frequently when abundant.
3. Generally abundant but yields a honey crop only occasionally in Iowa.

Some plants which contribute to the honey crop indirectly[2] *(Listed in approximate order of blooming)*

Red Maple
1. Willow
1. Poplar
2. Box elder
2. Wild cherry
Plum
Pear
Apple
Hard maple
Tame cherry
2. Hawthorn
Barberry
Red bud
1. Oak
2. Wild crab apple
2. Tartarian honeysuckle
1. Rose
Honey locust
Black locust
Raspberry
Catalpa
1. Corn
1. Ragweed
Goldenrod
Aster

1. Valuable for pollen only.
2. Valuable principally for pollen.

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[1] O. W. Park.
[2] O. W. Park.

VISITS OF HONEY BEES

C. C. LOUNSBERRY

The subject of pollination of flowers by insects has claimed the attention of many distinguished botanists from Christian Conrad Sprengel, first to see its possibilities, to Hermann and Fritz Mueller, Darwin and others, down to the present time; but they all have tried to find and name the various insect visitors of each plant rather than to determine the number of times a named insect visited a particular flower or floret under continuous observation for a specified time.

Three years ago at the suggestion of Doctor Pammel, who has done such splendid work in economic botany, the writer undertook to observe the frequency of visits of the honey bee, *Apis mellifica,* to the same flower or floret of a plant in a day's time.

Regardless of colors, which observers state most attract honey bees, they showed great preference for pollen or nectar from plants of wide distribution in this locality (Ames), such as dandelion, the clovers, raspberry, basswood, the cucurbits, etc., but in times of dry weather or scarcity of their favorite plants, they were to be found on many plants which they ordinarily passed by. They confined their attention practically to the major honey plant in bloom in the locality as the so-called "honey flow" progressed. For instance, when the yellow sweet clover was in bloom honey bees paid no attention to the black medic with similar yellow flowers mixed through the patch, and in the white Dutch clover season, they worked the white Dutch clover, and except in a few instances passed by alsike clover blooms interspersed among it.

Three years ago I sat for hours watching honey bees visit red raspberry blooms and found they did not visit the particular bloom watched by me more frequently than once in 15 seconds, otherwise flying close and passing it by; the longer the time between visits, the longer the bee worked on that bloom. Another fact that tends to bear out certain plant physiologists in their theory of pumping action of cells was the greater rapidity with which the honey bees worked as the wind blew harder, swaying the plants. The nectar seemed to rise faster.

I visited the pumpkin and squash patch in the north garden eptember 12, 1927, before daylight, and heard the whir of wings f thousands of honey bees as they came from the south at daybreak nd commenced working the south end of the patch. The nectar ow was rather slow just at daylight but as the light grew stronger he honey bees flitted from bloom to bloom and in fifteen minutes he nectar was coming fast, the honey bees had reached the middle f the patch, and usually three remained in each bloom until they ot their load, a period which varied from a few minutes in the arly morning to more than an hour toward 11 o'clock. When the looms closed at about 11 o'clock very few bees were imprisoned, xcept wild gray bees, which apparently had strong mandibles and ut round holes and got out. I also watched them in 1928 and 1929 n my pumpkin breeding work south of the campus and found many honey bees imprisoned just after noon when I tore off female blooms open pollinated; but when disturbed the honey bees forced the wilted petals apart and flew away.

Other evidence of the adaptability of the honey bee, in using certain times of day, meeting adverse conditions of weather, or using flowers not generally considered bee flowers, was shown in 1927 when bees visited one variety of cantaloupe, thrusting their front legs into the bloom, then withdrawing them and rubbing them on their proboscides. I noticed this same method used by honey bees in getting nectar which was too deep for their proboscides when they worked cabbage blooms in 1929 in the college greenhouse. While the honey bee's mandibles are notably weak, apparently the proboscis is relatively strong, for in 1927, late in the season, in a grove of wild cherry near my home, where the fruit remained on certain trees because it was too bitter for the birds, I observed numerous bees working these overripe cherries. The bee would press the proboscis against the fruit, holding it by the front legs, and after about 10 seconds I saw the proboscis penetrate the skin up to the bee's head, as I sighted against the sky light. The bee would remain sucking the juice about five seconds and then fly away. Again, in 1927 and 1928 I watched honey bees visiting the milkweed plantation of the plant physiology department in the north garden. The honey bees would cross the florets in one direction, pull away and clean the sticky material on their proboscides and fly away. Contrary to many observers, in no case did I find a dead bee tangled in the blooms. I also watched bees work sunflower, poplar leaf scales, rosin weed and other plants in their quest for propolis, and I was unable to find any bees stuck fast to the plants.

Special times of day and certain humidity conditions also are used by honey bees in getting pollen. I watched the elderberry blooms for weeks before I saw a bee raking the flowers just after a rain. In 1927 I sat a whole afternoon and did not find a honey bee visiting the strawberries in bloom where the blooms were below the leaves, but in 1929 and 1930, where the blooms were clearly exposed I frequently found bees early in the morning raking the pollen.

This year (1930) in the dry weather on May 19 and 20, at the Horticultural Farm the bees were working the strawberries hard, apparently getting a little nectar as well as pollen. Many flowers are not open all day in sunny weather. The dandelion on dewy mornings is not open till about eight o'clock, and it closes its blooms near noon if the day is warm.

Honey bees, as well as bumble bees, use their weight and the strength of their legs to get the nectar of flowers. In the north garden I watched them working scarlet sage. They ran out on the bloom, bending it down, and sipped the nectar as it ran from the mouth of the corolla. Each year, early in the spring, honey bees come through the ventilators of the college greenhouse, and I have watched them on many blooms but was particularly interested in seeing them force open the lips of the snapdragon with their heads and forelegs. When they got in they did not come out at once, and some of them I could see inside the blooms against the western sun near sundown, but they were always gone in the morning.

Honey bees are most apt to work the higher flowers of a plant and pass over those not well exposed to the light, as in shaded places and dark places in ravines. The number of times they visit a plant during one year has no bearing on the number of times they will visit it another year except in a relative way. For instance *Rosa setigera* was visited 12 times an hour in 1927 and 48 times in an hour on July 8 this year.

The following are some observations on economic plants as to frequency of visits of honey bees to a certain bloom of a plant in an hour and the estimated number of visits in the time the bees work that plant in a day.

Quercus macrocarpa var. *olivaeformis* (Michx. f.)

More or less shaggy in character. Scaly. Sometimes scales nearly cover the acorn.

Common in western Iowa.

Quercus bicolor Willd. Swamp White Oak

Fine tree 60 to 70 feet high, 2 to 3 feet in diameter. Winter buds broadly ovate and chestnut brown. Scales somewhat pubescent and

FIG. 61.—Swamp white oak (*Quercus bicolor*). Found near McGregor, Iowa.

Date	Plant	Visits per hr.	Est. No. per da.	Time of visit
June 17	Yellow sweet clover, *Melilotus officinalis*	30	300	1-2 sec.
	Alsike, *Trifolium hybridum*	10	100	2-3 ,,
	White Dutch clover, *Trifolium repens*	11	110	2-3 ,,
June 18	Red raspberry, *Rubus strigosus*	54	540	2-10 ,,
June 20	Watermelon, *Citrullus vulgaris*	16	160	2-3 ,,
	Cantaloupe, *Cucumis melo*	20	200	2-10 ,,
	Pumpkin, *Cucurbita pepo*	76	450	1-30 min.
	Cucumber, *Cucumis sativus*	20	200	2-4 sec.
	W. India gherkin, *Cucumis anguria*	12	120	2.10 ,,
	Martynia, *M. louisiana*	24	240	2-10 ,,
Sept. 12	Squash, *Cucurbita maxima*	132	792	8 sec.-30 min.
	Dandelion, *Taraxacum officinale*	20	100	1 sec.
1928				
	Basswood, *Tilia americana*	15	150	1-3 ,,
	Corn, *Zea Mays*	12	50	2-3 ,,
1929				
	Apple, *Pyrus Malus*	10	100	1-2 ,,
	Sunflower, *Helianthus annuus*	16	160	1 ,,
1930				
	Strawberry, *Fragaria vesca americana*	24	240	1-2 ,,
1927	*Other observations*			
June 14	Black raspberry, *Rubus occidentalis*	39	390	1-3 ,,
	Blackberry, *Rubus allegheniensis*	24	240	1-3 ,,
June 15	*Ptelea trifoliata*	24	240	1-2 ,,
	Philadelphus coronarius	14	140	1-2 ,,
June 16	*Amorpha fruticosa*	10	100	2-5 ,,
	Elaeagnus angustifolia	27	270	1 ,,
June 20	Waterleaf, *Hydrophyllum macrophyllum*	34	340	1 ,,
	Wild Geranium, *Geranium maculatum*	32	320	3-5 ,,
Sept. 5	*Bidens frondosa*	20	200	1 ,,
	Jewel weed, *Impatiens biflora*	12	130	3-5 ,,
	Alfalfa, *Medicago sativa*	12	120	1 ,,
	White sweet clover, *Melilotus alba*	24	240	1 ,,
	Sweet peas, *Lathyrus odoratus*	12	120	2-3 ,,
	Lythrum salicaria	16	160	1 ,,
	Bignonia radicans	14	140	10-20 ,,
	Gladiolus	10	100	6-30 ,,
	Lilium speciosum	12	120	5-20 ,,
	Polygonum pennsylvanicum	20	200	1 ,,

THE WEATHER AND HONEY PRODUCTION

L. A. KENOYER

The weather and its changes exert a marked influence on honey production.

That fact stands out clearly in the daily records of the weight of a hive of bees and of the accompanying weather conditions, kept for 29 years by J. L. Strong, a successful beekeeper of Clarinda, Page county, Iowa, and furnished for study to the Iowa Agricultural Experiment station.

The month of June, these records show, is preëminently the honey month of the year, with 56 per cent of the entire production of the hive for the period to its credit. Moreover, the honey production in June is an index for the production for the entire year, which is large or small according as the June gain is relatively large or small. Rather abundant rain is favorable for large honey production and especially if the rainfall in May is rather heavy, although excessive rain is likely to result in a poor honey year. South winds are apparently more favorable for good gains than winds from the other directions. The period of a rain is generally a time of depression in honey flow, and the clear days just preceding a rain show slightly greater increase than the days immediately following. Higher temperatures are accompanied by larger honey gains than lower, and a low barometer is favorable for good yields. A cold winter seems not to cut the yield of the succeeding season, but a cold March does.

In these and various other ways the records point to a direct relationship between weather and honey production, and they confirm many of the extended observances of experienced bee keepers.

SOURCE OF THE DATA[1]

The presentation in this bulletin of detailed data on the influence of weather on honey yield is made possible through the coöperation of J. L. Strong, who placed his extended records at the service of

1 Acknowledgments are due not only to J. L. Strong for furnishing the daily records on which the bulletin is based, but also to F. C. Pellett, bee inspector for Iowa, for securing them, to A. S. Van Sandt, G. M. Chappell and L. A. Welch for additional weather data, and to Dr. E. F. Phillips of the U. S. Department of Agriculture, Drs. L. H. Pammel and C. E. Bartholomew of Ames, Mr. F. C. Pellett, and C. P. Dadant for valuable suggestions in the use of the data.

he Iowa Agricultural Experiment station. These records were arefully made from day to day, through the period of 29 years rom 1885 to 1914. Each day's entry records the weight of one ive and also gives notes on weather conditions for the day. Other neteorological data for the locality of Mr. Strong's apiary, including barometer readings, were obtained from A. S. Van Sandt, the J. S. coöperating weather observer for that vicinity. The mean nonthly temperatures and rainfalls before 1890 were furnished by he U. S. weather bureau office at Omaha, Nebraska, because prior o 1890 no local records were kept at Clarinda.

Mr. Strong's apiary at Clarinda, Page county, is located in southwestern Iowa. In that region, as in most of the north Mississippi valley, white clover is the leading honey plant. Mr. Strong names as outstanding honey plants of his section, white clover, alsike clover, basswood, and smartweed; as those of secondary importance, he gives buckwheat and Spanish needle; as those which bees visit for nectar, but which probably produce a negligible amount of honey, he mentions willow, pear, apple, plum, red raspberry, black raspberry, blackberry, white and red clover, sweet clover, catnip, coral berry, goldenrod and dandelion. Some would differ with him as to the relative value of some of these plants, yet it is probable that his judgment is in the main correct for the region and the period under observation.

JUNE IS BEST HONEY MONTH

That June is preëminently the honey month of the year is one of the most outstanding facts attested by this 29 year record of daily honey gains. Fifty-six per cent of the entire gain in weight of the hive during the time recorded is credited to this month.

The average monthly distribution of increase in pounds is shown in table I.

Table I. Average monthly increase in honey for 29 years

April	1.2 lbs.
May	4.8 lbs.
June	59.6 lbs.
July	25.7 lbs.
August	9.9 lbs.
September	5.0 lbs.
Annual	106.2 lbs.

It will be seen that except in June and July, the honey crop is almost negligible.

Furthermore, the June flow is an index of the crop for the year. Of the ten best Junes, eight agree with the ten best years, likewise eight of the ten poorest Junes fall in the ten poorest years. It is still more remarkable that July flow is largely determined by that of June. Of the ten best Julys of the record, eight follow Junes of the leading ten, while seven of the ten poorest Julys follow poorest Junes.

A good honey crop tends to be preceded and followed by a poor one, very much as is known to be the case with the apple crop. The facts are shown in table II:

Table II. Relation of good and poor production years

Average for year preceding ten best years	74.6 lbs.
Average for year following ten best years	71.9 lbs.
Average for year preceding ten poorest years	136.5 lbs.
Average for year following ten poorest years	126.3 lbs.

A random arrangement of the annual yields would not show this contrast. Evidently there is in a year of heavy yield exhaustion of the honey plants from which they do not quite recover in the following year.

RAIN AND HONEY PRODUCTION

Rather abundant rain seems essential to stimulate plants to the vigor necessary to nectar production and to furnish the water contained in the secretion.

The important time for rains is indicated in table III.

Table III. Rainfall in good and poor years of honey production

	Av. for 10 best years	Av. for 10 poorest years
Precipitation for year	33.49 inches	30.32 inches
Precipitation for preceding year	35.09 inches	30.39 inches
Precipitation for preceding July-September	11.75 inches	10.12 inches
Precipitation for preceding October-December	6.63 inches	4.71 inches
Precipitation for preceding January-March	3.97 inches	3.64 inches
Precipitation for April	2.99 inches	2.59 inches
Precipitation for May	6.51 inches	3.02 inches
Precipitation for June	4.07 inches	4.87 inches

Some poor honey years are poor because of excessive rain; for example in one of them, 1902, June had 11.64 inches of rainfall. June, 1911, goes to the other extreme with .76 inch, and is also poor.

But the value of rain prior to the season is shown by all the sets of figures in the table, particularly those for May. Of the 10 Mays on our list having a rainfall of 5 inches and above, only two fail to be precursors of honey years falling in the "10 best" group, and

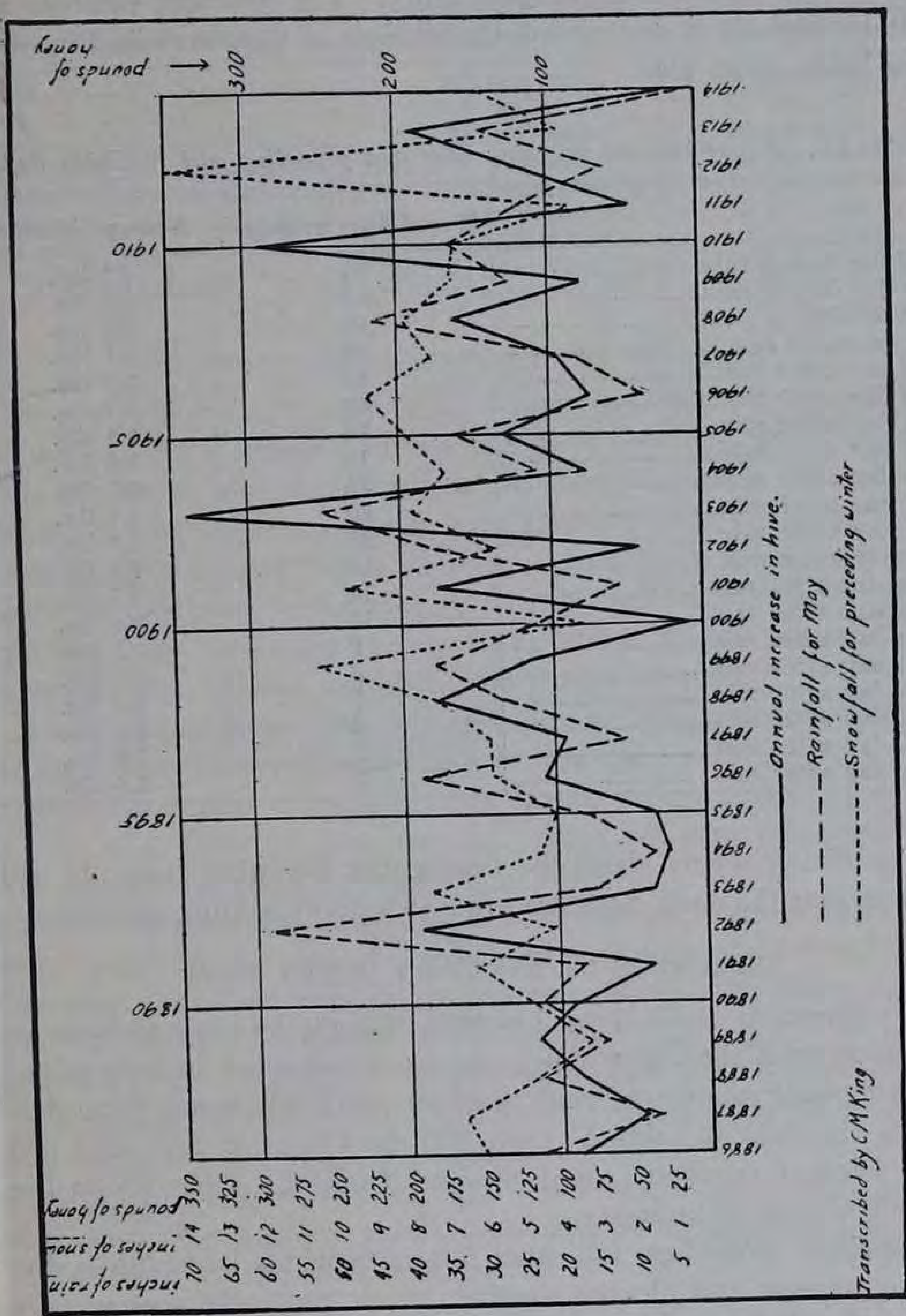

FIG. 569.—Curves showing relation of May rainfall and preceding winter's snowfall to honey production through a 29 year period.

one of these falls but little short of reaching the group. This is doubtless due to the fact that the honey plants, particularly the clovers, become established by humid weather in May.

A rainy period seems in general to be a time of depression in the honey flow. A comparison was made of the increase on rainy days with that on the few days preceding and following a rain, when these days were themselves not rainy. The averages embrace all suitable periods in our record, the number of days averaged in each case being given also.

Table IV. Honey increase on rainy days and preceding and following days

	No. of days averaged	Average increase
2nd day before rain	61	4.3 lbs.
1st day before rain	76	4.2 lbs.
Day of rain	80	2.2 lbs.
1st day after rain	80	3.7 lbs.
2nd day after rain	65	3.9 lbs.
3rd day after rain	49	3.7 lbs.
4th day after rain	34	4.6 lbs.
5th day after rain	18	3.6 lbs.
6th day after rain	35	3.3 lbs.
7th day after rain	30	2.8 lbs.
8th day after rain	21	3.7 lbs.
9th day after rain	16	3.8 lbs.
10th day after rain	14	3.5 lbs.
11th day after rain	14	3.4 lbs.
12th day after rain	9	3.1 lbs.
13th day after rain	8	3.9 lbs.
14th day after rain	7	3.7 lbs.
15th day after rain	6	2.3 lbs.
16th day after rain	5	1.8 lbs.
17th day after rain	5	1.6 lbs.

The climax occurs about the fourth day following rain. It will be seen that the daily decrease after this point is quite gradual.

INFLUENCE OF WINDS ON HONEY FLOW

The direction of the wind has been thought by some to have an influence upon the honey flow—one Iowa beekeeper in a questionnaire recently conducted replying that south winds are favorable. Hence the data in table V from 200 days each of high and low gain selected in about equal number from the same producing periods will be of interest:

The slight advantage indicated for south winds is doubtless due to the warmer and clearer weather which generally accompanies them; the slight disadvantage for east winds, to the clouds and rain which they frequently bring.

able V. Relation of wind to daily honey increase in 200 days of high and low gain respectively

Wind direction	Percentage of days of high increase	Percentage of days of low increase
outh	56 per cent	43 per cent
ast	9 per cent	17 per cent
orth	14 per cent	14 per cent
Vest	3 per cent	3 per cent
outheast	9 per cent	12 per cent
ortheast	4 per cent	3 per cent
outhwest	4 per cent	5 per cent
orthwest	1 per cent	3 per cent

TEMPERATURE AFFECTS HONEY INCREASE

Several beekeepers have told us the best weather for honey pro-uction is sultry weather, of the sort that precedes rain. In our able the days just preceding rain do show a slightly greater in-rease than the days just following. However, the honey gain on hese days is greater when they are clear than when they are loudy or partly so, there being for the day before rain an average ain of 4.7 lbs. if this day is clear and of 3.8 if it is cloudy, and for he second day before, just about the same average.

Most beekeepers on being asked as to the temperature desirable or best honey production will answer that hot weather is best. So t seems desirable to compare the mean temperatures of good nonths with those of poor months. Such temperatures together vith rainfall are given in table VI.

It will be seen that the good months average warmer than the oor, except in the case of August, where there is practically no lifference. The most remarkable difference is shown by those border nonths, May and September, which are ordinarily too cool in Iowa or much honey production. A low rainfall in these months seems dvantageous, because rainy conditions are most likely to be asso-iated with low temperature averages. June, the wet month of the year, should be a little drier than the average for a good yield, while July, often too dry, should be a little wetter than the average.

A study of all the cases in which the gain for single days is un-loubted (for part of our record has days grouped in twos and threes) shows that 61 per cent of the entire gain in weight was made on clear days, 13 per cent on partly cloudy, 13 per cent on cloudy, and 13 per cent on rainy. Clear days are preëminently the days for honey production. For June, clear days average 4.3 lbs. in-

Table VI. Relation of temperature, rainfall and honey yield with best yielding months and poorest compared

	Best				Poorest			
	No. of months	Mean temp.	Rainfall	Av. yield honey	No. of months	Mean temp.	Rainfall	Av. yield honey
May	10	62.5°	4.07 in.	13.2 lbs.	15	60.4°	5.55 in.	0 lbs.
June	10	71.4°	3.78 in.	109.8 lbs.	10	70.9°	5.55 in.	18.3 lbs.
July	10	77.0°	4.54 in.	61.8 lbs.	10	76.0°	2.99 in.	.8 lbs.
Aug.	10	74.3°	3.71 in.	32.6 lbs.	15	74.4°	3.75 in.	0 lbs.
Sept.	8	66.0°	1.90 in.	16.3 lbs.	15	64.9°	4.11 in.	0 lbs.

crease per day, partly cloudy days 3.6 lbs., cloudy days 3.8 lbs., and rainy days 2.7 lbs. On some rainy days the increase was so slight that the weight was not recorded, so the average just given for such days is rather too high.

An examination of the same data shows that the morning temperature ranges between 40° and 70° as a rule, there being only one day on the record in which there was a gain in weight on a day that begins with a lower temperature than 40°. F. L. Sladen, however, states that the best honey day in a two-year record kept in England was from the heather plant following a morning of heavy frost. The Iowa record shows little relation between the average morning temperature and yield. For as table IX indicates, the days of good yield have practically the same minimum or morning average as the days of poor yield chosen from the same period, no matter from what months of the year the period is chosen.

Table VII shows the relation between maximum temperature and yield from all single days recorded.

Table VII. Relative total yields of honey at different temperatures for all single days recorded 1885 to 1914

Temperatures	Percentage of total honey produced 1885-1914
Less than 70°	1
70-80°	8
80-90°	53
90-100°	37
Over 100°	1

All the days of June, July, and August for the period are grouped in table VIII.

'able VIII. *Relative total yields of honey at different temperatures for all days of June, July, and August, 1885-1914*

Temperatures	Percentage of total honey produced
All days less than 80°	17.3
All days from 80° to 90°	45.4
All days over 90°	37.3

Hence it appears that the days attaining a maximum between 80° nd 90° are the best yielding days, being even slightly superior to hose of higher temperatures, for 53 per cent of the days yield 45.4 er cent of the honey. This may be due to the fact that dry weather s so often associated with 90° days.

Table IX shows that good days as a rule have a maximum temper- ture higher than that of the poor days from the same period.

This table includes all the continuous periods of increase of the 29-year record, and the days of high and low gain are in all cases bout equally distributed through the period. Twenty-six such eriods with an aggregate difference in range of 106.7° have the greater range on the good yielding days, while on the other hand 13 with an aggregate difference of 15.9° have it on the poor yielding lays. This strongly indicates that days with a wide range are the est days for honey production.

The indication is borne out even more fully if, instead of using he figures of the U. S. observer as has been done by the author from 1893 onward, Mr. Strong's data be used. The latter data are based on early morning and midafternoon temperatures, which are more o the point than daily maximum and minimum temperatures, in- asmuch as the author has shown experimentally that low tempera- tures favor the accumulation of sugar and high temperatures the secretion of the accumulated sugar.[2] If Mr. Strong's figures are used throughout, we find favoring the theory 32 periods with an aggregate difference of 149.8°, opposing it 6 periods with an ag- gregate difference of 10.1°.

To be sure cloudy and rainy days are apt both to be days of low production and to have low temperature ranges. So it was thought well to give, besides the general average range, the average range for clear days. It will be seen that this generally agrees with the statement we have made.

In the same table are given the averages of barometric readings,

2 See the following paper.

Table IX. Temperature and barometer record for good and poor honey yielding days, 1885 to 1914

Period	Good yielding days						
	No. of days	Av. gain lbs.	Av. min. temp. (°)	Av. max. temp. (°)	Av. temp. range (°)	Range clear days (°)	Barom.
Sept., 1885	6	8	57.8	85.3	27.5		
June, 1886	9	6.1	63.0	90.6	27.6	28.0	
June, 1887	4	3.4	63.5	87.5	24.0		
June, 1888	2	3	64.0	92.0	28.0		
Aug.-Sept., 1888	10	5.3	52.0	82.7	30.7	31.8	30.11
June-July, 1889	14	5.3	57.8	86.3	28.5	29.0	30.08
May-June, 1890	5	4.8	60.6	87.4	26.8		29.72
July, 1890	6	2.7	71.7	95.8	24.1	27.3	
June, 1891	10	2.2	62.7	85.0	22.3		
June-July, 1892	16	6.7	61.0	88.2	27.2	29.6	30.03
June-July, 1893	8	2.1	65.2	83.6	18.4		29.90
June, 1895	3	5	59.7	82.4	22.7	24.0	29.93
June-July, 1896	9	5.1	63.4	87.0	23.6	21.1	29.93
May, 1897	6	2.5	53.2	75.7	22.5		30.06
June, 1897	13	4.8	69.0	88.5	19.5	21.1	29.84
June, 1898	15	5.7	67.5	83.4	15.9		29.92
Aug., 1898	9	2.5	73.3	95.9	22.6		29.90
June-July, 1899	8	6.8	61.5	90.4	28.9	29.0	30.00
June, 1900	6	2.5	58.7	88.5	29.8		29.93
June, 1901	14	6.7	64.9	88.5	23.6	30.8	29.86
Aug., 1901	9	3.4	59.9	95.8	35.9		30.00
June, 1902	3	4.3	59.0	88.8	29.8		29.83
July, 1902	8	3.6	64.0	87.2	23.2		29.94
June-July, 1903	24	8.1	57.1	87.7	30.6	31.4	29.90
Aug., 1903	7	6.8	62.9	89.7	26.8	26.8	29.87
May, 1904	8	1.4	41.0	67.5	26.5	25.8	
June-July, 1904	16	3.8	56.8	81.0	24.2		
June-July, 1905	16	6.3	58.6	84.6	26.0	25.7	
June, 1906	5	4	52.0	83.8	31.8	31.8	
June-July, 1907	10	3.9	61.8	88.6	26.8	27.0	
Aug., 1907	11	2.6	58.7	86.3	27.6	27.0	
June-July, 1908	16	5.2	59.4	82.6	23.2	26.0	
Sept., 1908	5	5.6	57.6	86.2	28.6		
June-July, 1909	7	5.7	64.7	86.1	21.4		
June-July, 1910	20	9.2	60.2	85.9	25.7	25.7	
Aug., 1910	7	4.9	68.0	85.3	17.3		
June, 1911	6	4.2	62.5	84.5	22.0		
June-July, 1912	5	7	61.7	93.0	31.3		
Aug., 1912	3	4	61.3	90.3	29.0		

small, on the larger branches papery or curling back. Bark of small branches reddish or purplish, brown on the larger trees. Leaves obovate or oblong-obovate, usually soft downy and white hoary beneath. Cup about half as long as the acorn, woody; acorn an inch to $1\frac{1}{2}$ inches long.

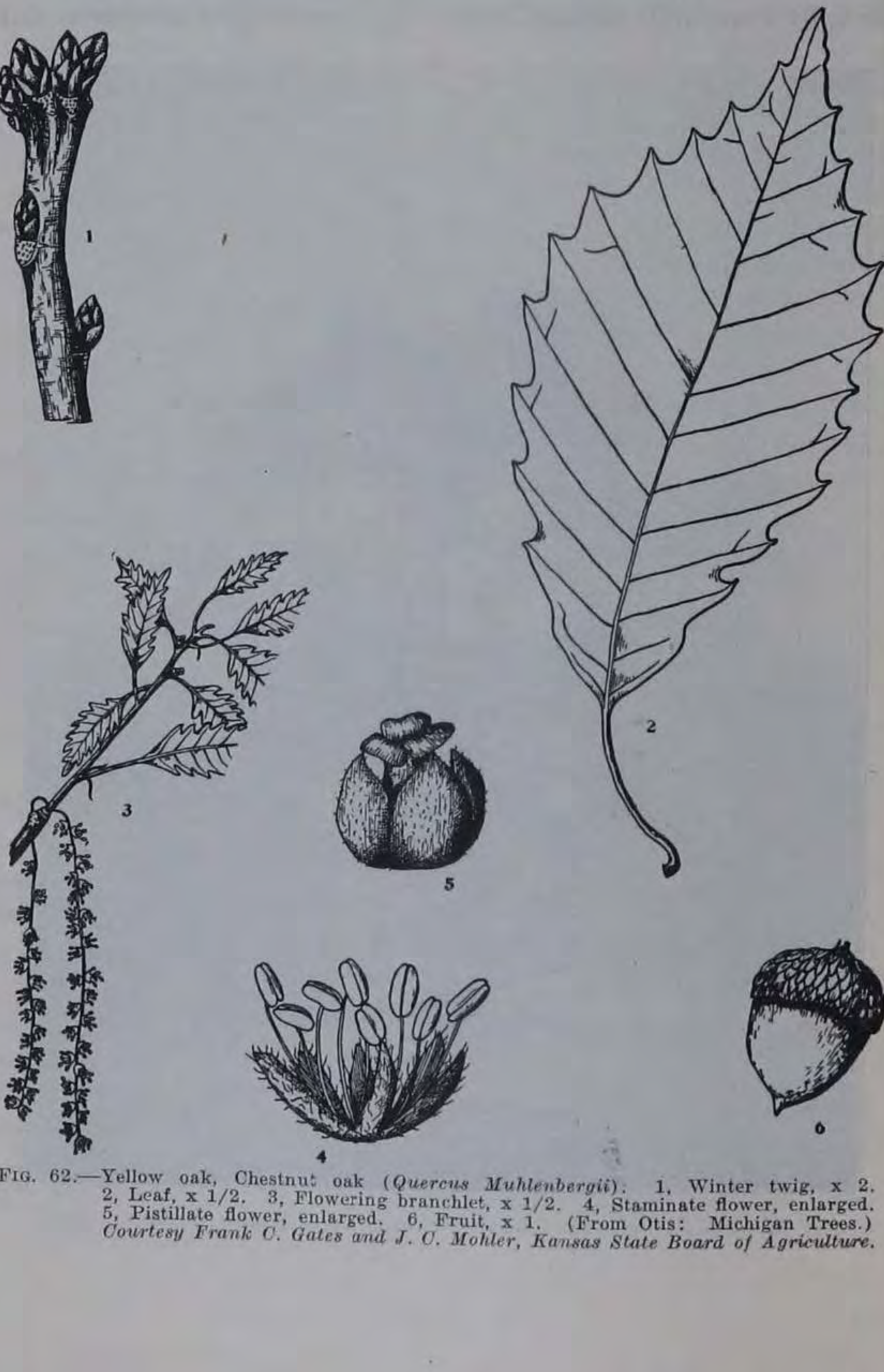

FIG. 62.—Yellow oak, Chestnut oak (*Quercus Muhlenbergii*). 1, Winter twig, x 2. 2, Leaf, x 1/2. 3, Flowering branchlet, x 1/2. 4, Staminate flower, enlarged. 5, Pistillate flower, enlarged. 6, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Table IX (continued)

Period	Poor yielding days							Excess of temp. range good days	Excess of barom. poor days
	No. of days	Av. gain lbs.	Av. min. temp. (°)	Av. max. temp. (°)	Av. temp. range (°)	Range clear days (°)	Barom.		
ːpt., 1885	7	1.5	54.7	77	22.3			5.2	
ıne, 1886	10	2.2	59.6	81.3	21.7	20.8		5.9	
ıne, 1887	4	.5	65.0	83.0	18.0			6.0	
ıne, 1888	3	1	64.0	84.6	20.6			7.4	
ug.-Sept., 1888	7	1.3	57.6	82.1	24.5	29.7	30.09	6.2	–.02
ıne-July, 1889	14	1	61.0	84.2	23.2	28.2	30.04	5.3	–.04
ːay-June, 1890	9	.2	60.9	80.0	19.1		29.78	7.7	.06
uly, 1890	9	.5	67.4	92.8	25.4		26.1	–1.3	
une, 1891	20	0	61.0	75.0	14.0			8.3	
une-July, 1892	11	1.6	60.8	87.4	26.6	27.6	29.98	.6	.05
une-July, 1893	20	.4	63.4	82.1	18.7		29.96	– .3	.06
une, 1895	4	0	58.5	79.0	20.5	20.0	30.02	2.2	.09
une-July, 1896	9	1.8	58.1	77.4	19.3	22.7	30.05	4.3	.12
[ay, 1897	7	0	50.3	73.6	23.3		30.04	– .8	–.02
une, 1897	9	.7	53.2	72.4	19.2	24	29.94	.3	.10
une, 1898	12	.6	65.7	82.1	16.4		29.96	– .5	.04
ug., 1898	9	1	75.1	92.8	17.7		29.92	3.1	.02
une-July, 1899	12	3	60.2	87.1	26.9	28.4	30.04	2.0	.04
une, 1900	10	0	59.1	83.6	24.5		29.97	5.3	.04
une, 1901	16	.7	60.9	82.4	21.5	23.0	29.90	2.1	.04
ug., 1901	9	.1	60.3	93.8	33.5		30.01	2.4	.01
une, 1902	12	0	55.3	75.5	20.2		29.95	9.6	.12
uly, 1902	8	0	63.1	87.9	24.8		30.04	1.7	.10
une-July, 1903	15	1.5	57.7	81.1	23.4	29.5	29.96	7.2	.06
ug., 1903	7	1.9	60.3	83.6	23.3	24.0	29.95	3.5	.08
Iay, 1904	8	0	47.4	70.4	23.0	23.2		3.5	
une-July, 1904	16	0	57.8	82.3	24.5			– .3	
une-July, 1905	11	0	60.6	82.6	22.0	21.4		4.0	
une, 1906	6	1.5	56.2	87.2	31.0	27.5		.8	
une-July, 1907	13	1.1	59.1	89.0	29.9	30.0		–3.1	
ug., 1907	11	.4	62.3	88.4	26.1	29.0		1.5	
une-July, 1908	18	1.3	61.8	85.6	23.8	25.2		– .6	
ept., 1908	7	2.7	54.8	84.3	29.5			– .9	
June-July, 1909	7	.6	60.5	82.6	22.1			– .7	
June-July, 1910	13	2.1	56.9	82.6	25.1			.6	
Aug., 1910	7	.2	56.0	74.9	18.9			–1.6	
June, 1911	12	1.3	61.6	86.4	24.8			–2.8	
June-July, 1912	5	8	61.8	95.8	34.0			–2.7	
Aug., 1912	7	1.1	63.6	92.9	29.3			– .3	

taken three times daily during each period and corrected to sea level. Sixteen cases with an aggregate difference of 1.03 inch, against 3 cases with an aggregate difference of 0.08 inch, show that a low barometer favors honey production.

There is but one case in which the figures for temperature range and pressure both disagree with what has been stated, and this is a period in May of not very great yield. It may be worth while, then, to introduce a rule for honey production, stating that it is theoretically equal to 1/5 the daily temperature range, measured in degrees Fahr., minus excess corrected barometric pressure over 30 in., measured in tenths of an inch.

COLD WEATHER AND HONEY YIELD

One matter that has aroused the curiosity of bee-men is the possible relationship of cold weather the previous winter to yield for the summer. Hence the facts in table X are submitted:

Table X. Relation of winter temperatures to succeeding honey yields

	Winter preceding	
	Ten best years	Ten poorest years
Av. mean temp. for Dec., Jan., Feb.	23.3°	24.4°
Av. mean temp. for March	38.7°	33.1°
Average number days below 0°	15.6	12.0
Average lowest temperature	21.3°	16.8°

It would perhaps be straining the point to argue that a cold winter has been beneficial, but we certainly cannot hold that it is detrimental. A warm March, however, seems to make more certain a good year. This is doubtless due both to the more rapid building up of the bee colony and the greater vigor given to the clover by lack of severe weather in March.

Investigation of the relation of the yield to snowfall the previous winter gives interesting results. The average for the winter preceding the ten best honey years is 38.92 inches while that for the winter preceding the ten poorest is 27.08 inches, the difference being 11.84 inches in favor of the good years. For the earlier years of the period the snowfall record for Clarinda is not at hand and it was necessary to substitute that for Omaha, which, of course, would be similar. If these years are omitted the difference in favor of the good years becomes increased to 16.51 inches. While 8 of the 9 good years in this portion of the period are preceded by snowfalls of over 30 inches, only one poor year is so preceded, and this is the best year of the 7 in this portion. Evidently a heavy snowfall the preceding winter is decidedly beneficial to the honey yield. In the benefit are doubtless involved both the increased amount of available moisture, and protection afforded the clover plant by the snow covering.

CONCLUSIONS[3]

1. June yields 56 per cent of the annual hive increase, July about half of the remainder.
2. A large June increase is indicative of a good honey year.
3. There is an evident alternation between good and poor years.
4. A good year has a rainfall slightly above the average, the honey season being preceded by an autumn, winter and spring with more than the average precipitation.
5. A rainy May scarcely fails to precede a good honey season.
6. South wind seems favorable and east wind unfavorable.
7. The yield shows a gradual depression preceding and a gradual increase until about the fourth day following a rainy day, after which it remains fairly constant until about the fourteenth day following the rain.
8. Good honey months average slightly higher in temperature than poor, this being especially true of the spring and fall months.
9. Clear days are favorable to production of honey.
10. Yield is best on days having a maximum of 80 to 90° Fahr.
11. A wide daily range of temperature is favorable for a good yield.
12. A low barometer is favorable for good yield.
13. The fluctuations in yield for a producing period seem to be closely correlated with the temperature range and the barometric pressure, acting jointly.
14. A cold winter has no detrimental effect on the yield of the succeeding season, but a cold March reduces it.
15. A winter of heavy snowfall is in the great majority of cases followed by a larger honey yield.

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3 C. P. Dadant, who is one of the veteran American bee keepers, says that the conclusions numbered 4, 5, 6, 9, 11 and 15 agree with his experience.

ENVIRONMENTAL INFLUENCES ON NECTAR SECRETION

LESLIE ALVA KENOYER

This study was undertaken to summarize and supplement existing knowledge of the factors which stimulate or retard the secretion of nectar. The work was carried out under the direction of the botany section of the Iowa Agricultural Experiment Station in coöperation with the chemistry section, being done mostly at Ames from June, 1914, to June, 1916.

HISTORICAL

One of the most complete treatises on nectar, with quite an extensive account of some of the environmental factors in its secretion, was given us by Bonnier.[1] The subject of secretion has been debated from a physical standpoint. Godlewski[9] attributes it to a fluctuation in the concentration of the cell sap due to alternate splitting and recombination of complex molecules. Pfeffer[19] advances three possible causes for secretion: First, an unequal permeability of the membrane of the absorbing and excreting portion of the cell; second, an unequal distribution of solutes in the absorbing and excreting portions of the cell; third, the transformation into sugar of the outer portion of the cell wall, and the osmotic action of this sugar upon the liquid contents of the cell. Lepeschkin[14] in a study of the coenocytic plant, *Pilobolus,* finds evidence that the first of Pfeffer's theories is the correct one for the excretion of water drops. Wilson[29] gives evidence in support of Pfeffer's third theory, showing that the thorough washing of a nectary stops the secretion if the nectary is past the stage of metamorphosis of the cell wall, but that secretion is resumed on the addition of sugar to the surface of the nectary. The validity of his results are called in question by Lepeschkin[14] and Büsgen[5].

Haupt[10] in a study of extrafloral nectaries finds that after washing, some nectaries become inactive, while others, as those of the leaves of *Impatiens parviflora,* continue excretion of water but not of sugar, thus becoming equivalent to hydrathodes.

Livingston[16] likens nectar secretion to guttation, accounting for the latter by decrease in the permeability of the plasma membrane induced by an increased turgidity, for the former by hypothetical rapid increase in the solute content and thereby of the osmotic pressure in the cell,—a change which induces a like decrease in the permeability of the membrane.

Comparatively little work has been done on the chemistry of nectar. Wilson,[28] Von Planta[27] and Bonnier[1] have analyzed a few sorts of nectar, finding that in some cases it contains no sucrose while in others it is almost wholly this kind of sugar. In some cases fructose and in others glucose is the dominating reducing sugar. The sucrose of nectar is almost wholly digested in honey, Browne[4] finding as the average composition of 138 honey samples from widely separated localities 38.65 per cent fructose, 34.48 per cent glucose and 1.76 per cent sucrose.

EXPERIMENTAL

I. Methods.—Nectar, when secreted in sufficient quantities, was measured by means of a graduated capillary pipette, or weighed after absorption on strips of filter paper which had been previously weighed in small vials. Many of the most important honey plants secrete such small amounts of nectar to the individual flower that neither of these methods is practicable. In these the amount of sugar external to the nectaries was approximately determined by adding to a counted or weighed quantity of the flowers a definite volume of water, shaking frequently for a half hour, then decanting. A similar method was employed by Von Planta[27] and Bonnier.[2] In some of the flowers investigated, this treatment extracts some sugar from the floral tissues, as shown by the appearance in the solution of colors from the floral envelopes. Hence it is of value mainly for the comparison of flowers of the same species. Buckwheat, because of its rapid maturing and its value as a honey producing crop as well as its comparative freedom from the above noted source of error, was employed in many of the experiments.

Sugar determinations were made by reduction of Fehling's solution. The method found most practicable and employed for the greater part of the work was based on that described by Schoorl.[24] A carefully measured amount (1 cc. and for minute quantities of sugar, 10 cc.) of the material to be analyzed was placed in a 150 cc. Erlenmeyer flask, heated on an asbestos gauze over a flame so adjusted that the liquid began to boil in just two minutes, then boiled two minutes longer. To the contents of the flask, after cooling to 60° degrees C., were added sulphuric acid and potassium iodide. The liberated iodine, which corresponds to the unused copper sulphate, was titrated against sodium thiosulphate. Sugar values were obtained by the careful analysis of known quantities of sugar. This method has the advantage of being both rapid and delicate enough to determine minute quantities of sugar with a probable error of not over 0.04 mg.

Floral tissues, when not too bulky, can be analyzed by the same method, the reagents being added directly to the tissues after covering them with water. When tissues were more bulky or when greater accuracy was required, extractions were made with alcohol or water, and were purified by treatment with neutral lead acetate.

II. Humidity.—It is well known that any watery exudation from plants accumulates when atmospheric humidity is high and evaporation thereby is retarded. This can easily be demonstrated in connection with bleeding from several tissues, or with guttation through water stomata. Bonnier[1] states that nectar secretion corresponds to guttation and that it varies inversely with the transpiration. So far as the volume of nectar is concerned this was found to be true in all the plants experimented upon with this end in view. But, as shown by Pfeffer,[20] two factors are involved in nectar secretion, the exudation of water and that of sugar. Haupt[10] has found that extrafloral nectaries begin secreting only when humidity is relatively high, an observation which confirms the theory that secretion is due to a decreased permeability caused by increased turgor, but that after secretion begins, increased air moisture increases water secretion, the secretion of sugar remaining constant. It is probable that this applies to nectaries in general. Nectar is more dilute when humidity is high, and honey that is stored at such times is likely to be high in water content.

At Ames the seasons of 1914 and 1915 represented extremes of humidity, the summer months of the former year being excessively dry and warm, while those of the latter were excessively wet and cool. Hence the comparisons in table I of nectar washed from flowers are of interest.

Table I. Comparisons of nectar washed from flowers in seasons of different humidity

	1914 (Dry and warm)		1915 (Wet and cool)	
	No. of samples analyzed	Av. mg. sugar per gm.	No. of samples analyzed	Av. mg. sugar per gm.
Melilotus alba, flowers	6	2.13	3	.65
Medicago sativa, flowers	4	1.15	3	.80
Trifolium pratense, corollas	4	3.64	13	3.90

It is seen that the wet season yielded scarcely as much sugar as the dry. It may be stated further that bee visitors to *Melilotus* were several times as abundant in 1914 as in 1915. The author found by experiment that flowers of alfalfa grown in dry soil contain about 60 per cent more sugar than those grown in wet soil.

Buckwheat flowers kept humid under a bell jar secreted much more liquid than flowers exposed to the rather dry greenhouse air.

However, 12 comparative analyses of the nectar of each showed in the humid, 1.04 mg. sugar per 10 blossoms; in the dry, 0.98 mg. sugar per 10 blossoms. Analysis of the flower after removal of the nectar, in 6 of the above pairs of cases showed 0.74 mg. per 10 blossoms in the humid, and 0.98 mg. per 10 blossoms in the dry. More sugar accumulated in a dry atmosphere and practically the same amount is excreted.

The accumulation of sugar under low moisture conditions is in line with the discovery by Lundegarth[17] that increase of moisture favors the accumulation of starch, decrease of moisture its digestion.

Six plants of *Impatiens Sultani* in saturated air accumulated in a day 3.26 mg. sugar each from the extrafloral nectaries, the basal teeth of the leaves, while 6 plants in greenhouse air accumulated 5.42 mg. sugar each. The excess of the latter is very likely due in part to the running away of drops under the humid conditions. The nectar averaged 23.4 per cent sugar in the former and 45.3 per cent in the latter.

III. Rainfall.—The author has shown in a statistical study[12] that heavy rainfall just prior to the secreting season is advantageous as it gives the plants greater vigor. But during the season of greatest secretion, good years are somewhat drier than poor. Also, a rainy day shows a lighter honey yield than a day before or after the rain.

The deterrent effect of the rain on the honey flow is twofold: It hinders the activities of bees and it washes away the nectar. To illustrate the latter point, in 1915 on the morning following a day of continual rainfall, red clover corollas were found to contain 0.02 mg. sugar per gm., whereas a day earlier they contained 3.8 mg.; a day later, 0.6 mg., and two days later 4.4 mg. Buckwheat blossoms were subjected to an experiment to determine the extent to which rains wash away the nectar. Flowers subjected before gathering to a spray for 20 minutes, 15 mm. of water falling, were found to contain 0.12 mg. per 10 as against 1.28 mg. per 10 untreated flowers. A 30 minute rain of 35 mm. reduced the nectar of red clover blossoms from 0.48 to 0.19 mg. per 10 and that of white clover blossoms from 0.27 to 0.07 per 10.

IV. Temperature.—Wilson[29] states that temperature has not a marked effect upon the rate of secretion of nectaries that have commenced secreting. He finds, however, that *Prunus Laurocerasus* will not begin secretion unless the temperature is 12° C. or over. Haupt[10] also finds that a minimum temperature is necessary to induce secretion. Lepeschkin[14] finds in the hyphae of *Pilobolus* a secretion steadily increasing with, and much more rapidly than, the absolute temperature. In other cases he finds an optimum above which secretion diminishes. In the case of secreting hairs of the bean leaf this optimum is 20° C., in the *Abutilon* nectary it is 26° C.

Experiments were carried out in uniform temperature incubators. For much of the work, to avoid light exclusion, which is detrimental to secretion, incubators were employed which were especially constructed for the purpose, being covered with two glass plates separated by an air space.

The optimum temperature for amount of secretion lies between 20° C. and 25° C. for *Cucurbita pepo, Lilium speciosum, Canna indica, Euphorbia pulcherrima,* and extrafloral nectaries of *Impatiens Sultani.* For *Salvia splendens* and most of the Leguminosae tested it is about 15° C. As a rule the sugar concentration of the nectar does not differ materially for the different temperatures. Table II gives typical sugar determinations obtained from the flower of *Abutilon striatum,* the blossoms being quartered and one piece of each placed in each incubator, thereby eliminating any error due to individual variations.

Table II. Typical sugar determinations for Abutilon striatum

Degrees temperature	Mg. invert sugar per flower			
	10°C	16°C	23°C	30°C
After 36 hours	10.20	12.00	16.00	10.32
After 16 hours (another set)	3.07	6.57	12.97	10.87

Here the optimum is clearly not far from 23° C.

Bonnier and Flahault[3] call attention to the fact that nectar secretion is greater in the same species at high latitudes and altitudes than at low when the species grows normally in both latitudes of altitudes compared, and furthermore that species which do not secrete in France are nectariferous in Norway and in the Alps. He suggests that this fact may be due to the greater range between maximum and minimum daily temperatures which prevails at high altitudes and latitudes, or to the greater range in the humidity of the air.

Phillips[21] observes that alfalfa is, as a rule, valuable as a honey lant in the great prairie region of the west and not in the eastern tates, that buckwheat is of more value in New York, Pennsylvania nd Michigan than in Indiana and Illinois, and that white clover s of greater importance in the north than in the south. Basswood s said to secrete better in the more northerly portions of its range. t therefore seems desirable to investigate the hypothesis of Bonier.

As already shown by the author[12] the study of a 30-year weight ecord of a hive at Clarinda, Iowa, lends strong support to this assumption. Thirty-eight periods of continual and fairly rapid gain n weight were selected, and the days of each divided about equally etween days of high gain and days of low gain. In 32 cases the verage diurnal temperature range for the days of high gain is greater than that for the days of low gain. In all of the six exceptional cases the difference between the average is small.

Sladen[14] states that the heaviest single day's increase in hive weight noted for two seasons in England in a record kept by Dr. Moore Ede was on a day that began with a heavy early morning frost, the honey coming from the heather, *Calluna vulgaris.*

Table III represents the amount of reducing sugar in mgs. found after keeping the plants or flowering branches for a time in the incubators. Each column represents a different experiment.

Table III. Amount of reducing sugar in various plants after incubation

Trifolium incarnatum, 10 corollas 2 da	0.56	0.63	0.43	0.38	......
Trifolium repens, 10 fls. 2 da	......	1.12	0.94	0.70	......
Nectar washed from same	......	0.07	0.02	0.01	......
Trifolium repens, 10 fls. 2 da	0.93	0.63	0.47	......	0.56
Nectar washed from same	0	0	0	......	0.08
Medicago sativa 10 fls. 4 da	3.44	2.08	0.52	......	......
Caragana frutescens 10 fls	37.55	22.22	11.95	......	24.33
Nectar washed from same	0.64	4.80	2.00	......	2.88
Fagopyrum esculentum 10 fls. 4 da	0.69	0.73	0.58	......	......
Nectar washed from same	1.36	0.80	0.0	......	......
Salvia splendens 10 corollas 4 da	......	25.7	13.8	12.9	......
Coleus Blumei 10 corollas 4 da	......	0.86	0.78	0.62	......
Taraxacum officinale per gm. fls. 1 day	38.7	45.0	19.3	13.9	......
Taraxacum officinale per gm. fls. 1 day	15.6	17.1	11.9	not developing	

In field conditions it can readily be shown that lower temperatures increase the sugar content in dandelion and the clovers.

VanRysselberghe[26] determined that with increase in temperature the permeability of the protoplast to water and solutes rapidly increases—that of *Tradescantia* epidermal cells for water being eight times as great at 30° as at 0° C., and that of solutes seeming to follow the same proportional rule. To demonstrate whether this holds for nectary cells, the lowest sucrose concentration necessary to plasmolyze the multicellular secreting hairs which cover the nectary of *Abutilon* was determined. After four days at 10° C. a 0.6 molecular solution was found sufficient, while for another portion of the same flower after four days at 25° C. a 1.1 molecular solution was necessary.

In a study of the influence of low temperature Müller-Thurgau[18] found that sugar accumulates in potatoes when surrounding temperature is below 10° C., and the same thing is true of hemp seedlings and various other plant organs. He advanced the theory that the accumulation comes from the digestion of starch or oil more rapidly than the resulting sugar can be utilized—its respiratory destruction being retarded by the low temperature.

The accumulation of stored sugar from starch in low temperature is a well-known phenomenon in the twigs of woody plants and is amply discussed by Fisher.[8] Indeed this accumulation seems to be rather common in its occurrence among plant tissues. Besides being applicable to floral tissues, as table III so clearly shows, it affects the leaves and the peduncles of white clover, the former after two days treatment having 30 per cent more sugar, and the latter 58 per cent more, at 10° C. than at 25° C.

The evidence points to the conclusion that at a uniform temperature the secretion of nectar is a balance between two factors,—the accumulation of sugar in and near the flower under the influence of low temperatures and increasing permeability of the plasma membrane under the influence of high temperature. The position of the optimum, then, might be represented somewhat as in the figure below.

The two graphs are limiting factors to nectar secretion and the intersection, i. e., the point where the effective limit stands highest, is the optimum secretion temperature. If the fact discovered by Eckerson[7] for root cells, that above a certain point (25°-35°) the permeability again decreases, applies also to nectary cells, the situation may be somewhat complicated thereby.

Better than any uniform temperature for secretion is a change from a lower to a higher temperature—as the table indicates. The

This species is less widely distributed than the preceding and occurs especially in southeastern Iowa, in Van Buren, Lee and Appanoose counties, northward along Mississippi river to New Albin and at the mouths of the larger streams entering the Mississippi.

Quercus Muhlenbergii Engelm. Chestnut Oak, Yellow Oak

A fine tree growing in Iowa 60 to 70 feet high and with a trunk 2 to 3 feet in diameter. Buds ovate, chestnut brown. Bark on older trees closely appressed, grayish brown in color. Leaves crowded to the end of the branches, slender, petiolate, oblong to oblong-lanceolate, pointed and pinnately veined. Acorn globose, about one-fourth inch long; cup shallow, thin, of small appressed scales.

This species occurs along the Mississippi from Keokuk to New Albin and westward along the streams to Boone and Webster counties and also in Fremont county.

FIG. 63.—Red oak (*Quercus rubra*). *Photo by Ada Hayden.*

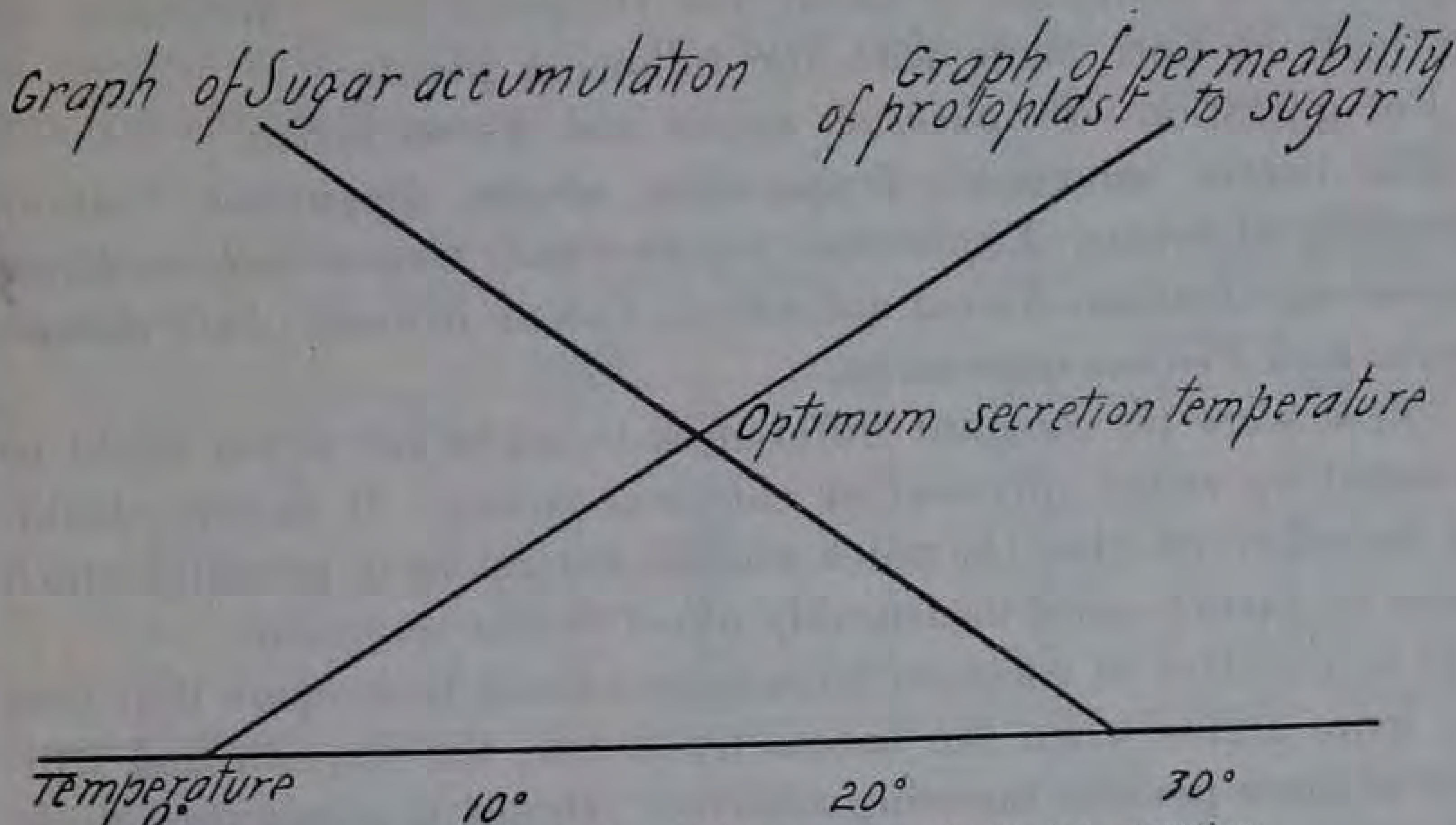

FIG. 570.—The relation of temperature to nectar secretion.

influence of such a change might be graphically indicated by folding the above diagram so that two temperatures—say 10° C. and 30° C.—are brought together. Both limiting factors are raised; the sugar which has accumulated at the lower temperature is secreted at the higher.

V. Atmospheric Pressure.—In the author's study previously cited[12] it was shown that of 18 periods of continual honey production, 16 have a lower barometric pressure on the days of heavier yield than on the days of lighter yield, the two exceptional cases having very slight differences. The increased secretion already credited to high altitudes might be attributed to the diminished pressure, but this explanation would of course not account for the similar increase at high latitudes.

In investigating experimentally the influence of pressure, the plant under experiment was covered with a tabulated bell jar waxed to fit tightly to a ground glass plate and connected by means of a stop cock with the water aspirator. A similar plant was placed under a control bell jar. In some of the experiments air was daily renewed in both low pressure and control jar; in others its continual renewal was provided for by admitting a current of air which bubbled thru water and in the case of the low pressure jar, entered by means of a capillary tube with a very small aperture. This latter method is similar to one employed by Schaible.[22] By the use of an aneroid barometer the pressure was maintained at about 50 cm. or two-thirds atmospheric pressure, the prevailing condition at altitudes of about ten thousand feet. Repeated investigations were made with the following plants:

For guttation—*Tropaeolum majus* and *Avena sativa.*

For nectar secretion—*Tropaeolum majus, Impatiens Sultani, Abutilon striatum, Euphorbia pulcherrima, Canna indica, Fagopyrum esculentum, Salvia splendens, Coleus Blumei, Antirrhinum majus* and *Prunus americana.*

There were no constant differences in secretion which could be detected by either physical or chemical means. It is very doubtful therefore whether the much smaller variations in pressure which occur in nature could measurably affect nectar secretion.

It is a matter of common knowledge among beekeepers that bees are more active when the barometer is low, the warmth and stillness of such periods favoring activity. Hence it seems very probable that any relation between atmospheric pressure and honey flow is to be attributed to the bees and not to the plants.

VI. Light.—Darwin,[6] Wilson[29] and Haupt[10] note the fact that the extrafloral nectaries of several species of *Vicia* are stimulated to activity by light. The first author adds *Lobelia crinus* and the last the Euphorbiaceae as plants that require light stimulus for secretion. The two latter authors, however, state that in the greater majority of cases, secretion is only indirectly related to light. Haupt found that in most extrafloral nectaries even disturbances in photosynthesis by darkness show their influence on secretion only very slowly. Light in *Vicia* doubtless increases the permeability of the protoplast, as Lepeschkin[15] has found that it does in the pulvini of Leguminosae in general.

Schimper[23] found that extrafloral nectaries on the leaves of *Cassia neglecta* cease their activity in a few days when the plant is kept in darkness or in an atmosphere deprived of carbon dioxide, but that secretion continues when the leaf is in the light and only the nectaries are darkened.

The author experimented upon both the floral and the extrafloral nectaries of *Impatiens Sultani* and it seems clear that the withdrawal of light makes its influence fairly rapidly and very decidedly felt. Table IV gives a typical study of floral nectaries, the measurements being millimeters in length of the part of the spur which contains nectar. The table includes average increases over last measurement of the spur in those flowers which were open when the last record was taken, and the average measurement for ose flowers which have opened since the last record. One plant as covered with a bell jar, the other was in an opaque jar of out the same size.

Table IV. Nectar secretion in dark and light

Days	Gains (Light)	New flowers (Light)	Gains (Dark)	New flowers (Dark)
2	4.4	21.6	1.2	16.1
3	4.8	22	1.1	13.6
4	2.	23	1.1	15.7
6	3.5	29	−1.2	17.8
7	5	20	0.1	16
8	4.1	21.7	0.5	14
9	3.3	19	−0.4	13
10	3.2	22	−0.5	

At this time the dark plant had taken on an etiolated appearance nd new flowers were scarcely developing. Secretion from extra-oral nectaries had practically stopped after 3 days in the dark.

Half the leaves of a plant were covered with black tissue paper vhich was fastened by means of small brass paper clips, the basal r nectar-secreting teeth only being left uncovered. These leaves ecreted very little after the third day, whereas the uncovered eaves of the same plant were uninterrupted in their secretion.

Buckwheat flowers were gathered at the same time from under ight and dark jars and it was found that after two days in the lark, although the total amount of liquid secretion was not in the least diminished, the proportion of sugar began to decrease, the secretion not tasting sweet nor giving a very positive sugar test. An average of eleven such analyses of the nectar of flowers that had been covered for two to eight days gives per 10 blossoms 1.20 mg. invert sugar in the light and 0.41 mg. in the dark. Sugar contained in the flowers does not differ greatly, however, in the two cases, there being 0.79 mg. to 10 flowers from the light and 0.73 mg. to 10 flowers from the dark. Plants which had been left in the dark for some time continued to secrete less than normal quantities of nectar for a week or more after the removal of the cover.

That the diminution of sugar is due to the interference with photosynthesis may be shown by removing all the leaf blades from a number of plants. Eleven analyses averaged in mg. invert sugar in the nectar of ten flowers, 0.36 from plants with leaves removed from 3 to 10 days, 0.85 from the normal plants serving as checks. Seven of the above pairs of cases give for the entire invert sugar synthesis and has greater reserves of food to be secreted by the nectaries.

Kurr[13] makes the statement that secretion of nectar commences very rarely before the dehiscence of the anthers; it is generally most rapid during the pollination period; and it ceases as soon as the fruit begins to develop. Bonnier[1] agrees to this proposition and insists that nectar is simply a manifestation of the surplus food stored in the nectariferous part corresponding to an arrest in the development of the organ. In the case of floral nectaries, then, it is most pronounced after the ovary has attained maximum development and before the fruit has commenced to develop. He

Table VI. Secretion of nectar and maturing of flowers

	Buds		Mature flowers		Declining flowers	
	Invert sugar	Sucrose	Invert sugar	Sucrose	Invert sugar	Sucrose
Medicago sativa (Alfalfa) per gm.	32.5	2.8	56.4	0	26.1	0
Melilotus alba (White sweet clover) per gm.	22.2	2.6	31.1	trace	....	
Melilotus officinalis (Yellow sweet clover) per gm.	16.0	0	28.8	0	....	
Trifolium repens (white clover) per gm.	8.1	.1	8.3	1.8	7.5	0
Trifolium hybridum (Alsike clover) per gm.	*13.8	*	*8.6	*	*	
Taraxacum officinale (Dandelion) per gm.	17.8	....	27.2	....	....	
Impatiens Sultani per 100 fls.	47.5	0	248.4	0	190.0	48.9
Lilium speciosum rubrum per flower	119.5	26.7	179.3	10.9	76.0	1.0
Lilium longiflorum per flower						
Younger	51.4	14.9	....	....	....	
Older	95.9	21.3	95.2	11.3	22.2	0

* Including sucrose.

finds a maximum proportion of sucrose in the floral organs corresponding to this time of greatest secretion. Chemical analysis of the floral tissues shows that the climax of sugar accumulation is about the time of the dehiscence of the stamens, and that as the flower withers there is a very rapid decrease in the amount of sugar. Table VI gives some examples from my work, the tissues having been extracted and purified.

It seems that in most cases the excess of sucrose, the storage form of sugar, is rather before the flower opens and nectar secretion begins.

Recognition is due Doctors Pammel and Dox and Professor Coover of Iowa State College, Doctors Cowles and Crocker of the University of Chicago, Doctor Phillips of the Bureau of Entomology, and Mr. Pellett, bee inspector for Iowa, for encouragement and assistance in this work.

SUMMARY

1. By increasing humidity, the secretion of water, but not that of sugar, from nectaries is increased.
2. Excessive water supply lessens the sugar surplus in the parts of the flower.
3. Dilution and washing by rain causes much of the sugar of nectar to be lost.
4. Rate of secretion for both sugar and water increases with temperature up to a certain optimum.
5. Accumulation of sugar in the flower and its vicinity varies inversely as the temperature.
6. The optimum condition for sugar secretion is an alternation of low and high temperatures.
7. Variation of atmospheric pressure has no marked influence on secretion.
8. Sugar excretion is markedly diminished in darkness on account of limitation of the food reserves of the plant.
   Water excretion may or may not continue, depending on the species. Removal of the leaves has the same deterrent effect.
9. The more favorable all conditions for growth and the more vigorous the plant, the greater is the amount of sugar secreted.
10. Nectar is most abundant early in the blooming season, other things being equal.
11. Accumulation and secretion of sugar are most pronounced near the time of the opening of the flower.

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GLOSSARY

Acaulescent. Having only a very short aerial leaf-bearing stem, apparently none, as in the dandelion; acauline; acaulous.

Accumbent. Lying against, as when the edges of the cotyledon lie against the caulicle or radicle.

Achene. A dry, hard, 1-celled, 1-seeded, indehiscent fruit.

Actinomorphic. Regular and polysymmetrical as the flowers of radish.

Acuminate. Tapering somewhat gradually to a point.

Acute. Ending in a sharp angle, not prolonged.

Adventitious. Out of the usual place, as buds on a leaf or at a distance from the node; growing spontaneously out of its native locality, but not fully established; adventive.

Aerial roots. Those appearing on the stems above ground; may be brace roots as in corn, or clinging roots as in ivy.

Aeolian soil. Wind-borne soil.

Agamogenesis. Asexual reproduction of any kind.

Aggregated. Collected together but not cohering; about the same as agglomerated.

Albumen. Nutritive material in seeds accompanying the embryo.

Aleurone grains. Protein grains replacing albumen in a few oily seeds and starch in others.

Aleurone layer. Outer layer of the endosperm next to the perisperm.

Allogamous. Habitually cross-fertilized.

Allogamy. Cross-fertilization.

Allotropic. A group of insects feeding upon nectar and pollen; also carnivorous.

Alluvial. Pertaining to deposits forming the flood plains of rivers.

Alternate (leaves). One at the node, not opposite; (flowers) parts of one whorl opposite to intervals of next.

Alveolate. Deeply pitted so as to resemble honey-comb, like the receptacle in many Compositae.

Ament. A slender spike of naked and usually separated flowers with imbricated scales or bracts; catkin.

Amentaceous. Resembling, consisting of, pertaining to, aments.

Anandrous. Without stamens.

Anatropous. Inverted and straight.

Androdioecious. Having perfect flowers on one set of plants and staminate flowers on another set, but no individuals with pistillate flowers.

Androgynous. Monoecious with the staminate and pistillate flowers in the same inflorescence.

Andromonoecious. Having staminate and perfect flowers on the same plant, but no pistillate flowers.

Anemophilous. Having the pollen or seeds conveyed by the wind.

Anemometer. Instrument for measuring wind.

Angiosperms. Higher seed plants.

Annual. A plant that completes its life cycle from germination to matured seed in one season.

Annual (winter). A plant that germinates in the fall, grows until frost, but blooms and matures seed the following spring.

Anther. The pollen-bearing part of a stamen.

Antheridium. The male sexual organ in cryptogams.

Anthodium. The capitulum or head of flowers in Compositae.

Anthophilous. Insects such as bees, with joints of hind tarsi dilate and pubescent.

Apetalous. Without petals.

Apex. Is opposite to point of attachment.

Apogamy. Habitual nonsexual reproduction, especially vegetative reproduction where sexual reproduction usually occurs, as in the budding of a prothallus in ferns.

Appressed. Lying flat against.

Aquatic. Growing in water or wet soil.

Arachnoid. Cobwebby; covered with tangled hairs, fewer and longer than when tomentose.

Archegonium (pl. archegonia). The female organ in the higher cryptogams.

Aril. A false coat which sometimes surrounds the seed, growing from the funiculus, hilum, or placenta, as the mace of nutmeg.

Aromatic. Possessing aroma, especially if spicy.

Arrow-shaped. See sagittate.

Ascending. Rising obliquely or curving upward.

Asexual. Without sex; destitute of stamens and pistils in flowering plants or of other sexual organs in cryptogams.

Asexual generation. The second stage or generation in plants ving an alternation of generations. It produces spores asexually, ut is itself the result of fertilization.

Auricle. An ear-shaped appendage.

Auriculate. Having auricles, or earlike lobes or appendages.

Autarigynous. Self-sterile.

Autoecious. Said of a parasitic fungus which inhabits the same ost-plant through all its stages of growth.

Autogamous. Self-fertilizing.

Autogamy. Close-fertilization; the fertilization of a flower by its wn pollen.

Autogenous. Self-originating. Applied to diseases which have ieir origin or cause with the affected organism.

Awn. An appendage consisting of a bristle.

Axil. The upper angle formed between the leaf and stem.

Axillary. In the axil.

Axis. The central line of any organ or support of a group of rgans.

Barbed. With rigid points or short awns usually reflexed.

Barren. Unproductive; sterile—said of a plant or organ.

Base. The part of an organ nearest its point of support.

Bast. A vegetable tissue composed of thick-walled, strengthening ibers or cells.

Beard. Awns of grasses; a tuft of hairs, generally stiff and long.

Biennial. Of two years' duration; a plant germinating one season and maturing seed the next.

Biotic. Pertaining to life.

Biternate. Dividing into three parts, each of which is divided into three.

Bract. A modified leaf subtending a flower or flower branch.

Bracteate. Furnished with bracts.

Bracteolate. Having secondary bracts.

Bristle. A short stiff hair.

Bulb. A leaf bud with fleshy scales; usually subterranean.

Bulbiferous. Bulb-bearing.

Callose. A substance which covers surfaces, as in grafts, and sieve pores, as in grapes.

Callus. A hard protuberance or callosity.

Calyx. The outer part of the perianth.

Canescent. Hoary with gray or white pubescence.

Cantharophilous. Pollinated by beetles.

Capillary. Long and narrow like hair; said of a filament or channel.

Capitate. Furnished with a globose head; growing in a head.

Caprification. (1) The fertilization of the fig by hand or by means of insects. Sometimes extended to the artificial fertilization of other fruits. (2) The process of accelerating the ripening of figs, by placing on the cultivated plant branches of the wild fig (*Caprificus*).

Capsule. A dry dehiscent fruit composed of more than one carpel.

Carina. The two united anterior petals of papilionaceous flowers.

Carpel. A simple pistil or one element of a compound pistil.

Caryopsis. A dry one-seeded indehiscent fruit with a thin, adherent pericarp, as in the seeds of grasses.

Catkin. See ament.

Caulicle. The first internode of the stem above the true root.

Cauline. On the stem.

Cell. One of the structural elements of living bodies, by the multiplication of which growth is effected. In plants the cell usually appears as a closed sac surrounded by a firm wall of cellulose and containing the essential element protoplasm and usually a nucleus, the active agent in cell-division.

Cellulose. Primary cell wall substance. A carbohydrate having the general formula ($C_6H_{10}O_5$).

Cement-disk. Müller's term for glandular disk or retinaculum of orchids.

Cenanthy. The suppression of stamens and pistils.

Cephalanthium. See anthodium.

Chaff. A small thin scale or bract becoming dry or membranous, as in the glume of grasses or bracts on head of Compositae.

Chalaza. The end of the ovule opposite the micropyle.

Chasmogamy. The opening of the perianth at flowering time.

Cheiropterophilous. Pollinated by bats.

Chlorenchyma. An assimilating tissue usually composed of parenchyma cells.

Chlorophyll. Green coloring matter of plants.

Chromatophore. A granule of protoplasm bearing a pigment of color.

Ciliate. Having hair or bristles on margin.

Circumscissile. Dividing by a transverse circular line, as in capsule of purslane.

Quercus prinoides Willd. Chestnut Oak

Much like the preceding but of low stature, in some cases shrub like. Leaves undulate and shorter petioled. Acorns smaller and the cup about one-half the length of the acorn. This species is found here and there in rather dry places. It is rather uncommon in the state but occurs in Guthrie and Madison counties.

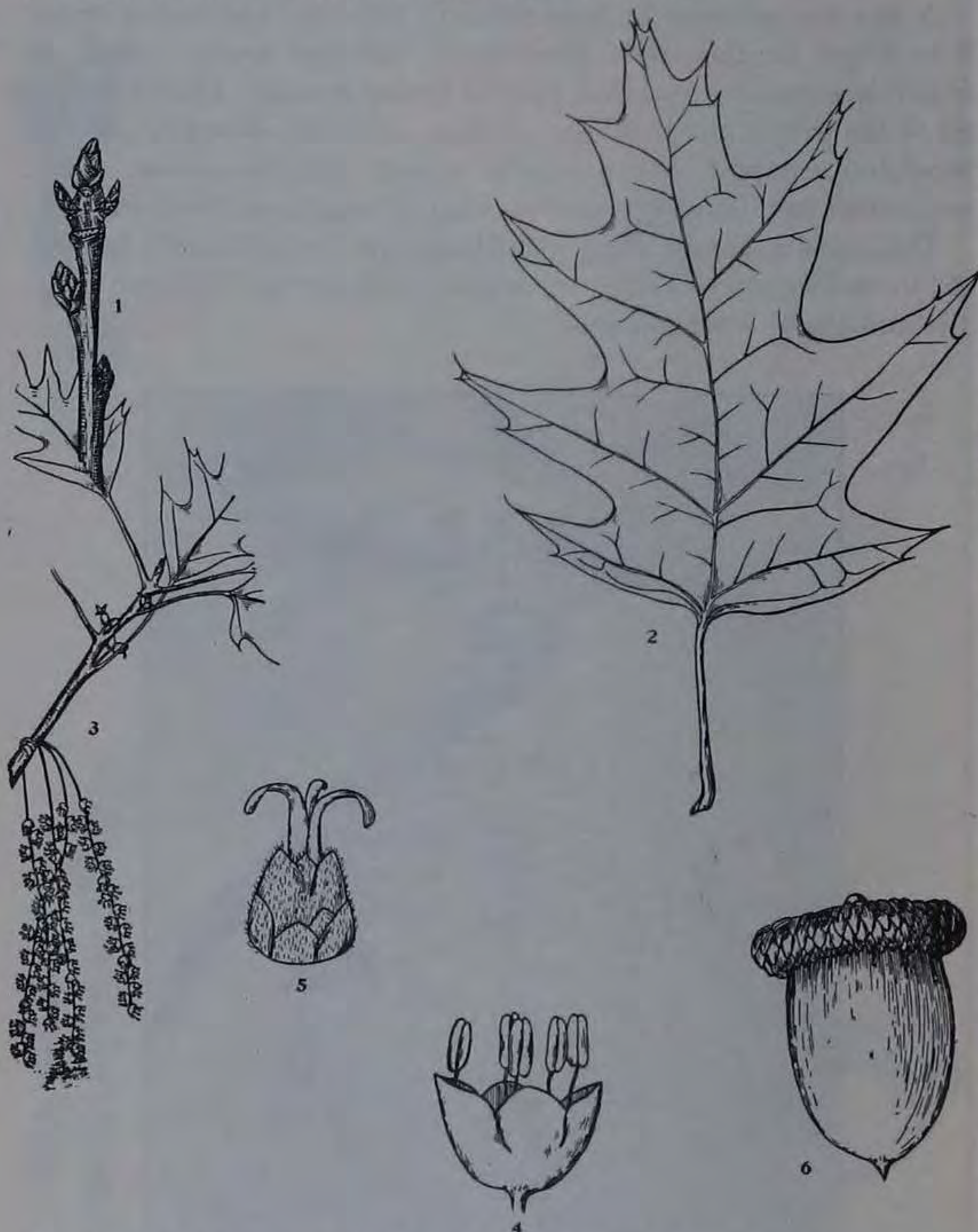

FIG. 64.—Red oak (*Quercus rubra*). 1, Winter twig, x 1. 2, Leaf, x 1/2. 3, Flowering branchlet, x 1/2. 4, Staminate flower, enlarged. 5, Pistillate flower, enlarged. 6, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Circumvallate. To surround with a wall. Walled.

Clavate. Club-shaped; gradually thickened away from the point of attachment.

Cleft. Having narrow sinuses extending about half-way to base, as cleft leaf.

Cleistogamous. Fertilized in bud; closed flowers; having closed fertilization; a term applied to certain more or less depauperate flowers, sometimes underground, which never open, but are self-fertilized, as in some violets.

Cleistogamy. Self-fertilization without the flowers opening; closed fertilization.

Cleistogene. A plant which bears cleistogamous flowers. It may bear the flowers of the ordinary form also.

Climbing. Rising by laying hold of other objects without twining.

Close-fertilization. The fertilization of pistils, by pollen from the same flower; self-fertilization.

Coenocytic. Relating to aggregation of protoplasmic units enclosed with common wall.

Collagen. A chemical compound in connective tissue.

Collecting hairs. Hairs upon the style in certain Compositae which serve to collect the pollen as it is discharged from the anther.

Column. The united filaments and styles in a gynandrous flower, as an orchid.

Coma. A silky tuft of hairs.

Compound. Composed of two or more similar, subordinate parts.

Conductive tissue. That through which the pollen tube passes on its way to the ovary. It is often loose in texture and moist with nutritive fluid for the growth of the pollen tube.

Conduplicate. Folded upon itself lengthwise.

Conidia. In fungi, propagation cells or spores borne upon special branches of the plant body or thallus.

Conidiophore. In fungi, a branch of the mycelium that bears conidia.

Cordate. Heart-shaped with point upward.

Coriaceous. Leathery.

Corms. The enlarged base of an herbaceous stem, consisting of one or a few short internodes and serving for the storage of starch or other reserve food material. It differs from a tuber mainly in being upright, or more nearly so, and in seldom being produced upon an elongated subterranean stem. The Indian turnip and crocus are examples.

Corolla. The conspicuous part of most flowers, being the inner set of floral envelopes when there is more than one, commonly distinguished by its fine texture and by having some other color than green.

Corymb. A convex or flat-topped indefinite or centripetal inflorescence, like a raceme with the lower pedicels elongated.

Cosmopolitan. Widely distributed.

Cotyledons. The first leaves of a plant as found in the embryo.

Creeping. Running along above the ground or beneath the surface, and rooting.

Cremocarp. Fruits of Umbelliferae.

Crenate. Dentate with rounded teeth.

Crested. Having a crest or elevated appendage.

Cross. A union of two varieties of the same species. Applied in narrower sense to the offspring of two flowers which have been cross-fertilized.

Cross-fertilization. The fertilization of a flower by pollen from another flower, especially from one of another variety of the same species.

Cross-pollination. The conveyance of pollen to the stigma of another flower.

Crown. An appendage in the throat of the corolla in some flowers, as *Silene* and *Narcissus*; corona; paracorolla. In some cases it represents a circle of metamorphosed stamens. Any circle of organs in the form of a crown, as the scales at the apex of an achene.

Crystalloids. Protein bodies in the form of crystals.

Culm. The stem of grasses.

Cumarin. A crystalline compound contained in Tonka bean and sweet clover.

Cuneate. Wedge-shaped.

Cut. Having divisions deeper than when dentate.

Cyaneous. Pure blue. Azure blue.

Cyanophyll. See phyllocyanin.

Cyme. A somewhat flat-topped, determinate inflorescence, resembling a corymb.

Cytoplasm. Protoplasm of the cell body.

Deciduous. Falling at the usual time, or at the close of a season. Applied to leaves which fall in autumn after one season's rowth and to plants which bear such leaves. Also applied to etals which fall immediately after blossoming.

Declinate. Bent or curved downward; declining; declined. Applied to the stamens it means curved to one side, neither outward or inward nor erect.

Declinous. See declinate.

Decumbent. Reclining but with end rising.

Dehiscent. Opening in a regular manner by valves or slits to ischarge seeds.

Dentate. Toothed, usually with teeth directed outward.

Denticulate. Finely dentate.

Determinate inflorescence. Flowers arise from terminal bud nd check growth of axis.

Diadelphous. Having filaments united by their edges in two ets (one of which may be only a single stamen), as in the pea.

Diamesogamous. Fertilized by the aid of some external agent, as wind, water or insects.

Dichogamous. Having flowers in which the stamens and pistils nature at different times; either protandrous or protogynous.

Diclinous. Having the stamens and pistils in separate blossoms—ither monoecious or dioecious; separated; digamous; unisexual.

Dicotyledonous. Plants producing two cotyledons.

Didymous. In pairs.

Didynamous. Having two long and two short stamens.

Diffuse. Spreading loosely and irregularly.

Digamous. See diclinous.

Digenous. Containing both sexes or produced sexually.

Digitate. Compounds with parts radiating from apex of support.

Dimorphic. Existing in two forms.

Dimorphous. Existing under two forms, as two forms of leaves, sterile and fertile, on one plant in ferns.

Dioecious. Having stamens and pistils in separate flowers upon different plants.

Dioeciously polygamous. When some of the flowers in dioecious plants are perfect. Each set of plants may have perfect as well as unisexual flowers and the other all staminate or all pistillate; polygamo-dioecious.

Disk. Any flat, circular area; the central part of such an area or of any flat body as opposed to the border; disc. Especially (1) the central part of a head of flowers in Compositae, generally bearing tubular florets only; (2) the portion of the receptacle of a flower between the stamens and the pistil, often more or less dilated and serving as a nectary.

Disk flower. See tubular floret.

Distinct. When parts of the same kind are unconnected; opposed to coherent.

Diurnal. Said of flowers which open in the day and close at night.

Divided. Having incisions extending to base or midrib.

Dorsal. Pertaining to back or outer surface of organ.

Downy. Having a dense covering of short weak hairs.

Dysteleology. The doctrine of purposelessness in nature.

Echinate. Spiny or prickly.

Ecology. In botany, a division of the sciences which treats of the relation of plants to their environment.

Ellipsoidal. Nearly elliptical in outline.

Elliptical. Oblong and rounded at the ends.

Emarginate. Notched at end.

Embryo. Rudimentary plantlet within the seed.

Endogenous. Produced within another body. Applied also to the stems of monocotyledons, and their manner of growth, which was formerly supposed to take place chiefly at or near the centre.

Endosperm. Albumen of seed in embryo-sac as distinguished from perisperm.

Entomophilous. Adapted to pollination by insects.

Ephemeral. Lasting but a day or a very short time, as the corolla of purslane.

Epicarp. Outer layer of pericarp.

Epidermis. External layer of cells in any organ.

Epigynous. Corolla seems to rise from top of ovary.

Erect. Perpendicular, or nearly so, to the surface to which attachment is made.

Erose. Having irregular sinuses, as if bitten out. Eroded.

Etiolated. Bleached by exclusion of light.

Eutropic. Twining or turning with the sun.

Exserted. Protruding beyond margin of envelope, as stamens from corolla.

Extine. The outer coat of a pollen-grain.

Extrafloral nectaries. Nectaries outside the flower.

Extrorse. Applied to anthers that face away from the axis of the flower.

Falcate. Scythe-shaped.

Fascicles. A bundle, as the clustered leaves on the dormant anches or spurs of the larch; a bundle of tuberous roots, as in e dahlia; a fibrovascular bundle, especially if rudimentary; a ose cyme, as in sweet-William.

Fertile. Producing fruit, or reproductive bodies of any kind; ving pistillate or perfect flowers.

Fertilization. The process by which the pollen causes the ovule develop as a seed. It is the essential feature of sexual reproction, being the union of the male and female reproductive dies. In some cases and perhaps always, it consists of the coalesnce of the nuclei of two cells of different nature and origin.

Fibrovascular bundle. A bundle of stringlike, woody, fibrovaslar tissue, containing xylem and phloem.

Filament. Stalk of a stamen supporting the anther. Filiform. read-shaped.

Fimbriate. Fringed; bordered by lax, slender processes, genally larger than hairs.

Floccose. Covered with mats or flocks of soft woolly hairs.

Floral nectaries. Nectaries situated within the flower.

Fluviatile. Produced by action of a river.

Foliaceous. Leaflike, having leaves intermixed with the flowers, foliaceous spike; foliose.

Foliate. Leaved, as trifoliate (three-leaved).

Follicle. A simple pod opening by the ventral suture only, as in e milkweed.

Fructose. A variety of sugar obtained from fruits.

Fruit. The mature ovary and its contents with any closely adering part.

Funicle. The stalk of a seed or ovule.

Fusiform. Enlarged in the middle and tapering toward each nd.

Gamete. Any sexual protoplasmic body, naked or invested with membrane, motile or nonmotile, as an oösphere or antherozoid.

Gametophyte. The prothallus or sexual generation in ferns.

Gamopetalous. Having the petals more or less united; sympetlous.

Geitonogamy. The fertilization of a pistil by pollen from another lower of the same plant—the closest kind of cross-fertilization.

Gibbous. Convex as though swollen; protuberant, especially upn one side, or some distinct part of the surface.

Glabrous. Smooth.

Gland. Secreting surface or structure. A gland is generally a group of cells having a peculiar form and character to adapt them to their special function. They sometimes form wartlike projections upon the surface or depressions within it. The hairs of many plants also serve as glands.

Glandular. Glandlike or bearing glands.

Glaucous. Covered with a whitish bloom, as on cabbage.

Globoids. Granules of calcium magnesium phosphate found in grain of aleurone.

Globose. Spherical or nearly so.

Glomerate. Compactly clustered in a head.

Glume. One of the outer floral envelopes of grasses.

Glutinous. Viscid; sticky.

Gonidium. A propagative cell produced asexually.

Guttation. Formation of small drops.

Gymnospermous. Having the seeds naked (not enclosed in a pericarp), as in Coniferae.

Gynaecium. See gynoecium.

Gynandrous. Having stamens and pistils united.

Gynodioecious. Having only pistillate flowers on one set of plants and perfect flowers upon another set.

Gynoecium. The pistils of a flower taken together.

Hadrome. Applied to the phloem-like portion of the fibrovascular bundle in vascular cryptogams.

Hairy. Covered with hairs longer and coarser than when pubescent.

Halberd-shaped. See hastate.

Hastate. Describing leaves which have spreading lobes at the base.

Haustorium. The special organ of certain parasites by means of which they obtain food from their host.

Hemitropic. Adapted to pollination by certain insects, which are only partly adapted for visiting flowers.

Herb. A plant which contains but little wood in the stem and which dies down to the ground each year.

Herbaceous. Having the characters of an herb.

Hercogamous. Said of an hermaphrodite flower when some structural obstacle prevents self-fertilization, as in many orchids.

Hermaphrodite. Having both stamens and pistils in same flower.

Heteroclinous. Having male and female flowers in separate heads or receptacles.

Heterodichogamy. Difference in length of stamens and pistils of a flower with corresponding height of stamens and pistils of flowers of other plants of the same species.

Heterogamous. Said of the heads of flowers in Compositae when the florets are not all alike in sex.

Heterogonous. Having two or more kinds of flowers differing in the relative lengths of the stamens and styles; heterostyled.

Heterostyled. See heterogonous.

Hilum. The scar of the seed; its place of attachment.

Hirsute. Clothed with rather coarse or stiff hairs.

Hispid. Beset with erect stiff hairs or with bristles.

Homogamous. Having all the florets of a head in Compositae alike in sex.

Homologue. An organ exhibiting correspondence with some other organ.

Homotype. See homologue.

Honey-dew. A sweet substance found on the leaves of plants, usually a secretion from plant-lice.

Honey-guide. See nectar-guide.

Honey-pore. The supposed pore in flowers which secretes honey.

Hybrid. The offspring of two species of the same genus.

Hydathode. Water-secreting cell.

Hydrophilous. Having the pollen conveyed to the stigma by means of water.

Hypha. The thread of the negative part of a fungus, comparable to the root system of higher plants.

Hypoderm. Beneath the epiderm.

Hypogynous. With parts under pistil.

Idiopathic. A morbid condition not preceded by any other disease.

Imbricated. Overlapping either vertically or spirally, like shingles of a roof. In aestivation, one piece is wholly external and one wholly internal.

Imperfect. Said of a flower which lacks either stamens or pistils.

Included. Opposed to exserted; not protruding from the envelope.

Incumbent. Applied to cotyledons when the radicle is folded back against one of them.

Indehiscent. Not opening by valves or slits.

Indeterminate inflorescence. Flowers arranged laterally and successively as floral axis elongates.

Indigenous. Strictly native; aboriginal.

Indurated. Hardened.

Inflexed. Bent abruptly inward or downward.

Inflorescence. The flowering part of a plant.

Inserted. Attached to or growing out of.

Integuments. Coats of ovule.

Internode. Any part of a stem situated between two nodes.

Interrupted. Applied to surface or series the continuity of which is broken.

Intine. The inner coat of a pollen-grain.

Introrse. Facing or turning inward. Applied to anthers which open on the side next the pistil.

Involucre. A circle or collection of bracts immediately subtending a flower or inflorescence.

Irregular. Denoting flowers in which one or more of the organs of a set are different in size or form from the others.

Isodiametric. Equal in three dimensions.

Jassid. One of the Jassidae, a family of insects belonging to the group Hemiptera, or bugs.

Joint. A node.

Keel. A ridge somewhat resembling the keel of a boat; applied especially to the two anterior united petals of a papilionaceous flower.

Labellum. Lip; upper petal of the orchid.

Labiate. Gamopetalous, with two divisions, anterior and posterior; two-lipped; bilabiate.

Lamella. A thin plate.

Lamina. Blade or expanded part of leaf.

Lanate. Covered with long curled hairs like wool; lanose.

Lanceolate. Lance-shaped; tapering abruptly toward the base and gradually toward the apex.

Lateral dehiscence. The opening of an anther upon one or both sides instead of on the surface facing or opposite to the pistil.

Lemma. The lower of two bracts which inclose the flower in grasses.

Lenticular. Lentil-shaped; in the shape of a double convex lens.

Leptome. See phloem.

Ligneous, lignose, lignified. Woody in texture.

Ligulate. Having a ligule; strap-shaped and about four to six times as long as broad.

Ligule. A strap-shaped corolla in Compositae, such as those on the outer margin of the head in most sun-flowers; a membranous appendage on the inner side of the leaf in many grasses and some other endogens at the top of the sheath.

Linear. Long and narrow with nearly parallel margins.

Loam. A soil mixture of sand, clay and organic matter.

Lobe. A rounded portion or segment of any organ.

Locule. A cell of a compound ovary. The cavity of a pollen sac.

Lodicule. One of the small scales at the base of the grain between the stamens and palet of many grasses.

Loess. A soil of aeolian origin.

Loment. A jointed legume with spurious transverse partitions, as in Desmodium.

Lumen. Internal space or cavity of a cell.

Lyrate. Lyre-shaped.

Malacophilous. Adapted to pollination by snails.

Malpighian cells. Palisade cells in which one or more light lines are present.

Mean. Intermediate point between two extremes.

Mellittophilous. Pollinated by large bees.

Membraneous or membranous. Thin, soft and generally translucent.

Mesocarp. Middle layer of pericarp.

Mesophyll. All of the fundamental tissue within the epidermis.

Micromyiophilous. Pollinated by small Diptera.

Micropyle. Opening through which pollen tube passes.

Monadelphous. Having the filaments free and united in a ring around the pistil, as in most Malvaceae. Stamens united in one set.

Mongrel. Properly, a cross.

Monocotyledon. Plants with one cotyledon.

Monoecious. Having stamens and pistils in separate flowers on the same plant.

Monoeciously polygamous. Having perfect and separate flowers on the same plant.

Mother cells. Large dense cells in pollen lobes.

Motile. Having power of motion.

Mucronate. Tipped with a short stiff point.

Multiple. Compound.

Muricate. Beset with short and hard or prickly points.

Mycelium. The vegetative portion of a fungus, consisting of hyphae.

Myiophilous. Pollinated by flies. Odor disagreeable.

Nectar. A sweet secretion by some part of a flower.

Nectar gland. Tissue specialized for purpose of nectar secretion.

Nectar-guide. A term applied to various color-marks on flowers which seem designed to indicate to insects the locality of the nectar; honey-guide; pathfinder.

Nectariferous. Secreting nectar, or having a nectary.

Nectarium. See nectary.

Nectary. The part of a flower which secretes nectar. Applied especially to spur-shaped appendages to the petals containing nectar, as in the columbine.

Naked. Destitute of the usual covering, as a cell without a wall, a stem without leaves, a flower without floral envelopes.

Nerve. A vein on the floral envelopes of grasses.

Nodding. Curved over near the top, as the flower of narcissus upon its stem.

Node. The place on a stem where one or more leaves are attached; the joint.

Nototribe. Said of an irregular flower which is arranged so that the pollen from the stamens strikes the back of a visiting insect.

Nucellus. Nucleus of an ovule.

Oblanceolate. Lanceolate with the broadest part toward the apex.

Oblong. Widely linear.

Obovate. Inverted ovate.

Obtuse. Blunt or rounded at the apex.

Oligotropic. Applied to certain insects which visit only bee and bumble-bee flowers.

Oögonium. The female sexual organ in Oösporeae before fertilization and containing one or more oöspores, as in *Peronospora*.

Oöspore. The sexual spore.

Ornithophilous. Flowers in which pollination is brought about by birds.

Osteosclerids. Cells generally accompanying malpighian cells.

Ovary. Seed case of pistil.

Quercus Prinus L. Chestnut Oak

Thick leaves, obtuse to lanceolate in outline and pointed, with minutely downy hairs beneath. Has a larger acorn than that of the preceding species. Sometimes cultivated in the state.

Quercus rubra. L. Red Oak

A tree 70 to 80 feet high, or occasionally more than 100 feet high; trunk 3 to 4 feet in diameter with smooth branches. Winter buds ovate. Bark in young stems light gray, on the older trees dark brown. Leaves lobed, 7 to 11, bristle-tipped. Older leaves generally pale beneath. Staminate flowers pubescent. Calyx 4- to 5-lobed.

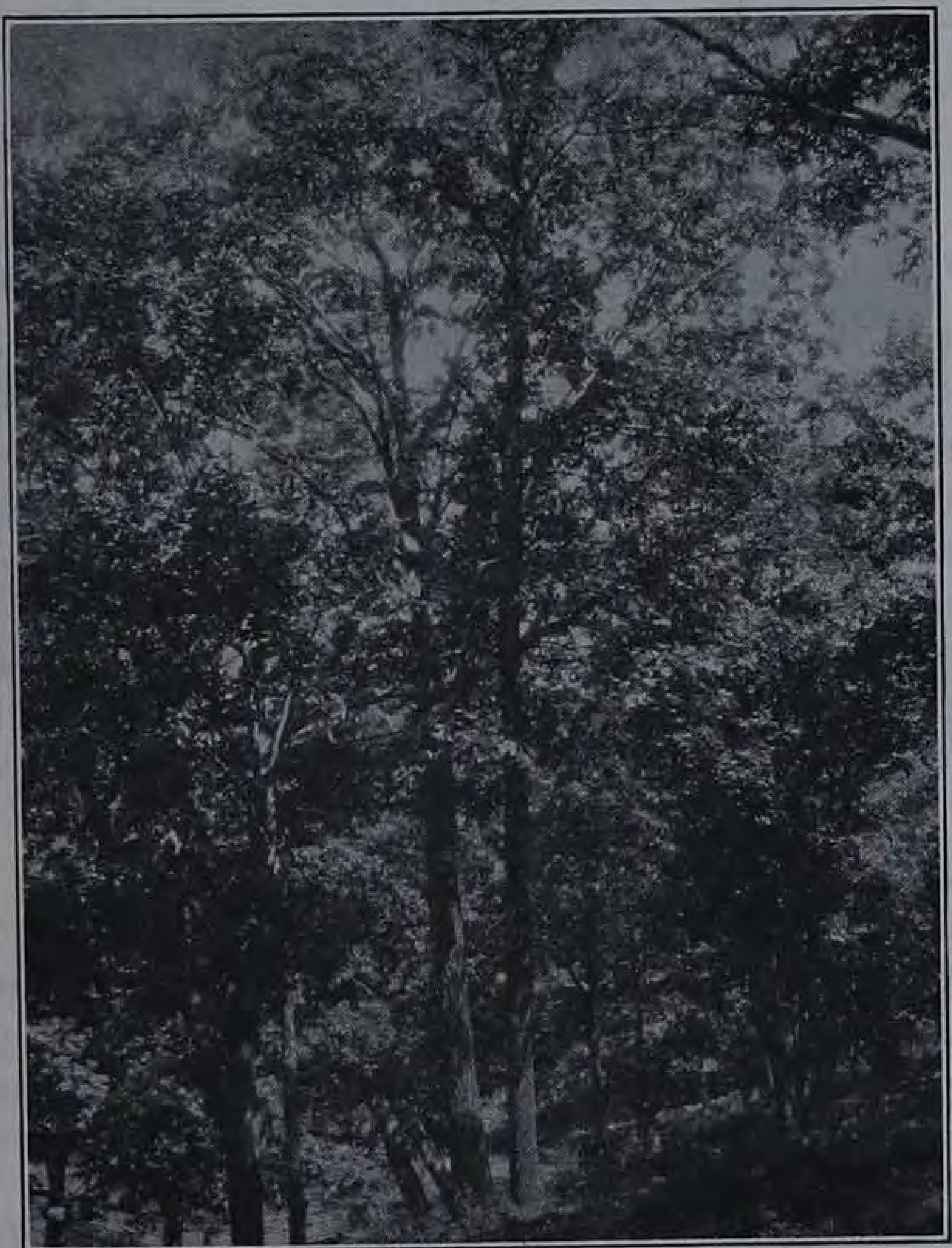

FIG. 65.—"A pair of red oak trees in natural timber. Note the straightness of the stems and their freedom from limbs for a considerable height. These are characteristics of red oak when grown in forest conditions" (By Scott). *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

Ovate. Outline like that of an egg, with larger part downward.

Ovoid. Of the shape of a hen's egg, and attached, if at all, at the larger end.

Ovule. Unripe seeds in ovary.

Palea. The inner bract of a flower in grasses (palet); one of the bracts or scales upon the receptacle in Compositae.

Palet. Upper bract of the flower in grasses.

Palisade cells. Elongated cells perpendicular to epidermis on upper side of leaf.

Palmate. Radiately lobed or divided.

Panicle. Loosely, irregularly branched raceme.

Papilionaceous. Having flowers as in the Papilionaceae, a tribe of the Leguminosae or pea family; i.e., with a large upper or posterior petal called the vexillum, two lateral petals called wings, and two small inferior petals more or less united into a carina or keel.

Papilla. A soft elongated projection.

Papillate, papillose. Having papillae.

Pappus. The modified limb of the calyx in Compositae, especially, when the summit is developed into a feathery or plumose shape.

Parenchyma. The tissue making most of the substance of leaves, fruits and stems.

Pedicel. The support of a single flower.

Pericarp. The matured ovary.

Phloem. Portion of fibrovascular bundle containing the bast and sieve tissues.

Photosynthesis. Process by which sugar and starch are produced in a plant by means of the chlorophyll grain.

Phyllocyanin. A dark blue coloring matter contained in Chlorophyll.

Pilose. Covered with long soft hairs.

Pinnate leaf. Compound with leaflets arranged on each side of a common petiole.

Pinnatifid. Pinnately cleft.

Pistil. The central seed-bearing organ of the flower consisting of ovary, style and stigma.

Pistillate. Provided with pistils; properly, without stamens.

Placenta. The part of the ovary to which the ovules are attached.

Plasmolyze. To induce contraction of protoplasm of an active cell.

Plumose. Like a feather, having fine hairs on each side, as in the pappus-bristles of thistles.

Pod. A dry, dehiscent fruit.

Pollen. The fertilizing powder, usually yellow, produced in the anthers of flowers.

Pollen-grain. The usual term for an individual spore, cell, or particle of pollen.

Pollenization. See pollination.

Pollen-tube. A thin slender tube which issues from the pollen-grain on its contact with the stigma, which it penetrates until it reaches the ovule, where fertilization takes place.

Pollination. The placing of pollen upon the stigma—the first stage of fertilization; pollenization.

Pollinium (pl. pollinia). A coherent mass of pollen-grains in certain plants, as orchids and milk-weeds, so arranged as to be conveyed by insects; pollen-mass.

Polygamous. Producing male and hermaphrodite or female and hermaphrodite flowers on the same or on different individuals; i.e. having both perfect flowers and those of one sex.

Polymorphic. Of several forms.

Polypetalous. Having distinct petals (opposed to Gamopetalous).

Polysymmetrical. Divisible into similar halves in more than one direction.

Polytropic. Applied to insects visiting many kinds of flowers.

Pore-canal. The passage through a bordered or other pit between adjoining cells.

Prickles. Short, stiff, spinelike growths from the epidermis, as in the rose.

Procambium. Fibrovascular tissue of an organ formed before it is differentiated into xylem and phloem.

Procumbent. See prostrate.

Promycelium. In Uredineae and Ustilagineae a short and short-lived mycelial growth proceeding from a resting spore and upon which sporidia are borne.

Prostrate. Lying flat on the ground.

Protandrous. Having stamens which ripen their pollen before the pistils of the same flower are ready for fertilization.

Protein. A plant food manufactured in the plant from starch or sugar by the addition of one of the compounds of nitrogen, phosphorous, potassium or other similar substances.

Proterandrous. See protandrous.

Proterogynous. Having pistils ready for fertilization before anthers are matured.

Protogynous. See proterogynous.

Protoplasm. The substance which forms most of the content of a cell.

Protoplasts. Protoplasmic contents of a cell.

Puberulent. Minutely pubescent.

Pubescent. Covered with fine, soft, short hairs.

Raceme. A simple indeterminate inflorescence of pediceled flowers arranged along a rather long, common axis.

Rachilla. Axis of spikelet in grasses.

Rachis. The axis of a spike or other body.

Radiate. Having rays or ray-florets.

Radical. Proceeding from the root or base of stem.

Range. The extent, or limits through which quantity is distributed.

Raphe. The continuation of the seed-stalk along the side of an anatropous ovule or seed.

Ray. A branch of an umbel or other somewhat radiating inflorescence. The ligulate corolla of an outer floret in a head of Compositae.

Ray-flower. One of the marginal florets of a head in Compositae; ray-floret; ligulate floret.

Receptacle. Summit of flower-stalk.

Reflexed. Abruptly bent or turned downward.

Reniform. Kidney-shaped.

Repand. Having a slightly undulating margin.

Respiration. Process of absorption of oxygen and giving out of products of oxidation.

Reticulated. Net-veined.

Retrose. Directed backward or downward.

Rhizome. Any subterranean stem, usually rooting at the nodes and rising at the apex.

Rib. A primary or prominent vein in a leaf.

Ringent. Bilabiate, with lips widely separated and the throat open, as in Lamium.

Root. The descending axis of the plant, which supplies it with nourishment.

Rootstock. See rhizome.

Rugose. Wrinkled, as the leaves of sage.

Runcinate. Sharply toothed, the teeth directed backward.

Runner. A slender stolon that roots and forms new plants at intervals.

Saccate. In the form of a bag or pouch; sacciform.

Sagittate (leaves). Arrow-shaped, with acute lobes and apex.

Sapromyiophilous. Pollinated by carrion flies or beetles.

Scabrous. Having a rough surface.

Scale. Any thin appendage, morphologically modified, degenerated leaf.

Scape. A peduncle rising from the root, without proper foliage.

Scapose. Resembling a scape.

Scarious. Dry and membranous.

Sclerenchyma. Lignified tissue as applied to thick-walled fibers.

Sclerotic. Consisting of sclerenchyma.

Seed. The ripened ovule, enclosing a rudimentary plant, and the food necessary for its germination.

Self-fertile. Capable of fertilization by pollen of same flower.

Self-fertilization. Fertilization by pollen of the same flower.

Sepal. A division of the calyx.

Serrate. Having sharp teeth pointing forward.

Serrulate. Finely serrate.

Sessile. Without a stalk; thus a leaf is sessile when the blade is seated directly upon the stem.

Sex. One of the attributes of nearly all living bodies, which manifests itself in a certain method of reproduction, the first stage of which is the blending of the contents of two cells which are usually of distinct character and different origin, one of which is called the male, the other female.

Sexual generation. The generation or stage which bears the sexual organs in plants which have an alternation of generations.

Sheath. A tubular envelope, as the sheath of grasses.

Shrub. A woody perennial smaller than a tree and usually having several stems.

Sieve tube. A form of vessel characteristic of the phloem portion of fibrovascular bundles. Sieve tubes consist of elongated, thin-wâlled cells, united end to end in rows, with the transverse septa perforated in a sievelike manner so that the protoplasm is continuous from one vessel to another.

Silique. A short pod, as that of shepherd's purse. The fruit n Cruciferae—a pod of two carpels, which separate in dehiscence rom a framelike placenta called a replum.

Silt. Soil composed of sediment deposited by water.

Simple. Without subdivisions, opposed to compound; leaves, as ak, dock, etc.

Sinuate. Having strongly wavy margin.

Sinuous. Wavy, curving back and forth.

Sinus. The cleft between two lobes or divisions.

Spatulate. Shaped like a druggist's spatula, rounded at the ummit and gradually narrowed downward.

Sphingophilous. Pollinated by nocturnal Lepidoptera.

Spicate. Arranged in a spike.

Spike. An inflorescence like a raceme, except that the flowers re sessile.

Spikelet. The characteristic inflorescence of grasses.

Spindle-shaped. See fusiform.

Spine. A sharp, rigid process growing from the stem.

Sporangium. Spore case.

Spore. Pollen grain; reproductive body of flowerless plants.

Sporidium. A spore produced upon a promycelium; germ cell; econdary spore.

Spreading. Applied to branches that bend outward at less than a right angle.

Spur. (1) A short stout branch as those in the larch, bearing a uft of leaves or in the apple bearing the fruit. (2) A tubular appendage of a petal or sepal, usually containing nectar as in larkspur.

Stamen. The pollen-bearing organ of a flower, usually consisting of an anther or part immediately enclosing the pollen and a filament or stalk.

Staminate. Applied to a flower or plant which has stamens but no pistils.

Stellate. Star-shaped.

Stereome. Strengthening tissue.

Sterile. Unfruitful, as a flower without a pistil, or an antherless stamen.

Sterile flower. One containing no perfect pistils. It may or may not contain stamens.

Stigma. The part of the pistil which receives the pollen. It is usually the apex of the style, variously expanded, which is destitute of epidermis and secretes the stigmatic fluid.

Stipules. Leaf-like appendages arranged in pairs at the base of the leaf stalk.

Stolon, or stole. A trailing or reclining and rooting shoot.

Stoma. Opening into the epidermis by which air enters and moisture escapes.

Strap. The ligule of a ray-floret in Compositae.

Striate. Marked with parallel lines or ridges.

Style. The slender part of a pistil supporting the stigma.

Sub-. A prefix meaning somewhat or slightly.

Subcuneate. Somewhat wedge-shaped.

Subtend. To enclose or embrace in its axil.

Subulate. Narrow and tapering to a sharp rigid point, as the leaves of Juniper; awl-shaped.

Sucrose. A crystalline compound with the composition of corn sugar.

Succulent. Juicy, fleshy.

Sulcate. Having one or more large, straight, longitudinal grooves or channels, as the stem of parsnip.

Suspensor. Filament of cells in ovary.

Synema. That part of the column in orchids which represents the united filaments of the stamens.

Tapetal cells. Cells surrounding mother cells in pollen and containing food material.

Tassel. The popular name for the staminate inflorescence or terminal compound spike of Indian corn.

Teleutospore. A thick-walled, usually compound gonidium. Produced by the Uredineae or rust fungi late in the season and serving to reproduce the fungus the next year; pseudospore.

Telial. Referring to telium.

Telium. The product of the final stage in rust fungi.

Terete. Round; cylindrical.

Terminal. Attached to or pertaining to the extremity or apex, as the terminal bud.

Ternate. Growing in threes, as the leaflets in clover.

Terrace. A step on the slope of a flood plain.

Testa. Outer seed coat. Sometimes both coats are spoken of as the testa.

Tomentose. Densely pubescent with matted wool.

Tomentum. Pubescent, with matted, woolly hairs.

Trailing. Prostrate on the ground but not rooting.

Transpiration. Process by which leaves lose moisture.

Trichome. A plant hair of any kind.

Trimorphic. See trimorphous.

Trimorphous. Having three kinds of flowers in the same species, differing in the relative lengths of their stamens and pistils.

Trioecious. Having a polygamous condition in which there are staminate, pistillate and perfect flowers, each on different sets of plants.

Truncate. Ending abruptly as if cut off transversely.

Tuber. A short thickened subterranean branch.

Tubercle. Any small wartlike excrescence, as those upon the rootlets of various Leguminoseae.

Tubular. In the form of a tube or pipe.

Tubular floret. A disk flower in Compositae, when, as is usual, it differs from those of the ray in having a small and regular corolla; disk floret.

Turbinate. Topshaped.

Turgid. Thickened like a tuber, or distended with a liquid (never with air).

Umbel. Any indeterminate inflorescence in which the peduncles or pedicels of a cluster seem to rise from the same point.

Umbellate. Like an umbel.

Undulate. Having a wavy surface.

Unisexual. Applied to an individual or flower which has one kind of sexual organs only; diclinous.

Uredospore. A form of unicellular spore or gonidium in the Uredineae or rust fungi, produced earlier in the season than the teleutospores and destined for immediate germination.

Urticating. Stinging. A term applied especially to the plant hairs of members of the Urticaceae, some of which are poisonous.

Utricle. A small inflated membranous 1-seeded fruit.

Vacuole. A sap-cavity in protoplasm.

Valve. One of the parts of a dehiscent fruit.

Vascular. Pertaining to or containing vessels.

Vein. A bundle of threads of fibrovascular tissue in a leaf or other organ.

Verrucose. With a warty surface.

Verticillate. Whorled.

Villous. Bearing long, soft, straight hairs.

Viscid. Sticky, glutinous.

Wavy. Margin forms wavy line bending inward and outward in succession.

Wedge-shaped. See cuneate.

Whorl. An arrangement of organs in a circle around a stem.

Wing. 1. Any thin or membranous expansion attached to or bordering an organ. 2. The lateral petal of a papilionaceous flower.

Winter annual. See annual.

Xenogamy. See cross-fertilization.

Xylem. Woody part of fibrovascular bundle containing larger continuous air-containing vessels; the water-conducting tissue.

Zoidiophilous. Pollinated by the agency of animals, including for example, protozophilous and entomophilous. It is the converse of Anthophilous, said of insects or other animals which convey the pollen.

Zoösporangium. A sporangium enclosing zoöspores.

Zoöspore. A spore possessing power of independent motion.

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Italic numbers indicate text figures

Pistillate flowers in short, smooth peduncles. Fruit solitary or in pairs, sessile, base broad and the cup saucer-shaped. Widely distributed in eastern North America.

Widely distributed throughout the state. Next to the bur oak it is found in more counties than any other species. Common and abundant from Keokuk to Boone, Webster and Fremont counties and less common along Missouri river to Sioux City.

Date of bloom, Ames, April 20, 1925; Tabor, May 1, 1927.

Honey Production in Quercus rubra, Red Oak (O. W. Park)

Year	Period of bloom	Full bloom	Period worked by bees	Period of honey flow	Notes
1920	5–19		5–10		Bees working
1921	4–26 5–10	5–2	5–4	5–5 5–9	heavily for
1923	5–8 5–12				pollen

Quercus palustris Muench. Spanish Oak, Pin Oak

A fine tree 70 to 80 feet high, with a trunk 2 to 3 feet in diameter. Drooping branches; winter buds ovate, smooth; bark light grayish brown; leaves obovate, divided into deep sinuses. Staminate flowers in pendent catkins, pistillate on short tomentose peduncles. Fruit sessile, acorn nearly hemispherical, cup saucer-shaped.

Common species in southeastern Iowa along Chariton, lower Des Moines and Iowa rivers and northward along the Mississippi to the Wapsipinicon. The type of trees found in the Wapsipinicon area indicates that this is an old stream valley. This tree is freely cultivated for ornamental purposes.

Quercus coccinea Muench. Scarlet Oak

Fine tree. Not native to the state but sometimes cultivated. Easily recognized by the lobed leaves and the turbinate thin cup of the acorn, which is light reddish brown with the upper part curved inwardly. It is widely distributed east of Mississippi river.

Quercus ellipsoidalis E. J. Hill. Northern Pin Oak, Yellow Oak, or Black Oak

A fine tree 60 to 70 feet in height, with a trunk 3 feet in diameter. Winter buds ovate, acute, smooth or ciliate on the margin. Bark

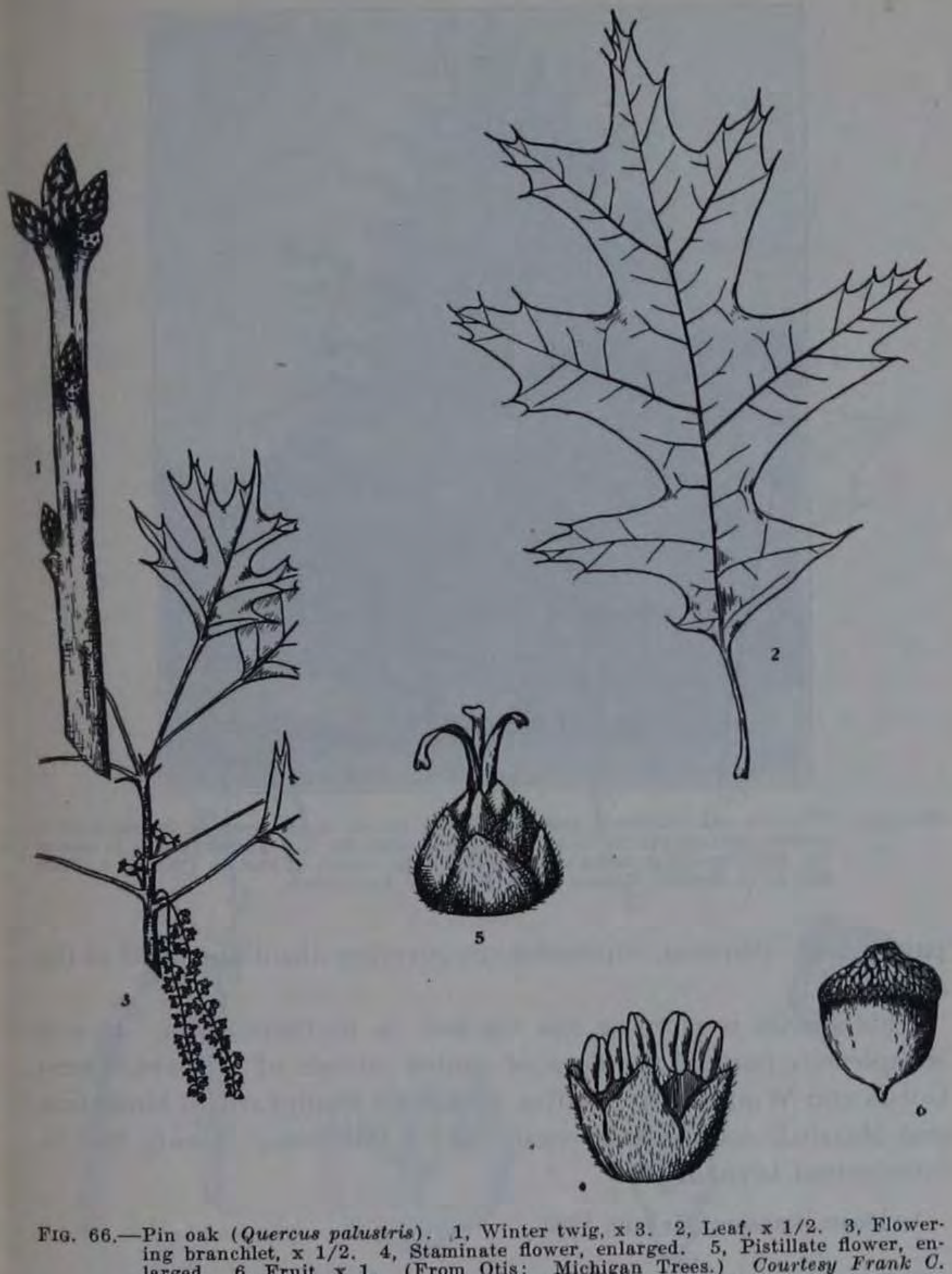

FIG. 66.—Pin oak (*Quercus palustris*). 1, Winter twig, x 3. 2, Leaf, x 1/2. 3, Flowering branchlet, x 1/2. 4, Staminate flower, enlarged. 5, Pistillate flower, enlarged. 6, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

thin, dark brown in color. Leaves ovate in outline, deeply divided, 5 to 7 lobes. Staminate flowers in drooping catkins, pistillate flowers in 1- to 3-flowered clusters, peduncled. The fruit solitary or in

FIG. 67.—"The pin oak (*Quercus palustris*) when grown in the open is symmetrical in outline and retains its limbs from the ground up. In appearance it is one of our most beautiful broad-leaved trees" (By Scott). *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

pairs; acorn ellipsoid, cup turbinate, covering about one-third of the acorn.

This species is more or less common in northern Iowa. It is a conspicuous part of the flora of timber islands of Howard, Cerro Gordo and Winneshiek counties, extending southward to Muscatine and Marshall counties and westward to Winnebago county and to some extent beyond.

In bloom, Lansing, May 10, 1925.

Quercus velutina Lam. Black Oak or Yellow Barked Oak, or Quercitron

Large trees, some of them 100 feet high with the trunk 3 to 4 feet in diameter. Winter buds ovate, hoary, tomentose. Bark on the young branches smooth, on the older trees deeply divided, dark

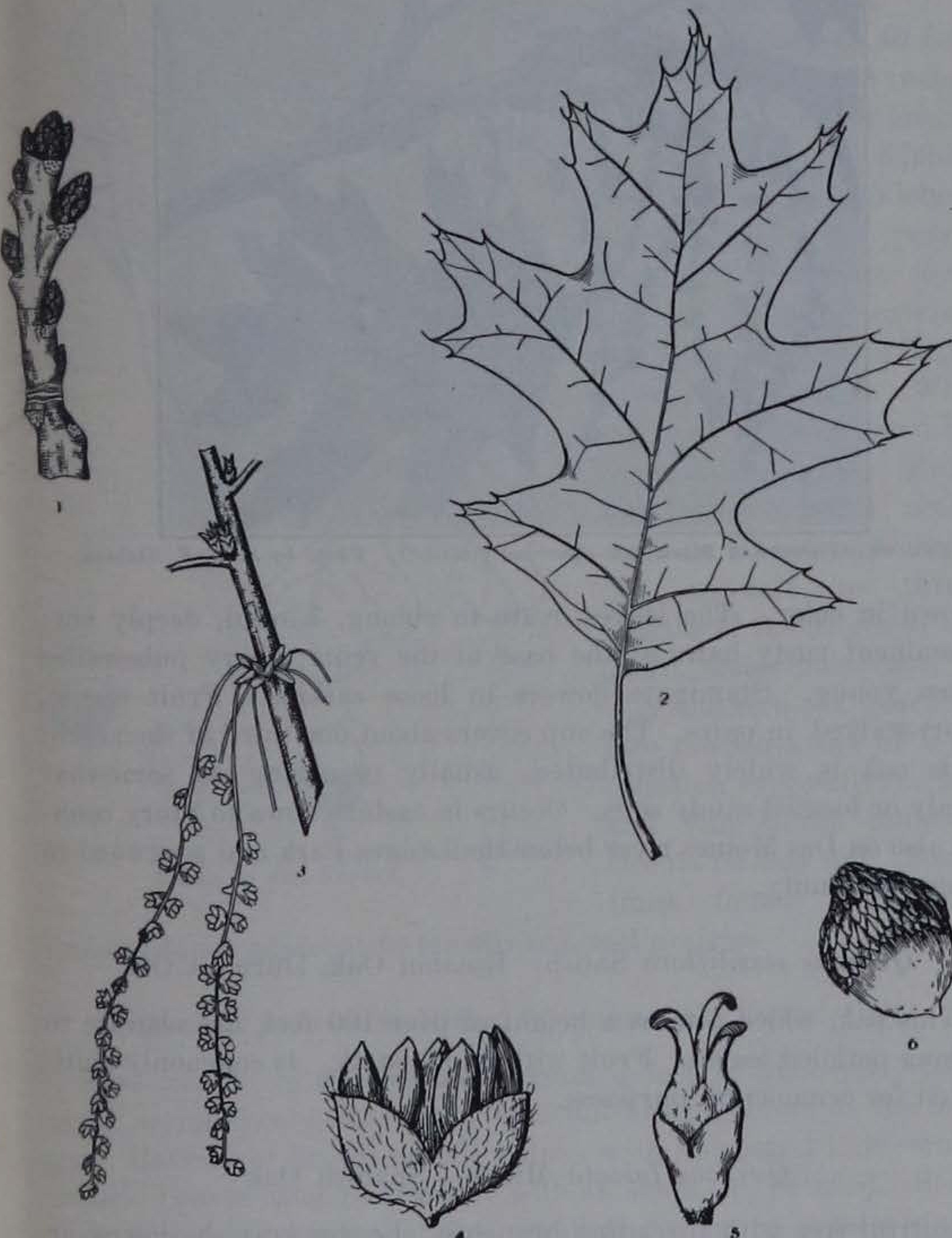

FIG. 68.—Black oak (*Quercus velutina*). 1, Winter twig, x 1. 2, Leaf, x 1/2. 3, Flowering branchlet, x 1/2. 4, Staminate flower, enlarged. 5, Pistillate flower, enlarged. 6, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

FIG. 69.—Flowers of Black oak (*Quercus velutina*). *Photo by S. G. F. Sheldon.*

brown in color. The leaves ovate to oblong, 7-lobed, deeply cut; prominent rusty hairs at the base of the veins; hoary pubescence when young. Staminate flowers in loose catkins. Fruit sessile, short-stalked, in pairs. The cup covers about one-third of the acorn. This oak is widely distributed, usually occurring on somewhat sandy or loessial sandy soils. Occurs in eastern Iowa to Story county, also on Des Moines river below the Ledges Park and westward to Fremont county.

Quercus sessiliflora Salisb. Russian Oak, Durmast Oak

This oak, which attains a height of over 100 feet, has obovate to oblong petioled leaves. Fruit with a long stalk. Is commonly cultivated for ornamental purposes.

Quercus falcata Michx. Spanish Oak

Beautiful tree with spreading branches. Leaves grayish, downy or fulvous underneath with acorn in a turbinate cup. Short-stalked winter buds, pubescent. This oak is common in the southern states and is cultivated in Burlington and Keokuk.

FIG. 70.—Black jack oak (*Quercus marilandica*). *Drawn by Ada Hayden.*

Quercus marilandica Muench. Black Jack or Barren Oak

Small trees 20 to 40 feet high, trunk 12 to 18 inches in diameter. Leaves broadly obovate, usually 3-lobed but some of them 5-lobed, deeply cut on the young sprouts. Staminate flowers in drooping catkins. Pistillate flowers solitary or in pairs, stalked. Winter buds ovate, covered by a pubescent scale. Fruit solitary or in pairs; acorn with an oblong cup covering one-half to three-fourths of the length of the acorn, scales pubescent.

A southern oak, reaching into the south tier of Iowa counties, especially in Lee and Van Buren counties. Occurs on clay soil. Sometimes found in floristic timber islands adjacent to the streams and prairies.

Quercus imbricaria Michx. Shingle Oak, Laurel Oak

Fine tree 50 to 60 feet high, trunk 3 feet in diameter. Buds ovate, scales closely imbricated, chestnut brown, ciliate on the margin. Bark light brown on old trunks with appressed light brown scales. Leaves oblong-lanceolate with an acute tip, petioled. Staminate flowers in slender catkins, pistillate flowers on slender stalks. Fruit solitary or in pairs, stalked; acorn nearly as broad as long, the cup covering about one-third the length of the acorn; scales reddish brown, smoothish except on the margin.

This species is fairly common in the southern part of the state, its northern limit extending from Mississippi river in Scott county to lower Johnson and Mahaska counties and westward.

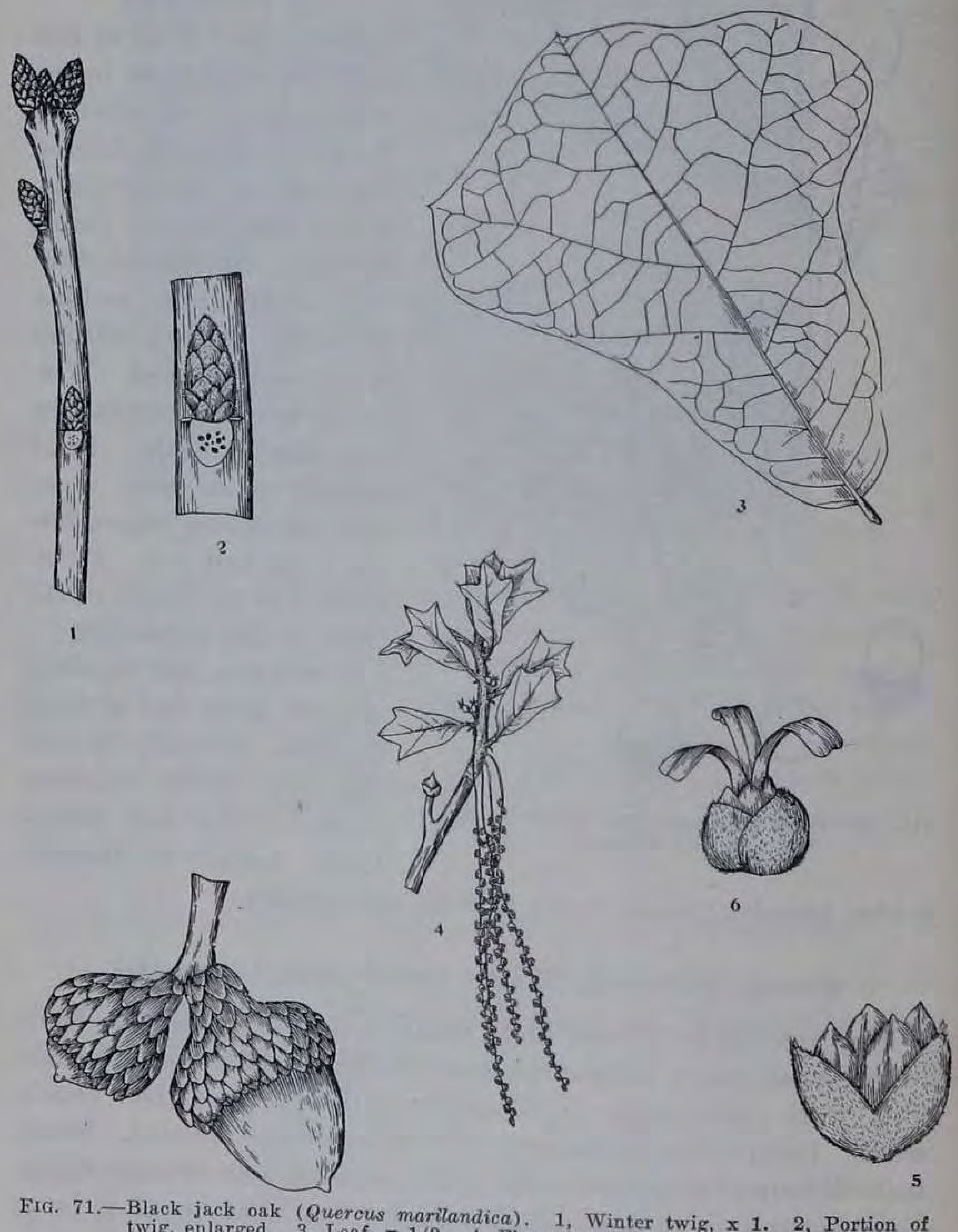

FIG. 71.—Black jack oak (*Quercus marilandica*). 1, Winter twig, x 1. 2, Portion of twig, enlarged. 3, Leaf, x 1/2. 4, Flowering branchlet, x 1/2. 5, Staminate flower, enlarged. 6, Pistillate flower, enlarged. 7, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

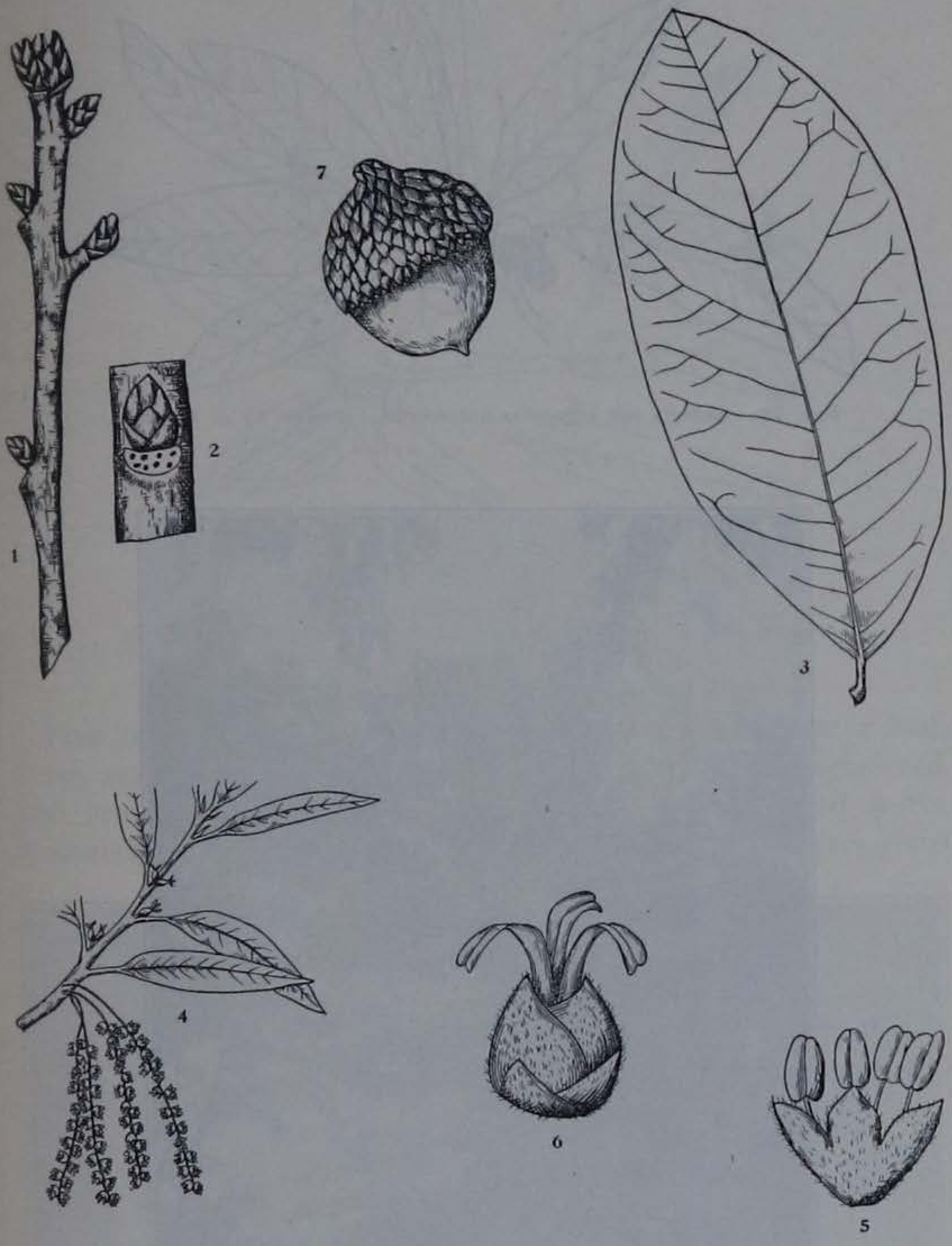

FIG. 72.—Shingle oak, laurel oak (*Quercus imbricaria*). 1, Winter twig, x 2. 2, Portion of twig, enlarged. 3, Leaf, x 1/2. 4, Flowering branchlet, x 1/2. 5, Staminate flower, enlarged. 6, Pistillate flower, enlarged. 7, Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

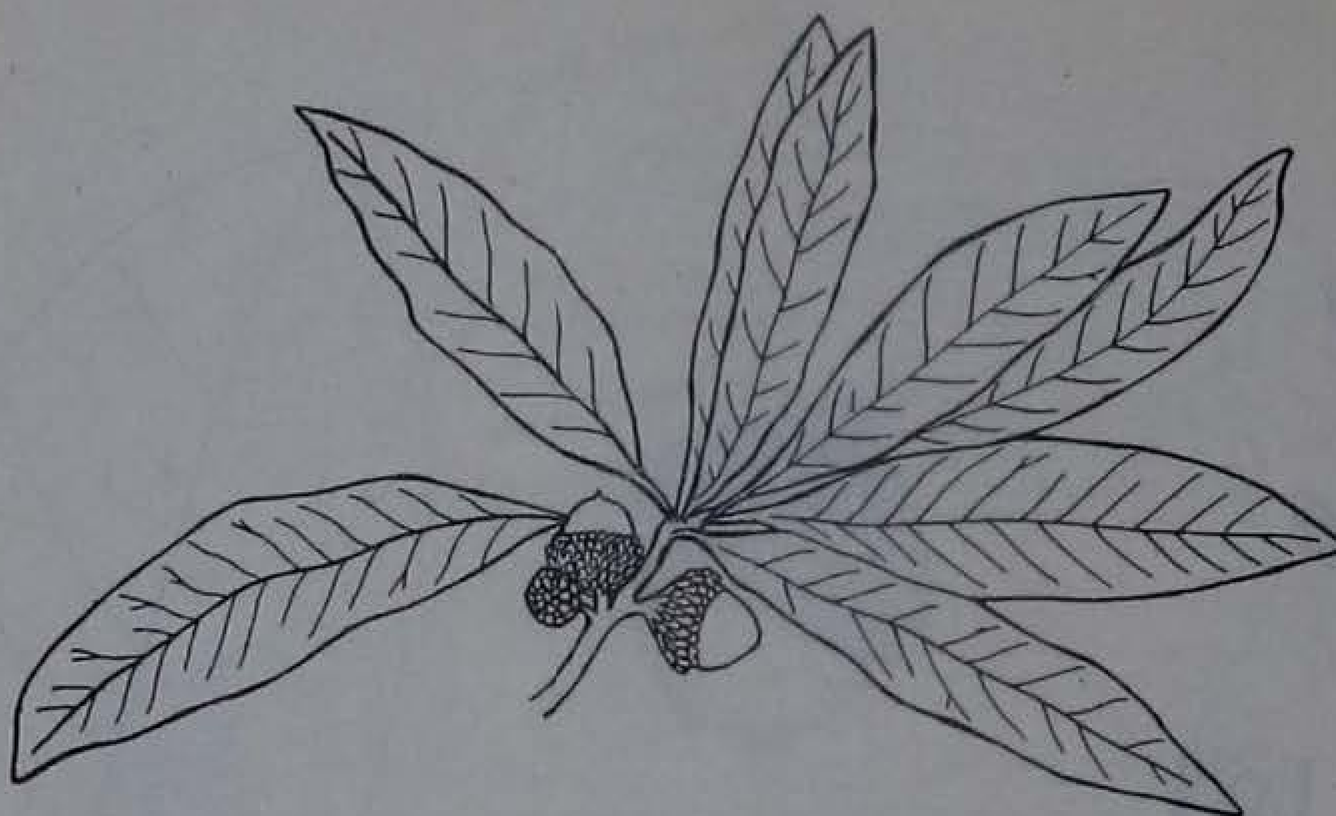

FIG. 73.—Shingle oak (*Quercus imbricaria*). *Drawn by A. Hayden.*

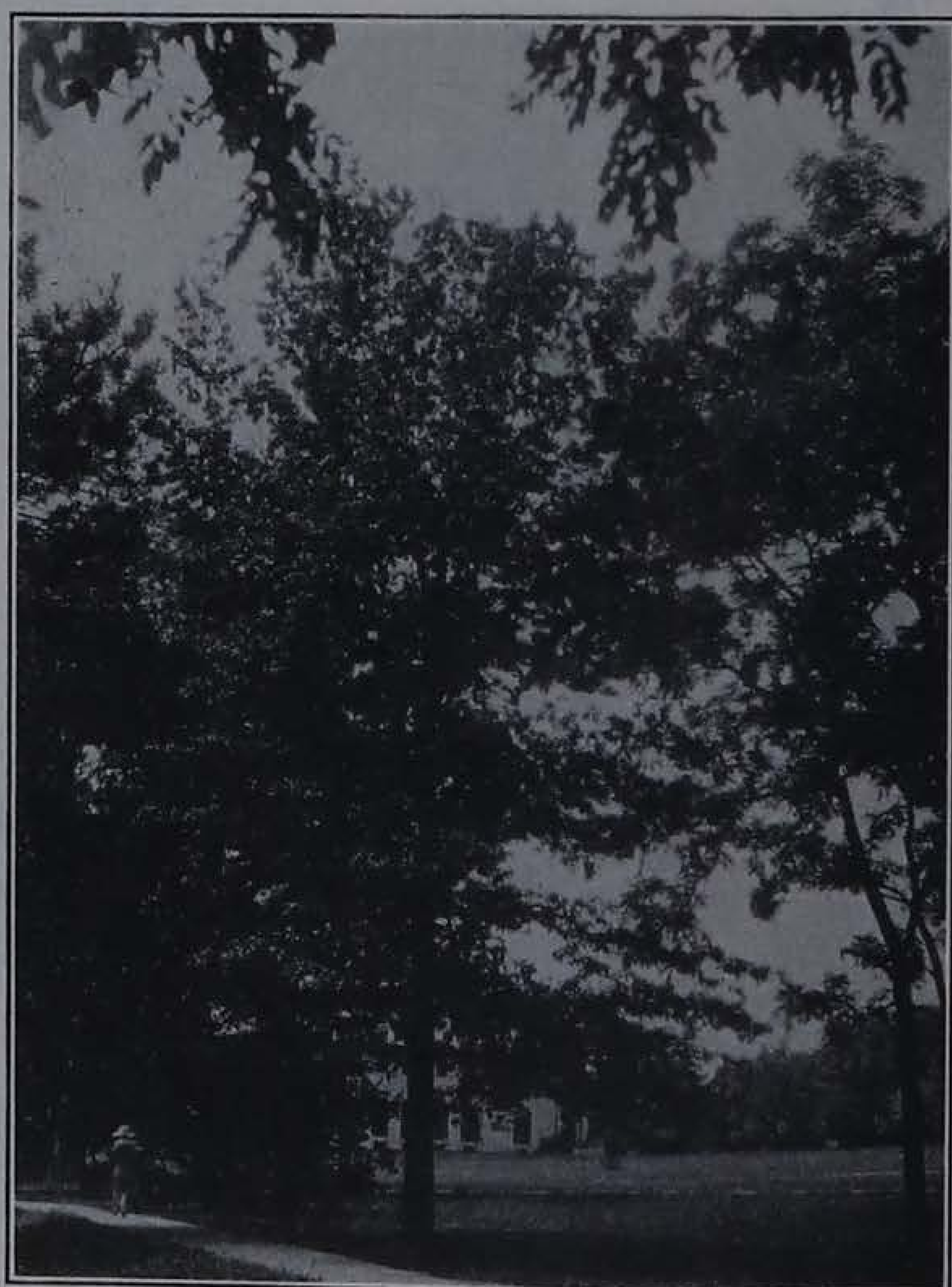

FIG. 74.—A shingle oak. "This tree is approximately 40 feet in height and a fine specimen" (By Scott). *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

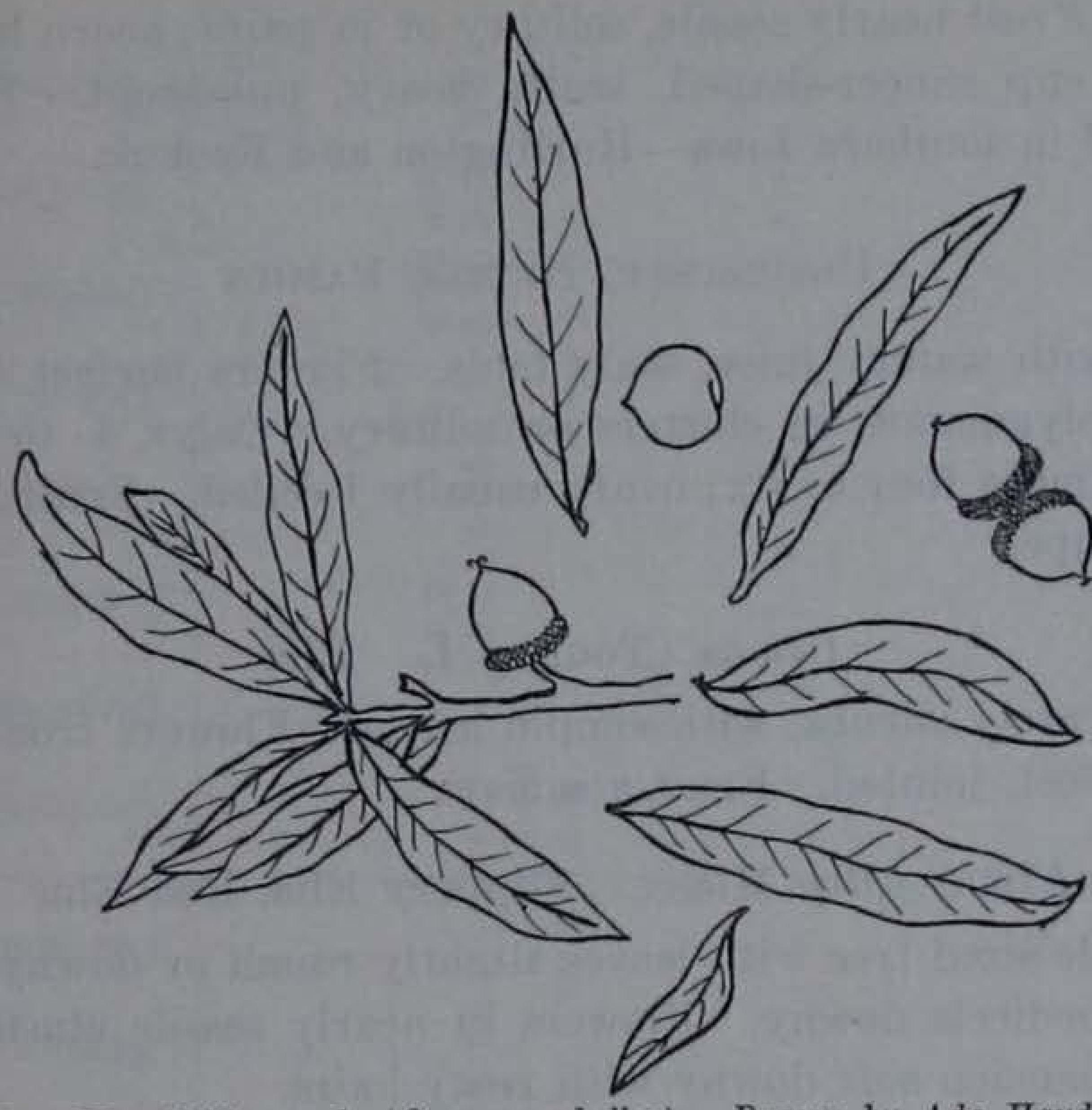

FIG. 75.—Willow oak (*Quercus phellos*). *Drawn by Ada Hayden.*

Quercus phellos L. Willow Leaved Oak

Fine tree 70 to 80 feet high, 2 feet in diameter. Winter buds ovate, scales chestnut brown, pale. Bark on young branches reddish brown, on old trees brownish with closely appressed scales. Staminate flowers in pendent clusters and pistillate flowers short

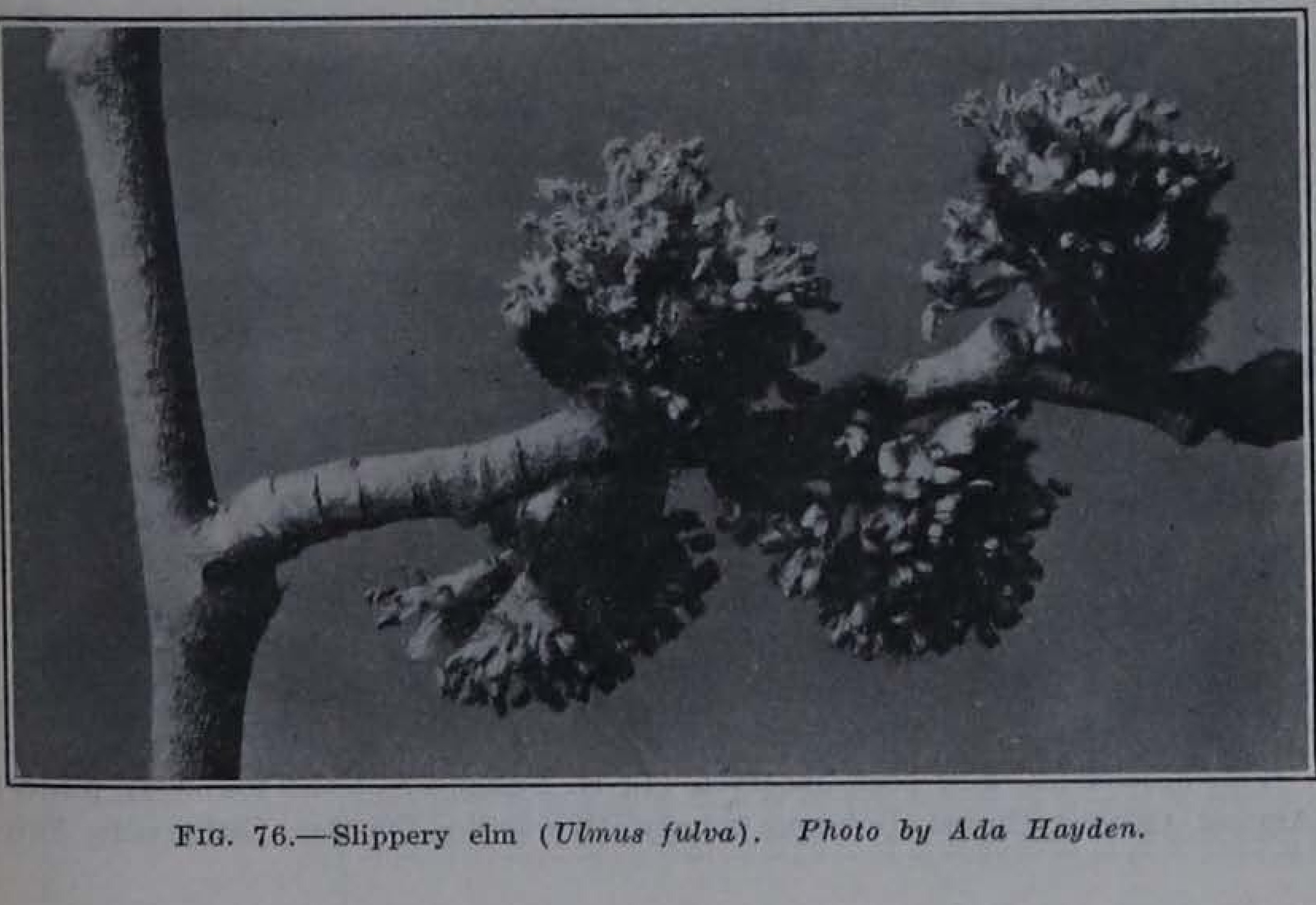

FIG. 76.—Slippery elm (*Ulmus fulva*). *Photo by Ada Hayden.*

stalked. Fruit nearly sessile, solitary or in pairs; acorn hemispherical, the cup saucer-shaped, scales hoary, pubescent. Sometimes cultivated in southern Iowa—Burlington and Keokuk.

Urticaceae, Nettle Family

Trees with watery juice, scaly buds. Flowers perfect or monoeciously polygamous, in clusters or solitary. Calyx 4- to 9-parted, lobed; stamens four to six; ovary usually 1-celled. Fruit a samara, nut or drupe.

Ulmus (Tourn.) L. Elm

Trees, rarely shrubs, with simple leaves. Flowers from axillary buds, perfect, jointed. Fruit a samara.

Ulmus fulva Michx. Slippery Elm, Red Elm

A middle-sized tree with leaves slightly rough or downy, branchlets and pedicels downy. Flowers in nearly sessile clusters, buds before expansion soft downy with rusty hairs.

The slippery elm is an upland tree, never on alluvial bottoms except of smaller streams; common throughout Iowa in rich clay soils or in soils mixed with sand and clay. It is associated with *Anemone nemorosa, Hepatica acutiloba, Sanguinaria canadensis, Claytonia virginica, Thalictrum dioicum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Atlantic, Beaman, Bellevue, Boone county (two specimens), Burlington, Centerville, Cherokee, Clarinda (two specimens), Clinton, Council Bluffs, Dawson, Delaware county, Delhi, Des Moines, Dillon, Dubuque (two specimens), Edgewood, Eldora, Fairfield, Farmington, Forest City, Garner, Harvey, Indianola, Jackson county, Jefferson, Kelley, Keokuk, Keosauqua, Lake Mills, Lansing (two specimens), Lime Springs, Liscomb, Little Sioux, Lost Island, Lyons, Manchester, Marble Rock, Marion county, Marshall county, McGregor, Muscatine, Nashua, Okoboji, Otter creek, Ottumwa, Payne, Perry, Postville, Rochester, Rockford, Sioux City (two specimens), Stratford, Strawberry Point, Warren county, Waterloo, Waukon Junction, Webster City, Whiting (L. H. Pammel), Missouri Valley, Oto (four specimens, H. B. Clark), Allamakee county (O. Schultz), Ames (two specimens, M. Clapper, G. W. Carver), Charles City (three specimens, C. L. Webster), Decatur county (J. P. Anderson), Decorah (R. I. Cratty), Fayette (B. Fink), Gladbrook (Ruth Vanderwold), Hardin county (C. M. King), Johnson county (T. J. Fitzpatrick), Mount Pleasant (H. E. Jaques), Mount Zion (Pammel and MacDonald), Union (J. P. Anderson), Whitney (Pammel and Clark).

This species has also been observed (L. H. Pammel) at the following places: Algona, Calmar, Cresco, Dubuque county, Dyersville, Elkader, Estherville, Fair-

Blooming dates for Ulmus fulva

	Northern Section			Central Section											Southern Section							
	Emmet Co.	Forest City	Lansing	Ames	Boone	Cedar Rapids	Iowa City	Oskaloosa	Grinnell	Marshalltown	Le Grand	West Union	Newton	Des Moines	Cincinnati	Ottumwa	Keokuk	Corydon	Lamoni	Creston	Woodbine	Garden Grove
1901				4–16																		
1902				4–2						4–12	4–12											
1903				4–1																		
1904				4–23																		
1905																			3–24			
1906			4–15	4–6			4–12	4–12	4–12								4–9			4–12	4–8	
1907		4–7	3–10	3–22	4–9	3–27		4–6				4–12	4–26				3–21	4–25		3–23	3–30	3–27
1908			4–9	4–4	4–3	3–27									3–26							
1909			4–18	4–12	4–18									4–12	4–5							
1910	3–23			3–20	3–15																	
1911	4–15		4–23		3–19											4–19						
1912	1–17		4–26		4–3																	
1913			4–12	4–3	4–1																	
1914			4–16	4–10	4–6																	
1915	4–15		4–12	4–12																		
1916	1–18		4–10		4–2																	
1917			4–5	4–10	4–2				4–18 to													
1918			4–10	3–22	3–21				4–25													
1919			4–3	4–10	4–1																	
1920			4–18	4–10	4–17																	
1921			3–28	3–20																		
1922			4–25	3–30																		
1923			4–24	4–18																		
1924			4–13	4–9																		
1925			4–15	4–10																		
1926				3–25																		
1927				3–25																		

field, Fort Atkinson, Fort Dodge, Glenwood, Green Island, Hamburg, Indianola, Jefferson, Keokuk, Lansing, Lehigh, Mason City, Marquette, McGregor, New Hampton, New Vienna, Pine Creek Hollow (Dubuque county).

General distribution for the United States:

Illinois—Kankakee (R. I. Cratty), Pecatonica (L. H. Pammel and V. C. Fisk), Peoria (L. H. Pammel); Missouri—Columbia, Rose Hill (L. H. Pammel); Minnesota—Cass Lake (L. H. Pammel and P. S. McNutt), Canyon Falls, Graceville, Howard, Star Island, (L. H. Pammel), Golden Valley (Mrs. Roy Westley); Nebraska—Blair (H. S. Clark); New York—Ithaca (H. E. Summers, W. C. Muenscher and A. R. Bechtel), Ohio—Baltimore (Asa Horr), Kelley's Island (L. H. Pammel); Oklahoma—Muskogee (L. H. Pammel).

HONEY BEE VISITS

The elms bloom very early in this latitude, about the middle of March or early in April. This elm furnishes pollen acceptable to bees, but its blooming period is rather short and the weather is often quite inclement when it blooms, interfering with bees' visits.

Ulmus americana L. American Elm

A large branching tree. Leaves oval, pointed, soft pubescent at first, soon glabrate. Flowers in close clusters, on slender drooping pedicels, appearing in April, before the leaves.

The American elm is usually a species of alluvial bottoms, also along smaller streams, in rich clay or sandy soils. It is associated with *Claytonia virginica, Aster Tradescanti, Phlox divaricata.*

The elm is said to be especially valuable to bees for pollen in most seasons, a large tree often being frequented by bees in such numbers that they produce a humming sound like that from a hive of bees. The period of pollen production is very short.

The flowers are anemophilous; that is, wind pollinated, and proterogynous. The method is described by Knuth as follows:

"Shortly before dehiscence of the anthers the filaments elongate to twice their original length. The anthers open completely in dry weather, but close again when it is damp. The insects can secure cross pollination by their visits, but they come to the flowers largely for pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Anamosa, Backbone Park (Delaware county), Beaver Junction, Bellevue, Burlington (two specimens), Carnforth, Cedar Falls, Centerville (two specimens), Charles City (two specimens), Clarksville (two specimens), Clemon's Grove, Colfax, Council Bluffs (two specimens), Dawson, Dubuque (two specimens), Eagle Rock (Marion county), Eddyville, Gillett Grove, Hamburg, Indianola (two specimens), Keosauqua, Liscomb, Little Rock, Lost Island (Palo Alto county), Lyons, Madison county, Mahaska county, Manchester (two specimens), Mason City, McGregor (three specimens), Muscatine county, Nashua, New Albin, Okoboji, Osage, Pisgah (two specimens), Postville, Redfield, Rochester (two specimens), Rock Rapids, Salem, Saratoga, Sioux City, Spirit Lake (two specimens), Stratford (five specimens), Toolsboro, Wallingford, Waverly, Webster City, West Burlington (L. H. Pammel), Armstrong, Clear Lake (R. I. Cratty), Lansing, Waukon (two specimens, O. Schultz), Algona (two specimens, E. B. Watson), Ames (Marion Clapper, J. C. Blumer), Decatur county (J. P. Anderson), Fairfield (W. R. Geager), Fayette (B. Fink), Fraser (Botany Seminar), Howard county (Mrs. F. M. Tuttle), Johnson county (T. J. Fitzpatrick), Keokuk (three specimens, P. H. Rolfs), Missouri Valley (two specimens, H. B. Clark), Mount Pleasant (H. E. Jaques).

It has also been observed (L. H. Pammel) at Arnold's Park, Calmar, Camanche, Carroll, Cherokee, Clinton, Cresco, Davenport, Decorah, DeWitt, Dexter, Dyersville, Eldora, Estherville, Fort Atkinson Fort Madison, Hamburg, Humboldt, Iowa City, Iowa Falls, Lansing, Lebanon, LeMars, Marion, Marshalltown, Missouri Valley, Mount Vernon, Montrose, Muscatine, New Albin, New Vienna (Dubuque county), Onawa, Otho, Pine Creek Hollow (Dubuque county), Polk City, Redfield, Rock Rapids, Sergeant Bluff, Shenandoah, Sioux City, Spirit Lake, Stratford, Tama, Traer, Turin, Webster City.

General distribution for the United States:

Alabama—Birmingham (L. H. Pammel); Connecticut—New Haven (W. H. Mast); Delaware—northern Delaware (William Canby), Wilmington (Wm. Tatnall); Illinois—Peoria, Walnut (L. H. Pammel), East St. Louis (two specimens, H. Eggert); Indiana—Crawfordsville (L. H. Pammel); Minnesota—Foley, Jackson county, southern Minnesota (R. I. Cratty), Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), Cloquet, Star island, International Falls (Mrs. Roy Westley); Missouri—Columbia, Jefferson Barracks, Kansas City (L. H. Pammel), Rockford (A. O. Simonds); New Mexico—Santa Fe (A. Isabel Mulford); New York—Geneva, Goat Island, Watkins Glen (L. H. Pammel), Ithaca (three specimens, H. E. Summers); North Dakota—Minot (J. C. Blumer); Ohio—Gambier (L. H. Pammel), Sandusky (L. H. Pammel and F. Crow), Worthington (Asa Horr); South Dakota—Hartford Beach, Sioux Falls, Brookings (L. H. Pammel and N. E. Hansen); Texas—Fort Worth (Albert Ruth); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood); Wisconsin—De Soto, St. Charles (L. H. Pammel), St. Croix (L. H. and H. E. Pammel).

HONEY BEE VISITS

Ames, April 21, 1920. Stamens and pistils almost all killed by a freeze which came two weeks previous. A few honey bees gathering pollen. (L.H.P.)

April 26, 1922, 1 p.m. Warm south wind, not strong. Honey bees abundant collecting pollen, bees one and one-half, two, one and one-half, one, one, one and one-half seconds in a flower. One bee to about five hundred flowers.

July 8, 1927, 7 a.m. Clear, cool. Bees busy on honey-dew. (C.M.K.)

Ames, Spring of 1929. Bees numerous on honey-dew on *Ulmus americana*. (C.M.K.)

Honey production in Ulmus americana, Elm (O. W. Park)

Year	Period of bloom	Full bloom	Period worked by bees	Period of honey flow	Notes
1918	3-26				One of the important sources of early pollen.
1919	3-31		3-31	Freeze	Ordinarily no nectar is produced in Iowa. Pollen
1921	3-29	3-19 4-5	4-5 to	4-23	bright yellow.
1922	4-2 to 4-15	4-2		4-2	Bees very numerous on elm
1923	4-13	4-19	4-19		bloom.

FIG. 77.—Corky bark elm (*Ulmus racemosa*). *Photo by Ada Hayden.*

Ulmus racemosa Thomas. Cork or Rock Elm

A fine tree 60 to 80 feet in height, 3 feet in diameter. Rather compact. Winter buds ovate, acute, chestnut brown scales. Bark grayish, on young branches corky, on old trees with irregular compact scales. Leaves obovate to oblong-oval, one-sided, doubly serrate, pale beneath, bright green above. Flowers in elongated drooping racemes. Fruit ripens early, ciliate on the margin.

Blooming date for Ulmus americana

	Northern section						Central section									Southern section							
	Allamakee Co.	Emmet Co.	Forest City	Armstrong	Lansing	Waukon	Ames	Boone	Des Moines	Anamosa	Iowa City	Oskaloosa	West Union	Cedar Rapids	Grinnell	Ottumwa	Cincinnati	Garden Grove	Corydon	Lamoni	Creston	Woodbine	Keokuk
1886							4–23																
1891							4–24																
1892							5–15																
1896							4–3																
1901							4–15																
1902							4–2																
1903							4–2																
1904							4–22																
1905							3–23													3–24			
1906	5–5				4–18		4–6				4–7	5–10			4–10						4–12		4–4
1907			4–3	4–1	3–30	5–10	3–26	4–10				3–22	4–4	3–23				3–23	4–18			3–25	3–20
1908					4–2		4–5	4–5		4–6				3–11									3–20
1909					4–20		3–20	4–18	4–16								4–5						
1910		3–23					3–20	3–17															
1911		4–15					3–14	3–20								3–22							
1912		4–11			4–7			4–6															3–27
1913		4–15			4–12		4–1	4–3															
1914		4–16			4–18		4–10	4–10															
1915		4–15			4–14		4–9	4–18															
1916		4–14			4–13			4–9							4–9 to 4–17								
1917					4–3		4–10	4–22															
1918					4–6			3–19															
1919					4–2		3–22	3–28															
1920					4–14		4–10	4–17															
1921							3–20	3–14															
1922							3–20																
1923					4–24		4–18																
1924					4–13		4–9																
1925					4–6		3–26																
1926					4–15		4–10																
1927							3–25																

Ulmus alata Michx. Wahoo or Winged Elm

Prominent, corky winged branches. Leaves downy beneath, ovate-oblong. Downy fruit. Not native to Iowa, but sometimes cultivated in the southeastern part of the state.

SOME EXOTIC ELMS

A number of exotic elms are commonly cultivated and these furnish pollen.

Ulmus campestris L. English Elm

A tall tree with irregular branches and deeply fissured bark. Pedicels short, leaves ovate, quite unequal at the base.

Ulmus glabra (sometimes known as *Ulmus montana*) Huds. Wych Elm

Fine tree 120 feet high with round top. Bark more or less smooth when young, young branches pubescent. Short pedicels, leaves short-petioled, obovate and doubly serrate, rough above. Large samara.

Ulmus parvifolia Jacq. Chinese Elm

In recent years the Chinese elm has been used much as an ornamental plant. A small tree, 40 to 50 feet. Smooth bark. Elliptic leaves, serrate.

Date of bloom, Ames, March 25, 1927.

Celtis (Tourn.) L. Hackberry

Trees or shrubs. Leaves alternate, serrate or entire, deciduous; Stipules falling early. Flowers greenish, axillary, appearing with the leaves, polygamo-monoecious or rarely monoecious.

Celtis occidentalis. Hackberry

Has light brown or silver gray bark, opposite scales, sometimes with wartlike excrescences. Leaves rough.

Widely distributed in Iowa.

"I have never seen bees working on this in the north, but in 'American Honey Plants' it is reported as being visited by bees in Texas."

FIG. 78.—Hemp (*Cannabis sativa*). *After Faguet.*

Cannabis (Tourn.) L. Hemp

A tall annual plant with rough digitate compound leaves and greenish flowers; the inner bark containing tough fibers.

Cannabis sativa L. Hemp

The common hemp plant of waste and cultivated grounds. Found throughout the state. Adventive from Asia.

The flowers of hemp are inconspicuous in color, dioecious and anemophilous. The staminate flowers are in panicled clusters, apetalous, with five sepals and five drooping stamens. They are sometimes visited by bees for pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls, Fraser, Marshalltown, Nevada (L. H. Pammel), Ames (L. H. Pammel and Robert Combs, George Carver), Cedar Rapids (R. E. Buchanan), Colfax (F. P. Sipe), Decorah (R. I. Cratty), Des Moines (Emma and L. H. Pammel), Fayette (B. Fink), Fort Dodge (J. C. Blumer), High Bridge (Boone county) (G. M. Lummis), High lake (B. O. Wolden), Kelley (Pearl Clayton), northeastern Iowa (H. Goddard), Ontario (E. Hodson), Slater (H. S. Fawcett, W. I. Tener and C. Reinbott).

HONEY BEE VISITS

Clayton, August 4, 1923, 3 p.m. Bees getting pollen. Three, three, three, three, two, two seconds in a flower. (L.H.P.)

Morus (Tourn.) L. Mulberry

Trees or shrubs with dioecious or monoecious flowers, four-parted calyx, four stamens, ovary two-celled, two styles. Fruit aggregate, that is, the calyx and parts adjacent become thickened and juicy. In fact, it consists of a cluster of flowers which have become more or less fleshy.

Morus rubra L. Red Mulberry

This is the only species native to Iowa. It has heart-shaped leaves, serrate, rough above, downy beneath, lobed. It is found east as far north as Allamakee county and west as far north as Sioux City.

In bloom, Lansing, May 10, 1925.

Morus alba L. White Mulberry

This species is freely cultivated. Leaves obliquely heart-shaped, serrate, lobed. Fruit whitish. More or less spontaneous near buildings.

This species is included though it is not mentioned by either Knuth or Mueller as being visited by honey bees.

Date of bloom, Lansing, May 10, 1925.

HONEY BEE VISITS

Ames, May 10, 1929, 2:30 p.m.
May 23, 1929, 12:30 p.m. No bees. Evidently not visited by honey bees. On *Lonicera Morrowi*, a short distance away, bees abundant.

A related plant is Osage Orange (*Maclura aurantiaca*). Dioecious flowers. A four-parted calyx with large aggregate fruit. Leaves oblong-lanceolate, acuminate. This species was widely distributed as a hedge plant, but it is not much used as a honey plant. Honey bees have been found on it in Iowa and bees have been reported on it elsewhere.

In bloom, Ames, May 31, 1925.

HONEY BEE VISITS

Clayton, August 4, 1923, 3 p.m. Bees gathering pollen on a very late blooming plant. (L.H.P.)

Urtica (Tourn.) L. Nettle

Herbs having greenish apetalous flowers; pistillate and staminate flowers in separate clusters. The staminate flowers produce an abundance of pollen which is attractive to bees.

Urtica gracilis Ait. Nettle

A slender plant with serrate narrow lanceolate-oblong leaves. Common in moist grounds.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Delhi, Dubuque, Gillett Grove, Harlan, Indianola, Lamont, Liscomb, Sac City (two specimens), Sheldahl, Slater (two specimens), Ames (R. E. Buchanan), Decatur county (T. J. and M. F. L. Fitzpatrick), Decorah (E. W. D. Holway), Fraser (Botanical Seminar), Greenfield (F. C. Stewart), High Bridge (Boone county) (G. M. Lummis), High lake (B. O. Wolden), Kelley (C. E. Maxwell and L. H. Pammel), Spirit Lake (H. E. and L. H. Pammel).

General distribution in the United States:

Colorado—Fort Collins, Silver Plume (three specimens, L. H. Pammel), River Flats (C. S. Crandall); Michigan—Muskegon (L. H. Pammel); Minnesota—Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt), International Falls (H. S. Kellogg); Itasca State Park (L. H. Pammel), McKinley (Mrs. Joseph Clemens), Minneapolis (R. I. Cratty); Montana—Bitter Root Mountains (L. H. Pammel and H. S. Fawcett); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Cedar Point (L. H. Pammel); South Dakota—(L. H. Pammel); Washington—Near Montesano (A. A. and E. G. Heller).

POLYGONACEAE, Buckwheat Family

Herbs with alternate entire leaves and sheathing stipules; joints of the stem swollen. Fruit an achene.

Polygonum (Tourn.) L. Smartweed, Knotweed

Herbaceous plants with fibrous roots, including many common weeds. Blooming throughout late summer. Flowers in axillary fascicles or in dense spikes. Calyx 4- to 6-parted, petal-like, per-

General distribution in the United States:

California—Santa Cruz (L. H. Pammel); District of Columbia—Potomac Flats (Lester Dewey); Florida—Palmetto (S. M. Tracy); Illinois—Argyle (L. H. Pammel), Englewood (J. R. Churchill), Grand Tower (H. A. Gleason), Savanna (L. H. Pammel); Michigan—Whitehall (L. H. Pammel); Minnesota—Cass Lake, Monticello (L. H. Pammel), Hibbard (Lyle Clapper), St. Cloud (R. Gmelin); Missouri—Allenton (George W. Letterman); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (Muenscher and Bechtel); Ohio—Huron (L. H. Pammel); Oklahoma—Muskogee (L. H. Pammel); South Dakota—Brookings (Edna C. Pammel); Texas—Austin (two specimens, B. C. Thorpe), College Station (three specimens, L. H. Pammel), Kerrville (A. A. Heller), Lake Worth (Albert Ruth), Texarkana (A. A. and E. G. Heller).

HONEY BEE VISITS

Ames, August 26, 1918, 2 p.m. Northeast wind. Clear. Plant not very attractive to bees. In ten minutes three bees over area 15 by 15 feet. (L.H.P.) In bloom, Cedar Rapids, August 1, 1908. Ames, July 25, 1922.

Polygonum amphibium L. Water Smartweed

May be considered with *Polygonum Muhlenbergii.*

A perennial aquatic smartweed rooting in the mud, glabrous, rarely branching. Leaves long-petioled, elliptical. Spike terminal, dense ovoid, 1 inch to 1½ inches long; flowers bright rose-color, with pleasant odor, the five stamens and style exserted. The short-styled flowers open wider than the long-styled flowers. This species is visited by honey bees, flies and Lepidoptera.

Rather common in low marshy grounds near lakes and other waters. It is associated with *Typha latifolia, Alisma Plantago* var. *americana, Sagittaria variabilis.*

Knuth says, "The flowers are pink to purple-red in color, smell like honey, and are dimorphous. Nectar is secreted at the base of the ovary by 5 yellow-orange glands."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Emmet county (R. I. Cratty), Kossuth county (L. H. Pammel).

This species has also been observed (L. H. Pammel) at Calhoun county, Iowa lake, Lake Okoboji, Pocahontas county, Ruthven, Spencer, Spirit Lake, Twin lakes.

General distribution in the United States:

Connecticut—Beaver Pond, Crescent Lake (aquatic form), Flander's Pond (aquatic form), Meriden, Southington; Illinois—Lake View (R. W. Larrabee); Louisiana—Lake Ascension (T. L. Andrews); Michigan—Stamburgh (L. H. Pammel); Montana—University of Montana; Nova Scotia—Near Pictou (C. D. Howe and W. F. Lang); Wisconsin—La Crosse (Emma Pammel); Wyoming—Wheatland, Albany county, Dunn's Ranch (Aven Nelson), Tabegauche Basin (Edwin Payson).

HONEY BEE VISITS

Ames, August 15, 1915. An occasional *Bombus* observed. (L.A.K.)

Blooming dates, 1908, Cedar Rapids, June 9. 1916, Lansing, June 17.

Polygonum amphibium var. *Hartwrightii* (Gray) Bissell. Water Smartweed

A form with spreading foliaceous sheaths.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong (R. I. Cratty), Eagle Grove (R. E. Buchanan), Jewell Junction (F. C. Stewart).

General distribution in the United States:

California—Portola (L. H. and Mrs. L. H. Pammel); Connecticut—Southington (two specimens, T. L. Andrews); Illinois—below Oquawka (Harry M. Patterson); Minnesota—Leech Lake, Walker (L. H. Pammel), Cass Lake, Star Island (L. H. and H. E. Pammel and P. S. McNutt), Brainerd (E. B. Watson); New York—Ithaca (Muenscher and Bechtel); Prince Edward's Island—Malpeque (M. L. Fernald and Harold St. John).

Polygonum Muhlenbergii (Meisn.) Wats. Tanweed, Marsh Smartweed

May be considered with *Polygonum amphibium*. A perennial smartweed, variable in appearance, with long dark-colored roots, decumbent, or nearly erect; somewhat pubescent. Leaves thinnish, large, long-pointed. Flowers rose-colored, in spikes from an inch to three inches in length.

Sometimes found on dry ground, but common in low grounds in soil usually mixed with a little peat. It sometimes occurs in cultivated fields. It is associated with *Polygonum lapathifolium*, *Cyperus esculentus* and *Scirpus atrovirens*.

The nectar is secreted at the base of the ovary by orange-colored glands.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belmond, Centerville, Dillon, Eddyville, Forest City, Ogden, Spirit Lake, Turin (L. H. Pammel), Ames (Ewing Johnson), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Mount Pleasant (J. W. Mills), Osage (Mrs. F. M. Tuttle), Osceola (S. B. Burbank), Peru (D. E. Hollingsworth), Slater (H. S. Fawcett, C. Reinbott and W. I. Tener).

It has been observed (L. H. Pammel) at Cherokee, Cresco, Dubuque, Fort Atkinson, Fort Dodge, Hamburg, Jefferson, New Albin, Polk City, Shenandoah.

FIG. 80.—Marsh Smartweed (*Polygonum Muhlenbergii*). *Photo Section, Iowa Agr. Exp. Sta.*

General distribution in the United States:

Connecticut—Southington, (aquatic form, riparian form) (Truman Andrews), Southington Misery swamp (Transition form and riparian form) (Truman Andrews), Glastonbury, (riparian form, Southington riparian form) (four specimens, Truman Andrews); Idaho—Sand Point (L. H. Pammel and W. S. Dudgeon); Massachusetts—Springfield, riparian form (T. Andrews); Missouri—Jackson county (Kenneth Mackenzie), Neosho (S. E. Meers); Ohio—Cedar Point (L. H. Pammel); Ontario—Rainy river (H. S. Kellogg); Oregon—Crook county (K. Whited); South Dakota—Brookings (L. H. Pammel and N. E. Hansen), Milbank (L. H. Pammel); Wisconsin—Dresser Junction, La Crosse (L. H. Pammel).

HONEY BEE VISITS

Dillon, September 4, 1914, a. m. Southeast wind. No bees. Some other insects. It is, however, occasionally visited by honey bees at Ames.

Des Moines, September 3, 1929, 11:45 a.m. Bees fairly common (near an apiary). One, one, one, two, two, one, two seconds in a flower. (L.H.P.)

In bloom, Cedar Rapids, July 4, 1908.

Polygonum pennsylvanicum L. Pennsylvania Smartweed, Heart's-ease

An annual herbaceous plant, with lanceolate leaves, the branches above bearing stalked glands. Flowers bright rose-colored, in short, erect spikes. There are usually 8 stamens.

Grows in moist grounds in open waste places. Common on all kinds of cultivated soil; widely distributed in Iowa cornfields. It is associated with *Setaria viridis*, *Setaria glauca*, *Oxalis corniculata*, *Polygonum Convolvulus*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville, Council Bluffs, Gillett Grove, Granite, Keystone, Little Rock, Madison county, Nashua, Oelwein, Rock Rapids, Saratoga, Shenandoah, Sioux City, Steamboat Rock, Washington, West Burlington (L. H. Pammel), Eagle Grove, Hartwick, Marshalltown (three specimens), Missouri Valley (T. J. and M. F. L. Fitzpatrick), Keokuk, New Hampton (P. H. Rolfs), Ames (seven specimens, L. H. Pammel, C. E. Maxwell and E. Elijah, F. C. Stewart, H. Ness), Charles City (L. H. Pammel and E. M. Sherman) Decatur county (J. P. Anderson), Des Moines (two specimens, A. L. Bakke), Fayette (C. C. Parker), Fraser (Botany Seminar), Garner (L. H. Pammel and W. Gilbert), Kelley (L. H. Pammel and C. E. Maxwell), Ledges (T. Macklin and L. H. Pammel).

It has been observed (L. H. Pammel) at Algona, Burlington, Bellevue, Camanche, Cedar Rapids, Cherokee, Clinton, Cresco, Davenport, Decorah, Dubuque, Estherville, Forest City, Gilbert, Hamburg, Indianola, Jefferson, Lake Okoboji, Le Mars, Maquoketa, Mason City, Muscatine, Nevada, New Albin, Shenandoah, Spirit Lake, Story City.

General distribution in the United States:

Alabama—Huntsville (C. F. Baker), Tuskegee (G. W. Carver); Illinois—Savanna, Walnut (L. H. Pammel), Champaign (H. A. Gleason); Kansas—

FIG. 81.—*Polygonum pennsylvanicum.* *Photo Section, Iowa Agr. Exp. Sta.*

Wichita (T. L. Andrews); Kentucky—Poor Fork (Harlan county) (T. H. Kearney, Jr.); Maine—Orono (M. L. Fernald); Maryland—Principio Furnace (L. H. Pammel); Massachusetts—Cambridge (J. W. Blankinship); Minnesota—Lake City (L. H. Pammel); Mississippi—Long Beach (F. E. Lloyd and S. M. Tracy); Missouri—Allenton (G. W. Letterman), St. Louis (P. T. Barnes);

Nebraska—Callaway (J. M. Bates), Holdredge (J. G. McMillan); New York—Geneva (two specimens, L. H. Pammel); Ohio—Pickerington (Asa Horr); Rhode Island—Nantucket (Bessie Woodbridge); Texas—Austin (B. C. Thorpe, W. C. Werkenthin), College Station (L. H. Pammel), Texarkana (A. A. and E. G. Heller).

Blooming dates for Polygonum pennsylvanicum

	Central section			
	Ames	Boone	Ledges	Cedar Rapids
1903			7–4	
1908				6–26
1909	5–25			
1910	7–23 height	6–21		
1911		7–15 height		

HONEY BEE VISITS

Centerville, September 2, 1914, a.m. Cloudy, rain previous day. Ten honey bees, one steel blue fly. In flower one to five seconds. (L.H.P.)

Ames (Railway) July 28, 1914, a.m. Partly cloudy, west wind. Many small bees and wasps, evidently for nectar. Bees change between this plant and *Melilotus alba.* (G.H.M.)

(Campus) August 3, 1914. Clear, southeast wind. Bee getting nectar; small Hymenoptera collecting pollen; wasps, flies. (G.H.M.)

(Campus) August 19, 1915, a.m. Clear, cool. One bee gathering nectar. More than on buckwheat. (L.A.K.)

(Campus) August 20, 1915, 9 a.m. Five bees gathering nectar. More than on buckwheat. (L.A.K.)

3 p.m. One bee, a few other Hymenoptera. (L.A.K.)

(Campus) August 21, 1915, 8 a.m. to 9 a.m. Clear, moderate temperature. Four bees, several *Eristalis.* (L.A.K.)

(Campus) August 23, 1915, 8:30 a.m. Warm. Six bees.

(Campus) August 26, 1915. Cloudy. No insects. (L.A.K.)

(Campus) September 1, 1915. Clear, warm. One bee. None on *Polygonum Persicaria.*

(Campus) September 2, 1915. Warmer. Occasional bees. (L.A.K.)

August 26, 1918, 2 p.m. One bee visited 28 or 35 flowers in one minute. Much time lost in going from one flower to another. Not many bees about this flower until after September 1. (L.H.P.)

September 5, 1918. In an area four by four feet two bees in two minutes.

September 6, 1918, p.m. Warm, clear. In an area four by four feet four bees were working three minutes. Four hundred fifty flowers in the space. Visits short, one-fourth flowers of each head visited. Other Hymenoptera numerous. (L.H.P.)

West Burlington, September 8, 1918. One bee visited 28 flowers in one minute. Six open flowers in one spike. In an area four by four feet, 1300 flowers were open at the same time. Bees seem to prefer this flower to *Bidens aristosa* and visited it as freely as buckwheat.

September 9, 1918, 9 to 10 a.m. Bright and clear. More bees on this plant than on *Bidens aristosa.*

Le Mars. Honey abundant some years. (E.G.B.)

Ames, September 22, 1918. Twenty-eight flowers on six spikes were visited by one bee in one minute. Another bee seven flowers on seven spikes in twenty seconds.

July 26, 1919. Cool north wind. Plant has been in bloom several days. No honey bees but numerous small Hymenoptera.

August 24, 26, 1919. No honey bees. Other Hymenoptera common.

June 11, 1920, 1:15 p.m. Partly cloudy. Time of honey bee in flower three, four, four, five seconds, visiting the pale flowers only. (L.H.P.)

June 26, 1920. Bumble bee one, two, one seconds in a flower.

August 26, 1920, 2 p.m. Bright, clear, east wind. Low ground. Flowers visited in one minute, 28 to 35. Three bees on an area 15 by 15 feet in 10 minutes. (L.H.P.)

August 27, 1923. Clear, warm morning. Many bees getting nectar. One, two, one, one seconds in a flower.

September 1, 10, 1923. Bright days. Bees abundant, getting nectar.

McGregor, August 13, 1924, 4 p.m. No bees. (L.H.P.)

Marshalltown, August 30, 1927, 10 a.m. Bees fairly common. One, two, two, two, one, one seconds in a flower. (L.H.P.)

Bevington, September 20, 1927, 9:20 a.m. Cool north wind. No bees. Nor on *Bidens aristosa, Aster novae-angliae, Solidago rigida, Rudbeckia laciniata, Melilotus alba.* (L.H.P.)

Shenandoah, Aug. 8, 1928. Bees two, two, two, two, one seconds in a flower.

Hamburg, August 25, 1928, 3:30 p.m. No bees but plenty of beetles. (L.H.P.)

August 27, 1928. Two, two, two, two, two seconds in a flower. (L.H.P.)

August 5, 1929. Abundant from Jewell to Blairsburg to Iowa Falls, Hampton, Allison, Waverly. In full bloom. Not many bees.

Waukon, August 18, 1929, 10 a.m. Abundant bloom but no honey bees.

Decorah, August 18, 1929, 11:30 a.m. No bees although a solid patch.

Huxley, August 22, 1929. No bees though many open flowers. (L.H.P.)

Des Moines, August 28, 1929, 4 p.m. Many open flowers but no bees. (L.H.P.)

Centerville, September 1, 1929, 9 a.m. Warm. Rain night before. Bees one, one, one, one, one seconds in a flower. (L. H. P.)

Montrose, September 2, 1929, 10 a.m. Bees numerous. One, one, one, one, one one seconds in a flower. (L.H.P.)

Donnellson, September 2, 1929, 3 p.m. No bees. Plenty of wasps. (L.H.P.)

Keokuk, September 2, 1929. Bees abundant. One second in a flower.

Alexandria, Mo., September 2, 1929. Bees abundant. One, one, one, one seconds in a flower. Flower beetles common. (L.H.P.)

Hamilton, Ill., September 3, 1929. One, one, one, one, one seconds in a flower.

Mount Pleasant, September 4, 1929, 9 a.m. No bees (Near an apiary).

9:30 a.m. One-half mile away from other observation. One, one, one, one, one seconds in a flower. Bumble bees and other small Hymenoptera present.

Fremont, September 4, 1929. Bees one, one, one, one, one seconds in a flower.

Des Moines, September 21, 1929. Bees common. One, one, one, two seconds in a flower. (L.H.P.)

Polygonum pennsylvanicum is a dominant plant in some vacant places, also abundant in corn fields throughout southeastern Iowa. At Centerville, Keosauqua, Farmington, Donnellson, New Boston, Keokuk, Montrose, Fort Madison and Burlington freely visited by bees. In low grounds there are other species of Polygonum, like *P. Hydropiper,* with white flowers, which are less frequently visited by bees.

This smartweed is closely related to buckwheat and like it is visited by a great variety of insects; by honey bees almost only in the morning. Bees rather more frequent on this plant than on buckwheat. Honey said to be of poor flavor. Called heart's-ease by bee men.

Honey production in Heart's-ease (Polygonum pennsylvanicum)
(O. W. Park)

Year	Period of bloom	Full bloom	Period worked by bees		Period of honey flow		Notes
1918	8–5	8–10	8–8	9–21	8–13	9–8	Very light yield
1919	6–29	7–30			8–17	8–31	Ordinarily this plant is not one from which large yields of honey are secured, although in some seasons it is an important source of nectar. The honey is usually amber-colored and has quite a spicy flavor.
1921	6–25 till frost	7–30	7–27 on		8–16	8–31	
1922	7–1		8–14				
1923	7–12	8–25	8–10				
							Bees garnering honey from heart's-ease often bring in a small load of pollen at the same time.

"If there is much rain in September it will yield much fine honey." Lovell.

Polygonum Hydropiper L. Water Pepper

Much like lady's thumb, *Polygonum Persicaria.* Spreading, often decumbent; flowers greenish, in slightly nodding spikes.

Widely distributed in the state of Iowa and in eastern North America.

HONEY BEE VISITS

Montrose, September 2, 1929. Bees one, one, one, one seconds in a flower.

FIG. 82.—Water pepper (*Polygonum Hydropiper*). *Photo Section, Iowa Agr. Exp. Sta.*

Polygonum acre H.B.K. Water Smartweed

A smooth perennial smartweed two to five feet high; stems rooting at the decumbent base. Leaves slender, lanceolate. Dense erect spikes with white or flesh-colored flowers, stamens eight. Grows in wet places. From tropical America. Associated with *Asclepias incarnata* and *Vernonia fasciculata*.

The flowers of this species contain some nectar, which is secreted

FIG. 83.—Water smartweed (*Polygonum acre*). *Photo Section, Iowa Agr. Exp. Sta.*

at the base of the ovary. It is visited by a variety of insects, both flies and Hymenoptera.

HONEY BEE VISITS

Bees have been reported on this species.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

McGregor, Moingona, Postville, Steamboat Rock (L. H. Pammel), Ames (Elva Barton, H. O. Sampson, E. D. Ball, G. W. Carver, Royal Meeker, F. Rolfs), Decatur county (two specimens, J. P. Anderson), Decorah (F. R. Goddard), Fayette (two specimens, B. Fink), Guttenberg (R. Gmelin), Ledges (Boone county) (two specimens, E. Bissell and L. H. Pammel), northeast Iowa (two specimens, H. Goddard), Waukon (E. Orr).

This plant has also been observed (L. H. Pammel) at Britt, Burlington, Cedar Rapids, Centerville, Cone, Cresco, Davenport, Des Moines, Forest City, Fort Atkinson, Fort Dodge, Garner, Indianola, Iowa City, Jefferson, Keokuk, Muscatine, Peterson.

General distribution in the United States:

Alabama—Tuskegee (G. W. Carver); Arkansas—Lawrence county (P. H. Rolfs); California—Merced (L. H. Pammel); Colorado—Fort Collins (C. S. Crandall); Illinois—Grand Tower (H. A. Gray); Massachusetts—Dedham (M. A. Day and M. L. Fernald); Michigan—Whitehall (L. H. Pammel); Minnesota—Clear Lake (L. H. Pammel); Missouri—St. Louis (H. Eggert); Nebraska—Halsey (J. C. Blumer); New York—Ithaca (W. C. Muenscher and A. R. Bechtel); Canada—Ontario (H. S. Kellogg), Prince Edward's Island (M. L. Fernald and Harold St. John); South Dakota—Spring Creek (L. H. Pammel); Wisconsin—Muscoda (L. H. Pammel).

Blooming dates for Polygonum acre

	Central section	
	Sioux City	Boone
1911		6–27
1912		7–12
1913		6–26
1915		6–17
1917		8–5
1918	9–9	8–1

FIG. 84.—Ragged sailor, Prince's feather (*Polygonum orientale*). *Photo Section, Iowa Agr. Exp. Sta.*

Polygonum orientale L. Ragged Sailor, Prince's Feather

A tall branching annual, softly hairy; large ovate petioled leaves; flowers large, rose-colored pendant spikes. Introduced from India.

FIG. 85.—Prince's feather (*Polygonum orientale*). Photo by *Ada Hayden.*

Distribution as shown by specimens in the I.S.C. Herbarium:

Illinois — Champaign (B. Fink); New York—Ithaca (Muenscher and Bechtel); North Carolina—Sartwell (W. A. Hayams); South Carolina—Pickens county (H. P. Anderson).

Other localities observed (L. H. Pammel)—Illinois, Michigan, Missouri, Minnesota, Ohio, Wisconsin, occasionally Iowa.

HONEY BEE VISITS

Ames. Latter half of August and during September. The plant is freely frequented by bees.

September 21, 1923. Bees numerous and active. Plant freely blooming.

Summer 1928. Bees observed on this plant. (L.H.P.)

Polygonum Persicaria L. Lady's-Thumb

A smooth herbaceous plant growing to a height of two or three feet. The sheaths above the joints are somewhat ciliate. Leaves lanceolate, pointed, often with a dark triangular spot near the middle. Flowers rose-colored, stamens usually six. Introduced from Europe. Common in rich cultivated soil, in damp grounds and waste places. It is associated with *Polygonum pennsylvanicum* and *P. lapathifolium.*

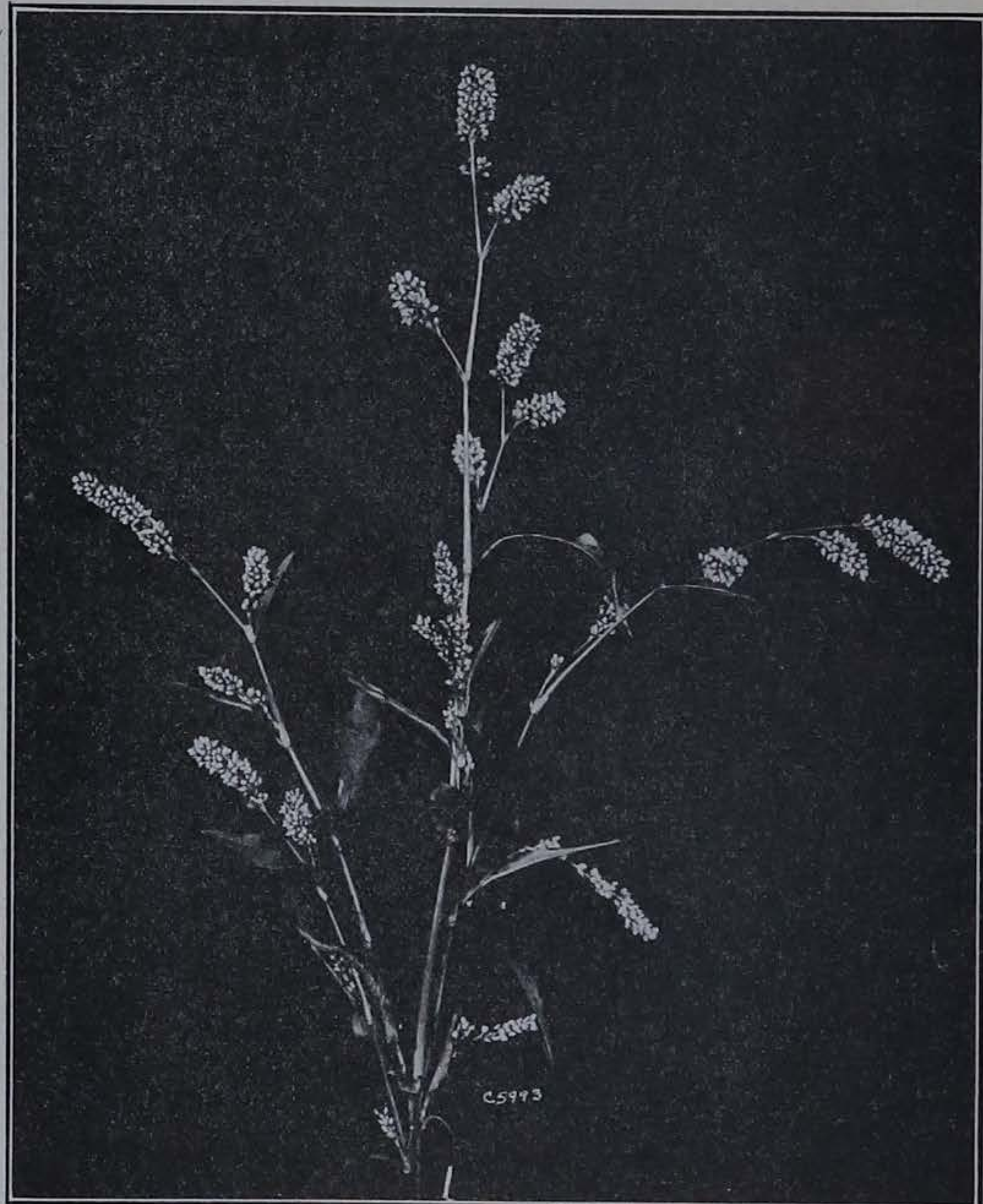

FIG. 86.—Lady's-thumb (*Polygonum Persicaria*). *Photo Section, Iowa Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belmond, Garner, Gillett Grove, Hamilton county, Marshalltown, Nevada (L. H. Pammel), Algona (E. B. Watson), Ames (two specimens, J. R. Campbell), Charles City (L. H. Pammel and E. M. Sherman), Decatur county (J. P. Anderson), Des Moines (Geo. W. Carver), Fayette (B. Fink), Fraser (two specimens, Botany Seminar), Hall (W. Newell and Jensen), Kelley (Pearl Clayton), New Hampton (P. H. Rolfs).

General distribution in the United States:

Alaska—Hyder (K. Whited); California—Oroville (A. A. Heller), Yosemite Valley, Patterson (L. H. Pammel); Colorado—Petersburg (G. M. Lummis);

Illinois—Chicago (two specimens), Argyle Park (L. H. Pammel); Louisiana—(C. R. Ball); Minnesota—Cass Lake, Norway Beach (L. H. and H. E. Pammel), International Falls (H. S. Kellogg); Montana and Idaho—Bitter Root valley (L. H. Pammel and H. S. Fawcett); New York—Ithaca (Muenscher and Bechtel); Newfoundland—Torbay (C. D. Howe, W. F. Land); Ohio—Worthington (Asa Horr); Oregon—Crook county (Kirk Whited); Pennsylvania—Towanda (L. H. Pammel); Texas—Lake Worth (Albert Ruth); Washington—Langley (two specimens, J. M. Grant); Wisconsin—La Crosse (Dora S. Pammel, two specimens, C. M. King and Dora Pammel); Wyoming—Laramie Plains (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. M. Lummis).

HONEY BEE VISITS

While honey bees are recorded on *P. Persicaria*, the flowers are less conspicuous than those of *P. pennsylvanicum*, which in the west is commonly called heart's-ease and is a much more valuable honey plant. Bees are not common on *P. incarnatum*. *Polygonum Muhlenbergii* and *P. Hartwrightii* should be good honey plants. These species are visited by bees, but they bloom less freely than heart's-ease. Bees sometimes visit *Polygonum dumetorum* var. *scandens*. L. H. Pammel records observing bees at work upon *P. Persicaria*.

Knuth says of flowers of *P. Persicaria*, "There is a nectary at the base of each of the eight stamens, but the secretion is scanty."

"*P. Persicaria* yields in Nebraska and other states in that section of the country immense quantities of honey." A B C of Bee Culture.

Blooming, Sioux City, September 9, 1918. Blooming Ames, July 12, 1924.

Polygonum sagittatum L. Arrow-leaved Tear-thumb

In this smartweed the smooth slender stem is 4-angled; the leaves are arrow-shaped and short petioled, the flowers in small loose heads. The achene is 3-angled. The plant frequents low boggy springy ground and borders of woods and is a common annual in northern and eastern Iowa. The specimen from Keokuk is somewhat out of its range.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City (Mrs. F. May Tuttle), Fayette (B. Fink), Keokuk, Lawler (P. H. Rolfs), northeastern Iowa (H. Goddard).

It has been observed (L. H. Pammel) at Cresco, Decorah, Manchester, New Albin, Postville and Saratoga.

General distribution in the United States:

Illinois—Iuka (H. I. Featherly); Kentucky—Bell county (T. H. Kearney, Jr.); Louisiana—(T. L. Andrews); Maine—Jackson (E. R. Hodson); Maryland—High Island (Montgomery county) (Lyster H. Dewey); Michigan—Whitehall (L. H. Pammel); Minnesota—Clear Lake, Howard, Wildwood (L. H. Pammel), Brainerd (two specimens, E. B. Watson); Missouri—Meramec (H. Eggert); New York—Ithaca (Muenscher and Bechtel); Ohio—

Fig. 87.—Wild buckwheat or black bindweed (*Polygonum Convolvulus*). *Photo Section Iowa Agr. Exp. Sta.*

Columbus (H. A. Gleason), Pickerington (Asa Horr); Wisconsin—Blue Mounds (L. H. Pammel), La Crosse (Dora Pammel), St. Croix Falls (L. H. and H. E. Pammel).

HONEY BEE VISITS

Nectar is secreted at the base of the ovary. The flowers are visited by flies, honey bees and other Hymenoptera.

Polygonum Convolvulus L. Wild Buckwheat

This is an annual twining or weak-stemmed plant; the joints do not bear the sheathlike stipules. Leaves halberd or heart-shaped, pointed. Flowers in clustered racemes, the outer calyx lobes keeled. Achene dull black, pitted. The plant grows commonly in waste grounds and grain fields.

A weed in gardens and cultivated fields. It is associated with *Capsella Bursa-pastoris* and *Eragrostis major*.

Knuth says, "Nectar is secreted in small quantities at the base of the stamens." He also observed bees at work in the flowers.

The senior author has occasionally observed a good many bees on this species at Ames, also in northeastern Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Hanlontown, Mason City, Steamboat Rock (L. H. Pammel), Ames (Geo. W. Carver, Pearl Clayton, Lois Pammel), C. & N. W. Ry. High Bridge (Boone county) (Botanical Party), Cedar Rapids (R. E. Buchanan), Chickasaw county (W. D. Spiker), Decatur (J. P. Anderson), Fayette (B. Fink), New Hampton (P. H. Rolfs), Osage (R. I. Cratty, Mrs. F. M. Tuttle), Winneshiek county (H. Goddard).

General distribution in the United States:

Alaska—Juneau (J. P. Anderson); Arizona—Walnut creek (D. T. MacDougal); Colorado—Engelmann canon (F. E. and E. S. Clements), Fort Collins (C. S. Crandall), Greeley (G. M. Lummis), Idaho Springs (L. H. Pammel); District of Columbia—Potomac Flats (E. S. Steele); Florida—Braidentown (S. M. Tracy); Idaho—Fish Haven (A. Isabel Mulford); Louisiana—(T. L. Andrews); Michigan—Stambaugh, Whitehall (L. H. Pammel); Minnesota—McKinley (Mrs. Jos. Clemens), Star island, Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), Black Duck (Mrs. Roy Westley), Minneapolis (R. I. Cratty); New York—Geneva (L. H. Pammel), Rye lake (Mrs. L. M. Parker); Ohio—Pickerington (Asa Horr); South Dakota—Brookings (Edna C. Pammel); Texas—College Station (L. H. Pammel); Utah—Peterson canon (L. H. Pammel and R. E. Blackwood); Washington—Bremerton (L. H. Pammel, B. Athanassiou, A. L. Bakke, L. S. Parke), Tacoma (L. H. Pammel); Wisconsin—Fond du Lac (E. Waters and L. H. Pammel), La Crosse (L. H. and H. E. Pammel); Wyoming—Sheridan county (L. H. Pammel and E. M. Stanton), Yellowstone Park (Aven Nelson).

Date of bloom, Ames, June 1, 1925.

FIG. 88.—Climbing false buckwheat (*Polygonum scandens*). *Photo Section, Iowa Agr. Exp. Sta.*

Polygonum scandens L. Climbing Buckwheat

This is a smooth perennial climbing plant. The leaves are halberd to heart-shaped, pointed. The flowers in panicled leafy racemes. Achene very smooth and shining. The plant is very widely distributed in copses and on rocky hills and along streams and upland swales. It is associated with *Corylus americana, Celastrus scandens, Prunus americana, Pyrus ioensis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls, Eddyville, Estherville, Hamburg, Ledges (Boone county), Polk City, South Dakota (opposite Hawarden), Steamboat Rock (L. H. Pammel), Ames (Ada Hayden, F. A. Sirrine, L. H. Pammel and H. H. Hume, L. H. Pammel and Mina Belle Lynch, L. H. Pammel and C. R. Ball, Fred Rolfs), Armstrong (Emmet county) (R. I. Cratty), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (G. W. Carver) (two specimens, A. L. Bakke), Fayette (B. Fink), Greenfield (F. C. Stewart), High Bridge (Boone county) (two specimens, G. M. Lummis), Kelley (H. S. Fawcett), Ontario (E. R. Hodson), Slater (two specimens, H. S. Fawcett, C. Reinbott, W. I. Tener).

It has been observed (L. H. Pammel) at Burlington, Cedar Rapids, Centerville, Clinton, Cresco, Davenport, Dubuque, Indianola, Marshalltown, McGregor, New Albin.

General distribution in the United States:

Illinois—Posey (J. S. Wright); Kentucky—Bell county (T. H. Kearney, Jr.); Michigan—Stambaugh (L. H. Pammel); Missouri—Wicks (L. H. Pammel); Ohio—Pickerington (Asa Horr); Texas—Ennis (Ellis county) (L. H. Pammel).

HONEY BEE VISITS

Nectar is secreted in small quantities at the base of the stamens. Bees frequent it for honey. It is not, however, of much importance as a honey plant.

The senior author has observed a good many bees on this species at Ames and near McGregor.

The following species of *Polygonum*, according to E. Brown of Sioux City, are not visited by bees: *P. Persicaria* and *P. acre*.

Fagopyrum esculentum Moench. Buckwheat

The common buckwheat is a smooth annual herb with abundant bloom, bearing large clustered racemes of white or greenish flowers with eight stamens and eight nectar glands lying between them. It blooms from midsummer to September. The leaves are triangular heart-shaped with roundish sheaths.

In many parts of Iowa some buckwheat is raised and it sometimes remains in old fields as a weed after cultivation. It prefers sandy and black prairie soils and a cool moist climate, but in hot dry atmospheres it fails to produce much nectar. It is said to be an important honey plant for surplus in the Great Lakes region.

Mueller says, "The flowers are made conspicuous by their white perianth (sepals), by aggregation and by perfume.

"Eight rounded yellow glands at the base of the stamens secrete

HONEY BEE VISITS

Meservey, May 24, 1929, 8 a.m. Clear but cool. Some bees gathering pollen. One, one, one, one, one second in a flower. (L.H.P.)

12:15 p.m. Bees numerous. Gathering pollen. One, one, one, one second in a flower.

NYCTAGINACEAE, Four O'Clock Family

Herbaceous perennial plants with opposite entire leaves. Flowers 3 to 5 in a 5-lobed broad open involucre, which becomes thin in the fruit.

Oxybaphus nyctagineus (Michx.) Sweet. Wild Four O'Clock

A smooth perennial plant, with forked stems. Leaves broadly ovate, cordate. Pedicels slender. Flowers in clusters, purplish. Involucre becoming half an inch across.

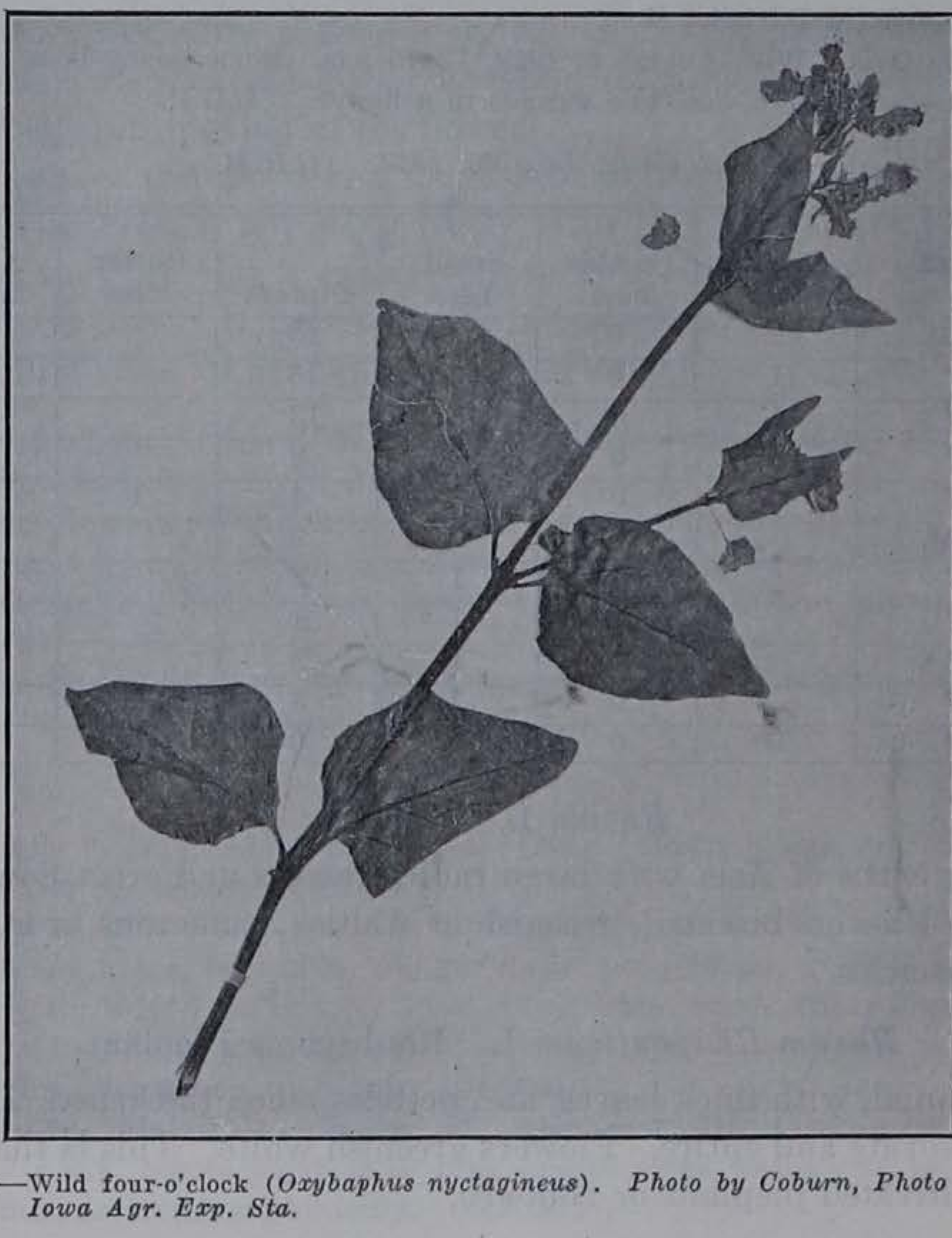

Fig. 89.—Wild four-o'clock (*Oxybaphus nyctagineus*). *Photo by Coburn, Photo Section, Iowa Agr. Exp. Sta.*

Found generally throughout the state in fields and on embankments.

Bees frequent these flowers in some years. (L.H.P.)

PORTULACACEAE, Purslane Family

Succulent herbs with regular flowers. Sepals two, petals five. Pod 1-celled, 2- to many-seeded.

Claytonia (Gronov.) L. Spring Beauty

Perennial woodland plants sending up simple stems in early spring from a small deep tuber, and bearing a loose raceme of delicate rose-colored blossoms.

Fig. 90.—Spring beauty (*Claytonia virginica*). *Photo by Ada Hayden.*

Claytonia virginica L.

Leaves linear-lanceolate. Found in moist open weeds. Common.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Crocker Woods (Des Moines), Delaware county, Farmington, Keosauqua, Ottumwa (L. H. Pammel), Ames (Geo. W. Carver, E. D. Ball), Chickasaw county (W. D. Spiker), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (H. Goddard), Des Moines (L. H. and Edna Pammel), Fayette (C. C. Parker), Guttenberg (R. Gmelin), "Iowa" (B. Fink), Ledges (E. Bissell and L. H. Pammel).

General distribution in the United States:

District of Columbia—Brightwood (G. McCarthy); Illinois—Chicago (Stella L. Goodspeed), Peoria (F. E. McDonald), Urbana (B. Fink); Maryland—Baltimore (F. B. Trenk); New Brunswick—Fredericton (W. F. Ganong); New York—Brooklyn (Elsie Tribby), Ithaca (two specimens, H. E. Summers, Muenscher and Bechtel); Ohio—Worthington (Asa Horr); Oklahoma—Campus, University of Oklahoma (W. E. Bruner); Pennsylvania—Wrightsville (John K. Small); Texas—Tarrant county (Albert Ruth); Virginia—Northern Virginia (L. H. Pammel, Lyle Blundell and F. Trenk); Wisconsin—Madison (L. H. Pammel).

Knuth says, "The flowers of this species secrete nectar at the base of the filaments. The stamens are at first erect, but afterwards bend back towards the petals, giving free access to the stigma, so that small insects covered with pollen are able to effect crossing."

Pellett says, "Appearing so early in the spring it is much sought by the bees at a time when there is little of either nectar or pollen available."

HONEY BEE VISITS

Ames, April 28, 1928, 11:30 a.m. Clear, fairly warm. Some bees gathering pollen. Two, three, two, three seconds in a flower. (L.H.P.)

Blooming, Ames, April 17, 1924; Boone, April 13, 1924; Ames, April 6, 1925; Ames, April 20, 1926; Lansing, April 20, 1926.

Portulaca (Tourn.) L. Purslane

Fleshy annuals. Pod opening by a lid. Calyx two-cleft. Petals five or six.

Portulaca oleracea L. Purslane

A prostrate annual plant with fleshy, smooth, ovate leaves and small, sessile yellow flowers opening usually only in sunshine. Petals five, pod globular, 1-celled, many-seeded, opening transversely. Common in gardens and other cultivated grounds, in both black and clay soils. Naturalized from Europe.

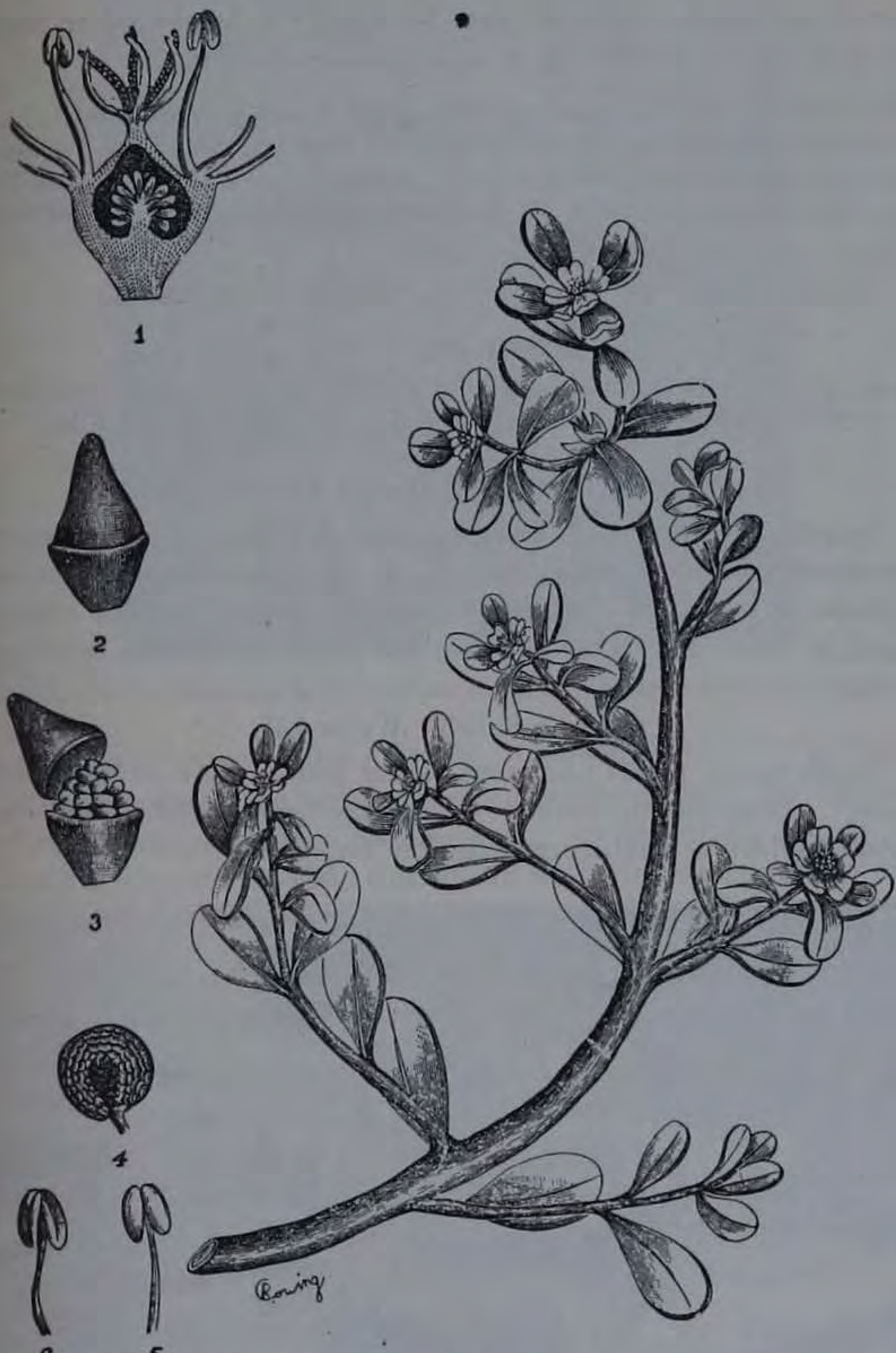

FIG. 91.—Common purslane (*Portulaca oleracea*). *Dewey, U. S. D. A.* 1, Flower with stamens and pistil partly removed; 2, Capsule before dehiscence; 3, Dehisced capsule; 4, Seed; 5 and 6, Stamens.

The small yellow flowers of *Portulaca* open about five hours on sunny mornings. They are said by Kerner to be devoid of honey and odor. The flowers are of slight value to bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Granite, Hawarden (L. H. Pammel), Ames (J. G. C., Fred Rolfs, two specimens, A. S. Hitchcock), Decorah (E. W. D. Holway), Fayette (B. Fink), Kelley (Pearl Clayton), Keokuk (P. H. Rolfs), northeastern Iowa (H. Goddard).

General distribution in the United States:
Illinois—Kaneville (B. Fink); Texas—Navasota (L. H. Pammel).

HONEY BEE VISITS

Ames, July 8, 1914, a.m. Experimental plot. Clear, north wind. Twenty insects on one cluster in one hour. Small bees, flies and bugs. (G.H.M.)

NYMPHAEACEAE, Water Lily Family

Aquatic perennial herb with horizontal, apparently endogenous rootstocks; leaves generally peltate or sometimes cordate, floating or immersed. Sepals three to six, petals numerous, in many rows or three or four. Pistils several with one ovule. Cotyledon thick and fleshy.

Castalia Salisb. Water Lily

Sepals green, petals numerous, white, pink, yellow or blue, very showy. Stamens numerous. Ovary 12- to 35-celled. Fruit depressed, globular, maturing under the water.

Fig. 92.—White water lily (*Castalia tuberosa*) and nuphar. *Photo by Ada Hayden.*

FIG. 93.—White water lily (*Castalia tuberosa*). *Photo by Ada Hayden.*

Castalia tuberosa (Paine) Greene. Common White Water Lily

Leaves rather large, reniform-orbicular. Rootstocks bearing numerous detaching tubers. Sepals green. Petals white. Seeds enclosed by the aril. Widely distributed in North America, especially fresh water lakes and bayous.

HONEY BEE VISITS

Bees have been reported on this plant, chiefly for its pollen.

Nelumbo (Tourn.) Adans. Lotus or Sacred Bean

Leaves rising out of water on long stalks from a tuberous rootstock. Leaves peltate. Flowers large, sepals and petals numerous, in several rows. Stamens numerous, free and deciduous. Pistils one or several, 1-ovuled, immersed in an obconical receptacle. More or less top-shaped at maturity and enclosing a nutlike fruit.

Nelumbo lutea (Willd.) Pers. Nelumbo or Water Chinquapin

Leaves standing out of the water, circular, peltate with a depressed center. Flowers pale yellow with numerous anthers and several pistils. Tubers starchy and edible. Seed also edible. Widely distributed in North America from the Gulf of Mexico to Lake

FIG. 94.—American lotus (*Nelumbo lutea*). *Photo by C. M. King.*

Pepin, Minnesota. At many localities in Iowa, such as Amana, Dubuque, Hamburg, Lansing, Marquette, McGregor, Montrose, Winterset. In Wisconsin at La Crosse and French Island; Minnesota at La Crescent. Also in Florida, Texas, Tennessee, Kentucky, Missouri, Lake Ontario, Lake Erie and at Concord, Massachusetts.

HONEY BEE VISITS

Honey bees have been observed on this flower in Wisconsin, Minnesota and Iowa. They also have been observed gathering pollen. (Ada Hayden.) Montrose, September 3, 1929. Bees very numerous. (V. A. Edwards.)

RANUNCULACEAE, Crowfoot Family

Herbs polypetalous or apetalous with sepals often colored like a corolla. Sepals, petals, stamens and pistils all distinct and unconnected. Seed achene-like. Leaves radical or alternate, palmately veined.

Ranunculus Flammula L. Smaller Spearwort

Stem rooting below, leaves lanceolate, entire, petioled. Petals five to seven, longer than calyx, bright yellow. Carpels small, mucronate.

Of this plant Knuth says, "The bright yellow blossoms are proterandrous. The stigmas are mature before the anthers of the innermost stamens have dehisced. Should insects covered with pollen alight on the middle of the flower crossing must result."

Ranunculus fascicularis Muhl. Early Crowfoot

Low ascending herb more or less hairy; root thick and fleshy. Pinnate, radical leaves. Common in northeast Iowa, extending as far west as Marshall county. Widely distributed in eastern North America from Massachusetts to Minnesota.

Bees have been observed upon this plant.

Ranunculus septentrionalis Poir. Common Buttercup

An ascending smooth or hairy plant with long runners. Leaves three-divided. Divisions wedge-shaped to ovate, three-cleft or parted.

On low ground. Widely distributed in woods and along railways throughout the state of Iowa and common eastward to the Atlantic coast.

Bees have been observed upon this plant also.

Date of bloom, Ames, May 1, 1926; May 14, 1927. Tabor, May 12, 1927.

Thalictrum (Tourn.) L. Meadow Rue

Perennials with terminal compound leaves, dilate petioles. Flowers in corms or panicles, sepals greenish. Polygamous or dioecious, largely dioecious, although Knuth states in referring to *Thalictrum aquilegifolium*, "Anemophily does not obtain very often because although the pollen grains are more or less adhesive the crowded stamens keep pollen from the stigma." Hermann Mueller has reported the honey bee upon *Thalictrum flavum* and *Thalictrum aquilegifolium* and Knuth also upon *Thalictrum flavum*.

Thalictrum dioicum L. Early Meadow Rue

Smooth, pale or glaucous plants with compound leaves, thin leaflets 3 to 7, dioecious. Sepals purple or greenish white.

Common in oak woods in central Iowa. Associated with *Hepatica acutiloba*, *Isopyrum biternatum* and *Geranium maculatum*. Common in eastern North America.

Bees have been observed by the senior author on this species.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Fraser, Ledges, Postville (L. H. Pammel); Ames (C. R. Ball and R. Combs, G. W. Carver, L. V. Ellis, L. H. Pammel and B. Zimmerman), Buffalo creek, Boone county (L. H. Pammel and W. M. Rosen), Cherokee (G. A. Ellis), Chickasaw county (W. D. Spiker), Denison (Clara Blume), Fayette (B. Fink), Fort Dodge (L. H. Pammel and B. Zimmerman, F. W. Paige, F. Horton), Ledges (E. Bissell and L. H. Pammel, R. E. Buchanan).

Thalictrum dasycarpum Fisch. and Lall. Meadow Rue

A much taller plant, three to four feet tall. Compound leaves which are usually purplish, usually 3-toothed. Flowers dioecious. Sepals purplish.

FIG. 95.—Meadow Rue (*Thalictrum dasycarpum*). *Photo by Ada Hayden.*

This plant is associated with *Carex vulpinoides, Phlox pilosa* and *Veronica virginica.*

Widely distributed in alluvial soils.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ankeny, Belmond, Bluffton, Clear Lake, Coon Rapids, Delhi, Dubuque, Edgewood, Fairbanks, Hancock county, Hanlontown, Keosauqua, Lake Mills, Lake View, Madison county, McGregor, Postville, South Dakota opposite Hawarden, Winterset (L. H. Pammel), Lake Okoboji, Ottumwa (R. I. Cratty), Alden (C. S. Stevens), Ames (A. Hayden, F. Rolfs), Chickasaw county (W. D. Spiker), Crawford county (I. D. Butler), Decorah (H. Goddard), Fayette (B. Fink), Forest City (L. H. Pammel and A. L. Bakke), Fort Dodge (F. W. Paige), Jackson Junction (L. H. and L. Pammel), Kelley (Pearl Clayton), Ledges (J. V. Ellis), Ogden (L. H. Pammel and W. C. Donnelson), Ontario (E. R. Hodson), Osage (Mrs. F. M. Tuttle), Peru (D. E. Hollingsworth), Spirit Lake (H. E. and L. H. Pammel), Webster County (L. H. and H. E. Pammel and J. L. Seal).

Distribution occurs quite generally in the northern United States.

Hepatica (Rupp.) Hill. Liverleaf

Herbs with radical leaves, heart-shaped and 3-lobed. The involucre is close to the flower of three oval bracts. Sepals white to purplish.

The hepatica is pollinated by pollen-collecting bees and by syrphus flies.

Flowers with nectar half concealed. At the base of each petal there is a nectar pit.

Hepatica triloba Chaix. Liverleaf, Hepatica

Leaves with three ovate rounded lobes; sepals six to twelve, blue, purplish to white; achenes hairy.

Common in woods from Nova Scotia southward to Minnesota and Missouri. Not common in Iowa. Reported from Lansing.

Frequented by honey bees.

FIG. 96.—Flowers of hepatica (*Hepatica acutiloba*). *Drawn by C. M. King*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Chickasaw county (W. D. Spiker), Guttenberg (R. Gmelin). Also observed by L. H. Pammel at Lansing, Yellow river.

General distribution in the United States:

Florida—Bristol (L. H. Pammel and J. L. Seal); Ohio—Worthington (Asa Horr); Michigan—Houghton (L. H. Pammel); Missouri—Eagle Rock (B. F. Bush); New York—Ithaca (Muenscher and Bechtel, H. E. Summers, Charles S. Sheldon); North Carolina and Georgia mountains—(S. B. Buckley); South Carolina—Pickens county (two specimens, A. P. Anderson); Wisconsin—Holmen (L. H. Pammel).

Hepatica acutiloba D. C. Hepatica

This hepatica has heart-shaped, 3-lobed leaves which persist through the winter, new ones appearing later than the flowers, in early spring. Lobes of the leaves pointed. Sepals six to twelve, pale blue to purple.

FIG. 97.—Hepatica (*Hepatica acutiloba*). *Photo by Ada Hayden.*

Common in woodlands with an abundance of leaf mould. The most widely distributed of the early blooming plants of Iowa; preferring north slopes.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Delaware county, Luxemburg, McGregor, Moingona, Postville (L. H. Pammel), Ames (S. W. Beyer, Royal Meeker, H. O. Sampson, E. D. Ball, G. W. Carver, Fred Rolfs), Chickasaw county (W. D. Spiker), Decatur (J. P. Anderson), Estherville (B. O. Wolden), Fayette (B. Fink), Guttenberg (R. Gmelin), *Blooming dates for Hepatica acutiloba.*

	Northern section				Central section													Southern section			
	Ossian	Armstrong	Lansing	Waukon	Ames	Boone	Des Moines	Cedar Rapids	Grinnell	Iowa City	Oskaloosa	West Union	Marshalltown	Anamosa	Avoca	Le Grand	Tama Co.	Lamoni	Keokuk	Shenandoah	Ottumwa
1901					4–10																
1902					3–28								4–10				4–3				
1903																					
1904					3–29										4–12	4–10					
1905					3–23													4–1			
1906			4–3		4–4				4–7	4–2	4–4								4–5		
1907	4–20		4–5	4–21	3–22	3–25		3–24				4–5		4–20	3–23				3–24	3–21	
1908			4–3		3–22	3–23		3–27						4–3					4–3		
1909			4–15		4–5	4–6	4–9												4–1		
1910						3–21															
1911			4–9		4–6	4–1															3–21
1912			4–6		4–4																
1913		3–29	4–7		4–23	4–1															
1914			4–14		4–4	4–15															
1915			4–12		4–11	4–7															
1916			4–9		4–14	4–2															
1917					4–13	4–14															
1918			4–30		3–23	3–21															
1919			3–29		4–12																
1920			4–28		4–6	4–17															
1921			3–30		3–19	3–20															
1922			4–4		3–10																
1923			4–17		4–16																
1924			4–9		4–6	4–13															
1925			4–10		4–2																
1926			4–12			4–20															
1927					4–3	3–31															

Ledges (E. Bissell and L. H. Pammel), northeastern Iowa (H. E. Goddard), Osage (Mrs. Wm. Gardner), Waukon (E. Orr).

General distribution in the United States:

Illinois—Mahomet (H. A. Gleason); Ohio—Put-in-Bay (L. H. Pammel); Michigan—Whitehall (L. H. Pammel); Missouri—Meramec Highlands (W. W. Ohlweiler), Pacific (H. Eggert); New York—Ithaca (Muenscher and Bechtel); North Carolina and Georgia mountains—(S. B. Buckley); Virginia—Eggleston (Dr. Britton and party); Wisconsin—Madison, Galesville (L. H. Pammel).

HONEY BEE VISITS

Ames, March 18, 1921. In bloom.
April, 1920. Bees numerous (C.M.K.)
Bees often reported on Hepatica on sunny days.
Bees reported upon this flower in 1929 by A. Hayden.

Anemone (Tourn.) L. Anemone

Perennial herbs with lobed radical leaves. Sepals petal-like, petals none, achenes pointed. Leaves whorled into an involucre somewhat raised from the flower.

The large bluish violet sepals are very attractive to insects. The nectar is secreted by the outermost stamens, and insects going into the flower come first in contact with these stamens and then pass to the pistil and pollination is secured. The flowers are slightly proterogynous.

Honey bees have been observed by Hermann Mueller and Knuth.

Anemone patens L. var. *Wolfgangiana* (Bess) Koch. Pasque Flower

Plant silky. A single erect flower stalk; leaves three-parted; sepals five to seven, purplish to pale blue.

Prairies of Wisconsin, Illinois, Texas, north and west.

Pellett says, "It is especially valuable as a source of early pollen on the Canadian prairies, where it is the first bloom to supply the bees with material for early brood rearing."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (Bernice Banks, Etta Budd, R. W. Trowbridge), Armstrong (three specimens, R. I. Cratty), Cedar Falls (C. W. Lantz), Chickasaw county (W. D. Spiker), Decorah (F. R. Goddard), Dunlap (M. Beck), Fayette (B. Fink), High lake (B. O. Wolden), Jewell Junction (F. C. Stewart), northeastern Iowa (H. Goddard), Postville (P. Bender), Radcliffe (H. C. Benbow), Sioux City (Ida Grillette), Spirit Lake (D. E. Roberts).

General distribution in the United States:

Colorado—Marshall Pass (L. H. Pammel and party); Crystal Park (F. E. and E. S. Clements), Mount Guyot (J. P. Anderson), Tolland (L. A. Kenoyer),

. 98.—Pasque flower (*Anemone patens* var. *Wolfgangiana*). *Photo by Ada Hayden.*

rview (L. H. Pammel and party); Minnesota—Larkspur (J. F. Cavell); ssouri—St. Louis (L. H. Pammel); Montana—(M. J. Elwood), Missoula (J. Witham, Bozeman (A. Kimpton); South Carolina—Dixon canon (C.S.C.); ith Dakota—Spearfish canon (C. M. King); Wisconsin—La Crosse (two cimens, L. H. Pammel), Fountain City (R. Gmelin), Madison (L. H. Pam-); Wyoming—Manville (T. S. Grant), Laramie Hills (Aven Nelson).

HONEY BEE VISITS

es, April, 1929. Bees at work. (A. Hayden.)

Blooming, Ames, April 6, 1924; Lansing, April 9, 1924; Boone, April 13, 24; Ames, April 3, 1925, April 10, 1926; Lansing, April 3, 1925, April 1, 26; Ames, April 1, 1927.

Anemone canadensis L. Canadian Anemone

Grows on low ground. Involucre of three leaves bearing a naked duncle. White flower, five sepals.

Common on river banks and low ground in the state of Iowa. Common eastward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ankeny, Council Bluffs, Dubuque, Lehigh, McGregor, Postville, Red Oak, Webster City, Winterset (L. H. Pammel), Emmet county, West Bend (R. I. Cratty), Dubuque, Pocahontas county (F. Trenk), Hawkeye, Reinbeck (Grundy county) (L. H. Pammel and B. B. Zimmerman), Ames (E. D. Ball, J. C. Blumer, Violet Pammel, G. W. Carver, Edna Pammel, S. W. Beyer, F. Rolfs), Battle Creek (E. G. Preston), Chickasaw county (W. D. Spiker), Forest City (A. L. Bakke and L. H. Pammel), Fort Dodge (F. W. Paige), High lake (B. O. Wolden), Kelley (Pearl Clayton), Mount Pleasant (J. H. Mills), northeastern Iowa (H. Goddard), Prairies (B. Fink), Valley Junction (L. H. Pammel and E. R. Harlan).

Anemone quinquefolia L. Wood Anemone

Small smoothish perennial from a brownish rootstalk. Involucre

FIG. 99.—Anemone (*Anemone quinquefolia*). *Photo by Ada Hayden.*

of three trifoliate leaves. Sepals white sometimes slightly tinged with purple.

Widely distributed in woods. Associated with *Hepatica acutiloba, Isopyrum biternatum* and *Geranium maculatum.*

Representative types in the Herbarium are as follows:

Delaware county, Petersen (L. H. Pammel), Ames (E. D. Ball, S. W. Beyer, G. W. Carver), Chickasaw county (W. D. Spiker), Fayette (B. Fink), Fort Dodge (F. W. Paige), High lake (B. O. Wolden), Ledges (E. W. Bissell and L. H. Pammel).

HONEY BEE VISITS

This species is closely related to *Anemone nemorosa.* Hermann Mueller reports honey bees and states that they not only collect pollen but also suck the base of the flower to obtain sap, which is required for moistening the pollen.

We have observed honey bees in Iowa. Honey bees have been reported by Roberts.

Clematis L. Virgin's Bower

Perennial plants, often woody vines climbing by their leafstalks. Leaves opposite. The flowers of clematis are proterogynous and rendered attractive by the odor. Visited by many insects including bees.

Clematis virginiana L. Virgin's Bower

A perennial vine, somewhat woody, climbing by the bending of the leafstalks. Leaves 3-foliolate; leaflets ovate-acute, thin, silky beneath when young. Small white flowers in paniculate cymes. Achenes bearing plumy styles.

In borders of woods and thickets near streams.

The white color and the easily obtained nectar attract small flies and some bees. The flowers apparently produce some nectar.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Algona (E. B. Watson), Creston (T. L. Andrews), Decatur county (two specimens, J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Ledges (Boone county) (L. H. Pammel, J. V. Ellis), northeastern Iowa (H. Goddard), Osage (F. M. Tuttle), Postville (two specimens, O. Schultz), West Bend (R. I. Cratty).

It has been observed (L. H. Pammel) at Ames, Cedar Rapids, Clinton, Dubuque, Eldora, Fairfield, Marshalltown, McGregor, Steamboat Rock, Story City, Waukon.

General distribution in the United States:

District of Columbia—Piney Branch Road (C. R. Ball and A. E. Paddock); Indiana—Crawfordsville (W. H. Evans); Kentucky—Harlan county (T. H.

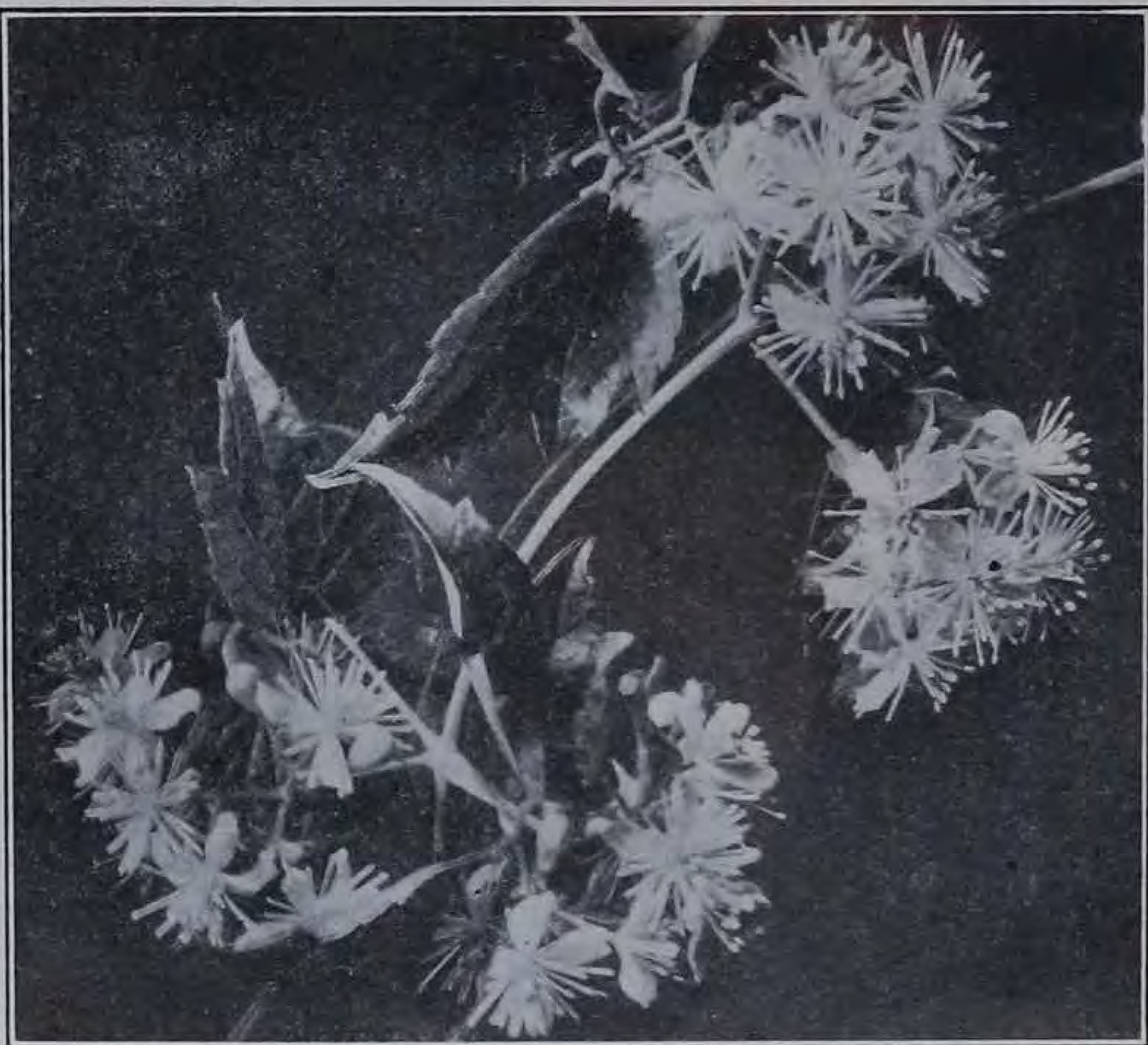

FIG. 100.—Virgin's bower (*Clematis virginiana*). *Photo by Ada Hayden.*

Kearney, Jr.); Louisiana— (two specimens, T. L. Andrews); Michigan—Ironwood (Mrs. Joseph Clemens); Whitehall (Mrs. K. G. Smith); Minnesota—Graceville (two specimens, L. H. Pammel), St. Cloud (R. Gmelin); Missouri—Mansfield (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Nova Scotia—Pictou county (Harold St. John); Ohio—Pickerington (Asa Horr); Vermont—Peacham (F. Beauchard); Wisconsin—Wauzeka (L. H. Pammel), La Crosse (C. M. King and Dora Pammel), Bangor (L. H. Pammel and Matilda Koch).

HONEY BEE VISITS

Atlantic, July 31, 1914. Hot, dry. Small bees, small flies. (L.A.K.)

Clayton, August 4, 1923. Clear, sunshiny. On east slope of hill along Mississippi river. No bees observed. (L.H.P.)

La Crosse, Wisconsin (sandy soil), August 6, 1927, 8 a.m. Clear, moderate temperature. Height of bloom. Bees very abundant. One, one, one, one, one second in a flower. (L.H.P.)

5:30 p.m. Season moist. Bees abundant. One, one, one, one, one second in a flower getting pollen and nectar.

August 7, 1927, 9:30 a.m. Bees abundant. One second in a flower.

11:30. Fewer bees. One second in a flower.

Blooming dates for Clematis virginiana.

	Northern section	Central section				Southern section
	Lansing	Boone	Ames	Cedar Rapids	Le Grand	Ottumwa
1902					7–4	
1906			7–23			
1908	7–20	8–3		7–21		
1909	8–18	8–26				
1911		8–30				5–31
1912	7–30					
1913		8–3				
1914	7–20		7–20			
1920	8–16					
1922			7–20			
1923						
1924			6–18			

Clematis Pitcheri T. and G. Leather Flower

Perennial vine. Calyx bell-shaped. Flowers large, solitary, on long peduncles, nodding. Sepals thick, dull, purple, petals none. Achenes with plumose tails. Leaflets three to nine; uppermost often simple.

Indiana to Nebraska and southward.

Common in somewhat sandy soils, borders of woods, and along railroad rights-of-way.

FIG. 101.—Leather flower (*Clematis Pitcheri*). *Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Des Moines, Farmington, Wild Cat Den (Muscatine county), Pammel Park, Winterset (L. H. Pammel), Decatur county, Fremont county (J. P. Anderson), Ames (R. E. Jeffs, E. B. Watson), Fraser (Botany Seminar), Johnson county (T. J. and M. F. L. Fitzpatrick), Keosauqua (L. H. Pammel and G. B. MacDonald); Muscatine (C. R. Ball), Peru (D. E. Hollingsworth).

It has also been observed (L. H. Pammel) at Boone, Burlington, Clinton, Davenport, Fairfield.

General distribution in the United States:

Colorado—Denver (A. R. Van Vleet); Illinois—Hamilton, Red Bud (L. H. Pammel), Champaign (B. Fink), Peoria (F. E. McDonald), Allenton (G. W. Letterman); Kansas—Wichita (T. L. Andrews); Missouri—Hogan, St. Louis (L. H. Pammel), H. Eggert; Texas—Clay Station (L. H. Pammel).

Blooming dates for Clematis Pitcheri.

	Northern section	Central section		
	Lansing	Ames	Boone	Cedar Rapids
1898		6–18		
1907				6–18
1908				6–10
1914		6–13		
1915	7–20	7–1		
1916			6–26	
1923		6–20		

HONEY BEE VISITS

Ames, July 9, 1914. Clear. Twelve honey bees per flower in one hour. (G.H. M.)

Clematis verticillaris D. C. Purple Virgin's Bower

A woody-stemmed climber, peduncles bearing single large spreading flowers. Leaflets slightly heart-shaped; flowers pinkish purple; tails of the achene plumose, long. Of wide distribution in the United States. Somewhat rare in northeastern part of Iowa. In rocky woods with calcareous soil.

Visited by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decorah (two specimens, E. W. D. Holway).

General distribution in the United States:

Colorado—Cache la Poudre canon (Ada Hayden), Fort Collins (C. S. Crandall); Idaho—(C. A. Davis); New York—Ithaca (H. E. Summers); Oregon—Eastern Oregon (Wm. C. Cusick).

Clematis erecta L. Upright Virgin's Bower

Herb with erect, ascending or slightly woody base. Smooth leaflets, five to nine, ovate, pointed, entire, with numerous panicles of white flowers. This species is commonly cultivated.

HONEY BEE VISITS

Ames, June 24, 1927, 8 a.m. A fine honey plant. (L.H.P.)

Clematis paniculata (Thunb.) White Clematis

A vigorous climber with many fragrant white flowers. Odd pinnate leaves ovate to broadly ovate; terminal leaflets with very long stems. Flowers white, sepals four. Commonly cultivated.

HONEY BEE VISITS

Jefferson, September 2, 1927, 3 p.m. No bees.
3:30 p.m. Several bees.
Bees work on the plants at Jefferson, Iowa, freely throughout the season, especially in the morning. (Mrs. B. B. Carlisle.)
Oskaloosa, September 30, 1928. Bees noted. (L.H.P.)

Clematis Flammula L. White Clematis

Much like the preceding. Leaves with two to five leaflets. Flowers in an axillary terminal panicle, pure white and fragrant.

HONEY BEE VISITS

Ames, June 16, 1928, 2 p.m. Warm, windy. Bees abundant. Two, two, one, two, one, one, two seconds in a flower. (L.H.P.)

Isopyrum biternatum (Raf.) T. and G. False Meadow Rue

Slender smooth perennial, with two to three ternately compound leaves. Flowers white.

In moist shady woods, early spring. Contributes pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone county, Delaware county, Fraser, Keosauqua, Marshall county, Palisades (L. H. Pammel), Ames (S. W. Beyer, Bernice Banks, G. W. Carver, C. R. Ball, L. H. Pammel, Robert Combs, P. H. Rolfs), Cedar Rapids (C. M. Palmer), Chickasaw county (W. D. Spiker), Clermont (L. R. Walker), Decatur county (J. P. Anderson), Fayette (B. Fink), Guttenberg (R. Gmelin), High lake (B. O. Wolden), Iowa lake (R. I. Cratty), Red Rock (L. H. Pammel and C. M. King), Story City (L. H. Pammel and S. W. Beyer), Winterset (L. H. Pammel and Craig).

General distribution in the United States:

Illinois—Peoria (F. E. McDonald); Indiana—Indianapolis (L. H. Pammel);

FIG. 102.—False meadow rue (*Isopyrum biternatum*). *Photo by Ada Hayden.*

Missouri—Allenton (G. W. Letterman), Creve Coeur Lake (L. H. Pammel), Adams county (Kenneth Mackenzie); Wisconsin—Madison (L. H. Pammel).

Blooming, Ames, April 20, 1924; April 6, 1925; April 20, 1926. Lansing, April 5, 1925.

HONEY BEE VISITS

Ames, April 28, 1928, 11:30 a.m. Clear, fairly warm. Bees two, two, three, two seconds in a flower. (L.H.P.)

April 29, 1928, 9 a.m. Cool, cloudy. Some bees collecting pollen. One, one, one, one second in a flower. (L.H.P.)

Note—*Caltha palustris* L. Marsh Marigold. Bees visit this flower. (L.H. P.)

Aquilegia (Tourn.) L. Columbine

Perennial plants with two to three ternately-compound leaves. Flowers large, regular. Sepals five, colored like petals. Petals five, with a spreading lip and with large spurs. Attractive to bumble bees and to humming birds. Flowers rendered conspicuous by brightly colored stamens and pistils projecting from the center. Honey bees go to the flower only for pollen as the nectar is inaccessible to them.

FIG. 103.—Columbine (*Aquilegia* sp.). *Photo by Ada Hayden.*

Aquilegia canadensis L. Wild Columbine

Flowers pendant, scarlet to yellow inside, turn upward. Leaves ternately-compound. Fruit a follicle. Flower five sepals and five petals, nodding. Widely distributed in rocky woods. Associated with *Comandra umbellata.*

Bees have been observed collecting pollen.

Date of bloom, Ames, April 27, 1925; May 6, 1926; May 12, 1927. Boone, April 28, 1925. Lansing, May 1, 1925; May 9, 1926.

Aquilegia caerulea James. Rocky Mountain Columbine

Plants from one and one-half to three feet tall, mostly smooth or glabrous below, but pubescent above. Leaves glaucous. Beautiful flower with blue and white spurs straight or spreading.

Commonly cultivated as an ornamental plant.

FIG. 104.—Columbine (*Aquilegia canadensis*). *Photo by Ada Hayden.*

HONEY BEE VISITS

Ames, June 21, 1927, 8 a.m. Bees getting pollen. Three, four, five, three, five seconds in a flower. (L.H.P.)

Delphinium (Tourn.) L. Larkspur

Perennials or annuals. Leaves palmately divided. Sepals five, irregular and with the upper pair prolonged into a spur. Petals four, or occasionally two, irregular, the upper pair continuing into the spur.

This is a bumble bee flower; therefore, honey bees cannot get nectar normally, but frequent the flowers for pollen. The pollination of one of the species, *Delphinium elatum*, is described by Knuth as follows:

Delphinium elatum—"As Hermann Mueller has explained in a masterly fashion, the spur of the sepal not only serves to protect the nectar, but also compels the bumble-bees that alight in search of nectar to do so in the only way that effects pollination. The hollow, sharply conical end of the posterior process of each upper petal secretes nectar, getting so full of it that some enters the semi-conical cavity of this process, which is open on its inner side. As the two spurs are closely apposed they together form a hollow cone, splitting at the end into two horns filled with nectar. The proboscis of a bumble-bee — if long enough — is thus unfailingly guided, while, at the same time, the length of the cone denies access to shorter-tongued insects. The forwardly directed parts of the same petals prolong the upper part of the hollow cone to the front, and as they expand and turn up anteriorly, they afford a convenient approach to the proboscis of a bumble-bee, and also direct it with certainty to the nectar receptacle. These anterior parts of the upper petals separate on slight pressure, so that the head of a bumble-bee can be entirely thrust between them, thus diminishing the distance to the nectar by 6 to 7 mm."

Delphinium Penardi Hyth. Prairie Larkspur

Erect pubescent plants with strict elongated raceme. Flowers numerous, nearly white, the spur ascending. Prairies.

FIG. 105.—Larkspur (*Delphinium Penardi*). *Photo by Ada Hayden.*

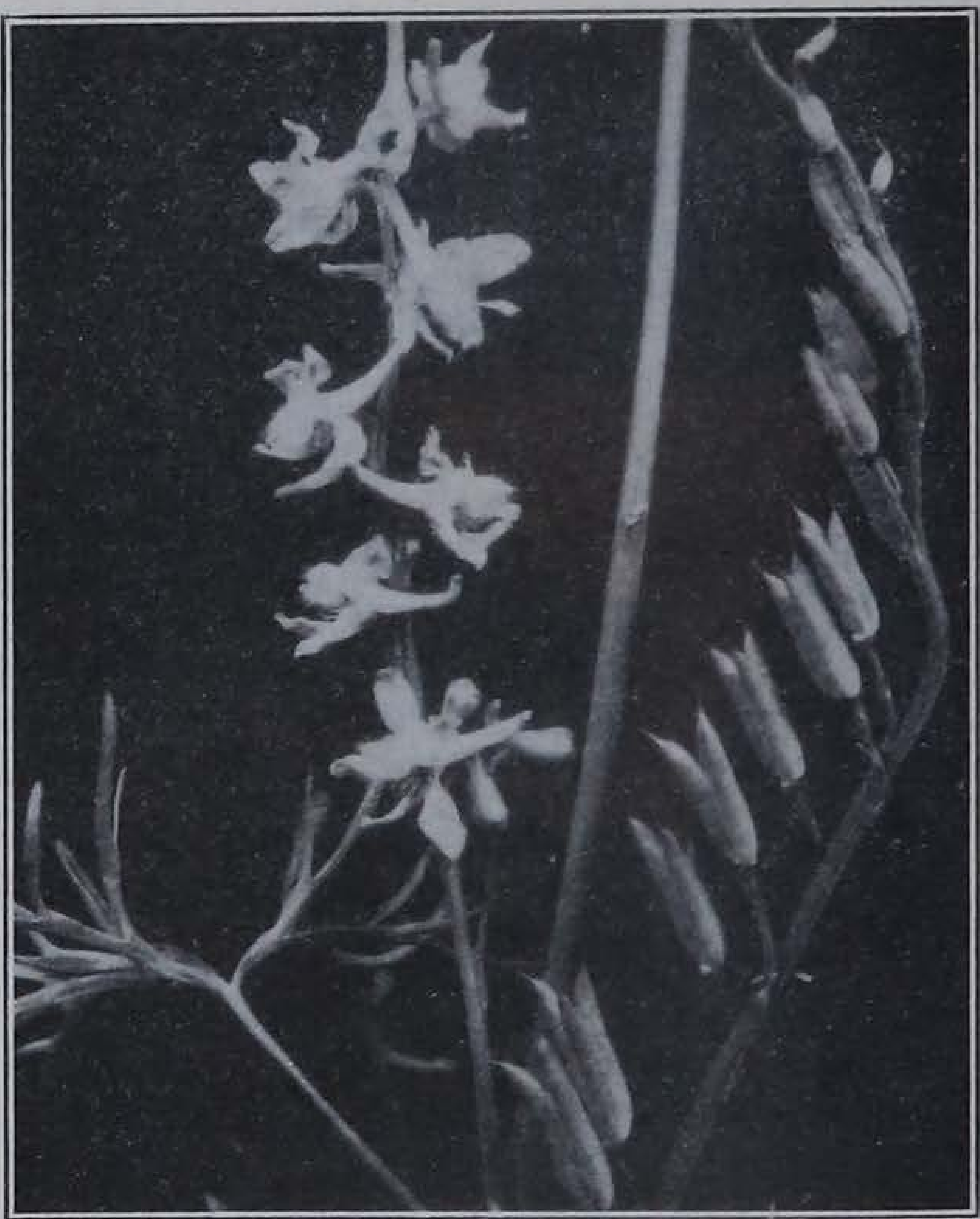

FIG. 106.—Larkspur (*Delphinium Penardi*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ankeny, Backbone Park (Delaware county), Carroll, Council Bluffs (L. H. Pammel), Fort Dodge, West Bend (F. W. Paige), Ames (R. Combs and C. R. Ball, E. B. Watson), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson), Eagle Grove (R. E. Buchanan), Emmet county (V. C. Fisk, L. H. Pammel), Fayette (B. Fink), Kelley (Pearl Clayton), Little Rock (C. R. Ball), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Shelby county (T. J. Fitzpatrick).

Date of bloom, 1927, Ames, May 5; Tabor, May 1.

Delphinium grandiflorum L. Cultivated Larkspur

Perennial, much branched. Leaves divided into fine segments. Peduncles spreading, bearing blue or violet flowers. Fruit a follicle one-half to one inch long.

FIG. 107.—Boquet larkspur (*Delphinium grandiflorum*).

A, B, C. Face, side and back views of flower. D. Longitudinal section of flower showing nectary (n). E. Proterandrous stamens. Mature stamens bending outward from pistils. F. Portion of flower showing nectar spurs on the two upper petals, also their hairy anterior portions which arch over the stamens and which also converge around an opening through which the bee approaches the nectar gland.

a. The upper sepal which includes (b) the two spurred petal nectaries. c. Pistils showing immature and mature stigmatic surfaces. d. Mature pistils. e. Detail of anterior portion of nectariferous petal. f. Undehisced stamens. g. Dehiscing stamens. n. Nectary. *Drawn by Ada Hayden.*

FIG. 108.—Larkspur, cultivated (*Delphinium grandiflorum*). *Photo by Ada Hayden.*

HONEY BEE VISITS

Ames, I.S.C. formal gardens, July 30, 1927, 9 and 10 a.m. Dry, cloudy. Bees collecting pollen. Ten to seven seconds in a flower.

Delphinium Consolida L. Field Larkspur

Leaves dissected into narrow linear lobes. Flower in a loose panicle, few or scattering, blue, violet or sometimes purple in color.

HONEY BEE VISITS

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary.) Bees getting pollen. Two, three, three, one seconds in a flower. (L.H.P.)

Ames, July 19, 1929. Bees present. (L.H.P.)

Paeonia Tourn. Paeony

Erect perennial plants with large basal leaves. Flowers large and showy, red, purple, yellow and white. Sepals five, petals five to ten. Fruit a follicle.

Paeonia officinalis Retz. Paeony

Stems stout. Leaves simple, biternate, smooth or somewhat pubescent. Flowers crimson, white or yellow.

Kerner notes bumble bee visits to the flower. We have found honey bees on this not uncommonly as the following notes indicate.

HONEY BEE VISITS

Ames, June 4, 1927, 11 a.m. Sunshiny, warm. Five bees in a single flower of white peony at one time; ten bees in five minutes; 50 seconds in a flower.

FIG. 109.—Paeony (red) (*Paeonia officinalis*). *Photo by Ada Hayden.*

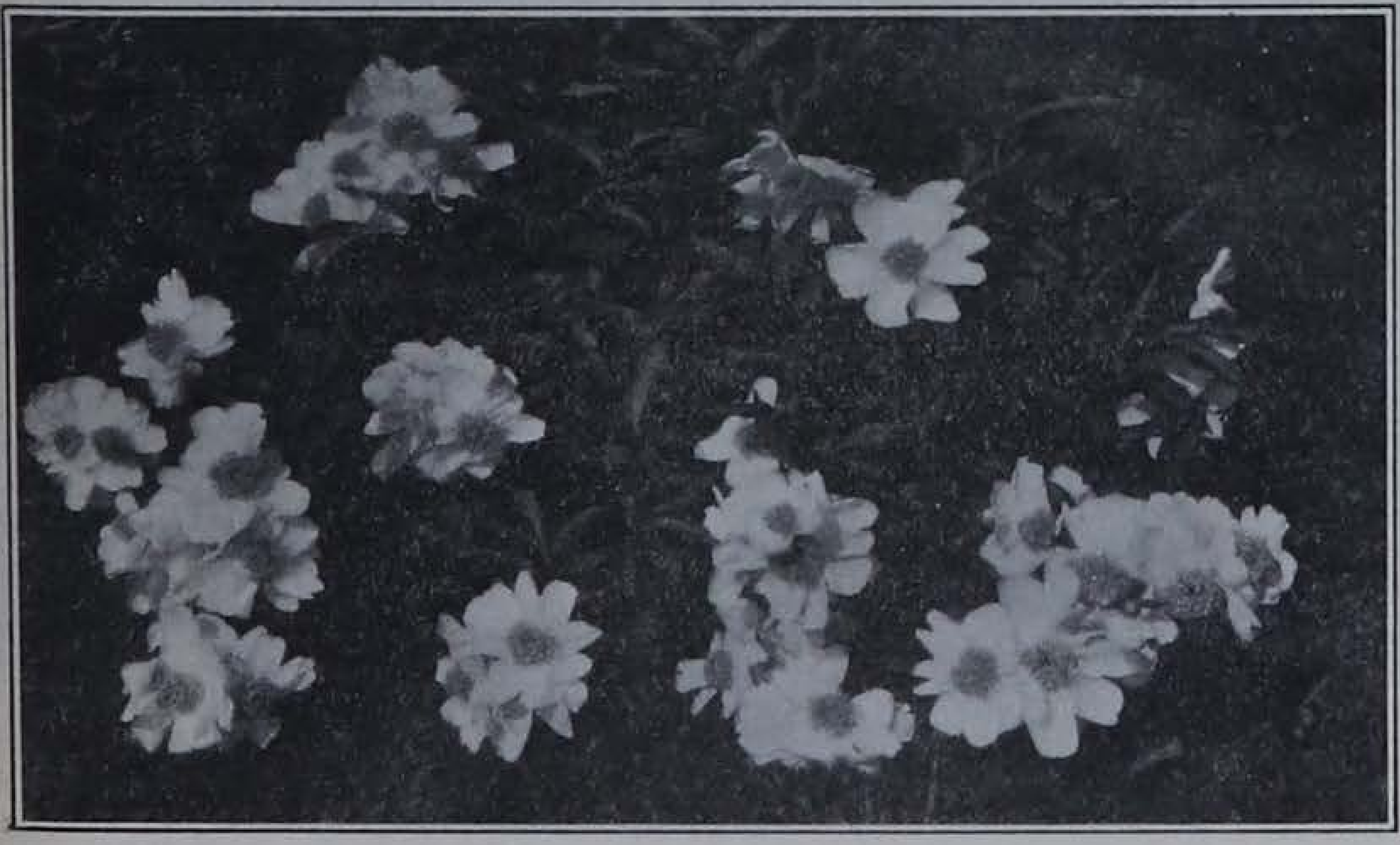

FIG. 110.—Paeony (white) (*Paeonia officinalis*). *Photo by Ada Hayden.*

June 5, 1927, 10 a.m. North wind. Bees abundant; 12, 14, 10, 16 seconds in a flower; five bees in three minutes in a flower. (L.H.P.)

June 6, 1927. Cloudy, warm. Bees abundant; 15, 25, 5, 35 seconds in a flower. (L.H.P.)

June 7, 1927. Sunshiny, clear. Bees gathering pollen; 25, 25, 25, 20 seconds in a flower. (L.H.P.)

June 8, 1927, 8:30 a.m. A few bees; 25, 35, 25 seconds in a flower.

June 9, 1927, 8:30 a.m. Clear. Bees abundant; 15, 20, 25 seconds in a flower. (L.H.P.)

June 14, 1927, 9 a.m. to 10 a.m. Windy, cool, sunshine. Bees frequent.

June 15, 1927, 4 p.m. to 5:30 p.m. Sunny, cool. Bee visits, 12 during one and one-half hours. (L.H.P.)

May 30, 1929, 3 p.m. Bees numerous; 15, 16, 18, 18 seconds in a flower.

June 3, 1929, 10:30 a.m. Bees abundant, gathering pollen; twenty, twenty-five, twenty-eight, eighteen seconds in a flower. (L.H.P.)

June 12, 1929, 5 p.m. Cool, cloudy. Bees 15, 14, 16 seconds in a flower.

Alton, June 4, 1929. Bees 100, 95, 60 seconds in a flower. (L.H.P.)

Orange City, June 4, 1929. Bees gathering pollen and nectar. Very active. Rolled round in flowers as if drunk. (L.H.P.)

Rolfe, June 11, 1929. No bees. Flowers past prime. (L.H.P.)

Blcoming, Ames, May 31, 1925.

FIG. 111.—Tulip tree (*Liriodendron Tulipifera*). *Photo by Ada Hayden.*

MAGNOLIACEAE, Magnolia Family

Trees or shrubs. Calyx and corolla colored alike, in rows of three, and folded in the bud; sepals and petals deciduous; pistils many. Leaves alternate.

Liriodendron Tulipifera L. Tulip Tree

Tall trees, some over 150 feet high with a trunk eight feet in diameter. Leaves dark green, shiny; lobes two lateral and two upper, with a broad shallow notch. Flowers greenish yellow marked with orange. Fruit cone-like, one and one-half to three inches long. Carpels an inch to one and one-half inches long. Bark thin and scaly on young branches, on older trees furrowed, brown. Winter buds dark red.

Commonly cultivated in the southern part of the state.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium: Davenport, Indianola (L. H. Pammel), Indianola (Prof. Jenner).

FIG. 112.—A yellow poplar or tulip tree "This tree is probably 60 years of age and is fully 60 feet in height. A beautiful specimen of the tulip tree as it grows in the open." (By Scott.)

FIG. 113.—Yellow poplar or tulip tree in winter. (By Gates.)

Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.

General distribution in the United States:

Florida—Gainesville (U. S. Nat. Museum); Indiana—Logansport (L. H. Pammel); Kansas—Manhattan (L. H. Pammel); Maryland—Forest Glen; Missouri—Botanical Gardens (L. H. Pammel); New York—Ithaca (H. E. Summers); North Carolina—Rowan (A. A. Heller); Ohio—Cincinnati (C. G. Lloyd); South Carolina (J. L. Seal).

HONEY BEE VISITS

Manhattan, Kansas, May 16, 1927, 2:30 p.m. Clear. Bees abundant. Twelve, sixteen, nineteen, sixteen, twenty seconds in a flower. (L.H.P.)

Ames (cult.), June 14, 1928, 1:30 p.m. Some bees. Twelve, fourteen, twelve, twelve, fourteen seconds in a flower. Not many flowers, high up in tree.

Fremont, Nebraska, June 10, 1929. Abundantly visited by honey bees. (W. Kuhn.)

Magnolia L. Magnolia

Trees with ashy gray or smooth brown scaly bark. Leaves entire, in some instances auriculate, generally deciduous. Sepals three, petals six to nine. Fruit a rusty brown cone. Seed at maturity red or scarlet.

Several species are cultivated for ornamental purposes and are sometimes visited by bees.

The species cultivated in the state are the following:

Magnolia glauca L. Magnolia

Small trees 50 to 70 feet in height with the leaves scattered along the branches. Leaf buds tomentose or with a silky pubescence. The leaves oblong or oval, glaucous at maturity. Bright green above and pale beneath. Flowers glabrous, fragrant.

Cultivated in southeastern Iowa.

Magnolia acuminata L. Cucumber Tree

Trees 50 to 60 feet high with a trunk four feet in diameter. Leaves scattering, oblong-ovate or subcordate, petioled. Flowers bell-shaped, green or pale yellow. Fruit red when ripe.

This species is hardy to the north line of the state eastward. Cultivated in southern Iowa.

Visited by bees but not an important honey plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Des Moines, Marshalltown.

General distribution in the United States:

Missouri—St. Louis (L. H. Pammel); New York—Six Mile Gorge (W. C.

Muenscher, A. R. Bechtel); Ohio—Cleveland (F. D. Fullmer), Lancaster (Dr. Bigelow); Pennsylvania—Cameron county (A. A. Heller); South Carolina—Clemson (J. L. Seal); Tennessee—(A. Gattinger); Virginia—Smyth county (J. K. Small).

CALYCANTHACEAE, Calycanthus Family

Shrubs with opposite, entire leaves, without stipules. Flowers brownish, petals and sepals similar. Fruit much like that of roses. Handsome ornamental shrub freely planted.

Calycanthus L. Carolina Allspice

Aromatic shrub with brownish purple flowers. Calyx of many sepals united into a fleshy cup; petals inserted on top of the closed calyx tube; stamens numerous; pistils several or many.

Calycanthus floridus L.

Leaves in many cases downy underneath, oval in outline. Flowers brownish, fragrant. Handsome ornamental shrub, perfectly hardy as far north as central Iowa.

HONEY BEE VISITS

Bees observed in Florida.
Winterset, June 6, 1929. No bees. (Mrs. Lewis.)
Ames, June 7, 1929. No bees. (C.M.K.)

ANONACEAE, Custard Apple Family

Trees or shrubs with naked leaves, alternate buds. Flowers perfect, sepals three, petals six, pistils thickish, several or many, forming a cohering mass. Fruit cohering in a mass, fleshy or pulpy.

Asimina triloba Dunal. Common Papaw

Leaves large, obovate, lanceolate, sharp pointed, narrow at the base, light green, pale on the lower surface. Flower rather large, two inches across. Common on banks of streams in southeastern Iowa as far north as Dubuque and in southwestern Iowa in Fremont county.

It is said to be sometimes visited by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Hamburg, Keokuk, Lyons (L. H. Pammel), Des Moines county (T. J. Fitzpatrick), Dubuque (A. Horr), Keokuk (P. H. Rolfs), Payne (L. H. Pammel and H.B.C).

General distribution in the United States:

Alabama—Birmingham (L. H. Pammel); Arkansas—Hot Springs (L. H. Pammel); Florida—Buckley; Illinois—Oquawka (H. N. Patterson), Rock Island (L. H. Pammel), Starved Rock (L. H. Pammel and M. Heavenhill), Utica (Mrs. J. Clemens); Indiana—Logansport (M. Rees), Turkey Run (L. H. Pammel); Missouri—Saint Charles (L. H. Pammel), Saint Louis (P. T. Barnes, L. H. Pammel); New York—Ithaca (H. E. Summers); Ohio—Buckeye Lake (L. H. Pammel and Prof. Griggs), Cincinnati (C. G. Lloyd); Pennsylvania—Riddlesburg (Mrs. J. Clemens), Spruce Creek (L. H. Pammel); Texas—Houston (A. Hayden); Virginia—Richmond (J. R. Churchill).

BERBERIDACEAE

Shrubs or herbs. White or yellow flowers in terminal or axillary racemes. Fruit a berry or pod. Leaves alternate.

Berberis (Tourn.) Barberry

Shrubs with yellow wood. Flowers yellow, regular, imbricated in the bud; petals six; stamens irritable, as many as petals; pistil single.

The flowers of the barberry produce nectar concentrated or nearly so. The inner sides of the sepals and petals are yellowish in color. The nectar is secreted by two fleshy swellings. Sometimes the nectar is quite concentrated and forms drops. Many species possess sensitive stamens which, when touched, move toward the pistil. This occurs when the insect comes into contact with the base of the filament and as it goes into the flower comes into contact with the stigma and leaves pollen. As the insect touches the filament the stamens move forward.

Berberis vulgaris L. Common Barberry

This plant is distinguished by its drooping many-flowered racemes and scarlet berries. Naturalized from Europe, it became thoroughly wild in thickets and waste grounds in New England; it is elsewhere occasionally spontaneous.

Once common in prairie pastures, rocky soils, clay, limy and black soils. Cultivated, and escaped in many places in the East and in Iowa.

It is against the Iowa law to grow this barberry because it harbors the common grass rust.

The barberry has sensitive stamens for the purpose of insuring pollination. The yellow flowers are borne in racemes and contain some nectar, which is secreted by two fleshy orange-colored glands at

FIG. 114.—Flowers of the common barberry (*Berberis vulgaris*). (*Drawing by C. M. King.*)

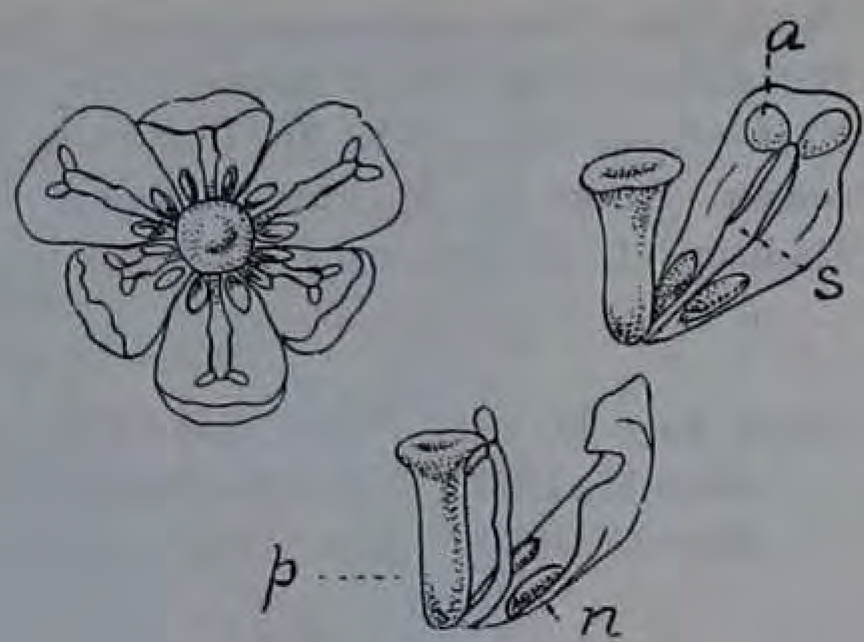

FIG. 115.—Flower of the common barberry (*Berberis vulgaris*) which has been irritated. To the left the flower with stamens, pistils and nectar gland and petals. To the right (lower figure) end of the nectar glands. Upper figure, the stamens after irritation, with pistil, stigmas and nectar glands and stamens. a—anthers.

the base of each petal. The honey collects between the stamens and ovary. When the insect visits a flower it thrusts its head into one of the angles and in so doing comes in contact with the stamens, which are sensitive and move forward, shedding pollen on the insect. The anthers open by uplifted valves.

Hermann Mueller says, "The insect usually flies away at once after the first drop of honey, after being struck by the stamen, and as it thrusts its proboscis into the flower. Its head must soon be dusted all around with pollen, and it must fertilize every succeeding flower that it visits."

The hive bee is one of the frequent visitors and collects honey.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames College Campus (two specimens), Burlington, Cedar Falls, Council Bluffs (twelve specimens), Clear Lake, Edgewood, Fonda, Harcourt, Hamburg, Hampton, Hancock county (two specimens), Humboldt (three specimens), Iowa Lake, Kelley (four specimens), Monmouth, McGregor (four specimens), Montpelier, Pocahontas, Walnut creek (L. H. Pammel), College Farm (Ames), Garner, Northwood (L. L. Rhodes), Calmar, Clinton county (two specimens, J. J. Wilson), Jones county, Vida (Linn county), Wyoming (Thomas), Buena Vista county, Clermont, Marathon, Fayette, escaped 1894 (B. Fink), Stuart, (H. H. Plagge), Albia (Fred Townsend), Ames (F. A. Sirrine, F. C. Stewart) escaped as early as 1892, Clarksville (J. M. Ramsey), Johnson county, escaped 1895 (T. J. and M. F. L. Fitzpatrick).

General distribution in the United States:

Illinois—Galva, Mount Carmel (L. H. Pammel), Rockford (L. H. Pammel and V. C. Fisk), Hamilton (two specimens, F. C. Pellett); Massachusetts—

Cambridge (two specimens, L. H. Pammel), Gloucester (Mr. and Mrs. L. Blundell); Minnesota—Cannon Falls (L. H. Pammel and Lois Pammel); New York—Goat Island (L. H. Pammel); Ohio—Lancaster (Dr. Bigelow); Wisconsin—Beloit (L. H. Pammel and V. C. Fisk), La Crosse (three specimens), Madison (L. H. Pammel).

HONEY BEE VISITS

Ames, May 25, 1917. Cool, cloudy, windy. Bees common. (L.H.P.)
June 12, 1917. Bees abundant, flowers strongly scented. (L.H.P.)
May 13, 1920, 4 p.m. Cool, east wind. No bees. (L.H.P.)

Blooming dates for *Berberis vulgaris.*

	Northern section	Central section		Southern section
	Lansing	Ames	Cedar Rapids	Ottumwa
1901		5–9		
1904		5–11		
1905		5–3		
1907			5–21	
1908			5–20	
1911				5–18
1915	5–10			
1916	5–20			
1919		5–15		
1921	4–23			
1923		5–15		

Berberis Thunbergii D. C. Japanese Barberry

This is a low shrub with leaves one-half to one inch long. Flowers solitary or in pairs, on slender spiny stalks. Berries bright light scarlet. The foliage becomes red in the fall. Widely used in Iowa as a cultivated ornamental plant.

Flowers pale yellowish white in a few axillary clusters; petals five, each with two fleshy yellowish nectaries at the base. Stamens sensitive; when the insect comes in contact with the back of the filament of the stamen the latter moves forward to the pistil. The anther dehiscing leaves pollen on the insect. When the insect leaves the flower and goes to another in search of nectar it comes in contact first with the stigma and then with the stamens.

The Japanese barberry flowers are not nearly as conspicuous as those of the common barberry, but it is one of the most consistent honey producers of the early spring blooming plants. The honey bee is the most important visitor.

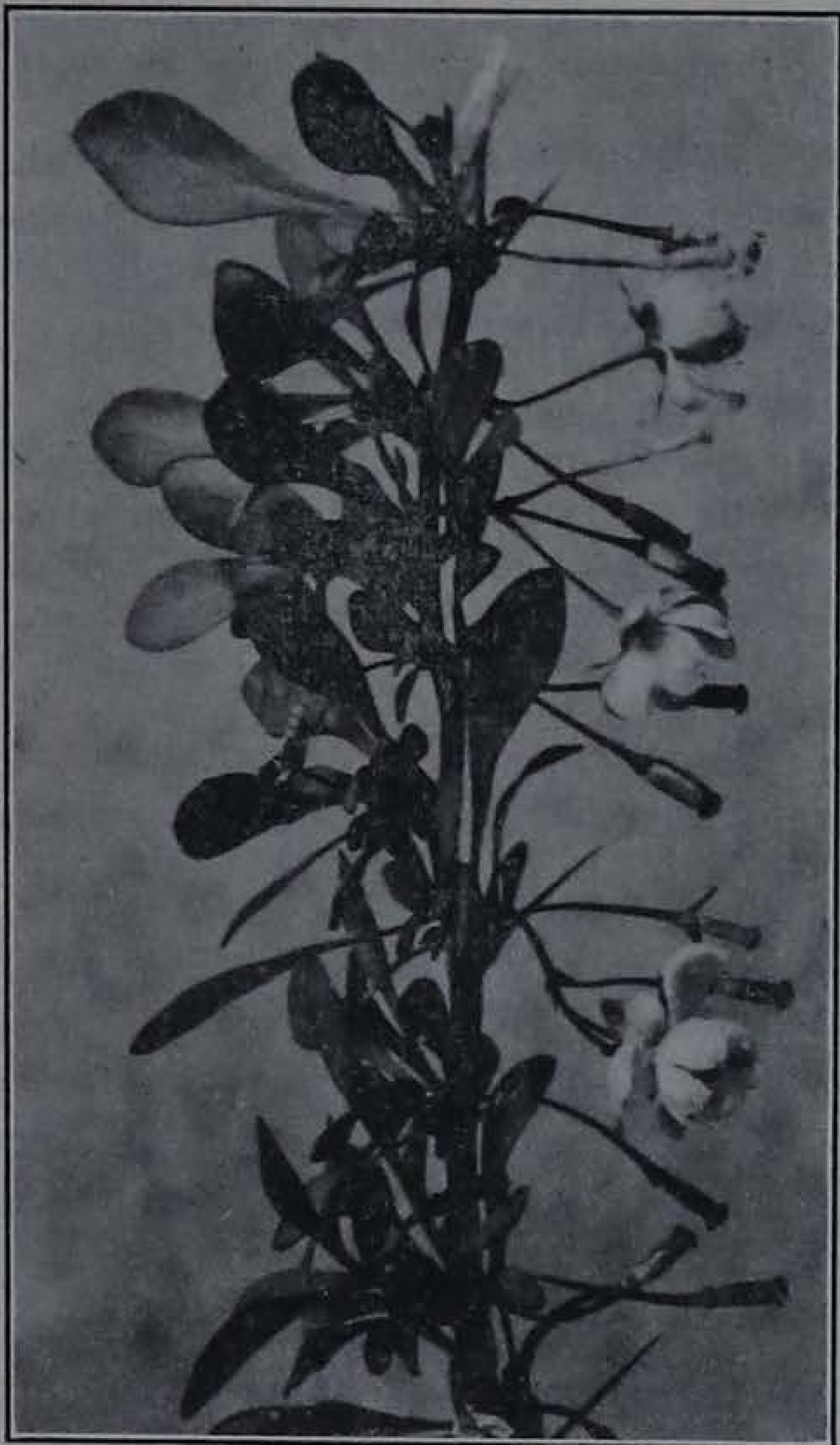

FIG. 116.—Japanese barberry (*Berberis Thunbergii*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Albia (Dr. Miller), Ames (cult.) (L. H. Pammel), (two specimens, F. A. Sirrine), Charles City (escaped) (L. H. Pammel). Escaped plants also observed in Mason City by L. H. Pammel.

HONEY BEE VISITS

Ames, May 10, 1919. A few bees. Two to three seconds in a flower. (L.H.P.)
May 13, 1919, 12 m. One bee two, two, three seconds in a flower.
April 23, 1921, 9 a.m. Bees gathering honey, not pollen. Three, five, two, ten seconds in a flower. (L.H.P.)
April 25, 1921, 9 a.m. Bees two, two, one, two, one, two seconds in a flower. (L.H.P.)
April 26, 1921, 9 a.m. Some bees at work. Two, three, four, five, six, four, three seconds in a flower. One bee visits several nectaries successively. (L.H.P.)
May 2, 1921, 12 m. Warm. One bee. (L.H.P.)

May 4, 1921, 8:30 a.m. Cool, clear, windy. Honey bees about three to each bush getting nectar. Five, six, seven, five, nine, six seconds in a flower. (L.H.P.)

May 5, 1922, 8:30 a.m. Some bees. Five, seven, six, four, five, four seconds in a flower. (L.H.P.)

May 14, 1922, 1 p.m. Clear, southeast wind. Bees three, seven, three, three, four, three seconds in a flower. (L.H.P.)

Blairsburg, May 12, 1924. Some bees. (L.H.P.)

Ames, May 15, 1924, 12:30 p.m. Partly cloudy. No bees. (L.H.P.)

May 9, 1926, 10 a.m. and 12:15 p.m. Dry and warm. No bees. (L.H.P.)

May 5, 1927, 4:30 p.m. Warm, windy. Nectar abundant. Bees four, four, five, three seconds in a flower. (L.H.P.)

June 9, 1927, 8 a.m. Cool, southeast wind. Some bees. (L.H.P.)

Keosauqua, May 6, 1928, 9 a.m. Clear, slight breeze. Bees common. Four, five, four, four seconds in a flower.

May 6, 1928, 3 p.m. Bees four to six seconds in a flower.

Davenport, May 14, 1928, 4:30 p.m. Bees nine, six, five, six, five, ten seconds in a flower. (L.H.P.)

Ames, May 6, 1929. Fair. Drops of nectar could be seen. Bees abundant.

May 8, 1929, 12:15 p.m. Fair. Bees three, four, three, three, three, two seconds in a flower. (L.H.P.)

Ames, May 9 to 22, 1929. Three to six seconds in a flower. Abundant.

Eldora, May 25, 1929. Only a few flowers left. Few bees. (L.H.P.)

Mason City, May 11, 1929, 1 p.m. Flowers just coming into bloom. No bees on hedge 160 feet long. (L.H.P.)

Meservey, May 24, 1929, 9 a.m. Nectar abundant in form of drops. Three, four, three, four, four seconds in a flower.

Blooming dates for Berberis Thunbergii.

	Central section	
	Ames	Grinnell
1901	5–12	
1905	5–8	5–5
1910	4–6	
1917	5–17	
1918	5–5	
1919	5–2 to 5–12	
1922	5–4	

Sassafras Nees.

Trees with spicy aromatic odor. Flowers dioecious with a 6-parted spreading calyx; the sterile flowers with nine stamens in three rows with a pair of glands at the base of each; fertile flowers with six short rudimentary stamens. Flowers in corymbed racemes. Fruit ovoid on a rather fleshy, reddish pedicel.

Sassafras variifolium (Salisb.) Ktze.

Aromatic trees with stout branches. Leaves simple, alternate, oval to oblong or obovate; 1- to 3-lobed with deep sinuses; dark green above, paler beneath. Flowers appear early, dioecious, greenish yellow, on slender stalks in a few drooping racemes. Calyx deeply 6-lobed, corolla none, stamens in staminate flowers nine. Fertile

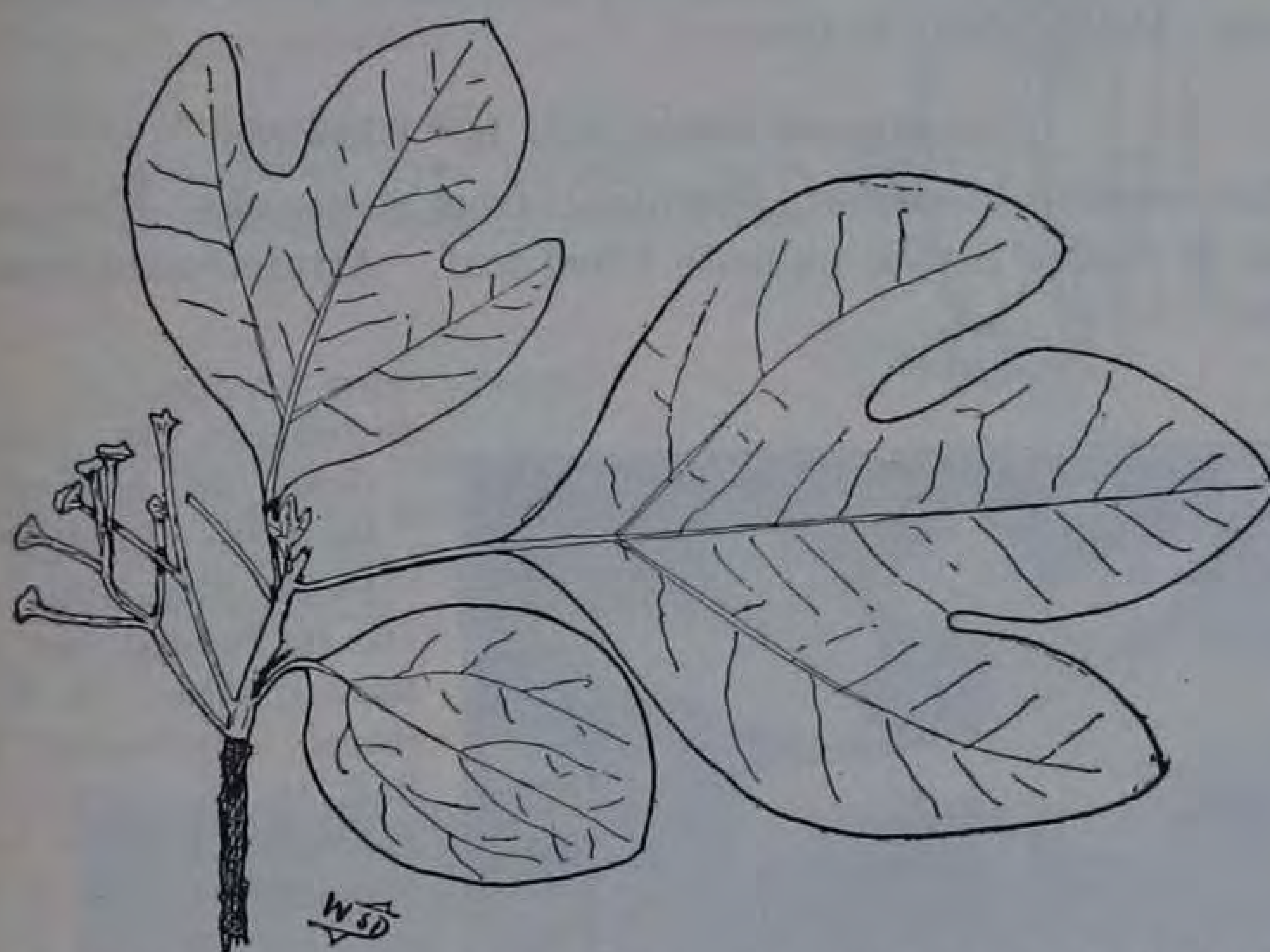

FIG. 117.—Sassafras (*Sassafras variifolium*). *Drawing by W. S. Dudgeon.*

flowers with six rudimentary stamens, ovary ovoid. Fruit a drupe.

This is not uncommon in a few counties in southeastern Iowa.

Widely distributed in eastern North America from southern Maine to Michigan. Southeastern Iowa and Kansas to the Gulf.

We have not had an opportunity to study the plant in central Iowa so far as its value as a honey plant is concerned. But we have found bees upon it in the southern states and since the species is native to southeastern Iowa it may be regarded as a honey plant in that region.

Pellett states that he has found bees working on the plant in the southern states. He also reports it in Leon county, Texas, as an important honey plant.

H. B. Parks reports that it yields honey in Missouri.

PAPAVERACEAE, Poppy Family

Herbs with milky or colored juice, regular flowers. Sepals two, early falling; petals usually four.

Sanguinaria (Dill) L. Bloodroot

Perennials with thick prostrate rootstock. Orange-colored juice. Produces a palmately lobed leaf and a single white flower with two sepals. Petals eight to twelve.

Sanguinaria canadensis L. Bloodroot

The common bloodroot; perennial, from rootstocks. Two sepals, eight to twelve petals, palmate lobed leaf. Attractive to bees, for pollen.

Fig. 118.—Common bloodroot (*Sanguinaria canadensis*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Forest City, Pilot Knob (L. H. Pammel and A. L. Bakke), Ames (R. E. Buchanan, Ada Hayden, E. D. Ball, G. W. Carver, L. H. Pammel), Chickasaw county (two specimens, W. D. Spiker), Creston (T. L. Andrews), Decorah (F. R. Goddard, E. W. D. Holway), Des Moines (Crocker Woods) (Mrs. Henry Frankel), Emmet county (B. O. Wolden), Fayette (B. Fink, C. C. Parker), Guttenberg (R. Gmelin), Lowden (J. F. Briel), Muscatine (L. H. Pammel and E. R. Hodson), southern Iowa (J. P. Anderson), Story county (S. W. Beyer).

General distribution in the United States:

Florida — Appalachicola River near Bristol (L. H. Pammel); Illinois—Urbana (B. Fink, H. A. Gleason);

Michigan—Keweenaw Point (Frank E. and Floyd J. Wood); Minnesota—Cass Lake (L. H. and H. E. Pammel), Saint Cloud (Dr. Gmelin); New York—Ithaca (Muenscher and Bechtel, two specimens, H. E. Summers); Nova Scotia—Pictou county (Harold St. John); Ohio—Worthington (Asa Horr); Ontario—Kingston (J. Fowler); South Carolina—Oconee county (two specimens, A. P. Anderson); Tennessee—Clarksville (T. L. Andrews).

Blooming, Ames, April 15, 1924. Lansing, April 16, 1924. Boone, April 15, 1924. Ames, April 4, 1925. Lansing, April 12, 1926. Boone, April 5, 1925.

FIG. 119.—Common bloodroot (*Sanguinaria canadensis*). Common wild native plant of our woodlands. *Drawing by Ada Hayden.*

HONEY BEE VISITS

Ames, April 20, 1926, 2 p.m. Clear and warm. Honey bees abundant, gathering pollen only. A bee in the flower 25, 60, 25, 15, 65 seconds.

April 21, 1926. Dry. Bees collecting pollen. (L.H.P.)

FIG. 120.—Common bloodroot (*Sanguinaria canadensis*). Woodland scene. *Photo by Ada Hayden.*

Chelidonium majus L. Celandine

Introduced; grows about towns. Biennial herb with saffron-colored juice, pinnately divided leaves and small yellow flowers. Introduced near Cherokee near an old log cabin. Reported by Nestor Stiles.

HONEY BEE VISITS

Ames, May 30, 1929, 11 a.m. Some bees. First observed this year. One, two, two, one, two, three seconds in a flower. Gathering pollen. (L.H.P.)

Papaver (Tourn.) L. Poppy

Annual herbs with whitish juice. Flower with four petals, two sepals. The capsule many-seeded, opening by pores around the top.

Papaver somniferum L. Opium Poppy

Smooth, with clasping leaves and globose pod. Corolla white or purple.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium: Dubuque (two specimens, Asa Horr).

HONEY BEE VISITS

Brookings, South Dakota, July 31, 1922. Bees abundant. Often four bees on a single flower. One bee fifteen, sixteen, fifteen, eighteen seconds in a flower. (L.H.P.)

FIG. 121.—Poppy (*Papaver somniferum*).

Papaver Rhoeas L. Common Poppy

Slender branching annual, with spreading hairs. Capsules less than one inch long. Flowers deep red or scarlet with a dark eye.

HONEY BEE VISITS

Ames, June 5, 1927, 10 a.m. North wind. No bees. (L.H.P.)

Ames, July 22, 1927, 11 to 12 a.m. After rain, cloudy, warm. Bees five, ten seconds in a flower for pollen. (C.C.L.)

Jefferson, September 2, 1927, 3 p.m. Bees visit flower for pollen.

Tingley, June 20, 1929, 10 a.m. Some bees. Six, six, six, seven seconds in a flower. (L.H.P.)

Papaver orientale L. Oriental Poppy

Robust, hairy perennial, three to four feet tall. Flowers large, scarlet with dark center.

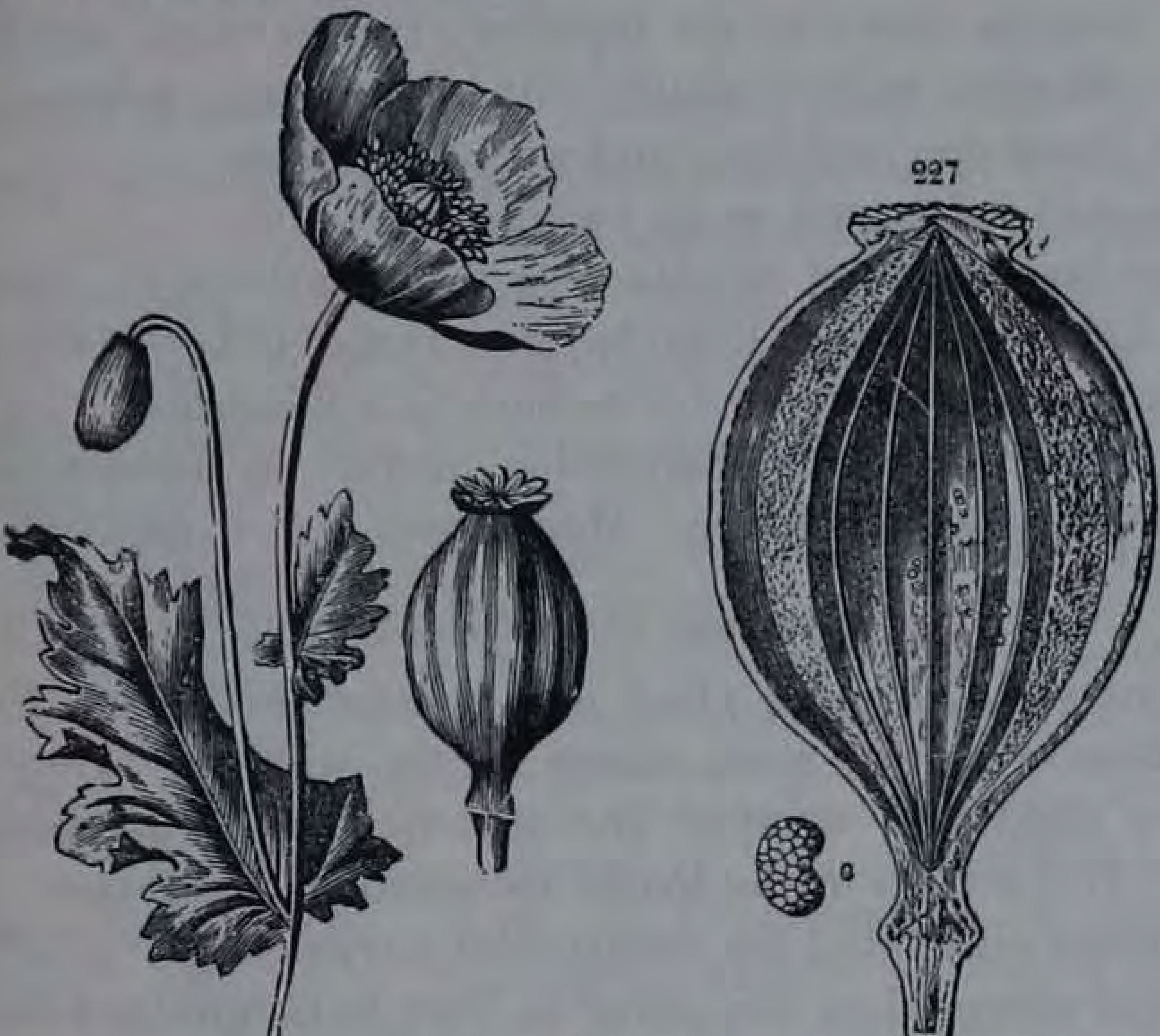

FIG. 122.—Garden oriental poppy. To the left flower and young capsule. To the right mature capsule.

HONEY BEE VISITS

Rolfe, June 11, 1929, 12:30 p.m. Bees abundant. Sixteen, twelve, eighteen, eleven seconds in a flower. (L.H.P.)

Manson, June 11, 1929, 5 p.m. Bees present. (L.H.P.)

Argemone L. Prickly Poppy

Annual or biennial herbs with prickly bristles and yellow juice; leaves with prickly teeth, sinuate lobed, many of them blotched with white. Flowers whitish, yellow or rose-tinted. Sepals two or three, in some cases prickly; petals four to six; stamens numerous, stigmas united. Pod prickly.

Several species, frequently cultivated for ornamental purposes and sometimes escaped from cultivation.

FIG. 123.—Oriental Poppy (*Papaver orientale*).

Argemone grandiflora. Sweet Argemone, Prickly Poppy

Plant one to three feet high, with glabrous stems or only slightly spiny. Leaves with few spines, white veined. Flowers more or less in clusters, three to six together; two or three inches across, white. Stamens many, pistils with short style, stigmas radiate. Capsule about one inch long and with few spines.

Commonly cultivated as an ornamental plant.

Honey bees observed on this very abundantly in the formal garden at Ames, August 7, 1929, by Mrs. Irma Ortner Webber. Bees gathering pollen, ten to twelve seconds in a flower.

This plant was under observation in July by the senior author but honey bees were not seen. Honey bees visit it regularly later.

Argemone intermedia Sweet

A stout very glaucous plant one to four feet high. Peduncles leafy; flowers two or more inches across, white or rarely purple. Capsules rigid and spiny. The variety *rosea* with rose-colored flowers. Indigenous to the Rocky mountains and Mexico.

Sometimes cultivated for ornamental purposes.

Bees not observed on this plant in Iowa but abundant during the months of February and March in the Rio Grande valley.

Argemone mexicana L. Mexican Poppy

Something like the preceding but less glaucous; flowers yellow or rarely cream-colored. Waste places, occasionally naturalized northward. Common in Texas and Mexico.

Bees were commonly observed on this plant in the months of February and March in the Rio Grande valley. Not seen on this species in Iowa.

Eschscholtzia californica Cham. California Poppy

Diffuse plants a foot to two feet or more high, leaves ternately dissected into linear segments. Flowers two to three inches across, opening in sunshine, pale yellow or orange-colored. Capsule three to four inches long.

HONEY BEE VISITS

Ames, July 22, 1927, 11 to 12 a.m. After rain. Cloudy, warm. A fair plant for pollen. Bees one, three seconds in a flower. (C.C.L.)

July 31, 1927, 10:20 a.m. Some bees. Six, six, five, four, three, two, four, eight seconds in a flower. (L.H.P.)

CRUCIFERAE, Mustard Family

Herbs with pungent juice, and regular cruciform flowers. Stamens six. Pod a silique or silicle.

Capsella Bursa-pastoris (L.) Medic. Shepherd's Purse

A widely distributed winter annual. Stem-leaves arrow-shaped, basal leaves pinnately divided, variable. Small white flowers and triangular 2-valved pod.

Fig. 124.—Shepherd's purse (*Capsella Bursa-pastoris*). Showing a part of the plant with the flowers, upper right-hand corner, and the seed and pod to the left.

Distribution for Iowa as shown by specimens in I.S.C. Herbarium:

Ames, Hamburg, Keokuk, Pacific Junction, Wall Lake (L. H. Pammel), Alden (F. F. Stevens), Ames (Edna Pammel, Bernice Banks, A. B. Hoopes, George W. Carver, F. C. Stewart, B. G. Porter, E. D. Ball, Fred Rolfs), Chickasaw county (W. D. Spiker), Decorah (E. W. D. Holway), Decatur county (J. P. Anderson), Des Moines (H. Frankel), Fayette (B. Fink), Fort Dodge (F. W. Paige), High lake (B. O. Wolden), Kelley (Pearl Clayton), Lake Park (S. E. Meek), Ledges (L. H. Pammel and R. Combs), New Hampton (P. H. Rolfs and A. H. Moore), northeast Iowa (H. Goddard), Perry (L. H. Pammel and Zimmerman).

General distribution in the United States:

California—Butte county (A. A. Heller), Wauwona (L. H. Pammel); Canada—Calgary (L. H. Pammel); Colorado—Crags (L. H. Pammel, R. L. Barrett, R. V. Lee and Frank Raney), Larimer county (L. H. Pammel); District of Columbia—(Agnes Chase); Illinois—Eureka (I. C. Brownlie); Kansas—Garretson Crossing, Manhattan (L. H. Pammel); Louisiana—(T. L. Andrews), Gretna (C. R. Ball); Maryland—Emmetsburg (L. H. Pammel); Massachusetts—Cambridge (L. H. Pammel); Minnesota—Hibbing (L. Clapper); International Falls (H. S. Kellogg); Mississippi—Vicksburg (L. H. Pammel); Missouri—St. Louis (L. H. Pammel); Nebraska—eastern (J. P. Anderson); Hastings (L. H. Pammel); New York—Westburg (Elis Tubby), Whitetown (J. V. Haberer); Ohio—Baltimore (A. Horr); Oklahoma—Norman (W. E. Bruner); Oregon—La Pine (Kirk Whited), Portland (L. H. Pammel and W. S. Dudgeon); South Dakota—Brookings (Edna Pammel), Elk Point (B. Fink; Texas—Austin (B. C. Thorpe), Tarrant county (A. Ruth), University Campus (F. C. Werkinthin); Utah—Salt Lake (F. E. Leonard); Vermont—Bread Loaf (Emile F. Williams); Washington—"Langley," Everett (J. M. Grant);

Burlington (H. Walker), Cedar Falls (A. A. Berger), Des Moines (A. L. Bakke), Kelley (Pearl Clayton), Little Rock (C. R. Ball), Morning Sun (G. W. Carver), northeast Iowa (H. Goddard), Slater (H. Fawcett, W. I. Tener, C. Reinbott), Story City (L. H. Pammel and S. W. Beyer), Tama county (F. A. Sirrine).

Observed in fields June 13, 1924 (L. H. Pammel). Abundant in many of the fields at Council Bluffs, Dubuque, Eldora, Forest City, Hubbard, Hawarden, LeMars, Nevada, Sioux City, Story City, Waterloo, Zearing.

General distribution in the United States:

California—Alexandria (Lyster H. Dewey); Colorado—Fort Collins (J. H. Cowen); Minnesota—International Falls (H. S. Kellogg); Missouri—Sheffield (Kenneth K. Mackenzie); Montana—Hamilton (L. H. Pammel and H. S. Fawcett); New York—Cincinnatus (Lyster H. Dewey), Ithaca (H. E. Summers); North Dakota—Fargo (L. H. Pammel); South Dakota—Brookings (Edna C. Pammel); Utah—Logan (L. H. Pammel, R. L. Barrett, L. V. Lee, F. Raney); Wisconsin—La Crosse (L. H. Pammel); Virginia—Oroville (A. A. Heller).

HONEY BEE VISITS

Ames, June 15, 1923, 1 p.m. Warm, sunshiny. Bees abundant. Two, three, two, three, two, two seconds in a flower. (L.H.P.)

Blooming dates for Brassica arvensis.

	Northern section			Central section					Southern section	
	Lansing	Emmet Co.	Armstrong	Ames	Des Moines	Cedar Rapids	Marshalltown	Le Grand	Missouri Valley	Woodbine
1898			5–24							
1902							5–28	5–28	6–8	
1903				5–19						
1905					5–11					
1906										5–25
1908						5–20				
1910				5–28	(7–23 height)					
1912		5–29		6–1						
1913	6–13									
1914		5–27		5–20						
1917	6–10			6–6						
1921	5–25									
1922	6–10			5–10						
1923	6–23			5–28						
1925	6–18									
1926				5–25						
1927				5–24						

Brassica juncea (L.) Cosson. Indian Mustard

An annual or biennial glaucous herb; upper leaves oblong, attenuate at the base, the lower lyrate. Pod one and one-half inches long, pedicels spreading; the beak of the slender pod seedless; leaves not clasping. A weed of grain fields, in clay and black prairie soils with *Brassica arvensis* and species of *Polygonum*.

Mustard flowers are rather conspicuous, sepals four, greenish; petals four, yellow. There are four rather conspicuous nectaries, two on the inner side of the short stamens and the other two between the insertion of the long stamens.

This plant blooms abundantly during June and early July. It is frequently visited by the honey bee, which is a normal visitor. Diptera and Coleoptera are reported on other mustards.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Badger, Kossuth county, Marathon (L. H. Pammel), Alden (C. I. Stevens), Ames (R. I. Cratty, B. S. Porter, C. M. King, H. S. Kellogg and R. E. Jeffs), Burlington (H. Walker), Fraser (Botany Seminar).

General distribution in the United States:

Florida—Gainesville (L. H. Pammel); Michigan—Whitehall (L. H. Pammel); Oregon—Crook county (Kirk Whited); South Dakota—Clear Lake (Edna Pammel).

HONEY BEE VISITS

Ames, August 27, 1916. Cloudy, moderately cool. Field on Squaw creek. Six bees after nectar which can be seen in sparkling drops about the four nectaries at base of stamens.

September 1, 1916. Clear, cool, northwest wind. A bee gathering nectar. Pollen upon its legs. (L.A.K.)

Brassica nigra (L.) Koch. Black Mustard

A common coarse branching annual along roadsides; green, bristly, leaves slender petioled, the lower with a large lobe. Pods short, appressed.

A wayside field and garden weed in clay and black soils, in cultivated lands and waste places.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Badger, Boone, Cedar Falls, Des Moines, Forest City, Gillett Grove, Harlan, Indianola, Lake Mills, Marshalltown, McGregor, Moravia, Nevada, Postville, Steamboat Rock, Webster City (L. H. Pammel), Okoboji, Ontario (R. I. Cratty), Ames (L. H. Pammel, C. E. Maxwell and E. Elijah, M. Clapper, three specimens, E. R. Campbell, H. S. Fawcett, P. H. Rolfs), Carroll (J. F. Coupe),

FIG. 128.—Black mustard (*Brassica nigra*). *Dewey, U. S. D. A.*

Clarion (R. W. Edwards), Fayett (B. Fink), Fraser (two specimen Botany Seminar), Johnson count (E. B. Graff), Kelley (L. H. Pammel and E. E. Maxwell), Keoku (P. H. Rolfs), Ledges (Boone county) (R. E. Buchanan), Osage (Rut Walker), Palo Alto county (count agent).

General distribution in the Unite States:

Idaho—Sand Point (L. H. Pammel and W. S. Dudgeon); Michiga —Detroit (L. H. Pammel); Minnesota—Kelly lake (Lyle Clapper) New York—Geneva (L. H. Pammel); Ohio—Cedar Point (L. H Pammel); Utah—Fort Douglas, Sal Lake City (L. H. Pammel and R. E Blackwood), Logan (A. Isabel Mulford).

HONEY BEE VISITS

Story City, June 19, 1917. Warm sunshiny. Some bees. Three three, two, three, two seconds in a flower.

Bloomfield, July 25, 1927, 10:30 a.m. Bees fairly abundant. Two, two, two one, one, one seconds in a flower. (L.H.P.)

Ames, I.S.C. Formal Gardens, July 30, 1927, 9 and 10 a.m. Cool, dry and cloudy. Bees working vigorously. Two, three seconds to a flower. (C.C.L.)

Bloomington, August 25, 1927, 11 a.m. Bees common. One, two, two, one, one two seconds in a flower. (L.H.P.)

Marshalltown, August 30, 1927, 10 a.m. Warm, clear. Bees one, one, one two, one seconds in a flower. (L.H.P.)

Forest City to Thompson, July 12, 1928. Black mustard common along fences Odor vanilla-like. (L.H.P.)

Jewell, July 6, 1929. Bees fairly abundant. Two, two, two, two seconds in a flower. (L.H.P.)

Lansing, August 17, 1929, 3 p.m. Bees abundant. Very pleasant odor. Moisture conditions for honey secretion favorable. Bees two, three, two, three, three seconds in a flower. (L.H.P.)

Waukon, August 18, 1929, 10 a.m. Odor pleasant. Bees fairly common. Bees two, two, two, two seconds in a flower. (L.H.P.)

Brassica Napus L. Rape

The rape of agriculture, largely grown in Iowa, sometimes an escape.

A glaucous bluish green annual and biennial plant with smooth leaves, clasping, on the flower stems. The pod long and slender. Thickened parts are formed above the ground.

In sandy and clay soils, and in black prairie soils.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington (H. Walker), Kelley (Pearl Clayton).

General distribution:

Alaska—Juneau, Sitka (J. P. Anderson).

HONEY BEE VISITS

Ames, June 27, 1914 (Experimental Plot). Cloudy, southeast wind. Three insects per hour. No bees. (G.H.M.)

Honey bees have been observed on this species at Ames. (L.H.P.)

Brassica Rapa L. Turnip

The leaves of the turnip are green, lyrate; the flowers small, yellow; and the root thickened. It is commonly cultivated in the state.

The flowers are attractive to bees, and are said by Mr. J. S. Harbison to make a profitable crop of honey. Bees have been observed on this species in Iowa.

General distribution:

Oregon—Crook county (K. Whited).

Brassica campestris L. Ruta-baga

A glaucous plant with scattered hairs when young. Leaves lyrate lobed, clasping at the base. Flowers rather large, pale yellow.

HONEY BEE VISITS

Ames, June 28, 1927, 8 a.m. Some bees. Two, two, two, two, one, three seconds in a flower. (L.H.P.)

Brassica oleracea L. Cabbage

The garden cabbage. A biennial with rounded, thick, fleshy leaves collected in a head; flowers yellow; plant glaucous.

Mr. J. S. Harbison said of it, "Cabbage blossoms afford a considerable amount of honey of a fair quality and flavor."

Matthiola incana Br. Common Stock

Flowers large and showy, white to purple. Broad winged seeds. Common cultivated stock, with flowers of many colors.

HONEY BEE VISITS

Ames, Formal Gardens, I. S. C., July 13, 1927. Hot, dry, clear. Bees three to seven seconds in a flower. (C.C.L.)

Raphanus (Tourn.) L. Radish

Annual or biennial herbs. Leaves generally lyrate lobed or pinnatifid with indehiscent linear or oblong pods which are several seeded with a spongy material between the seeds. Pod more or less constricted between the seeds. Flowers white, pink or purplish, generally in racemes.

Raphanus sativus L. Radish

Annual plant. Leaves lyrately divided. Flowers in racemes, petals pale purple. Pods thick, scarcely moniliform.

HONEY BEE VISITS

Mitchellville, August 31, 1929, 1 p.m. Cool, cloudy. Bees six, six, four, four, six seconds on a flower. (L.H.P.)

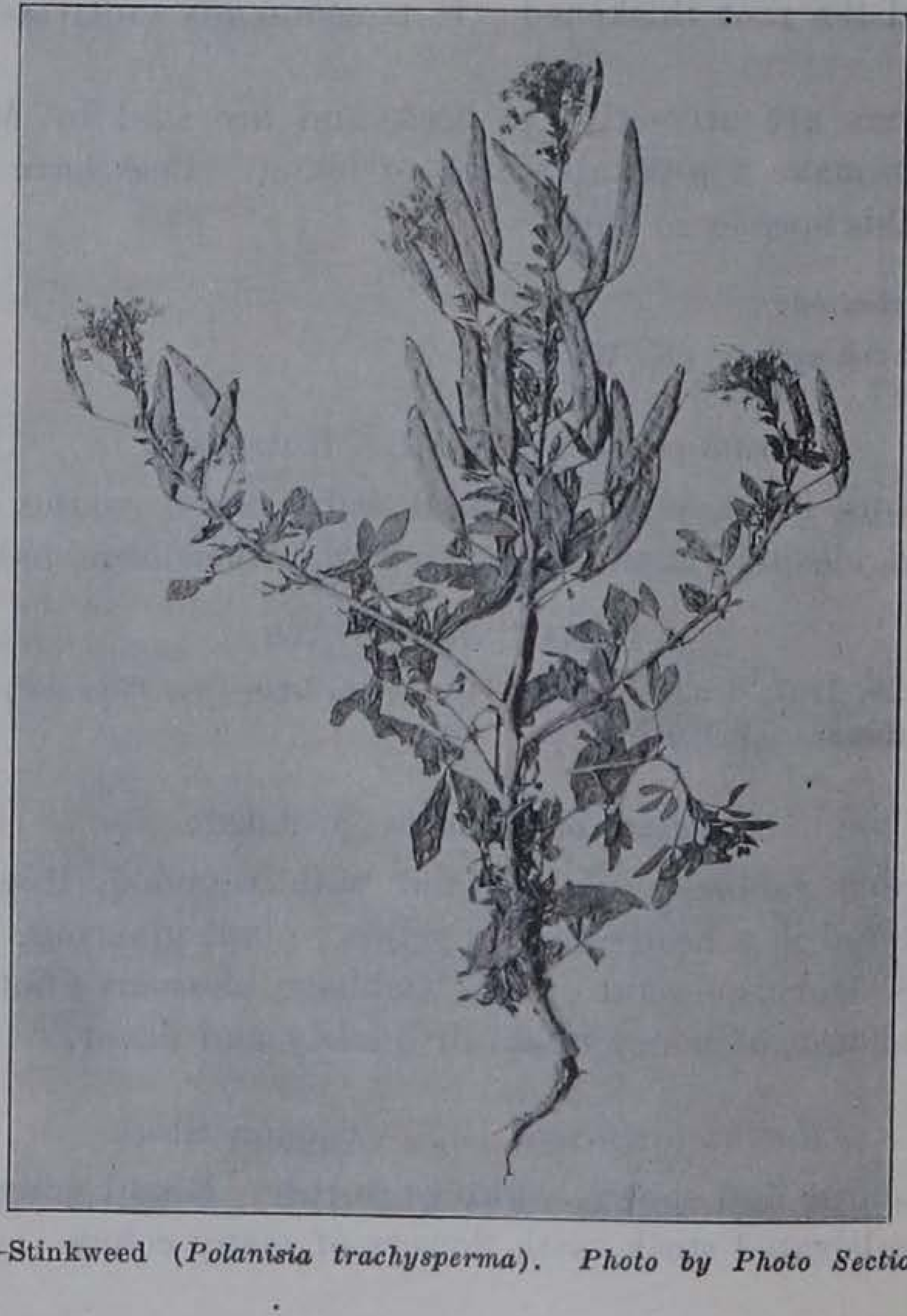

FIG. 129.—Stinkweed (*Polanisia trachysperma*). *Photo by Photo Section, I.S.C.*

CAPPARIDACEAE

Herbs with cruciform flowers, six or more stamens, one-celled pod and kidney-shaped seeds. Leaves alternate, palmate.

Polanisia Raf. Polanisia

Herbs with cruciform flowers. Petals with claws, notches at apex. Stamens eight to thirty-two, unequal. Annuals with glandular hairs. Flowers in leafy racemes.

Polanisia trachysperma T. and G. Clammy-weed

Has yellowish white cruciform flowers, sepals greenish, petals whitish, slightly purplish. Stamens numerous, pistil single.

Nectar is secreted copiously and where the plant is common honey is produced from it. The plant occurs in sandy soil.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls, Lamoni, Rock Rapids, Spirit Lake (L. H. Pammel), Chickasaw, New Hampton (W. D. Spiker), Ames (E. Brown, S. W. Beyer, C. R. Ball), Armstrong (R. I. Cratty), Colfax (P. Sipe), Kelley (P. Clayton), Osage (Mrs. F. M. Tuttle), Peru (D. E. Hollingsworth).

General distribution in the United States:

Arizona—Tucson (L. H. Pammel); Colorado—Denver, Littleton (L. H. Pammel), Fort Collins (C. S. Crandall), Fort Logan (G. M. Lummis), New Windsor (G. E. Osterhout); Kansas—Wichita (two specimens, Dr. T. L. Andrews); Ohio—Cedar Point (L. H. Pammel); Minnesota—Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt), Lake City (L. H. Pammel), Ralston (P. G. Holden); Montana—Glendive (L. H. Pammel); New Mexico—Fort Bayard (L. H. Pammel), Santa Rita (A. Isabel Mulford); South Dakota—Hot Springs (J. C. Witham); Texas—Clay Station (L. H. Pammel), Corpus Christi (A. A. Heller); Wyoming—Halleck canon (Aven Nelson).

HONEY BEE VISITS

Commonly visited by honey bees in Iowa. Especially common where the plant occurs in sandy soil. Many bees were observed on Muscatine Island and west in 1928 and previously at Bellevue, also some in central Iowa near Ames. Many bees observed on these flowers in Wisconsin and northeastern Iowa.

Cleome L. Spider Flower

Annual herbs, with cruciform flowers. Leaves alternate. Pod long and slender with many seeds. Flowers of species rose-colored or yellow.

Cleome serrulata Pursh. Rocky Mountain Bee Plant

A smooth annual; leaves of three lanceolate, oblong leaflets; flow-

FIG. 130.—Rocky Mountain bee plant (*Cleome serrulata*). *Photo by Colburn.*

ers in bracteate racemes; petals usually rose-colored, short-clawed; stipe of pod as long as the pedicel.

This is a common plant in the Missouri loess of western Iowa. Naturalized sometimes in sandy and gravelly soils.

The whitish or rose-colored petals are provided with claws. The receptacle is produced beyond the petals and stamens and bears a conspicuous nectar gland. The flowers of this species are abundantly visited by honey bees and other Hymenoptera. They produce a large amount of nectar.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Onawa (two specimens), Turin (L. H. Pammel), Ames, (R. Meeker and C. R. Ball, F. A. Sirrine), Fremont county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), LeMars (W. F. Coddington), Sioux City (two specimens, J. R. Campbell).

FIG. 131.—Rocky Mountain bee plant (*Cleome serrulata*). *Drawing, Ada Hayden.*

This species has been observed (L. H. Pammel) at Polk City (introduced), Council Bluffs, Glenwood, Hamburg, Missouri Valley, Payne, Sioux City.

General distribution in the United States:

Arizona—Flagstaff (D. T. MacDougal); Arkansas —Lawrence county (P. H. Rolfs), Canada—Calgary (L. H. Pammel); Colorado—Altamont (Carolyn Anderson), Denver (E. W. D. Holway), Georgetown (Reppert and Witter); Manitou (E. and E. S. Clements), New Windsor (George E. Osterhout), Poudre River (C. S. Crandall); Kansas—western (H. I. Featherly); Missouri—Jefferson City (L. Krause), Kansas City (Kenneth Mackenzie); Montana—Billings (F. S. Hunt), Custer (J. N. Blankinship), Livingston, Glendive (L. H. Pammel), Sheridan (L. A. Fitch); Nebraska—Callaway (J. M. Bates), Lincoln county (F. G. Miller), Willow Island (Joseph Wahl); New Mexico— Lamy (A. Isabel Mulford); South Dakota—Highmore (Quick), Hot Springs (J. C. Whitman, Paddock and Reppert); Wyoming—Cheyenne (L. H. Pammel), Kimball (two specimens, L. H. Pammel, I. C. Brownlie), Laramie (L. H. Pammel, I. C. Brownlie and E. E. Pattee, two specimens, Aven Nelson), Naturita (Edwin Payson), Yellowstone Park (R. R. White, Aven and Elias Nelson), Canon (L. H. Pammel and R. E. Blackwood), Laramie Hills (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. M. Lummis).

HONEY BEE VISITS

This species is freely visited by honey bees in western Iowa and is considered one of the valuable honey plants. Bees were noted especially at Sioux City, Council Bluffs, Tabor and Hamburg and also sometimes on the escaped plants in Polk county.

L. H. Pammel states "I have seen many honey bees on this species in the west, also in western Iowa at Hamburg, Sioux City and Council Bluffs."

Hamburg, August 25, 1928, 4 p.m. Bees abundant. Six, seven, four, five, six seconds on a flower. Missouri loess soil.

Cleome spinosa L. Spider Flower

A tall clammy pubescent annual. Leaflets five to seven, lanceolate, serrulate, with a raceme of handsome white or rose-colored flowers. Cultivated as a garden flower, occasionally escaping to waste grounds. Introduced from the tropics. The flowers are

FIG. 132.—Rocky Mountain bee plant (*Cleome serrulata*). *Photo by H. I. Featherly.*

cruciform, white to rose-colored, petals with claws, stamens with long filaments, pistil single.

The nectar is secreted abundantly. The flower is much frequented by bees late in the afternoon and early in the morning. Under favorable conditions an excellent honey plant.

General distribution as shown by specimens in the I.S.C. Herbarium:

Cuba (Santa Clara province) (Robert Combs), Florida (Hillsborough county) (A. Fredholm).

Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

Ames, Campus, August 27, 1915, 11 a.m. Partly cloudy. Six bees.
3 p.m. to 4 p.m. Four bees. Quite freely visited on other days. (L.A.K.)
A bee pollinated flower.

RESEDACEAE, MIGNONETTE FAMILY

Herbs with flowers four- to seven-divided. Capsule opening at the top. Leaves alternate, stipules glandlike. Flowers in terminal spikes or racemes.

FIG. 133.—Spider flower (*Cleome spinosa*). *Photo by Ada Hayden.*

Reseda odorata L. Mignonette

HONEY BEE VISITS

Ames, July 13, 1927, 7:30 p.m. Some bees. Two, two, two, three, two, two seconds in a flower. (L.H.P.)

July 22, 1927, 11-12 a.m. After rain. Cloudy, warm. Four visit plant for pollen. Bees, two, three seconds in a flower. (C.C.L.)

July 31, 1927, 10:30 a.m. Bees creeping over the flowers. One, one, one, two, one seconds in a flower.

August 27, 1927. Bees fairly common. Two, two, two, two, three, three seconds in a flower.

CRASSULACEAE, STONECROP FAMILY

Succulent herbs, with small symmetrical flowers in cymelike clusters.

Sedum Telephium L. Live-forever

Fleshy leaved plant with red or purple flowers. Blooms rather late in the summer and early autumn. Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

Ames, August 27, 1927, 4:30 p.m. Bees abundant.

August 31, 1927, 12:30 p.m. Bees one, one, one, one seconds in a flower. Visiting 16, 12, 14 flowers in a cluster.

September 5, 1927, 9:30 a.m. Bees one, one, two, one, two, one seconds in a flower. (L.H.P.)

September 7, 1927, 4:20 p.m. (near apiary). Bees abundant. Two, two, two, two seconds in a flower. (L.H.P.)

SAXIFRAGACEAE, Saxifrage Family

Herbs or shrubs. Leaves alternate without stipules. Abundant albumen in the seeds. Plants roselike.

Of this group Knuth says, "The nectar is exposed, rarely half concealed, and is secreted by the outer wall of the ovary."

Heuchera L. Alum Root

Perennial herbs with roundish leaves principally from the rootstock. Flowers in small clusters, petals five.

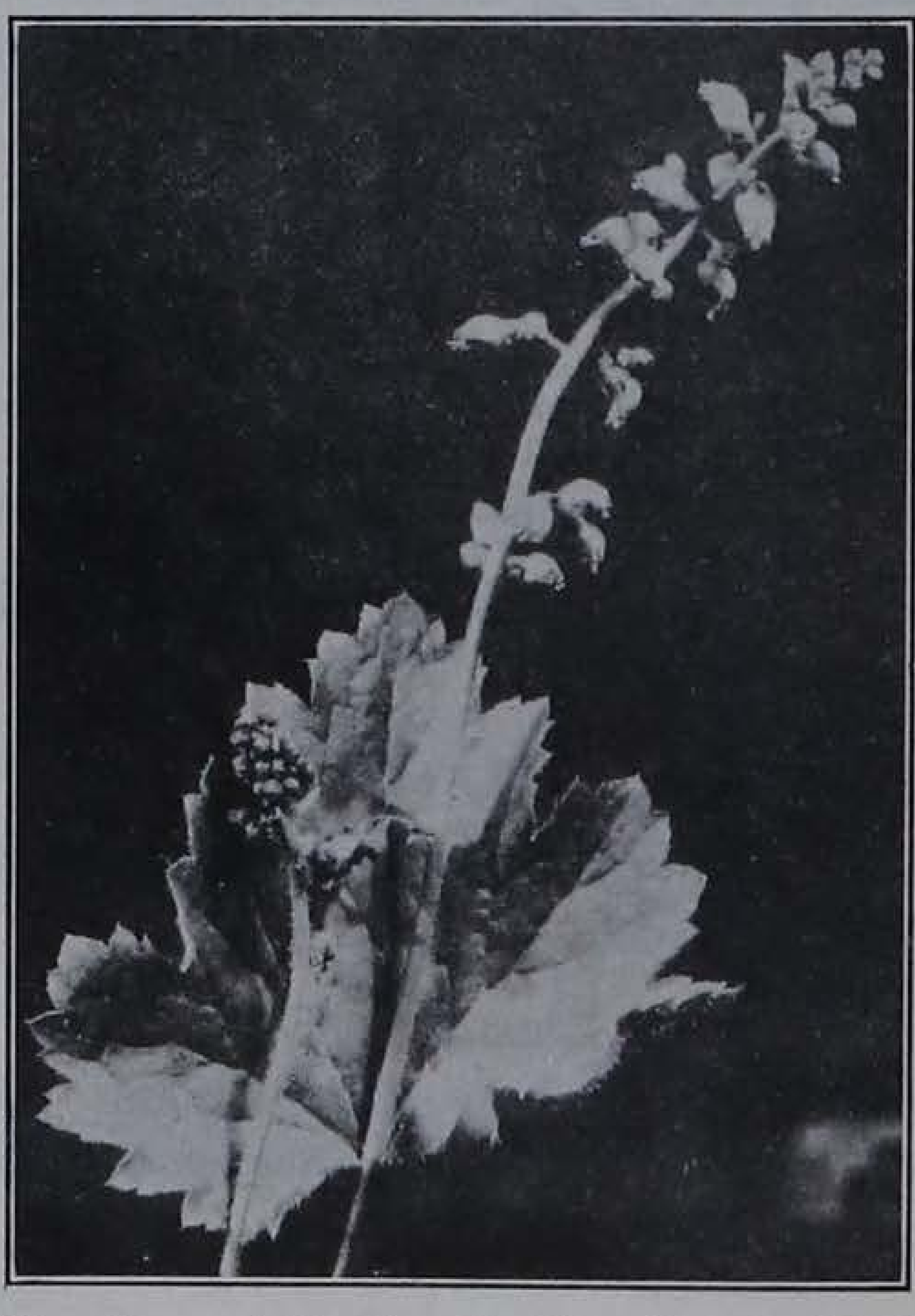

Fig. 134.—Alum root (*Heuchera hispida*). *Photo by Ada Hayden.*

Heuchera sanguinea Englm. Coral Bells

Perennials with nearly round or somewhat cordate leaves. Flowers bright red, bell-shaped. Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

Ames, June 26, 2 p.m. Some bees. One, one, one, one, one seconds in a flower.

Heuchera hispida Pursh.

Perennial one and one-half to two feet high. Stems hispid or hirsute with spreading hairs or slightly glandular; panicle narrow; calyx ovate and often irregular; stamens exserted, longer than the petals.

Rather widely distributed on prairies in Iowa.

Philadelphus L. Syringa

Shrubs, with opposite toothed leaves and clusters of showy white flowers, petals four to five, styles united nearly to the top. Cells of capsule splitting apart when ripe, seeds numerous.

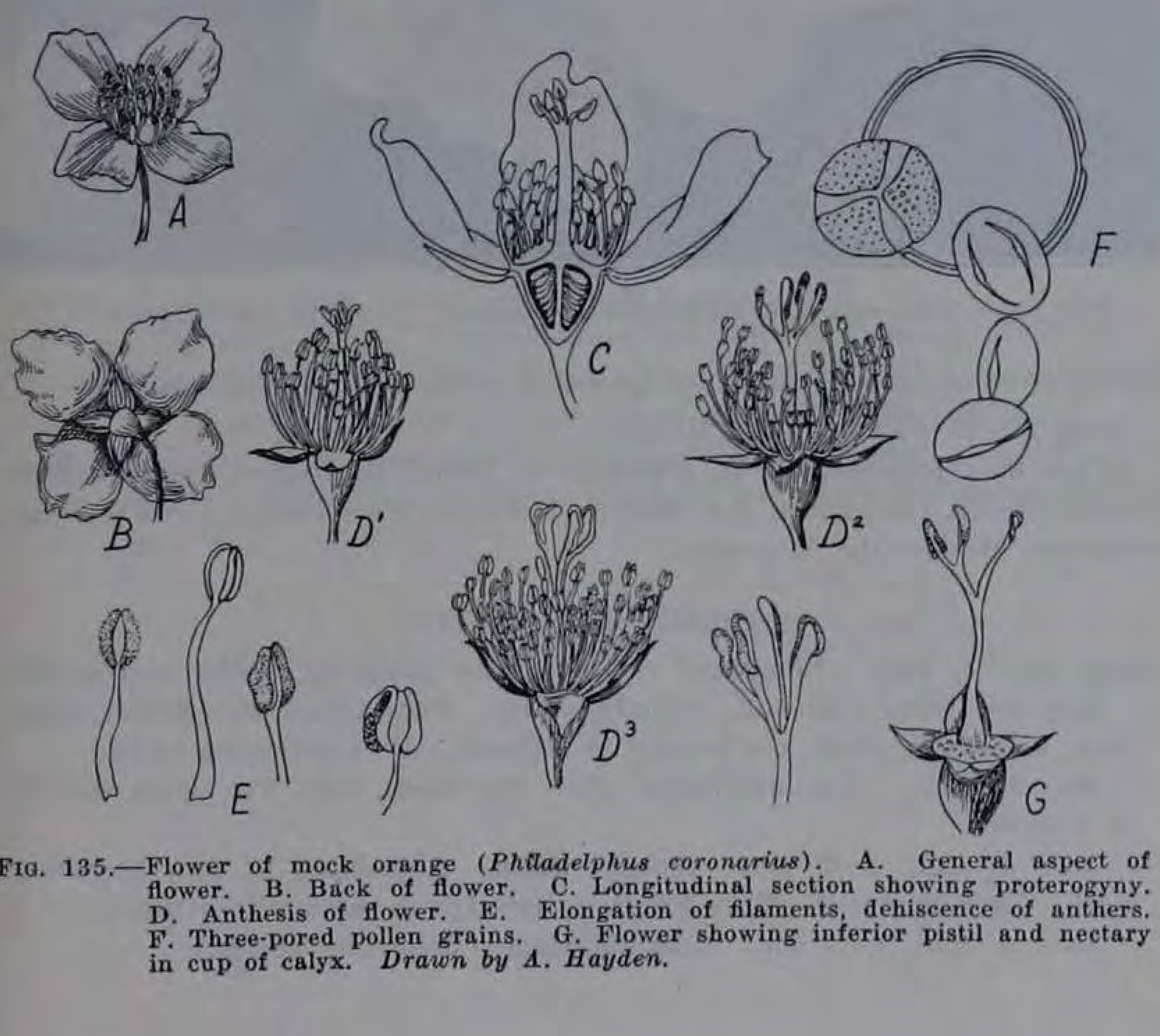

FIG. 135.—Flower of mock orange (*Philadelphus coronarius*). A. General aspect of flower. B. Back of flower. C. Longitudinal section showing proterogyny. D. Anthesis of flower. E. Elongation of filaments, dehiscence of anthers. F. Three-pored pollen grains. G. Flower showing inferior pistil and nectary in cup of calyx. *Drawn by A. Hayden.*

Philadephus coronarius L. Mock Orange

A woody shrub with erect branches, smoothish oblong-ovate leaves and close clusters of handsome fragrant creamy white flowers, in late spring.

The shrub was introduced from Europe and is widely cultivated as an ornamental plant in Iowa.

Honey is secreted by a white fleshy disc on the upper surface of the ovary. It is accessible to insects, which are attracted to the flower by its white color and strong fragrance.

FIG. 136.—Mock orange (*Philadelphus coronarius*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel, J. C. Blumer).

It has been observed (L. H. Pammel) at Boone, Burlington, Cedar Rapids, Council Bluffs, Davenport, Des Moines, Dubuque, Fort Dodge, Keokuk, Marshalltown, Mason City, Muscatine.

HONEY BEE VISITS

Ames, May 8, 1921. Somewhat cloudy. Bees gathering nectar and pollen.

May 23, 1921, 8:30 a.m. Cloudy, warm. Bees abundant. Seven, eight, nine, seven, one, three, ten seconds in a flower. Bees gathering nectar.

May 26, 1921. Bees abundant. Five, six, seven, four, five, seven seconds in a flower.

June 1, 1922, 2:30 p.m. Cloudy, warm. Abundance of rain preceding week. Bees abundant. Take fifteen to twenty-five seconds in a flower.

June 4, 1922, 8:30 a.m. Bees abundant. Collecting nectar.

June 5, 1922, 11 a.m. and 12 m. Clear. A few bees. Ten, eight, ten, eight seconds in a flower.

2:30 p.m. A few bees collecting nectar.

June 6, 1922, 1 p.m. Bees common. Five, six, three, two, five, six seconds in a flower. (L.H.P.)

June 8, 1922, 9 a.m. Bees one, four, five, four, eight, three seconds in a flower. (L.H.P.)

June 10, 1923, 9 a.m. Bees in the flower three, five, six, eleven, ten seconds. (L.H.P.)

June 13, 1923, 9 a.m. Bees collecting pollen and nectar. Three, five, six, eleven seconds in a flower. (L.H.P.)

June 14, 1923, 9 a.m. Clear, warm, southeast wind. Bees six, five, four, ten, eleven, six seconds in a flower. (L.H.P.)

June 18, 1923, 12:30 p.m. Bees getting both pollen and nectar. Six, six, seven, eight, six seconds in a flower.

July 5, 1924, 8 a.m. Cool, clear, dew. No bees. (L.H.P.)

May 7, 1927, 4 p.m. Clear, warm. Bees fourteen, twelve, sixteen, eighteen seconds in a flower. (L.H.P.)

May 8, 1927, 1 p.m. Warm, slight wind. Bees abundant. Seven, six, ten, eleven, seven seconds in a flower.

June 4, 1927, 11 a.m. Warm, sunny slope. One bee in four minutes to a flower. Bees fourteen, fifteen, sixteen, fourteen, fifteen, four seconds in a flower. (L.H.P.)

June 10, 1927, 2 p.m. Bees five, four, seven, six seconds in a flower.

June 11, 1927, 8:30 a.m. Bees abundant. Four, five, three, five, three seconds in a flower. (L.H.P.)

June 14, 1927, 11 a.m. Flowers passing. Bees five, six, five, six, two, one, six seconds in a flower. (L.H.P.)

June 15, 1927, 10 a.m. Flowers on the wane. Bees ten, four, three, two, three seconds in a flower. (L.H.P.)

June 21, 1927, 8 a.m. and 11:30 a.m. No bees. (L.H.P.)

6 p.m. Warm, sunny. Some bees. (L.H.P.)

June 24, 1927, 12 m. A few flowers left. A few bees. (L.H.P.)

June 28, 1927, 8 a.m. Late bloom. Few bees. (L.H.P.)

Ames (six miles north), June 1, 1929. Bees at work. (H. Hagge.)

Rolfe, June 11, 1929. Bees six, five, six seconds in a flower. (L.H.P.)

Ames, June 17, 1929, 11 a.m. Many small Hymenoptera and some Diptera. No honey bees. (L.H.P.)

Blooming dates for Philadelphus coronarius.

	Northern section	Central section					Southern section
	Lansing	Ames	Boone	Newton	Oskaloosa	Anamosa	Keokuk
1906	6–31						
1907				6–23	6–17		
1908			5–27			5–30	5–15
1909	6–1		6–10				
1910			5–28				
1911	5–28						5–15
1912							
1913			6–12				
1914	6–3	6–1	6–1				
1915	6–8		5–30				
1917		6–17					
1919		6–2					
1922		6–3					
1923							
1924		6–4					

Deutzia Thunb. Deutzia

Shrubs with opposite leaves, petiolate, serrate. Flowers white or purplish, bisexual.

Deutzia scabra Thunb. Deutzia

Small shrubs five to six feet high, ascending branches. Leaves ovate-lanceolate to acuminate, base broadly crenate. Flowers whitish. Blooms in late spring and early summer. Generally cultivated as an ornamental plant throughout the northern United States.

The nectar is accessible to honey bees and these have been observed in numerous places.

HONEY BEE VISITS

Ames, June 27, 1927, 3 and 4 p.m. Warm, windy, dry Bees abundant (C.C.L.)

Ribes L. Currant. Gooseberry

Low shrubs, blossoming in the spring, fruit mostly edible. Leaves alternate, palmately lobed. Flowers for the most part greenish yellow, clustered in many-blossomed racemes.

The nectar is free, or sometimes concealed. It is secreted by the epigynous disk.

"Currants and gooseberries are dependent upon insect pollination and are well adapted to bees."—A B C of Bee Culture.

There is much variation in the insect relations of the genus *Ribes*. Some species, like the Rocky Mountain flowering currant (*Ribes aureum*), have a long calyx tube and are pollinated by humming birds, though bees occasionally visit the flowers. Some species are not highly specialized.

The nectar is secreted in a shallow depression and is accessible to short-tongued insects, as in the commonly cultivated *Ribes alpinum*. In *Ribes vulgare* the depressions are much deeper.

In the commonly cultivated gooseberry (*Ribes Grossularia*) the flowers are bent downward and the opening of the tube is smaller. Pendent flowers make for ready access by the bees. In the cultivated black gooseberry (*Ribes nigrum*) the flowers are more or less bell-shaped and pendulous.

In the Rocky Mountain currant, as in some of the other species of the genus *Ribes*, the color of the petals changes when pollination has been effected, the petals turning from yellow to carmine red; that is to say when the styles and anthers have withered. Delpino makes the suggestion that this is to tell the insect visitors that their services are no longer needed, but objections have been made to this theory.

Ribes Cynosbati L. Prickly Gooseberry

Low prickly shrub; leaves round-ovate, soft pubescent, loose racemes of small greenish flowers. Berries with long prickles. Favors rocky woods.

This grows best in rocky (limestone) soil in sandy woodlands, along streams. It is fairly common. Associated with *Vicia caroliniana, Geranium maculatum, Phlox pilosa, Thalictrum dasycarpum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Clear Lake (two specimens), Backbone Park (Delaware county), Johnson county, Lansing, Ledges (Boone county, six specimens), Marion county, Mahaska county, McGregor (two specimens), Marquette, Palisades (Linn county), Peterson, Red Rock, Waukon Junction (two specimens), Webster City (L. H. Pammel), Fort Dodge, Webster City, Woodman's Hollow (F. Horton), Postville, Yellow river (L. H. Pammel, E. Orr, O. Schultz), Algona (R. I. Cratty), Ames (J. O. Ellis), Decorah (E. W. D. Holway), Fayette (B. Fink), Fort Dodge (F. C. Stewart), Fraser (woods northeast) (R. I. Cratty and L. H. Pammel), Iowa county (G. W. Carver).

General distribution in the United States:

Colorado—Palmer Lake (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank

Raney); Massachusetts—Deerfield (M. A. Day); Michigan—Whitehall (L. H. Pammel); Minnesota—Cass Lake, Cedar island (two specimens, L. H. and H. E. Pammel), St. Cloud (Dr. Gmelin), Thompson (J. H. Sandberg); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Wisconsin—Prairie du Chien (L. H. Pammel), St. Croix Falls (L. H. and H. E. Pammel).

HONEY BEE VISITS

Ames, May 1, 1924, 2 p.m. Bright, clear, fairly warm. Some bees and other Hymenoptera.

Blooming dates for Ribes Cynosbati.

	Northern section	Central section					Southern section
	Lansing	Ames	Boone	Le Grand	Iowa Falls	Palisades	Keokuk
1902				4–24			
1904					5–7		
1908							4–19
1910			3–31				
1911			4–25				
1912		4–25	4–27				
1913			4–25				
1914			4–30				
1915			4–25				
1916	5–2	5–1	5–2				
1917	5–12		5–5				
1918	5–6		4–10				
1919	4–26		4–23				
1920	4–29		4–28			4–27	
1921	4–15		4–18				
1922	4–25	5–14					
1923		5–1					
1924	5–20	5–5					
1925	4–13	4–20					

Ribes gracile Michx. Missouri Gooseberry

This gooseberry bears upon its stem stout reddish spines; the peduncles are long and slender, the flowers whitish; berry smooth. Common in borders of woods and on bottoms along small streams in rocky woodlands and in clay and alluvial soil; with *Phlox divaricata* and *Podophyllum peltatum*.

The wild gooseberry (*Ribes gracile* and *R. Cynosbati*) are both early flowering species and are visited by the honey bee and by *Bombus pennsylvanica,* also by species of *Vespa*.

The greenish flowers grow in axillary clusters of two or three. The pendulous position and the characters of the flowers indicate adaptation to bees.

The honey bee visits them for pollen and honey.

FIG. 137.—Missouri gooseberry (*Ribes gracile*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Beaman, Cedar Falls, Cherokee, Dubuque, Fremont county, Glenwood, Granite, Hamburg, Kelley, Lansing, Ledges (Boone county), Lost Island lake, Mills county, Nashua, New Albin, Otter creek, Palisades (Linn county), Peterson, Pisgah, Postville, South Dakota (opposite Hawarden), Shenandoah, Walnut creek, Warren county, (L. H. Pammel), Armstrong, Clear Lake, Emmet county (R. I. Cratty), Dakota City, Fort Dodge, Mud lake (Hamilton county), Webster City (F. C. Stewart), Ames (Bernice Banks, S. A. Miller), Colfax (F. P. Sipe), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Hamburg (L. H. Pammel and H. B. Clark), Missouri Valley (H. B. Clark), northeast Iowa (H. Goddard), Rome (L. H. Pammel and J. Kelso), Spirit Lake (L. H. Pammel and H. E. Pammel), Wild Cat Den (Muscatine county) (L. H. Pammel, J. Helm, E. R. Hodson).

It has been observed (L. H. Pammel) at Adel, Algona, Burlington, Carroll, Centerville, Charter Oak, Davenport, Denison, Des Moines, Dexter, Eldora, Elkader, Estherville, Fairfield, Forest City, Fort Atkinson, Jefferson, Keokuk, Mason City, Muscatine, Onawa, Redfield, Sioux City, Steamboat Rock, Waukon Junction, Woodbine.

Blooming dates for Ribes gracile.

	Northern section			Central section								Southern section			
	Armstrong	Emmet Co.	Waukon	Ames	Boone	Cedar Rapids	Palisades	Marshalltown	Oskaloosa	Iowa Falls	Le Grand	Lamoni	Preston	Woodbine	Keokuk
1898	5–1														
1901				4–27											
1902								4–27			4–27				
1903				4–26											
1904				5–5						5–6					
1905				5–2								4–21			
1906									4–28				4–23	4–5	4–28
1907			5–13		4–28				4–23						
1908						4–25									4–13
1909				5–6											
1910		4–8		4–9											
1911		4–29		4–30											
1912		5–4													
1913	5–2	5–4													4–12
1914		5–6					4–27								
1915		4–24													
1919															
1921				4–15											
1923															
1924				4–15											
1925				4–18	4–19										
1926			4–17	4–22											
1927				4–18	4–19										

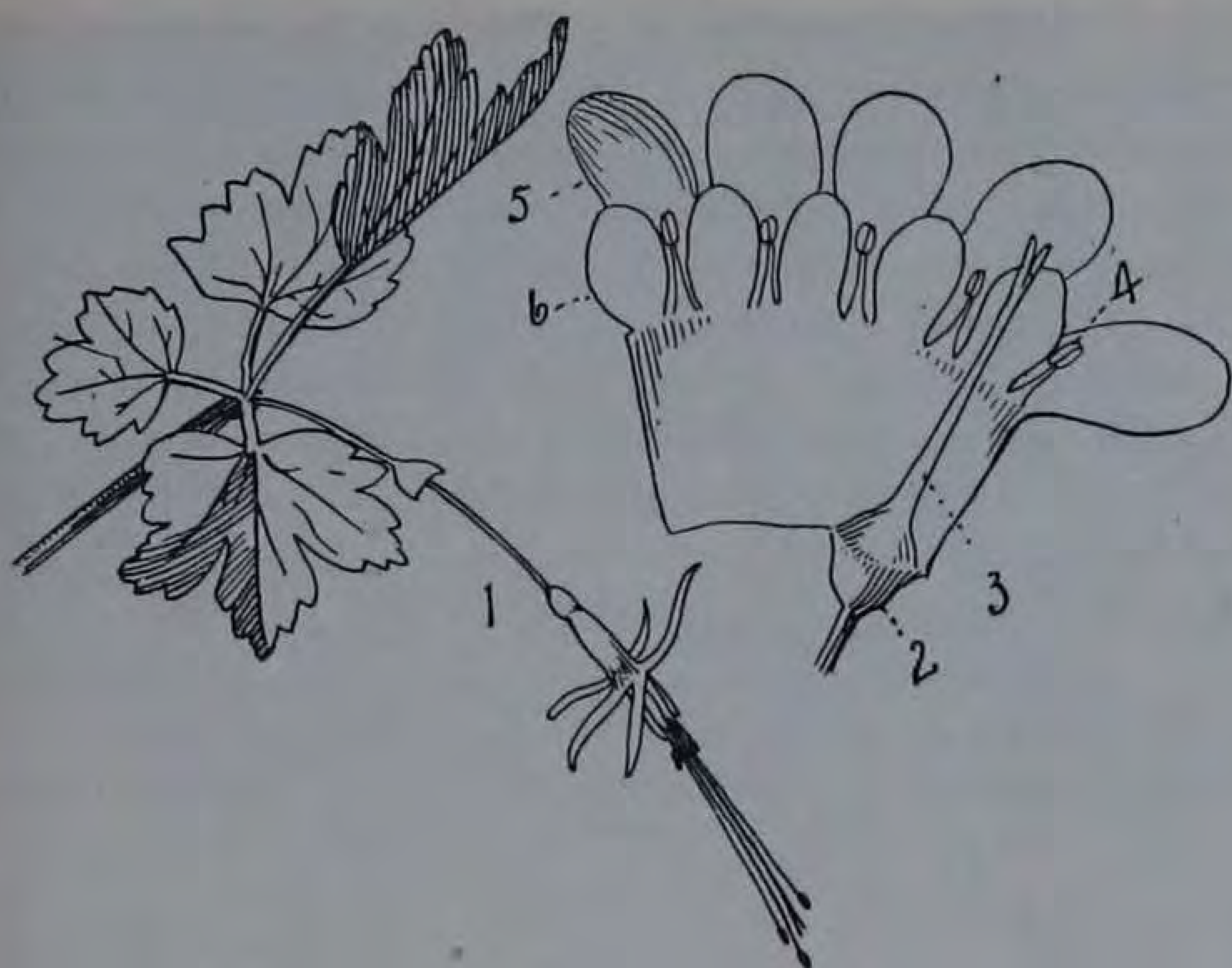

FIG. 138.—Flower of gooseberry (*Ribes gracile*). To the right prickly gooseberry (*R. Cynosbati*). *Drawn by C. M. King.*

General distribution in the United States:

Minnesota—Graceville (two specimens), Ortonville, (L. H. Pammel), Cass Lake, Cedar island (L. H. and H. E. Pammel), St. Anthony Park (J. H. Sandberg); Missouri—Greenwood (Kenneth K. Mackenzie); South Dakota—Lake Tetonkeha (N. E. Hansen and L. H. Pammel); Wisconsin—Fond du Lac (Elizabeth Waters and L. H. Pammel), Madison (L. H. Pammel).

HONEY BEE VISITS

Ledges, Boone county, May 5, 1919. Cool. Bees getting nectar. Abundant on the flowers in the woods. Five bees at work in one clump five feet across.

Ames, April 26, 1921. No honey bees. Some bumble bees.

May 3 to 10, 1924. Warm. No bees.

Dayton Park, May 1, 1927. Bees not abundant. Gathering pollen. Bees three, two, three seconds in a flower. (L.H.P.)

May 5, 1927, 4:30 p.m. Warm, windy. Bees collecting pollen. Four, three, two, four, three seconds in a flower. (L.H.P.)

Ames, April 30, 1929, 8:30 a.m. Bees three, two, three, two, three, two seconds in a flower. (L.H.P.)

April 30, 1929, 12:15 p.m. Five, four, four, four, five seconds in a flower.

May 1 to 5, 1929. Cool. No bees.

Mason City, May 11, 1929, 12:15 p.m. Some bees. (L.H.P.)

Ribes Grossularia L. European Gooseberry

This form has stout spines. It is the gooseberry of gardens but as an escape from cultivation it is locally established in some places. A low prickly bush, berry usually finely pubescent. Sepals of the flowers are green, usually with reddish tips, while the petals are white. The nectar is secreted in the base of the bell-shaped part of the receptacle. After fertilization the sepals curve upward.

Gooseberries are very attractive to bees and are of some importance, especially in plantings grown for market. Honey bees visit them very freely in Iowa.

Blooming dates for Ribes Grossularia.

	Northern section	Central section			Southern section		
	Lansing	Ames	Boone	Iowa City	Lamoni	Keokuk	Cincinnati
1902		5–25					
1903		4–26					
1904		4–26					
1905					4–9		
1906				4–30		4–19	
1907		5–6					
1908							4–16
1911	5–4		4–24				
1914							
1918		4–22					
1920		5–9					
1922		5–1					
1923							

Honey production in Gooseberry. O. W. Park.

Year	Period of bloom	Full bloom	Period worked by bees	Period of honey flow	Notes
1919	4–27 5–15				
1921	4–21 4–26	4–26 5–4			5–4 Bees numerous
1922	4–28	5–5			Of secondary importance. Both nectar and pollen are used.

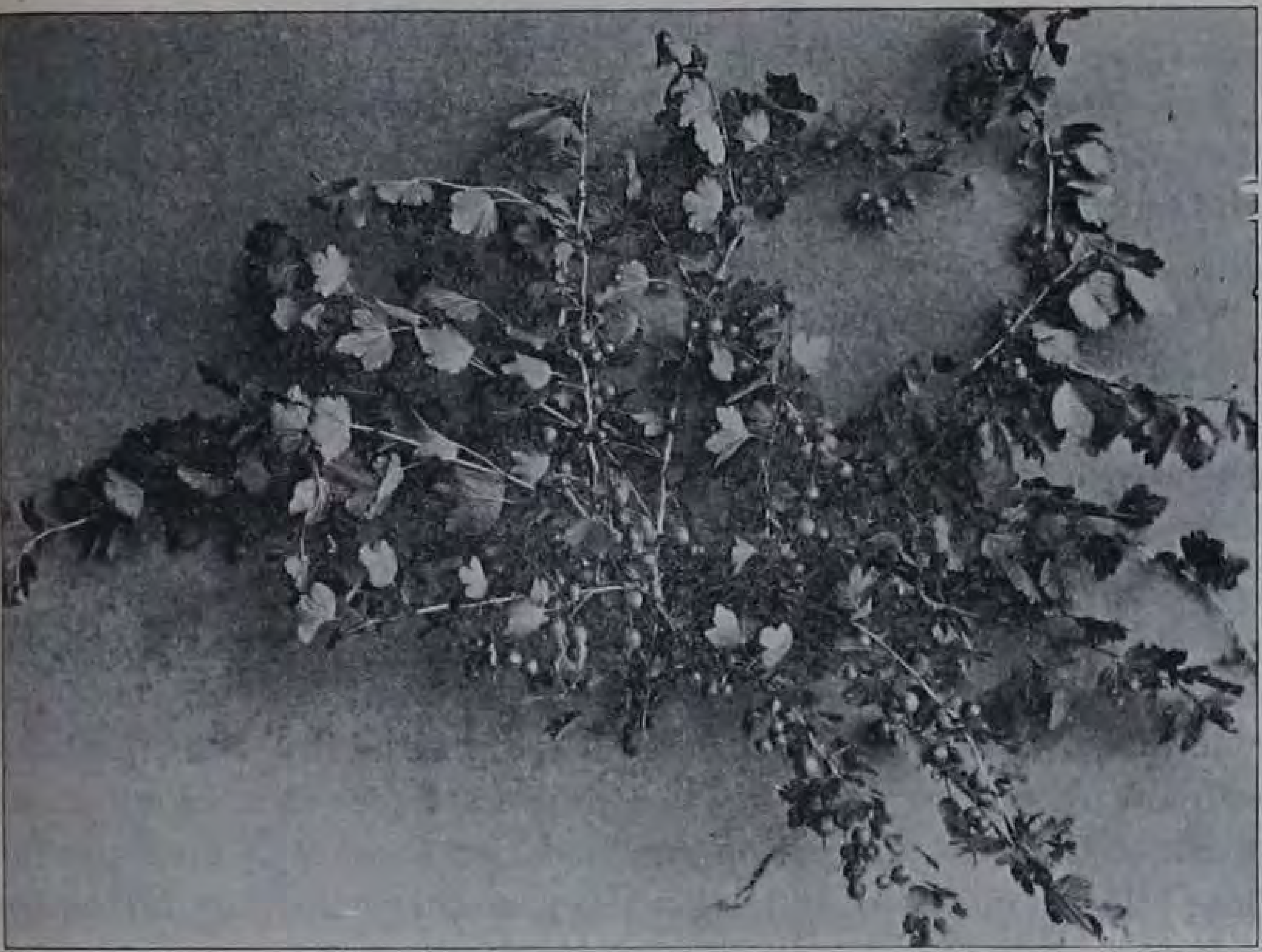

FIG. 139.—Cultivated gooseberry (*Ribes Grossularia*).

HONEY BEE VISITS

Manhattan, Kansas, May 5, 1918, 6:30 a.m. Bees abundant.

Ames, May 5, 1919. Cool. Bees abundant on flowers in the woods; five bees on one clump.

Peterson, May 10, 1920, 10 a.m. Sunshiny after shower. Numerous bees on this plant. (C.M.K.)

May 15, 1920. Cool, somewhat cloudy. Some bees. (L.H.P.)

May 16, 1920. Ten bees on a cluster with about four thousand flowers. Bees one, two, three, six, five seconds in a flower. (L.H.P.)

May 5, 1922, 6 p.m. Bees not numerous. Four, three, four seconds in a flower. Three thousand flowers on small bush three feet high.

Ames, May 7, 1922, 8:30 a.m. No bees.

May 10, 1922, 7:30 a.m. Cloudy. South wind. No bees.

1 p.m. Some bees. Two, three, three, three, two, two seconds in a flower.

May 6, 1924, 8 a.m. Partly cloudy. Bees one, two, one, one, one seconds in a flower.

May 1, 1927, 2 p.m. Warm, slight wind (west). Bees abundant. Eight, six, three, six, four seconds in a flower.

Bloomfield, May 7, 1928, 1 p.m. Clear, warm. Bees four, four, six, four, six, five seconds in a flower. (L.H.P.)

Ames, April 30, 1929, 12:15 p.m. Bees three, four, three, three, three seconds in a flower. (L.H.P.)

May 1 to 5, 1929, Cool, west wind. No bees.

May 8, 1929. Bees three, two, three, two, three seconds in a flower.

Ribes floridum L'Her. Wild Black Currant

This black currant is a shrub found in woodlands. The leaves are heart-shaped, sharply 3- to 5-lobed and serrate. The racemes of whitish yellow flowers drooping. The berries are large, black and spicy.

The black currant is common in low ground along the Mississippi, even in lands subject to overflow, in swampy places, marshes, peat bogs. Sometimes also in uplands, along fences where it has been scattered by birds.

Associated with *Sanguinaria canadensis, Podophyllum peltatum, Claytonia virginica, Phlox divaricata, Anemone nemorosa.*

The pale yellow flowers are in drooping racemes. Calyx tubular, bell-shaped, open; petals five, inserted in the throat of the calyx, small, erect, at first pale yellowish becoming reddish. The nectar is secreted by an epigynous disk. The five stamens abut along on the pistils so that self-pollination may occur in absence of cross-pollination. The honey bee and other Hymenoptera are but infrequent visitors.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Clarksville, Clinton, Granite, Hancock county, Lake Mills, Lost Island lake, Marshalltown, Mason City, Ogden, Palisades (Linn county) Palo Alto county, Postville, Wapsipinicon river (L. H. Pammel), Armstrong, Emmet county (two specimens, R. I. Cratty), Charles City (E. B. Watson), Dakota City (F. C. Stewart), Decorah (E. W. D. Holway), Fayette (B. Fink), Fort Dodge (G. W. Carver), northeast Iowa (H. Goddard), Osage (Mrs. Tuttle), Woodman's Hollow (L. H. Pammel and F. W. Paige).

General distribution in the United States:

Colorado—Fort Collins (Ada Hayden); Massachusetts—Newton (Wm W. Nolen); Michigan—Whitehall (L. H. Pammel); Minnesota—Ortonville, Graceville, Norway Beach, Cass Lake, Cannon Falls, Pipestone (L. H. Pammel), Hibbing (Mrs. Joseph Clemens), St. Anthony Park (J. H. Sandberg), Star island, Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (H. Gmelin); Nebraska—Scotts Bluff county (F. G. Miller); New York—Ithaca (Muenscher and Bechtel), Ithaca (H. E. Summers); Ohio—Cedar Point (two specimens, L. H. Pammel); Saskatchewan—Shellbrook (C. A. Hansen); South Dakota—Watertown, Lake Poinsett, Brookings (L. H. Pammel).

Blooming dates for Ribes floridum.

	Northern section		Central section				
	Emmet Co.	Armstrong	Ames	Cedar Rapids	Iowa City	Iowa Falls	Le Grand
1902			5–2				5–3
1904			5–24			5–11	
1905			5–1				
1906					4–30		
1907				5–24	5–6		
1908				5–20			
1909			5–19				
1910	4–24						
1911	5–7						
1912	5–11	5–12					
1913	5–14						
1915		4–30					

Ribes vulgare Lam. Garden Currant

The common garden currant, with 3- to 5-lobed leaves and drooping racemes of red berries.

The cultivated *Ribes vulgare* is frequently visited by bees and furnishes in some seasons considerable nectar. The most common species is *R. gracile*, which is abundant and is freely visited by honey bees for pollen. *Ribes Cynosbati* is also commonly visited by honey bees for nectar. The gooseberries are really wasp flowers. The honey is accessible.

In looking up the literature we find that there is a good deal of variation in the honey bee visits as reported by Hermann Mueller and by Plateau. We have found a good deal of variation in Iowa with reference to honey bee visits. In some years bees visit the flowers rather freely and in some years less frequently. In 1929 few bees were observed.

The red or garden currant is commonly cultivated in all parts of the state and throughout the United States.

No bees were observed in 1929 although *Ribes gracile and R. Grossularia* adjacent were frequently visited. (L.H.P.)

Ribes nigrum L. Black Currant

A rather stout bush with the wood more or less blackish. The plant emits a strong odor.

Leaves broad-triangular to nearly orbicular, three- to five-lobed, irregularly serrate, resinous dotted beneath. Flowers in racemes, petals about one-half the length of the sepals. Berry black, fruit more or less aromatic.

The honey bee is a frequent visitor, taking nectar out of the open blossoms. The nectar is freely secreted and is easily accessible to honey bees.

This species is sometimes naturalized in the state of Iowa and eastward. It is commonly cultivated for its aromatic fruit.

HONEY BEE VISITS

Ames, May 10, 1920, 10 a.m. Sun shining after shower. Light breezes. No insects. (C.M.K.)

May 5, 1922, 6 p.m. Bees not abundant. One, three, four, four, two, one seconds in a flower. Plant two and one-half feet tall bore thirteen branches, fifteen flowers in a raceme. About 8,500 to 10,000 flowers on the bush.

May 7, 1922, 9 a.m. No bees.

12:15 p.m. Partly cloudy. Bees not numerous. One to four seconds in a flower.

May 2 to 10, 1924. Mostly warm. No bees.

May 1, 1927, 2 p.m. Flowers shallow. Few bees. Two, one, two seconds in a flower. (L.H.P.)

May 4 to 25, 1927. Cool, windy. No bees.

Blooming—Ames—April 27, 1924.

Blooming dates for Ribes nigrum.

	Northern section		Central section				Southern section	
	Emmet Co.	Lansing	Ames	Boone	Storm Lake	Mt. Joy, Scott Co.	Creston	Keokuk
1892			5–10					
1900						5–1		
1903			5–26					
1904			5–8					
1905			4–24					
1906			4–30		5–4		4–21	4–19
1907								4–14
1911			4–19	4–21				
1913			4–22	4–22				
1915	4–29			4–23				
1916	5–11	5–6		5–1				
1917		5–14						
1918		5–9		5–24				
1919		4–29		4–25				
1921		4–19		4–15				
1922			4–30					
1925			4–20					

Ribes aureum Pursh. Missouri Currant

Tall slender branches, shrub without spines. Leaves 3- to 5-lobed; flowers golden yellow, spicy, fragrant; tube of salver form, calyx three to four times longer than the lobes. Berries yellow or black. Common in cultivation; also on banks of streams from Minnesota southwestward.

FIG. 140.—Golden or Missouri currant (*Ribes aureum*). *Photo by G. H. Munger.*

Frequently cultivated in many parts of Iowa and a not infrequent escape.

The flowers are very fragrant and are frequently visited by bees. They cannot, however, get the nectar, which is accessible only to long tongued bees; if obtained at all, it is done through perforations in the calyx tube. The petals are at first yellow and then turn red.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Tete des Morts (naturalized) (L. H. Pammel), northeast Iowa (cult.) (H. Goddard), Wayland, escaped (G. W. Carver), Goldfield (L. H. Pammel).

It has been observed (L. H. Pammel) at Ames, Boone, Burlington, Cedar

Rapids, Cherokee, Clarinda, Clinton, Council Bluffs, Des Moines, Dubuque, Forest City, Fort Dodge, Hamburg, Indianola, Jefferson, Marshalltown, Mason City, Muscatine, New Albin, Shenandoah, Webster City.

General distribution in the United States:

Colorado—Boulder Falls canyon (J. C. Blumer), Fort Collins (L. H. Pammel and C. S. Crandall), Manitou (two specimens, L. H. Pammel); Idaho—Fish Haven (A. Isabel Mulford); Illinois—Urbana (B. Fink); Mexico—(Jessie Gaston); Nebraska—Halsey (J. C. Blumer), Scotts Bluff county (F. G. Miller); Nevada—Glendale (two specimens, P. B. Kennedy); New Mexico—Pleasant Valley (A. Isabel Mulford); North Dakota—near Crookston, Minn. (Mrs. Roy Westley); Oregon—Crook county, O'Neil (Kirk Whited); Utah—Farmington canon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Kamas, East Duchesne (two specimens), Uintah mountains (L. H. Pammel and E. M. Stanton), Logan (A. Isabel Mulford), Ogden canon (three specimens, L. H. Pammel and R. E. Blackwood); Washington—Mabton, Yakima river (J. S. Cotton), Spokane (J. H. Sandberg and J. B. Leiberg); Wyoming—Sand creek (Aven Nelson).

HONEY BEE VISITS

Ames, May 10, 1920, 9 a.m. Sun after early shower, slight southeast breeze. Bloom full, fragrant. No insects, bloom continued for several days, but insects were never numerous about it (C.M.K.)

May 18, 1920. Midbloom, some bees. (L.H.P.)

May 9, 1926, 10:30 a.m. and 12:15 p.m. Dry and warm. No bees.

May 3, 1927, 9 a.m. Flowers fragrant. No bees. (L.H.P.)

May 12, 1927, 8 a.m. Cool, west wind. No bees. (L.H.P.)

Blooming, Ames, April 12, 1925; Boone, April 27, 1925; Ames, May 6, 1926.

Missouri currant is a humming bird flower.

Honey production in Flowering Currant. O. W. Park.

Year	Period of bloom	Full bloom	Period worked by bees	Period of honey flow	Notes
1918	4–12	4–8	4–16	4–16	Light amount
1919	4–18		4–18		Pollen pale greenish
1920	4–26	5–8	4–30		
1921	4–10 5–4	4–18	4–12	4–23	Honey bees secure only pollen from this source. It is of very little importance and they pay little attention to it
1922	4–28 5–15				
1923		5–1 5–10			

	Northern section				Central section										Southern section						
	Armstrong	Lansing	Forest City	Waukon	Ames	Boone	Avoca	Grinnell	Mt. Joy, Scott Co.	Oskaloosa	Iowa Falls	Iowa City	Harlan	Anamosa	Keokuk	Corydon	Ottumwa	Cincinnati	Woodbine	Shenandoah	Creston
1886					4–28																
1892					5–4				4–30												
1896									4–16												
1898									4–24												
1901					4–30																
1902					4–25						5–3										
1903					4–22																
1904					5–5																
1905					4–22																
1906		4–26			4–25					4–22		4–25			4–29				4–27		4–28
1907	5–29	5–9	5–17	6–1		5–2	4–26	4–23		4–12			5–1	5–8	4–9	4–19				4–24	
1908		4–28				4–18								4–25	4–10			4–18			5–3
1909					5–21													5–8			
1910					4–7	4–8															
1911		4–24			4–30	4–30											4–19				
1912					5–3	5–4									4–25						
1913	5–3				5–2	5–1															
1914		5–2																			
1915					4–19																
1916					5–1	5–2															
1917		5–10			5–10	5–12															
1918					4–22																
1919		4–27			5–3 to 5–20																
1920		5–10			5–5																
1921		4–11			4–4																
1922		5–5			4–20																
1923						5–25															
1924					4–22																
1925					4–12																
1926					5–6																
1927					4–22 to 5–5																

ROSACEAE, Rose Family

Trees, shrubs or herbs, with regular flowers, numerous stamens inserted in the calyx, pistils one to many, distinct or in some cases combined with the calyx tube. Leaves alternate, with stipules.

The flowers are rendered conspicuous by the massing in some cases, like the *Sorbus* or mountain ash, or the flowers themselves are large. They are arranged in racemose umbels or panicles.

The quantity of nectar differs greatly. In many it is secreted from an annular ring. Some species are without nectar, as, for instance, roses, but these furnish an abundance of pollen.

Regarding insect visitors, Knuth says, "In this order the flowers are made conspicuous in very different ways in the various genera. There are numerous transitions from the insignificant little blossoms of *Alchemilla* to the large one of roses. Many of the flowers secrete nectar from an annular ridge on the inner surface of the receptacle. The quantity varies greatly."

Physocarpus Maxim. Ninebark

Shrubs three to nine feet high, with slender branches and loose bark. Simple palmately-lobed leaves and umbel-like clusters of white flowers. Stamens many. Carpels inflated, nearly smooth, reddish as they ripen. Seeds roundish. Resembles the spiraeas.

Physocarpus opulifolius (L.) Maxim. Ninebark

Often cultivated. Resembles the variety *intermedius*. Has smooth pods.

General distribution in the United States:

Illinois—Utica (Mrs. Joseph Clemens); Minnesota—St. Cloud (R. Gmelin); New York—Ithaca (Muenscher and Bechtel); Ohio—Columbia (H. A. Gleason), Put-in-Bay (two specimens, L. H. Pammel), Worthington (Asa Horr); Washington—Pullman (Mrs. R. O. Westley).

Physocarpus opulifolius (L.) Maxim. var. *intermedius* (Rydb.) Robinson

A tall shrub with long branches; the heart-shaped leaves cut-toothed and partly 3-lobed; white flowers in umbel-like corymbs; flowers regular, stamens numerous, pistils few; the membranous pods turning purplish. Growing wild on rocky banks, occasional in the woods. Resembles *P. opulifolius* (L.) Maxim. Commonly cultivated.

In sandy and rocky (limestone) soils. Not uncommon from north-

FIG. 141.—Ninebark (*Physocarpus opulifolius* var. *intermedius*). *Photo by C. M. King.*

eastern Iowa to central Iowa (Boone county); in the latter on Coal Measures sandstone. In Clayton and Allamakee counties sometimes on St. Peter sandstone and on limestone (magnesium and calcium carbonate).

It is associated with *Aquilegia canadensis, Prunus pennsylvanica. Celastrus scandens, Ostrya virginica, Carpinus caroliniana* and *Geranium maculatum.*

Nectar is secreted by inner surface of calyx cup. Bees as in the Spiraeae visit ninebark freely and remain in the flower for some time. The wild plants are not numerous in central Iowa, though they are common in northern and eastern parts of the state.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Bellevue, Bixby State Park, Backbone Park (Delaware county), Dubuque, Edgewood, Lansing, Madison county (four specimens), Strawberry

Point, Tete des Morts, Waterloo (L. H. Pammel), Iowa City, Waterloo (A. S. Hitchcock), Allamakee county (O. Schultz), Decatur county (J. P. Anderson), Decorah (R. I. Cratty), Dubuque (Asa Horr), Fayette (B. Fink), Lamont (I. T. Bode), Ledges (Boone county, A. F. Miller, L. H. Pammel), McGregor (Ada Hayden), North McGregor (H. Goddard), Osage (Mrs. Tuttle), Ottumwa (Jessie Peters), Peru (D. E. Hollingsworth), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson), Yellow river (L. H. Pammel, E. Orr and O. Schultz).

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); Colorado—Golden, Manitou (L. H. Pammel), Boulder Falls, Palmer Lake (I. W. Clokey), Fort Collins (Ada Hayden, L. H. Pammel and C. P. Johnson); Indiana—Crawfordsville (W. H. Evans); Minnesota—Cannon Falls (L. H. and Lois Pammel), Faribault, Lake City (L. H. Pammel); Michigan—Green, Northern Michigan (L. H. Pammel and V. C. Fisk); Utah—Farmington canon (L. H. Pammel and R. E. Blackwood); Wisconsin—Holmen, Prairie du Chien (L. H. Pammel).

HONEY BEE VISITS

Ames, May 25 to June 1, 1917. Cloudy. Few bees. Other days bees common.

June 1, 1919. Intermittent showers. Honey bees two, three, four seconds in a flower. (L.H.P.)

June 8, 1919, 12 m. Honey bees abundant on flowers. (L.H.P.)

May 25, 1921, 12:30 p.m. Clear, warm. Bees collecting pollen and nectar. One to three seconds in a flower.

June 1, 1922, 8 a.m. Bees abundant collecting pollen. (L.H.P.)

2:30 p.m. Cloudy. Abundance of rain preceding week. Bees collecting nectar, two, three, three, two, three seconds in a flower. (L.H.P.)

June 2, 1922. Many bees about the plant most of the day. Some collecting pollen, others nectar. (L.H.P.)

June 5, 1922. Clear. Bees numerous about the plant getting pollen and nectar. (L.H.P.)

5 p.m. Clear. Bees one, one, two, three, four, two, one seconds in a flower. About 8,500 flowers on a small bush.

June 6, 1922, 1 p.m. Bees two, three, four, two, three seconds in a flower.

June 7, 1922, 5 p.m. Slight breeze. Fewer fresh flowers. Few bees on the side of bush sheltered from the wind. (L.H.P.)

June 8, 1922, 9 a.m. Bees one, two, four, three, two seconds in a flower. The older follicles reddish. Bees not as active as when more flowers were open. The red color of the follicles confusing to the bees. (L.H.P.)

May 1, 1923, 1:30 p.m. Many small bees, no honey bees. Several flies.

May 6, 1923, 12:15 p.m. Partly cloudy. Bees gathering pollen. One, one, one, one seconds in a flower. (L.H.P.)

May 31, 1923, 12:15 p.m. Partly cloudy. Bees collecting pollen. One, one, one, one, one, two, one seconds in a flower. (L.H.P.)

May 8, 1927, 1 p.m. Warm, slight wind. Bees abundant. Two, four, two, three, two, three seconds in a flower. (L.H.P.)

June 2, 1927. Warm, partly cloudy. Bees two, two, two, three, two, two seconds in a flower. (L.H.P.)

June 4, 1927, 11 a.m. Warm, sunny. Bees collecting nectar. Three bees in five minutes. Bees one, two, two, two, two, one seconds in a flower.

June 6, 1927. Cloudy, warm. Bees abundant collecting nectar. Bees two to three seconds in a flower.

June 7, 1927, 1 p.m. Sunshiny, clear. Bees three, four, four, four, three, two, three seconds in a flower. (L.H.P.)

June 9, 1927. Clear, south wind. Few flowers left. No honey bees.

June 11, 1927, 8:30 p.m. Bees two, three, two, three seconds in a flower.

July 1, 1927. Belated blooms, no bees. (L.H.P.)

May 28, 1929, 3 p.m. Bees two, two, one, one, one seconds in a flower.

May 31, 1929, 12:15 p.m. Some bees. Two to three seconds in a flower.

June 2, 1929, 5:30 p.m. Bees two to three seconds in a flower.

Blooming dates, Ames, 1925, May 25; 1926, June 1.

Spiraea (Tourn.) L. Meadow-sweet

Mostly hardy, shrubs with simple leaves. The perfect flowers are often proterogynous with the odor of hawthorn. The ovary not enclosed in a calyx-like tube, fruits not inflated.

The densely crowded flowers and the abundance of pollen and some nectar attract numerous insects and bees. A ring-shaped, orange-colored disk at the base of the receptacular tube secretes drops of honey and nectar.

Knuth states that the honey bee visits the flower for both pollen and honey.

Spiraea salicifolia L. Meadow-sweet

Erect shrub one to four feet in height, with yellowish brown stems. Leaves finely serrate, lance-shaped, firm. White flowers in compact clusters. Found chiefly in low grounds, New York westward. In swampy, peaty places of northern and northeastern Iowa, on Iowan and Wisconsin drift, where it is fairly common.

Associated plants, *Thalictrum dasycarpum, Phlox maculata, Habenaria leucophaea, Parnassia caroliniana, Caltha palustris.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City (three specimens), Fairbanks, Mason City (L. H. Pammel), Armstrong, Emmet county (R. I. Cratty), Ames (E. R. Hodson), Cedar Falls (George W. Carver), Eagle lake (L. H. Pammel and Winifred Gilbert), Forest City (L. H. Pammel and A. L. Bakke), Ringgold county (J. P. Anderson), Taylor county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Winneshiek county (H. Goddard).

FIG. 142.—Meadow-sweet (*Spiraea salicifolia*). A. Young flower with outspread stamens ready to dehisce and young stamens still coiled at base of flower. B. In the older flower all the stamens gradually become erect. C. Receptacle, with nectary situated in its cup. D. Immature and dehiscent stamens. *Drawn by A. Hayden.*

It has been observed (L. H. Pammel) at Belmond, Cresco, Decorah, Lake Mills, Lamont, McGregor, Manchester, New Albin, New Hampton.

General distribution in the United States:

Illinois—Cheltenham Beach (L. H. Pammel), Utica (Mrs. Joseph Clemens); Massachusetts—Cambridge (B. Fink); Michigan—Whitehall (L. H. Pammel); Minnesota—Bemidji, Cass Lake, Graceville, Itaska State Park, Owatonna, Pipestone, Saint Paul, Wadena (L. H. Pammel), Brainerd, (two specimens), Saint Cloud (E. B. Watson), Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt), Anoka (R. I. Cratty), Backus (Ada Hayden), Cass Lake (L. H. and H. E. Pammel), International Falls (H. S. Kellogg), Saint Cloud

(R. Gmelin), Vermilion (J. H. Sandberg); New Jersey—Egg Harbor (two specimens, F. Hexamer); New York—Ithaca (H. E. Summers, Muenscher and Bechtel), Saint Regis Falls (E. R. Hodson), Watkins (G. McCarthy); North Dakota—Pembina (L. H. Pammel); Ohio—Baltimore (Asa Horr); Wisconsin —Forest City, Holmen, Muscoda (L. H. Pammel), Madison (J. R. Heddle), Wildwood (Lois Pammel).

Saskatchewan—Shelbrooke (C. A. Hansen).

Said to be visited by honey bees.

Spiraea trilobata L. Bridal Wreath

An ornamental plant introduced from Siberia. A smooth spreading shrub, with round, crenately-cut, three-lobed leaves and showy flowers; blooming profusely in the early spring.

HONEY BEE VISITS

Ames, June 1, 1920, 1:15 p.m. Partly cloudy. Flies common, honey bees present. (L.H.P.)

May 25, 1923. No bees. (L.H.P.)

Date of bloom, Ames, 1926, May 26.

Spiraea Thunbergii Sieb. Spiraea

A compactly growing shrub with slender, drooping branches; leaves linear, sharply toothed, light green; flowers small and white, the umbels arranged in long open sprays. This beautiful plant blooms early in the season.

HONEY BEE VISITS

Ames, May 16, 1926, 12 m. A few bees. One, one, one, one second in a flower.

May 30, 1927, 3:30 p.m. Sunshine, warm. No bees. (L.H.P.)

June 1, 1927. Cool, cloudy. A few bees. (C.M.K.)

June 12, 1927. A few bees visiting the flowers. Food in general scarce. (C.M.K.)

Honey bees do not seem to like the odor of this plant. In the year 1929 there were no bees observed on the species. Only exceptionally do honey bees occur.

Date of bloom, Ames, 1926, April 9; 1927, April 18.

Spiraea Vanhouttei Zabel. Vanhoutte's Spiraea

A shrub growing to six feet in height; leaves rhombic-oblong, about three centimeters long. Flowers white, small, in umbels. Handsome spring flowering plant.

This is a hybrid, probably between *S. trilobata* and *S. cantoniensis*; both of these species are Asiatic. Has white flowers on leafy shoots. Leaves rhombic-ovate.

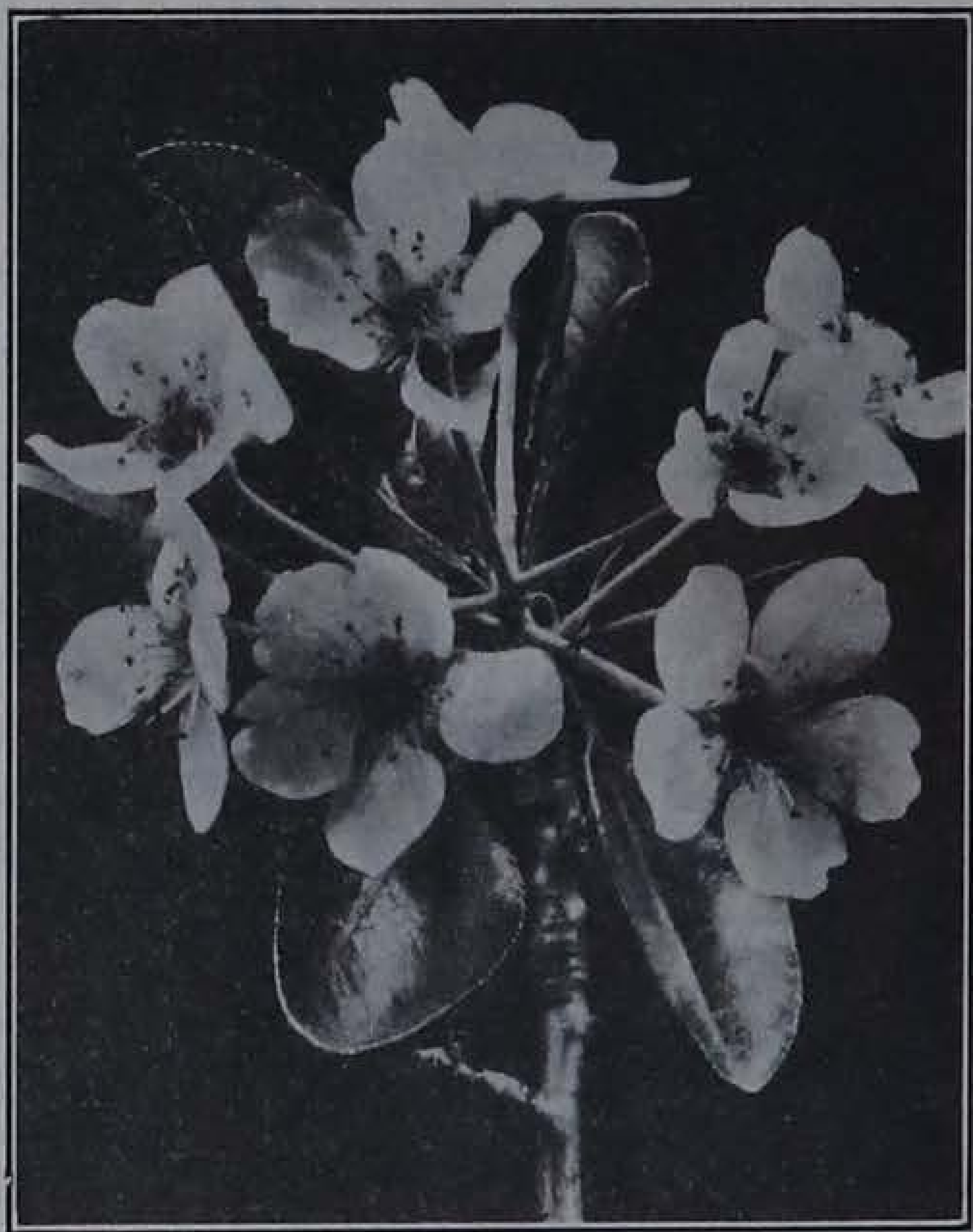

FIG. 144.—Flowers of the pear (*Pyrus communis*). *Photo by Ada Hayden.*

Pellett states, "Where grown commercially, it is the source of abundant nectar and pollen in the spring."

Blooming dates, 1925, Ames, April 20; Lansing, April 26. 1926, Ames, May 10. 1927, Ames, April 26.

Pyrus baccata L. Siberian Crab

Height 30 to 40 feet. Glabrous, wiry branches. Leaves oval or ovate, lanceolate, sharply crenate, serrate, smooth. Flowers white. Fruit yellow or reddish. Occurs from Siberia to Manchuria in northern China. Commonly cultivated as an ornamental plant.

General distribution in the United States:

South Dakota—(cult.) Brookings (L. H. Pammel).

HONEY BEE VISITS

Ames, May 14, 1914. Sunny, northwest wind. Moderate to warm. Insects abundant and lively. (L.H.P.)

May 10, 1920, 1 p.m. Warm and cloudy. Tree blooming. Bumble bees present. (L.H.P.)

May 3, 1928, 1 p.m. Partly cloudy, cool, dry. Northerly breeze. Bees abundant. Four, six, ten, eight, six seconds in a flower. (L.H.P.)

May 8, 1929, 12:15 p.m. Bees abundant. Four, twelve, sixteen, four, six, four, ten seconds in a flower. (L.H.P.)

Mason City, May 11, 1929, 12:30 p.m. Rain the night before. Bees twelve, eight, ten, ten seconds in a flower. (L.H.P.)

Ames, May 12, 1929, 12:30 p.m. Only a few bees. Ten, twelve, ten, twelve seconds in a flower.

Pyrus ioensis (Wood) Bailey. Iowa Wild Crab Apple

This crab apple is native to the region west of the Great Lakes. A small tree somewhat armed with thorns; leaves oblong to oval, dull green, toothed; lower surface of the leaf, petioles and young growth whitish pubescent. Large rose-colored flowers in corymbs. Abundant and beautiful bloom in middle of May, very fragrant. Fruit a small green fragrant apple.

FIG. 145.—Wild crab (*Pyrus ioensis*). *Photo by C. M. King.*

A handsome ornamental tree. Is often cultivated and is freely visited by honey bees.

In thickets throughout Iowa except northwestward where it is rare. Most common in eastern Iowa in clay soil or sometimes limy and sandstone soil.

Associated with *Prunus americana, Prunus virginiana, Rhus glabra, Polygonatum commutatum, Viola cucullata, Rhus Toxicodendron, Vitis vulpina.*

Pyrus ioensis furnishes fine bee pasturage, ranking as one of the best of the early wild honey producing plants. It has a flowering period of about ten days. There is a good deal of variation with reference to honey bee visits. They are much more frequent in some places than in others. It is not as good a honey plant as the cultivated apple, and in fact the wild crab is not in competition with the late flowering type of cultivated apple.

Bumble bees and numerous other Hymenoptera also visit the flowers freely.

In *P. ioensis* nectar is secreted by the calyx tube to which the stamens are attached, being arranged in a ring around the top of the receptacle tube. To reach the nectar, the bee thrusts its proboscis between the numerous filaments at their base.

FIG. 146.—Iowa crab (*Pyrus ioensis*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bassett, Boone, Centerville, Clarksville, Clinton, Clinton county, Carnforth, Crapo Park (Burlington), Eagle Lake, Fayette, Garner, Greene county, Guthrie county, Indianola, Keokuk (two specimens), Lamont, Lansing, Liscomb (two specimens), Maquoketa, Mason City, Middle River, New Albin, Osage, Otter creek, river east of Kelley, Saylorville, Sidney, Toolsboro, Walnut creek, Wapsipinicon river, Warren county (L. H. Pammel), Fort Dodge, Mud lake (F. C. Stewart), Des Moines, Osage (F. May Tuttle), Iowa City, Squaw creek (Ames) (A. S. Hitchcock), Ames (F. C. Stewart, L. Clapper, Bernice Banks, Mina Belle Lynch), Beaver creek (L. H. Pammel, J. H. Lees, Winifred Gilbert), Columbus Junction (E. B. Watson, A. A. Miller), Decatur county (T. J. and M. F. L. Fitzpatrick), Des Moines county (Skunk river valley) (Paul Barker), Des Moines (H. Frankel), Fayette (B. Fink), Floyd county (L. H. Pammel and B. B. Zimmerman), Fraser (Botany Seminar), Howard county (F. M. Tuttle), Ledges (L. H. Pammel and Robert Combs), Morning Sun (G. W. Carver), Muscatine (E. R. Harlan), Rockford (L. H. Pammel and G. B. Mac-

Donald), Shell Rock (E. W. Fyler), Salem (G. B. MacDonald, L. H. Pammel and H. E. Jaques), West Union (L. H. Pammel and Emma Hancock).

It has been observed (L. H. Pammel) at Adel, Agency, Albia, Algona, Brooklyn, Cresco, Davenport, Decorah, Dexter, Dubuque, Fairfield, Fort Dodge, Forest City, Garner, Grinnell, Iowa City, Lawler, Lebanon, Madrid, Marshalltown, Moravia, New Hampton, Oskaloosa, Ottumwa, Postville, Redfield, Wapello, Waukon, Webster City.

General distribution in the United States:

Alabama—Birmingham (L. H. Pammel); Delaware—Christiania (Pennypacker and Tatnall); Illinois—Chicago (Stella L. Goodspeed), Urbana (B. Fink); Missouri—Cambridge (cult.) (L. H. Pammel), Jackson county (Kenneth K. Mackenzie); Ohio—Cincinnati, Huron (L. H. Pammel); Virginia—Pulaski county (John K. Small); Wisconsin—Madison (L. H. Pammel)—Probably *P. ioensis*.

HONEY BEE VISITS

Ames, May 15, 1913, 6:14 p.m. No wind, clear. Trees in the open. In five minutes five honey bees, and one other bee gathering pollen over a group of two hundred flowers. Flowers in cymose clusters; sweet characteristic odor. color at first reddish, later pale, stamens twenty to twenty-four, maturing at same time with stigma. Nectar secreted close to and inside of stamens, from top of disk. Insect alights upon stamens and thrusts its proboscis between them. (L.H.P.)

Moingona, May 6, 1914, 3:14 p.m. Warm, clear. Bees numerous on trees. On tree fifteen feet high five large bumble bees and many honey bees. On group of one hundred fifty flowers seven honey bees, three smaller bees and one bumble bee. The honey bee lights on stamens, puts its proboscis between them for the nectar, the thorax coming in contact with the stamens and stigmas. Bees collecting honey, pollen, or both. (L.H.P.)

Ames, May 17, 1917, 11:20. Warm, clear, southwest wind. Trees ten feet high. In three-fourths of a minute three honey bees, seven other bees, one bumble bee. Time of bee in flower collecting pollen thirty, twenty-one, thirty seconds. (L.H.P.)

2 p.m. Small bees were gathering pollen. Time of bee in flower collecting nectar seven, fourteen, eleven, eighteen, eighteen seconds. (L.H.P.)

4 p.m. The honey bee in collecting nectar lights on the stamens, changes its position in the flower by passing over and around the stamens. The bee rests sometimes two of its legs upon the petals anywhere that they are in reach. (L.H.P.)

June 1, 1917, 6:30 p.m. Bees abundant. (L.H.P.)

May 10, 1919. Flowers passing. A few bees at work.

May 25, 1920, 12 m. Time of honey bee in flower one, two, five, eight, one, two, nine, twenty seconds. Three honey bees in two minutes in one hundred flowers; six bees in two minutes over five hundred flowers.

1:30 p.m. Five honey bees in three minutes working in three hundred flowers. Eighteen, twenty, fourteen, sixteen seconds in a flower.

6:30 p.m. Clear. Three honey bees in three hundred flowers in two minutes. (C.M.K.)

May 26, 1920, 8:30 a.m. Cool, northeast wind. Time in flowers nineteen, thirty-three seconds. (C.M.K.)

Clarksville, May 29, 1920, 10 a.m. Bees common. Time in flower nine, ten, fifteen, sixteen seconds. Bumble bee twenty-one seconds in one flower. Honey bees three in one hundred flowers in a half minute.

Ames, May 4, 1921, 5:45 p.m. Warm. Some bees collecting nectar. Fourteen, sixteen seconds in a flower. (L.H.P.)

May 9, 1922, 8 a.m. Partly cloudy. Odor strong, blossoms bright. One bee on small tree.

8:50 a.m. Southeast wind. Three bees on area containing three hundred flowers. Nine, ten, ten, nine seconds in a flower. Tree seven feet tall. Number of flowers fifty thousand. Bees abundant.

6 p.m. Southeast wind. Eighteen, six, five, ten, twelve, eight seconds in a flower. Fifteen bees working on the tree. (L.H.P.)

May 13, 1922. Clear, little breeze. Bees abundant. Two, three, four, four, three, two, two, eight seconds in flowers collecting pollen. (L.H.P.)

12 m. Clear, south wind. Twelve, fourteen, ten seconds in flower. (C.M.K.)

May 14, 1922, 10:20 a.m. Partly cloudy. Some bees collecting both pollen and nectar. Ten, six, four, six, twelve, eight seconds in a flower. (C.M.K.)

May 16, 1922, 9:30 a.m. Some dew. Bees abundant collecting nectar and pollen. Eight, sixteen, ten, twelve seconds in a flower. (C.M.K.)

Eldora, May 16, 1924, 4 p.m. Windy, fairly warm. Bees ten, twelve, fourteen, eight, six, eight seconds in a flower. Bumble bees and small Hymenoptera also present. (L.H.P.)

May 18, 1924. Bumble bees and honey bees fairly numerous. Honey bee eleven, twelve, fourteen, ten seconds in a flower. (L.H.P.)

Ames, Campus, May 18, 1924, 9:30 to 11:30 a.m. South wind, sunshiny. Many insects. Small bees push head first between the stamens for honey; large bees reach in between stamens from the side.

May 20, 1924, 2 p.m. Bright, warm, slight breeze. Tree in full bloom. Many bees constantly about the plant getting nectar and pollen. Bee five, eight, five, ten, fifteen, ten, eight, four, eight, ten seconds in a flower. A bee visits four to twelve flowers before leaving plant. (C.M.K.)

6 p.m. Cool, sunshiny. A few bees. Ten, eleven, twelve, fourteen seconds in a flower. (L.H.P.)

Boone, May 21, 1924. Bright, moderate. Bees fairly numerous. Ten, twelve, fourteen seconds in a flower.

May 22, 1924, 3 p.m. Clear, warm. Abundance of honey bees.

Pine Hollow, Dubuque, 1924. Bees at work. Numerous.

Ames, April 29, 1927, 7 a.m. Sunshine, cool, slight north wind. No bees.

May 1, 1927, 12:30 p.m. Close of blooming period. Bees two, one, two, one, two, four seconds in a flower. (L.H.P.)

May 13, 1927. A few bees. Four, five, six, four seconds in a flower.

May 15, 1927. Many bees. Six, ten, fourteen, twenty seconds in a flower.

May 16, 1927. Many bees. Five, sixteen, ten, fourteen, sixteen, twenty seconds in a flower.

May 18, 1927. Rain, cold. No bees. (L.H.P.)

May 24, 1927, 1 p.m. Warm, sunshiny, west wind. Flowers passing. Bees abundant. Six to fourteen seconds in a flower.

Rock Island, Ill., May 15, 1927, 12:15 p.m. Warm. Bees twelve, twelve, ten, fifteen seconds in a flower. (L.H.P.)

Ogden, May 12, 1929, 6 p.m. Shady slope. Only a few bees. Twelve, fourteen, sixteen seconds in a flower. (L.H.P.)

Elkhart, May 14, 1929, 12:15 p.m. Cool. Not many bees. Six, six, five, nine, six, nine seconds in a flower. (L.H.P.)

Ames, May 14, 1929, 2 p.m. Six, six, seven, eight, ten seconds in a flower.

May 17, 1929, 8:30 a.m. No bees. (L.H.P.)

11 a.m. Bees abundant at same trees where none were observed at 8:30 a.m. today. Flowers very fragrant. Twelve, fourteen, sixteen, ten, four seconds in a flower. (L.H.P.)

May 19, 1929, 2 p.m. Bees abundant. Fifteen, fifteen, twelve seconds in a flower. (L.H.P.)

May 23, 1929, 5:15 p.m. Clear, windy. A few bees active. One-half to one second in a flower. (C.M.K.)

Eldora, May 25, 1929. Flower past its prime. Not many bees. Four, three, six, four seconds in a flower.

Belmond, May 26, 1929, 11:30 a.m. Some bees. Ten, ten, eight, ten seconds to a flower.

Honey flow of Wild Crab Apple (O. W. Park)

Year	Period of bloom	Full bloom	Period worked on by bees	Period of honey flow
1919				5/12 — 5/25
1922	5/7 — 5/25	5/10 — 5/20	5/8	
1923	5/5	5/15		

Blooming dates: 1925, Ames, April 24; Boone, April 23; Lansing, May 1. 1926, Ames, May 6. 1927, Ames, May 12.

Pyrus ioensis var. *plena* Rehd. Bechtel's Crab

Blooming dates: Ames May 20, 1924; May 8, 1925.

HONEY BEE VISITS

Ames, Campus, May 25, 1926, 8:30 a.m. Protected situation. Bees common. Getting pollen. Ten, ten, sixteen, twelve, thirteen seconds in a flower.

Ames, Campus, I.S.C. Protected situation. Bees common, getting pollen. Ten, ten, sixteen, twelve, thirteen seconds in a flower. (L.H.P.)

Davenport, May 14, 1928. Warm, partly cloudy. Bees twelve, fourteen, twelve, fourteen seconds in a flower. (L.H.P.)

Eldora, May 25, 1929, 2 p.m. Bombus and small *Hymenoptera*. Bees six, six, eight, ten, ten seconds in a flower. (L.H.P.)

Pyrus Malus L. Apple

This is a hybrid between the European *Pyrus sylvestris* and *Pyrus communis*. It is therefore not a pure species but has had a hybrid origin. Other varieties may also have entered in. It was assumed formerly that some *P. prunifolius* was a part of its origination.

This is a tree with buds and lower face of simple leaves woolly; flowers white, tinged with pink, in simple umbels on short woolly peduncles; quite large, various.

Beach in "Apples of New York" states that 'the common apples which are grown mostly for their fruit belong to the species which Linnaeus called (*Pyrus*) *Malus*. It is characterized by simple, soft leaves, flowers white or pink, short stemmed and borne in a simple umbel. Fruit depressed at both ends, calyx persistent. This species is very variable. Under cultivation it has developed innumerable varieties. Some varieties which because their fruit is large are called apples doubtless are hybrids between this species and the primitive Siberian crab, called by Linnaeus *Pyrus baccata*.'

The apple has perfect flowers. The calyx is urn-shaped; petals five, white to rose-colored; stamens numerous; styles five, stigmas five. The stigmas ripen earlier than the stamens.

Some of the shorter stamens curve towards the center. Fresh flowers are opening over a period of about six days. Nectar, which is freely secreted, is readily accessible to the numerous insect visitors. The honey bee is the chief pollinator, being abundant in favorable weather, and less frequent during cool and damp days.

When, as in 1924, the weather is inclement, there are few insect visitors, and only a small proportion of the blossoms set fruit. The importance of bees in the pollination of flowers of the apple is recognized by horticulturists.

This was also true in 1929. But where bees were in the apiary, a more abundant setting of fruit took place this year.

"Honey from fruit blossoms is among the very best. There will be an occasional spring when quite a little honey is gathered from the blossoms" (apple, pear, peach).—A B C of Bee Culture.

Waite says, "Be sure there are sufficient bees in the neighborhood to pollinate the blossoms freely."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Dubuque (L. H. Pammel); Ames (A. A. Miller and A. F. Sample), Decatur county (T. J. and M. F. L. Fitzpatrick). Seedlings of this species are commonly found in Allamakee, Clayton, Dubuque and Winneshiek counties.

General distribution in the United States as represented in the I.S.C. Herbarium:

Illinois—Walnut (L. H. Pammel); Indiana—Crawfordsville (L. H. Pammel); Michigan—Northern Michigan (L. H. Pammel); New York—Ithaca (H. E. Summers).

HONEY BEE VISITS

Ames, May 6, 1914, 9:19 a.m. Slight east wind. Sunny. 80° F. Three hundred flowers in the group observed, on which were present eight honey bees and eight other Hymenoptera. Honey bees collecting nectar, or pollen, do either exclusively. Bee in flower collecting pollen eleven, six, eleven, fourteen seconds. In flower collecting honey ten, fourteen, seventeen, eighteen, twenty-one, twenty seconds. (L.H.P.)

May 6, 1914, 10:49 a.m. to 11 a.m. Bees hive one-fourth mile away. Honey bees frequent; more than on cherry; fewer of the smaller insects since the nectar is less exposed. The honey bee alights on the stamens and thrusts its proboscis between them. Small bees also alight upon the stamens. The nectar appears in shiny globules secreted on the calyx tube inside the stamens; odor pleasant, stronger than in cherry. Stamens eighteen to twenty; styles five, mature at the same time as the stamens.

May 6, 1914, 2:30 p.m. Sunny. Two bees getting honey, ten other Hymenoptera. (L.H.P.)

May 10, 1914, 10:45 a.m. Slight east wind. Bright sunshine, 80° F. Hives one-fourth mile away. Honey bees frequent. On 300 flowers in two minutes, eight honey bees, ten other Hymenoptera.

2:13. Same place; same conditions. In three minutes honey bees two, other Hymenoptera ten. The average time of honey bee in a flower gathering nectar was sixteen seconds. Pollen gathered by some honey bees. (L.H.P.)

May 14, 1914. Sunny, northwest wind, moderately warm. Insects "thick and lively." (L.H.P.)

May 19, 1914, 9:30 a.m. and 11:15 a.m. Cool, north wind. No bees; some other Hymenoptera. (L.H.P.)

April 12, 1915. A few honey bees at work.

May 12, 1919. Sun obscured, warm, good breeze. Bees numerous. Visits one to five seconds long. A bee passes from cluster to cluster. (C.M.K.)

May 13, 1919. Bright day. Observations made on two trees in proximity; one the "Beyer" tree; numerous bees, gathering nectar. Four, six, eight, ten seconds in a flower. The same flower visited by different bees. A number of small Hymenoptera at work. The other, the "Holden" tree: Some bees. Not collecting pollen. (C.M.K.)

May 18, 1919, 10 a.m. Sunshine, some clouds, warm south wind. Tree full of bloom, fragrant. Numerous bees. At hives one-eighth mile away bees active coming and going. Tree at Olsan's. Conditions as above. More bees coming and going. More bees on side of tree sheltered from the wind than on windy side. (C.M.K.)

May 10, 1920, 9 a.m. Sun after shower, southeast wind. Apple blossoms just opening. Numerous bees deep in the flowers. Tree fragrant. Bees six to ten seconds in the flower, collecting nectar. (C.M.K.)

May 12, 1920. Cold wind and rain. Cloudy all day. No bees. (C.M.K.)

May 13, 1920, 11 a.m. Cool, slight east wind. Apple trees at apiary visited by a few bees.

11:45. Warmer, sunshiny. A few bees on the newly opened flowers.

4 p.m. Cooler, clearing. (C.M.K.)

Ames, May 14, 1920, a.m. Cool, p.m. A few bees, many bees. (C.M.K.)

May 15, 1920. Many bees working on the apple. (C.M.K.)

Newton, May 18, 1920, 7 a.m. Heavy dew. No bees. Later—mid-bloom. Time in flower six, eight, five, six seconds. (C.M.K.)

May 19, 1920, 5:30 p.m. Bees abundant. Four bees working on 150 flowers in two minutes. Gathering both pollen and nectar. Time in flower, fifteen, fourteen, twenty, fifteen seconds. (C.M.K.)

Cedar Rapids, May 19, 1920, 8:15 a.m. Rain during night. Plants wet. Six honey bees visiting 115 flowers in two minutes. Bee in flower five, three, four seconds. Bees getting pollen. (L.H.P.)

Ames, May 7, 1922, 9 a.m. Clear, warm, slight breeze. Ten, ten, eight, ten, eight seconds in a flower.

10:30 a.m. Clear. Bees numerous, getting honey. Ten, eight, ten, twelve seconds in a flower.

3 p.m. A little rain. Six, eight, seven seconds in a flower.

Campus, I.S.C., May 19, 1920. Late bloom. Flowers still visited by bees. Two to three seconds in a flower.

May 9, 1922, 7:30 a.m. Some dew. South wind. Bees fairly common.

May 10, 1922, 7:30 a.m. Clear. Sixty thousand to 85,000 flowers on a 12 foot tree. Only a few bees at work. Eight, nine, ten seconds in one flower. 8:30 a.m. Clear. Bees six, eight, nine, four seconds in a flower. Some bees getting honey, other bees collecting pollen.

May 11, 1922, 8:30 a.m. Southeast wind. Trees in prime of bloom. Bees getting nectar and pollen. Twelve, fifteen, five, twelve, five seconds in a flower.

May 5, 1924, 12:30 p.m. Warm, sunshiny. Bees abundant. Twelve, fourteen, seven, five, eight, fourteen, twelve seconds in a flower. (L.H.P.)

May 5, 1924, 6 p.m. Clear, warm. Strong south wind. A few bees.

May 6, 1924, 8 a.m. Partly cloudy. Apple in full bloom. Many bees.

Blairsburg, May 12, 1924, 12:30 p.m. Partly cloudy. Bees fairly numerous. Ten, twelve, fourteen, eight, ten seconds in a flower. (L.H.P.)

Ames, May 14, 1924. Cool, cloudy. No bees. (L.H.P.)

May 15, 1924, 12:30 p.m. Partly cloudy. Bees fairly numerous. Ten, twelve, fourteen, eight, ten seconds in a flower. (L.H.P.)

Blairsburg, May 16, 1924. Windy, fairly warm. Bees three, three, five, eight, ten, four, eight, ten seconds in a flower. Bees numerous; other small Hymenoptera also present. (L.H.P.)

May 9, 1926, 10:30 a.m. and 12:15 p.m. Dry and warm. No bees.

May 10, 1926, 2 to 6 p.m. Clear, warm, north breeze. No bees. Dry weather greatly influenced honey flow. (L.H.P.)

Ames, May 2, 1927, 2 p.m. Many small bees. Ten, eight, eleven, ten seconds in a flower. (L.H.P.)

May 4, 1927, 8:30 a.m. Clear, strong west wind. Bees abundant.

May 9, 1927, 8 a.m. Cool, southeast wind. Some bees collecting pollen and nectar. Bees fifteen, twelve, fourteen, twelve, fifteen seconds in a flower. (L.H.P.)

Grinnell, May 5, 1928, 12:30 p.m. Bees ten, twelve, six, eight seconds in a flower. (L.H.P.)

Keosauqua, May 6, 1928, 9 a.m. Clear, bright. Bees abundant. Sixteen, twelve, fourteen, fourteen, twelve seconds in a flower. (L.H.P.)

Bloomfield, May 7, 1928, 1 p.m. Clear, warm. Bees ten, ten, twelve, ten, twelve, six seconds in a flower. (L.H.P.)

Centerville, May 7, 1928, 2 p.m. Warm and clear. Bees sixteen, sixteen, twelve, four and eight seconds in a flower. (L.H.P.)

Corydon, May 8, 1928, 4 p.m. Clear and warm. Bees abundant. Twelve, fourteen, six, ten seconds in a flower. (L.H.P.)

May 10, 1928, 5:30 p.m. Warm, cloudy. Bees ten, fourteen, sixteen, twelve seconds in a flower. (L.H.P.)

Ames, April 30, 1929, 11 a.m. Bees ten, twelve, twelve, ten seconds in a flower.

May 3, 1929, 1 p.m. Not many bees. Ten, twelve, twelve, fourteen seconds in a flower.

May 4, 1929, 12:15 p.m. Warmer. Some bees. Six to ten seconds in a flower.

May 5, 1929, 12:15 p.m. Warm. Bees abundant. Twelve, fifteen, fifteen, twelve, fifteen seconds in a flower. (L.H.P.)

May 6, 1929, 2 p.m. Cloudy, fairly warm. Ten, twelve, ten, ten seconds in a flower.

May 8, 1929, 5 p.m. Only a few bees. Ten, eight, six, ten, ten seconds in a flower. (L.H.P.)

May 9, 1929, 8:30 a.m. Rather cool. Only a few bees. Six, eight, eight, eight, ten, eight seconds in a flower.

11:30 a.m. Flowers very fragrant. Maximum secretion of nectar when warm. Ten, twelve, ten, twelve, fourteen seconds to a flower. (L.H.P.)

Ames, May 12, 1929, 10:30 a.m. Ten, twelve, twelve, ten seconds in a flower.

Ogden, May 12, 1929, 4:30 p.m. Clear. Ten, twelve, twelve, ten seconds in the flowers. (L.H.P.)

Ames, May 12, 1929, 7:00 p.m. Clear. Eight, eight, eight, nine, ten seconds to a flower. (L.H.P.)

May 16, 1929, 8 a.m. Fair. Ten, eight, twelve, ten, fourteen seconds to a flower.

5 p.m. Some bees. Ten, twelve, twelve, ten seconds in a flower.

May 17, 1929. Warm. Ten, eight, ten, six seconds to a flower. (L.H.P.)

6:30 p.m. Ten, four, six, five seconds to a flower. (L.H.P.)

May 19, 1929, 9 a.m. No bees.

3 p.m. Some bees. Ten, eight, four, six seconds in a flower.

May 21, 1929, 11:50 a.m. Flowers past prime. Some bees. Ten, six, seven, ten seconds to a flower. (L.H.P.)

General distribution in the United States:

Michigan—Lake Au Train (L. H. Pammel), St. Ignace (L. H. Pammel); Minnesota—Carleton county (J. H. Sandberg), International Falls (H. S. Kellogg), Star island, Cass Lake (L. H. Pammel, H. E. Pammel and P. S. McNutt), McKinley (Mrs. J. Clemens), Star island, Cass Lake (L. H. Pammel and H. E. Pammel); New York—McLean (W. C. Muenscher and A. R. Bechtel); North Carolina—Watauga county (J. K. Small and A. A. Heller).

Pyrus japonica Lindl. Japan Quince

A thorny shrub with alternate deciduous leaves which have serrate margins. Large stipules. Flowers solitary or in clusters.

FIG. 147.—Japanese quince (*Pyrus japonica*). *Photo by Ada Hayden.*

HONEY BEE VISITS

Ames, April 28, 1927, 8 a.m. and 1 p.m. Sunny, southeast wind. No bees. (L. H.P.)

April 29, 1927. Sunny, cool, slight north wind. No bees. (L. H.P.)

May 1, 1927, 2:30 p.m. No bees. (L.H.P.)

It is visited by honey bees in Florida and other southern states.

Blooming date: Ames, 1927, April 25.

Amelanchier Medic. Juneberry, Service Berry

Small trees or shrubs with simple leaves. Flowers in racemes, white; petals oblong, rarely linear. The fruit berry-like, sweet and edible. Flowers in early spring. Fruit ripe in early summer.

The service berry is rather common in woods throughout eastern and central Iowa. Usually on slopes of hills.

Amelanchier canadensis (L.) Medic. Juneberry

Small tree 10 to 30 feet high. Leaves ovate, pointed, sharply serrate, glabrous or nearly so. Flowers white, in drooping racemes coming before the leaves. Fruit a berry-like pome, crimson to purple. Dry open woodlands and on crests of river bluffs.

Widely distributed along banks of streams, in somewhat light drift soil mixed with clay and sand, or in clay soil, or rocky limestone soil.

Associated with *Phlox divaricata*, *Aquilegia canadensis*, *Geranium maculatum*, *Viola pubescens*, *Viola cucullata*, *Dicentra Cucullaria*, *Juniperus Virginiana*.

The Juneberry of our woodlands blooms from about the first to the twenty-seventh of April. The numerous white flowers appear earlier than the leaves.

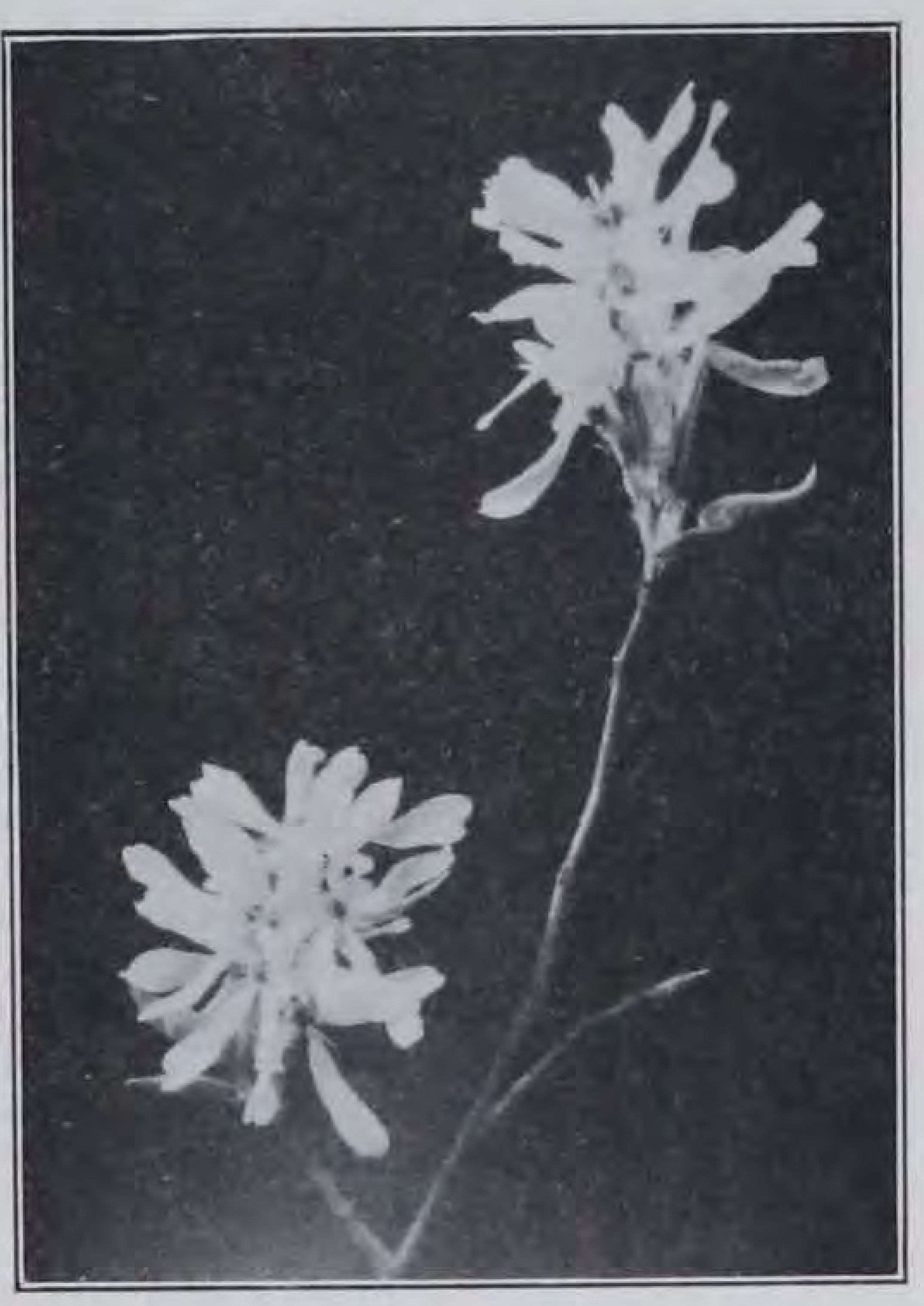

FIG. 148.—Service berry (*Amelanchier canadensis*). *Photo by Ada Hayden.*

According to Robertson, nectar is secreted by that portion of the receptacular tube which lies between the ovary and the base of the filaments. The flowers are pollinated by bees principally of the genus *Andrena*. The honey bee is a very frequent visitor, getting both nectar and pollen.

When the flower opens, the five styles, with their receptive stigmas, are exposed above the inflected stamens whose anthers are still closed. The stamens straighten and turn outwards in succession, the anthers discharging their pollen in the same order.

The flowers are abundantly visited and until the anthers dehisce, there is full opportunity, in all favorable weather, for the stigmas to receive pollen from other flowers of the same or of distant trees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Delaware county, Devil's Backbone, Fraser, Jefferson, Louisa county, Mahaska county, Moingona, Muscatine, Myerholz lake, Ottumwa, Palo Alto county, Palisades (Linn county), South River, Steamboat Rock, Wapello, Warren county (two specimens), Webster City (L. H. Pammel), Woodman's Hollow, Otho, Webster county (L. H. Pammel and F. W. Paige), Algona (Woods south) (R. I. Cratty), Allamakee county, Yellow river (Orville Schultz), Ames (R. Combs, F. W. Faurot, G. W. Carver, H. Stewart, P. H. Rolfs (two specimens), F. A. Sirrine, C. E. Bessey), Colfax (P. Sipe), Decorah (E. W. D. Holway), Decatur county (J. P. Anderson), Eagle Rock (L. H. Pammel and E. R. Hodson), Fayette (B. Fink), Fraser (Boone county) (two specimens, L. H. Pammel and R. I. Cratty), Iowa City (three specimens, A. S. Hitchcock), Ledges (Boone county) (L. H. Pammel and A. F. Miller, R. E. B. and C. M. King), northeast Iowa (H. Goddard), Wayland (G. W. Carver).

General distribution in the United States:

Colorado—Arapahoe (L. H. Pammel); Illinois—Glen Park (L. H. Pammel and Mark Heavenhill), Lake Jurich (E. J. Hill), Starved Rock (two specimens, L. H. Pammel and M. Heavenhill); Maryland—Hagerstown (F. R. Trenk); Michigan—Stambaugh, Marquette, northern Michigan, Au Train (two specimens, L. H. Pammel), Green (L. H. Pammel and V. C. Fisk), Port Huron (C. K. Dodge), Michigan (F. E. Wood); Minnesota—Leech Lake, Norway Beach, Cass Lake, Itaska State Park, Cloquet (L. H. Pammel), Golden Valley, International Falls (Mrs. R. O. Westley), Star island (D. C. Poshusta); St. Cloud (E. B. Watson); Missouri—Rolla, Washington (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Cedar Point, Put-in-Bay (L. H. Pammel); South Dakota—Spring Creek (L. H. Pammel); Virginia—Smyth county (John K. Small); Wisconsin—Coon Valley, Kilbourne, Madison, Holmen (two specimens, L. H. Pammel).

HONEY BEE VISITS

Ames, April 27, 1916. C. E. Bartholemew notes considerable numbers of honey bees collecting pollen. Kenoyer examined trees on three or four occasions and failed to notice bees.

May 13, 1922, 1 p.m. Flowers just opening. A few bees working upon them. (L.H.P.)

May 14, 1922, 1 p.m. Clear, sunshiny, west wind. Not many bees. One, two, three, two, two, one seconds in a flower. (L.H.P.)

Ledges, Boone county, May 1, 1924. Some bees and other small Hymenoptera.

Ames, April 28, 1928, 11:30 a.m. Clear, fairly warm. Bees swarming on flowers. Six, four, three, six, six, four seconds in a flower. (L.H.P.)

	Northern section					Central section							Southern section		
	Lansing	Waukon	Forest City	Emmet Co.	Allamakee Co.	Ames	Boone	Oskaloosa	Iowa Falls	Mt. Joy, Scott Co.	Iowa City	Cedar Rapids	Lamoni	Keokuk	Ottumwa
1886						4–30									
1891						4–26									
1892						5–1									
1896						4–15									
1898										5–24					
1900										5–14					
1901						4–26									
1902						4–24									
1903						4–18									
1904						5–8			5–7						
1905						4–20							4–12		
1906					5–5	4–20		4–30			4–22			4–19	
1907		5–13	5–17			4–23	4–21	4–9				4–30			
1908						4–16	4–18					4–15		4–11	
1909						5–6	5–5								
1910				4–9		3–26	3–26								
1911				5–8		4–23	4–23								4–19
1912						4–26	4–30							4–21	
1913						4–22	4–22								
1914						4–23	4–22								
1915	4–20					4–17	4–18								
1916	5–2					4–23	4–25								
1917							4–28								
1918						4–20	4–14								
1919						4–22 to 5–8	4–18								
1920						4–28	5–1								
1921						4–20	4–4								
1922						4–2									
1923						4–28									
1924						4–27									
1925						4–10									
1926						4–26									
1927						4–6									

Amelancier spicata (Lam.) C. Koch. Low Juneberry

A shrub 3 to 12 feet high; leaves at first very woolly, oval or roundish, coarsely dentate toward the end; veins strongly conspicuous; petals white, oblong; fruit dark purple, autumnal. Along banks of streams, eastward and westward from the Great Lakes region.

FIG. 149.—Service berry (*Amelanchier spicata*). *Photo by Ada Hayden.*

Only on shores of lakes and streams in Wisconsin drift sheet, in gravelly soil. Associated with *Phlox divaricata, Sanguinaria canadensis, Viola cucullata, Claytonia virginica* and *Hepatica acutiloba.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bassett, Iowa Falls, Lake Park, McGregor, Postville (L. H. Pammel), Dickinson county, Iowa lake (R. I. Cratty), Chickasaw county (W. D. Spiker), Clinton county (George D. Butler), Charles City (J. C. Anderson), Dubuque county (George D. Butler), Emmet county (B. O. Wolden), McGregor (S. W. Stookey), Winneshiek county (H. Goddard).

General distribution in the United States:

Michigan—Muskegon, Saint Ignace, Whitehall (three specimens, L. H. Pammel), Mackinac Island (R. I. Cratty); Minnesota—Cannon Falls, Cass lake, Cloquet (L. H. Pammel), Anoka, Coleraine (R. I. Cratty), Cass Lake, Cedar island, Duluth, Norway Beach (L. H. and H. E. Pammel), Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt); North Dakota—Minot (J. C. Blumer); South Dakota—Spearfish canyon (two specimens, C. M. King); Washington—(E. R. Garner); Wisconsin—Kilbourne (three specimens), Prairie du Chien (L. H. Pammel), Lake Geneva (H. E. Fabian).

HONEY BEE VISITS

Ames, May 1, 1920, a.m. Windy. A few honey bees. Two, two seconds in a flower. (L.H.P.)

May 5, 1927, 5 p.m. Bees three, two, two, three seconds in a flower.

May 3, 1928, 1 p.m. Partly cloudy, cool, dry, northerly breeze. Bees abundant. Four, six, ten, eight, six seconds in a flower.

Blooming dates for Amelanchier spicata.

	Emmet Co.	Ames
1912	5–5	
1913	5–4	
1914	5–7	
1915	5–27	
1916	5–12	
1924		4–22
1925		4–12
1926		4–28
1927		4–26

Crataegus L. Hawthorn, White Hawthorn

Thorny shrubs or small trees with simple lobed leaves. Stipules deciduous. Flowers in corymbs. Petals white or pinkish. Stamens 5 to 25. Pome small, usually red or yellowish. Seeds 1 to 5 in a bony, hard nutlet.

The clusters of white flowers are very conspicuous. Nectar is secreted in the receptacular tube, and is not concealed. Hawthorn flowers are visited by Diptera and small Hymenoptera. The honey bee is an occasional visitor.

There is much variation in the visits of bees to this group of plants. In some cases the bees remain but a moment in the flower, others remain one or two seconds and in others considerable time is spent in getting the nectar. Generally when the flowers are past blooming stage there is a very strong odor. Knuth says the flowers have a smell something like herring brine (trimethylamide). However, it appears to us that the odor is rather of the bitter almond, or cyanogenetic.

Knuth says, "On account of their odor the hawthorn attracts a class of nauseous flies which are fond of putrefying substances."

Hermann Mueller says that the stigmas are nearly mature when the flowers open and project from the center, but the anthers are still unripe. The outer stamens are erect, but the inner ones are so bent inwards as to lie beneath the stigmas. After one to two days the outermost anthers begin to dehisce and get covered with pollen all around.

Most observers do not report the honey bee though Hermann Mueller does report it.

McLeod observed the honey bee in the Flanders district.

Crataegus Crus-galli L. Cockspur Thorn

Trees with spreading branches, bark dark gray, spines long, shining, dark brown, numerous. Leaves 2 to 10 inches long, 1 to 4 inches wide, sharply serrate except near base. Corymbs glabrous. Fruit ellipsoidal, ovoid to subglobose, about one inch thick, greenish to dull red.

In dry soils of uplands and hills of southern and southeastern Iowa in the Kansan drift sheet.

Associated with *Corylus americana, Prunus serotina, Quercus alba, Carya ovata, Lespedeza capitata, L. violacea, Monarda mollis.*

This species resembles *C. coccinea* but blooms later. Robertson states: "It blooms May 20 to June 1 (southern Illinois)."

These trees are conspicuous when in bloom. Honey bees have been reported as visiting the flowers freely for nectar and pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, South River, Warren county (L. H. Pammel), Mount Pleasant (L. H. Pammel, G. B. MacDonald and H. E. Jaques), Salem (H. E. Jaques, G. B. MacDonald and L. H. Pammel), Clinton, Wapsipinicon river (two specimens, L. H. Pammel).

General distribution in the United States:

Arkansas—Ashley county (R. E. Fennell); Illinois—Starved Rock (L. H. Pammel); Kentucky—Harlan county (T. H. Kearney, Jr.); Michigan—Ann Arbor, Muskegon (L. H. Pammel); Minnesota—Hennepin county (J. H. Sandberg); Missouri—St. Charles, St. Louis (L. H. Pammel), Carsonville (H. Eggert); Ohio—Huron (two specimens, L. H. Pammel), Licking county (Asa Horr); Oklahoma—Muskogee (L. H. Pammel); Pennsylvania—Towanda (L. H. Pammel); Texas—Denison (L. H. Pammel); Virginia—Roanoke (N. L. Britton and party).

HONEY BEE VISITS

Manhattan, Kansas, May 16, 1927, 2:30 p.m. Clear. Bees abundant. Three, two, two, three, two, two, three, three seconds in a flower. (L.H.P.)

Ames, June 10, 1927, 2 p.m. A few bees. Ten, twelve seconds in a flower. June 14, 1927, 11 a.m. No bees. (L.H.P.)

Blooming dates: 1925, Ames, May 20; Boone, May 17; 1926, Ames, May 20; 1927, Ames, May 30.

Crataegus punctata Jacq. Large-fruited Thorn

Flat-topped trees 3 to 10 meters high, with grayish brown bark; spines straight, 2 to 7 inches long. Leaves ovate to oblong, 2 to 8 inches long, 1 to 5 inches broad, dull gray-green, and with strongly impressed veins above. Corymbs tomentose. Flower two inches broad. Stamens about 20. Fruit yellow to red.

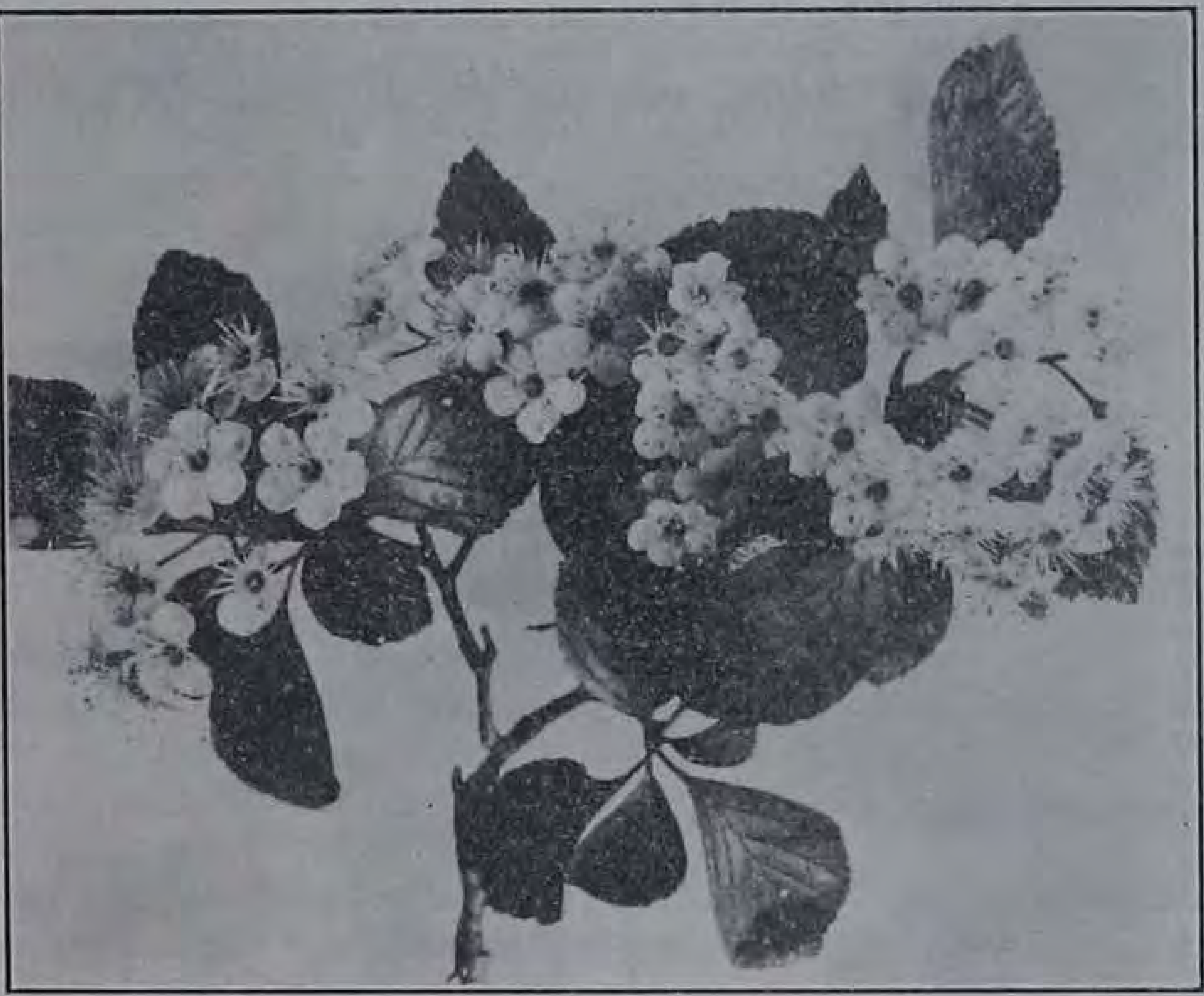

FIG. 150.—Washington or large-fruited thorn (*Crataegus punctata*). *Photo by C. M. King.*

Widely distributed along streams. On second bottoms, in alluvial clay and sandy soils.

Associated with *Crataegus mollis, Juglans nigra, Cornus Amomum, Claytonia virginica.*

This is a late blooming hawthorn, blooming from a week to ten days later than *C. mollis*. Just before clover begins to yield, bees work upon this tree quite freely.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eldora (June 13, 1924, just blooming), Sioux City (L. H. Pammel), Boone, Skunk river bottom (L. H. Pammel and R. E. Buchanan), Ames (L. H. Pammel and Alice Hess), Arnold's Park (L. H. and H. E. Pammel), Cedar Rapids (three specimens, R. E. Buchanan), Charles City (Mr. and Mrs. C. L. Webster), Decorah (E. W. D. Holway), Fayette (B. Fink), Forest Mills (O. Schultz), Fraser (Botany Seminar), Ledges (Boone county) (R. E. Buchanan, L. H.

Pammel and A. F. Miller), Muscatine (L. H. Pammel, J. Kelso, E. R. Harlan), Osage (two specimens, Mrs. F. M. Tuttle), Pine Creek Hollow (Dubuque county) (L. H. Pammel and F. E. Trenk), Rockford (L. H. Pammel and G. B. MacDonald, C. L. Webster), Salem (L. H. Pammel, G. B. MacDonald and H. E. Jaques), Steamboat Rock (C. M. King).

HONEY BEE VISITS

Ames, May 15, 1914, 3 to 5 p.m. (Path up town). Clear, moderate. Bumble bees. Three small bees. (L.H.P.)

Eldora, June 13, 1924. Some bees on these flowers. (L.H.P.)

Ames, May 23, 5 p.m. Warm. Bees ten, five, six, ten, twelve seconds in a flower. (L.H.P.)

Boone, May 24, 5 p.m. Bees common. (L.H.P.)

Blooming dates for Crataegus punctata.

	Northern section		Central section		
	Emmet Co.	Armstrong	Ames	Boone	Cedar Rapids
1898		5–18			
1905			6–3		
1906					
1907			6–13		5–19
1908			6–1		5–14
1909					
1910			5–17		
1911	5–19		5–9		
1912					
1913			5–28		
1914	5–24		5–20 to 6–25		
1915	5–16		5–10	5–2	
1916					
1917			6–5		
1918				5–21	
1919			5–22 to 6–2		
1920			6–1		
1921					
1922			5–18 to 5–24		
1923			5–22 to 5–25		
1924		5–29	5–25		
1925				5–17	
1926			5–20		

Crataegus Margaretta Ashe. Brown's Thorn

This hawthorn belongs to a group with oblong-ovate to oval leaves, crenate-lobed, pointed at the tip and cuneate at base, dark green, shining glabrous above, paler beneath. Corymbs with few to many flowers. Fruit rusty green to reddish. A tree with narrow open crown 10 to 14 feet high.

This species is common in sandy woods and floodplains of streams in eastern Iowa to the Iowa river at Steamboat Rock, also occurs to Missouri river but less common westward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Bangor, Cedar Falls, Centerville, Clear Lake, Clinton, Davenport, Dubuque, Farmington, Gillett Grove, Iowa City, Johnson county, Keokuk, Mahaska county, Marshalltown, Monticello, Montrose, Moulton, Mount Pleasant, Nora Springs, Steamboat Rock, Wapsipinicon State Park (L. H. Pammel), Centerville (three specimens), Goodell, Keosaqua, Rockford (G. B. MacDonald and L. H. Pammel), Cedar Rapids (L. H. Pammel and Fred Perkins, S. W. Stookey, F. Lazell), Columbus Junction (E. B. Watson), Delaware county (I. T. Bode), Eldora (L. H., H. E. and Lois Pammel), Iowa City (A. S. Hitchcock), Moulton (L. R. Buck), Mount Pleasant (H. E. Jaques), New Hampton (two specimens, L. H. Pammel and W. D. Spiker).

General distribution in the United States:

Michigan—St. Ignace (L. H. Pammel); Minnesota—Ortonville (L. H. Pammel); Missouri—Northern Missouri near Moulton, Iowa; North Dakota—Minot (J. C. Blumer).

HONEY BEE VISITS

Steamboat Rock, 1927. Bees on these flowers. (L.H.P.)

Eldora, May 25, 1929, 1:30 p.m. Warm and clear. Bees numerous. Six, six, eight, ten, seven, twelve seconds in a flower. (L.H.P.)

Steamboat Rock, May 25, 1929, 3 p.m. Six, eight, six, eight, ten seconds in a flower. (L.H.P.)

Honey bees were frequent in 1929. We found bees upon every plant of this species examined at Steamboat Rock and Eldora. It is quite as good a honey plant as the other species.

Blooming date: Eldora, 1926, May 18.

Crataegus coccinea L. Scarlet Thorn

A tree with rough-pubescent leaves, villous corymbs and calyx. Flowers about three-fourths inch wide, stamens 10. Fruit pubescent.

The flowers are more fragrant and smaller than those of *C. mollis.* The nectar-bearing disc is concave and narrow.

Robertson reports, "The honey bee is a frequent visitor collecting nectar and pollen."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City (three specimens), Eldora, Indianola, Otter creek, Ottumwa, Pine creek, Princeton, Warren county (L. H. Pammel), Ames (L. H. Pammel and A. T. Erwin), Fayette (B. Fink), Fraser (five specimens, Botany Seminar), Johnson county (T. J. and M. F. L. Fitzpatrick), Keokuk (P. H. Rolfs), Lee county (P. Bartsch), Osceola (F. C. Stewart), Postville (Ellison Orr, D. O. Wilson and L. H. Pammel).

The specimens in the herbarium do not fully indicate its distribution. It is fairly common in northern Iowa, especially toward the northeast.

General distribution in the United States:

Michigan—Ontonagon (L. H. Pammel), Houghton (L. H. Pammel and V. C. Fisk), Alma (Charles A. Davis); Missouri—Carondolet (H. Eggert), Jackson county (K. K. Mackenzie); Ohio—Mansfield (E. Wilkinson), Cascadilla creek (Muenscher and Bechtel); Virginia—Shannon Gap (John K. Small); Wisconsin—La Crosse (Tillie Koch), North Bend (L. H. Pammel).

HONEY BEE VISITS

Boone, May 5, 1927, 5 p.m. No bees. (L.H.P.)

The bee is in some seasons a frequent visitor.

Blooming dates for Crataegus coccinea.

	Central section		Southern section	
	Ames	Cedar Rapids	Ottumwa	Missouri Valley
1892	5–22			
1904				6–8
1908		5–14		
1911	——		5–5	

Crataegus tomentosa L. Black Thorn, Hairy Haw

A shrub three to twelve feet tall; leaves rather small, obtuse at apex, crenate. Corymbs or clusters few-flowered; tomentose; fruit subglobose, yellowish green.

Side hills and bottoms of smaller streams, in clay soils or occasionally with a little sand. It also occurs in upland woods.

Associated (at Ames) with *Ulmus fulva, Quercus alba, Q. rubra, Tilia americana, Fraxinus americana, Ostrya virginica, Phlox divaricata, Podophyllum peltatum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Lake Mills, Ledges (Boone county), Little Sioux, Liscomb, Nashua, Stratford (L. H. Pammel), Ames (four specimens, G. W. Carver, J. C. Blumer, Fred Rolfs, L. H. Pammel and S. W. Beyer, A. S. Hitchcock), Boone (L. H. Pammel and Miller), Columbus Junction (E. B. Watson), Decatur county (J. P. Anderson), High Bridge (Boone county) (two specimens, G. M. Lummis), Iowa City (A. S. Hitchcock), Mount Pleasant (H. E. Jaques), Soper's Mill (Ames) (L. H. Pammel and R. Combs), Webster county (F. C. Stewart).

FIG. 151.—Hairy haw (*Crataegus tomentosa*). *Photo by Ada Hayden.*

The specimens in the Herbarium only indicate the distribution of this tree in Iowa. It is far less common in central Iowa than *C. mollis, C. punctata* and *C. coccinea.*

HONEY BEE VISITS

Ames, May 15, 1914. Cloudy, northeast wind. Nectar secreted around the calyx cup, glistening. Honey bees and bumble bees at work upon the flowers. (L.A.K.)

May 29, 1914, 3 p.m. Cloudy, north wind. Blooming. Nectar secreted around the calyx cup. Both honey bees and bumble bees at work. Flowers white, twenty-five stamens, anthers white, twenty-five capitate stigmas. Stamens and pistils mature at the same time. (L.A.K.)

May 30, 1927, 11:30 a.m. A few bees. Three, two, three, three seconds in a flower. (L.H.P.)

May 27, 1929, 7:15 a.m. A few bees. Only in flower a short time. Rapidly go from one cluster to another. In flower two to four seconds.

8 a.m. Some bees. Eight, six, four, six seconds in a flower. (L.H.P.)

May 28, 1929, 1 p.m. Few bees. Two to six seconds in a flower.

June 2, 1929, 4:30 p.m. No bees, nor on *Trifolium repens* in the vicinity.

Blooming dates for Crataegus tomentosa.

	Central section				Southern section
	Le Grand	Ames	Cedar Rapids	Marshalltown	Lamoni
1902	5–25			5–25	
1905					5–18
1907			6–16		
1910	5–18				
1911	5–20				
1912	5–8				
1915	5–1				
1916	5–6				
1918	5–18				
1922	5–22				
1925		6–15			

Crataegus mollis (T. and G.) Scheele. Hawthorn

A round-topped tree, sometimes growing to the height of thirty or forty feet. Leaves broadly ovate, one to four inches long, somewhat cordate at the base, slightly rugose, tomentose below, with narrow acute lobes. Flowers about one inch wide, with about 20 stamens; fruit subglobose, scarlet, with deciduous calyx lobes and yellow flesh. This is the most common of the haws in Iowa; especially common along the smaller streams. It flowers in May.

FIG. 152.—*Crataegus mollis* at Twin Lakes in Calhoun county.

Widely distributed in Iowa in bottoms of smaller and larger streams, in alluvial or clay soils, or somewhat sandy soils in western Iowa, in ravines or bluffs of Missouri loess.

Associated with *Juglans cinerea, Claytonia virginica, Heracleum lanatum and Viola glabrescens.*

Common southern Ontario to eastern South Dakota, south to Kentucky.

Charles Robertson says, "In Crataegus this part of the tube (the nectar-bearing disc) is expanded into a concave disc, and the filaments have no effect in concealing the nectar, which is sought by numerous short-lipped insects.

In this form the nectar-bearing disc measures six millimeters across. The flowers have a disagreeable odor and sometimes the discs of the older flowers turn purplish."

On May 5 and 9, 1929, honey bees were abundant on these blossoms, getting nectar and pollen. This is a common occurrence.

The large white corymbs of bloom appear at the same time as the leaves.

FIG. 153.—Large-fruited red haw (*Crataegus mollis*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville, Charles City, Clarksville, Clinton, Dawson, Des Moines, Dubuque, Forest City, Gillett Grove, Greene, High Lake, Indianola, Lake Mills, Lake Okoboji (two specimens), Ledges (Boone county), Liscomb, Marble Rock, Marshalltown (two specimens), Mason City, McGregor, Middle River, Moingona, Moulton, Nashua, Oakland, Postville, Steamboat Rock, Strawberry Point, Toolsboro, Traer, Union, Warren county, Winterset (L. H. Pammel), Algona, Clear Lake, Emmet county (R. I. Cratty), Charles City, Rockford (Mr. and Mrs. C. L. Webster), Howard county, Osage (Mrs. F. M. Tuttle), Ames (A. S. Hitchcock, Fred Rolfs, H. Cornell), Arnolds Park (L. H. and H. E. Pammel), Boone (T. J. Miller and W. O. Fitzwater; two specimens, L. H. Pammel and R. E. Buchanan), Cedar Rapids (two specimens, R. E. Buchanan), Clinton (L. H. Pammel and O. Burroughs), Decorah (E. W. D. Holway), Fayette (B. Fink), Forest Mills (three specimens, O. Schultz), Fort Dodge (F. C. Stewart), High Bridge (Boone county) (G. M. Lummis), Ledges (Boone county) (L. H.

FIG. 154.—Common red haw (*Crataegus mollis*). *Photo by F. L. Owen.*

Pammel and A. F. Miller), Missouri Valley (H. B. Clark), northeast of Fraser (L. H. Pammel and R. I. Cratty), Postville (L. H. Pammel and Ellison Orr, O. Schultz), Shell Rock (E. S. Fyler), Skunk river bottom (two specimens, L. H. Pammel and Alice Hess), Sioux City (Rose Schuster Taylor), Steamboat Rock (two specimens, C. M. King), Yellow river (three specimens, O. Schultz).

General distribution in the United States:

Illinois—Kankakee (R. I. Cratty), Quincy (L. H. Pammel and Mark Heavenhill), Wady Petra (V. H. Chase); Indiana—Wills county (Charles C. Deam); Missouri—Columbia (L. H. Pammel), Jackson county (Kenneth K. Mackenzie), Rock Point (A. O. Simmonds); Ohio—Huron (two specimens, L. H. Pammel); Texas—Melissa (L. H. Pammel), Fort Worth (Albert Ruth).

HONEY BEE VISITS

Ames, May 10, 1914, 10 a.m. No bees.

May 15, 1914, 3 p.m. Sunny, northeast wind. Bumble bee and ladybird on the flowers. (L.A.K.)

May 17, 1914. Nearly past flowering. Nectar easily accessible, but not abundant. Two small Hymenoptera at work on the flowers. (L.A.K.)

May 19, 1920, 9 a.m. Honey bee in one flower two, three, two, two seconds. (L.H.P.)

FIG. 156.—Red Haws in Ledges State Park. *Photo by G. Schneider, Ogden.*

Eldora, May 16, 1924, 4 p.m. Windy, fairly warm. Honey bees numerous. Bumble bees also present. (L.H.P.)

Fraser, May 16, 1924. Bees abundant. Twelve, twelve, twelve, eight, ten seconds in a flower. (L.H.P.)

Ames, May 8, 1926, 1:30 p.m. Warm and dry. No bees, no nectar. (L.H.P.)

East of Bloomfield, May 7, 1928, 11:30 a.m. Bees sixteen, ten, sixteen, twelve, six, four, three seconds in a flower.

May 6, 1929, 8 a.m. Partly cloudy. Bees abundant. Ten, twelve, fourteen, ten seconds in a flower.

2 p.m. Ten, six, twelve, ten, six, ten seconds in a flower.

May 8, 1929, 5 p.m. Only a few bees. Ten, six, six, six seconds in a flower. (L.H.P.)

Mason City, May 11, 1929, 1:30 p.m. Bees abundant. Twelve, fifteen, ten, six seconds in a flower. (L.H.P.)

Ames, May 12, 1929, 3:30 p.m. Five to ten seconds in a flower.

May 13, 1929, 2 p.m. Past its prime. Not many bees. Two, five, four, six, six seconds in a flower.

Belmond, May 24, 1929, 11 a.m. Bloom nearly over. Bees ten, eight, eight, eight seconds in a flower.

Ames, May 30, 1929, 8:30 a.m. No bees. Past its abundant flowering stage.

FIG. 155.—Thicket of wild thorn (*Crataegus mollis*) in Oak Grove State Park, near Hawarden, Iowa.

	Northern section				Central section										Southern section						
	Lansing	Emmet Co.	Armstrong	Allamakee Co.	Ames	Boone	Des Moines	Oskaloosa	Iowa City	Newton	Cedar Rapids	Harlan	Marshalltown	Le Grand	Crescent City	Ottumwa	Cincinnati	Corydon	Keokuk	Woodbine	Garden Grove
1898			5–10																		
1901					5–3										5–2						
1902					5–4								5–10	5–10							
1903					5–7																
1904					5–6																
1905					5–3																
1906	5–12			5–10					5–6										5–2	5–4	
1907	5–23				5–9	5–12		4–24		5–12		5–14						5–11	4–13	5–15	5–27
1908	5–8							5–7			5–8						5–1		4–26		
1909					5–20 to 6–1	5–18	5–13														
1910		4–15			4–10	4–5										4–8					
1911	5–9					5–7										4–28					
1912		5–10			5–1	5–3															
1913					5–1	5–1															
1914	5–9	5–16			5–4	5–3															
1915		5–1			4–26 to 5–6	4–26															
1916	5–18	5–15			5–1	5–2															
1917	5–18				5–18	5–14															
1918	5–11				5–4	5–3															
1919	5–24				5–11 to 5–21	5–5															
1920	5–20				5–14	5–15															
1921	4–30				4–25	4–24															
1922					5–15																
1923	5–18				5–7														5–2		
1924					5–4																
1925					4–18																
1926	5–13				5–4																
1927					5–5																

Crataegus Oxyacantha. English Hawthorn

A thorny tree 20 feet high with smooth branches. Leaves roundish to broadly obovate, 3- to 5-lobed, usually serrate. Flowers white turning pink. Not uncommon in cultivation. Native to Europe.

HONEY BEE VISITS

Ames, May 13, 1926, 1 p.m. Cool, humid. Bees fairly common, getting pollen and nectar. Three, three, four, six, three, two, two seconds in a flower.
May 21, 1928, 11 a.m. Bright, moderately cool. Bees abundant. (C.M.K.)
May 22, 1928, 11 a.m. and 2 p.m. Fair, warm. Bees abundant. (C.M.K.)
Davenport, May 14, 1928. Warm, partly cloudy. No bees.

Fragaria (Tourn.) L. Strawberry

Stemless perennial herbs with three-foliolate leaves and white flowers. Receptacle pulpy, bearing dry achenes upon its surface.

Fragaria virginiana Duchesne. var. *illinoensis* (Prince) Gray. Wild Strawberry

Leaves of firm texture; shining, smooth. Fower cluster flat-topped, globular, with a narrow neck. Grows in moist rich woodlands and prairies. A fairly stout plant, leaves usually overtopping the clusters of fruit.

FIG. 157.—Wild strawberry (*Fragaria virginiana* var.). *Drawing by Ada Hayden.*

Associated with *Geranium maculatum, Phlox pilosa, Heuchera villosa, Liatris scariosa, Cacalia tuberosa, Potentilla canadensis, Thalictrum dasycarpum, Cirsium Hillii, Poa pratensis, Solidago nemoralis, Prunus americana, Corylus americana.*

This plant is extremely abundant in native prairies.

Charles Robertson says, "Nectar is secreted by a narrow portion of the receptacle and is held between the bases of the filaments and the anthers. It is, therefore, only imperfectly concealed and can be obtained by small bees and flies. The principal visitors are the bees of the genus *Halictus.*"

In observations recorded the honey bee is not mentioned.

Frank Pellett says, "Wild strawberries seldom are sufficiently abundant to be of much value to the bee."

Mueller finds that in this flower honey is secreted by a narrow fleshy ring at the base of the receptacular tube. The honey bee is a visitor.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Fraser, Quarry (L. H. Pammel), Ames (Fred Rolfs, H. S. Fawcett, C. R. Ball and R. Combs), Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson), northeastern Iowa (H. Goddard).

It has been observed (L. H. Pammel) at Clinton, Council Bluffs, Cresco, Des

Blooming dates for Fragaria virginiana.

	Northern section		Central section								Southern section				
	Lansing	Emmet Co.	Ames	Boone	Oskaloosa	Grinnell	Storm Lake	Cedar Rapids	Marshalltown	Le Grand	Crescent City	Ottumwa	Woodbine	Lamoni	Keokuk
1901			4–29								5–6				
1902			5–3						5–24	5–24					
1903			5–8												
1904															
1905			4–24											4–22	
1906					4–20	5–1	4–25						4–20		4–22
1907			5–1												
1908			5–16					4–25							
1909				5–4											
1910		4–13	4–9	4–4											
1911		5–9	5–9	4–20								5–5			
1912		5–8		4–14											4–25
1913		5–12													
1914	5–6	5–9		4–27											
1915		4–30		4–19											
1916	5–8	5–7		4–23											
1917	5–12		5–18	5–12											
1918	5–15			4–20											
1919	5–14		5–10	4–20											
1920				5–1											
1921			5–12	4–18											
1922			4–25												
1924			5–12												
1925			4–14												
1926			4–29												
1927			5–3												

Moines, Forest City, Fort Dodge, Garner, Hamburg, Iowa City, Indianola, Jefferson, Marshalltown, Mason City, Missouri Valley, Mount Pleasant, Muscatine, Postville, Red Oak, Rockwell City, Shenandoah, Sioux City, Spencer, Twin lakes, Waukon.

HONEY BEE VISITS

Ames, May 29, 1927, 8 a.m. and noon. Cool, cloudy. No bees. (L.H.P.)
May 31, 1927, 1 p.m. Bees four to six seconds in a flower.
1 p.m. One bee visited fifty-five flowers in one clump. Time in flower one second.

Fragaria vesca L. var. *americana* Porter. Wood Strawberry

Plant rather slender; leaflets strongly toothed. Flower clusters irregular. The fruit ovoid to spherical.

Frequents dry woods throughout the state, especially in Coal Measures sandstone in central Iowa. Associated with *Ribes Cynosbati, Mitella diphylla, Aquilegia canadensis, Phlox divaricata, Thalictrum dioicum, Woodsia obtusa, Polypodium vulgare, Camptosorus rhizophyllus.*

On calcareous soils of northeastern Iowa, associated with *Physocarpus opulifolius* var. *intermedius, Campanula rotundifolia, Phlox pilosa, Aquilegia canadensis.*

This plant is found generally on limestone or sandstone rocks in shady places. Not so common at Ames as the *F. virginiana* var. *illinoensis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Boone, Dubuque, McGregor, Postville (L. H. Pammel), Fort Dodge, Webster City (F. C. Stewart), Decorah (F. R. Goddard), Fayette (B. Fink), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), northeastern Iowa (H. Goddard), Otho (Webster county) (L. H. Pammel and F. W. Paige), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson), Yellow river (L. H. Pammel, Ellison Orr and O. Schultz).

It has also been observed (L. H. Pammel) at Clermont, Cresco, Dolliver Park, Eldora, Elkader, Fort Atkinson, Iowa Falls, Lansing, New Albin, Steamboat Rock.

Blooming dates for Fragaria vesca var. *americana.*

	Northern section	Central section	Southern section
	Emmet Co.	Boone	Keokuk
1908		4–15	4–19
1910	4–12		
1911	5–4		
1912	5–5		
1913	5–3		
1914	5–10		
1916	5–5		
1921		4–28	

Fragaria chiloensis Duchesne. Garden Strawberry

Our cultivated strawberry comes from Chile, but is also native along the Pacific coast. It is a low growing plant with thick, dark leaves. The plants are clothed with long shaggy hairs, runners numerous, fruit large, with a large calyx. Petals white, inclined to be dioecious. Flowers in May and June.

Most of our cultivated forms belong to the variety *ananassa* Bailey.

"The flowers are visited by honey bees and many wild bees, which gather both pollen and honey." A B C of Bee Culture.

FIG. 158.—Cultivated strawberry (*Fragaria chiloensis* var.). Staminate and pistillate flowers. b.—stamens and pistil in the same flower. Upper left-hand corner female flowers. *Drawing by C. M. King.*

Pellett finds that the cultivated strawberries are a source of both pollen and nectar, valuable in early brood rearing. Honey bees are very important to the strawberry growers as many varieties are not self-pollinated. The bees carry pollen from staminate blossoms to the pistils of the incomplete flowers.

The white flowers of the strawberry are conspicuous, producing numerous stamens and pistils. Nectar is secreted by the receptacle at the base of the filaments next to the outer row of pistils, where it is held. The plant may be self-pollinated, though it is nearly always cross-pollinated. It is frequently visited by honey bees at Ames.

The visits of pollinators are especially important in cultivated strawberries, since many of them are deficient in stamens and require cross-fertilization.

HONEY BEE VISITS

Ames, May 27, 1917. Honey bees common. One bee visited several flowers, going then to the dandelion. (L.H.P.)

May 30, 1927, 4 to 6 p.m. Visits of bees to single flower during two hours: blackberry, sixty-three; red raspberry, two hundred fifty; cultivated strawberry, nine.

4:15 to 6:15 p.m. Bees' visits to a single flower during three hours: blackberry, seven; raspberry, fifty-six; cultivated strawberry, none. (C.C.L.)

May 31, 1927, 1 to 4 p.m. Bees' visits to single flower during three hours: blackberry, fifty-six; raspberry, ninety-seven; cultivated stawberry, nine. (S. Goodell.)

Blooming dates for Fragaria chiloensis.

	Northern section	Central section				Southern section	
	Lansing	Ames	Boone	Mt. Joy, Scott Co.	Iowa City	Creston	Keokuk
1892				5–7			
1898				5–10			
1903		4–26					
1904		5–4					
1905		4–25					
1906					4–27	4–29	
1907		5–2					
1909							5–2
1910		4–9					
1914			5–10				
1915		4–14	4–14				
1916	5–19	5–14					
1917			5–16				
1919		5–18 to 6–10	5–14				
1920	5–11	5–10					
1926		4–29					

Potentilla L. Five-finger

In the flowers of this genus, there are five petals and numerous achenes, calyx with bracts at the clefts. Usually herbs, with compound leaves.

Knuth says, "Flowers with half concealed nectar, secreted as a rule only as a thin annular shining layer on the inner wall of the receptacle."

Potentilla arguta Pursh. White Cinquefoil

A stout, erect, brownish, hairy perennial plant, one to four feet high, stems somewhat clammy above, with pinnate leaves of five to eleven ovate leaflets, and a close cyme of rather large whitish flowers.

Found from New England westward; on gravelly knolls in sandy and gravelly soils. Associated in Iowa with *Oenothera serrulata*, *Anemone patens* var. *Wolfgangiana*, *Liatris scariosa*, *L. pycnostachya*, *Solidago nemoralis*, *Aster sericeus*.

Knuth says that the white or yellow flowers have half concealed nectar which lies on the inner wall of the receptacles in a thin shining layer not forming drops.

FIG. 159.—Rough cinquefoil (*Potentilla arguta*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dubuque, Keystone, Mason City (two specimens), Postville (L. H. Pammel), Emmet county (two specimens), Goldfield, Osage (R. I. Cratty), Ames (Mina Belle Lynch, two specimens, G. W. Carver), Decatur county (J. P. Anderson), Fayette (C. C. Parker), Kelley (two specimens, Pearl Clayton), Ledges (Boone county) (R. E. Buchanan), Little Rock (C. R. Ball), northeastern Iowa (H. Goddard), Peru (D. E. Hollingsworth).

HONEY BEE VISITS

Ames, July 3, 1914. (Interurban Track) Cloudy, west wind. Many small bees and some flies. Three honey bees per flower per minute. (G.H.M.)
July 9, 1924. (Interurban Track) Cloudy. Small bees; *Syrphus* twenty per hour. (G.H.M.)

Potentilla monspeliensis L. Fivefinger

A stout, hairy, erect annual one to two and one-half feet high; leaves 3-foliolate; leaflets obovate, the uppermost toothed nearly the entire length. Flower cluster close, leafy; calyx large, petals yellow.

Open soil, Newfoundland to Alaska and southward. A weed in

FIG. 160.—Cinquefoil (*Potentilla monspeliensis*).

cultivated fields in black and clay soils. Associated with *Lactuca scariola, Polygonum pennsylvanicum, Chenopodium album.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls, Cedar Rapids, Clinton county, Des Moines, Ogden, Steamboat Rock, Sumner, Tete des Morts, Turin, Wapsipinicon river (L. H. Pammel), Ames (Violet Pammel; two specimens, L. H. and H. E. Pammel; two specimens, A. S. Hitchcock, S. W. Beyer, Alberta Wolfe), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Delaware county (I. T. Bode), Des Moines (two specimens, G. W. Carver), Fayette (two specimens, B. Fink), Fraser (Botany Seminar), Kelley (two specimens, Pearl Clayton, L. H. Pammel and C. E. Maxwell), Ledges (Boone county) (T. H. Macklin and L. H. Pammel), Little Rock (C. R. Ball), Muscatine county (L. H. Pammel, J. Kelso, E. R.

Harlan), New London (Lamphear Bros.), northeastern Iowa (H. Goddard), Osage (R. I. Cratty), Palisades (Cedar Rapids) (R. E. Buchanan), Peru (D. E. Hollingsworth), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson).

This plant has been observed (L. H. Pammel) in almost every county in the state.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall), Fraser (D. S. Jeffers), Buxton Park (F. E. and E. S. Clements); Illinois—Champaign (B. Fink), East St. Louis (H. Eggert), Oquawka (H. N. Patterson), Peoria (F. E. McDonald); Minnesota—Blackduck (Mrs. R. Westley), Cass Lake (two specimens, L. H. Pammel), Duluth (L. H. and H. E. Pammel), St. Cloud (R. Gmelin); Missouri—St. Louis (H. Eggert); Montana—Deer Lodge (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel), Niagara Falls (G. H. Frazier); North Dakota—Wahpeton (L. H. Pammel); Ohio—Cedar Point (L. H. Pammel); South Dakota—Brookings (two specimens, Edna C. Pammel and L. H. Pammel); Utah—Logan (A. Isabel Mulford); Wisconsin—Forest county, Holmen (L. H. Pammel); Wyoming—Centennial (Aven Nelson), Hartville (B. Fink); Naturita (Edwin Payson), Snake River (two specimens, Aven and Elias Nelson).

Honey bees have been occasionally observed on this common weed, although it does not have any great value as a honey producing plant.

FIG. 161.—Shrubby cinquefoil (*Potentilla fruticosa*). *Photo by Ada Hayden.*

HONEY BEE VISITS

Ames, July 10, 1915, a.m. Clear, southeast wind. Many very small bees and flies; thirty per flower per hour. (L.A.K.)

July 14, 1915. Partly cloudy, north wind. In a day's observation of three plants three small bees, two syrphidae noted. No honey bees. (L.A.K.)

Potentilla fruticosa L. Shrubby Cinquefoil

Is an erect shrubby plant three to three and one-half feet tall. Freely branched. Pinnate leaves. Leaflets five to seven, oblong-lanceolate, paler beneath, margins revolute. Flowers clustered, petals yellow.

Found in a few places in northeastern Iowa. Common in boggy places and upland woods throughout the northern United States, also in the Rocky Mountains.

Bees have occasionally been observed on this plant at Ames, although they are not in abundance.

HONEY BEE VISITS

Ames, June 4, 1927, 11 a.m. Sunshiny, warm. Few flowers in bloom. No honey bees. (L.H.P.)

Campus, Ames, July 1, 1927, 10 a.m. Cool and rainy. No honey bees.

Campus, Ames, July 1, 1928. Some bees. (L.H.P.)

Rubus (Tourn.) L. Bramble*

Plants of this genus are perennial woody shrubs with spines or bristles. The numerous pistils are fleshy in fruit and crowded together upon a spongy receptacle. Color of flowers white, whitish or greenish.

The blackberry and dewberry are much frequented by bees. They furnish much nectar.

Charles Robertson says, "Nectar is secreted by a narrow ring between the base of the receptacle and the filaments. The nectar is entirely concealed and rendered quite deep-seated by the dense circle of numerous stamens.

"On account of their large size and rather deeply seated concealed nectar, the flowers seem to be especially adapted to bumble bees, which are in fact the principal and most efficient visitors, but smaller insects occur and may effect pollination though by no means so readily."

Honey bees were abundant May 24 and 29, 1929, getting nectar.

"Honey bees manifest a preference for pollen rather than the scanty supply of nectar of blackberries." ABC of Bee Culture.

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* Forms in Iowa not distinctly separated.

Rubus idaeus var. *aculeatissimus* C. A. Mey. Wild Red Raspberry

FIG. 162.—Wild red raspberry (*Rubus idaeus* var. *aculeatissimus*). *Drawn by A. Hayden.*

Generally found in thickets and on hill-sides. The stems are upright and beset with straight bristles; leaflets three to five, oblong-ovate, deeply serrate, downy underneath, the lateral ones sessile; petals greenish white, as long as the sepals. Calyx bristly hispid.

In rocky woodland in sandy and clay soils, with humus. Associated with *Phlox divaricata, Quercus alba, Corylus americana, Bromus purgans, Prunus pennsylvanica, Podophyllum peltatum.*

There are not many of these plants growing in central Iowa although they are common in northeastern Iowa.

Nectar is abundantly secreted by the flattened disc between the filaments and the pistils and is obtained by bees by inserting their proboscides between the stamen and pistil. Honey bees are abundant upon these flowers.

The red raspberry furnishes in some years in Iowa a considerable amount of nectar. The importance of the red raspberry as a honey producing plant is well known in northern Wisconsin, Michigan and Minnesota. It comes at a time when bees are in need of a honey producing plant.

"Upon tracts from which the hardwood lumber has been cut the wild red raspberry offers as reliable a bee pasturage as is to be found anywhere."—Lovell.

"When the raspberry is cultivated on a large scale for market it is an important honey plant." ABC of Bee Culture.

This plant is much cultivated and is an important source of nectar. Much surplus is obtained in the cut-over pine lands of the north.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Charles City, Clarksville, Dubuque, Edgewood, Emmetsburg, Fort Dodge, Granite, Jefferson, Lake Mills, Lamont, Lansing, Ledges (Boone county) (two specimens), Marion, McGregor, New Hampton, Palo Alto county, Postville, Waterville, Waukon, Waukon Junction, Wheelerwood (two specimens) (L. H. Pammel), Pilot Knob, Hancock county (L. H. Pammel and Winfred Gilbert), Algona (E. B. Watson), Arnolds Park (L. H. and H. E. Pammel), Boone (W. Ellis), Cedar Rapids (R. E. Buchanan), Colfax (F. P. Sipe), Decatur county (two specimens, J. P. Anderson), Decorah (H. Goddard), Fayette (B. Fink), High Bridge (Boone county) (G. M. Lummis), Steamboat Rock (J. P. Anderson), West Union (L. H. Pammel and Emma Hancock), Yellow river (L. H. Pammel, Ellison Orr and O. Schultz).

Observed (L. H. Pammel) at Ames (about two and one-half miles northeast of Skunk river), Eldora, Iowa Falls.

General distribution for the United States and Canada:

British Columbia—Glacier (E. W. D. Holway); Canada—Laggan (L. H. Pammel); Colorado—Minnehaha (F. E. and E. S. Clements), Rout county (Reppert and Whittier), Lorimer county, Fort Collins (L. H. Pammel), Mount Baldy (J. P. Anderson), Ward (R. E. Buchanan); Michigan—Mackinac island (R. I. Cratty), Port Huron (E. K. Dodge), St. Ignace (L. H. Pammel); Minnesota—Brainerd (three specimens, E. B. Watson), Lake City, Wadena (L. H. Pammel); Montana—Hughes creek, Warm Springs creek, Wood's creek (L. H. Pammel and H. S. Fawcett); New York—Ithaca (Muenscher and Bechtel); North Carolina—Mount Mitchell (Biltmore Herbarium); Nova Scotia—Yarmouth (C. D. Howe and W. F. Land); South Dakota—Hartford Beach (L. H. Pammel), Spearfish canyon (C. M. King); Utah—East Provo canyon (L. H. Pammel and E. M. Stanton), Peterson (L. H. Pammel and R. E. Blackwood); Wisconsin—La Crosse, Nelson Dewey Park (L. H. Pammel); Wyoming—Mount Everts (Aven and Elias Nelson), Laramie Hills (B. C. Buffum).

HONEY BEE VISITS

McGregor, May 3, 1918, 3 p.m. Cloudy. Bees active.

Clarksville, June 29, 1920. Common on sandy soil along Shell Rock river. Bees at work. (L.H.P.)

Ames, June 10, 1920, 8 a.m. Bees spend five, six, five, five seconds in a flower.

June 12, 1920, 9 a.m. Bees four, six, eight, ten seconds in a flower. 4 p.m. Clear. Bees three, six, five, three, four seconds in a flower. Three honey bees in two minutes in fifty flowers. (L.H.P.)

6 p.m. Honey bees three, four, three, five, three, four seconds in a flower.

6:30 p.m. Cloudy. Bees three, four, three, four, three, two seconds in a flower. Honey bees abundant.
7 p.m. Bees two, two, two, one seconds in a flower. Five bees in three minutes in fifty flowers. (L.H.P.)

June 13, 1920, 6:30 p.m. Clear, warm. Two bees in one minute in fifteen flowers. Twenty-five, twenty, fifteen seconds in a flower.

June 14, 1920, 1:30 and 5:30 p.m. Some bees. (L.H.P.)

June 15, 1920, a.m. After a shower. Bees two, two, ten, fourteen seconds in a flower. (L.H.P.)

June 5, 1922, Noon. Clear, south wind. Bees eleven, twelve, four, five, six, three, two, five, four seconds in a flower. Bees abundant collecting both pollen and honey. Three bees at work over three hundred flowers in two minutes. About fourteen hundred flowers on a single plant.

June 6, 1922, 1 p.m. Bees six, four, two, four seconds in a flower.

June 7, 1922, 9 a.m. Bees abundant. Four, three, four, six seconds in a flower. (L.H.P.)

June 11, 1922, 3:30 p.m. Clear, southwest wind. Bees six, five, three, two, six seconds in a flower. Towards the end of flowering season. Few bees at work. (L.H.P.)

July 10, 1923, 6 p.m. Warm and clear. Bees six, ten, twelve, five, four seconds in a flower.

June 14, 1924, 11 a.m. Bees abundant. Six, seven, eleven, ten, fourteen seconds in a flower. (L.H.P.)

May 21, 1925, 4:30 p.m. Dry. Bees twelve, fourteen, sixteen seconds in a flower. (L.H.P.)

May 27, 1925, 4 p.m. Bees abundant. Twelve to twenty-one seconds in a flower.

May 30, 1925, 8 a.m. Bees six, six, one, one, one, two, seven, fourteen seconds in a flower. (L.H.P.)

Manhattan, Kansas, May 17, 1927, noon. Clear, sunshiny. Bees four, four, six, seven, five, five, four seconds in a flower.

Ames, May 30, 1927, 11:30 a.m. Bees three to five seconds in a flower.

June 1, 1927, 1 p.m. Cloudy, cool, damp. A few bees. Four, five, six, seven, five, twelve seconds in a flower. (L.H.P.)

June 4, 1927, 1 p.m. Bees abundant. Twelve, ten, five, six, eight seconds in a flower. (L.H.P.)

June 6, 1927. Sunshiny, cool, north wind. Bees abundant. Four, six, four, six seconds in a flower. (L.H.P.)

June 15, 1927, 11 a.m. to 12 m. Warm, sunny, windy. In one hour fifty-two honey bees and two small bees. Bees fifteen seconds in a flower.
Bee visits to a single flower some seconds apart; flowers not immediately visited by another bee. (C.C.L.)

June 17, 1927, 10 a.m. Sunshiny. Bees five, two, four, five, three, six seconds in a flower. (L.H.P.)

June 27, 1927. Bees go from flower to flower quite rapidly. Six, six, five, six, five seconds in a flower. (L.H.P.)

June 15, 1928, 7:30 p.m. Warm. A few bees. Ten, twelve, twelve, ten seconds in a flower. (L.H.P.)

June 17, 1928, 11:30 a.m. Bees abundant. Six, eight, six, four, three seconds in a flower. (L.H.P.)

June 5, 1929, 1:30 p.m. Numerous bees. Splendid honey plant. Six, eight, six, nine, eight, seven seconds in a flower.

Rolfe, June 11, 1929. Bees six to four seconds in a flower.

Manson, June 11, 1929, 5 p.m. Bees six, six, five, four, six seconds in a flower.

Ames, June 18, 1929, 4:30 p.m. Bees four to six seconds in a flower.

Blooming dates: 1925, Lansing, May 1. 1927, Ames, June 1.

Rubus occidentalis L. Black Raspberry

Cultivated throughout the state, and found on borders of fields and thickets, especially where the ground has been burned over. The long recurving stems are glaucous and bear hooked prickles. Leaflets 3, ovate-pointed, downy beneath, coarsely toothed, the lateral ones stalked. Flowers in close umbel-like clusters, petals shorter than sepals. Fruit purple-black, ripe at midsummer.

FIG. 163.—Wild black raspberry (*Rubus occidentalis*). *Drawn by A. Hayden.*

Sandy, gravelly or clay soils, associated with *Quercus rubra, Carya ovata, Quercus alba, Phlox divaricata, Aquilegia canadensis, Arisaema triphyllum, Viola pubescens, Viola cucullata.*

Charles Robertson says, "The flowers grow in quite inconspicuous clusters, and open in succession. The honey secreting ring between the outer pistils and inner stamens is more readily accessible than in *R. villosus.*"

During some years this is a very valuable honey plant, as the record of bee visits at Ames shows.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Auburn, Clarksville, Dubuque, Estherville, Granite, Lansing, Ledges, Marion county, Palo Alto county, Stratford, Waukon Junction (L. H.

Pammel), Algona (R. I. Cratty), Ames (R. E. Jeffs, J. V. Ellis), Arnolds Park (L. H. and H. E. Pammel), Cedar Rapids (R. E. Buchanan), Colfax (F. P. Sipe), Missouri Valley (H. B. Clark), West Union (Emma Hancock and L. H. Pammel).

It has been observed (L. H. Pammel) at Albia, Burlington, Cedar Falls, Cedar Rapids, Centerville, Charles City, Cherokee, Clinton, Colfax, Council Bluffs, Davenport, Decorah, Des Moines, Eldora, Emmetsburg, Fort Dodge, Hamburg, Iowa City, Keokuk, Knoxville, Lake Okoboji, Lineville, Mason City, Marshalltown, McGregor, Muscatine, Osage, Postville, Red Rock, Sioux City, Smithland, Steamboat Rock, Waterloo, Webster City, Winterset.

General distribution for the United States and Mexico:

Delaware—New Stanton (Wm. M. Canby); Indiana—Nashville (John S. Wright); Maryland—Ridgeville (L. H. Pammel); Massachusetts—Newton, Lower Falls (Grace Gilbert); Mexico—Oaxaca (C. G. Pringle); Minnesota—Star island, Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), Pipestone (L. H. Pammel); Missouri—Kansas City (Kenneth K. Mackenzie), St. Louis (H. Eggert); New York—Ithaca (H. E. Summers, Muenscher and Bechtel); South Dakota—Sioux Falls (L. H. Pammel); Virginia—Smyth county (John K. Small); Wisconsin—Merrill (L. H. Pammel and V. C. Fisk), Galesville, La Crosse, Prairie du Chien (L. H. Pammel), Jeffreys Treble (J. H. Schuette), Geneva (George W. Carver), La Crosse county (L. H. Pammel); Wyoming—Dome Rock (B. Shimek), Raw Hide Butte (F. G. Miller).

HONEY BEE VISITS

McGregor, May 3, 1918, 3 p.m. Cloudy. Bees working on this plant. (L. H. P.)

Boone, May 26, 1920. Bees abundant. (L.H.P.)

Ledges, Boone county, May 21, 1921. Some honey bees. Numerous wild bees.

May 5, 1927, 5 p.m. Bees fairly common in flower. Two, one, one, two, three, four seconds.

May 30, 1927, 5:30 p.m. Bees common. Two in seventy-five flowers in three minutes. Four, five, six, eight, ten seconds in a flower.

Eldora, June 5, 1927, 4 p.m. Clear, warm. Bees abundant. Four, five, six, three, three, four seconds in a flower.

Ames, June 7, 1927, 6 p.m. Clear, warm. Quite a few bees. Six, five, four, five, six, five seconds in a flower. (L.H.P.)

June 3, 1929, 5:30 p.m. Bees abundant in sunshine, none in shade. Six, six, eight, eight, six seconds in a flower.

June 5, 1929, 12:30 p.m. Past its prime. Numerous honey bees. Splendid honey plant. Bees five, six, four, eight, eight, six seconds in a flower.

Rolfe, June 11, 1929. Six, six, ten, six, eight seconds in a flower. (L.H.P.)

Rubus odoratus L. Purple Flowering Raspberry

An ornamental form with showy purple flowers. Not native to Iowa. Frequently cultivated.

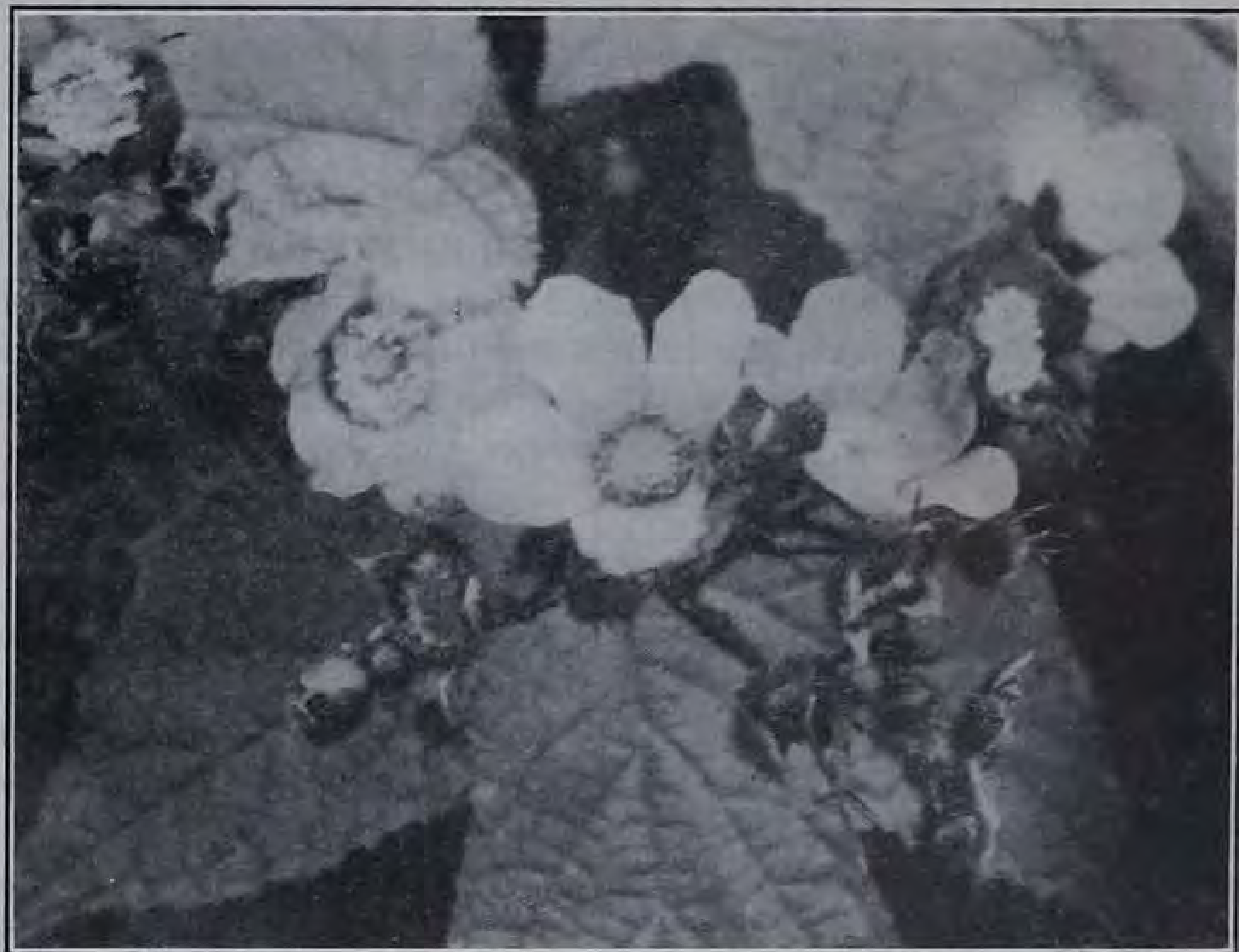

FIG. 164.—Purple flowering raspberry (*Rubus odoratus*). *Photo by Ada Hayden.*

General distribution in the United States and Canada:

British Columbia—Stanley Park (L. H. Pammel); District of Columbia—Washington (Ed Hyde); Kentucky—Bell county (T. H. Kearney, Jr.); Michigan—Marquette (two specimens, L. H. Pammel and V. C. Fisk); Missouri—St. Louis, Missouri Botanical Garden (John Kellogg); New Hampshire—Hanover (C. H. Hitchcock); New York—Cooperstown (Mrs. L. M. Parker), Ithaca (W. Muenscher and A. R. Bechtel, H. E. Summers), Niagara Falls (G. H. Frazier), Olcott (Miss S. L. Goodspeed), Watkins Glen (L. H. Pammel); Ohio—Fairfield county (Asa Horr); Vermont—East Corinth (H. S. Kellogg).

HONEY BEE VISITS

Ames, Campus, July 1, 1927, 10 a.m. Cool and cloudy. Bumble bees at work; fly to *Diervilla Lonicera.* (C.C.L.)

June 16, 1928, 1:30 p.m. Cool. Some bees. Eighteen, twenty, fourteen seconds in a flower, getting pollen. (L.H.P.)

Rubus parviflorus Nutt. Salmon Berry

A shrub with three- to five-lobed leaves mostly reniform. Petioles slightly pubescent. Flowers in dense corymb. Sepals broadly ovate. Flowers white.

Cultivated as an ornamental shrub in some parts of the state.

It is freely visited by honey bees.

Rubus allegheniensis Porter. Mountain Blackberry

A shrubby form with stout prickles. Stems more or less erect, one to six feet high, prickles strong; leaflets three to five, ovate, pointed, their lower surface and stalks hairy, glandular, velvety beneath. Flowers white, rather large, in leafy racemes. Fruit oblong. The old canes become purplish.

FIG. 165.—Blackberry (*Rubus allegheniensis*). Flower clusters. *Photo by Ada Hayden.*

Everywhere along thickets on black or loamy soils. Associated with *Solidago nemoralis, Aster azureus, A. laevis, Lespedeza capitata, Cassia Chamaecrista and Geranium maculatum.*

Pellett states that in the southeastern states it is a valuable honey plant of the genus and this confirms the observations of the senior author made in Florida, Georgia and Alabama. Pellett also states that farther north the nectar yield is not as good and in some localities bees do not get much honey from this source.

Lovell states that in New England there is very little nectar available from either wild or cultivated blackberries. The senior author's observations are that in some seasons it yields considerable nectar and is widely visited by bees in Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Madrid (two specimens), Mason City, North McGregor, Osage, Rochester (L. H. Pammel), Clermont (E. R. Walker), College Park (Ames) (Fred Rolfs), Fraser (L. H. Pammel and R. I. Cratty), West Union (Emma Hancock and L. H. Pammel).

General distribution in the United States:

Illinois—Bluffs near East St. Louis, E. St. Louis (H. Eggert), Sugar Grove (Bruce Fink); Louisiana—Alexandria (C. R. Ball); Minnesota—St. Paul (Dr. Gmelin); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Baltimore (Asa Horr); Wisconsin—Kilbourne (L. H. Pammel).

FIG. 166.—Same species showing leaf.

FIG. 167.—Blackberry (*Rubus allegheniensis*). *Photo by Miss Sheldon, Davenport.*

HONEY BEE VISITS

McGregor, May 3, 1918, 3 p.m. Cloudy. Bees working on this plant. (L.H.P.)

Ames, May 22, 1921, 6:30 p.m. Clear, warm. On three hundred flowers six honey bees. Five, six, seven, seven, six, five seconds in a flower. (L.H.P.)

May 25, 1921, 8:30 p.m. On three hundred flowers ten bees. Eight, seven, six, seven, six seconds in a flower. (L.H.P.)

June 5, 1922, 12 m. Bees five, three, two seconds in a flower. Two hundred flowers on single cane. Flowering season passing. (L.H.P.)

Manhattan, Kans., May 16, 1927, 5 p.m. Clear, sunshiny. Bees abundant. Three, four, five, four, three seconds in a flower. (L.H.P.)

Ames, May 29, 1927, 8 a.m. and noon. Cool, cloudy. No bees. (L.H.P.)

May 30, 1927, 11:30 a.m. Bees abundant, getting pollen and nectar. Bees three to seven seconds in a flower.

May 31, 1927. Bees two, one to four seconds in a flower.

1 p.m. Clear. Bees six, six, five, four, three, four, five seconds in a flower.

Boone, May 31, 1927, 4 p.m. Sunshine, no wind. Bees numerous. Bees six, four to eight seconds in a flower.

Eldora, June 5, 1927, 4 p.m. Clear, warm. Bees four, four, six, five, four, five seconds in a flower. (L.H.P.)

Rubus flagellaris Willd. Dewberry

The common dewberry, variable. Canes bearing prickles. Flowers one-third to one inch across.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

(Identified by M. L. Fernald) Madrid, North McGregor, Rochester (L. H. Pammel), Ames (Fred Rolfs), Clermont (E. R. Walker), northeastern Iowa (Herbert Goddard), Osage (R. I. Cratty).

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); Georgia—Camp Gordon (D. C. Poshusta); Maryland—Ridgeville (L. H. Pammel); Michigan—Houghton, northern Michigan (L. H. Pammel); Missouri—Jefferson Barracks, Washington (L. H. Pammel), St. Louis (H. Eggert); Newfoundland—Topsail (C. D. Howe and W. F. Lang); Pennsylvania—Spruce creek (L. H. Pammel); Wisconsin—LaCrosse (L. H. Pammel).

Rubus pergratus Blanchard. Blackberry

An erect form. Old canes strong, purplish, with stout prickles. Fruit short, cylindrical.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Fairbank, Indianola, Maquoketa, Otter creek, Warren county (L. H. Pammel), Ames (Geo. W. Carver), Decorah (E. W. D. Holway), Fayette (B. Fink), Osceola (F. C. Stewart).

Rubus argutus Link. Blackberry

Stems upright, recurving, copiously armed with stout prickles. Leaflets 5, smooth above, pubescent below. Flowers white, in prickly racemes. Fruit thimble-shaped. An American species included in the blackberry group.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
(Identified by M. L. Fernald) Fort Dodge (F. C. Stewart).

General distribution in the United States:
Florida—Duval county (A. Friedholm); Mississippi—Ocean Springs (S. M. Tracy).

Rubus Andrewsianus Blanchard. Erect Blackberry

With erect or arched branches, old canes stout, purplish, with stout prickles. Leaves pubescent with fine, sharp serrations. Flower stems woolly to bristly; flower two-thirds inch across. Fruit short, cylindrical, large.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
(Identified by M. L. Fernald) Farmington (L. H. Pammel).

General distribution in the United States:
Alabama—Montgomery (L. H. Pammel); Wisconsin—Holmen (L. H. Pammel).

Rubus villosus var. *humifusus* T and G. Dewberry

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
(Identified by M. L. Fernald) Keokuk (L. H. Pammel).

FIG. 168.—Blackberry (*Rubus villosus*). *Photo by Ada Hayden.*

Rosa (Tourn.) L. Rose

A group of many cultivated and more or less hardy shrubs. Stems prickly, leaves unequally pinnate; stipuled. Native species white to red in color, with crimson fruits.

The flowers are perfect with stamens and pistils. There is an abundance of pollen without nectar, although in some of the species there is a ring which simulates a nectary. Sometimes the flowers are pollinated automatically. Self pollination is said to occur in some of the species. In one species, *Rosa cinnamomea*, cinnamon rose, the leaves, as well as the flowers, are fragrant. The flowers are pinkish in color. Hermann Mueller records a nectary which occurs upon the broad margin of the receptacle. The flowers are slightly proterogynous. The structure of the flowers of the other species is not essentially different. They are freely visited by a large number of insects and this is particularly true of the prairie rose, *Rosa setigera*, which is one of the valuable pollen producing plants in Iowa.

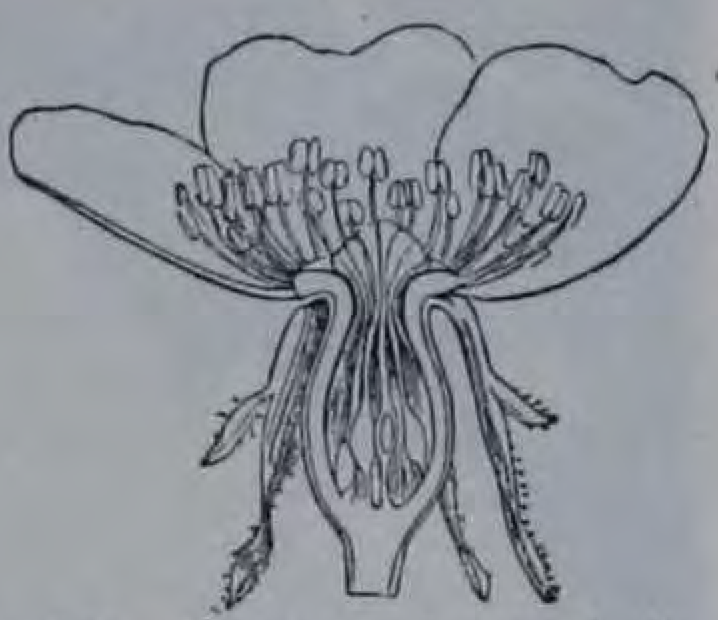

FIG. 169.—Perigynous flower of the rose. Three petals shown. Calyx reflected. Stamens attached to the calyx lobe.

Rosa cinnamomea L. Cinnamon Rose

Bush six feet in height. Flowers red, fragrant.

HONEY BEE VISITS

Ames, June 18, 1929, 2 p.m. Bees twelve, fourteen, fourteen seconds in a flower.

Rosa setigera Michx. Climbing Rose, Prairie Queen Rose

The stems of this rose are climbing and are armed with stout prickles; leaflets 3 to 5, ovate, acute, downy beneath; stalks and calyx glandular; flowers corymbed, sepals pointed. Petals deep rose-colored changing to white. Fruit globular. Grows in borders of prairies and thickets, Ontario west to Nebraska, south to Texas.

In Iowa only in southeastern part of the state in prairie thickets and borders of woods. Associated with *Lespedeza capitata, Aster laevis, Solidago serotina, Zizia aurea, Helianthus grosseserratus.*

The prairie rose of southern Iowa is of regular form with numerous stamens. No nectar is secreted, although it is abundantly visited by honey bees for pollen.

This rose is valued as an ornamental.

FIG. 170.—Prairie queen rose (*Rosa setigera*). Showing three stages of flowers.

General distribution in the United States:

Illinois—Red Bud (L. H. Pammel), St. Clair county (H. Eggert); Indiana—Upton (McDougal and Wright), Wells county (Charles C. Deam); Massachusetts—Gloucester (Mr. and Mrs. L. Blundell); Missouri—Columbia, Pilot Knob, St. Charles (L. H. Pammel); North Carolina, Georgia and Florida—(S. B. Buckley); Ohio—Castalia, Kelley's Island (L. H. Pammel), Mansfield (E. Wilkinson).

HONEY BEE VISITS

Ames, July 2, 1918. These roses have been a mass of bloom for two weeks. The flowers at first deep in color, becoming paler. Honey bees visit the bright blossoms freely, in the mornings 8 to 10. On cloudy days they visit the flowers after 12. (L.H.P.)

June 24 to 27, 1919. Bees gathering pollen. (L.H.P.)

July 2, 1919. Morning. Partly cloudy.

4 p.m. No bees at work on the rose, although busy on sweet clover at the same time. (L.H.P.)

July 3, 1919, 7:30 a.m. South wind. Clear. Honey bees gathering pollen. One bee visiting eight flowers in a minute. (L.H.P.)

July 4, 1919. Conditions as on the third. Bees gathering pollen. Not numerous. One bee visits nine flowers in a minute. On a cluster of 150 flowers in two minutes, three bee visitors. (L.H.P.)

July 5, 1919, 8 a.m. Some dew. Clear. One bee visits four flowers in a minute. Another visited seven flowers in a minute. Some time consumed in search for good flowers with pollen. (L.H.P.)

July 7, 1919, 8 a.m. Cold, raw east wind. One bee visits ten flowers in a minute. (L.H.P.)

June 24 to 27, 1920. Honey bees gathering pollen.

July 2, 1920, 5 p.m. No bees. (L.H.P.)

July 3, 1920, 5 p.m. Not many bees. Bees getting some pollen from *R. setigera.*

July 5, 1920, a.m. After a rain. Bees abundant. (L.H.P.)

July 7, 1920, 9:15 a.m. Sunshiny, little wind. Warm. Time in flowers eighteen, twenty-five, thirty, thirty-five seconds. Bees collecting pollen. Five bees on fifty flowers in one minute. Seven bees on sixty flowers in one minute. (L.H.P.)

July 8, 1920, 5:30 p.m. In four minutes no bees. (L.H.P.)

July 13, 1920, 12:15 p.m. Partly cloudy. Time in flowers, fourteen, twenty, fifteen, twenty, fifteen seconds, after pollen. Three bees in six flowers in one minute. (L.H.P.)

July 14, 1920, 8 a.m. Many bees.

6 p.m. No bees. (L.H.P.)

July 2, 1921, Noon. Partly cloudy, moderately warm. Was rainy at 8 a.m. Four honey bees working about one bush. Twelve, ten, nine, ten, eight seconds in a flower.

6:30 p.m. Cool breeze. One bee observed getting pollen. Flowers slightly fragrant. (C.M.K.)

July 3, 1921, 7:30 a.m. Mild breeze. Two bees getting pollen.

12 m. Sunshiny, breeze. Many bees at work.

6:30 p.m. Mild breeze, cloudy. Few bees (C.M.K.)

July 4, 1921, 8 a.m. Mild, damp, some breeze. Several bees.

12 m. Cool, clearing. Many bees.

6 p.m. Several bees. (C.M.K.)

July 5, 1921, 8 a.m. Rainy. Two bees observed.

July 6, 1921, 8 a.m. Cloudy, not wet, mild. Several bees.

12 m. Several bees. Bees visit the newer blossoms. Stay from ten to fifteen seconds in a flower. (C.M.K.)

June 29, 1922, 12 m. Clear, hot. No bees.

6:30 p.m. Clear, warm. No bees.

June 30, 1922, 12 m. Partly cloudy after rain. Bees abundant. Six, eight, twelve, twenty seconds in a flower.

1:30 p.m. Bees two, two, four, twelve, fourteen seconds in a flower. Bees collecting pollen. Sometimes circle around the flower. Sometimes run across.

July 3, 1922, 9 a.m. Clear, cool, dry. Bees eight, eight, one, two, eight, twenty-two seconds in a flower.

July 6, 1922, 4 p.m. Rain all day. ''Lull,'' bees sixty, twenty-six, twenty-five seconds in a flower for pollen. (L.H.P.)

July 8, 1922, 8 a.m. Clear, cool. Dew. Bees eight, twelve, twenty-four, thirty-six seconds in a flower. Bees abundant. (L.H.P.)

July 10, 1922, 5 p.m. Bees twenty-nine, fifteen, thirty seconds in a flower. Collecting pollen. (L.H.P.)

Campus, I.S.C., June 10, 1923. Blossoming apparently set back a few days by the cutting back of the plants.

June 20, 1923. Flowers opening. A few bees very active.

June 22, 1923. Dry warm days. A few bees at work.

June 24, 1923, 8 a.m. Warm, dry, windy. No bees; later a few bees.

June 25, 1923, 8 a.m. Flowers opening freely; bright and cool from recent shower of previous night. Many bees at work.

June 30, 1923, 2 p.m. Bees getting pollen. Six, seven, six, six, five, six seconds in a flower.

July 1, 1923, 2 p.m. Partly cloudy. Bees "go around and around" in the flower collecting pollen. Six, twelve, twenty-seven, twelve seconds in a flower.

June 10, 1924, 9 a.m. Sunshiny, cool. Bees six, six, nine, ten, eleven, six seconds in a flower. (L.H.P.)

June 30, 1927. Clear, hot, southerly wind. No bees. (L.H.P.)

July 1, 1927, 9 to 11 a.m. Many bees at work. Flowers newly open. (C.C.L.)

July 1, 1927. Bees abundant. Ten, fourteen, fifteen, twelve, sixteen, five seconds in a flower. Bees gathering pollen. One bee per minute, sixty bees per hour, four hundred eighty bees per eight hours. (L.H.P.)

10 a.m. Partly cloudy, north wind. Bees one, one, one, one, one, one, one seconds in a flower. One bee visits thirty flowers; one bee visits twenty-five flowers. (L.H.P.)

July 1, 1927, 10:45 to 11 a.m. Bees make five visits to the flower getting pollen. (C.C.L.)

July 3, 1927, 12 m. Partly cloudy, cool. Bees abundant, eleven, twenty, fourteen, twenty, ten seconds in a flower. Three bees in one flower at the same time. Young flowers darker, older flowers pale in color. Four bees on same flower in five minutes. (L.H.P.)

July 4, 1927, 12 m. Bees fairly common, ten, five, fourteen seconds in a flower. (L.H.P.)

July 7, 1927, 8:30 to 9:30 a.m. Very dry, cloudy. Thirty-two visits to a flower in one hour. Bees very numerous. (C.C.L.)

July 10, 1927, 11 a.m. Clear, warm. Most of the flowers pale. No bees.

July 2, 1929. Bees abundant. Fourteen, sixteen, ten, twelve seconds in a flower.

1:30 p.m. Comparatively few bees on the same bush. Pollen largely removed. Bees more abundant when the flowers open in the morning.

July 3, 1929. Bees abundant. Twelve, fourteen, sixteen, twelve seconds in a flower. (L.H.P.)

July 7, 1929, 10 a.m. Bees ten, ten, twelve, ten seconds in a flower. Apiary one-fourth mile away. Fifty flowers in bloom. (L.H.P.)

July 9, 1929, 12:30 p.m. Some bees. Most abundant pollen supply where flowers had just come in bloom. Four, ten, eight, eight, ten seconds in a flower. (L.H.P.)

July 10, 1929, 8 a.m. Bees fairly common. Twelve, twelve, four seconds in the flowers. Flowers just coming into bloom with darker colored petals than those of the previous day. Pink in color. (L.H.P.)

July 10, 1929. The opening flowers are bright pink. The stamens are ready to shed their pollen. The flowers one day old are pale pink in coloı and have shed most of their pollen. These have little visitation by bees. The older flowers are nearly white and the stamens have become reflexed toward the center. These flowers have lost their odor and the anthers have dehisced. Bees do not frequent these flowers. (A. Hayden.)

July 11, 1929, 8 a.m. Bees visited only the young flowers—pink petals. The flowers of the day before are light pink and not visited. Four, ten, ten, fourteen, six seconds in a flower. (L.H.P.)

12:15 p.m. No bees. (L.H.P.)

FIG. 171.—Prairie rose (*Rosa pratincola*). *Drawn by Ada Hayden.*

July 12, 1929, 8 a.m. Some moisture on plants following rain. Bumble bees abundant. No honey bees. Only on pink flowers. (L.H.P.)

July 17, 1929. Partly cloudy. Honey bees numerous, also several *Bombus*. Twelve, ten, twelve seconds in a flower. (L.H.P.)

July 18, 1929, 8:15 a.m. Four, four, eight, four seconds in a flower.

Rosa pratincola Greene. Prairie Rose

The common rose of Iowa prairies, with low, very prickly stems. Stipules narrow, glandular-toothed; leaflets 7 to 11, broadly elliptical, subcuneate at the base, firm in texture, strongly veined, simply toothed. Flowers corymbose, sepals rarely hispid.

In prairie soils, gravel knolls, calcareous prairie soils, alluvial bottoms. Associated with *Desmodium canadense*, *Aster sericeus*, *A. laevis*, *A. azureus*, *Solidago nemoralis*, *S. speciosa*, *Helianthus scaberrimus*, *Solidago rigida*, *Rudbeckia hirta*.

The prairie rose is abundantly visited by bees. The flowers are regular, large and attractive. Stamens numerous. No nectar is secreted.

FIG. 172.—Prairie rose (*Rosa pratincola*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eagle Lake, Granite, Ledges (Boone county), Missouri Valley, Rockford, Storm Lake (L. H. Pammel), Fayette, Volga river (B. Fink), Armstrong (two specimens), Osage (R. I. Cratty), Hanlontown, Worth county (L. H. Pammel and MacCorkindale), Ames (two specimens, F. A. Sirrine, J. C. Blumer, G. W. Carver), Anita (Lyle Clapper), Arnolds Park (L. H. and H. E. Pammel), Battle Creek (E. G. Preston), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (H. Goddard), Eagle Grove (R. E. Buchanan), Garner (L. H. Pammel and Winifred Gilbert), High Bridge (Boone county) (G. M. Lummis), Kelley (two specimens) (Pearl Clayton), Little Rock (two specimens) (C. R. Ball), Okoboji (L. H. Pammel and H. S. Coe), Plymouth (Oliver F. Brown), Steamboat Rock (C. M. King).

General distribution in the United States:

Missouri—Jackson county (Kenneth K. Mackenzie); Nebraska—Halsey (J. C. Blumer), Lincoln county (two specimens, F. G. Miller), Sheridan county (R. E. Buchanan); South Dakota—Brookings (Edna C. Pammel), Graceville (L. H. Pammel), Hitchcock (H. Goddard), Spearfish canyon (C. M. King); Wisconsin—Prescott (Mary Edgar).

HONEY BEE VISITS

Ames, June 20, 1914. Chicago & North Western railway right-of-way. Cloudy, hot, Flowers badly eaten by beetles, *Strigodemma* and *Rhychites*. (G.H.M.)

McGregor, May 3, 1918. Bees at work on this plant. (L.H.P.)

June 5, 1919. Honey bees seventeen, twenty-one, twenty seconds in a flower. (L.H.P.)

Ames, June 6, 1919, 8 a.m. Dew. Flowers partly open. The bee in a flower, ten to twenty seconds.

June 12, 1919, 8:15 a.m. Bees abundant. (L.H.P.)

May 27, 1920. Bees common on the flowers. (L.H.P.)

June 3, 1920. Honey bees abundant.

June 7, 1920. Honey bees getting pollen. Thirteen, twenty-two, twenty-five seconds in a flower. (L.H.P.)

June 8, 1920. Bees twenty-two, twenty-three, twenty-two seconds in a flower. (L.H.P.)

June 12, 1920. Bees four, six, seven, ten seconds in a flower. (L.H.P.)

July 7, 1923, 9 a.m. Honey bees abundant, getting pollen. Eleven, three, four, eight, ten, nine seconds in a flower. The time in the flower depends upon the depth of color in the flower. (L.H.P.)

5:30 p.m. No honey bees; bumble bees frequent the rose. (L.H.P.)

July 11, 1924, 9 a.m. Bees visiting the new darker flowers, never the faded ones. One bee in a flower one and a quarter minutes. The bee would proceed around the interior of the flower, gathering the pollen, then fly up, and return. Second bee three-quarters of a minute, third bee one-half minute in a flower. Bumble bees sometimes took possession of the flowers on which the bees worked, crowding out bees. (L.H.P.)

May 8, 1927, 1 p.m. Warm. Slight wind. Only a few bees. Seven, eight, seven, seven seconds in a flower. (L.H.P.)

June 7, 1927, 1 p.m. Sunshiny. Warm. Bees very abundant and collecting pollen. Bees fourteen, twenty, sixteen, eighteen seconds in a flower.

June 9, 1927. Clear, south wind. Very few bees.

June 11, 1927, 8:30 a.m. Some bees. Six, six, seven, six, eight seconds in a flower. (L.H.P.)

June 14, 1927, 8 a.m. Bees abundant. Six, six, six, five, three, five, four seconds in a flower. (L.H.P.)

11 a.m. Bees gathering pollen. Six, six, four, three, four, three, four seconds in a flower.

12 m. Bees abundant. Three, three, six, seven, five, four seconds in a flower. (L.H.P.)

June 15, 1927. Many bees active. (L.H.P.)

June 16, 1927, 10:30 a. m. Bees abundant, getting pollen. Bees four, six, ten, six, four seconds in a flower. (L.H.P.)

Ames, July 4, 1927, 11 a.m. Bees eighteen, twelve, six, three, eighteen, twelve, eight, eight seconds in a flower. Flowers at first pinkish turning pale; bees select the deeper shades.

In bloom, Ames, May 29, 1925; Lansing, June 1, 1925; Ames, May 22, 1927; Denison, June 25, 1928.

Rosa blanda Ait. Smooth Wild Rose

The stems of this rose are $1\frac{1}{2}$ to 6 feet high, occasionally covered by numerous prickles, many unarmed. Leaflets 5 to 7 inches, thin, cuneate at base, serrate; flowers large corymbose or solitary. Sepals hispid, entire. General distribution is on rocks and shores, New England westward to Missouri.

Found in rocky places. Occurs with *Geranium maculatum, Phlox divaricata, Geum canadensis, Festuca nutans, Viola cucullata.*

Flowers regular, pale rose color. Stamens numerous. Much frequented by bees for pollen. Bees remain in the flower for considerable length of time.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Forest City, Harvey, Indianola, Lake Mills, Ledges (Boone county), Lime creek (two specimens), Madrid, Marion county, Mason City, Middle River, New Albin, Pisgah, Postville, Warren county (L. H. Pammel), Algona (two specimens, E. B. Watson), Clear Lake (R. I. Cratty), Colfax (F. P. Sipe), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), High Bridge (Boone county) (G. M. Lummis), Ledges (Boone county) (J. V. Ellis), Muscatine (L. H. Pammel and F. Reppert), northeastern Iowa (H. Goddard).

General distribution in the United States:

Illinois—Champaign (B. Fink), Cheltenham Beach, Chicago, Graceland (L. H. Pammel); Michigan—Isle Royal (two specimens, E. W. D. Holway), St. Ignace (L. H. Pammel); Minnesota—Lake City, Leach Lake, Walker (L. H. Pammel), Brainerd (E. B. Watson), Itasca county (J. H. Lundberg), Star Island (D. C. Poshusta); Pennsylvania—State College (L. H. Pammel); South Dakota—Brookings (L. H. Pammel), Spearfish canyon (C. M. King); Utah—Logan canyon (Isabel Mulford); Vermont—Royalton (W. W. Eggleston); Wisconsin—Bellevue, Brown county (five specimens), Cook's Oaks, Green Bay (three specimens), La Crosse, Lily bay (two specimens), Port Howard marsh, Sturgeon bay (two specimens) (L. H. Pammel).

HONEY BEE VISITS

Ames, June 5, 1919. Honey bee spending seventeen, twenty, twenty-one seconds in a flower. (L.H.P.)

June 6, 1919, 8 a.m. Dew. Flowers partly open. Bee spends ten, thirteen, seventeen, twenty seconds in a flower. (L.H.P.)

12 m. Cloudy. Bee spends eighteen, twelve, twenty-six seconds in a flower.

June 12, 1919, 8:15 a.m. Bees abundant.

June 3, 1920. Honey bees abundant. (L.H.P.)

June 7, 1920, 9 a.m. Honey bees getting pollen. Thirteen, twenty-two, twenty-five seconds in a flower. (L.H.P.)

June 8, 1920. Bees twenty-two, twenty-three, twenty-two seconds in a flower. (L.H.P.)

June 12, 1920. Bees four, six, eight, ten seconds in a flower. (L.H.P.)

June 13, 1920, 8:30 a.m. Bees abundant. (L.H.P.)

May 23, 1921, 8:30 a.m. Cloudy, warm. Bees taking pollen only. Five, seven, three, five, six, seven seconds in a flower. (L.H.P.)

May 25, 1921, 12:30 p.m. Bees collecting pollen. Two, three, four, five, six seconds in a flower. (L.H.P.)

May 27, 1921, 8 a.m. Bees abundant. Two to five seconds in a flower.

May 29, 1922. Bees abundant. Fifteen, twenty, fifteen, twenty-five seconds in a flower. (L.H.P.)

May 31, 1922. Cloudy, abundance of rain preceding week.

2:30 p.m. Bees fifteen, twenty-five, fifty, twenty-five, fifty seconds in a flower. Securing honey. (L.H.P.)

June 1, 1922, 8:30 a.m. Partly cloudy. Bees abundant. Fifteen, twenty-five, thirty seconds in a flower. (L.H.P.)

June 5, 1922, 11 a.m. Bright, clear. Many bees collecting pollen. (L.H.P.)

June 30, 1923, 2 p.m. Bees collecting pollen. One, two, three, eight seconds in each flower. (L.H.P.)

May 28, 1927, 1 p.m. Clear, sunshiny. Not many bees. Twelve, fourteen seconds in a flower. (L.H.P.)

June 2, 1927. Warm. Partly cloudy. Bees abundant. Eleven, fourteen, twelve, fourteen, ten, four seconds in a flower. (L.H.P.)

June 4, 1927, 11 a.m. Warm, sunny. Bees abundant. Three bees in five minutes in a single flower. Bees, fifteen, twenty, twenty-five, sixteen, six, five, ten, twenty-one seconds in a flower. (L.H.P.)

June 7, 1927. Sunshiny, warm. Bees collecting pollen in a curious, rapid, frantic manner. Twenty-five seconds in a flower.

June 13, 1927. Cloudy. Cool. Bees abundant. Collecting nectar.

June 15, 1927, 10 a.m. Bees getting pollen. Ten, twelve, fourteen, sixteen seconds in a flower. (L.H.P.)

Rosa rugosa Thunb. Japanese Rose

This valued ornamental is generally cultivated in many sections of the state. The bush is large and spreading, the stems are densely clothed with long, stout spines; leaflets 7 to 11, round ovate, thick, dark green above and tomentose below, coarsely toothed; the stipules leafy. Flowers large, mostly single, white or red. The fruit large, nearly globular, orange red. Bloom continues from June through the season.

General distribution in the United States:

Illinois—Chicago (L. H. Pammel); Wisconsin—LaCrosse (L. H. Pammel).

HONEY BEE VISITS

Ames, June 4, 1920. Clear. Bees getting pollen only. Two, four, six, eight, ten seconds in a flower. (L.H.P.)

June 9, 1920, 9 a.m. Bees abundant on hybrid roses.

June 10 and 20, 1920. Honey bees and bumble bees getting pollen.

June 5, 6 and 7, 1923. Clear and bright. Bees numerous, collecting pollen.

May 7, 1927, 1 p.m. Sunshine, warm. Bees twenty-five, twenty, twenty-five seconds in a flower. (L.H.P.)

May 8, 1927, 1 p.m. Warm, slight wind. Some bees. Ten, eight, six, twelve seconds in a flower. (L.H.P.)

June 2, 1927. Warm, partly cloudy. Two bees in four minutes in the same flower. Two hundred forty bees per day a fair estimate. Bees twelve, fourteen, four, eight, twenty-one, fourteen, ten seconds in a flower. (L.H.P.)

June 3, 1927, 4 p.m. Cool, cloudy. No bees.

June 4, 1927, 10 a.m. Cool. Bees collecting pollen only. Eight bees in five minutes, or about ninety-six bees in eight hours. Bees two, eight, fourteen, eleven, twenty-two, twenty-five, thirty seconds in a flower. Bees tumble about in flower. (L.H.P.)

June 14, 1927, 11 a.m. Bees six to nineteen seconds in a flower.

June 16, 1927, 10:30 a.m. Bees thirty-seven, fifteen, twenty-four seconds in a flower. (L.H.P.)

Ames, June 5, 1929, 2 p.m. Warm. Bees very active. Twenty-six, twenty-four, eighteen seconds in a flower. (C.M.K.)

Blooming, Ames, May 24, 1924; May 12, 1925; June 1, 1926; May 25, 1927.

Rosa rubiginosa L. Sweet Brier

An erect shrub with hooked prickles with or without scattered smaller ones. Leaflets resinous and aromatic, doubly serrate. Flowers pink. A commonly introduced plant in Iowa.

Bees visit this species at Ames for pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clayton, Polk county, escape (L. H. Pammel), Ft. Dodge (F. W. Paige), south of Ames (R. I. Cratty).

General distribution in the United States:

Delaware— (Wm. M. Canby); Michigan—Green (Hansen), Muskegon (L. H. Pammel); New York—Ithaca (H. E. Summers); Nova Scotia—Gaspereaux Valley (Harriet L. Bailey); Ohio—Kelley's Island (L. H. Pammel); Oregon—Carson Heights (L. H. Pammel and W. S. Dudgeon), Corvallis (Otto Elmer); Wisconsin—Coon Valley (L. H. Pammel).

Rosa humilis Marsh

A slender shrub with straight, slender prickles. Outer sepals lobed.

Rosa cathayensis Bailey. Crimson Rambler

HONEY BEE VISITS

Ames, July 4, 1929, 11:30. Bees ten, twelve, ten seconds in a flower. Bees abundant. (L.H.P.)

July 4, 1929, 1:30 p.m. Bees gathering pollen. Four, three, twelve, ten, seconds in a flower.

Rosa sulphurea Ait. Yellow Rose

A slender shrub with hooked prickles. Flowers double, light yellow. Leaflets five to nine, obovate, pointed at apex, coarsely toothed, more or less glaucous, smooth and slightly pubescent below. Light yellow petals, glabrous. This species is commonly cultivated in gardens. Has occasionally escaped from cultivation in Iowa.

HONEY BEE VISITS

Ames, May 7, 1927, 1 p.m. Sunshine, warm. Few bees. (L.H.P.)

May 8, 1927, 1 p.m. Warm, slight wind. Some bees. Seven, six, five seconds in a flower for pollen. (L.H.P.)

Blooming, Ames, May 17, 1925.

Prunus (Tourn.) L.

Trees or shrubs with simple leaves bearing stipules. The fruit is a stone-fruit or drupe, in some species edible. Calyx bell-shaped. Petals five, white or rose-colored.

The nectar is secreted in the receptacle. In some cases the stamens and pistils are homogamous, but in many cases they are proterogynous. Sometimes there is as much as two days' interval between maturity of stamens and pistils. In some species the stamens are attached to the calyx tube and the stigmas project beyond the inner stamens while the outer ones are at the same level. In some species the odor of the flower is pronounced. In the common cherry, particularly in the later stages, there is a bitter almond (cyanogenetic) odor.

"Honey bees are frequent visitors, both sucking nectar and collecting pollen." ABC of Bee Culture.

Prunus serotina Ehr. Wild Black Cherry

Tall tree, reddish brown branches, inner bark aromatic; leaves oblong, taper pointed, serrate, thickish, shining. The small white flowers are borne in racemes. Petals obovate. Fruit purplish black. Nova Scotia to Florida, west to Dakota and Arizona.

FIG. 173.—Black cherry (*Prunus serotina*). *M. M. Cheney in Green's Forestry in Minnesota.*

The wild black or rum cherry is widely distributed in upland woods, in clay, black and gravel soils.

Widely distributed in clay soils of glacial drift hills in Winnebago county along upland streams. Also widely naturalized in black prairie soils along fence rows in Pocahontas and Palo Alto, Story and Boone counties.

Associated with *Quercus macrocarpa, Prunus virginiana, Populus tremuloides, Prunus americana, Pyrus ioensis, Juglans cinerea, Anemone nemorosa, Claytonia virginica.*

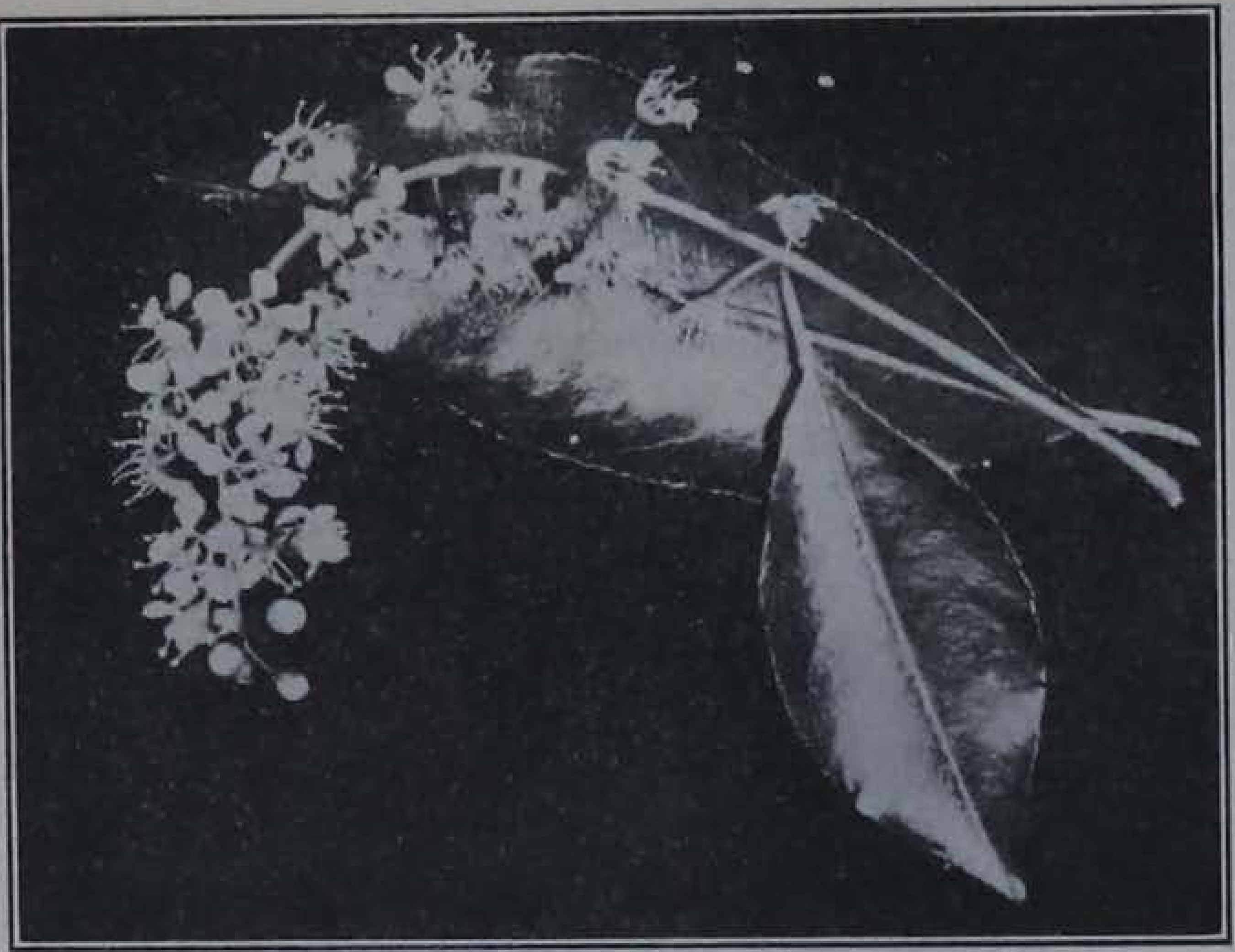

FIG. 174.—Wild black cherry (*Prunus serotina*). *Photo by S. G. F. Sheldon.*

Charles Robertson says, "The receptacular tube forms a shallow cup, the inner wall of which secretes nectar. The nectar is readily accessible to short lipped insects, the style and stamens forming a very trivial obstruction in the way of the guests.

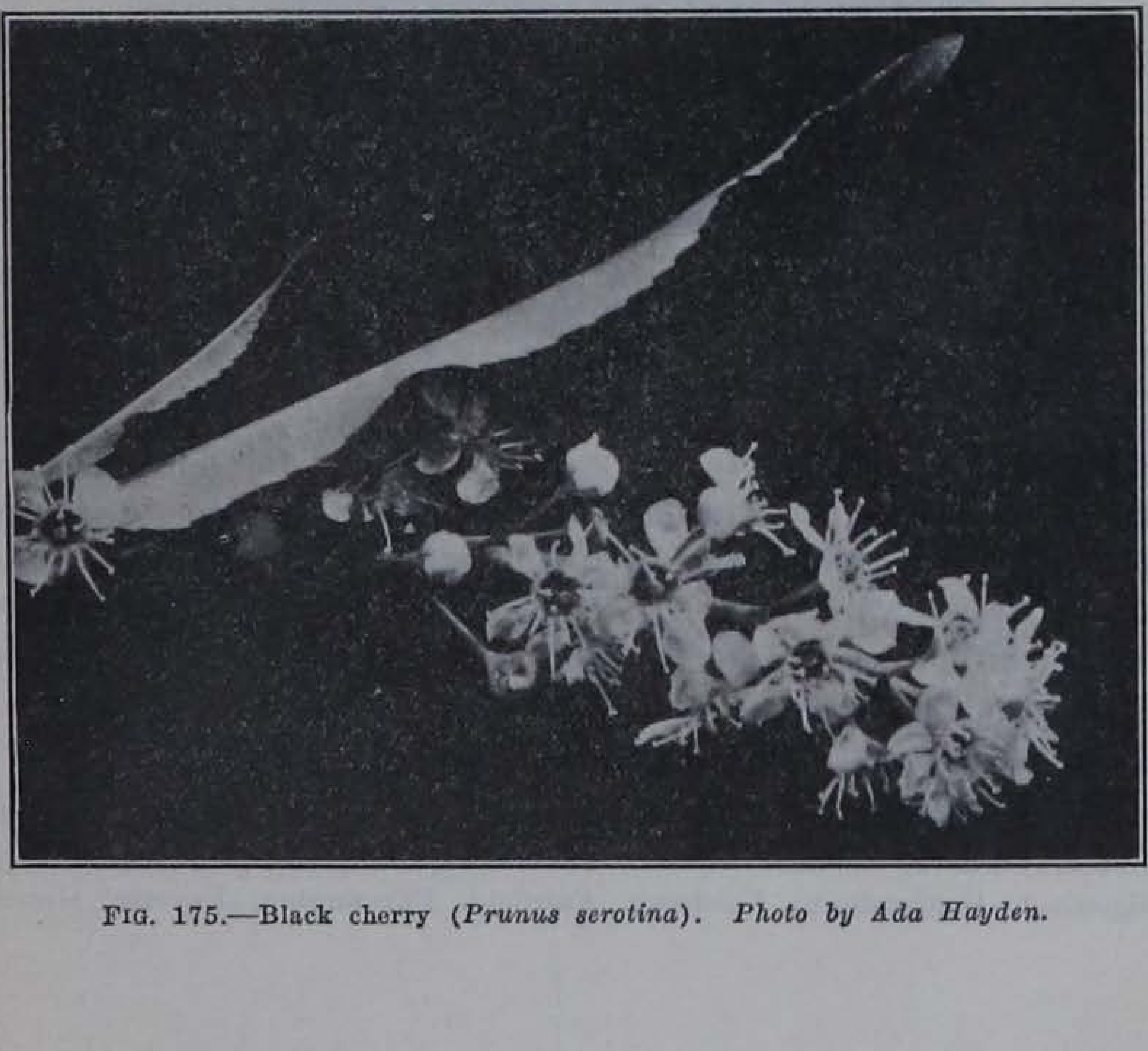

FIG. 175.—Black cherry (*Prunus serotina*). *Photo by Ada Hayden.*

This species blooms later than *P. americana*, April 25 to May 23 (southern Illinois), and has more exposed nectar. The honey bee is among the insect visitors collecting nectar and pollen."

Honey bees are abundant at some times, at other times scarce. The wild cherry furnishes considerable nectar. When the flowers are old, there is a strong hydrocyanic odor which bees do not like.

FIG. 176.—A black cherry tree. "This tree, growing in the open, has developed a shorter stem and broader crown than it would have developed in a stand of timber. The cherry naturally develops a straight clear stem and a small crown." (By Scott.) *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

The authors have made many observations of the flowers of this species as a honey producing plant. The period of blooming is very short. It does furnish some nectar. For instance bees were numerous at Ames toward the end of May, 1929, and were abundant on a number of species in Florida and other states where the blooming period is much longer.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Atlantic, Beaman, Buffalo creek, Centerville, Charles City, Clarinda, Clinton, Cordova, Council Bluffs, Pammel Park, Dubuque, Eagle Rock, Edgewood, Emmetsburg, Fairbank, Fairfield, Farmington, Fayette, Greene, Harvey, Johnson, Keokuk, Keosauqua (four specimens), Lake Mills, Lamont (two specimens), Lime creek, Lime Springs, Link creek, Liscomb, Lost Island lake, Manchester, Maquoketa, Marion county, Marshall county, Mason City, McGregor, Mormon Ridge, Mount Zion, Muscatine, Otter creek, Pike's Peak (McGregor), Pilot Knob (Hancock county), Red Rock, Rowley, Shenandoah, South river, Steamboat Rock, St. Olaf, Stratford, Strawberry Point, Tete des Morts, Traer, Warren county, Waterloo, Webster City (two specimens), Winterset (L. H. Pammel), Ames (R. E. Buchanan, Edna C. Needham, E. R. Hodson, L. H. Pammel and R. Combs, G. W. Carver, H. Sage), Charles City (Mrs. F. M. Tuttle), Council Bluffs (three specimens, L. H. Pammel and H. B. Clark), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Fraser (L. H. Pammel and R. I. Cratty), Hamburg (L. H. Pammel and C. B. Clark), Keosauqua (three specimens, L. H. Pammel and G. B. MacDonald), Ledges (Boone county) (L. H. Pammel and C. R. Ball), Mount Pleasant (H. E. Jaques), Postville (O. Schultz), Rice Lake (L. H. Pammel and A. L. Bakke), Rome (L. H. Pammel and J. Kelso), Salem (H. E. Jaques, L. H. Pammel and G. B. MacDonald), Shell Rock (E. S. Fyler), Union (J. P. Anderson), West Union (Emma Hancock and L. H. Pammel).

General distribution in the United States:

Alabama—Auburn, Birmingham (L. H. Pammel); Connecticut—New Haven (W. H. Mast); Delaware—New Castle county (Wm. M. Canby); District of Columbia—Washington (H. E. Pammel, E. A. Hyde); Florida—Gainesville (L. H. Pammel); Illinois—Galena (L. H. Pammel), Kankakee (R. I. Cratty), Pecatonica (L. H. Pammel and V. C. Fisk), Peoria (E. F. McDonald), Starved Rock (L. H. Pammel and Mark Heavenhill); Indiana—Crawfordsville (W. H. Evans); Kansas—Wyandotte county (Kenneth K. Mackenzie); Kentucky—Harlan county (T. H. Kearney, Jr.); Louisiana—Baton Rouge (L. H. Pammel); Maryland—Forest Glen, Ridgeville (L. H. Pammel); Massachusetts—Stockbridge (H. S. Kellogg); Michigan—Merriweather, Muskegon, Whitehall (L. H. Pammel); Minnesota—Bemidji, Cass Lake, Grand Marais, Wadena (L. H. Pammel); Missouri—Cabanne, Columbia, Kansas City (L. H. Pammel), Rockport (A. O. Simonds); New York—Bronx (L. H. Pammel), Ithaca (Muenscher and Bechtel); New Durham (A. C. Hexamer and F. W. Maier); Ohio—Put-in-Bay, Sandusky (L. H. Pammel); Worthington (Asa Horr); Pennsylvania—Towanda (L. H. Pammel); South Carolina—Oconee county (five specimens, A. P. Anderson); Virginia—White Top Mountain (two specimens, John K. Small); Wisconsin—Beloit, Forest county, Holmen, Kilbourne (two specimens), Onalaska, Prairie du Chien (L. H. Pammel), North Racine (L. H. Pammel and V. C. Fisk), Platteville (L. H. Pammel and B. B. Zimmerman), St. Croix Falls (L. H. and H. E. Pammel).

HONEY BEE VISITS

Toledo, May 17, 1915. No bees. One Syrphus. (L.A.K.)

Ames, May 15, 1915, 10 a.m. Clear and cool. A few bees. Two, three, three, four, three, two seconds in a flower.

May 18, 1921, 6 p.m. Clear, windy. Numerous bees. One, two, one, two, one seconds in a flower. (L.H.P.)

May 27, 1923. Partly cloudy. Three to six seconds in a flower.

Winterset, May 22, 1924, 3 p.m. Clear, warm, strong odor. No bees. (L.H.P.)
Ames, May 23, 1927, 10 a.m. Clear, southeast wind. Bees abundant. Six, five, four seconds in the flowers. Odor of amygdalin.
5 p.m. Clear, windy. A few bees. Three, two, three seconds in a flower.
May 28, 1927, 1 p.m. Clear, warm. Some bees. Two, three, four, five, seven seconds in a flower. (L.H.P.)
May 27, 1929. In full bloom. Bees abundant. Three, three, four, three, four seconds in a flower. (L.H.P.)
Eldora, May 21, 1929. Some bees. (L.H.P.)
Ames, May 25, 1929. Some bees.

Blooming dates, Ames, May 14, 1925; Eldora, May 21 to 30, 1929.

Prunus virginiana L. Choke Cherry

A small tree, with grayish bark, found throughout the state. Leaves oval, abruptly pointed, sharply serrate with slender teeth, thin. Flowers in racemes, appearing after the leaves, late in spring. Petals roundish; fruit red turning a dark crimson, astringent.

FIG. 177.—Choke cherry (*Prunus virginiana*). *Drawing by Ada Hayden.*

The choke cherry is widely distributed in rich woodland slopes, on clay, rocky and sometimes sandy soil. Frequent in rocky limestone hills of Iowan and Wisconsin drift soils, and in shady slopes of Missouri loess bluffs. Widely naturalized in black and prairie soils. Associated with *Corylus americana, Cornus alternifolia, C. asperifolia, Pyrus ioensis, Smilacina racemosa, Viola pubescens, Phlox divaricata, Claytonia virginica, Podophyllum peltatum.*

Like the wild black cherry the choke cherry furnishes some nectar, but the period of blooming is longer and like the black cherry the flowers have a strong odor of bitter almond and this odor seems more or less objectionable to bees.

Frank Pellett made a study of cherry honey obtained by Mr. Pangburn and stated that it had a distinct cherry taste and was bright yellow in color, showing no trace of granules. Varieties in

FIG. 178.—Choke cherry (*Prunus virginiana*). *Photo by Ada Hayden.*

the northern states which bloom just before the time of the opening of white clover should prove worth while where present in quantities.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Allamakee county, Cedar Rapids, Centerville, Cresco, Dillon, Fayette, Fraser, Gillett Grove, Greene, Howard county, Jefferson, Kelley, Keokuk, Lake Okoboji, Lamont (two), Lime Springs, Liscomb, Little Rock, Marquette, Muscatine, Oelwein, Pike's Peak (McGregor), Postville, Rowley, South Dakota (opposite Hawarden), Stratford, Tete des Morts, Walnut creek, Wapsipinicon river, Webster City, Winterset, Yellow river (L. H. Pammel), Algona, Osage (R. I. Cratty), Eagle Lake, Garner (L. H. Pammel and Winifred Gilbert), Ames (G. W. Carver, L. H. Pammel and Edna Pammel Needham, A. A. Miller), Des Moines (L. H. Pammel and Emma Pammel Hansen), Fayette (C. C. Parker), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), Maquoketa (S. H. Blunt), Missouri Valley (L. H. Pammel and H. B. Clark), northeastern Iowa (H. Goddard), Ottumwa (Jessie Peters), Rockford (Mr. and Mrs. Webster), Spirit Lake (two specimens) (L. H. Pammel and H. E. Pammel), Waukon Junction (O. Schultz).

General distribution in the United States:

Alabama—Birmingham (L. H. Pammel); Colorado—Larimer county (C. S. Crandall), Littleton (L. H. Pammel), Wady Petra (Virginius R. Chase); Massachusetts—Hammond's Pond, Waltham (L. H. Pammel), Blue Hills Reservation (Mr. and Mrs. L. L. Blundell), Stockbridge (Harriett Kellogg); Michigan—Whitehall (L. H. Pammel); Minnesota—Anoka, Cannon Falls, Cass Lake, Itasca Park, Norway Beach, Ortonville, Pike's Bay, South Huron (two specimens), Wadena (L. H. Pammel), Backus (Ada Hayden), Brainerd (two specimens, E. B. Watson), Duluth (two specimens, L. H. and H. E. Pammel), International Falls (M. C. Ghostly), Star Island (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (R. Gmelin), Wildwood (Lois Pammel); Nebraska—Halsey, Pine Ridge (two specimens, J. C. Blumer), Blair (H. B. Clark); New York—Geneva, Watkin's Glen (L. H. Pammel), Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Pickerington (Asa Horr); Pennsylvania—Gettysburg, State College, Towanda (L. H. Pammel); South Dakota—Brookings, Lake Tetonkeha (N. E. Hansen and L. H. Pammel), Sioux Falls, Spring Creek (L. H. Pammel), Mitchell (B. Fink); Wisconsin—Appleton Junction, Fond du Lac, Forest county, Galesville (two specimens), Holmen (two specimens), La Crosse, Madison, Mouth of Kickapoo river, Portage, Prairie du Chien, St. Charles, St. Croix Falls, Oshkosh (Mrs. Joseph Clemens).

HONEY BEE VISITS

Ames, May 8, 1914, 9:30 a.m. Cool north wind. No bees. 10:30 a.m. A few bees.

May 13, 1914, 10 to 12 m. Clear, moderate temperature, north wind. Fair quantity of insects. (L.H.P.)

May 17, 1914. Southeast wind. On 200 flowers in one minute; no bees, two black flies, one large black bee, other flies, in all fifteen insects. Odor noticeable seventy-five feet. (L.H.P.)

April 25, 1915, 10:40 a.m. South wind. In five minutes on 250 flowers; no honey bees, a number of small Hymenoptera. (L.H.P.)

May 7, 1915. Many Diptera and various insects about the flowers. Odor strong. (L.H.P.)

Toledo, May 13, 1915. Many bees and very numerous small pollen-gathering Andrenidae. (L.A.K.)

Ames, May 13, 1915, 11 a.m. Southwest wind. On 250 flowers in five minutes; two small Hymenoptera, no bees. (L.A.K.)

May 3, 1916. College orchard. Many *Apis* and yellow-faced *Andrena*, a *Bombylius*, another fly. (L.A.K.)

Mr. Pellett of Atlantic noticed in 1914 and 1915 that one of his plum trees was visited by "wild bees" only. Observations this year reveal both *Apis* and "wild" forms. The "wild" forms are pollen gatherers. They do not take sustained flights, and their value as pollinators is less than that of *Apis*.

May 25, 1917. Cool, cloudy, windy. Bees common. (L.H.P.)

May 9, 1919, 2 p.m. Bright, clear. A few small bees and flies. No honey bees. (L.H.P.)

May 16, 1922, 8:30 a.m. Clear, warm. Bees abundant, collecting nectar. One, two, four, four, three, two, three seconds in a flower. Number of flowers on a small tree eight feet high, 50,750. Strong cyanogenetic odor from blossoms. Bees in some cases seemed dazed. (L.H.P.)

Winterset, May 22, 1924, 3 p.m. Clear. Warm. No honey bees. Strong amygdalin odor. Diptera abundant. (L.H.P.)

May 13, 1929, 2 p.m. Many bees. Strong cyanogenetic odor. Three, four, three, four seconds in a flower. (L.H.P.)

May 17, 1929, 9:30 a.m. No honey bees. Many Diptera and small

Hymenoptera. Strong odor of bitter almonds or amygdalin, known as cyanogenetic odor. (L.H.P.)

Blooming date, Ames, 1925, April 20; 1927, April 25.

Prunus demissa Walp. Western Choke Cherry

The western choke cherry is now generally recognized to be the same as the common choke cherry. It is a small plant, blooms later and the leaves are somewhat smaller. Obovate or acuminate leaves with fine serrations. The fruit is black and astringent. This species is found throughout the Rocky Mountain country. Probably, however, *P. demissa* is the northwestern type while the Rocky Mountain type is known as *P. melanocarpa*. We have seen specimens in Colorado, New Mexico, North Dakota, Wyoming and Saskatchewan, while *P. demissa* was found in British Columbia, California, Oregon and Washington.

Prunus demissa is sometimes cultivated in Iowa and is visited by honey bees.

Prunus Padus Linn. Small Bird Cherry, May Day Tree

A small tree with thin, oval, pointed leaves and white fragrant flowers in long, loose, drooping, many-flowered racemes. Cultivated in Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

(Iowa specimens are cultivated) Ames (E. R. Hodson, F. Sirrine, F. C. Stewart, P. H. Rolfs), Blencoe (W. D. Bassett), Des Moines (L. H. Pammel).

HONEY BEE VISITS

Des Moines, May 3, 1919. Cold, raw. In full bloom. Some bees flying about tree. (L.H.P.)

Ames, May 4, 1918. Trees in full bloom. (L.H.P.)

May 2, 1921, 12 m. Moderate. No bees. (L.H.P.)

April 28, 1927. Sunshiny, southeast wind. Only a few bees; many other Hymenoptera. Bees two, two, two, one seconds in a flower. (L.H.P.)

May 10, 1928, 5 p.m. Bees abundant. Fourteen to twenty seconds in a flower.

May 3, 1929, 1 p.m. Cool. Not many bees. Six, four, four, five, five seconds in a flower. (L.H.P.)

May 6, 1929, 2 p.m. Fair. No bees. Strong cyanogenetic odor. (L.H.P.)

Blooming dates, Ames, 1925, April 20; 1926, May 1.

Prunus pennsylvanica L. Wild Red or Pin Cherry

A tree 15 to 30 feet high, with light red-brown bark, leaves oblong, lanceolate pointed, finely and sharply serrate, shining, green and

FIG. 179.—Wild red cherry (*Prunus pennsylvanica*). Drawn by *Ada Hayden*.

smooth on both sides. Flowers many in a cluster, on long pedicels; fruit globose, small, light red. Flesh sour. Rocky woods and clearings, Labrador to British Columbia, south to Pennsylvania, Great Lakes region, central Iowa, and along the mountains to Colorado.

Clay banks, sandy soil of Iowan and Wisconsin drift areas, along streams, on borders of woods and in limestone rock soils in northern Iowa. The species does not extend much south of Ledges, Boone county. A few plants still left there. Thence it extends northwestward to Clay county. Associated with *Phlox divaricata, Geranium maculatum, Smilacina stellata, Viola cucullata, Viola glabrescens.*

The pin cherry is a valuable nectar producing plant. The honey is secreted inside of the calyx tube. This species produces a great deal of nectar and is of considerable value in northeastern Iowa, where it is more abundant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belmond, Boone, Cedar Heights, Backbone Park (Delaware county), Forest City, Lake Mills, Ledges (Boone county) (two specimens), Madrid, Marshall county, Mormon Ridge, Palisades (Linn county), Squaw creek, Steamboat Rock, Story county line, Stratford, Strawberry Point, Traer, Waterloo, Waterville, Wheelerwood (L. H. Pammel), Webster county, Woodman's Hollow (F. Horton), Ames (F. Rolfs, C. R. Ball), Boone county northeast of Fraser (two specimens, L. H. Pammel and R. I. Cratty), Centerville (F. Trenk), Decorah (E. W. D. Holway), Fayette (B. Fink), Ledges (Boone county, L. H. Pammel, R. E. Buchanan and C. M. King), Pilot Knob (L. H. Pammel and Winifred Gilbert), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson), Yellow river (L. H. Pammel, O. Schultz and E. Orr).

It has also been observed (L. H. Pammel) at Clermont, Cresco, Decorah, Fort Atkinson, New Albin, Peterson, Waukon.

General distribution in the United States:

Colorado—Golden, Larimer county, Rist's Canyon (L. H. Pammel), near Fort Collins (C. S. Crandall), Palmer's Lake (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); Idaho—(C. A. Davis); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Michigan—Detroit, St. Ignace, Whitehall (L. H. Pammel), Alexandria (C. R. Ball), Gogebic (Mrs. Joseph Clemens), Mackinac (R. I. Cratty); Louisiana—Alexandria (C. R. Ball); Minnesota—Norway Beach, Pike's Bay, Wadena, Wilmer (L. H. Pammel), Cass Lake, Star Island (L. H. and H. E. Pammel and P. S. McNutt), Brainerd (E. B. Watson), Duluth (two specimens), International Falls (H. S. Kellogg); New York—Ithaca (Muenscher and Bechtel); Pennsylvania—Altoona (L. H. Pammel); Wisconsin—Bloomingdale, Holmen, Prairie du Chien (L. H. Pammel), Green, Wausau (L. H. Pammel and V. C. Fisk).

This species is freely visited by honey bees in Iowa. Is more common in northeast Iowa than in the central part.

Blooming dates, Ames, 1924, May 7; 1926, May 10; 1927, May 25. Lansing, May 12, 1927.

Prunus angustifolia Marsh. Chickasaw Plum

A small thorny tree. Leaves lanceolate, glabrous, acute. Flowers in lateral umbels. Drupe red.

BEE VISITS

Waco, Texas, March 17, 1929, 3 p.m. Bees five to seven seconds in a flower.
Dallas, Texas, March 19, 1929, 3 p.m. Twelve, fourteen, fourteen, sixteen seconds in a flower. (L.H.P.)

Prunus Cerasus L. Morello and Early Richmond Cherries

The garden cherry is a low-headed tree with spreading grayish branches. The flower clusters are from lateral buds along the branches, in advance of the leaves. Leaves firm, obovate, the point abrupt, the leaf somewhat glossy; the fruit roundish, various, red, tart.

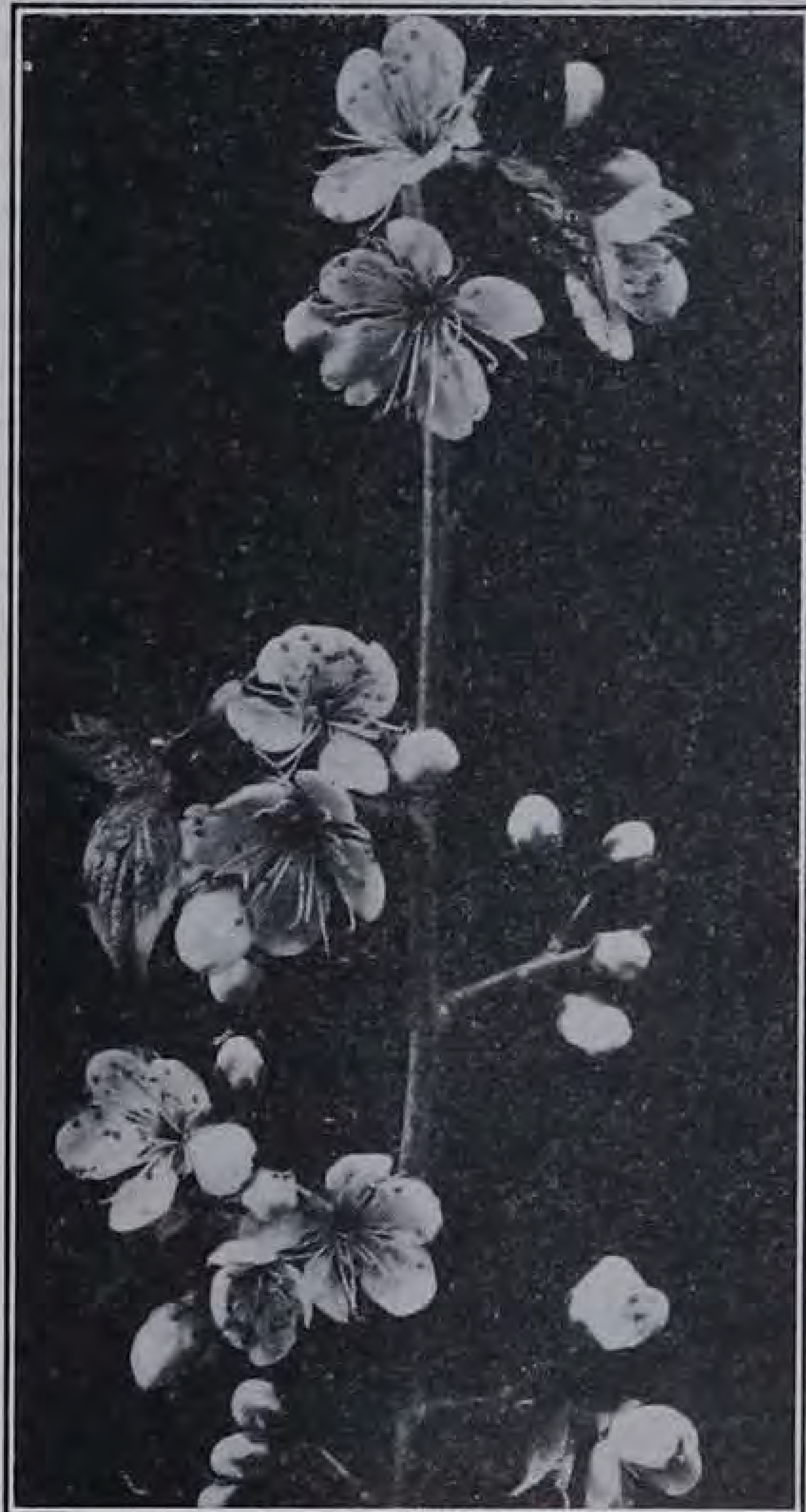

FIG. 180.—Cultivated cherry (*Prunus Cerasus*). *Photo by Ada Hayden.*

The cultivated cherry is frequently visited by honey bees, which are important in pollination.

The cherry furnishes a great deal of nectar, which is secreted by the sides of the calyx cup. It is especially attractive to bees.

Pollen continues in fresh condition for seven or eight days.

HONEY BEE VISITS

Ames, May 8, 1914, 9:30 a.m. Cool. No insects.

11:15 a.m. Bees returning. (L.H.P.)

May 10, 1914, 10 a.m. 80°. Clear, east wind. On 500 flowers in eight minutes; six bees and ten other Hymenoptera.

10:15 a.m. Sunshiny, slight east wind. Bees collecting nectar. Many flowers have evidently been visited before. Time in a flower four, four, two, five, three, two, four, two, seven, two, nine, thirty seconds. The bee alights either upon a petal or upon the stamens. (L.H.P.)

2:08 p.m. Sunshiny. Two bees and three other Hymenoptera observed about the flowers. Time the bees remain in a flower, two to thirty seconds, collecting nectar which appeared in shining globules on the cup-shaped calyx-tube. Stamens maturing at same time as pistil.

May 13, 1914. Cloudy, cool, northwest wind. Bees inactive, stiff with cold. (L.H.P.)

April 25, 1915, 10:40 a.m. Southwest wind. No bees.

11 a.m. Southwest wind. On 100 flowers; one bee, two flies and three small

Hymenoptera. Time in flower two to thirty seconds. The cherry is being less visited than the plum. (L.H.P.)

April 26, 1915, 7 a.m. Cloudy. Drops of rain. No insects. (L.H.P.)

June 26, 1917. Cloudy, rainy. Some bees working. (L.H.P.)

Des Moines, May 3, 1919. Cold and somewhat raw. Cherry in full bloom. Some bees flying. (L.H.P.)

Ames, May 12, 1919. Sun obscured. Warm, good breeze. Numerous bees.

May 13, 1919, 11 a.m. Bright, sunny. Marston tree. A few bees. Time in flower two to six seconds. Beyer tree, bees numerous, time in flower same. Period bees attracted to cherry blossom about 8 to 10 days in length. (C.M.K.)

May 10, 1920, 9 a.m. Sun after shower. Southeast breeze. Numerous bees at work upon a group of trees about 300 feet from the hive. Bees get both pollen and nectar. The air full of the humming of bees, one bee five seconds in a flower; seem to prefer the flower that is one day old. Upon a group of trees a quarter of a mile from hive, bees numerous. (C.M.K.)

May 11, 1920, 11 a.m. Cool. East wind, cloudy. On cherry tree near hives. No bees. (L.H.P.)

May 13, 1920, 11 a.m. Sunshiny, warm. Many bees working, six, ten seconds in a flower. (L.H.P.)

May 14 and 15, 1920. Warm. Many bees.

May 19, 1920, 12:15 p.m. Time of bee in flower two to five seconds.

May 20, 1920, 8:15 a.m. Over 100 flowers, two bees in two minutes. Time in flower one, two, three, three, one, two seconds. Late bloom. (C.M.K.)

May 4, 1922. Westerly wind. Time in flower two, three, four, four, three, five seconds. (L.H.P.)

May 5, 1922, 8:20 a.m. Partly cloudy. South wind. Bees humming, busily gathering nectar and pollen. Time in flower three, two, three, four, three, two seconds. (L.H.P.)

1 p.m. Bees six, five, three, seven, one, two seconds in a flower. Bees abundant, both pollen and nectar being collected. (L.H.P.)

May 6, 1922, 9 a.m. Cool. Bees not very abundant, six, eight, four seconds in a flower. (L.H.P.)

May 7, 1922. Bees active, nectar and pollen being collected; principally nectar. Twelve, fourteen, six, eight, eight, nine seconds in a flower.

10:30 a.m. Bees collecting pollen, principally. Ten, twelve, seven, eight seconds in each flower.

12:15 p.m. Partly cloudy. Ten, twelve, eight, ten, ten seconds in a flower. Pollen and nectar being collected.

3 p.m. Slight rain. Some bees at work. Four, eight, six seconds in a flower. (L.H.P.)

May 9, 1922, 7:30 a.m. South wind. Small tree ten feet high, has 80,000 flowers. Two, four, six, two, four seconds in a flower. (L.H.P.)

May 10, 1922, 7:30 a.m. Blossoms falling. Two, two, two, one seconds in a flower. A few bees collecting pollen.

May 11, 1922, 8:30 a.m. Flowers almost gone. No bees. (L.H.P.)

May 13, 1923, 4 p.m. Clear, southwest wind. Tree past prime bloom.

Not many bees. Twelve, ten, five seconds in a flower. (L.H.P.)

April 28, 1924, 9 a.m. Heavy dew, clear. Flowers just open. Bees ten, eleven, twelve seconds in a flower. Some smaller Hymenoptera, a few Lepidoptera present. (L.H.P.)

May 2, 1924, 8 a.m. Bees abundant. Eleven, twelve, fourteen, nine, ten seconds in a flower. (L.H.P.)

May 3, 1924, 8 a.m. Cool, north wind. A few bees. Five, four, ten, twelve, five seconds in a flower.

May 4, 1924. Noon. Clear, warm. Bees less abundant than on pear; flowers at their prime. Bees two, four, three seconds in a flower. (L.H.P.)

May 5, 1924, 12:30 p.m. Warm, sunshiny. Flowers falling. Late for the cherry. Bees nineteen, ten, four, six seconds in a flower. (L.H.P.)

May 6, 1924, 8 a.m. Partly cloudy. Few bees. (L.H.P.)

May 7, 1924, 5 p.m. Cloudy, north wind. No bees. (L.H.P.)

May 8, 1924, 8 a.m. Cloudy, north wind. No bees.

10 a.m. Clear, north wind. Numerous bees. Four, six, four, five, six seconds in a flower. (L.H.P.)

Blairsburg, May 12, 1924. Some bees.

Little Wall Lake, May 16, 1924. Some bees at work.

Ames, May 9, 1926, 10:30 a.m. and 12:15 p.m. Dry and warm. No bees.

April 4, 1927, 10 a.m. Sunshiny, southeast wind. Only a few flowers open. Bees fairly common. In flower five to seven seconds.

May 1, 1927, 2 p.m. Warm, slight west wind. Bloom at height. Small Hymenoptera abundant. Bees six, ten, eight, nine seconds in a flower.

May 5, 1927, 1:30 p.m. Cool, west wind. No. bees.

May 3, 1928, 6 p.m. Cloudy, warm. Bees abundant. Five, four, ten, eight seconds in a flower. (L.H.P.)

Grinnell, May 5, 1928, 12:30 p.m. Bees not abundant. Six, seven, eight seconds in a flower. (L.H.P.)

Keosauqua, May 6, 1928, 9 a.m. Clear, slight breeze. Bees abundant. Eight, twelve, twelve, ten seconds in a flower. (L.H.P.)

Bloomfield, May 7, 1928, 1 p.m. Clear, warm. Four to six seconds in a flower.

Centerville, May 7, 1928, 2 p.m. Warm and clear. Tree injured by frost. A few flies. No bees.

Corydon, May 8, 1928, 4 p.m. Clear and warm. Bees four, six, ten seconds in a flower. (L.H.P.)

Ames, May 10, 1928, 5:30 p.m. Warm, cloudy. Bees twelve, sixteen, twelve, fourteen seconds in a flower.

Dallas, Texas, March 19, 1929, 3 p.m. Six, ten, twelve, fourteen, twelve seconds in a flower. (L.H.P.)

Oklahoma City, Okla., March 20, 1929, 3 p.m. Partly cloudy. No bees.

Fairfield, April 29, 1929, 5:30 p.m. Bees abundant. Twelve to fourteen seconds in a flower.

Ames, April 30, 1929, 12:15 p.m. Ten to eleven seconds in a flower.

May 3, 1929, 5 p.m. Cool. Not many bees. Twelve to fourteen seconds in a flower. (L.H.P.)

May 4, 1929, 8 a.m. Cool. No bees.

12:15 p.m. Warmer. Some bees. Six, six, six, six, six, eight seconds in a in a flower. (L.H.P.)

May 5, 1929. Cool, west wind. Eight, six, six, six, six seconds in a flower.

May 7, 1929, 12:15 p.m. Bees abundant. Ten, twelve, fourteen, twelve seconds in a flower. (L.H.P.)

May 8, 1929, 5 p.m. Only a few bees. Six, six, eight, six, eight seconds in a flower. (L.H.P.)

May 9, 1929, 8:30 a.m. No bees. (Hive next to cherry tree.)

May 9, 1929, 11:30 a.m. Fourteen, sixteen, eighteen, ten seconds in a flower. Maximum secretion of nectar when it is warm and strong sunshine.

Mason City, May 11, 1929, 1 p.m. Small tree. Average number of bees four in five minutes. Ten, six, eight, six seconds in a flower. (L.H.P.)

Ames, May 12, 1929, 10:30 a.m. Past prime. Bees two, ten, twelve, ten, eight seconds in a flower. (L.H.P.)

Ogden, May 12, 1929, 4:30 p.m. Clear. Only a few bees. Six, six, six, eight, four seconds in a flower. (L.H.P.)

Meservey, May 23, 1929, 6 p.m. Some bees, past prime. Bees four, six, five seconds in a flower. (L.H.P.)

May 24, 1929, 6:30 a.m. No bees. Heavy dew. Cold and clear.

12:15 p.m. Some bees. Bloom nearly over. (L.H.P.)

Blooming dates, Ames, 1924, April 26; 1926, May 1. Boone, 1924, May 5.

Prunus americana Marsh. American Plum

A tree three to ten feet high, armed, leaves narrow obovate, acuminate, sharply serrate, the teeth not glandular. Narrow petals about one inch long; calyx lobes hairy on inner surface; fruit subglobose, red when ripe, an inch to two inches in diameter. River banks and borders of woods, Connecticut to Florida and westward to Colorado.

The wild plum is widely distributed in Iowa in thickets, borders of streams, low lands, hillsides, borders between prairie and forest, in black, sandy and calcareous soils.

Associated with *Pyrus ioensis, Phlox divaricata, Podophyllum peltatum, Geum canadense* and *Geranium maculatum.*

FIG. 181.—American plum (*Prunus americana*). *Drawn by C. M. King.*

Charles Robertson says, "Nectar is secreted by the broad wall of the receptacular tube. The tube is somewhat contracted at the mouth and slightly obstructed by the bases of the filament.

The flowers are in bloom from April 15th to May 5th (southern Illinois); they are mainly visited by bees and flies."

The honey bee is recorded as a visitor collecting honey and pollen.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Alton, Centerville, Cherokee, Clarinda, Decatur county, Dubuque, Forest City, Hamburg, Indianola, Keosauqua, Lake Mills, Lineville, Little Rock (two specimens), Liscomb, Lost Island lake, Marshalltown, Oelwein, Pisgah, South Dakota (opposite Hawarden), Traer, Warren county (L. H. Pammel), Eagle lake, Garner (L. H. Pammel and Winifred Gilbert), Ames (L. H. Pammel and S. W. Beyer, L. Clapper, L. H. Pammel and C. R. Ball), Clear Lake (two specimens, R. I. Cratty), Colfax (P. Sipe), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Fort Dodge (F. C. Stewart), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), Mount Pleasant (H. E. Jaques), Oto (H. B. Clark), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson, O. Schultz), Salem (L. H. Pammel and G. B. MacDonald), Sioux City (H. B. Clark), Spirit Lake (L. H. and H. E. Pammel), Winneshiek county (H. Goddard).

The plant has also been observed (L. H. Pammel) at Adair, Adel, Bartlett, Boone, Carroll, Charter Oak, Crescent, Denison, De Soto, Earlham, Glidden, Grand Junction, Ida Grove, Jefferson, Loveland, Mapleton, Menlo, Moingona, Missouri Valley, Ogden, Onawa (naturalized), Pacific Junction, Scranton, Soldier, Stuart, Folsom, Turin, Wall Lake (naturalized), West Side, Winterset.

General distribution in the United States:

Colorado—Manitou, Dixon Canyon (C. S. Crandall), Fort Collins (L. H. Pammel), Golden (R. Duthey and I. W. Clokey); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill), Pecatonica (L. H. Pammel and V. C. Fisk); Indiana—Wills county (Charles S. Deam); Louisiana—Alexandria (C. R. Ball); Minnesota—Crookston (Mrs. R. O. Westley), Graceville (L. H. Pammel); Missouri—Dodson (B. F. Bush), Rockport (A. O. Simonds); Texas —Denison (two specimens, L. H. Pammel); Virginia—Saltville, Smyth county (John K. Small); Wisconsin—Prairie du Chien, St. Croix Falls (L. H. Pammel).

HONEY BEE VISITS

Ames, April 28, 1927. Sunshiny, southeast wind. Bees getting pollen and nectar. Bees four, six, five, eight, nine, eight, seven seconds in a flower.

May 1, 1927, 12 m. Bloom at height. Bees four, three, five, five, four, three seconds in a flower. (L.H.P.)

May 3, 1927, 8 a.m. Bees abundant. Eleven seconds in a flower.

May 5, 1927, 5 p.m. Few bees. Three, two, two, two seconds in a flower. 6 p.m. Partly cloudy. Bees five, six, eight, ten, eight seconds in a flower.

May 3, 1928, 1 p.m. Partly cloudy. Fairly warm, dry. Bees four, three, four, six, five seconds in a flower.

Grinnell, May 5, 1928, 12:30 p.m. No bees.
Keosauqua, May 6, 1928. Bees twelve, fourteen, sixteen, twelve, twelve seconds in a flower. (L.H.P.)
Bloomfield, May 7, 1928, 1 p.m. Clear, warm. No bees. A few blossoms left.
Ames, April 27, 1929, 12:30 p.m. Bees ten, ten, ten, twelve seconds in a flower. (L.H.P.)
Fairfield, April 27, 1929. Bees twelve to fourteen seconds in a flower.
Ames, April 30, 1929, 8:30 a.m. Bees go hurriedly from flower to flower. 12:15 p.m. Bees three, three, two, three, four, three seconds in a flower.
May 1 to 3, 1929. Cool, north wind. No bees.
May 4, 1929, 12:15 p.m. Warmer. Some bees. Two, two, two, three, two, three seconds in a flower (L.H.P.)
May 5, 1929. Cool, west wind. Few bees. Past its prime.
May 8, 1929, 12:15 p.m. Six, three, two, two, three seconds in a flower. 5 p.m. Only a few bees. Two, three, two, three, two seconds in a flower.
Mason City, May 11, 1929. Rather cool. Rain previous night. A few bees. Pollen and nectar. Bees on ten small trees. Average number of bees per tree in five minutes, four. Five, four, four, six, six seconds in a flower. 2:15 p.m. Small tree with 6000 flowers. Four bees in three minutes. Three, four, five, four, four seconds in a flower.
Meservey, May 23, 1929, 6 p.m. No bees. (L.H.P.)
May 24, 1929, 6:30 a.m. Heavy dew. No bees.
12:15 p.m. Some bees. Bloom nearly over. (L.H.P.)

Blooming dates, Ames, 1924, April 19; 1925, April 13; 1926, April 30; 1927, April 10. Lansing, 1925, May 3.

Prunus domestica L. Cultivated Plum

Small trees with showy fragrant white flowers in clusters appearing about the time of the leaves. Leaves ovate to obovate, serrate. Fruits oblong in outline with compressed stone.

The plum flowers from the latter part of April to early May, according to the advancement of the season. Bees visit the flowers for both honey and pollen.

The pollinators are chiefly the honey bee, other Hymenoptera and some Diptera.

Nectar is secreted by the broad wall of the receptacular tube.

General distribution in the United States:

Delaware—New Castle county (Wm. M. Canby); Indiana—Crawfordsville (L. H. Pammel); Michigan—Whitehall (L. H. Pammel); Ohio—Kelley's Island (L. H. Pammel); Utah—Ogden (L. H. Pammel and R. E. Blackwood); Virginia—Monticello (W. A. Taylor and L. H. Dewey).

HONEY BEE VISITS

Des Moines, May 3, 1919. Cold and raw. Trees in bloom. Some bees flying about. (L.H.P.)

FIG. 182.—European plum (*Prunus domestica*). *Photo by Ada Hayden.*

Ames, May 13, 1919. Moderate temperature. Trees in full bloom. Some honey bees. (L.H.P.)

May 10, 1920, 10 a.m. Sun after rain. Light breeze. A number of bees active. On a second group of trees one-fourth mile from hive a few bees. (C.M.K.)

FIG. 183.—European May Day tree (*Prunus Padus*). *Photo by Ada Hayden.*

Prunus Padus Linn. Bird Cherry, May Day Tree.

A small tree with thin, oval, pointed leaves and white fragrant flowers in long, loose, drooping, many-flowered racemes. Cultivated in Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Iowa specimens are cultivated. Ames (E. R. Hodson, F. Sirrine, F. C. Stewart, P. H. Rolfs), Blencoe (W. D. Bassett), Des Moines (L. H. Pammel).

HONEY BEE VISITS

Des Moines, May 3, 1919. Cold, raw. In full bloom. Some bees flying about.

Ames, May 4, 1918. Trees in full bloom.

May 10, 1920, 1 p.m. Cloudy, warm. Small bees, no honey bees.

May 11, 1920, 8 a.m. Cool, east wind. Trees in full bloom from Clinton to Ames. No bees. (L.H.P.)

May 20, 1920. Late bloom. Flowers fading. Very few honey bees. (C.M.K.)

April 24, 1921, 2 p.m. Raining slightly. Numerous bees.

May 2, 1921, 12 m. Moderate, no bees.

May 23, 1921, 5 p.m. Cloudy, windy. Bees abundant in sheltered trees. One, two, two, two, two, three, two, one seconds in a flower. Many other Hymenoptera. (L.H.P.)

May 5, 1922, 8:20 a.m. Slight wind. A few bees collecting pollen. Two, three, two seconds in a flower. (L.H.P.)

10 a.m. Warm and sunny. Several bees at work. (L.H.P.)

6 p.m. Not many bees, one bumble bee; many Hymenoptera; over 80,000 to 100,000 flowers on a good sized tree. Flowers slightly purple after opening.

May 7, 1922, 12:15 p.m. Partly cloudy. Few honey bees. Small Hymenoptera abundant. Bees remain six, six, four, five seconds in a flower.

Ledges, Boone county, May 1, 1924, 2 p.m. Bright, clear, fairly warm. Small Hymenoptera. No honey bees.

Ames, May 2, 1924, 8 a.m. Bees not abundant. Eight, nine, seven, three, two, four, five seconds in a flower. (L.H.P.)

May 3, 1924, 3 p.m. Slight north breeze. Bees abundant. (L.H.P.)

May 4, 1924, 10 a.m. Clear, warm. Bees two, four, three, ten, six, four, two seconds in a flower. (L.H.P.)

May 5, 1924, 6 p.m. Clear, warm, southwest wind. A few bees.

May 6, 1924, 8 a.m. Partly cloudy. Petals falling. A few bees. One, one, one seconds in a flower. (L.H.P.)

May 7 to 10, 1924. Cloudy, north wind. No bees.

Blairsburg, May 12, 1924. Some bees on plum, none on May Day tree.

Ames, April 28, 1927. Sunshiny, southeast wind. Only a few bees; many other Hymenoptera. Bees two, two, two, one seconds in a flower. (L.H.P.)

May 10, 1928, 5 p.m. Bees abundant. Fourteen to twenty seconds in a flower.

Blooming date, Ames, 1927, April 12.

Prunus (Hansen) Hybrid

Ames, May 1, 1927, 2 p.m. Bloom past height. No honey bees. Many small Hymenoptera. (L.H.P.)

Prunus pumila L. Sand Cherry

A prostrate shrub, with acute oblanceolate leaves, pale underneath. Flowers two to four in a cluster, fruit dark, red, without bloom, about one centimeter in diameter.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

"In sandy soil, east shore of Lake Okoboji, gravel knolls in northwestern Iowa, and along the Missouri River." L. H. Pammel.

General distribution in the United States:

Maine—Fort Kent (B. L. Robinson and M. L. Fernald); Minnesota—Cass Lake, Duluth, Norway Beach (L. H. and H. E. Pammel), Backus (A. Hayden), Minneapolis (C. M. King); Nebraska—Halsey (J. C. Blumer); Wisconsin—Galesville, Muscoda, Onalaska (L. H. Pammel).

Prunus tomentosa Thunb. Tomentose Cherry

Compact hardy small tree, with pubescent young growth. Fruit cherry-like, light red, slightly hairy.

HONEY BEE VISITS

Ames, April 30, 1929, 11 a.m. Clear. Bees ten to twelve seconds in a flower.

Prunus Besseyi Bailey. Western Sand Cherry

Shrub with spreading branches, three to five feet high; leaves oblong, acute, serrate; flowers in clusters, opening with the leaves; fruit one-half to three-quarters inch in diameter, almost black, astringent. Sand hills, Manitoba southward to Colorado and Wyoming. Blooms late in April and early in May in Iowa.

General distribution in the United States:

Colorado—Denver (I. W. Clokey), Fairview (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney).

HONEY BEE VISITS

Ames, May 6, 1918, 5 p.m. Bees abundant.
May 7, 1918, 5 p.m. Honey bees abundant.
May 10, 1920, 1 p.m. Warm and cloudy. Small bees, no honey bees.
May 19, 1929, 2 p.m. Few bees. Two to four seconds in a flower.

Prunus Persica (L.) Stokes. Peach

A small tree, leaves lance-oblong, attenuate, serrate. Flowers very early before the leaves; drupe with sculptured stone. Grown in southern third of the state of Iowa.

The bright red flowers secrete nectar concealed at the base of the receptacle. Honey bees are frequent. The honey of the peach is important in building up colonies in the spring in the region where peaches are grown.

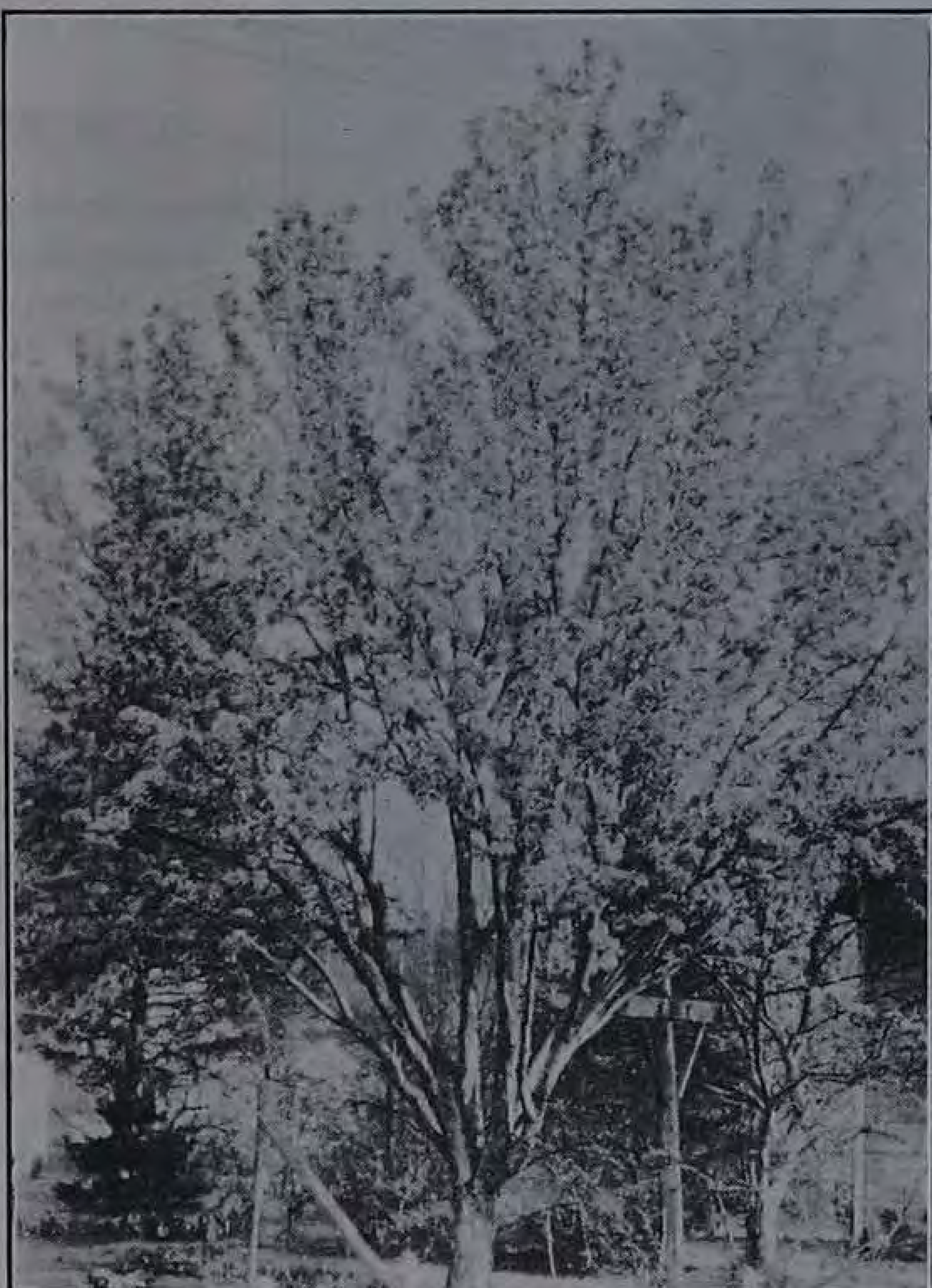

FIG. 184.—Peach tree in bloom at Ames. *Photo by Ada Hayden.*

This furnishes a very large amount of nectar from Florida to Texas and north through the peach growing district of Georgia and Alabama to Delaware. It is an unimportant source of nectar in Iowa because the peach is not commonly cultivated in this state.

Frank Pellett has made the comment that like most fruit trees the blooming period comes early before the bees are strong enough

FIG. 185.—Flowers of the peach. *Photo by Ada Hayden.*

to benefit to the fullest extent.

We have observed this year (1929) that the weather was quite inclement and the bees were not as frequent on the peach as they would be under more normal conditions.

HONEY BEE VISITS

Ames, April 19, 1919. One cluster of flowers visited by three bees in one minute. (L.H.P.)

April 28, 1927. Southeast wind, warm, sunshiny. Bees abundant. Fourteen, twelve, ten, six, seventeen, sixteen, fourteen seconds in a flower. Swarms of small Hymenoptera present. (L.H.P.)

The following plants were growing in proximity to *Prunus Persica*; *Pyrus communis, Prunus Padus, Ribes Grossularia, Taraxacum officinale.* Of these plants honey bees were abundant on *Pyrus communis, Prunus Persica* and *Prunus americana* only. A few bees visited *Prunus Padus,* and an occasional bee was seen on *Ribes.* (L.H.P.)

May 1, 1927, 2 p.m. Small bees abundant. Dark colored flowers most frequented. Bees ten, nine, eight, ten seconds in a flower. (L.H.P.)

May 2, 1927, 2 p.m. Visited most abundantly.

May 4, 1927, 1 p.m. Cold, west wind, cloudy. No bees. (L.H.P.)

Searsboro, May 5, 1928. Bees ten, eleven, nine, ten seconds in a flower.

Keosauqua, May 6, 1928, 10 a.m. Bees twenty-two, ten, twelve, sixteen, fourteen seconds in a flower. (L.H.P.)

East of Bloomfield, May 7, 1928, 1 p.m. Clear, warm. Bees four, six, eight, ten, eight, ten, twelve seconds in a flower. (L.H.P.)

Ames, May 12, 1929, 6 p.m. No bees.

May 14, 1929, 2 p.m. Bees abundant. Nine, seven, eight, ten, seven seconds in a flower. (L.H.P.)
Waco, Texas, March 17, 1929, 2:30 p.m. Bees ten to twenty seconds in a flower.
Fairfield, Iowa, April 27, 1929. Bees ten to twenty seconds in a flower.

Blooming date, Ames, 1927, April 29.

Prunus communis Fritsch. Almond

The almond is scarcely adapted to Iowa. However, it is occasionally cultivated. The tree is about the same size as the peach tree. Glabrous branches; flowers single, solitary and sessile; fruit edible.

The flowers are visited by honey bees.

Prunus nana Stokes. Russian Almond

Small bushes commonly cultivated. Smooth twigs and showy bloom. It is visited by honey bees.

HONEY BEE VISITS

Honey bees have been observed on this.
Ames, April 30, 1929, 11 a.m. Clear. Ten to twelve seconds in a flower.

LEGUMINOSAE, Pulse Family

The flowers with standard, wings, and keel; usually bright in color, and many of them fragrant. Stamens 10, pistil becoming a legume in fruit. Leaves alternate, with stipules; usually compound.

It has long been recognized that the flowers of this family, or most of them, are pollinated by insects and that the honey bee plays a very important part in the pollination of these flowers. A very large number of the plants of this family have irregular papilionaceous corollas. However, such types as the honey locust and the partridge pea have nearly regular flowers, which are fragrant and are attractive to insects. In a large number of the species the pistil and stamens mature at the same time, but in some cases the stamens mature first.

The flowers are rendered more conspicuous by their aggregation; that is, they are more or less clustered in the shape of heads or compact racemes. Heads as in the clovers, racemes as in the locust.

It is a really interesting fact also that in some closely related species the flowers are of different colors. For instance, this is well marked in the case of the clovers. The white clover (*Trifolium repens*) is white; the alsike (*Trifolium hybridum*) is rose-tinted;

the red clover (*Trifolium pratense*) is magenta to rose; the yellow hop clover (*Trifolium procumbens*) is yellowish. Of the two sweet clovers one is white and one is yellow. This is a distinct advantage to the insect because the bee will usually confine its visits to a single species of plant.

With reference to pollination, the calyx is gamosepalous and the petals are therefore held erect. The corolla consists of the following parts: the standard, above the two lateral wings, and the keel, consisting of two petals. The stamens and pistils are contained in the keel in the papilionaceous flowers. Some part of the flower usually contains a color slightly different and this serves as a nectar guide to insects.

The insect lights upon the keel, presses it down and the stigmas are pushed against its thorax. When the insect leaves the flower the stamens and pistil return to their former position.

Knuth has stated the method of pollination in general as follows:

"The carina is a protective structure, sheltering the stamens and pistils and keeping away unbidden guests (Lepidoptera and flies). When all ten filaments cohere, the flowers afford only pollen, but when the upper one is free, there is a slit on either side of it, leading to the nectar secreted inside the bases of the stamens. The closed or split cylinder formed by the filaments envelops the pistil, of which the style is usually upwardly curved at the tip, and projects somewhat beyond the anthers, so that the stigma first protrudes from the carina when an insect visits the flower, and first touches its under-side. Cross pollination therefore results if the insect has previously visited another flower of the same species. In some species the stigma is completely covered by the pollen of the same flower, but self-fertilization does not usually follow, for it becomes receptive only after visitors have rubbed against its papillae."

Delpino, the celebrated Italian ecologist, distinguishes four types of flower mechanism in this family with reference to pollination. One type, simple valvular arrangement, is represented by clover, the second type, explosive arrangement, by alfalfa, the third type, pump arrangement, by the lupines and the fourth type, brush arrangement, by pea and bean.

Gymnocladus Lam. Kentucky Coffee-tree

Medium sized tree with rough bark. Pinnately compound leaves. Flowers whitish, dioecious or polygamous, in racemes. Fruit a pod.

FIG. 186.—Coffee-tree (*Gymnocladus dioica*). 1. Winter twig, x 1; 2. Leaf, x 1/4; 3. Leaflet, x 1/2; 4. Vertical section of staminate flower, enlarged; 5. Vertical section of pistillate flower, enlarged; 6. Fruit, x 1/4. (Original). (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Gymnocladus dioica (L.) Koch. Kentucky Coffee-tree

Leaves large. Flowers whitish, in expanded racemes; polygamous or dioecious. Branches irregular with compound leaves without stipules. Fruit a pod with large, hard seeds. Widely distributed

FIG. 187.—Honey locust (*Gleditsia triacanthos*). 1. Winter twig, x 1; 2. Vertical section through lateral buds, enlarged; 3. Leaf, x 1/4; 4. Leaflet, x 1; 5. Staminate flowering branchlet, x 1/2; 6. Staminate flower, enlarged; 7. Pistillate flowering branchlet, x 1/2; 8. Pistillate flower, enlarged; 9. Fruit, flattened, x 1/3; Center, spine from trunk, x 1/2; 11. Mature fruit showing typical shapes, x 1/18. (Original). (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

in Iowa and in North America from New York to southeastern Minnesota, to Nebraska and Tennessee.

Grows on alluvial lowlands or sometimes on hillsides. Associated with the black walnut, *Juglans nigra, Quercus rubra, Celtis occi-*

dentalis, Morus rubra, Gleditsia triacanthos, Laportea canadensis, Urtica gracilis and *Solidago serotina.*

HONEY BEE VISITS

Manhattan, Kansas, May 16, 1927, 2:30 p.m. Clear. Bees abundant. Five, six, eight, ten, eight, seven, eight seconds in a flower. (L.H.P.)

5:15 p.m. Clear, sunshiny. Bees abundant. Six, ten, eight, ten, seven seconds in a flower. (L.H.P.)

Date of bloom, Ames, May, 1928.

Gleditsia L. Honey Locust

Thorny trees attaining good size. Leaves pinnately compound. Flowers polygamous, greenish, in slender racemes. Seeds flat, borne in long flat twisted pods.

Gleditsia triacanthos L. Honey Locust

This tree bears conspicuous long thorns, triple compound, leaves once or twice pinnate, leaflets oblong, serrate. Calyx 3- to 5-cleft, petals as many as the sepals. Stamens 3 to 10, inserted with petals at base of calyx. The long flat twisted and shining pods are produced abundantly. In rich woods.

A tree of alluvial bottoms of larger and smaller streams, in alluvial or sandy alluvial soil. Associated with *Geum canadense, Aster Tradescanti, Vernonia fasciculata, Penthorum sedoides, Leersia virginica, Ulmus americana, Populus deltoides, Betula nigra, Platanus occidentalis.*

Knuth says, "The four green sepals and petals are united below into a cup, which secretes nectar abundantly on its inner surface. It is protected by hairs at the bases of the stamens."

Distribution in Iowa as shown by specimens in the I.S.C Herbarium:

Adel (two specimens), Boone county (two specimens), Cedar Falls (two specimens), Centerville, Clarinda, Clinton, Dawson, Dubuque, Eagle Rock, Fairfield, Farmington, Hamburg, High Bridge, Indianola, Jefferson, Keokuk, Keosauqua, Ledges, Lime creek, Liscomb, Mahaska county, Marion county, Marshalltown, Muscatine, Muscatine county, Otter creek, Rockford, Skunk river valley, Squaw creek, Warren county, Waukon Junction (L. H. Pammel), Centerville, Keosauqua, Mount Pleasant (L. H. Pammel and G. B. MacDonald, H. E. Jaques), Council Bluffs, Hamburg, Payne (L. H. Pammel and H. B. Clark), Decatur county, Union county (J. P. Anderson), Ames (two specimens, L. Clapper, L. H. Pammel and Edna Pammel Needham, R. I. Cratty, G. W. Carver, C. R. Ball and A. F. Sample, E. R. Hodson), Cedar Rapids (R. E. Buchanan), Colfax (F. P. Sipe), Des Moines (L. H. Pammel and Emma Pammel Hansen), Iowa City (B. Shimek), Ledges (L. H. Pammel and R. F. Miller, J. V. Ellis), Shell Rock (E. S. Fyler), Stanhope (J. E. Sogard), Waukon Junction (O. Schultz).

FIG. 188.—Honey locust (*Gleditsia triacanthos*).

General distribution in the United States:

Colorado—East College (J. H. Cowan); Connecticut—New Haven (William H. Mast); Delaware—Wilmington (Wm. M. Canby); Illinois—Hamilton (L. H. Pammel), Oquawka (Harry N. Fullerton); Kansas—Wichita (T. L. Andrews); Louisiana—Alexandria (C. R. Ball); Missouri—Columbia (L. H. Pammel), Rockport (A. O. Simonds); New Mexico— (A. Isabel Mulford); New York—Ithaca (Muenscher and Bechtel); Ohio—Buckeye Lake, Cedar Point (L. H. Pammel); Oklahoma—Muskogee (L. H. Pammel); South Carolina—Oconee county (two specimens, A. P. Anderson); Tennessee—Memphis (L. H. Pammel); Utah—Salt Lake City (two specimens, L. H. Pammel and R. E. Blackwood) (cult.); Wisconsin—Boscobel, Kickapoo river (L. H. Pammel).

HONEY BEE VISITS

Ames, June 5, 6, 7, 1922. The days partly cloudy throughout. Bees fairly active, numerous, collecting honey. (C.M.K.)
June 7, 1929, 4 p.m. Bees numerous. (C.M.K.)
Des Moines, June 6, 1929, 3 p.m. Fragrant. No bees.

Date of bloom, 1926, Ames, May 28; 1927, Ames, May 12.
The bloom continues several days.

Cassia (Tourn.) L. Senna

Herbs with yellow flowers, not papilionaceous, and somewhat irregular pinnate leaves. Pods many-seeded.

Cassia marilandica L. Wild Senna

A smooth perennial herb, leaves with five to nine pairs of leaflets. Flowers in clusters. Petiole bears a gland at the base. The pods are linear.

In rich woods, also in upland alluvial bottoms of smaller and larger streams, and in sandy, loamy soil, especially in southeastern Iowa. Associated with *Boltonia asteroides, Polygonum pennsylvanicum, Aster Tradescanti.*

FIG. 189.—Wild senna (*Cassia marilandica*). (1) Flower; (2) Pod. Upper part showing leaves and flowers in racemes. *After Selby.*

According to Knuth, "The anthers do not dehisce but remain covered by a thin membrane which is ruptured by bumble bees."

The extrafloral nectaries, situated on the petiole, are visited by various insects.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (cultivated), Jackson county, Tete des Morts (L. H. Pammel), Appanoose county (T. J. and M. F. L. Fitzpatrick), Dubuque county (Paul Bartsch), Fremont county (J. P. Anderson), Marshalltown (Margaret Deischer).

It has been observed (L. H. Pammel) at Centerville, Davenport, Fort Madison, Keokuk and Muscatine.

General distribution in the United States:

Arkansas—Lawrence county (two specimens, P. H. Rolfs); Illinois—Fox (L. H. Pammel and Mark Heavenhill), Urbana (H. A. Gleason), Woodford county (F. E. McDonald); Kansas—Wichita (T. L. Andrews); Ohio—(C. G. Lloyd); Texas—College Station (L. H. Pammel); Virginia—Great Falls of the Potomac (C. R. Ball), Smyth county (John K. Small).

HONEY BEE VISITS

The flowers are visited by honey bees, as we have observed in southeastern Iowa. The species was under observation from July 27 to August 4, 1929, at Ames, but honey bees were not observed, nor from August 19 to 28, 1929.

Cassia Chamaecrista L. Partridge Pea

An annual suberect herb, with scanty pubescence. Leaves compound, leaflets ten to fifteen pairs, linear-oblong, sensitive to touch. A cup-shaped gland beneath the lowest pair of leaflets. Flowers large; many of the yellow petals have a purple spot at the base. Anthers unequal, two yellow and two purple.

Widely distributed in sandy and gravelly soil, in fields and embankments throughout the state. Associated with *Strophostyles*

FIG. 190.—Partridge pea (*Cassia Chamaecrista*). (a) Curved or sickle-shaped pistil; (b) Stamens; (c) Pod; (d) to the right—the gland on the leaf, to the left—compound leaf.

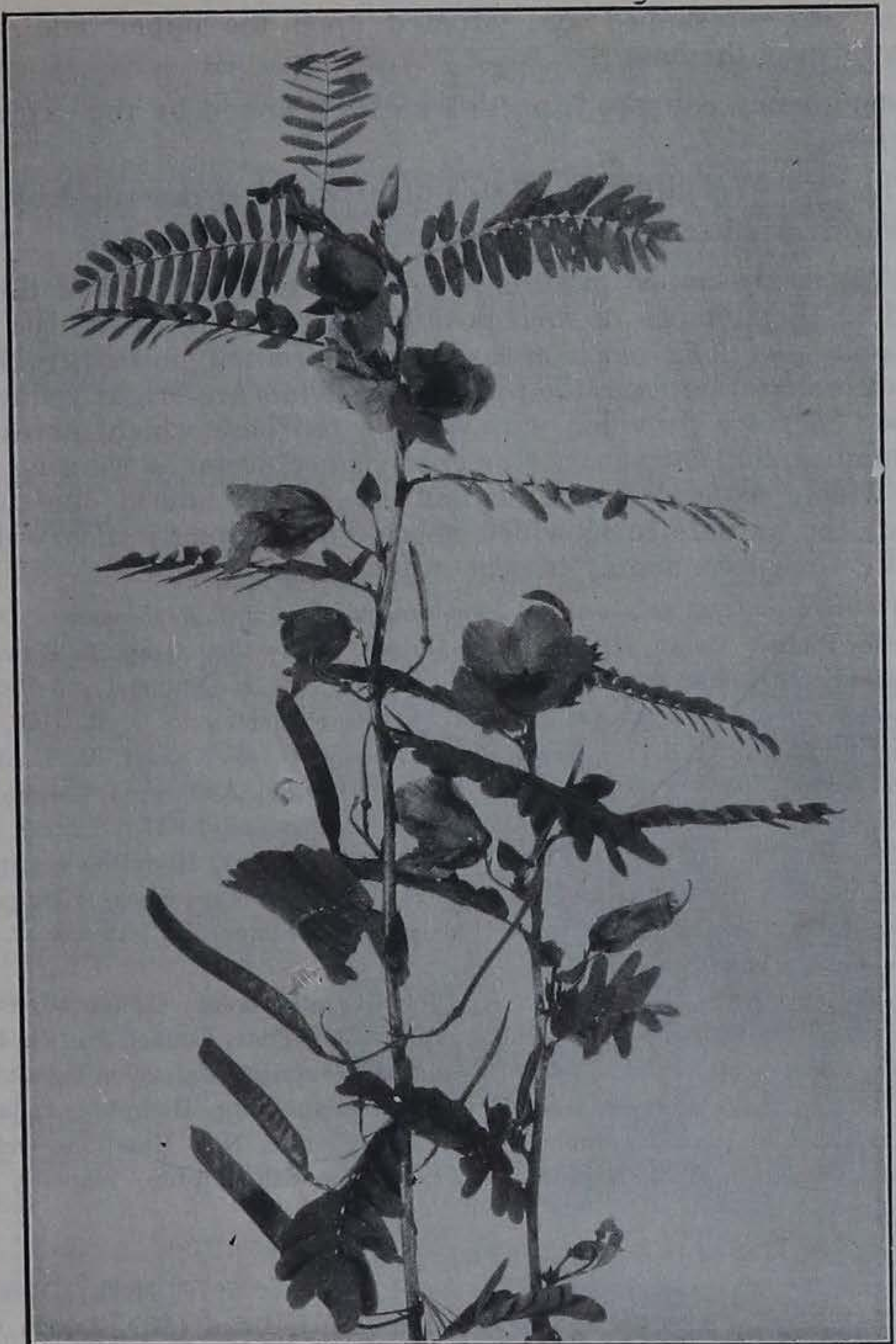

FIG. 191.—Partridge pea (*Cassia Chamaecrista*). *Photo Section, Iowa Agr. Exp. Sta.*

diversifolius, Lespedeza capitata, Tephrosia virginiana, Potentilla arguta, Cenchrus tribuloides, Panicum capillare.

The partridge pea secretes no nectar. It is visited for pollen by bumble bees, and is reported as a valuable source of pollen for honey bees in the southern states.

Robertson says, "Many insects visit the extrafloral nectaries, which are cup-shaped and situated upon the upper side of the petiole, near the base.''

Some honey is made from this nectar secreted by the extrafloral nectaries.

The type of pollination of this plant was first described by J. E. Todd. It is described also by Robertson as follows:

''The sickle-shaped pistil is turned either to the right or the left, holding the stamens in such position that it touches the bee upon the side; ten long black anthers with terminal pores turn in an opposite direction from the pistil. The petals are bright yellow, the upper ones are provided with a little red base which serves as a pathfinder, but not as a nectar guide, since nectar is wanting. All are widely expanded and flexible except the lateral one toward which the anthers turn, which is erect and strongly incurved and so stiff that it commonly breaks on being bent back.''

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belle Plaine, Cedar Rapids, Des Moines, Eddyville, Granite, Hawarden, Keystone, Marshalltown, Polk City, Sioux City (L. H. Pammel), Armstrong, Emmet county (R. I. Cratty), Ames (L. H. Pammel and C. R. Ball, Fred Rolfs, P. H. Rolfs, S. W. Beyer, C. E. Bessey, G. W. Carver, R. E. Jeffs), Battle Creek (E. S. Preston), Decatur county (J. P. Anderson), Decorah (R. I. Cratty, E. W. D. Holway), Des Moines (Emma and L. H. Pammel, A. L. Bakke), Fayette (B. Fink), Floyd (Mrs. F. M. Tuttle), Hamilton county (P. H. Rolfs), Kelley (Botanical Party, Pearl Clayton, two specimens), Maquoketa (E. F. Brown), northeastern Iowa (H. Goddard), Slater (H. Fawcett, C. Reinbott, W. D. Tener).

It has also been observed (L. H. Pammel) at Algona, Camanche, Centerville, Cherokee, Clinton, Coin, Columbus Junction, Cone, Council Bluffs, Dallas Center, Davenport, Dubuque, Emmetsburg, Estherville, Fairfield, Forest City, Fort Dodge, Fort Madison, Garner, Glenwood, Hamburg, Hampton, Independence, Indianola, Keokuk, Mount Pleasant, Muscatine, New Hampton, Oelwein, Onawa, Ottumwa, Rock Rapids, Sabula, Shenandoah, Tipton, Wapello, West Liberty, Winterset.

General distribution in the United States:

Arkansas—Ashley county (R. E. Fennell), Judsonia (S. E. Meek); Illinois—Champaign (B. Fink), Peoria (F. E. McDonald), Utica (Mrs. Joseph Clemens); Kansas—Wichita (T. L. Andrews); Michigan—Glencarlyn (Lyster H. Dewey); Minnesota—Jackson county (R. I. Cratty); Missouri—Crocker (Lee Swearingen), Hannibal (R. Gmelin), Jefferson county (H. Eggert), St. Louis (R. E. Vaughn); Nebraska—Lincoln (R. Gmelin); North Carolina—Biltmore (Biltmore Herbarium), Highlands (C. H. Boynton); Ohio—Central College (E. V. Wilson); Oklahoma—Muskogee (L. H. Pammel); South Carolina—Oconee county (A. P. Anderson); Texas—College Station (L. H. Pammel).

HONEY BEE VISITS

Ames, July 15, 1914. Railway. Partly cloudy, south wind. Small bees collecting pollen; twenty on each flower, per hour. (G.H.M.)

July 17, 1914. Railway. Clear, northwest wind. Several small bees. One *Bombus,* several Diptera. Twelve insects each hour on one flower. (G.H.M.)

Newburg, July 15, 1915. One *Bombus* about the flowers. (L.A.K.)

Atlantic, July 31, 1915, a.m. Clear, hot and dry. Bees and *Bombus* on the flowers. Several small bees on the extrafloral glands. (L.A.K.)

Ames, August 10, 1915. Clear, warm. One honey bee observed visiting a considerable number of plants. (L.A.K.)

Fruitland, August 5, 1915. Bees getting pollen. Two seconds in a flower.

Tama, August 6, 1928. Bumble bees present. (L.H.P.)

Cercis L. Red Bud

Trees, with rounded heart-shaped leaves and purplish red flowers in umbel-like clusters along the branches of the last year, appearing before the leaves.

Cercis canadensis L.

Red Bud

A small tree with purplish rose-colored flowers which appear before the leaves in early spring. This plant is most attractive to the honey bee.

Both honey and pollen are readily accessible, and the flowers are freely visited by both honey bees and bumble bees.

This plant is at times a valuable contribution to honey plants of southeastern and southwestern Iowa. Its bloom follows that of service berry.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (cult.), Burlington, Croton, Farmington, Glenwood, Hamburg, Keokuk, Keosauqua, Lacey-Keosauqua Park (L. H. Pammel), Appanoose county (T. J. and M. F. L. Fitzpatrick), Ham-

FIG. 192.—Red bud (*Cercis canadensis*). *Photo by Ada Hayden.*

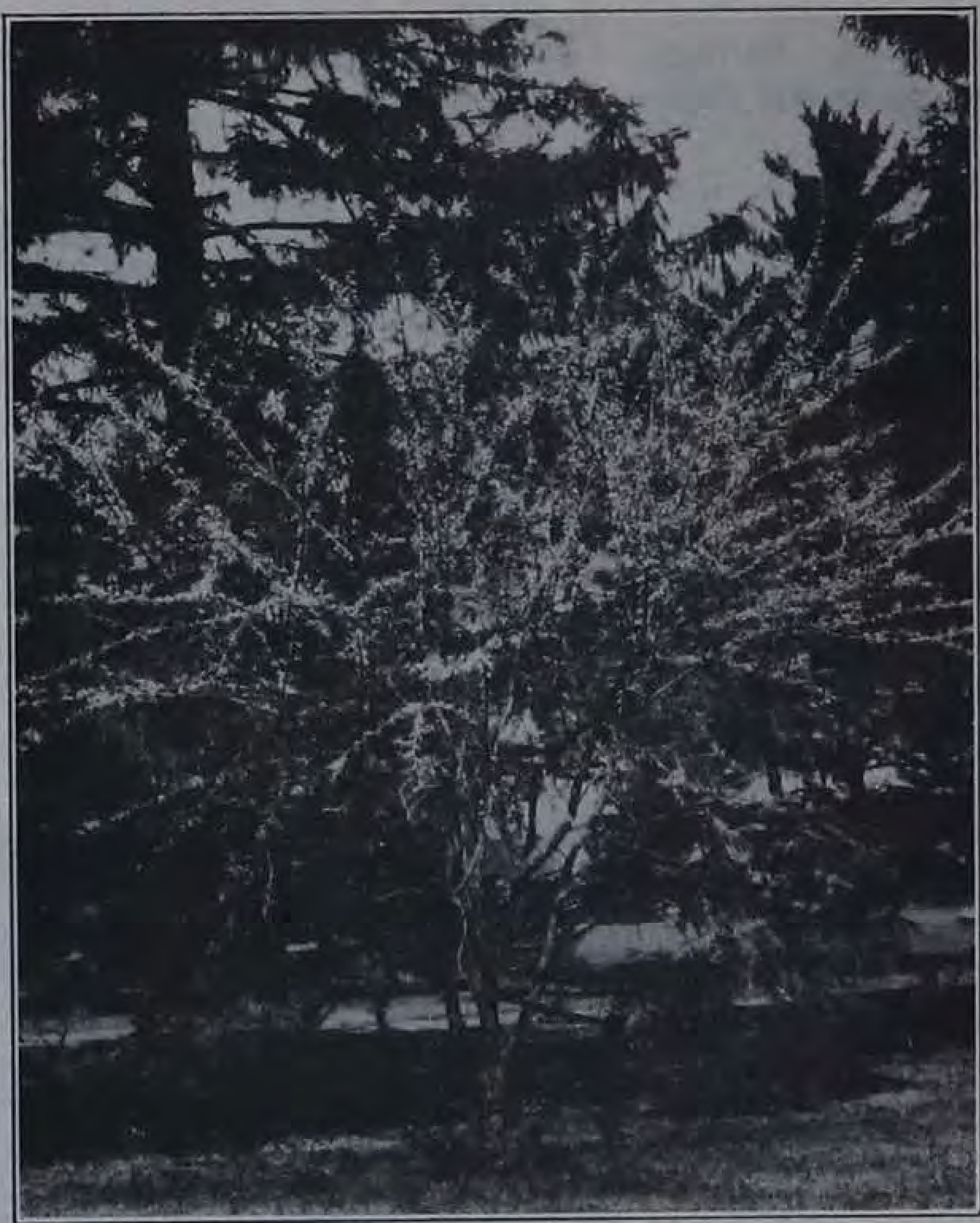

FIG. 193.—Red bud (*Cercis canadensis*), general view. *Photo by Ada Hayden.*

burg (L. H. Pammel and H. B. Clark), Jasper (J. A. Dibble), Keokuk (P. H. Rolfs), Mount Pleasant (H. E. Jaques), Muscatine (J. W. Merrill), Oakland Mills (L. H. Pammel, G. B. MacDonald, H. E. Jaques).

General distribution in the United States:

Alabama—Auburn, Montgomery (L. H. Pammel); Arkansas—Hot Springs (L. H. Pammel); California—Butte county, Chico (A. A. Heller); Florida—Gainesville (L. H. Pammel); Illinois—Hamilton (L. H. Pammel), Starved Rock (L. H. Pammel and Mark Heavenhill); Indiana—Indianapolis (John S. Wright), Turkey Run State Park (L. H. Pammel); Mississippi—Vicksburg (L. H. Pammel); Missouri— Allerton, Columbia, St. Louis (L. H. Pammel, H. Eggert); Nebraska—Lincoln (Dr. Gmelin); New York—Ithaca—(H. E. Summers); North Carolina—Biltmore (Biltmore Herbarium); Oklahoma—Muskogee (L. H. Pammel), Norman (W. E. Bruner); Pennsylvania—Spruce Creek (L. H. Pammel); South Carolina—Oconee county (A. P. Anderson); Texas—Austin (F. C. Werkenthin), Tarrant county (Albert Ruth); Virginia—Marion (John K. Small).

HONEY BEE VISITS

Keokuk, May 5, 1923. Clear and warm. Bees getting pollen and honey. Four, three, two, four seconds in a flower. Many other Hymenoptera. (L.H.P.)

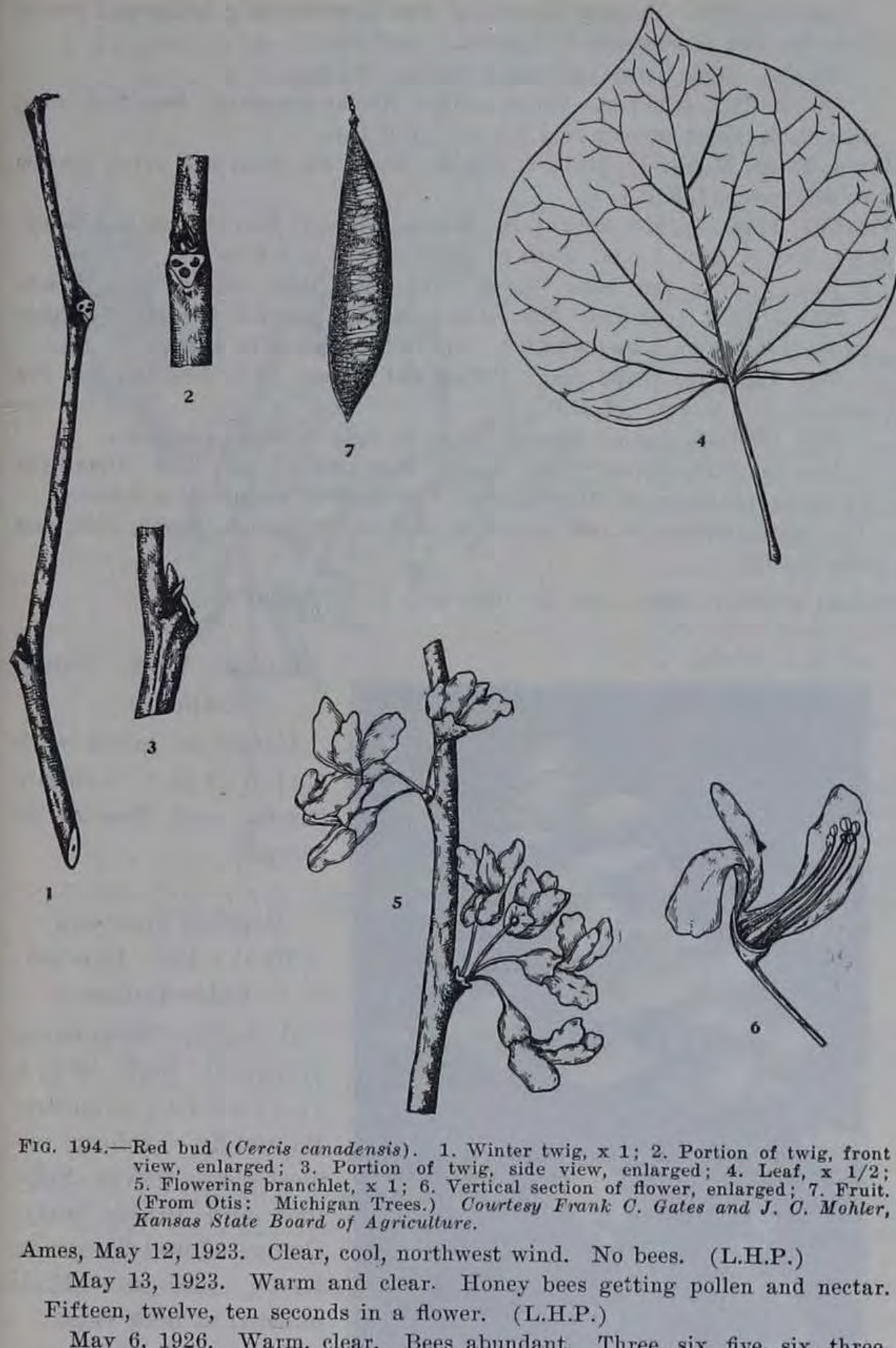

FIG. 194.—Red bud (*Cercis canadensis*). 1. Winter twig, x 1; 2. Portion of twig, front view, enlarged; 3. Portion of twig, side view, enlarged; 4. Leaf, x 1/2; 5. Flowering branchlet, x 1; 6. Vertical section of flower, enlarged; 7. Fruit. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Ames, May 12, 1923. Clear, cool, northwest wind. No bees. (L.H.P.)

May 13, 1923. Warm and clear. Honey bees getting pollen and nectar. Fifteen, twelve, ten seconds in a flower. (L.H.P.)

May 6, 1926. Warm, clear. Bees abundant. Three, six, five, six, three, four, five seconds in a flower. One bee a minute over 150 flowers. (L.H.P.)

May 10, 1926, 2 p.m. to 6 p.m. Clear, warm, north breeze. Bees fairly common. Six, six, four, six, one seconds in a flower. (L.H.P.)

May 12, 1926. Slightly humid. A few bees collecting honey and pollen. Ten, five, six, five seconds in a flower. (L.H.P.)

May 13, 1926, 1 p.m. Advanced bloom. No bees.

May 5, 1927, 4:30 p.m. Warm, windy. Nectar abundant. Bees four, four, five, three, three seconds in a flower. (L.H.P.)

Waco, Texas, March 17, 1929, 2:30 p.m. Four, six, four, five, seven seconds in a flower. (L.H.P.)

Fairfield, April 27, 1929, 12:30 p.m. Warm. Three to four seconds in a flower.

Ames, May 8, 1929, 1 p.m. Four to eight seconds in a flower.

5 p.m. Only a few bees. Four, three, four, three seconds in a flower.

May 9, 1929, 1:30 p.m. Not many bees. Six hundred flowers. Two bees in five minutes on a single branch. Six to five seconds in a flower.

May 12, 1929, 12:30 p.m. Pollen and nectar. Six, five, six, six, five seconds in a flower. (L.H.P.)

May 13, 1929, 2 p.m. Cloudy. Four to eight seconds in a flower.

May 19, 1929, 2 p.m. Fairly warm. Past season. Few bees. Bees light in flower, hasten on to other flowers. One to three seconds in a flower.

Bees were abundant on the flowers in Gainesville, Florida, March, 1926, and March, 1927.

Date of bloom, 1925, April 18; 1926, May 3; 1927, May 1.

FIG. 195.—Wild indigo (*Baptisia bracteata*). Photo by *Ada Hayden*.

Baptisia Vent. False Indigo

Perennial herbs with palmately 3-foliate leaves, and flowers in racemes.

Baptisia bracteata (Muhl.) Ell. Bracted False Indigo

A hairy, low-growing perennial herb with spreading branches. Palmately 3-foliate, almost sessile leaves. Stipules and bracts leafy. Cream-colored flowers in long racemes. Pods pointed at both ends.

This species is common in native prairies throughout northern

Iowa, especially between Ames, Eagle Grove and Hawarden.

Associated with *Ceanothus ovatus*, *Petalostemon purpureum*, *Lespedeza capitata* and *Anemone patens* var. *Wolfgangiana*.

FIG. 196.—Bracted false indigo (*Baptisia bracteata*). *Drawn by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Allamakee county, Ames, Carroll county, Polk county (L. H. Pammel), Boone county, Washington (J. V. Ellis), Dickinson county, Kossuth county, Palo Alto county (R. I. Cratty), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Elkader (R. Gmelin), Emmet county (R. I. Cratty and B. O. Wolden), Fayette county (B. Fink), Greene county (Allender), Lee county (L. H. Pammel, P. H. Rolfs), Story county (L. H. Pammel, S. W. Beyer), West Chester (Stella Goodspeed).

General distribution in the United States:

Louisiana—(T. L. Andrews); Missouri—Waldo Park (Kenneth K. Mackenzie); Oklahoma—Norman (W. E. Bruner); Wisconsin—Holmen, La Crosse (L. H. Pammel), Madison (J. R. Heddle).

HONEY BEE VISITS

Wall Lake (Hamilton county), May 25, 1924, 2 p.m. to 4 p.m. Clear, cool, windy. Warm at surface of the ground and in sheltered places. Plant just coming freely into bloom. Visited by bees for pollen. (C.M.K.)

Iowa City (near), October 4, 1927, 4 p.m. Four pods set fruit out of forty flowers. Ten pods out of thirty flowers. Fifteen pods out of sixty-five flowers. (L.H.P.)

Ames, June 16, 1928, 2 p.m. Warm, windy. Bees abundant. Twelve, twelve, thirteen, twelve, twelve seconds in a flower. (L.H.P.)

Cladrastis Raf. Yellow Wood

Fine tree with yellow wood, smooth bark. Nearly smooth pinnately compound leaves. Leaflets seven to eleven, ovate. Flowers in panicled racemes, showy. Calyx white, bell-shaped, five-toothed. Standard large, roundish, reflex. Stamens ten, distinct or nearly so. Fruit a pod, short and flat, three- to six-seeded.

Cladrastis lutea (Michx. f.) Koch. Yellow Wood

A tree native to the Alleghany mountains. Has graceful head, short trunk, smooth bark; panicles many-flowered. Flowers white, fragrant.

This tree, except as introduced, has a limited eastern range in Tennessee to North Carolina. It is cultivated in southeastern Iowa and is hardy as far north as Ames. It furnishes some nectar.

HONEY BEE VISITS

Manhattan, Kansas, May 16, 1927, 2:30 p.m. Clear. Bees abundant. Ten, ten, twelve, eight, eight seconds in a flower. Flowers fragrant. (L.H.P.) Probably visited by bees in Iowa.

Trifolium (Tourn.) Clover

Herbs usually with palmately compound leaves having three leaflets and a stipule at base of the petiole. Petals spreading. Stamens ten, nine united into a tube, the tenth apart. Inflorescence a head or spike. Flowers yellow, red or white, sweet-scented, nectar-secreting.

The *Trifoliums* are largely bee flowers, but it is not infrequent to find several different types of butterflies pollinating the flower.

Trifolium arvense L. Rabbit-foot Clover

This clover is a silky, erect annual, growing to a height of three or four feet. The leaflets are narrow. The dense heads of the flowers are silky and grayish in appearance.

Preferring dry gravelly soils. L. H. Pammel says, "I noticed quite a little along the roadsides in Hancock county, where it is well established."

This introduced clover is found with *Aster laevis, Solidago missouriensis, Solidago rigida, Vicia americana* and *Veronica virginica.*

The tube of this flower is hardly two millimeters long. Bees are among its insect visitors.

Knuth says, "The pollinators of these pinkish flowers are chiefly bees."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Garner, Hancock county (L. H. Pammel), northeastern Iowa (H. E. Goddard), Winneshiek county (T. J. and Mrs. M. F. L. Fitzpatrick).

General distribution in the United States:

Alabama—Auburn (L. H. Pammel); Georgia (H. Eggert); Massachusetts—Cambridge (B. Fink), Stockbridge (H. S. Kellogg); Michigan—Whitehall (L. H. Pammel); Pennsylvania—Harrisburg (J. K. Small); South Carolina—Pickens county (two specimens, A. P. Anderson); Virginia—Glencarlyn (Lyster H. Dewey).

HONEY BEE VISITS

Honey bees have been reported on it.

Trifolium incarnatum L. Crimson Clover

Sometimes cultivated and an occasional escape, not, however, persistent.

The flower mechanism of this species is similar to that of *T. pratense.* It is adapted to long-tongued insects.

The honey yield is reported to be good.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Fayette (B. Fink), Marengo (Mrs. Mary Welch).

It has been observed (L. H. Pammel) at Ames following its cultivation for a few years; apparently does not persist.

General distribution in the United States:

Alabama—Auburn (L. H. Pammel); South Carolina—Pickens county (A. P. Anderson).

Trifolium pratense L. Red Clover

A perennial clover with dense heads of fragrant rose-colored flowers. Three oval leaflets; head closely surrounded by the uppermost leaves. Extensively grown throughout the state. In bloom more or less throughout the season after June till late fall.

FIG. 197.—Red clover (*Trifolium pratense*). *United States Department of Agriculture.*

Found everywhere in all kinds of soils except alluvial soils.

Associated with *Trifolium repens, Rumex crispus, Setaria viridis, Setaria glauca, Oxalis corniculata, Ambrosia artemisiifolia, Polygonum pennsylvanicum.*

Knuth says, "Flowers fragrant with a smell like honey, but require for reaching the nectar, an insect with a proboscis at least nine-tenths of a millimeter long."

Bees are the usual visitors for honey. The honey bee frequents the flower for pollen.

A. I. and E. R. Root mention several cases when the red clover proved valuable honey plants at Medina, Ohio. The surplus was obtained in a drouthy year. The flower tubes were shorter and the bees could secure the nectar.

"Mammoth red clover a good yielder at times," says a writer in American Bee Journal.

FIG. 198.—Red clover (*Trifolium pratense*). *Photo by Ada Hayden.*

Ordinarily the nectar is beyond reach of short tongued insects. Honey bees have, however, been observed collecting nectar. This is probably only in some seasons when the nectar rises in the tube by capillarity and becomes accessible to bees.

The corolla consists of the following parts: An upper larger petal known as the standard, two lateral petals known as the wings and two lower petals resembling the keel of a boat, which are united and are commonly known as the keel. The keel contains ten stamens, each stamen consisting of an anther, to which is attached a threadlike affair known as the filament. But in the case of clover the filaments are united to form a tube, except the nearby free tenth stamen; the anthers contain the pollen. The pistil also is found in the keel. The lower portion is the ovary, the narrow neck is known as the style, the tip is the stigma. The color of the clover flower is especially attractive to Hymenoptera. The honey which the insect seeks is contained in the tube formed by the union of the fine threadlike bodies or filaments.

When an insect like the bumble bee lights on the flower it uses the keel and wings (the latter being attached to the tube containing the nectar) as a resting place, its weight pressing the keel down

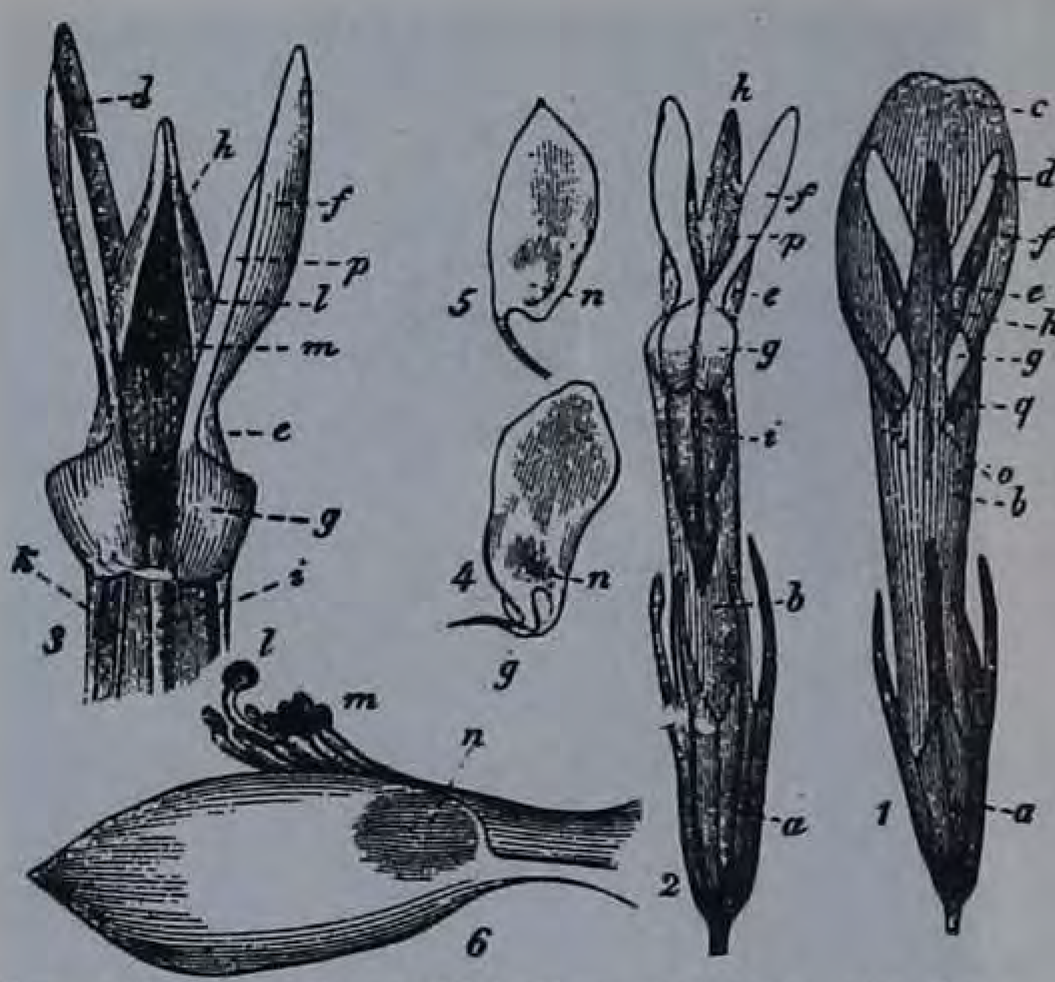

FIG. 199.—Red clover (*Trifolium pratense*). (1) Flower viewed from below; (2) Flower viewed from above; (3) The keel forced apart; (4 and 5) Winged petals; (6) Stamens and pistils emerging from the keel; (a) Calyx; (b) Tube formed by the union of the filament; (d) Concave inner part of the wings; (h) Keel; (l) Stigma; (m) Anthers. *After Mueller.*

and causing the pistil and stamens—the latter being somewhat shorter than the pistil —to come in contact with the under side of the bee's head. The insect is certain to leave some of the pollen from another flower on the stigma. The honey is obtained by the insect when it thrusts its proboscis into the united filaments of the stamens. The tube thus formed has a slit on the upper side to give place for a free tenth stamen. Self-pollination, or pollination of the flower from its own stamens, as the insect leaves the flowers, is not excluded. It has been shown, however, that self-pollination does not generally occur.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (six specimens, L. H. Pammel, Ruth Walker, C. R. Ball, A. A. Miller, F. C. Stewart, J. C. Blumer), Cedar Rapids (R. E. Buchanan), Charles City (L. H. Pammel), Decorah (E. W. D. Holway), Fayette (C. C. Parker, B. Fink), Kelley (two specimens, Pearl Clayton), Lawler (P. H. Rolfs), northeastern Iowa (H. E. Goddard).

The following are some places at which it has been observed (L. H. Pammel): Algona, Bellevue, Boone, Burlington, Carroll, Charles City, Cherokee, Clinton county, Columbus Junction, Cresco, Dallas Center, Davenport, Dubuque, Eldora, Elkader, Emmetsburg, Estherville, Fairfield, Fort Dodge, Fort Madison, Glenwood, Indianola, Iowa Falls, Jefferson, Keokuk, Lansing, Le Mars, Little Rock, Marshalltown, Marquette, Mason City, McGregor, Missouri Valley, Mount Pleasant, New Albin, New Hampton, Onawa, Postville, Rock Rapids, Shenandoah, Sioux City, Steamboat Rock, Strawberry Point, Tipton, Wallingford, Wapello, Waukon.

General distribution in the United States and Canada:

Alaska—Sitka (J. P. Anderson); District of Columbia—Washington (L. H. Pammel); Manitoba—Emerson (L. H. Pammel); Minnesota—Hibbing (Lyle

Clapper), Brainerd (E. B. Watson), International Falls (H. S. Kellogg), Star island (Cass Lake) (L. H. and H. E. Pammel and P. S. McNutt); Nebraska—Hastings (L. H. Pammel); Newfoundland—Humber Arm (M. L. Fernald and K. N. Wiegand); New York—Elizabethtown (G. H. Macy), Ithaca (H. E. Summers); Oregon—Crook county (K. Whited); South Carolina—Oconee (A. P. Anderson); South Dakota—Mount Vernon (B. Fink); Texas—Black mountains (Rev. Davis), College farm (J. H. Crandall); Utah—Logan (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Salt Lake City (L. H. Pammel and R. E. Blackwood); Wisconsin—LaCrosse (Dora S. Pammel), Prescott (Mary Edgar).

HONEY BEE VISITS

Ames, June 14, 1914, 2 p.m. Clear, warm. Many insects. No honey bees. (H.F.)

June 19, 1914, 8-10 a.m. Plot. Cool, northeast wind. Two bees, many bumble bees. (G.H.M.)

June 20, 1914, 6 a.m. Plot. Clear, cool, southeast wind. No insects. (G.H.M.)

June 27, 1914, 3-5 p.m. Campus. Cloudy, cold, southeast wind. No insects. (G.H.M.)

June 27, 1914. Campus. Partly cloudy, 72 deg., west wind. Bumble bees visit 160 heads in twenty minutes, then fly away. Older heads left unnoticed. (L.A.K.)

July 14, 1914, all day. C. & N. W. railroad right-of-way. Clear, warm, north wind. Observation continued for one day every half hour; on one hundred plants past their prime and containing little nectar, one honey bee, one wasp, three Lepidoptera. (L.A.K.)

July 22, 1914, all day. Plot. Cloudy, west wind. One bee in one day's observation, one to four bumble bees, none to three small bees, one to seven Diptera, one to four Lepidoptera. (G.H.M.)

August 4, 1914, all day. Plots. Clear, hot, dry. One to nine insects (climax 3 p.m.). Bumble bees one to six, small bees none to two, Diptera none to seven, Lepidoptera three to fifteen. (G.H.M.)

July 9, 1915, 6 p.m. Cloudy, cool breeze. No honey bees. A few bumble bees. (Rothschild.)

July 13, 1915, 5 p.m. Near apiary. Sprinkling. Ten or more honey bees gathering pollen; a few apparently getting nectar.

Eleven to fourteen flowers visited in one minute or two and a half seconds per flower. (H.F.)

July 17, 1915, 4 p.m. Apiary orchard. Partly cloudy. Saw five bees with pollen, two without. Bees work more rapidly on white clover than on red clover. (L.A.K.)

July 25, 1915. Very few honey bees, bumble bees dominant. (L.A.K.)

August 11, 1915, 2 p.m. Plot. One to nine bees, most of them with pollen on their legs. (L.A.K.)

August 12, 1915, 10 a.m. A few bees sucking nectar. (L.A.K.)

July 25, 1915. Very few honey bees, bumble bees dominant. (L.A.K.)

Sept. 1915. Partly cloudy, south wind. No honey bees, two bumble bees, two Lepidoptera, four heads per minute. (Camburn.)

Sept. 29, 1915, 9 a.m. Partly cloudy, southwest wind. Three bumble bees, three Lepidoptera, visiting thirty flowers per minute.

11:00 a.m. The bumble bees had disappeared.

July 13, 1920. Honey bees observed working red clover in plot very near apiary, but none elsewhere. According to C. E. Bartholomew, one bee gathered a load of honey from three heads.

August, 1926. Honey bees abundant on red clover after a rain, at Clayton, although none were observed at McGregor.

Ishpheming, Mich., August 12, 1927. Common. Blooming. No bees.

Clear Lake, June 22, 1929, 7 a.m. Bees active. Two, two, three seconds in a flower. (C.M.K.)

Des Moines, June 24, 1929. No bees. One thousand feet from an apiary.

Abundant bloom in Allamakee, Clayton, Winneshiek, Howard, Mitchell, Floyd, Cerro Gordo and Franklin counties in 1929. The clover flowers were darker in Winneshiek, Allamakee and Clayton counties than elsewhere in northern Iowa.

Date of bloom, 1925, Ames, May 15; 1926, Ames, May 28; Lansing, June 1; 1927, Ames, May 25.

Trifolium reflexum L. Buffalo Clover

This clover is annual or biennial, growing to a height of one foot, ascending in habit, downy. Leaflets are obovate, finely toothed. The heads of red flowers resemble those of red clover but the flowers are reflexed as they fade. Borders of fields and woods. Rare in the state.

It is wild toward the south and west.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Muscatine (F. Reppert), observed (L. H. Pammel) but not represented by specimens, Taylor and Ringgold counties.

General distribution in the United States:

Arkansas—Little Rock (two specimens, George W. Letterman); Georgia—Macon (John K. Small); South Carolina—Oconee county (A. P. Anderson).

Trifolium repens L. White Clover

A perennial clover, with creeping stems; leaflets three, notched; petioles and peduncles very long; heads small and loose, flowers white, reflexed in age.

Generally grown in lawns. Found on various kinds of soils except alluvial. Does best on clay soils of northeast Iowa in the Mississippi loess.

Associated with *Poa pratensis, Trifolium pratense, Phleum pratense, Ambrosia artemisiifolia. Oxalis corniculata*, etc.

FIG. 200.—White clover (*Trifolium repens*). *Photo by Ada Hayden.*

The flowers of *T. repens* are massed in a head and are quite conspicuous, making lawns white in June. The odor also attracts bees. The standard of the flower has a groove which leads to the nectary. Nectar is secreted at the bottom of the tube formed by the union of the filaments and can be reached only by means of the openings one on each side of the free tenth stamen. An insect, in order to reach the nectar, pushes its proboscis underneath the standard. The wings and keel are used as a resting place; pressure upon the latter causes the stamens and pistil to protrude.

The stamens and pistil come in contact with the lower surface of the body. When the insect leaves the flower, the parts return to their positions.

These flowers have the odor of honey. The calyx tube is only three millimeters long, so that even short-tongued bees are able to reach the honey.

Honey bees are the usual pollinators, although the flowers are pollinated by small Lepidoptera also.

FIG. 201.—White clover (*Trifolium repens*). *Photo by Ada Hayden.*

Self-fertilization rarely takes place and it was found by Darwin that when insects are excluded from white clover it is but slightly productive.

Insects, besides the honey bee, are not conspicuous on white clover. Those that are found are mainly small solitary bees and flies, largely Syrphidae.

The irregular papilionaceous flowers secrete nectar freely. There is much difference at different times in the honey-yielding quality of the white clover. In 1924 white clover was blooming freely all over the state and bees were getting much nectar from it.

Probably the winter of 1923 and 1924 was more favorable to the plant, also excessive rainfall in the fall of 1923 may have had an influence upon the succeeding summer's bloom.

White clover is the main standby for honey production in Iowa during some years. But in 1914 and 1915, in both of which years the nectar yield was low, the plant was not largely visited by bees. A dry spring and summer in 1914 was probably the deterrent factor. The summer of 1915 was unusually wet and cool. Mr. Tinsley thinks that clover yielded nectar, but that the bees could not gather it because of bad weather. He noticed that bees left white clover as soon as sweet clover bloomed, as though preferring the latter.

Chemical analyses in 1914, 1915 and 1916 indicate that the amount of nectar that can be washed from blossoms of white clover is relatively small, being generally less than one milligram per gram of flowers. Yields seem highest where the growth is vigorous, lower on closely mowed lawns and lowest where weedy, or stunted by drought.

It is especially abundant in Dubuque, Clayton and Winneshiek counties. Every meadow and pasture was covered with it. This clay soil is especially adapted to it. The odor was distinguishable from a distance. The same remarks apply to *T. hybridum*. There are not enough bees to utilize the clover nectar in northeastern Iowa.

Localities observed in bloom June 12, 1924 (L. H. Pammel): Sioux City, everywhere abundant in northern and western Iowa; the preceding winter had been very favorable for it. The plants were generally vigorous, especially in the true Missouri loess at Council Bluffs, Sioux City, Smith's Lake and Hawarden. Pastures, meadows and roadsides were white with it; the honey odor was easily detected. Very common and abundant in central Iowa, yielding considerable nectar. Common also at Waterloo, Independence, Dyersville, Dubuque, Des Moines, Eldora and Marshall county, in which regions the plants are very vigorous.

The month of June is the season for bloom of the white clover. Kenoyer states that 56 per cent of the annual hive increase in honey comes in this month, with about half the remainder in July.

White clover is given first place as a honey plant in America. Pellett says, "Alsike clover is similar in yield and quality of honey, but it is not so widely spread." Best yields come in seasons following a year of excessive rainfall. In wet years the conditions favor the rooting of thousands of new plants, which are ready to produce a crop of nectar the following summer.

A. I. and E. R. Root in "A B C of Bee Culture," speaking of the yield of honey secured by Dr. C. C. Miller of Marengo, Illinois, say. "A large surplus was obtained in 1913. This phenomenal surplus was largely due to a most favorable season, consisting of a succession of hot, humid days. The flow began about June 1 and continued until the last of August."

White clover does best in the bluegrass region from Kentucky to southern Wisconsin. There are years when it does not yield any surplus in central Iowa. Greater yields are obtained in northeastern Iowa.

The yield in 1929 was large as this was a most favorable year, cool and moist in spring.

Mr. Charles D. Reed places the white clover acreage this year (1929) in Iowa at around 10,000,000 acres in pastures and woodland pastures. The white clover crop this year if all gathered would amount to over $25,000,000 in round numbers.

Mr. E. G. Brown of Sioux City estimates that good white clover yields 200 pounds of honey per acre in good years, and 1929 was a good year.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (Ruth Walker, F. C. Stewart, C. R. Ball), Fayette (B. Fink), Kelley (Pearl Clayton), northeastern Iowa (H. Goddard).

Observed (L. H. Pammel) at the following places; Algona, Bellevue, Burlington, Carroll, Cedar Rapids, Charles City, Cherokee, Clinton, Columbus Junction, Cresco, Dallas Center, Davenport, Decorah, Denison, Des Moines, Dubuque, Elkader, Eldora, Emmetsburg, Estherville, Fairfield, Fort Dodge, Fort Madison, Glenwood, Hampton, Iowa Falls, Indianola, Jefferson, Keokuk, Lansing, Le Mars, Little Rock, Marquette, Marshalltown, Mason City, McGregor, Missouri Valley, New Hampton, New Albin, Onawa, Orange City, Postville, Rock Rapids, Shenandoah, Sioux City, Steamboat Rock, Strawberry Point, Tipton, Turin, Wallingford, Waukon.

General distribution in the United States and Canada:

Alaska—Juneau, Sitka (J. P. Anderson); Colorado—Ruxton Dell (F. E. and E. S. Clements); Georgia—Camp Gordon (D. C. Poshusta); Michigan—Ironwood (Mrs. Joseph Clemens); Minnesota—International Falls (H. S. Kellogg); Cass Lake (L. H. and H. E. Pammel), Star island, Cass Lake (L. H. and H. E. Pammel and P. S. McNutt); Nebraska—Hastings (L. H. Pammel); Newfoundland—Curling (M. L. Fernald); Ohio—Gypsum (J. C. Britton); Oregon—Tumalo Ditch, Crook county (K. Whited); South Carolina—Oconee county (A. P. Anderson); South Dakota—Mitchell (B. Fink); Utah—Vernal (L. H. Pammel and E. M. Stanton), Farmington canon (L. H. Pammel and R. E. Blackwood); Wyoming—Yellowstone Park (R. P. White); Wisconsin—La Crosse (Dora S. Pammel).

HONEY BEE VISITS

Ames, June 16, 1914. Roadside. Clear, cool, southeast wind. More honey bees present than on alsike. (G.H.M.)

June 17, 1914. Roadside. Clear, cool. Southeast wind. Honey bees present but none on alsike. (G.H.M.)

June 19, 1914. Plots. Clear, north wind. Few flowers out. A few honey bees. (G.H.M.)

June 20, 1914. Roadside. Cloudy, cool, southeast wind. First bees 9:45 a.m. (G.H.M.)

June 22, 1914. Plots. Partly cloudy, warmer, south wind. Numerous bees. (Lott.)

June 27, 1914. Campus. 65°, strong wind. Two bees observed in twenty minutes. (L.A.K.)

June 29, 1914. Campus. Clear, light southwest wind. Bees visited four hundred sixty flowers on two hundred heads in twenty-two minutes. Some pollen on legs. (L.A.K.)

July 1, 1914. Roadside. Clear. Two bees to the quadrat. A bee visits forty flowers a minute. (L.A.K.)

Railroad, July 7, 1914, 6 a.m. Clear, south wind, 90°. Bees arriving. Cease at 8 p.m. Climax 12 to 4 p.m. Fifty-five bees on quadrat at one time. Other miscellaneous insects about as numerous as bees. (L.A.K.)

July 8, 1914, 6:30 a.m. C. & N. W. railroad right-of-way. Clear, north wind. No bees. 9 a.m. Two bees. 12 m. Fifteen bees. (L.A.K.)

July 14, 1914. Railroad. Cloudy, 90°, west wind. Bees arrive at 8 a.m., cease at 8 p.m. Climax 1 p.m. to 4 p.m. Thirty bees; about one-fourth as many other insects as bees. (L.A.K.)

July 22, 1914. Plot. 7 a.m. One bee. 11 a.m. Forty-six bees. Small bees and wasps together, three-fourths as numerous as honey bees. (G.H.M.)

Pickering, Ohio, July 27, 1914, a.m. Partly cloudy, sultry, southwest wind. Thirty honey bees. *Archytas analis*, ten. (L.A.K.)

Atlantic, August 1, 1914. Hot, dry. Plants advanced. No honey bees. A few small bees. (L.A.K.)

Omaha, Nebraska, August 3, 1914. Vacant lot, clear, hot, dry. Ten bees on second crop plants. A few other Hymenoptera. (L.A.K.)

Council Bluffs, August 4, 1914, 7 a.m. Clear, hot, dry. No bees on *Melilotus alba* but a few on *Cassia*. (L.A.K.)

Hamburg, August 4, 1914. Plants old and drying. Four bees.

Ames, August 10, 1914. Plots. Cloudy, dry, east wind. Begin work at 9 a.m. Climax at 2 p.m. Forty bees, on area ten by ten feet. Other bees, wasps, and flies together one-fourth more numerous than honey bees. (L.A.K.)

August 29, 1914. Waste ground. Clear, southeast wind. Honey bees plentiful. Some small bees. (L.A.K.)

Sept. 29, 1914. Partly cloudy, southwest wind. Two bees visiting one flower per second. (Camburn.)

Tama, October 19, 1914. Clear, warm. Two or three bees. Two kinds of flies. (L.A.K.)

Ames, June 20, 1915. Campus. Partly cloudy. Six to nine heads visited in one minute. Six bees on the plot. (H. Fawcett.)

July 1, 1915. Clear, 80°, strong wind. Four bees visiting nine heads, four flowers on each head. Time in flower two seconds. (Rothschild.)

July 10, 1915. Noon. Cloudy, 70°, strong wind. Three flowers per head. Three bees at work, two or three seconds in a flower. (Rothschild.)

July 11, 1915, 3 to 5 p.m. Clear, rain previous day. Five bees in five minutes, visit two to five flowers in each head, four to eight seconds in a flower. (L.H.P.)

July 12, 1915, 7 p.m. Clear, 80°, still. Seven bees visit ten flowers per head. (Rothschild.)

July 15, 1915. Abundance of bloom. Bees numerous. (L.H.P.)

July 21, 1915, and following days. Wet. A few bees, not many at any time. (L.A.K.)

August 10, 1915. Plots. Clear, warm. Five bees and some *Syrphus* flies. Campus (Gravel hill). Five bees on the plot.

Ledges, Boone, August 15, 1915. Sultry. Five bees on area. (L.A.K.)

Ames, August 19, 1915. Plots. Clear, cool. One bee. (L.A.K.)

August 20, 1915. Clear, cool morning. A bee visits four flowers per head, two seconds to the flower. (L.A.K.)

August 21, 1915. Plots. Clear, warm. Two bees. (L.A.K.)

August 23, 1915. Clear, warmer. A few bees working. A bee tests but one flower per head. (L.A.K.)

August 25, 1915, 3 p.m. Clear. No bees. (L.A.K.)

August 26, 1915. Plots. Cloudy. Six bees. (L.A.K.)

August 27, 1915, 5 p.m. Partly cloudy. Two bees. Most seen on this plant since July 21. Season dry since then. (L.A.K.)

Sept. 1, 1915. Clear, warmer, following cool weather. Five bees.

Sept. 6, 1915. Warm, dry. A few bees.

May 29, 1916. Fields white with bloom. Much fragrance. Many bees at work. (L.H.P.)

Altoona, May 29, 1916. As above.

Centerville, May 29, 1916. As above.

June 7 to June 12, 1916. Plenty of moisture. Clover vigorous.

Ames, Centerville, Altoona, June 29, 1916. Fields white. Visited by many bees. (L.H.P.)

June 24, 1917. Bees abundant.

Marshalltown, June 26, 1917. White clover coming into bloom freely. Bees at work. (L.H.P.)

Ames, June 26, 1917. Plants mostly young seedlings; older plants killed the winter previous. Bees common. (L.H.P.)

July 11, 1917. Clear. Bees common.

Iowa City, July 13, 1917. Clear. Bees abundant. (L.H.P.)

August 14, 1917, 2 p.m. Dry weather. Some bees. (L.H.P.)

Centerville, Aug. 29, 1917, 3 p.m. Clear. Honey bees abundant.

Ames, May 9, 1918. Honey bees in white clover. (L.H.P.)

June 8, 1918, 10 a.m. Fine day. On area of ten feet square five honey bees were at work in three minutes.

June 29, 1918. Bees abundant. (L.H.P.)

Ames, August 3, 1918. Hot day, slight breeze. 12 to 3 p.m. Some bees.

Forest City, August 28, 1918, 7 p.m. Bees common. (L.H.P.)

September 23, 1918. Some honey bees. (L.H.P.)

Dubuque, October 4, 1918. Bees abundant.

June 8, 1919, 9 p.m. Bees visiting white clover. (L.H.P.)

June 16, 1919. Partly cloudy. Sprinkle of rain. Bees visited sixteen flowers in forty seconds. (L.H.P.)

June 22, 1919, 2 p.m. Bees eight, nine, ten seconds in a flower. One bee visits twenty flowers in a minute.

June 24, 1919. Bee visits eight, ten, twelve, twelve flowers in a minute.

June 29, 1919, 6:50 p.m. Warm, dry day. One bee visits thirty-seven flowers in one minute.

June 30, 1919. Thirty flowers visited by one bee in one minute. Ten bees working at one time on a clump of bloom with 4,800 flowers open.

July 4, 1919, 11:35 a.m. Bees abundant, some wasps. Bees getting water from the leaves. One bee visited twenty-five flowers in thirty seconds.

July 6, 1919, 6 p.m. East wind, clear. Twenty-five flowers in one minute by one bee. Twenty flowers in one minute by another bee. Five bees in one minute on a clump thirty by fifteen. Black flies and wasps numerous.

July 7, 1919. 4:15 p.m. and 7:15. Bees abundant on plant three and a half feet tall. Seven bees. On plant three and one half feet tall, four bees. On plant three and one half feet tall, five bees. On plant three and one half feet tall, four bees. (L.H.P.)

Marble Rock, July 8, 1919. White clover abundant and yielding honey.

Mason City, July 8, 1919. As above.

Rockford, July 8, 1919. As above. (L.H.P.)

July 22, 1919, 7:30. Thirty-two flowers visited in one minute.

October 21, 1919. Sunshiny. Two bees observed during period of two minutes on one cluster.

June, 1920, 4:15 p.m. Bees abundant. On a plant three and one half feet long, seven bees. On a plant three and one half feet long, five bees.

Ames, June, 1920. On a plant three and a half feet long, four bees. A bee visited fifteen flowers in a minute, on two different heads. On average sized plant, 1,500 flowers open at one time.

June 4, 1920, 3 p.m. Bee visits sixteen, three, twelve flowers in one head. Time in flower one to two seconds.

8 p.m. Bees still at work. (L.H.P.)

June 12, 1920. Partly cloudy. Time in flower two, two, two, two seconds.

June 24 to 29, 1920. Bees abundant. (L.H.P.)

June 30, 1920, 9 a.m. Sunshiny, warm, heavy dew. Bees abundant. One bee visiting seventeen flowers in one minute. (L.H.P.)

1:30 p.m. Warm, south wind. One bee goes to sixteen flowers in seventeen seconds. One bee goes to seventeen flowers in seventeen seconds. Three bees visit five hundred flowers in one minute. (L.H.P.)

July 2, 1920, 9 a.m. One bee visits thirty-eight flowers in one minute. Bees abundant.

July 3, 1920. Bright, sunny. Honey bee visits thirty flowers in one minute.

6 p.m. Bee visits three flowers in one head. Time in flower two seconds.

July 6, 1920, 9:30 a.m. Rainy. No bees. 12:30 p.m. Cloudy, cool, east wind. No bees. (L.H.P.)

July 8, 1920, 9 a.m. Heavy dew. The bee spends two seconds in a flower. 12:30 p.m. Visits three heads in one-half minute. Time in flower three, three, three, three, two, three, two, two, three seconds. (L.H.P.)

July 15, 1920, 8:45 a.m. Bees abundant.

Marshalltown, July 15, 1920. Abundance of white clover. Freely visited by bees. (L.H.P.)

Rockwell City, July 15, 1920, 6 p.m. Clear, sunshiny. Honey bees abundant. Meadow covered with white clover. Soil sandy and black loam.

Ames, July 19, 1920, 6:30 a.m. Time on flower one, one, two, one, two, one, one seconds. Three bees take two hundred fifty flowers in one minute.

July 20, 1920, 9 a.m. Bees abundant. Time in flower one to two seconds.

June 7 to 14, 1921. Clear. Bees two seconds in a flower.

June 15, 1921, 8:15 a.m. Cloudy. Heavy rain previous night. No bees. 6:30 p.m. Ten bees on five hundred heads. Two seconds in a flower.

June 30, 1921. Common everywhere in the state; Carroll, Coon Rapids, Des Moines, Ames, Winterset, Boone. White clover evidently yielding much nectar.

July 1, 1921, 2 p.m. Partly cloudy. Bee visits sixteen flowers on five heads in sixteen seconds.

July 2, 1921. Noon, partly cloudy. Four bees on three hundred heads. Two seconds in a flower. Clover blooms freely after rains.

July 5, 1921. Abundant bloom still in central and southern Iowa.

July 14, 1921, 4 p.m. Clear, warm. One bee over area with five hundred flowers. One, one, one, one, one, one, one, one, two, one seconds in a flower.

July 15, 1921. Abundant bloom noticed in northern Iowa.

June 1, 1922, 2:30 p.m. Cloudy, warm, abundance of rain preceding week. Bees not numerous, collecting nectar. Three, three, two, three, four seconds in a flower.

June 6, 1922, 5 p.m. Bees fairly abundant. Two, three, two, two, two, two, two seconds in a flower. Clay soil. One bee visited six flowers in one head. Four bees were at work over one hundred sixty flowers. Number of flowers in a head, one hundred, fifty-one, forty-five, eighty-four, one hundred.

Fort Atkinson, June 6, 1922, 11 a.m. Bees two, two, two seconds in a flower.

Ames, June 21 and 23, 1922. Clear. Bees two and three seconds in a flower.

June 30, 1922, 1:30 p.m. Partly cloudy after rain. Bees one, two, two, two, two, two seconds in a flower.

Nevada, July 3, 1922, 3 p.m. Clear and warm. Bees abundant. Two, three, two, two, three seconds in a flower. Roadside. Black soil.

Ames, July 4, 1922, 9 a.m. Clear, cool and dry. Bees two, two, two, two, two, three, two, three seconds in a flower. Roadside.

July 6, 1922. Lull in rainy weather. Bees abundant. Two, three, two, three, two, one seconds in a flower. One bee visited ten flowers in a single head. (L.H.P.)

Fort Atkinson, July 8, 1922, 3 p.m. Clear, cool, dew. Bees abundant. One, two, two, two, two, two, three, two seconds in a flower. Clay soil. (L.H.P.)

Clear Lake, Minnesota, August, 1922. Bees one second in a flower.

Winterset, May 30, 1923, 2 p.m. Plants in clay soil. Bees getting nectar. Two, two, three, three, two, three, four, three seconds in a flower. White clover abundant everywhere.

Ames, May 31, 1923, 2:30 p.m. Partly cloudy. Bees two, two, one, two seconds in a flower.

June 1 to July 7, 1923. Warm, sunny. Bees abundant. One to three seconds in a flower.

Fort Dodge, July 12, 1923. Bees at work upon the plant. (L.H.P.)

Council Bluffs, June 4, 1924, 5:30 p.m. Hazy. Few bees. One, one, two, two, one seconds in a flower.

Ames, June 10, 1924. Bees one, one, two, one, one seconds in a flower.
July 5, 1924, 8 a.m. Cool, clear, dew. No bees on white clover. (L.H.P.)
July 6, 1924. Bees common. One to two seconds in a flower.

Central Iowa, July 18 and 20, 1924. Bloom abundant everywhere in fields and pastures. Fragrance noticeable upon the air. Bees abundant but not enough to use all the bee pasture. (L.H.P.)

Bluffton, July 24, 1924. Bees abundant. (L.H.P.)

Giard, July 28, 1924, 2 p.m. Bees one to two seconds in a flower.

McGregor, August 13, 1924. Bees abundant. (L.H.P.)

Pella, October 11, 1924, 9:30 a.m. Bees common. (L.H.P.)

Ames, May 25, 1925, 3 p.m. Bees one to two seconds in a flower.
May 28, 1925, 4 p.m. Bright and clear. Bees abundant, two, two, two, one, two, two, one, three, two, one, four seconds in a flower. (L.H.P.)
May 30, 1925, 8 a.m. Clear. Bee one, two, two, two, two, three, two, one, one seconds in a flower. On seven flowers of one head as follows, one, one, two to four seconds.

Eldora, June 18, 1925, 4 p.m. Bees one to three seconds in a flower.

West Union, June 18, 1925, 8 a.m. Clear. Bees abundant. Two, two, two, two, one seconds in a flower. (L.H.P.)

Ames, July 5, 1925, 3 p.m. Bees two to three seconds in a flower.

Prairie du Chien, Wisconsin, July 5, 1925, 10 a.m. Partly cloudy. Soil sandy. Bees abundant. Two, two, two, one, two, two, three seconds in a flower.

Manhattan, Kansas, May 17, 1927, 2 p.m. Clear. Bees two, two, two, one, two seconds in a flower. (L.H.P.)

Ames, May 26, 1927, 1 p.m. Cool. Bees abundant. In flower two seconds.
May 27, 1927, 8 a.m. and 12 m. Cloudy. No bees.
May 28, 1927. Same as above.
June 3, 1927, 4 p.m. Cool. No bees. (L.H.P.)
June 4, 1927, 10 a.m. Clear, cool. Bees fairly common. Two bees in six minutes, about one hundred and sixty bees during the day. Bees two, two, three, two, three, two seconds in a flower. (L.H.P.)

Nevada, June 5, 1927, 6 p.m. Bees common. Two, two, two, three, three seconds in a flower.

Ames, June 7, 1927. Clear, warm. Bee visited twenty-five flowers in a head.
June 10, 1927, 1:30 p.m. Bees visiting a single plant in one hour, nine, twelve, eleven, thirteen. (S. Goodell.)
June 15, 1927, 10 a.m. Bees two to three seconds in a flower.
June 17, 1927. Warm, cloudy, windy. Bees in one head alsike, ten seconds; in white clover, eleven; in yellow sweet clover eighteen seconds. One bee collected only one kind of nectar. (C.C.L.)

Story City, June 19, 1927, 10 a.m. Clear, sunshiny, warm. Bees two, two, one, one, two seconds in a flower. (L.H.P.)

Stanhope, June 19 and 20, 1927. Cloudy, warm. Bees one to two seconds in a flower.

Ames, June 21, 1927, 8 a.m. Bees one to three seconds in a flower.

6 p.m. Warm, sunny. Bees abundant. Two seconds in a flower.

June 26, 1927. Bees abundant. Two, two, three, two, three, three, three seconds in a flower. (L.H.P.)

June 29, 1927, 11 a.m. Hot winds. Somewhat cloudy. Bees abundant. Two seconds in a flower. 1 to 3 p.m. Hot, dry, windy. No bees at work except where clover had been sprinkled.

(Campus, Iowa State College) July 1, 1927, 9 and 10 a.m. Cool, rainy. A few bees working; more on dandelion. (C.C.L.)

July 3, 1927, a.m. Clear, cool. East wind. Some bees, two, two, two, two, two, two seconds in a flower. (L.H.P.)

July 4, 1927, 10 a.m. Clear, cool, raw east wind. Bees two seconds in a flower.

July 6, 1927, 10:30 a.m. Clear and warm. Bees two seconds in a flower. 1 p.m. Very dry. Bees visit from two to four flowers in a head.

Eldora, July 10, 1927. Bees two, two, two seconds in a flower. (L.H.P.)

Ames, July 10, 1927, 11 a.m. Clear, warm. Clover drying up. Some bees, two, two, two seconds in a flower. (L.H.P.)

Colo, July 17, 1927, p.m. Warm, dry, clear, windy. Bees still working upon the plant heavily. (C.C.L.)

Ames, July 23, 1927. Clear, warm. A few bees. Three and two seconds in a flower.

Bloomfield, July 25, 1927, 10:30 a.m. Clear, sunshiny. Rain previous night. Bees two, two, two, two, two, two seconds in a flower. (L.H.P.)

Ottumwa, July 25, 1927, 4 p.m. Many bees. Two seconds in a flower.

Pella, July 26, 1927, 10:30 a.m. Bees two, two, two seconds in a flower.

Marquette, Wisconsin, August 16, 1927, 4 p.m. No bees on *Trifolium repens*, *Epilobium spicatum* nor other honey plants. (L.H.P.)

Escanaba, Michigan, to Milwaukee and Ishpeming, August 12, 1912. Blooming. Common.

Norwalk, September 7, 1927, 3 p.m. Clear, warm. Low grounds. No bees on white clover nor on *Bidens aristosa* and other blooming fall honey plants.

Ames, June 14, 1928, 11 a.m. Warm. Bees three, three, four, three, three, three seconds in a flower.

Des Moines, June 20, 1928, 11 a.m. Clear and warm. Bees abundant. Two, two, two, three, three, two seconds in a flower. The honey flow better than for several years. White clover vigorous. (L.H.P.)

Churdan, June 24, 1928. Cold, raw. Abundant, much nectar this year. Abundant also between Jefferson and Ames.

Ames, June 25, 1928, 11 a.m. Cool, bright. Bees common. Three, two, two, three, two seconds in a flower. (L.H.P.)

Denison, June 25, 1928, 4:20 p.m. Bees two to four seconds in a flower.

Waubeek (Jordan's Grove), June 29, 1928, 12:30 p.m. Clear, warm. Bees three, two, two, two, three, three seconds in a flower. (L.H.P.)

Abundance of white clover at Cedar Rapids, Center Point and Marion.

Carroll, Boone, Greene counties, July 1, 1928. Practically no bees on *Trifolium repens*. Enormous amount of nectar going to waste. Fields frequent, especially where soil contains clay.

Ames, May 27, 1929, 8 a.m. Warm and sultry. Two, two, three, three, two seconds in a flower.

Des Moines, May 28, 1929, 3 p.m. Bees two to three seconds in a flower.

Ames, May 28, 1929. Cloudy, warm. Bees two seconds in a flower.

Waukee, May 31, 1929. Pastures with abundance of white clover from Ames to Des Moines and Adel. Bees numerous everywhere. (L.H.P.)

Dallas, Polk, Boone, Story counties, June 1, 1929. Some pastures in these counties thickly covered with white clover. The plants and flowers unusually vigorous. Mr. H. E. Codlin reports bees abundant in Dallas county. Honey bees getting surplus of nectar in Madison county. (L.H.P.)

Adel, June 1, 1929, 12:10 p.m. Cloudy, moist. Bees common. Two, two, two, three, two seconds on a flower.

Boone, June 2, 1929, 4 p.m. Clear, east wind. No bees.

June 3, 1929. *Trifolium repens* luxuriant north to Eagle Grove from Ames. (L.H.P.)

10:30 a.m. Honey bees fairly common. Two, two, three, three seconds in a flower. Number of flowers visited in head, one, three, three, two.

5:30 p.m. Bees three, three, four, three seconds in a flower.

Orange City, June 4, 1929, 3:30 p.m. Bees two to four seconds in a flower.

Ames, June 5, 1929, 1:30 p.m. Numerous bees. Two, three, three, three, three seconds in a flower.

Des Moines, June 6, 1929, 3:30 p.m. Bees abundant. Next to apiary. Three, two, two, two seconds in a flower. No bees on *Trifolium pratense* and *Trifolium hybridum*. (L.H.P.)

Ankeny, June 6, 1929, 3 p.m. Bees two, three, two, two seconds in a flower.

Manson, June 11, 1929, 5 p.m. Bees three, two, two, two seconds in a flower.

Jewell, June 11, 1929. Abundant from Ames to Jewell in pastures. Vigorous. Not as abundant and vigorous between Manson and Rolfe as at Ft. Dodge.

Rolfe, June 11, 1929, 1:45 p.m. Some bees. Two to three seconds in a flower.

3:30 p.m. Bees abundant. Three, two, two, four seconds in a flower.

Jordan, June 15, 1929, 3 p.m. Warm, clear, strong south wind. Not many bees in vicinity. Two to three seconds in flower.

Dolliver Park, Ft. Dodge, June 16, 1929, 3 p.m. Bees fairly common. Bloom of this species luxuriant between Boone, Pilot Mound, Dayton, Lehigh and Fort Dodge. (L.H.P.)

Ames, June 18, 1920. Bees three, four, three, three seconds in a flower.

Tingley, June 20, 1929, 10:15 a.m. Some bees. Three seconds in a flower.

June 20, 1929. White clover abundant at Des Moines, Afton, Tingley and Arispe. The pastures were white with clover. Only a very small amount of the honey is used this year. (L.H.P.)

Clear Lake, June 22, 1929, 7 a.m. Bees active. Three seconds in a flower.

Des Moines, June 24, 1929. Cool, west wind. Only a few bees. Three, three, three, two, three seconds in a flower. One thousand feet from an apiary.

Steamboat Rock, June 29, 1929, 4 p.m. Bees three seconds in a flower.

Iowa Falls, July 1, 1929. No bees. Near an apiary. (L.H.P.)

Ames, July 1, 1929, 6 p.m. Warm. Bees three to four seconds in a flower.

July 7, 1929. Two to three seconds in a flower.

July 9, 1929, 2 p.m. Near *Veronica spicata*. No bees. (L.H.P.)

Marshall and Tama counties, July 13, 1929. Abundant in these counties. Many pastures were white from the clover and the air was fragrant from the blossoms.

Gladbrook, July 13, 1929, 3 p.m. Few bees. Two, two, two, one seconds in a flower. (Heavy rain the night before.) (L.H.P.)

Marshalltown, July 13, 1929, 6 p.m. Bees two, two, three, two, three seconds in a flower. (Heavy rain the night before.) (L.H.P.)

Livermore, July 15, 1929. Bees two, three, two, two seconds in a flower. Apiary 300 feet away.

On July 17, 1929, there was an abundance of white clover observed at Gilbert, Story City, Jewell, Eagle Grove, Goldfield, Livermore and Algona. Some pastures were white from the blooms of the plant. While bees were observed at these points they were not common. (L.H.P.)

Ames, July 18, 1929, 8:30 a.m. No bees though adjacent to *Veronica spicata*, which was visited by bees. Near apiary. (L.H.P.)

July 24, 1929. Heavy rains in the morning. No bees. (Apiary 1,000 feet away.) Bees occur on *Lythrum Salicaria, Echinops Rito* and *Veronica spicata*.

August 3, 1929, 3 p.m. No bees. Apiary 1500 feet away. Warm, sultry. 6 p.m. Cool, north wind. Bees fairly common. Two, three, three, three seconds in a flower. (L.H.P.)

Abundant in pastures between Boone, Ogden and Jefferson in 1929, yielding much nectar.

August 5, 1929. Abundant in pastures from Blairsburg to Jewell, Iowa Falls, Hampton, Allison, Strawberry Point. Good honey flow this year. Abundant and furnishing much nectar in Allamakee, Winneshiek and Cerro Gordo counties. Less abundant in Howard, Mitchell, Franklin and Floyd counties.

Ames, August 19, 1929. No bees. (L.H.P.)

August 26, 1929. No bees. (L.H.P.)

Des Moines, August 27, 1929. No bees.

Ames, September 17, 1929. Two, three, two, three seconds in a flower.

September 18, 1929. No bees. Few beetles and flies. Some *Pieris rapae*. Temperature 60°. Near an apiary. Bees on *Aster novae-angliae*.

Dates of bloom: 1925, Ames, June 1; Lansing, June 1. 1926, Ames, June 1. 1927, Ames, May 25.

Trifolium hybridum L. Alsike Clover

This clover is more branching and larger than the white clover; not rooting at the nodes; the blossoms resemble those of white clover in shape but are tinged with rose pink. The flowers may be distinguished by the absence of the purple spots at the sinuses of the calyx, these spots being characteristic of white clover. Leaflets rounded at the apex. Introduced from Europe. This clover is not uncommon in many parts of Iowa, especially where it has been sown for pasture.

FIG. 202.—Alsike clover (*Trifolium hybridum*). *Photo by Ada Hayden.*

In various soils; does exceptionally well in peat soils and in low places but not in alluvial soils. Associated with *Trifolium pratense, Poa pratensis, Polygonum pennsylvanicum.*

A. I. and E. R. Root state in "A B C of Bee Culture" that alsike yields fully as much nectar as white clover. This is not true for central Iowa.

The pink and white heads of the alsike are conspicuous. In alsike clover the nectar is secreted as in the other clovers and is easily obtained by honey bees. During some seasons it furnishes much nectar, in other seasons little. In 1924 this clover was much visited by bees.

It is thrifty and does well on low grounds, where it is often a reliable honey plant. "The honey is white in color, mild in flavor and is regarded as one of the best for table use. At times the yield is very heavy. In one case a single colony gathered seventy-two pounds in four days."

Alsike clover is highly recommended as a honey plant. Some of our observations, however, indicate that it is less visited by honey bees than is the white clover. Its corollas are but slightly inferior to those of white clover in the amount of sugar contained.

The insect visitors are very similar in kind to those of white clover, flies and various Hymenoptera being rather frequent.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Hanlontown, Marathon, Middle River, Missouri Valley, Warren county, Wheelerwood (L. H. Pammel), Ames (E. R. Hodson, G. W. Carver and L. H. Pammel, P. H. Rolfs), Center Point (F. L. Taylor), Decatur county (J. P. Anderson, M. F. L. and T. J. Fitzpatrick), Fraser (two specimens, Botany Seminar), Keokuk (P. H. Rolfs), Osage (Mrs. F. M. Tuttle).

It has been observed (L. H. Pammel) at Algona, Buffalo Center, Des Moines, Eagle Grove, Eldora, Emmetsburg, Estherville, Forest City, Fort Dodge, Iowa Falls, Jewell, Ledges (Boone county), Marshalltown, Nevada, Orange City, Tingley.

General distribution in the United States and Canada:

Alaska—Juneau, Sitka (J. P. Anderson); Canada—Banff (L. H. Pammel); Colorado—Idaho Springs (L. H. Pammel and D. S. Jeffers), Providence canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); Illinois—Champaign (H. A. Gleason); Massachusetts—Concord (Walter Deane); Minnesota—Brainerd (E. B. Watson), Crookston (Mrs. Roy Westley), Duluth (L. H. and H. E. Pammel), Hibbing (Lyle Clapper), International Falls (H. S. Kellogg); New York—Ithaca (H. E. Summers); Oregon—Crook county (K. Whited); Utah—Peterson (L. H. Pammel and R. E. Blackwood); Vermont—Peacham (Ferdinand Blanchard); Washington—Seattle (Emma A. Shumway); Wisconsin—(L. H. Pammel).

HONEY BEE VISITS

Ames, I.S.C. Campus, June 16, 1914. Clear, cool, southeast wind. Fewer bees than on white clover. Other insects numerous. (H. Frazier.)

June 18, 1914. Along street. Clear, warm, 70°. A few bees after 7:30 a.m. (G.H.M.)

June 19, 1914. Along street. Moderate. Bees plentiful. *Andrena* plentiful. (G.H.M.)

Summer of 1915. I.S.C. Campus. Cool. Wet season. Bees rarely observed on alsike. (L.A.K.)

June 8, 1918. Over a space ten by ten feet, five honey bees in three minutes.

June 8, 1919, 9 a.m. Some honey bees. One, two, one seconds in a flower. Honey bees observed to go from alsike to white clover blossoms. (L.H.P.)

June 9, 1918, 10 a.m. Somewhat cloudy. Honey bees visiting this plant, and observed again at 8 p.m.

June 18, 1919. Bees on white clover. None on alsike. (L.H.P.)

Marshalltown, July 15, 1920. Some bees at work in this plant.

Ames, June 1, 1921, 6 p.m. Clear, cool. Some bees at work. Two, two, one seconds in a flower.

June 4, 1921. Warm, clear. Three bees at work on fifty flowers. Two, two, two, one, two, one seconds in a flower. (L.H.P.)

June 1, 1922, 8:30 a.m. Partly cloudy. Bees two, two, two, one seconds in a flower. Bees less abundant than on white clover.

June 5, 1922, 2:30 p.m. Cloudy. Bees two, three, three, four, three, two seconds in a flower. (L.H.P.)

Fort Atkinson, 1922, 3 p.m. One hundred ten flowers in a single head. Bees abundant. Clay soil.

Ames, June 6, 1922, 1 p.m. Bees fairly common. Two seconds in a flower.

June 8, 1922, 9 a.m. Bees one to three seconds in a flower. Bees confine their work to one species.

May 31, 1923. Partly cloudy, warm. Bees two, two, two, one, two seconds in a flower. Bees flew from white clover to alsike clover. (L.H.P.)

June 15, 1923, Noon and 2 p.m. Warm, humid. Bees one, one, two seconds in a flower. (L.H.P.)

Storm Lake, June 22, 1923, 2:30 p.m. Bees abundant. Two, two, two, two, two, three, three, one, two, two, three seconds in a flower. (L.H.P.)

Ames, June 23, 1923, 3 p.m. Bees one to two seconds in a flower.

Observations, June 12, 1924 (L. H. Pammel): Alsike not as abundant as the other clovers in Iowa, but in Dubuque, Marshall, Hardin and Story counties the plants are vigorous and yield considerable nectar.

Central Iowa, Eldora, Marshalltown, Union, Zearing, Nevada, July 8, 1924. Large fields freely in bloom. Bees active upon the flowers. (L.H.P.)

July 9, 1924, 1 p.m. Partly cloudy. North wind, slight rain night before. Bees fairly common. Two to three seconds in a flower.

Ames, July 5, 1924, 8 a.m. Cool, clear, dew. No bees on alsike.

Bluffton, July 24, 1924. Bees one to two seconds in a flower.

Giard, July 28, 1924, 2 p.m. Bees two seconds in a flower.

Ames, June 4, 1927, 10 a.m. Clear, cool, north wind. Bees fairly common.

June 6, 1927, 2 p.m. Cloudy, warm. Bees go from this to white clover.

June 7, 1927. Clear, warm. The bee visited three, four, two flowers in a head. Bees two, two, two, two, one, two seconds in a flower. (L.H.P.)

June 10, 1927, 1:30 p.m. Fifteen bees visited the plant in one and a half hours. Bees visiting a single plant in one hour, nine, nine, nine, nine and thirteen. (S. Goodell.)

June 17 and 28, 1927. Cloudy. East wind. Bees one to three seconds in a flower.

July 3, 1927, 12 m. No bees but bees on *Melilotus officinalis*. (L.H.P.)

Iowa City (clay soil), August 4, 1927, 3 p.m. Clear, warm. No bees. Bees preferring white sweet clover. (L.H.P.)

Ishpeming, Michigan, August 12, 1927. Common, blooming. No honey bees.

Denison, June 24, 1928. Fair. Bees common. Three, three, two, three, three seconds in a flower. On a single patch 3 by 4 feet, 2000 flowers in bloom. Three bees observed in one second on the patch. Fowers not yet at height of bloom.

Ames, June 25, 1928, 4:20 p.m. Some bees. Three, three, two, three seconds in a flower. Apiary one-fourth mile away. (L.H.P.)

June 26, 1928, 2 p.m. Clear, moderate. Bees one, one, two, two, two seconds in a flower. No bees on *Melilotus officinalis, M. alba* nor *Trifolium repens.*

Whittier, June 9, 1928, 4 p.m. Bees two to three seconds in a flower.

Des Moines, June 24, 1929. No bees. One thousand feet from an apiary.

Ames, July 2, 1929, 9 a.m. Bees three, three, two, three seconds in a flower. First time observed this year. The alsike abundantly in bloom. (L.H.P.)

July 6, 1929, 11:30 a.m. Three, three, three, three seconds in a flower.

July 16, 1929. Bees abundant. Two, three, three, two seconds in a flower.

August 5, 1929. Common at Blairsburg, Allison, Iowa Falls and Maynard. Abundant bloom in Allamakee, Clayton, Floyd and Winneshiek counties, furnishing much nectar in 1929.

Dates of blooming, Ames, May 3, 1926.

Trifolium agrarium L. Yellow Hop Clover

The yellow hop clover grows to a height of one foot. The leaflets are small and grouped at the end of the petiole. A smoothish plant.

Occurs in clay soils of the Mississippi loess area, especially in Allamakee, Clayton and Winneshiek counties and northeastern Iowa generally. Rather rare. Associated with *Poa pratensis, Brauneria purpurea, Vicia americana, Geranium maculatum, Galium boreale*, etc.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Postville, Rowley (L. H. Pammel).

It has been observed (L. H. Pammel) in Clermont, Decorah, Elkader and Waukon.

General distribution in the United States:

District of Columbia—Rock creek (E. A. Hyde); Indiana—Wells county (Charles C. Deam); Maryland—Baltimore, College Park (F. B. Trenk), Baltimore county (K. A. Taylor); Michigan—northern Michigan (L. H. Pammel); New Hampshire—Shelbourne (Walter Deane); Pennsylvania—Maryville (John K. Small), Warren (H. E. Pammel); Vermont—East Corinth (H. S. Kellogg).

This clover is visited by bees for nectar.

Trifolium procumbens L. Hop Clover.

Similar to yellow hop clover. Spreading pubescent annual. Leaflets wedge-obovate, the lateral at a little distance from the other; notched at the end. Stipules ovate, short. More common than the preceding; found especially in sandy fields and roadsides and in prairie soils of central Iowa. Abundant only in cultivated soils. Associated with *Oxalis corniculata, Poa pratensis, Medicago lupulina, Polygonum pennsylvanicum.*

The low hop clover is more widely distributed than the specimens indicate.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Belmond, Hancock county, Sac City, Sigourney (L. H. Pammel), Lake Okoboji, Milford (H. S. Coe and L. H. Pammel), Aurelia, Polk City (R. B. Rutheford), Ames (two specimens, G. W. Carver, P. H. Rolfs, C. E. Bessey, S. W. Beyer), Beaman (Irwin Lepley), Osage (Mrs. F. M. Tuttle), Sigourney (County Agent), Spencer (W. C. Posey), Polk City (L. C. Swim).

Observed growing freely on I.S.C. Campus, 1922. (C. M. King.)

FIG. 203.—Hop clover (*Trifolium procumbens*). *Drawing by C. M. King, Photo Hart.*

General distribution in the United States:

Arkansas—Little Rock (George W. Letterman); District of Columbia—Washington (E. A. Hyde); Illinois—Makanda (H. A. Gleason); Massachusetts—Nantucket (J. R. Churchill); Minnesota—Faribault (L. H. Pammel); New York—Ithaca (H. E. Summers); Ohio—Kelly's Island (L. H. Pammel), Put-in-Bay (two specimens); Oregon—Carson Heights (L. H. Pammel and W. S. Dudgeon), Corvallis (E. P. W. and C. E. O.); South Carolina—Pickens county (two specimens, A. P. Anderson); Tennessee—Clarksville (T. L. Andrews); Utah—White Rock Agency (L. H. Pammel and E. M. Stanton).

HONEY BEE VISITS

Ames, Campus I.S.C., May 22, 1914. Clear, hot, southeast wind. Few insects, except a small fly. (G.H.M.)

May 25, 1914. Partly cloudy, hot, still. No large bees. Insects collected are small bees. Syrphus flies, a few small Lepidoptera. Honey bees seem not to be attracted by this flower, although it is occasionally visited by them. (L.H.P.)

Melilotus (Tourn.) Hill. Melilot

Flowers yellow or white, resembling those of *Trifolium* but arranged in racemes. The pod is wrinkled. The leaves are trifoliate. The flowers secrete nectar and have the odor of cumarin.

In the year 1929 there were over a million acres of sweet clover in Iowa along highways and railroad rights-of-way and in fields. The estimated yield of honey is about $7 per acre, making the yield about seven million dollars. Not nearly all of this nectar is gathered.

Melilotus officinalis L. Lam. Yellow Sweet Clover

A biennial plant two to three feet high, fragrant; oblong leaflets three, blunt at the end. Yellow flowers in loose racemes. Common along roadsides.

This occurs in prairie or clay soils associated with *Melilotus alba, Trifolium pratense, Cirsium ioense, Veronica virginica.*

The yellow sweet clover is very similar to the white sweet clover, but it is a lower, more straggling plant, and blooms about two weeks earlier, as noted by L. A. Kenoyer. The sugar content of the blossoms is practically the same as that of the white.

The following is taken from a report by L. A. Kenoyer—"On June 14, 1924, bees seemed equally numerous on white and yellow sweet clover. A full day's study on July 22 showed them to be but one-third as plentiful on yellow; while a like study on August 4 indicated that they were but one twenty-fifth as plentiful. This may perhaps be accounted for by the fact that

FIG. 204.—Yellow sweet clover (*Melilotus officinalis*). *Photo by Coburn, Photo Section, Ia. Agr. Expt. Sta.*

the yellow sweet clover is somewhat on the decline so late in the season, and hence not at its best as a producer of nectar. As visitors, solitary bees are rather more frequent than honey bees. Wasps, butterflies and flies are hardly more than occasional."

In 1929 plants were in bloom at Jewell, Webster City, Eagle Grove, Irvington, Livermore and Algona. There were no honey bees. It may be interesting to state that many specimens of second growth yellow sweet clover were watched for honey bees, but in no cases were the plants beyond prime visited by these bees, though they were abundant upon other plants in the vicinity. Apparently the greatest production of nectar occurs during the early blooming season of yellow sweet clover.

This would without doubt be a good plant to seed in waste places and roadsides with a view to increasing honey production. It is at its best before the white species is blooming.

The yellow sweet clover is less common than the white sweet clover. It occurs in clay, in black prairie soils and on railway rights-of-way. It is becoming quite abundant in places.

The corolla is papilionaceous and flowers are produced in racemes; the stamens are diadelphous. Nectar is secreted abundantly. The yellow sweet clover is one of the best of the Iowa honey plants, being less influenced by dry weather than white clover because of its deep root system.

Mr. Pellett says, "The yellow variety blooms about two weeks earlier than the white, and when both are present, a long honey flow may be expected. Sweet clover reaches its highest development in the secretion of nectar in the hot, dry summer climate of the plains region between the Mississippi river and the Rocky mountains."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, Dakota City, Emmetsburg, Garner, Hancock county, Marathon, Ogden, Slater (L. H. Pammel), Algona, Estherville (R. I. Cratty), Ames (C. R. Ball, G. W. Carver, C. M. King, J. H. Cowan), Decatur county (T. J. and M. F. L. Fitzpatrick), Mount Pleasant (J. H. Miller).

It has been observed (L. H. Pammel) at Adel, Algona, Alton, Boone, Colo, Council Bluffs, Denison, Des Moines, Dubuque, Dyersville, Eagle Grove, Eldora, Fort Dodge, Hawarden, Humboldt, Iowa Falls, Jefferson, Jewell, Jordan, Manson, Marshalltown, McGregor, Missouri Valley, Nevada, Ogden, Onawa, Orange City, Rolfe, Shenandoah, Sioux City, Tingley, Waterloo, Winterset.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Colorado—Fort Collins (L. H. Pammel, C. S. Crandall, L. H. Pammel and C. P. Johnson); District of Columbia—Washington (L. H. Pammel); Illinois—Champaign (B. Fink); Kansas—Wichita (T. L. Andrews); Louisiana—Gretna (C. R. Ball); Minnesota—Minneapolis (R. I. Cratty, F. H. Burglehaus), Rochester (Stella L. Goodspeed); Missouri—Columbia (L. H. Pammel); Nebraska—Wilcox (Mrs. Joseph Clemens); New Mexico—Santa Fe (A. Isabel Mulford); Ohio—Kelley's Island (two specimens, L. H. Pammel); South Dakota—Clear Lake (L. H. Pammel); Utah—Logan canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); Wyoming—Laramie (Aven Nelson).

HONEY BEE VISITS

Ames, June 19, 1914. Plots. Warm, clear, north wind. Twenty-six bees on the area. No other insects. (G.H.M.)

June 22, 1914. Plots. Warm, partly cloudy, south wind. Many bees. No other insects. Bees leave white for yellow, remaining three to four seconds on each flower. (Lott.)

June 22, 1914. Plot. All day 90°, sunny, southwest wind, rather dry. 7 a.m. to 4 p.m. Climax at 1 p.m. Two to sixteen bees on the area. A few small bees and other insects. (G.H.M.)

June 27, 1914. Waste ground. Cloudy, cool, strong southwest wind. Bees visiting six flowers per hour on a single plant. (G.H.M. and L.A.K.)

August 8, 1914. Plots. All day, cloudy to clear, east wind, dry. One to three honey bees on the area, from 11 a.m. to 4 p.m. only. Two to three small bees, three to ten Diptera and one to three Lepidoptera. (G.H.M.)

June 5, 1915, 3:30 p.m. Honey bees common.

July 13, 1915. An abundance of bees.

July 11, 1917. Clear, bees common.

August 14, 1918, 2 p.m. Dry weather. A few bees.

June 8, 1919, 9 a.m. Sunshiny, warm. Yellow sweet clover in flower about one week. Honey bees abundant, gathering pollen and nectar. A bee in a flower, one, two and three seconds. (L.H.P.)

June 13, 1919, 1:30 p.m. Sultry, cloudy. Bees active. One second in one flower. On one plant, 1,800 flowers. Sixteen honey bees on one plant in one minute.

5:30 p.m. Cloudy, threatening rain. Bees abundant.

June 15, 1919. Slight west wind, warm. Bee spends one, two, one, two, one, two seconds in a flower. One bee visits fourteen flowers in fifteen seconds. Twelve honey bees observed in one cluster of plants with 6,500 open flowers. Other bees present.

June 17, 1919, 5:40 p.m. Honey bees abundant.

June 21, 1919, 2:40 p.m. Four bees on plant in two minutes. Twenty-eight thousand flowers. (L.H.P.)

June 25, 1919. Cloudy, east wind. Honey bees visited nineteen flowers in one minute, nine flowers in fifteen seconds, fourteen flowers in thirty seconds. In a plot fifty by fifteen feet two honey bees in one minute. A single plant with sixteen stalks bears about twelve thousand flowers. Flower passing meridian of bloom. (L.H.P.)

July 4, 1919, 4:30 a.m. Fewer flowers than two weeks previous.

July 6, 1919, 6 p.m. East wind. Five hundred blossoms per plant.

July 13, 1920, 10 a.m. Time in flower one to two seconds.

June 12, 1921, 7 a.m. Clear. Some bees. Two seconds in a flower.

June 14, 1921, 7 a.m. Bees abundant. Two to one seconds in a flower.

June 15, 1921, 7:30 a.m. Cloudy. Heavy rain previous night. (L.H.P.)

6 p.m. Bees abundant. Two to three seconds in a flower.

June 6, 1922, 5 p.m. Bee two, three, two, two, three, four, two seconds in a flower. On a hillside with clay soil. (L.H.P.)

June 9, 1922, 2 p.m. Bright and still. Bees very eager and numerous; dozens of bees about a cluster of plants on a clay bank by the roadside.

6 p.m. As above. Bees two, three, two, one, two seconds in a flower.

June 10, 1922, 7 a.m. Bright and windy. No bees.

12 m. Windy. Numerous bees.

Smith's Lake, June 11, 1922. Bees one to two seconds in a flower.

Ames, June 15, 1922, 8 a.m. Bees abundant. Two to three seconds in a flower.

Colo, May 30, 1923, 3 p.m. Warm, clear day. The bee two seconds in a flower.

Ames, May 31, 1923, 5 p.m. Partly cloudy. Bees two to three seconds in a flower.

June 15, 1923. Bees abundant. Two seconds in a flower.

June 17, 1923, 1:30 p.m. Southwest wind. Bees one to three seconds in a flower. One bee visited eighteen flowers.

June 20 to July 4, 1923. Warm. Bees abundant. Three to one seconds in a flower.

July 7, 1923, 9 a.m. Some bees. Two, two, one, one, two, two seconds in a flower. Flowering approaching end. (L.H.P.)

Kelly, July 10, 1923, 3 p.m. Two, two, two, two seconds in a flower. (L.H.P.)

July 18, 1923, 11 a.m. Few bees. Two seconds in a flower.

Storm Lake, July 24, 1923. Bees two seconds in a flower.

Council Bluffs, June 10, 1924. Bees one, one, one, two, one seconds in a flower.

Smith's Lake, June 11, 1924, 9 a.m. Warm and sultry. Bees abundant. One, one, two, one, one seconds in a flower. (L.H.P.)

Sioux City, June 12, 1924. Clear, warm. Bees one second in a flower.

Ames, June 15, 1924, 12 m. and 2 p.m. Warm, humid. Bees one second in a flower.

Cedar Rapids, June 28, 1924, 8 a.m. Bees abundant. Noon, cloudy. Bee one to two seconds in a flower.

Ames, June 28, 1924, 11 a.m. Partly cloudy. Bees one to two seconds in a flower.

Iowa City, June 28, 1924. Bees abundant.

Ames, July 4, 1924, 4 p.m. Warm, sunshiny. Bees abundant. Two, two, one, one, two, one seconds in a flower. Not as abundant as on *M. alba*.

Eldora, July 8, 1924, 4 p.m. Visited by bees. No other insects.

Ames, July 10, 1924, 1:15 p.m. Clear, north wind. Bee in flower two, two, two, two, two seconds. (L.H.P.)

Central Iowa, Eldora, Marshalltown, Nevada, July 10, 1924. Large fields in full bloom. Bees active.

Central Iowa, July 18 to 20, 1924. Still blooming. Not so common as the white sweet clover. Observed at Lake View, Sac City, Fort Dodge, Webster City, Marshalltown, Colo, Ames, Nevada and Des Moines. (L.H.P.)

Oct. 19, 1924, 3 p.m. Bees abundant. One to two seconds in a flower.

away. Three, three, two, three, three seconds on a flower. No bees were observed on white clover, catnip and elderberry near by.

July 13, 1929. Was common in Story county and western Marshall county. Less common in northern Tama county. Bees said to gather considerable nectar from this plant.

Gladbrook, July 13, 1929. On yellow sweet clover. (L.H.P.)

Ames, July 18, 1929, 8:30 a.m. No bees. Second crop. Near *Veronica spicata.*

July 24, 1929. Heavy rains in the morning. No bees. (Apiary 1,000 feet away.) Bees occur on *Lythrum Salicaria* and *Veronica spicata.*

August 5, 1929. Common from Jewell to Blairsburg. Less common Iowa Falls and Hampton, Allison, Waverly and Strawberry Point. Good early honey flow. No bees observed on this date.

Less abundant on roadsides between Boone, Ogden, Grand Junction and Jefferson in 1929 than white sweet clover, but yielding much nectar.

Mason City, August 18, 1929. Second crop of yellow sweet clover abundant at Mason City, but no bees were observed during that day nor upon white sweet clover. (L.H.P.)

Date of bloom, 1925, Ames, May 6; 1926, Ames, May 20.

FIG. 205.—White sweet clover (*Melilotus alba*). *George H. Munger.*

Melilotus alba Desr. White Sweet Clover, Bokhara Clover

This plant is a biennial or annual, growing to a height of three to six feet. Its three oblong leaflets are truncately notched at the end; the small numerous white flowers are in loose racemes.

Widely distributed in Iowa on Missouri loess, clay soil and black soil. Less frequent in sandy soils. It is common on roadsides, in waste places and on railway rights-of-way and is spontaneous in gardens and fields. Associated with *Rhus glabra, Ceanothus ovatus, Trifolium repens, Poa pratensis.*

The flowers of white sweet clover are produced in racemes. Nectar is secreted at the base of the filaments and is copious at all times during bloom except late in the season.

This plant is less influenced by drought than the white clover. The blooming season is long. For a number of years the white biennial sweet clover has been the source of the bulk of honey produced in Iowa.

The honey bee is one of its principal visitors, although many different kinds of insects are attracted to the bloom of white sweet clover.

White sweet clover has recently become famous for its yield of honey, and is doubtless a near rival to white clover. Its main value comes in its long period of blooming, for flowers may be found any time between June 15 and October 15. It is best after basswood is through blooming and when white clover is declining in value as a producer.

Doctor L. A. Kenoyer in his studies found that the honey value is determined in part by the season. As many as forty honey bees were seen per quadrat during the warm dry summer of 1914; never more than six during the cool wet summer of 1915. Other insects also were less numerous in 1915. Coe says that the country over, the plant was little visited by bees in 1915 and yielded but little seed.

FIG. 206.—White sweet clover (*Melilotus alba*). *Photo by Ada Hayden.*

The average of several laboratory tests, made by L. A. Kenoyer during both years, shows that two and thirteen hundredths mg. sugar were secreted per gm. flowers in 1914; sixty-five hundredths mg. or only one-third as much, in 1915.

On July 4, 1914, L. H. Pammel kept under close observation for a day a clump of white sweet clover about three by twenty feet and about three feet high. There were about four thousand spikes of twenty flowers each, or eighty thousand flowers in the patch.

About fifty-five bees, on an average, put in nine hours work here. Each bee visited forty flowers per minute, indicating a possibility during the day of 1,188,000 visits of bees to these flowers—an average of fifteen to a flower. Of other insects at least five more visited each flower, giving each twenty insect visits in all. This should be amply sufficient to pollinate every flower in the clump; and that such visits were necessary was shown by the fact that buds covered with muslin to exclude insects failed to mature seeds.

Besides the honey bee the visitors of *M. alba* consisted of a few bumble bees, several solitary bees, a number of wasps—*Sphex* being conspicuous—a few small butterflies and skippers, and several forms of flies—the large white-faced *Archytas analis* being a conspicuous visitor.

Experimental work carried out at Ames points strongly to the fact that while sweet clover flowers are somewhat self-fertile the visit of an insect to spring the keel is as a rule requisite for the production of seeds. This insect need not be a honey bee, for a very small bee or fly seems capable of performing this service.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Coon Rapids, Crocker, Dakota City, Des Moines, Emmetsburg, Gillett Grove, Jefferson, Lime creek, Marion county, Marshalltown, Mason City, Nevada, northern Iowa, Onawa, Rockwell City, Sioux City, Turin (L. H. Pammel), Alden (C. J. Stevens), Algona (E. B. Watson), Ames (H. S. Fawcett and W. S. Dudgeon, C. M. King), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Fayette (B. Fink), Inwood (John R. Skewis), Kelley (L. H. Pammel and C. E. Maxwell, Pearl Clayton), Kossuth county (R. I. Cratty), Ledges (Boone county) (J. V. Ellis), Leeds (G. W. Rich), northeastern Iowa (H. Goddard), Osage (Flora M. Tuttle), Postville (L. H. Pammel, R. E. Buchanan, C. M. King), Slater (W. I. Tener and C. Reinbott), Spirit Lake (H. E. and L. H. Pammel).

In 1929 it was common from Ames to Eagle Grove, Orange City, Iowa Falls to Algona. From Ames to Des Moines, Tingley and Mount Ayr, Ames to Grinnell, Albia, Centerville and Fairfield, from Ames to Carroll and Denison.

General distribution in the United States and Canada:

Alabama—Birmingham (two specimens, L. H. Pammel); California—Chico (A. A. Heller); Colorado—Denver, Fort Douglas, Fort Logan, Greeley (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. M. Lummis), Fort Collins (Ada Hayden); Illinois—Aurora (B. Fink), Berwyn (H. S. Fawcett), Coffin (T. C. Wood), Muncie (H. A. Gleason); Massachusetts—(Miss Prince); Minnesota—Crookston, Minneapolis, Monticello, Ortonville (Mrs. Roy Westley); Nebraska—Lincoln county (F. G. Miller), Sheridan county (R. E. Buchanan); New York—Geneva (L. H. Pammel), Ithaca (H. E. Summers); Nova Scotia—Kingsport (C. D. Howe and W. F. Lang); Oregon—Crook county (K. Whited); South

Dakota—Clear Lake, Yankton (L. H. Pammel), Brookings (Edna C. Pammel); Utah—Logan canyon (two specimens, L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Salt Lake City (L. H. Pammel and R. E. Blackwood).

HONEY BEE VISITS

Ames, June 20, 1923, 3 p.m. Clear and warm. Bees two, two, two, one, two seconds in a flower. (L.H.P.)

June 26, 1923, 3 p.m. Bees abundant. Twenty-five bees on a single clump.

June 29 to July 8, 1923. Warm. Bees abundant. Two seconds in one flower.

Kelley, July 11, 1923, 5:30 p.m. Bees one, two, two, three seconds in a flower.

Boone, July 11, 1923, 3 p.m. Bees one, two, two, two, three, one seconds in a flower. (L.H.P.)

July 11-18, 1923. Honey bees abundant; one black bee visited seventeen flowers in a minute; honey bees twelve to fourteen flowers respectively.

Hamburg, July 15, 1923, 6:30 p.m. Bees two seconds in a flower.

Melilotus alba blooming freely at this time at Fraser, Fort Dodge, Storm Lake, Pomeroy and Rockwell City.

McGregor, Aug. 5-8, 1923. Bees abundant. (L.H.P.)

11:30 a.m. Partly cloudy. Movement of bees sluggish.

Ames, July 5, 1925, 8 a.m. Cool, clear, dew. Bee two, two, two, two, one seconds in a flower. (L.H.P.)

Central Iowa, July 18 and 20, 1924. Bees abundant upon the white sweet clover, which was freely in bloom along Illinois Central R. R., near Rockwell City and Webster City; the dominant flowering plant along highways, Sac City, Auburn, Lake View, Marshalltown, Nevada, Colo, State Center, Des Moines. (L.H.P.)

Bluffton, July 24, 1924. Bees two to one seconds in a flower.

Anamosa, August 7, 1924, 6 p.m. Clear. Bees abundant. One, one, one, two, two, one, one seconds in a flower. (L.H.P.)

Maquoketa, August 8, 1924. Bees abundant. One, one, one, one, two, one seconds in a flower. (L.H.P.)

McGregor, July 28, 1924, 3 p.m. Bees abundant.

August 10, 1924, 5 p.m. Bees abundant. One second in a flower.

Ames, June 7, 1927, 6 p.m. Clear, warm. Bees abundant. Two, three, four, two, three, four seconds in a flower.

June 10, 1927. Bees two, three, two, three, two seconds in a flower.

Story City, June 19, 1927, 3 p.m. Warm, sunshiny. Some bees. Two, two, two, two, two seconds in a flower. (L.H.P.)

Boone and Ogden, June 25, 1927, 10 a.m. Clear and warm. A few bees.

Ames, June 27, 1927. Bees abundant. Two seconds in a flower.

June 30, 1927. Clear, hot, southerly wind. Not many bees. Two, two, two, two seconds in a flower.

July 3, 1927, 10:30 a.m. Bees abundant. Two, two, two, two, two seconds in a flower. (L.H.P.)

July 4, 1927, 10 a.m. Clear, cool, raw east wind. Bees abundant. Two, one, two, two, two, two, two seconds in a flower. (L.H.P.)

July 5, 1925. Flowering plants in clumps. About 3750 flowers in each clump, over which worked six bees in one second. Time of insect in the flower, one, two, two, two, two, one, one, two seconds. (L.H.P.)

July 6, 10, 23, 30, 1927. Clear and warm. Bees abundant. Two seconds in a flower.

Ames to Nevada, July 10, 1927. Hot and dry. Bees numerous. No bees on white clover or on alsike.

Eldora, July 10, 1927, 4:30 p.m. Clear and warm. Bees abundant. Two, two, two, two, two seconds in a flower. (L.H.P.)

Story City, July 23, 1927, 5 p.m. Clear, warm. A few bees. Two, two, two seconds in a flower.

Grinnell, July 24, 1927, 5 p.m. Bees abundant. Two, two, two, two, two seconds in a flower. (L.H.P.)

Bloomfield, July 25, 1927, 10:30 a.m. Warm, clear. Bees abundant. Two, two, two, two, two seconds in a flower.

Ottumwa, July 25, 1927, 3 p.m. Warm, clear. Bees abundant. Two, two, two, two, two seconds in a flower. (L.H.P.)

Lancaster, Missouri, July 25, 1927, 12 m. Bees on some of the plants. Two, two, two, two seconds in a flower. (L.H.P.)

Pella, July 26, 1927, 10:30 a.m. Warm, clear. Bees abundant. Two, two, two, two, two seconds in a flower. (L.H.P.)

Iowa City, August 4, 1927, 3 p.m. Warm (clay soil). Bees abundant. Two, two, two, two seconds in a flower. (L.H.P.)

West Liberty, Conesville, Grand View, Fruitland, August 5, 1927. Bees abundant. Two to three seconds in a flower.

La Crosse, Wisconsin, August 7, 1927, 12:30 p.m. Wide stretches of white sweet clover about six miles northeast of La Crosse. No bees at work.

McGregor Heights, August 8, 1927, 8:30 a.m. Cloudy. Cool north wind. Bees abundant. Two, two, two, two, two seconds in a flower. (L.H.P.)

August 9, 1927, a.m. and p.m. Bees fairly numerous. Two seconds in a flower.

August 10, 1927, 3 p.m. Bees abundant. Two to three seconds in a flower.

Garnavillo, August 12, 1927, 10 a.m. Bees abundant. Two seconds in a flower.

August 12, 1927. Common from Prairie du Chien and La Crosse, Wisconsin, McGregor to Guttenberg and Dubuque, Chicago to Milwaukee to Escanaba, Michigan.

Ames, August 23, 1927, 3:30 p.m. Warmer. Bees abundant. Two, two, two, two seconds in a flower.

Boone, August 25, 1927, 3 p.m. Bees abundant. Two, two, two, two seconds in a flower. (L.H.P.)

Ames, August 26, 1927, 10:30 a.m. Bees abundant. Two seconds in a flower.

Lancaster, Missouri (12 miles north), August 25, 1927, Noon. No bees, finding *Asclepias tuberosa*, *A. syriaca*, and *Symphoricarpos orbicularis* more attractive. (L.H.P.)

Le Grand, August 30, 1927, 10:30 a.m. A few bees. Two, two, two, two, two seconds in a flower.

Ames, August 31, 1927, 2:30 p.m. Bees fairly common. Two, two, two, two seconds in a flower. (L.H.P.)

September 2, 1927, 10:30 a.m. Bees two, two, two, two seconds in a flower. None on second growth *Melilotus officinalis.*

Beaver, September 2, 1927, 2 p.m. Bees one to three seconds in a flower.

Ames, September 5, 1927, 9:30 a.m. Clear. Bees two seconds in a flower.

Norwalk, September 7, 1927, 4:30 p.m. Bright, clear, warm. Bees two, two, two, two seconds in a flower. Apiary one-fourth mile away. (L.H.P.)

Lyons, Clinton, September 10, 1927, 4 p.m. Bees abundant. One, one, one, one seconds in a flower. Visit five, four, six, two flowers in a head.

Ames, September 10, 1927, 4 p.m. Bees abundant. One, one, one, one, two, two seconds in a flower. (L.H.P.)

McGregor, (clay soil), September 11, 1927, 7 a.m. Clear, cool, dry. No bees. 8:45 a.m. Several bees. Two, two, two, two seconds in a flower. (L.H.P.)

Rock Island, Sept. 13, 1927, 5 p.m. Clay soil. Bees abundant. Two, two, two, two, two seconds in a flower. None on *Boltonia asteroides, Cosmos bipinnatus, Centaurea Cyanus.* Apiary one-fourth mile away. (L.H.P.)

Colo, September 16, 1927, 1:15 p.m. Bees two, two, two, two seconds in a flower. (C.C.L.)

Lyons, Clinton, Sept. 20, 1927. Bees two, two, two, two seconds in a flower.

Bloomington to Oskaloosa, September, 1927. Common. Blooming. Bees working freely. (L.H.P.)

Sioux City, October 4, 1927, a.m. High south wind. No bees on the following flowers still blooming: *Melilotus alba, M. officinalis, Solidago canadensis, Trifolium repens, Polygonum pennsylvanicum,* all near apiary. (L.H.P.) 1:30 p.m. A few bees leaving the hive and returning. Mr. Brown states that bees get much honey from heads of *Polygonum pennsylvanicum,* and some from goldenrods; the best honey plant is *Melilotus alba.* This plant blooming freely from Sioux City to Onawa and Carroll. (L.H.P.)

Urbandale Station, (near Sioux City), October 4, 1927, 4 p.m. Clear, warm. Sandy prairie soil. Some bees. Two, two, two, two seconds in a flower.

Peru, Winterset, St. Charles, October 14, 1927. No bees.

Ames, October 25, 1927, 12:15 p.m. Bees abundant. Two, two, two, two, two seconds in a flower. Red clover next to it. No bees in the clover. (L.H.P.)

October 29, 1927, 10 a.m. and 10:20 a.m. Clear, warm. Bees two seconds in a flower. Visits twelve, ten heads in a flower.

June 8 to 16, 1928. Warm. Bees abundant. Two to four seconds in a flower.

June 14, 1928, 5:30 p.m. Bees abundant in yellow, but few on white sweet clover. Just coming into bloom. (L.H.P.)

Des Moines, June 20, 1928, 5 p.m. Bees abundant. Three seconds in a flower. Early bloom.

Denison, June 24, 1928, 9 a.m. Bees two, two, three, two seconds in a flower. A single plant with 1500 flowers open. About one week in bloom. (L.H.P.)

Churdan, June 24, 1928. Cold, raw. No bees. (L.H.P.)

Whittier, June 29, 1928, 4 p.m. Near apiary. Bees two, three, three, three, seconds in a flower.

Crawford county, June 29, 1928. According to Paul A. Johnson of Denison, 14,000 acres in Crawford county yielding $6 worth of honey per acre. To this add 6,000 acres from highways and railways. Estimated possible yield of honey for the county, $120,000. Few bees in the county. Little of the nectar used. Much alfalfa also in the county. A single sweet clover plant bears upwards of 7,000 flowers. At 1 p.m. six bees observed in one minute on this plant. Yellow clover in midbloom.

Sweet clover abundant (June, 1928) at Fairfield, Des Moines, Davenport, Clinton, Mount Vernon, Marshalltown, becoming more plentiful. (L.H.P.)

Paton, July 6. Some bees.

Emmons, Minn., July 8, 1928, 4 p.m. Bees abundant. Two, two, two, two, three seconds in a flower. (L.H.P.)

Albert Lea, Minn., July 10, 1928, 2 p.m. Bees two, two, three, three, two seconds in a flower.

Story City to Jewell to Blairsburg, July 10, 1928. White sweet clover blooming. (L.H.P.)

Ames, July 21, 1928, 4:30 p.m. Bees not so common. Flowers fragrant, honey odor. Bees two, three, three, three, two seconds in a flower. (L.H.P.)

Churdan, July 29, 1928, 4 p.m. Bees two to three seconds in a flower.

Oakdale, August 1, 1928. Not clear, fairly warm. Two, two, two, two, three, two seconds in a flower. (L.H.P.)

Iowa City, August 2, 1928, 2 p.m. Two, two, two, two seconds in a flower.

Arispe, June 20, 1929, 3:20 p.m. Bees three, four, three, three, three seconds in a flower. (L.H.P.)

Eldora, June 29, 1929, 3:30 p.m. Bees three, three, three, three seconds in a flower. (L.H.P.)

Ames, July 2, 1929. Bees three, three, three, two seconds in a flower. (L.H.P.)

Boone, July 3, 1929. Bees three, three, four, three, four seconds in a flower.

Ames July 4, 1929. Bees three, three, three, four seconds in a flower. (L.H.P.)

July 7, 1929. Two, three, two, three, two seconds in a flower. One bee visited 110 flowers on a large plant. (L.H.P.)

Story, Marshall and Tama counties, July 13, 1929. Abundant in northern Story county and in Marshall and Tama counties, and was yielding much nectar. (L.H.P.)

Gladbrook, July 13, 1929, 3 p.m. Some bees. Two, two, three, two, one seconds in a flower. Heavy rain the night before.

Algona, July 15, 1929, 6 a.m. Bees three, three, three, two, two seconds in a flower. (L.H.P.)

Ames, July 16, 1929, 4:30 p.m. Three, two, three, two, three seconds in a flower. (L.H.P.)

Gilbert, July 18, 1929, 3:30 p.m. Bees two to three seconds in a flower.

Des Moines, July 22, 1929, 12:30 p.m. Bees three, two, two, two, two seconds in a flower. (L.H.P.)

Ledges, Boone, July 23, 1929. Bees abundant. (C. F. Henning.)

Boone, July 27, 1929, 9 a.m. Clear and warm. Bees numerous.

Dana, July 27, 1929, 10:30 a.m. Clear and warm. Bees two, two, three, two, one, one seconds in a flower. (L.H.P.)

1 p.m. Partly cloudy. Two, three, two, two, one, three seconds in a flower.

Ralston, July 27, 1929, 4 p.m. Windy, warm. Bees two to three seconds in a flower.

Des Moines, August 3, 1929, 1 p.m. Bees two to three seconds in a flower.

August 4, 1929, 2 p.m. Bees two, three, two, three, two seconds in a flower. Six hundred feet from apiary. Strong wind. (L.H.P.)

Ames, August 4, 1929, 11 a.m. Bees numerous. Three seconds in a flower.

August 5, 1929. Abundant from Jewell to Blairsburg. Good honey flow. Common from Blairsburg, Iowa Falls, Hampton. Good honey flow. Common from Hampton to Allison, Waverly and Strawberry Point. Good honey flow.

Waverly, August 5, 1929. Bees two, three, two, two seconds in a flower.

McGregor, August 7, 1929. Bees two, three, two, three, two seconds in a flower.

August 8, 1929, 3 p.m. Some honey bees. Two, three, two, two, three seconds in a flower. Somewhat sandy soil. (L.H.P.)

August 9, 1929, 7:30 a.m. Bees two to three seconds in a flower. Clay soil, Mississippi loess.

Abundant on roadsides between Boone, Ogden, Grand Junction and Jefferson in 1929, yielding much nectar.

In 1929 it was common along roadsides, waste places and rights-of-way of railroads—Jewell, Webster City, Eagle Grove, Irvington, Livermore and Algona. Honey bees observed on it at all points.

La Crosse, Wis., August 10, 1929, 4 p.m. Bees abundant. Three, three, three, three, two seconds in a flower. Black sandy soil. (L.H.P.)

McGregor, August 11, 1929, 6 p.m. Bees abundant. Three, three, three, two, two seconds in a flower. Mississippi loess soil. (L.H.P.)

Prairie du Chien, Wis., August 15, 1929, 8:30 a.m. Bees abundant. Two, three, three, two, three seconds in a flower. Sandy soil. (L.H.P.)

Lansing, August 17, 1929, 3 p.m. Bees three, three, three, two, three seconds in a flower. (L.H.P.)

Cresco, August 18, 1929, 1 p.m. Honey bees abundant. Two, three, two, three seconds in a flower.

Riceville, August 18, 1929, 4 p.m. Sweet clover fairly common. Bees one, two, two, three, two seconds in a flower. (L.H.P.)

Nora Springs, August 18, 1929, 5 p.m. Bees two, two, three, two, two seconds in a flower. (L.H.P.)

Mason City, August 18, 1929, 6 p.m. Bees abundant. Four, three, three, two seconds in a flower. Limestone talus. (L.H.P.)

Des Moines, August 20, 1929, 5 p.m. Warm. Some bees. Two, three, two and three seconds.

August 28, 1929. No honey bees though near an apiary. Many flower baths.

Mr. Frank Coverdale of Maquoketa reports large yields of honey from white sweet clover, and as late as August 12, 1929, as much as two pounds of honey per hive was taken in one day, largely from this plant, in Jackson County. Mr. Coverdale was one of the original promoters of this plant for honey.

Mitchellville, August 31, 1929. Bees three to two seconds in a flower.

Bloomfield, September 1, 1929. Some *Melilotus alba*. More than in Appanoose county. (L.H.P.)

Montrose, September 2, 1929, 9 a.m. Bees abundant. (Near an apiary.) Two, three, three, two seconds in a flower. (L.H.P.)

Donnellson, September 2, 1929. Old stalks and few flowers left. Two, two, three, two seconds in a flower. (L.H.P.)

Hamilton, Ill., September 3, 1929, 2 p.m. Clear and warm. Many bees. Two, two, two, one, three seconds in a flower. (L.H.P.)

September 3, 1929. Fairly common along roadsides in Lee and Des Moines and Van Buren counties. Less common in Appanoose county. Bees common. Plants past their height of bloom at Keokuk, Donnellson and Montrose. (L.H.P.)

Des Moines, September 3, 1929, 11:45 a.m. Bees two, two, two, one, one, two seconds in a flower. Near an apiary. (L.H.P.)

Mount Pleasant, September 4, 1929. White sweet clover abundant. (L.H.P.)

Batavia, September 4, 1929, 2 p.m. Bees two to three seconds in a flower.

Ames, September 10, 1929, 2 p.m. Warm. Bees two to three seconds in a flower.

September 17, 1929, 2 p.m. Bees three, three, two seconds in a flower.

Dates of bloom: 1925, Ames, May 12; Lansing, May 17. 1926, Ames, May 20; Lansing, May 22.

INSECTS ON *MELILOTUS ALBA*

Collected by H. S. Coe, Named by W. H. Wellhouse

Order Hemiptera
- Family Miridae
  - *Adelphocoris rapidus* Say
  - *Lygus pratensis* Linn.

Order Lepidoptera
- Family Pieridae
  - *Eurymus eurytheme* Bdv.
  - *Pieris rapae* Linn.
- Family Lycaenidae
  - *Heodes thoë* Bdv.-Lec.
  - *Everes comyntas* Godi.
- Family Librytheidae
  - *Hypatus bachmani* Kirt.

Order Coleoptera
- Family Coccinellidae
  - *Coccinella transversoguttata* Fald.

Order Diptera
- Family Muscidae
  - *Chrysomyia macellaria* Fab.
  - *Musca domestica* Linn.
- Family Syrphidae
  - *Syritta pipiens* Linn.
  - Other species mutilated.

Order Hymenoptera
- Family Sphecidae
  - *Sphex* sp.
  - *Sceliphron* sp.
  - *Isodontia harrisi* Fern.
  - *Cerceris* sp.
- Family Tiphiidae
  - *Elis quinquecincta* Fab.
- Family Vespidae
  - *Polistes* sp.
- Family Eumenidae
  - *Eumenes fraterna* Say

Superfamily Apidae
- *Halictus* sp.
- *Halictus provancheri*
- *Halictus lerouxii* Lep.
- *Colletes* sp.
- *Callipsis andreniformis* Smith
- *Augochlora* sp.
- *Apis mellifica* Linn.

Melilotus alba, annual form

The form of white sweet clover that is annual in its life period is designated commercially "Hubam." It is slightly smaller in its habit than the biennial form. It has been recognized but a few years, but it is regarded as an excellent honey plant, extending the seasonal range of the biennial form.

This form of sweet clover was first observed in the southern states; it has become recognized as valuable for forage, for soil improvement and for honey. It resembles *M. alba* but blooms the first year. Occurs only as the cultivated variety.

Medicago (Tourn.) L. Medick

Low growing herbs, many useful for forage. The flowers resemble those of the melilot and clovers. The pods are variously coiled. Leaves compound, three pinnately arranged leaflets.

Medicago sylvestris L. Medick

This plant is visited by honey bees in England, although fertilization does not occur, because the bee is not of sufficient weight to cause the explosion and consequently 99 per cent of the flowers remain unfertilized, according to Knuth. There are two arrangements in the unvisited flowers by which this is kept in check. (1) At the upper basal angle of either carinal petal there is an internal hollow process, forwardly directed and closely apposed to its fellow, the two together gripping the front part of the sexual column from above. A still more pronounced alar process fits into each of them. (2) From the upper edge of each ala a long fringelike process runs back, passing upwards and inwards so as to grasp, with its fellow, the upper side of the column at a point about one-third of its length from the base.

The various processes described forcibly maintain the sexual column in a horizontal position. But should an insect visitor press down the alae and carina, the stamens and pistil spring up out of the carina against the underside of its body or proboscis. The stigma projects beyond the anthers, and, therefore, first comes into contact with the insect, getting cross-pollinated if this insect has previously visited another flower of the species. The first flower visited by an insect will be self-pollinated as the visitor backs out of it. Should insect visits fail, automatic self-pollination of unexploded flowers is possible and may be effective under certain conditions.

According to Knuth, Burkill (Proc. Phil. Soc., Cambridge, VIII,

1894) has aptly described the basal process of alae and carina as two triggers, by which the flower is, so to speak, fired off. He states that the upper surfaces of the alae are beset with papillae, serving as footholds to insect visitors. There is also a marginal row of papillae on either side of the vexillum's inner surface, to which long-legged insects would appear to cling. The stigma remains unreceptive until its papillae have been subjected to friction. By covering a number of inflorescences with nets, in order to keep away insects, Burkill was able to confirm the conclusion at which Urban had previously arrived (Verh. bot. Ver., Berlin, XV, 1873) i.e., that unexploded flowers do not set fruits, although their stigmas are surrounded by pollen. He succeeded, however, in inducing such flowers to fruit by (1) squeezing the stigma through the tip of the carina, (2) piercing the carina with a needle and scratching the stigma, (3) rubbing off the tip of the carina and rubbing the stigma with a paint brush.

Medicago sativa L. Lucern. Alfalfa

Alfalfa is distinguished by its long tap root and purple flowers. The plant is one to two feet high; the three leaflets are oblong; the pod is linear, several-seeded and coiled. This plant is grown generally throughout the state, 404,000 acres being grown in Iowa in 1930. It is at present, so far as known, of value to bees in only a small section of the state, in the southwestern and western counties.

In Missouri loess and drift knolls (Wisconsin drift), associated with *Verbena stricta, Dalea enneandra, Dalea alopecuroides.*

The flowers are collected in dense racemes. They are irregular, papilionaceous; stamens diadelphous. The nectar is collected in the staminate tube. Visited frequently by honey bees for nectar.

Under hot dry weather conditions alfalfa is at its best as a honey producer and furnishes much nectar in drier regions.

Alfalfa in this section is rarely profitable as a honey plant and is a poor producer. Insect visitors are infrequent, particularly in humid weather. Tests in 1914 by L. A. Kenoyer showed that of the 33.6 mg. sugar contained in one gram of flowers only 1.2 mg. or one part in twenty-nine is on the surface of the nectaries in the form of available nectar. The white clover, it may be noted, has only half as much sugar in the same weight of blossoms, one-ninth of it being available as nectar.

Alfalfa is famous as a honey producer in the irrigated sections of

FIG. 207.—Alfalfa (*Medicago sativa*). *Photo by Geo. H. Munger.*

the Rocky Mountain regions. This is doubtless due in part to the drier atmosphere of this section, and in part to the greater extremes between day and night temperature, experiments having shown the proportion of sugar to be greatly increased by low temperature whereas secretion is better with high temperature. Dr. Kenoyer found that flowers of alfalfa grown in hot dry soil contain about sixty per cent more sugar than those grown in wet soil.

H. Ranchfuss, an extensive honey producer of Denver, says that in 1915 bees got very little honey from alfalfa on account of its being frosted in the spring — a condition which has also been noted in previous years.

L. A. Kenoyer states that it is remarkable how rarely the honey bee visits alfalfa in Ames, it having been noticed but few times by him during two years' observation. The most frequent visitors are butterflies. Observations were made on the yellow-flowered alfalfa also, on July 22 and August 4, 1914. Like the ordinary alfalfa it also was seldom noticed by either honey bees or bumble bees. The prevailing visitors were small bees (2 to 12 on July 22, 1 to 4 on August 4; Diptera 1 to 7 and Lepidoptera 1 to 2). On July 22 Lepidoptera were much more plentiful on purple than on yellow, otherwise numbers were about the same.

Knuth says, "The bluish or violet blossoms are aggregated into many-flowered racemes. Nectar is secreted by the flowers in the usual place, and there is a passage to it on either side of the free stamen."

A. I. and E. R. Root in "A B C of Bee Culture" say, "It is one of the most important honey plants in the west, in some localities easily the most important."

These authors cite San Joaquin Valley and Imperial Valley in California and parts of Colorado, Arizona and Nevada.

Though alfalfa is abundantly grown in Iowa it is not an important honey plant in this state, especially in central Iowa. Bees have been observed but not frequently. Though in bloom in eastern and northern Iowa by the middle of June in 1929 there were no honey bees, though these were common on the yellow sweet clover and white sweet clover.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, College Farm, I.S.C., Lost Island Lake, Marathon, Sioux City (L. H. Pammel), Ames (C. E. Bessey, two specimens, Botany Seminar), Decatur county (T. J. and M. F. L. Fitzpatrick), Skunk river valley, Lee county (P. Barker).

It has also been observed (L. H. Pammel) at Adair, Algona, Carroll, Cedar Rapids, Cherokee, Corning, Council Bluffs, Creston, Denison, Des Moines, Fort Dodge, Glenwood, Hamburg, Iowa Falls, Jefferson, Jordan, Logan, Marshalltown, Missouri Valley, Nevada, Onawa, Orange City, Rolfe, Shenandoah, Sioux City.

General distribution in the United States and Canada:

California—Crane Flats (L. H. Pammel); Colorado—Fort Morgan, Eaton, Golden (L. H. Pammel), Denver (E. W. D. Holway), Fort Collins (L. H. Pammel and C. P. Johnson); Idaho—Sand Point (L. H. Pammel); Minnesota—Star island (Cass Lake) (L. H. and H. E. Pammel and P. S. McNutt); Missouri—Sheffield (Kenneth K. Mackenzie); Nebraska—Kearney (L. H. Pammel and I. E. Brownlie); Lincoln county (F. G. Miller); New Mexico—Apache (A. Isabel Mulford); North Carolina—Statesville (M. E. Hyams); Ohio—Kelley's Island, Cedar Point (L. H. Pammel); Ontario—Plevna (J. Fowler); Oregon—Astoria (L. H. Pammel and K. Whited); South Dakota—Lake Poinsett (escape) (L. H. Pammel); Brookings (N. E. Hansen and L. H. Pammel); Texas—Austin (F. O. Werkenthin), El Paso (L. H. Pammel); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood); Farmington canyon (L.

H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), (L. H. Pammel, G. M. Lummis, R. E. Buchanan and C. P. Johnson); Wisconsin—Holmen, La Crosse (two specimens, L. H. Pammel).

HONEY BEE VISITS

Ames, June 14, 1914. Plots. Clear, warm. No bees. (G.H.M.)
June 17, 1914. Plots. Partly clear, cool. Four bees in one hour. Some beetles. (G.H.M.)
July 22, 1914. Plots. Clear, warm. Only two bees observed all day. Some Lepidoptera. (G.H.M.)
Atlantic, Aug. 1, 1914. Field. Clear warm day. Plants just coming into bloom. No bees. (L.A.K.)
Hamburg, Aug. 4, 1914. Upland. Clear, warm, very dry.
1 to 3 p.m. Several bees working fifteen flowers per minute. Some butterflies and flies. (L.A.K.)
Independence, Kansas, August 15 to 25, 1914. No bees noticed. (L.A.K.)
Ames, August 11, 1915. Plots. Cloudy, northwest wind. No bees or other insects. (L.A.K.)
Brookings, South Dakota, July 31, 1918, 11 a.m. Partly cloudy. Bee two, three, two, two seconds in a flower. (L.H.P.)
Ames, June 30, 1920. On alfalfa growing next to sweet clover, for several days no bees noticed; common on sweet clover at same time.
July 5, 1925. The bee two to four seconds in a flower.
Nevada, July 25, 1925, 8:30 a.m. Clear, no bees.
July 30, 1925, 3 p.m. Clear, hot. Honey bees two, two, two, three, two, two, two, one, three, three seconds in a flower.
July 8, 1927, 6 p.m. Young blooms, no bees; old blooms, bees numerous.
Manhattan, Kansas, May 17, 1927, 12 m. No bees. (L.H.P.)
Story City, June 19, 1927. Warm, sunshiny. No bees. (L.H.P.)
Ames, July 3, 1927, 10:30 a.m. Clear, northerly wind. Some bees; two, three, three, three, three, two seconds in a flower. Bees flew from alfalfa to white sweet clover.
4 p.m. Clear, cool. No bees. Bees abundant on *Trifolium repens*.
Des Moines, June 20, 1928, 5 p.m. Clear and warm. Bees abundant. Three, three, four, four, three, three, three seconds in a flower. (L.H.P.)
Whittier, June 29, 1928, 4 p.m. Bees three, three, three, four, three, two, three seconds in a flower. (Grimm alfalfa.) (L.H.P.)
Polk county, June 1, 1929. A few plants coming into bloom. No honey bees observed. (L.H.P.)
Jordan, June 15, 1929, 2:30 p.m. and 3 p.m. No honey bees in three fields. Many butterflies. (L.H.P.)
Ames, July 6, 1929. Adjacent to white clover and yellow and white sweet clover. No bees. (L.H.P.)
July 22, 1929, 9:30 a.m. No bees. Near apiary and bees common on *Veronica spicata*.
July 24, 1929. Heavy rains in the morning. No bees. (Apiary 1,000 feet away.) Bees occur on *Lythrum Salicaria*, *Echinops Rito* and *Veronica spicata*. (L.H.P.)

Des Moines, August 28, 1929, 4 p.m. Bloom abundant. No bees though seen on same plants June 20, 1928.
Pella, August 31, 1929. No bees.

Medicago falcata (L.) Russian or Siberian Alfalfa

This plant is similar to common alfalfa, of which it is considered by botanists to be a variety. Perennial, upright, three to three and one-half feet high; flowers bright yellow and the pods straightish or falcate, that is, sickle-shaped. Native to a wide range of country in Europe and Asia and one of the very important plants. Introduced into the United States from Europe by Dr. N. E. Hansen and has been grown largely in South Dakota, where it is proving to be a very hardy and successful plant.

This has escaped from cultivation in a few places in northern Iowa and may be found on waste ground.

This species furnishes a large amount of honey. Honey bees are reported on it in Germany by Hermann Mueller and by Knuth. Mueller also noted honey bees on *M. media* Pers., which is a hybrid between *M. falcata* and *M. sativa*. The color of this flower is generally yellow, later becoming bluish or violet. Doctor Hansen found it abundantly visited by bees in Russia and Siberia, and it is reported as a valuable honey plant in South Dakota. No bees have been observed on this plant in Iowa, but since it will no doubt become widely naturalized it is worth listing as a honey plant.

In this connection various other species of alfalfa might be mentioned such as *Medicago platycarpa*, *M. Ruthenica*, *M. glutinosa*, and *M. arboreum*.

An interesting account of these alfalfas and their value will be found in several splendid publications by Doctor N. E. Hansen.*

HONEY BEE VISITS

Brookings, South Dakota, August 2, 1918. Some honey bees. Freely visited by honey bees for nectar.

Medicago lupulina L. Black Medick

An annual pubescent procumbent plant with yellow flowers in dense heads. Pods black, single-seeded.

Black medick grows in various types of soil, including clay or black loamy and prairie soils. Associated with *Trifolium pratense*, *Poa pratensis*, *Trifolium repens*, in limestone prairies and opens in

* Wild Alfalfa and Clovers of Siberia with Prospective View of the World. Bul. United States Department of Agriculture, Bureau of Plant Industry No. 150.
Plant Introductions. South Dakota Agr. Expt. Sta. Bul. 224.

northeastern Iowa and on gravel knolls of Wisconsin and Iowan drift, and in Mississippi loess.

This plant has become extremely common in central Iowa and in many parts of the United States. In most seasons it is not freely visited by bees. The flowers are very small, but the honey bee is a frequent visitor in some years.

In England this plant was observed as a honey plant by Charles Darwin and by McLeod in Flanders and by Knuth in Germany. Knuth says that it visits a few flowers on one inflorescence and then flies away to another plant of the same species. We have not seen many bees on this species in the state, although Hermann Mueller reports that it is visited by honey bees in Germany.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Badger, Kelley, Lake Mills (L. H. Pammel), Ames (E. R. Hodson), Dows (Henry Riggar), Grundy county (County Agent), Irvington (J. R. Armstrong). Kelley (Pearl Clayton), Moville (J. P. Dunning), Orson (Boswick Hedges), Polk City (L. C. Swim), Red Oak (Ed Hayes, F. F. Barker), Webster City (W. O. McConnell), West Liberty (F. E. Fountain).

It has also been observed (L. H. Pammel) at Carroll, Denison, Des Moines, Jefferson, Missouri Valley.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); California—San Diego, naturalized (L. H. Pammel); District of Columbia—Rock creek (E. A. Hyde), Washington (L. H. Pammel); Louisiana—Gretna (C. R. Ball), New Orleans (L. H. Pammel); Michigan—Mackinac island (L. H. Pammel); Minnesota—Hennepin county (F. H. Burglehaus); Missouri—Glencoe (Geo. W. Letterman), Sheffield (Kenneth K. Mackenzie); Nebraska—Elgin (Fred Cooley), Otoe county (J. P. Anderson); New Mexico—Portales (F. C. Werkenthin); New York—Ithaca (H. E. Summers); Ohio—Columbus (E. V. Wilcox), Mansfield (E. Wilkinson), Put-in-Bay (L. H. Pammel); Oregon—Belmond (K. Whited), Crook county (two specimens); Texas—Tarrant county (Albert Ruth); Utah—Farmington canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Salt Lake (two specimens, L. H. Pammel and R. E. Blackwood), Ogden (L. H. Pammel); Wisconsin—Oshkosh (L. H. Pammel).

HONEY BEE VISITS

Columbia, Missouri, May 31, 1924. Bees abundant. One, one, one, one, one, one, one, one seconds in a flower.

Smith's Lake, June 4, 1924. Bee one, one, one seconds in a flower.

Council Bluffs, June 10, 1924. Bee one second in a flower.

Ames, June 6, 1929, 3 p.m. Next to apiary. No bees. (L.H.P.)

Date of bloom, 1927, Ames, June 1.

Amorpha L. Indigo Lead Plant

Shrubs with odd-pinnate leaves with minute dots. Flowers violet or purple in spikes. Monadelphous stamens.

Amorpha canescens Pursh. Lead Plant

A low growing downy shrub with pinnately compound leaves. Leaflets 31 to 51, small, covered with hoary down. Leaflets oblong elliptical, smooth above and white hoary beneath. A number of spikes clustered at the summit.

FIG. 208.—Lead plant (*Amorpha canescens*). *Photo by Ada Hayden.*

The species is widely distributed in Iowa from New Albin to Keokuk, west to Hamburg and north to Rock Rapids. Also widely distributed in the northern United States.

The mechanism for pollination is very much the same as for the wild indigo plant. The flowers are proterogynous and the color of the flowers is violet to purple. They are crowded into a terminal raceme.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Cedar Rapids, Cherokee, Gillett Grove, Hamburg, Lake Mills, McGregor, Sioux City, Wheelerwood (L. H. Pammel), Armstrong, Decorah, West Bend (R. I. Cratty), Allamakee county (Paul Bartsch), Ames (G. W. Carver, Robert Combs), Centerville (C. W. Clark), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson), Keokuk (Iza Mitchell), Postville (Orville Schultz), Slater (H. S. Fawcett), Steamboat Rock (Pammel and Pratt), Waukee (J. A. Mattern), Winneshiek county (H. Goddard).

HONEY BEE VISITS

Near Ames, July 17, 1927. Three miles from apiary. No bees. (L.H.P.)

Ames to Nevada, July 10, 1927. Hot, dry. A few bees. About one second in each flower. (C.C.L.)

Amorpha microphylla Pursh. Dwarf False Indigo

This species is nearly glabrous, somewhat smaller than *Amorpha canescens.* Is more or less rigid with solitary spikes. It occurs in Minnesota and reaches into western Iowa, and is not uncommon in the western and northwestern parts of this state.

This, like the other species, is visited by honey bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Emmet county, four specimens (R. I. Cratty, F. W. Paige), Decatur county (J. P. Anderson), Guthrie Center (L. H. Pammel), Jack creek (Emmet county) (B. O. Wolden).

Amorpha fruticosa L. False Indigo

A tall, somewhat pubescent shrub, growing along banks of streams and lakes. Leaves compound, 9 to 25 elliptical leaflets. Flowers violet or purple, anthers bright yellow; flowers in crowded spikes.

FIG. 209.—Wild indigo plant (*Amorpha fruticosa*). *Photo by C. M. King.*

In this plant the keel and wings are wanting and the standard surrounds the stamens and pistil, which are exserted. The flowers are proterogynous, at Ames as elsewhere, as observed by Trelease, Robertson, Mueller and Beal. It is visited by *Bombus* and the honey bee at Ames.

Hermann Mueller reports the honey bee as a frequent visitor in Germany and we confirm these observations in this country, as has also been done by Robertson, Trelease and others.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Carroll county, Cedar Falls, Centerville, Charles City, Clayton county, Council Bluffs, Delaware county, Delhi, Dickinson county, Keokuk, Lake City, Linn county, Little Rock, Marshall county, Missouri Valley, Oelwein, Palo Alto county, Pocahontas county, Polk county, Postville, Rockwell City, Sioux City, Storm Lake, Valley Junction (L. H. Pammel), Ames (C. R. Ball, R. Meeker and J. C. Blumer), Cedar Rapids (R. E. Buchanan), Clear Lake (R. I. Cratty), Decatur county (J. P. Anderson), Fayette county (B. Fink), Osage (Mrs. Tuttle), Volga (Hazel King), Wall Lake (Spurrell), Winneshiek county (H. Goddard, E. W. D. Holway).

General distribution in the United States:

Arkansas—Little Rock (George Letterman); Colorado—Fort Collins (C. S. Crandall); Florida—Lemon City (S. M. Tracy), Jacksonville (A. H. Curtiss); Illinois—DeKalb (H. Eggert), Hamilton (L. H. Pammel), Peoria (F. E. McDonald); Kansas— (T. L. Andrews); Louisiana—Alexandria (C. R. Ball); Minnesota—Cannon Falls (J. H. Sandberg), Ortonville (L. H. Pammel); Missouri—Allenton (George W. Letterman); Nebraska—Kearney (L. H. Pammel and I. C. Brownlie), Lincoln county (F. G. Miller), Sheridan county (R. E. Buchanan); Oklahoma—Norman (W. E. Bruner); South Dakota—Sisseton (opposite Hawarden) (L. H. Pammel); Tennessee—Ennis (L. H. Pammel), Tarrant county (Albert Ruth), Kerrville (two specimens, A. A. Heller).

HONEY BEE VISITS

Ames, June 14, 1927. Flowers in full bloom. One bee visited thirty flowers out of sixty in a spike. Two bees in three minutes. Four, three, four, five, four seconds in a flower. (L.H.P.)

June 16, 1927. 10 a.m. Sunshine, windy, cool. Bees visiting frequently, alighting with some difficulty on the petals. (C.C.L.)

Des Moines, June 6, 1929, 3:45 p.m. Bees common. Two, two, two, one, two seconds in a flower. (L.H.P.)

Pilot Mound, June 16, 1929, 12:30 p.m. Warm, south wind, clear. Past its prime. Two, three, three, two seconds on a flower. (L.H.P.)

Petalostemum Michx. Prairie Clover

Perennial upright plants with crowded three-foliate leaves. Very minute stipules. Flowers in dense peduncled heads or spikes.

Petalostemum purpureum (Vent.) Rydb. Purple Prairie Clover

A smooth perennial herb one foot to two feet high. Leaves compound, leaflets five, narrow, linear. Each stem is terminated by a close globose, ovate spike of rose-purplish flowers. Calyx silky, hoary. On limestone soils of prairies and open regions of northeastern Iowa, on gravel knolls of the Wisconsin and Iowan drifts and on Mississippi loess. A typical common prairie plant associated with *Petalostemum candidum, Dalea enneandra, Solidago rigida, S. speciosa, Aster missouriensis, Aster azureus, A. sericeus, A. laevis.*

Robertson finds that bees collect pollen as they crawl around the spikes. The nectar is not deeply seated and the plant is valuable for both nectar and pollen in the localities where it is still plentiful.

FIG. 210.—Prairie clover (*Petalostemum purpureum*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Garner, Marshalltown, Mason City, Muscatine, Palo Alto county, Sioux City (three specimens), South Dakota (opposite Hawarden), Story City, Webster City, Willow creek (L. H. Pammel), Ames (E. R. Hodson, L. H. Pammel and C. R. Ball, G. W. Carver, R. E. Jeffs, C. E. Bessey), Cedar Falls (G. W. Carver), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Kelley (Pearl Clayton), Ledges (Boone county) (R. E. Buchanan), Miller's Bay (L. H. Pammel and H. S. Coe), northeastern Iowa (H. Goddard), Polk county (C. E. Bessey), Red Oak (F. G. Miller), Slater (two specimens, B. Fink).

This plant has also been observed by L. H. Pammel at Algona, Bellevue, Boone, Burlington, Carroll, Centerville, Charles City, Cherokee, Clinton, Cresco, Dallas Center, Davenport, Dubuque, Eldora, Estherville, Fairfield, Forest City, Fort Dodge, Indianola, Jefferson, Keokuk, Lansing, Lawler, Le Mars, Liberty, Mason City, Missouri Valley, Mount Pleasant, Muscatine, New Albin, New Hampton, Postville, Rock Rapids, Turin, Waukon, West Liberty.

General distribution in the United States and Canada:

Canada—Calgary (L. H. Pammel); Colorado—Fort Collins (L. H. Pammel, Fred Rolfs and C. P. Johnson, A. Hayden), Larimer county (Witter), Trail Glen (F. E. and E. S. Clements); Illinois—Collinsville (H. I. Featherly), Englewood (S. L. Goodspeed), Kaneville (H. Eldredge), Peoria (F. E. McDonald), St. Clair county (H. Eggert); Minnesota—Faribault, Minneapolis, Morris, St. Cloud (L. H. Pammel), Brainerd (E. B. Watson, J. H. Sandberg), Jasper (Carl A. Hansen), St. Paul (R. Gmelin); Missouri—Allenton (George Letterman); Nebraska—Halsey (J. C. Blumer), Lincoln (F. G. Miller), Maxwell (L. H. Pammel), Sheridan county (R. E. Buchanan), Willow Island (Joseph Wahl); Oklahoma—Noble (Klein); South Dakota—Brookings (E. C. Pammel and L. H. Pammel), Sisseton (L. H. Pammel); Wisconsin—La Crosse (L. H. Pammel), Oshkosh (Mrs. Joseph Clemens); Wyoming—Hallett canyon, Albany county (A. Nelson).

HONEY BEE VISITS

Ames, July 14, 1914. Interurban track. Partly cloudy, warm, north wind. On one plant under day's observation six small bees and one butterfly. (G.H.M.)

Jordan, Aug. 4, 1914. Cloudy, south wind. One bee per spike per minute. (G.H.M.)

Iowa City (clay soil), August 4, 1927, 3 p.m. Warm, clear. No bees. Bees preferring white sweet clover. (L.H.P.)

Petalostemum multiflorum Nutt. Round-headed Prairie Clover

Erect branching perennials with compound leaves. Leaflets three to nine, linear to oblong. Head globose, bracts shorter than the acutely toothed calyx.

This occurs on the loess bluffs of western Iowa. Probably visited by honey bees.

Petalostemum candidum Michx. White Prairie Clover

Perennial upright plant with pinnate leaves and small white flowers in a dense, terminal head. Native to dry prairies in Iowa and surrounding states.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Cherokee, Dubuque, Granite, Marathon, Palo Alto county, Story City, Thurman, Webster City, Wheelerwood (L. H. Pammel), Emmet county, West Bend (R. I. Cratty), Ames (C. E. Bessey, E. R. Hodson and G. W. Carver), Battle Creek (E. G. Preston), Cedar Falls (G. W. Carver), Chickasaw county (W. D. Spiker), Crawford county (I. D. Butler), Decatur county (J. P. Anderson), Fayette (B. Fink), Fort Dodge (F. W. Paige), Hamilton county (P. H. Rolfs), Kelley (Pearl Clayton), Lamont (I. T. Bode), Ledges (L. H. Pammel, C. M. King, R. E. Buchanan), Newton (W. Drew), northeast Iowa (H. Goddard), Ontario (E. R. Hodson), Osceola (L. H. and H. E. Pammel).

FIG. 211.—White prairie clover (*Petalostemum candidum*). *Photo by Ada Hayden.*

General distribution in the United States:

Colorado—Fort Collins (A. Hayden, Reppert and Witter), Greeley (L. H. Pammel); Illinois—Kaneville (H. Eldridge); Kansas—Wichita (T. L. Andrews); Louisiana—Alexandria (C. R. Ball); Minnesota—St. Paul (R. Gmelin), Wildwood (Lois Pammel), Cass Lake, Morris, St. Cloud (L. H. Pammel); Missouri—Allenton (G. W. Letterman), St. Louis (H. Eggert); Oklahoma—Noble (Klein); South Dakota—La Bolt (L. H. Pammel); Wisconsin—La Crosse (L. H. Pammel).

HONEY BEE VISITS

Probably visited by honey bees but not frequently, as many observations have been made.

Iowa City (clay soil), August 4, 1927, 3 p.m. Warm, clear. No bees. Bees preferring white sweet clover. (L.H.P.)

Robinia L. Locust

Trees or shrubs with zigzag branchlets. Often spines for stipules. Leaves unequally pinnately compound, petioled; leaflets entire.

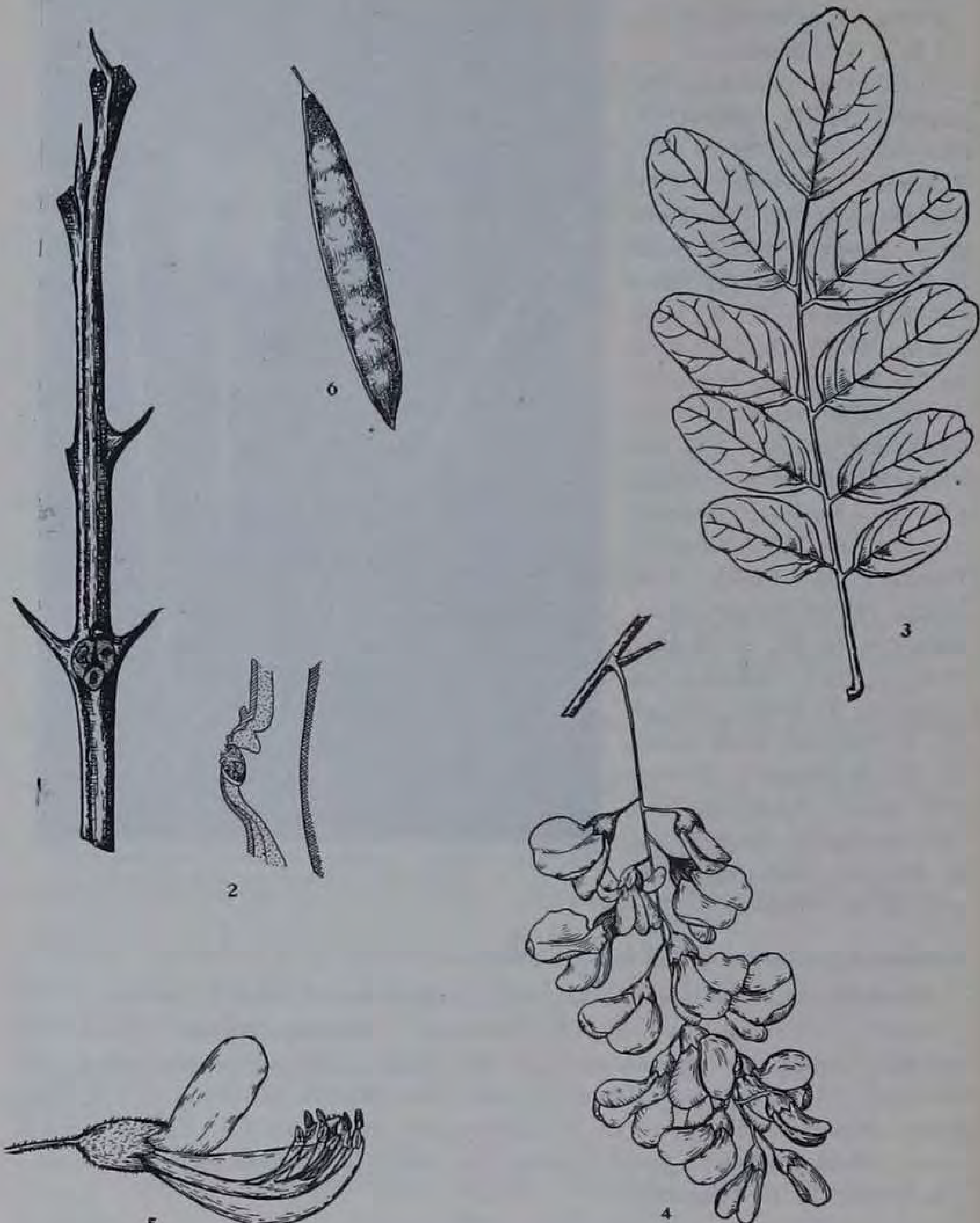

FIG. 212.—Black locust (*Robinia Pseudo-Acacia*). 1. Winter twig, x 1; 2. Vertical section through lateral buds, enlarged; 3. Leaf, x 1/2; 4. Raceme of flowers, x 1/2; 5. Flower, with part of corolla removed, enlarged; 6. Fruit, x 1/2. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Flowers on long peduncles in racemes; calyx bell-shaped, five-toothed; corolla papilionaceous. The standard large, reflex, slightly longer than the wing; stamens ten, diadelphous. Fruit a legume, flattened, many-seeded.

Robinia Pseudo-Acacia L. Common Locust, False Acacia

A tree 70 to 80 feet high, trunk three to four feet in diameter, usually with erect branches. Bark deeply furrowed, dark brown. Compound leaves 8 to 14 inches long; leaflets seven to nine; stipules

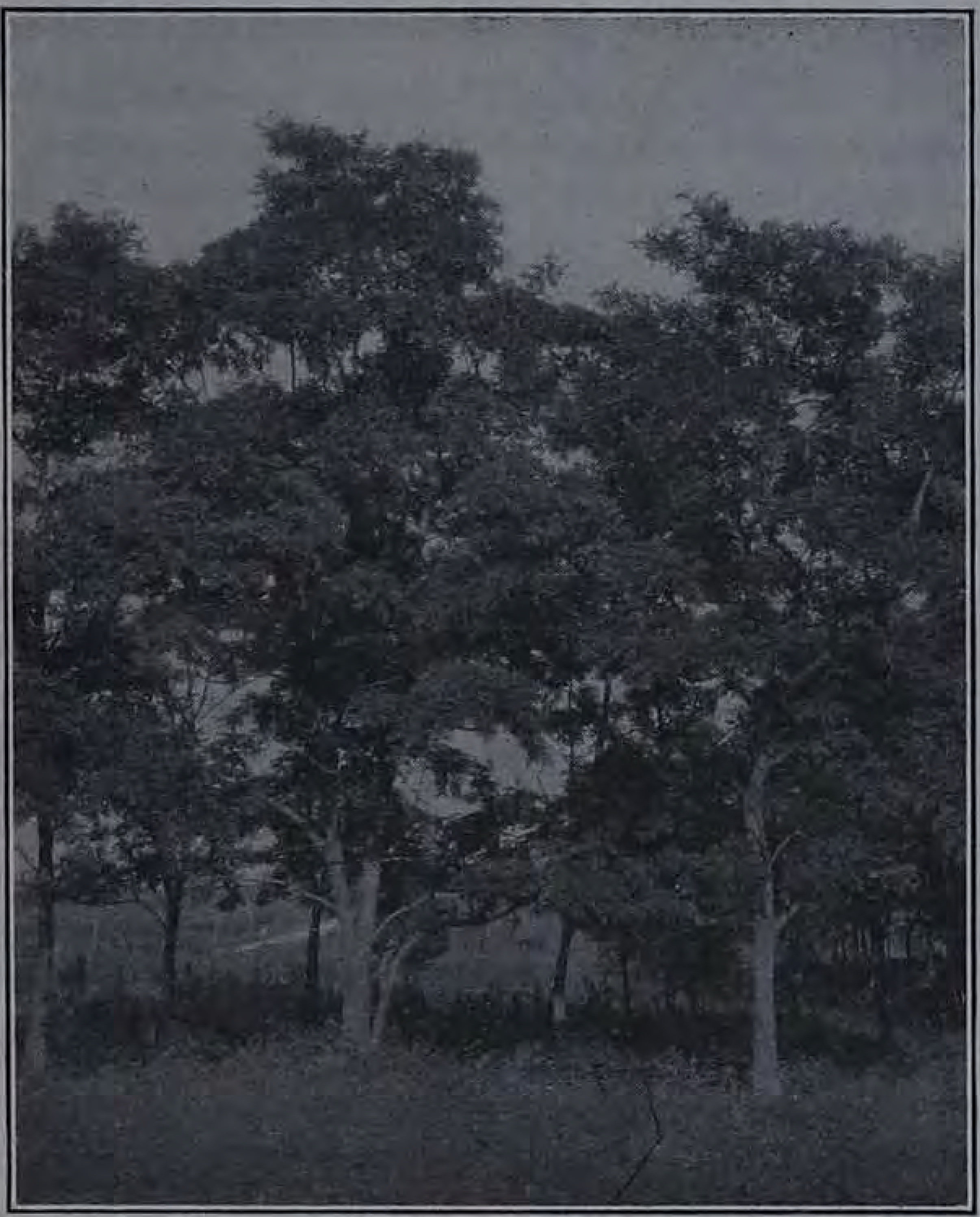

FIG. 213.—"A group of black locusts. This is one of the hardiest of our broad-leaved species and adapts itself readily to most types of soil. The black locust borer is its worst enemy. When not attacked, the black locust makes a rapid growth and is a very useful wood." (By Scott.) *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

spiny, persistent. Flowers white, fragrant, in drooping racemes. Pods glabrous, 4- to 7-seeded.

Commonly planted as an ornamental tree and in the early days planted as a wind break. One of the few trees naturalized in the state of Iowa. Native to the Appalachian mountains, Pennsylvania to northern Georgia.

Mostly a bumble bee flower. The insect lights upon the keel and presses it down and the pollen is thrust against the thorax of the insect. The style is somewhat longer than the stamens and in coming from another flower the insect leaves pollen upon the stigma.

HONEY BEE VISITS

Ames, May 24, 1927, 1 p.m. Warm. Bees numerous. Five, six, five, five, three seconds in a flower. (L.H.P.)

Ames, May 30, 1927, 3:30 p.m. Sunshine, warm. No honey bees. Many small bees. (L.H.P.)

Boone, May 31, 1928, 3 p.m. Warm. Bumble bees abundant. Some honey bees. Twelve, fourteen, ten, twelve, twelve seconds in a flower. (L.H.P.)

June 1, 1928, 3 p.m. Cool. Some honey bees. Twelve, ten, twelve, twelve seconds in a flower.

Ames, May 20, 1929. Bees working in the flowers. (C. C. Mantle.)

No bees were found on the black locust at Des Moines on June 6, 1929. About one-half in bloom. Bees were found on neighboring clover plants.

In bloom, Ames, May 18, 1926.

Robinia hispida L. Bristly Locust, Rose Acacia

A shrub from six to nine feet in height with bristly stalks and branches. Flower structure the same as in the common black locust. Deep rose color. Pods glandular-hispid.

Widely cultivated as an ornamental shrub. Has a rather longer blooming period and is occasionally visited by honey bees though normally a bumble bee flower. The honey bee is hardly capable of pressing down the keel with its contained stamens and pistils. Our observations are that honey bees remain only momentarily in the flower. Native of the mountains from Virginia to Georgia.

HONEY BEE VISITS

Ames, June 4, 1929. Bees on flowers only momentarily. (L.H.P.)

Date of bloom: 1926, Ames, May 18; 1927, Ames, May 20.

Galega L.

Bushy perennials, with odd-pinnate leaves and racemes of blue or white flowers.

Galega officinalis L. Goat's Rue

Height two to three feet. Leaflets oblong, flowers purplish blue.

HONEY BEE VISITS

Ames, June 23, 1929, 3:35 p.m. Bees two to three seconds in a flower.

July 1, 1929. Bees fairly common. Four, three, four, four, three seconds in a flower. (L.H.P.)

July 4, 1929. Three, three, two seconds in a flower. (L.H.P.)

July 11, 1929. No bees though near *Veronica spicata*.

July 18, 1929. Some bumble bees. No honey bees.

Astragalus (Tourn.) L. Milk Vetch

Perennials with odd-pinnate, compound leaves. Flowers in racemes or spikes. Calyx five-toothed. Corolla long and narrow. Stamens diadelphous. Pods several- to many-seeded.

There are several species of *Astragalus* in the Iowa flora. We have made observations on only a single species in central Iowa which is visited by honey bees. Without doubt other species, like the ground plum (*Astragalus caryocarpus*), which produces a turgid pod and violet-purple flowers, are visited by honey bees. This is a prairie species and is common in gravelly soil.

Another species found in western Iowa along waste bluffs (*Astragalus plattensis*) is likewise visited by honey bees. This plant has short stems, compound leaves and yellowish flowers, but the heads are small.

Hermann Mueller reports the presence of honey bees on several species of *Astragalus* in Europe, though the bumble bee is the normal visitor. The insect lights on the keel, using it as a support, and the stamens are pressed down against the insect. In the case of honey bees Mueller says, according to Knuth,

> "The edges of the carina are so close together in the front part containing the anthers that they scrape off some of the pollen and leave it outside when the carina moves up again. The alae interlock only with the anterior front of the carina; the lower edges of their finger-like processes, which are broad and flat, abut closely on the sexual column. Only the upper one-half of the flower is ensheathed by the broad base of the vexillum, which passes into its erect portion. Along the middle of this is a deep groove serving as a guide for the proboscis of bees. An open cleft remains between the claws of the carina and alae through which the honey bee is in the habit of stealing nectar from the side."

Various insects, mainly Hymenoptera, are found about the flower. Knuth says of the genus *Astragalus*, "Nectar-yielding bee flowers, violet or yellowish in color."

Astragalus canadensis L. Milk Vetch

Tall, erect, perennial plants, 3 to 24 inches high, somewhat pubescent, or smooth; leaflets 21 to 27, oblong, flowers irregular, with standard, two wings and keel, greenish cream color, pleasant odor, very numerous, in crowded spikes.

Dry or gravelly soil, western Quebec to northern Georgia and far westward. Blossoms during July and August.

In Iowa on black prairie soils or borders of woods in clay soil.

FIG. 214.—Cow or milk vetch (*Astragalus canadensis*). *Photo by R. E. Buchanan.*

Associated with *Vicia americana, Geranium maculatum, Andropogon provincialis, A. scoparius, Cirsium ioense, C. canescens.*

Bumble bee lights on keel and holds itself to the wings, depressing the keel. Nectar is secreted in abundance at the base of the staminal tube.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Gillett Grove, Keosauqua, Lake Mills, Marquette, Marshalltown, North McGregor, Palo Alto county (L. H. Pammel), Emmet county, West Bend (R. I. Cratty), Ames (Fred Rolfs, G. W. Carver, C. R. Ball and L. H. Pammel, Violet Pammel), Arnold's Park (Spirit Lake) (L. H. and H. E. Pammel), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Dunlap (Mrs. Laura Bailey), Fayette (two specimens, Bruce Fink), High Bridge (Boone county) (Botanical party), Kelley (Pearl Clayton), Ledges (Boone county) (two specimens, L. H. Pammel, R. E. Buchanan and C. M. King, J. V. Ellis), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle).

FIG. 215.—Milk vetch (*Astragalus canadensis*). *Photo by Ada Hayden.*

The plant has also been observed (L. H. Pammel) at Algona, Burlington, Carroll, Centerville, Charles City, Cherokee, Clinton, Council Bluffs, Dallas Center, Davenport, Decorah, Denison, Des Moines, Dubuque, Emmetsburg, Estherville, Forest City, Fort Dodge, Glenwood, Hamburg, Indianola, Jefferson, Keokuk, Lake Okoboji, Mason City, Milford, Muscatine, New Albin, Pisgah, Rock Rapids, Shenandoah, Sioux City, Waukon.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall, Ada Hayden); Illinois—Peoria (F. E. McDonald); Michigan—Ontonagon (L. H. Pammel); Minnesota—Bemidji, Cass Lake, Itasca, Lake Park, Minneapolis, Morris (L. H. Pammel), St. Cloud, St. Paul (R. Gmelin), Centre City (J. H. Sandberg); Nebraska—Sheridan county (R. E. Buchanan); New York—Ithaca (H. E. Summers); Ohio—Castalia, Cedar Point, Put-in-Bay (L. H. Pammel); Oregon—Eastern Oregon (Wm. C. Cusick); South Dakota—Brookings (two specimens), Watertown (Edna C. Pammel); Wisconsin—Bloomington, Rockton (L. H. Pammel); Wyoming—Lusk, South Sybille (Aven Nelson), Mammoth Hot Springs (Aven and Elias Nelson).

HONEY BEE VISITS

Ames, July 13, 1914. Railroad. Partly cloudy, north wind. Eight insects per flower per hour. Those collected are the fly (*Archytas*), an ant, a bee, two bugs. (L.A.K.)

July, 1914. Flowers giving pleasant odor. Nectar secreted in abundance at base of staminal tube. One spike was visited during one hour, by the following insects: one fly, one ant, one bee, two bugs and one bumble bee observed on the plant. (L.A.K.)

Honey bees have been observed by us a few times in different places. It is, however, not an important honey produc'ng plant.

The following species of *Astragalus* furnish nectar for honey bees.

Astragalus lotiflorus Hook. Low Milk Vetch

This is a common plant in western Iowa. It has yellowish flowers in small heads with short stems. The plant itself is more or less hairy.

Astragalus adsurgens Pall. Ascending Milk Vetch

An ascending or decumbent, pubescent or smooth perennial with numerous leaflets. It is found in northern and northwestern Iowa.

Astragalus distortus T. and G. Bent Milk Vetch

This is a low, diffuse, nearly smooth perennial with many leaflets. Flowers in short spikes. Pale purple in color. Found in sandy soil. Widely distributed in the state.

Astragalus hypoglottis L. Purple Milk Vetch

Slender plant, diffusely spreading. Leaves with many leaflets, slightly pubescent. Flowers violet, in short heads. Most common in northwestern Iowa.

Oxytropis DC. Loco-weed

A genus closely related to the preceding. A perennial with numerous short stems. The rootstock scaly. Leaves are pinnately compound and with many leaflets. Flowers in spikelike clusters. It is visited by the honey bee in Europe, according to Mueller.

Oxytropis Lamberti Pursh. Loco-weed

Perennial with silky stems. Pinnately compound leaves. Leaflets linear. Flowers large, purple, violet or sometimes white. Pod firm.

This species is more or less abundant in western Iowa. It is abundant also in the western states, especially in the Rocky mountains, and is one of the so-called loco-weeds.

The method of pollination is very much like that of *Astragalus.*

Bees have been observed on this plant, but it is not an important source of nectar.

Caragana Lam. Pea Tree

Shrubs or sometimes small trees which are spiny or spineless. Pinnately compound leaves. Flowers papilionaceous, with upright standard, keel and diadelphous stamens. Fruit a pod.

Several species are cultivated for ornamental purposes.

Caragana frutex Koch. Pea Tree

Shrubs with compound leaves in clusters, a spiny tip in place of an end leaflet. Flowers yellow. Pod slender.

The pea tree has yellow irregular papilionaceous flowers. The diadelphous stamens contain a tenth free stamen on the upper side. There is a single pistil.

The nectar is secreted at the base of the staminal tube and is contained in the tube; although the nectar is deep seated the flowers are sometimes visited by honey bees.

FIG. 216.—Siberian pea tree (*Caragana frutex*). *Photo by Ada Hayden.*

It is reported by W. E. Lake to give in Canada a good yield of light honey of fine quality. This species is commonly cultivated for ornamental purposes.

HONEY BEE VISITS

Ames, May 19, 1918. Honey bees at work. One bee attempted to get nectar inside the calyx and not by way of the keel. The insect repeated the effort on five flowers; apparently not getting nectar. (L.A.K.)

Bees were observed on this species in 1927 and 1928, but normally it is not adapted to honey bees for pollination.

Ames, May 6, 1929, 2 p.m. Some bees. (L.H.P.)

Caragana arborescens Lam. Pea Tree

An erect shrub, slightly winged compound leaves, four to six pairs. Flowers yellow. This species is commonly cultivated as an ornamental plant. We have observed bees more frequently on it than on the preceding species.

HONEY BEE VISITS

Ames, May 6, 1926, 9 a.m. Sunny. Bees getting pollen. Twelve to six seconds in a flower.

May 8, 1926, 1:30 p.m. Strong warm south breeze. Honey bees abundant. Six, six, six, eight, ten seconds in a flower. Bumble bees also at work.

May 12, 1926, 5 p.m. Slightly humid. Honey bees and bumble bees abundant. Getting pollen. (L.H.P.)

During the spring of 1929 we observed bumble bees on this species. Though we looked frequently, honey bees were not observed.

Kirchner, according to Knuth, observed the bumble bee on this species at Wurtemberg.

Dates of bloom: 1925, Ames, April 22; 1926, Ames, May 10; 1927, Ames, May 10.

Desmodium Desv. Tick Trefoil

Perennial herbs with pinnately compound leaves and flat pods often in distinct sections. Flowers purplish.

Desmodium canadense DC. Tick Trefoil

A native perennial herb. Flowers in a naked terminal dense raceme, pink-purple. The roundish joints of the pod adhering to passing objects. Throughout the north and western parts of the middle United States.

Widely distributed in typical black prairie soils, borders of woodlands, gravel knolls and prairies. Associated with *Astragalus cana-*

FIG. 217.—Tick trefoil (*Desmodium illinoense*). *Photo by Oliver Miller.*

densis, Petalostemum candidum, Vicia americana, Geranium maculatum.

The purplish irregular papilionaceous flowers are produced in a raceme. The stamens are diadelphous and the nectar is secreted at the base of the staminal tube.

This plant is not much frequented by honey bees, generally being pollinated by bumble bees. We observed honey bees on it in 1928 and probably they are more or less frequent visitors. What is true of *Desmodium canadense* is true of the other species, like *Desmodium illinoense*, which is a large plant with a tall stem and persistent stipules and larger flowers. The leaves are roughly pubescent.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eddyville, Garner, Hancock county, Indianola, Lake Okoboji, Lost Island lake, New Albin, Ogden, Osage, Pilot Knob (Hancock county) (L. H. Pammel), Armstrong, Decorah, West Bend (R. I. Cratty), Adel (Chas. F. Clark), Alden (C. T. Stevens), Ames (G. W. Carver, Fred Rolfs, R. E. Jeffs, C. E. Bessey), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Delaware county

(I. T. Bode), Fayette (two specimens, Bruce Fink), Ledges (Boone county) (two specimens, L. H. Pammel and T. Macklin, L. H. Pammel, R. E. Buchanan and C. M. King, J. V. Ellis), Miller's bay (L. H. Pammel and H. S. Coe), Monroe (H. L. Orcutt), northeastern Iowa (H. E. Goddard), Ontario (E. R. Hodson), Osage (Mrs. F. M. Tuttle).

General distribution in the United States:

Illinois—Litchfield (J. M. Burglehaus); Minnesota—Cass Lake (L. H. and H. E. Pammel), Minneapolis (J. H. Sandberg), St. Cloud (R. Gmelin), Wildwood (Lois Pammel); Missouri—St. Louis (M.B.L. and P.B.); Nebraska—Halsey (J. C. Blumer), Sheridan county (R. E. Buchanan); New Hampshire—Laconia (Miss Price); New York—Ithaca (Muenscher and Bechtel, H. E. Summers), Watkins Glen (L. H. Pammel); Ohio—Cedar Point (L. H. Pammel); South Dakota—Sisseton, Watertown (L. H. Pammel); Wisconsin—Galesville, Dresser Junction (two specimens), La Crosse, Holmen, St. Croix Falls (L. H. Pammel), Madison (J. R. Heddle).

Lespedeza Michx. Bush Clover

Generally upright perennials. Herbs or sometimes inclined to be shrubby, rarely annual. Pinnate three-foliate leaves. Flowers pinkish or purplish, some polygamous; calyx five-cleft. Of the several species occurring in the state the following are the most common.

Lespedeza violacea (L.) Pers. Bush Clover

Stems with setaceous stipules. Leaflets thin, oval or oblong, pubescent beneath. Plant loosely few-flowered. This species is found in southeastern Iowa and sometimes bees have been found on it.

Lespedeza repens (L.) Bart. Creeping Bush Clover

This is a more or less slender, glabrous plant with finely appressed hairs. More or less trailing, prostrate. Found in southeastern Iowa. Bees have been reported on this species.

Lespedeza capitata Michx. Prairie Clover

An erect plant more or less hairy. Leaves compound on short petioles. Leaflets nearly elliptical. Flowers in more or less globular heads, white. This is widely distributed in the state of Iowa and is the common prairie clover.

Lespedeza leptostachya Engelm. Prairie Bush Clover

This, like the preceding, is an erect plant with closely appressed hairs and linear leaflets. Spikes somewhat loosely flowered.

Occurs on prairie soils in northwestern Iowa. Honey bees have been observed on it.

Vicia (Tourn.) L. Vetch

Herbs, usually climbing more or less by a tendril at the end of the pinnate leaves. Pod flat, with two to several round seeds.

Vicia Cracca L. Vetch

The blossoms are clustered in handsome racemes. The abundance of nectar leads to plentiful insect visits. Honey bees are very abundant. The bees are said to avoid the old darker colored flowers and to visit the ones which have just opened. The flowers have a mechanism adapted to bee visitation.

Knuth says, "Nectar-yielding bee flowers, with a stylar brush."

Hermann Mueller states, "The anthers, which lie close round the brush of hairs, dehisce and shed their pollen upon the hairs when the flower has scarcely attained half its full size and the stigma, which is overlapped all round the outer side by hairs, is also covered with pollen. The brush of hairs thus covered above and all round with pollen lies in a pouch of the flattened tip of the carina and emerges when the carina is depressed from the narrow slit at its tip." The rather small sized flowers make it possible for honey bees to reach the nectar.

In Europe the honey bee is reported as an important visitor. Hermann Mueller mentions it in a number of instances and he states that it takes at least six to eight seconds to brush off the pollen from the flowers.

Vicia Cracca has been naturalized in Iowa at some points.

General distribution in the United States:

California—Patterson (L. H. Pammel); Iowa—Northeastern Iowa (H. Goddard); Massachusetts—Cambridge (J. W. Blankinship); New York—Ithaca (Muenscher and Bechtel), Cooperstown (Mrs. L. M. Parker); Washington—Whatcome county (W. N. Suksdorf); Vermont—East Corinth (H. S. Kellogg), Peacham (Ferdinand Blanchard).

HONEY BEE VISITS

Ames, July 17, 1914. Clear, northwest wind. Wild bees thirty per flower per hour. (G.H.M.)

July 22, 1914, all day. Partly cloudy, warm. One *Bombus* at eight—no other insects; flowers wilting at ten. (L.A.K.)

Bombus visited fifty flowers in five minutes then went to *Asclepias verticillata*. It seemed to have a hard time getting proboscis into place; clutching wings of the flower the insect thrusts proboscis against keel. No honey bees observed on this flower. (L.H.P.)

Vicia sativa L. Spring Vetch

Annual or winter annual at first pubescent then becoming smooth. Stems simple or branched. Compound leaves of four to eight

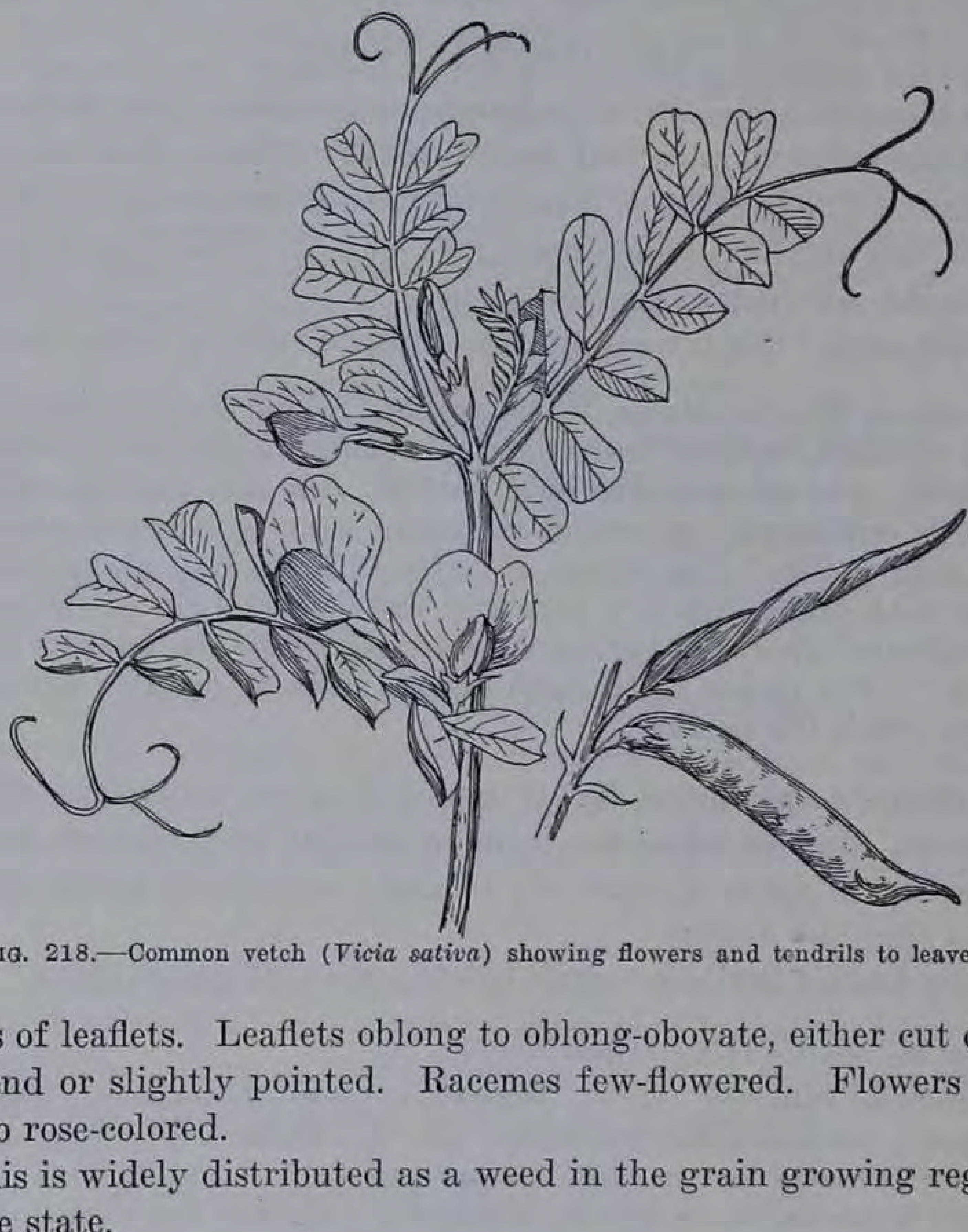

FIG. 218.—Common vetch (*Vicia sativa*) showing flowers and tendrils to leaves.

pairs of leaflets. Leaflets oblong to oblong-obovate, either cut off at the end or slightly pointed. Racemes few-flowered. Flowers purple to rose-colored.

This is widely distributed as a weed in the grain growing regions of the state.

HONEY BEE VISITS

Ames, June 6, 1927, 2 p.m. Cloudy, warm. Bees not common. Collecting pollen and nectar. Bees ten, eight, five, six, eight seconds in a flower. (L.H.P.)

Vicia americana Muhl. Purple Vetch

Smooth perennial plants with compound leaves. Leaflets elliptical or ovate-oblong. Flowers purplish, in racemes which are four- to eight-flowered.

This is a common prairie plant throughout Iowa.

Ames, May 29, 1929. Many bees. (H. P. Hagge.)

Date of bloom: 1927, Ames, June 1.

Vicia villosa Roth. Hairy or Winter Vetch

Annual or biennial with villous stems and leaves. Violet or white flowers. Freely planted for its forage value and is frequently an escape.

Honey bees have been observed on this by the senior author.

Lathyrus (Tourn.) L. Everlasting Pea

Perennial herbs, generally smooth. Pinnately compound leaves. Flowers rather large, resembling those of *Vicia* but with a larger standard.

Lathyrus palustris L. Wild Pea

A slender glabrous perennial, usually winged stems with rather broad stipules. Leaflets smooth, lanceolate to elliptical, peduncles with three to nine flowers. Color of flowers purplish.

Lathyrus pratensis L. Meadow Pea

Hermann Mueller states that this species affords us another example of papilionaceous flowers in which when the carina is depressed the tip of the style emerges and sweeps part of the pollen out of the apex of the carina by means of a brush, applying it to the underside of the bee, which afterwards leaves it upon the next flower.

Our species of vetch, like all of the others, has a brush on the style, which is important in connection with the pollination of this plant.

Lathyrus odoratus L. Sweet Pea

Twining, climbing annual herb with very fragrant flowers. Tendril-bearing leaves. Leaflets oval to oblong. Flowers variable in color.

This is one of the most widely grown ornamental plants and is freely visited by honey bees.

Lathyrus venosus Muhl. Veiny Pea

A stout climbing perennial with small stipules. Leaflets oblong-ovate. Flowers four to six in a cluster.

Honey bees have been observed on this plant.

Phaseolus (Tourn.) L. Kidney Bean

Twining herbs. Racemose purple flowers, 3-foliate leaves. Pod scythe-shaped.

Phaseolus vulgaris L. Bean

The twining, bush and kidney beans, with racemes of white or purplish flowers shorter than the leaf. Pods linear, straight, many varieties. Cultivated in various soils, sandy, black and clay.

HONEY BEE VISITS

Ames, October 1, 1914. Cloudy, southeast wind. One *Bombus*, active. Each flower visited every four minutes. (Camburn.)

Bloomfield, July 25, 1927, 10:30 a.m. Bees make momentary visits. (L.H.P.)

Phaseolus multiflorus Willd. Scarlet Runner

The red-flowered twining bean, the racemes of flowers longer than the leaves; pods broadly linear, nearly straight. A native of tropical America, commonly grown as an ornamental vine. Cultivated in various soils.

HONEY BEE VISITS

Dubuque, July 10, 1914. Cloudy, northwest wind. Many *Bombus*, honey bees and other Hymenoptera. One bee per bush per minute. (L.H.P.)

Ames, August 27, 1923, 8 a.m. Clear, bright. Many bees getting nectar. (G.H.M.)

September 10, 1923. Warm, bright. Frequent bees. (G.H.M.)

September 21, 1923, noon. Bright and warm. Several bees. Bees sometimes visit the scarlet runner very freely.

Phaseolus lunatus L. Lima Bean

Twining plants with greenish flowers and broad flat pods. Beans large, flat. Cultivated in sandy, black and clay soil.

Honey flow from beans is regarded as quite dependable for the bees.

Pellett in "American Honey Plants" says, "There are two varieties of the garden bean which are the source of nectar in quantity." He refers to lima and black-eyed beans, and further says, "The honey from lima beans is almost water white in color and of fine flavor, according to M. H. Mendleson of Ventura, California. The black-eyed beans yield a dark amber colored honey but one of good quality."

Knuth states that the honey bee and other small bees which are too feeble to depress the carina use the hole made by *Bombus terrestis* in the calyx for stealing nectar.

Strophostyles Ell. Wild Bean

Prostrate or climbing herbs more or less hairy. Flowers purplish. The standard nearly orbicular, wings obovate. The keel contains the stamens and style but no spiral coil. Pod flattish. Seed more or less angular.

Strophostyles pauciflora (Benth.) Wats. Small Wild Bean

An annual low-climbing pubescent herb with oblong or oblong-lanceolate leaves. Common in the southeastern part of the state.

Bees have been observed on this plant.

Strophostyles helvola (L.) Britton. Trailing Wild Bean

An annual climbing plant. Compound leaves. Leaflets ovate to oblong-ovate, the basal lobe rounded. Flowers greenish purple. More or less common in sandy soil along our streams.

Honey bees have been observed on these plants.

Robertson says "The keel is bent strongly to the right and curves around so that its tip stands over its base. The base is large and sacklike and is produced above into a ridge which opposes the passage to the nectary. The left wing is turned to the right, so that the bee is required to alight upon the right side, and she enters the flower between the tip and the basal process of the keel. Seizing this process with her front feet, the bee pulls the keel downward and backward, whereupon the stigma and the pollen-laden brush of the style sweep out over her thorax. In this way the stigma receives pollen already deposited by another flower, and the style brush leaves a new load. As soon as the bee lets go her hold upon the basal process, the keel returns to its place against the banner, and the style draws back into it."

Vigna Savi. Cow Pea

This genus closely resembles the bean, but the keel is not spirally coiled at the tip. Leaves pinnately three-foliate.

Vigna sinensis (L.) Endl. Cow Pea

An annual with broadly ovate leaflets. Flowers few, about two-thirds inch long, in clusters. Standard nearly orbicular-auricled at base, larger than the wings. Keel slightly curved. The flower has extra-floral nectaries. Commonly cultivated as a cover crop in corn fields.

Sometimes said to yield honey. Pellett states that Nestor reports that it yields freely in Texas and where sufficient acreages are planted yields an excess.

Frank Pellett in his "American Honey Plants" has a number of statements with reference to the value of this plant for honey purposes and quotes a statement from "Gleanings in Bee Keeping" to the effect that in North Carolina it is a valuable honey plant. Also it is reported as a valuable honey plant in Missouri and in Virginia.

Amphicarpa Ell. Hog Peanut

A slender perennial with twining stems with brownish hairs. Leaves pinnately three-foliate. Flowers irregular, papilionaceous, also cleistogamous. Flowers produced from creeping branches. Stamens diadelphous. The flowers are light purplish in color. Keel is rather large.

Amphicarpa Pitcheri T. and G. Pitcher's Hog Peanut

Perennial plants more or less hispid. Flowers purplish or violet. Pod hairy. We have observed bees on this plant.

Amphicarpa has fertile cleistogamous flowers and also flowers which open but are for the most part barren. In 1929 generally only one pod was produced from a single one of the open flower clusters.

LINACEAE, Flax Family

Herbs with regular four- to six-parted flowers. Five stamens, monadelphous at the base. Pod eight- to ten-seeded.

Linum (Tourn.) L. Flax

Sepals, petals, stamens and styles five. Pod five-celled, ten-seeded. Seeds flat and mucilaginous.

Herbs with fibrous cortex, simple sessile leaves and panicled flowers. Corolla ephemeral.

Linum usitatissimum L. Common Flax

A slender annual cultivated herb, one to two feet high. Leaves narrow, lanceolate, flowers corymbose, delicate blue. Seeds mucilaginous. Extensively cultivated for seeds and fiber. Occasionally spontaneous in fields and on roadsides.

Naturalized, usually in black prairie soil and along railroad embankments.

It does best on new broken prairie that has never been cropped.

About ten thousand acres of flax are raised annually in Iowa. This is owing to plant disease relations.

The five filaments are adherent by their expanded bases to a fleshy ring in the base of the flower which bears honey secreting glands.

Common flax is pollinated by the honey bee and other small Hymenoptera.

This is said to be a honey bee flower and was so reported by Hermann Mueller in Germany, but we have not seen the honey bee on it in Iowa nor is it reported by Frank Pellett or by Root in "A B C of Bee Culture."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Alden (C. T. Stevens), Little Rock (C. R. Ball), northeastern Iowa (H. Goddard).

Widely distributed in the state of Iowa. Spontaneous along railways, but nowhere abundant.

General distribution in the United States:

California—Portola (Mr. and Mrs. L. H. Pammel); Illinois—Chicago (L. H. Pammel); Minnesota—Sauk Center (escape) (L. H. Pammel); North Dakota—Crookston (Mrs. Roy Westley); South Dakota—Brookings (Edna Pammel).

HONEY BEE VISITS

Ames, July 10, 1914. Partly cloudy, northwest wind. *Bombus*, Hymenoptera, flies, butterflies, thirty per plant per hour. Thrust proboscis into flower. (G.H.M.)

July 15, 1914. Cloudy, north wind. Mostly flies—two dark for bees to fly. (G.H.M.)

TROPAEOLACEAE, TROPAEOLUM FAMILY

Succulent herbs often climbing by coiling petioles. Leaves alternate, flowers solitary.

Tropaeolum L. Nasturtium

Introduced garden plants, peltate leaves, showy flowers.

Tropaeolum majus L. Garden Nasturtium

Smooth succulent annual, with peltate leaves and vari-colored flowers.

HONEY BEE VISITS

Ames, July 4, 1929, 9 a.m. A few bees gathering pollen. (Mrs. I. O. Webber.)

OXALIDACEAE, Wood Sorrel Family

Small family of plants with sour juice. Herbs with palmately compound leaves, in some cases radical and others caulescent. Flowers regular, five sepals and five petals. Ovary compound, five-celled. Capsule two- to many-seeded.

Oxalis L. Wood Sorrel

Perennial or annual, bulbous or with a rootstock. Caulescent or acaulescent; five sepals and five petals. Ten stamens. Somewhat monadelphous. Pod cylindrical. Several species produce cleistogamous flowers and some dimorphic; stamens in two sets in two different plants, others trimorphic with three sets of stamens which are on three different plants.

Honey bees are reported on some of the species like *Oxalis Acetosella.* This plant does not occur in the state. McLeod reports honey bees on *Oxalis stricta* in Flanders.

Oxalis violacea L. Violet Wood Sorrel

Nearly glabrous bulbous perennials with radical leaves and violet petals. Common in woods.

Robertson reports that it is visited very abundantly by bees of various kinds, including the honey bee.

Oxalis stricta L. Yellow Field Sorrel

Pale green, usually perennial with palmately compound leaves on long petioles with short appressed hairs. Flowers in cymose clusters. Pedicels deflected. Petals yellow with few flowers.

Many observations have been made but bees have not been found on it in Iowa though reported elsewhere.

Oxalis corniculata L. Yellow Oxalis

An erect or decumbent herb with numerous runners. Palmately compound leaves. Flowers in cymose clusters. Pedicels pubescent, not deflected. Pods are erect. This is one of the common weeds of Iowa in fields and gardens.

HONEY BEE VISITS

Manhattan, Kansas, May 17, 1927, 12 m. No bees. (L.H.P.)

Repeated observations have been made on this plant in Iowa but no bees have been found though reported elsewhere.

Date of bloom, 1926, Ames, May 5.

GERANIACEAE, Geranium Family

Herbaceous plants with regular five-parted flowers. Capsules opening elastically. Leaves lobed or divided. Roots with astringent properties.

Geranium (Tourn.) L. Cranesbill

Stamens usually ten, styles smooth inside, when separated from the axis. Stems widely branching. Peduncles one- to three-flowered.

Geranium maculatum L. Wild Geranium

Perennials with light pinkish purple flowers, petals bearded on the claw. Plant erect, hairy; leaves with about five divisions. Pedicels and beak of fruit hairy but not glandular.

A plant of open woods and fields, of wide distribution, from Maine to Manitoba and southward.

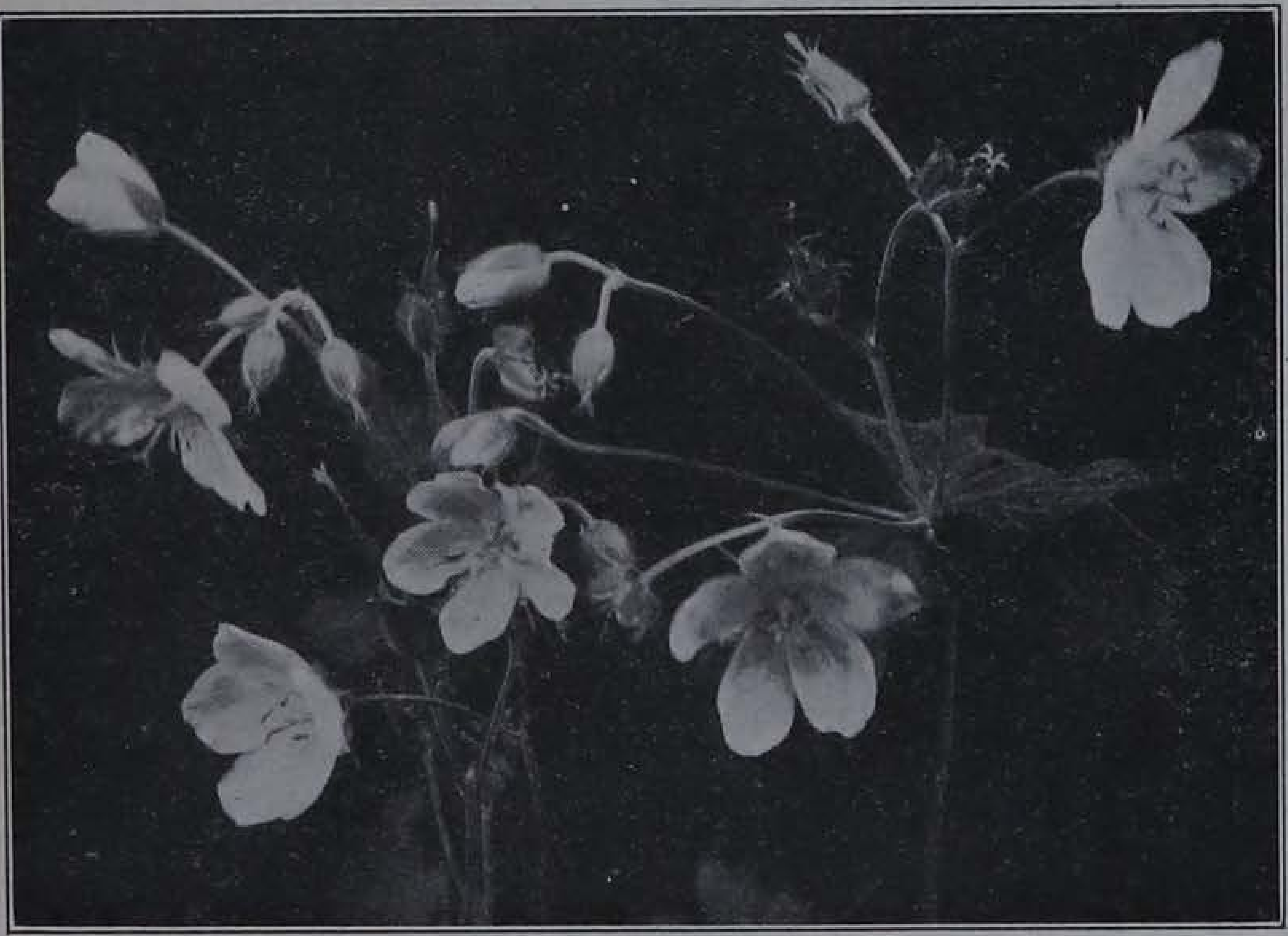

Fig. 219.—Wild geranium (*Geranium maculatum*). *Photo by Ada Hayden.*

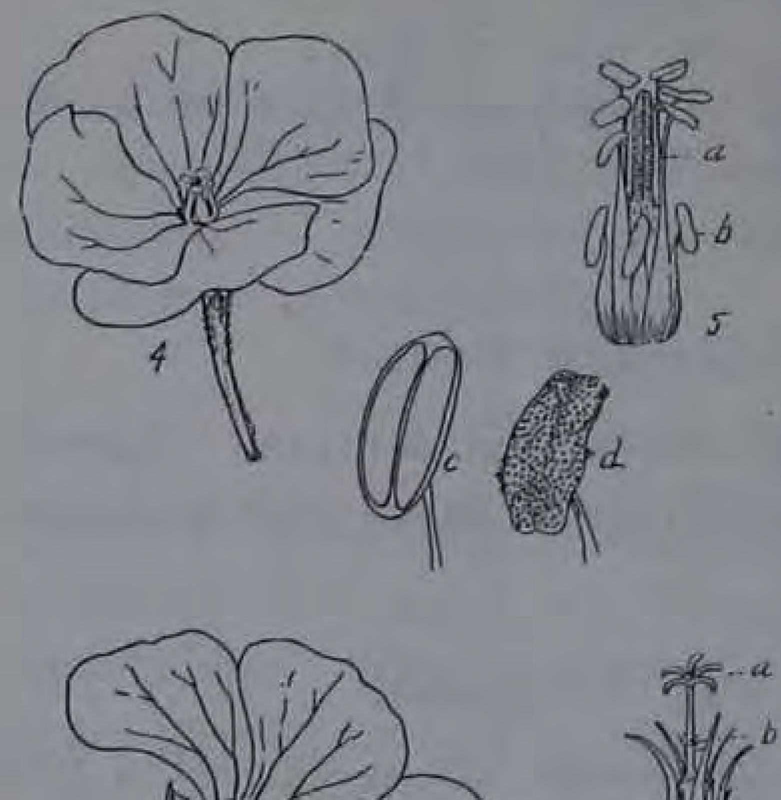

FIG. 220.—Geranium or Pelargonium (*Pelargonium hortorum* Bailey). The common fish geranium is one of the humming-bird flowers, although occasionally it may be visited by the honey bee for pollen. The flowers are proterandrous and an abundance of nectar is secreted.

Bees are attracted to the flowers by the color of the petals. The flowers are proterandrous, stamens maturing before the pistil. Nectar is concealed and is secreted at the base of the five inner stamens. The inner five stamens mature first, followed by the next five stamens. The pistil develops when the pollen has been shed. At the time of shedding of the pollen the stigmas are closed. Self pollination is impossible because of the difference in time of development of stamens and pistil. Hairs at the base of the petals serve to protect the nectar.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, McGregor, Postville, Sedan, Yellow river (L. H. Pammel), Ames (C. R. Ball, G. W. Carver, S. W. Beyer), Chickasaw county (W. D. Spiker), Decorah (F. R. Goddard), Dubuque (L. H. Pammel and F. French), Emmet county (B. O. Wolden), Fort Dodge (L. H. Pammel and F. W. Paige), Ledges (J. V. Ellis), Muscatine (L. H. Pammel and E. R. Hodson).

It has also been observed (L. H. Pammel) at Adel, Alton, Burlington, Cedar Rapids, Chariton, Clinton, Council Bluffs, Des Moines, Eagle Grove, Eldora, Hamburg, Keokuk, Keosauqua, Linn Grove, Marshalltown, Mason City, McGregor, Peterson, Winterset.

General distribution in the United States:

District of Columbia—Washington (L. H. Pammel); Illinois—Peoria (F. E. McDonald), Champaign (B. Fink), Bluff lake (L. H. Pammel), Chicago (Stella L. Goodspeed); Maryland—Baltimore (F. B. Trenk); Minnesota—St. Cloud—(R. Gmelin); Missouri—St. Louis (L. H. Pammel); Nebraska—Long Pine (G. M. Bates); New York—Ithaca (Muenscher and Bechtel), Staten Island (Elsie Tribbley), New York (Percy Wilson), Tompkins county (H. E. Summers); Ohio—Worthington (Asa Horr); Pennsylvania—Gettysburg (L. H. Pammel); Wisconsin—McFarland (L. H. Pammel).

HONEY BEE VISITS

Manhattan, Kansas, May 16, 1927, 5:15 p.m. Clear, sunshiny. No bees.
Boone, May 31, 1927, 1 p.m. No bees. (L.H.P.)
Eldora, June 5, 1927, 4 p.m. Clear, warm. Bees five, six, eight, five, four, four seconds in a flower. In five minutes three to five bees in one flower.
Ames, June 7, 1927. "North Orchard" (Horticultural Dept. I.S.C.), 48 visits of honey bee to one geranium bloom in one and one-half hours. Bee getting nectar—three to five seconds in a flower. (C.C.L.)

Blooming, Lansing, May 16, 1924; Ames, May 20, 1925; May 10, 1926; Lansing, May 11, 1926; Ames, May 8, 1927.

Geranium carolinianum L. Carolina Cranesbill

A diffuse hairy branched annual with five-parted leaves. The divisions are cut. Flowers in cymose clusters. Petals pale pink. This is a common weed in Iowa. Common in West. We have not observed bees on it.

Erodium L'Her. Storksbill

The filaree or storksbill is an annual with flowers resembling those of the geranium. Five glandlike discs alternate with the petals. Style and fruit twist spirally.

Erodium cicutarium (L.) L'Her.

Low annual, spreading; pinnate leaves; leaflets sessile. Filaments not toothed. Occasionally found as an escape.

FIG. 221—Storksbill (*Erodium cicutarium*).

Pellett states that the filaree is common in California and is said to furnish some nectar and has considerable value as a honey plant. It probably will never be important in this state as the plant is rarely found in Iowa.

RUTACEAE, Rue Family

Plants with alternate simple or compound leaves, having pellucid glands and containing bitter-aromatic oil. Fruit usually capsular. The rue is sometimes naturalized in the east.

This family contains a number of plants which are of some importance as bee flowers. Among these are the common rue (*Ruta graveolens*), which is sometimes cultivated in gardens, also various members of the genus *Citrus* like the orange (*Citrus Aurantium*), grapefruit (*Citrus maxima*) and the lemon (*Citrus Limonia*), which furnish a large amount of nectar where the plants occur.

Among the plants sometimes cultivated in gardens is *Dictamnus albus* L. (sometimes known as burning bush). This strong scented plant grows in clumps. It has compound leaflets and slightly irregular flowers. The stamens are much like those occurring in the horse chestnut and the buckeye.

Bees have been reported on this plant by Loew in Germany. We have not observed honey bees on it in Iowa.

Zanthoxylum L. Prickly Ash

Shrubs or trees with pinnate leaves, stems prickly. The flowers are dioecious, small, greenish. Petals four or five. Pistils two to five with styles slightly united. Pods thick and fleshy, one- to two-seeded. Seed coat black, shining.

Zanthoxylum americanum Mill. Northern Prickly Ash

Leaves and flowers in sessile axillary clusters, leaflets in two to four pairs, with an odd leaflet, ovate, downy when young. Plant aromatic. A common shrub in borders of woods. Wide distribution.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Anamosa, Atlantic, Auburn, Bellevue, Burlington, Cherokee, Clarksville, Colfax, Davison, Fairfield, Fayette, Forest City, Hawarden, Keosauqua, Lake Mills, Liscomb, Madrid, McGregor, Moingona, Palisades, Princeton, Red Rock, Sidney, Stratford (L. H. Pammel), Council Bluffs, Hamburg, Milford (L. H. Pammel and H. S. Coe), Fort Dodge, Osceola (F. C. Stewart), Algona, Clear Lake, Osage (R. I. Cratty), Oto, Sioux City (H. B. Clark), Goodell, Rockford (L. H. Pammel and G. B. MacDonald), Cedar Falls, Wayland (G. W. Carver), Ames (Violet Pammel, C. E. Bessey, E. R. Hodson, A. S. Hitchcock, Fred Rolfs), Camp Dodge (L. H. Pammel and E. R. Harlan), Cedar Rapids (R. E. Buchanan), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Delaware county (E. W. D. Holway), Dubuque (F. B. Trenk), Fayette (Bruce Fink), Greene (L. Price), Iowa City (B. Shimek), Keokuk (P. H. Rolfs), Lansing (L. H. Pammel), Ledges (L. H. Pammel, R. E. Buchanan and C. M. King, T. Macklin and L. H. Pammel), Ottumwa (Jessie Peters), Shell Rock (E. S. Fyler), Skunk river valley (Paul Bartsch), Slater (H. S. Fawcett, W. I. Tener and C. Reinbott).

General distribution in the United States:

Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill; Minnesota—Cannon Falls, Howard, Ortonville, Port Huron (L. H. Pammel), Cass Lake (L. H. Pammel and T. R. Truax), St. Cloud (R. Gmelin); Missouri—Allenton, Washington (L. H. Pammel), St. Louis (H. Eggert); Nebraska—Blair (H. B. Clark); New York—Ithaca (two specimens, Muenscher and Bechtel); Ohio—Washington (Asa Horr); Pennsylvania—Cedar Hill (John K. Small); Wisconsin—Fond du Lac (L. H. Pammel and E. Waters).

HONEY BEE VISITS

Honey bees have been observed but they are not common. Bees are fairly numerous on the related species, the southern prickly ash (*Zanthoxylum Clava-Herculis* L.). We have observed bees on this species in Florida, and according to Frank Pellett it is a source of some honey in eastern Texas.

Ledges, Boone, May 1, 1924, 2 p.m. Bright and clear. Some small bees. No honey bees.

Blooming, Ames, May 14, 1925; May 10, 1926.

Ptelea L. Shrubby Trefoil, Hop Tree

Shrubs with three-foliolate leaves and greenish white flowers in terminal cymes. Flowers polygamous. Petals three to five; stamens three to five. Fruit a two-seeded samara, nearly orbicular, winged all around.

Ptelea trifoliata L. Hop Tree

Leaflets downy when young, ovate, pointed. Associated with *Rhus typhina, Lespedeza violacea, Pycnanthemum linifolium, Hedeoma pulegioides, Corylus americana, Quercus alba, Carya ovata.*

The greenish flowers are arranged in racemes. Nectar is concealed in the base of the flower.

The flower possesses a hyacinth-like odor. Honey bees are frequent visitors and the honey yield of the tree is very good in favorable seasons.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Clinton county, Fairmont, Farmington, Keosauqua (L. H. Pammel), Keokuk (P. H. Rolfs), Mount Pleasant (H. E. Jaques), Ottumwa (Jessie Peters).

It has been observed (L. H. Pammel) at Cedar Rapids, Centerville, Clinton, Davenport, Fort Madison.

General distribution in the United States:

Alabama—(L. H. Pammel); Illinois—Rockford, Starved Rock (L. H. Pammel and V. C. Fisk), Chicago (L. H. Pammel), Glen Park (L. H. Pammel and Mark Heavenhill), Kankakee (R. I. Cratty), Oquawka (Harry N. Patterson); Indiana—Indianapolis (John S. Wright), South Bend (Mrs. Joseph Clemens); Massachusetts—Waltham (L. H. Pammel); Michigan—Muskegon (L. H. Pammel); Missouri—Hogan, Jefferson City (L. H. Pammel); New Jersey—Perth Amboy (L. H. Pammel); New Mexico—Fort Bayard (J. C. Blumer); North Carolina—Wilmington (Biltmore Herbarium); South Carolina—Columbia (K. A. Taylor); Texas—Houston, San Antonio (L. H. Pammel), Kerrville, San Antonio (two specimens, A. A. Heller); Virginia—Great Falls of the Potomac (C. R. Ball).

According to Miss M. Mitchell a good honey plant at Keokuk.

HONEY BEE VISITS

Ames, June 10, 1927, 2 p.m. Bees getting honey. Twelve, six, ten, eleven, six, six seconds in a flower. (L.H.P.)

June 15, 1927. Clear, moderate. Bees abundant. One, two, two, two, three, one seconds in a flower. Flowers fragrant. (L.H.P.)

June 29, 1927, 11 a.m. Hot wind, somewhat cloudy. Some flowers. No bees.

EUPHORBIACEAE, Spurge Family

Plants with milky acrid juice and apetalous flowers, ovary free, usually three-celled. Fruit is commonly a three-lobed capsule.

Euphorbia L. Spurge

Herbaceous plants with milky juice. Many staminate flowers, and pistillate flowers, grouped within an involucre. Glabrous capsule separating into three one-seeded carpels. Flower groups terminal, umbellate. Many plants of this genus are said to furnish an acrid honey.

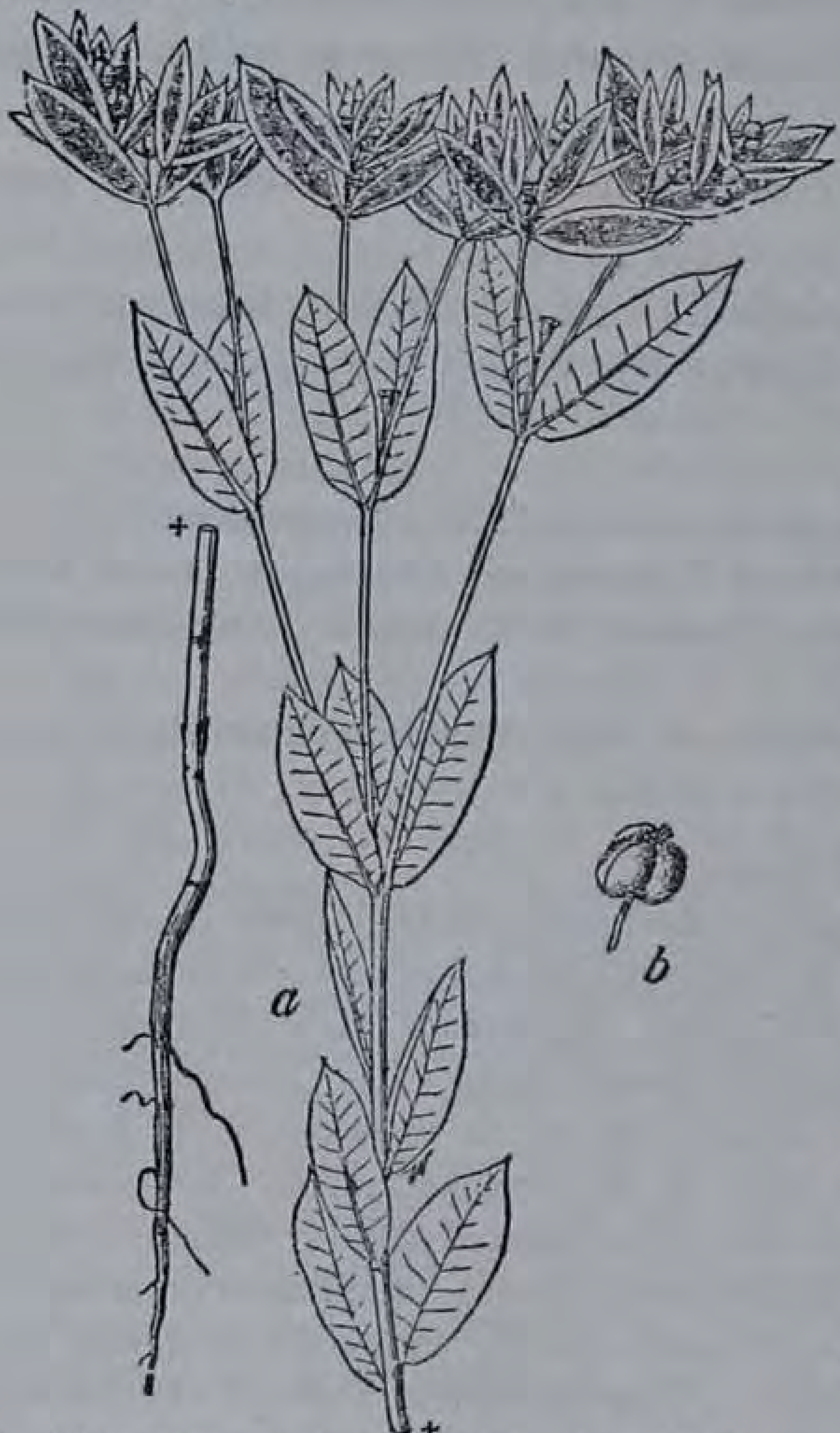

FIG. 222.—Snow-on-the-mountain (*Euphorbia marginata*). A frequent escape from gardens. (b) seed capsule.

Euphorbia marginata Pursh. Snow-on-the-Mountain

Annual plant with milky acrid juice, stout stems, two to three feet in height. Uppermost leaves with conspicuous white petal-like margins, somewhat hairy, sessile, ovate or oblong, glands with broad white appendages.

Widely distributed in western Iowa and extensively cultivated as an ornamental plant.

This is freely visited by honey bees.

HONEY BEE VISITS

Shenandoah, August 27, 1928. Bees gathering pollen. One, two, two, one, one, two seconds in a flower. (L.H.P.)

Euphorbia corollata L. Flowering Spurge

A smooth plant from one to three feet tall; deep rooted. Stem simple to half its height, then branching diffusely. Leaves ovate to linear. Involucres long-peduncled, with showy white appendages, resembling petals. The flowering spurge has conspicuous white bracts. Some nectar is secreted.

Ranges from New York to Florida and west to Minnesota. The plant is common in sandy soils.

FIG. 223.—White flowering spurge (*Euphorbia corollata*). *Photo by Photo Sect., Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Auburn, Chariton, Cherokee, Creston, Delhi, Dubuque, Edgewood, Eldora, Indianola, Keystone, Marble Rock, New Hampton, North Branch, Oneida Junction, Redfield, Rockford, Sioux City, Warren county (L. H. Pammel), Cedar Rapids, Ledges (L. H. Pammel), Ames (S. W. Beyer, J. C. Blumer), Colfax (P. Sipe), Decatur county (J. P. Anderson), Denison (Clara Blume), Donnellson (Mabel Busard), Emmet county (B. O. Wolden), Fayette (Bruce Fink), Fraser (Botanical Seminar), Grinnell (Vinnie Williams), Kelley (Pearl Clayton, Botanical Party), Lamont (I. T. Bode), Lawler (P. H. Rolfs), McGregor (L. H. and Lois Pammel), Muscatine (L. H. Pammel and Ferdinand Reppert), New Boston (Anna Weber), Newton (G. Drew), northeastern Iowa (H. Goddard), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson), Winterset (G. W. Carver).

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); District of Columbia—Washington (A. E. Paddock and C. R. Ball); Florida—River Junction (A. H. Curtis); Illinois—Cheltenham Beach, Walnut (L. H. Pammel), Starved Rock (L. H. Pammel and Mark Heavenhill); Kansas—Wichita (T. L. Andrews); Kentucky—Poor Fork (T. H. Kearney, Jr.); Michigan—Green (L. H. Pammel and V. C. Fisk); Minnesota—Cannon Falls (L. H. Pammel), St. Paul (R. Gmelin); Missouri—(H. Eggert), Hannibal (R. Gmelin), Jackson county (Kenneth K. Mackenzie); Nebraska—Lincoln (R. Gmelin); Ohio—Orrville (H. S. Coe); Oklahoma—Norman (W. E. Bruner); Texas—College Station (L. H. Pammel); Virginia—Arlington (A. E. Paddock and C. R. Ball); Wisconsin—Bluff Siding, Holmen, Middleton (L. H. Pammel), La Crosse (R. Gmelin, Dora S. Pammel), Oshkosh (Mrs. Joseph Clemens), Prescott (Mary Edgar), Stevens Point (L. H. Pammel and V. C. Fisk).

HONEY BEE VISITS

Bees occasionally visit this flower.

Euphorbia heterophylla L. Painted Leaf or Cruel Plant

An erect, glabrous annual with alternate petioled leaves which are generally ovate-fiddle-shaped and toothed or linear, lanceolate-entire; the upper leaf with a red base; involucres about as long as the peduncles, with five ovate cut lobes and almost sessile glands; seeds nearly globular; common in prairie regions from Minnesota to Illinois, Iowa, Kansas, Texas and Florida.

HONEY BEE VISITS

Ames, October 2, 1929, 1:30 p.m. One, one, one, one, one seconds in a flower.

October 13, 1929, 12:30 p.m. Clear, a slight north breeze. Bees abundant. One, one, one, two, one, one seconds in a flower. (L.H.P.)

October 14, 1929, 1:30 p.m. Bees one, one, one, one seconds in a flower.

October 16, 1929, 9:30 a.m. Clear and cool. Bees one, one, one, one, one, one seconds in a flower. (L.H.P.)

ANACARDIACEAE, Sumach Family

Trees or shrubs with milky, resinous or acrid juice, alternate leaves, small, regular, frequently polygamous flowers; five stamens, compound pistil with three styles or stigmas. Fruit drupelike.

Rhus L. Sumach

Shrubs or shrublike plants, with compound leaves. Flowers greenish. Fruit dry, berry-like.

Rhus typhina L. Staghorn Sumach

A treelike shrub reaching a height of thirty feet. The large compound leaves have eleven to thirty-one leaflets, pale underneath; the branches are velvety, pubescent. Flowers greenish, in a terminal cluster. Fruit covered with crimson hairs.

The staghorn sumach is common in eastern Iowa along the bluffs in rocky soils. It may be also found in similar places along the small streams of northeastern Iowa. It is associated with *Juglans cinerea, Acer saccharum, Carya ovata, Quercus velutina, Rhus glabra, Tilia americana, Scutellaria lateriflora, Amelanchier canadensis, Amelanchier spicata, Rhus Toxicodendron, Vitis bicolor, Smilacina racemosa, Osmunda Claytoniana.*

The conspicuous flowers yield abundant honey, which is easily accessible to bees, which visit them freely. The nectar is secreted by the receptacle.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Backbone Park, Delaware county (three specimens), Lake Mills, Lansing, Strawberry Point, Waterville, Waukon Junction (two specimens), Winnebago county (L. H. Pammel), Decorah (E. W. D. Holway), Delaware county (I. T. Bode), Fayette (Bruce Fink), Iowa lake (R. I. Cratty), northeastern Iowa (H. Goddard), West Union (L. H. Pammel and Emma Hancock).

It has been observed (L. H. Pammel) at Cresco, Dubuque, Elkader, Maquoketa, Marquette, McGregor, Postville, Waukon, Waukon Junction.

General distribution in the United States:

Indiana—Steuben county (Charles C. Deam); Michigan—Stambaugh, St. Ignace (L. H. Pammel), Northern Michigan (L. H. Pammel and V. C. Fisk); Minnesota—Annandale, Cass Lake, Clear Lake, Cloquet, Granite Falls, Howard, Norway Beach, South Huron (L. H. Pammel), Star island (L. H. and H. E. Pammel and P. S. McNutt); New York—Ithaca (H. E. Summers), Niagara Falls (G. H. Frazier), Watkins Glen (L. H. Pammel); Ohio—Cedar Point (L. H. Pammel), Lancaster (Asa Horr); Vermont—Peacham (Ferdinand Blanchard); Virginia—Great Falls of the Potomac (C. R. Ball); Wisconsin—Bangor

(L. H. Pammel and Matilda Koch), Bloomingdale, La Crosse, Oshkosh (Mrs. Joseph Clemens).

HONEY BEE VISITS

Ames, June 26, 1927, 11:30 a.m. Bees two, three, three, three, three, two, three seconds in a flower. (L.H.P.)

June 27, 1927. Bees two, three, four, four, three, three seconds in a flower.

June 23, 1929, 8:30 a.m. No bees. (L.H.P.)

Rhus glabra L. Smooth Sumach

A glaucous shrub three to fifteen feet in height. Leaflets eleven to thirty-one, pale beneath, lanceolate, oblong, pointed, serrate, turning in fall to brilliant reds and yellows. Flowers in panicled clusters, greenish yellow; fruits clothed with acrid crimson hairs; a dry drupe.

Of general distribution. Common in dry soils. Blooms in June and July.

The common sumach is widely distributed in Iowa, on rocky hills, sandy soils, loess soil, clay soil, often appearing after clearings in clay, somewhat sandy or limestone soils. Often the pioneer in borders of woods.

It is associated with *Rhus Toxicodendron, Bouteloua racemosa, Sorghastrum nutans, Andropogon provincialis, Silene stellata, Phlox pilosa, Ceanothus ovatus, C. americanus, Lithospermum canescens, Lithospermum angustifolium, Viola pedata, Solidago rigida, S. nemoralis, Aster laevis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville, Cherokee, Dubuque, Lake Mills, Liscomb (three specimens), Little Sioux, Worth county (L. H. Pammel), Missouri Valley, Oto (H. B. Clark), Cedar Falls (G. W. Carver), Cedar Rapids (R. E. Buchanan), Charles City (E. L. Webster), Clear Lake (R. I. Cratty), Fayette (B. Fink), Fraser (Botany Seminar), Hamilton county (P. H. Rolfs), High Bridge (Boone county) (G. W. Lummis), Osage (Mrs. Tuttle), Plymouth county (Olive E. Brown), Sioux City (Mrs. Rose Schuster Taylor).

It has been observed (L. H. Pammel) at Adel, Algona, Audubon, Belle Plaine, Bellevue, Brooklyn, Burlington, Camanche, Carroll, Clermont, Clinton, Council Bluffs, Cresco, Creston, Dallas Center, Davenport, Des Moines, Eldora, Emmetsburg, Fairfield, Fort Dodge, Glenwood, Greenville, Grinnell, Hamburg, Indianola, Jefferson, Keokuk, Keosauqua, Little Rock, Logan, Madrid, Marshalltown, Mason City, Montrose, Mount Pleasant, Muscatine, New Albin, Onawa, Red Oak, Shenandoah, Sioux Rapids, Steamboat Rock, Tama, Traer, Turin, Union, Waukon.

General distribution in the United States:

Alabama—Opelika (L. H. Pammel); Arizona—Flagstaff (T. D. MacDougall); Colorado—Fort Collins (J. H. Cowan); Connecticut—New Haven (W. H. Mast); Illinois—Galesburg, Quincy (L. H. Pammel), Rockford (L. H. Pammel and V. C. Fisk); Kansas—Wichita (T. L. Andrews); Minnesota—Norway Beach, Ortonville, Pike's Bay (L. H. Pammel), Anoka (R. I. Cratty), Brainerd (E. B. Watson), Cass Lake (L. H. Pammel and T. R. Truax), St. Paul (R. Gmelin); Missouri—Pilot Knob (L. H. Pammel); Montana—Missoula (J. E. Kirkwood); Nebraska—Lincoln county (F. G. Miller); New Mexico—Santa Rita (A. Isabel Mulford); Ohio—Pickerington (Asa Horr); Oklahoma—Norton (W. E. Bruner), Muskogee (L. H. Pammel); Pennsylvania—Spruce Creek (L. H. Pammel); South Carolina—Oconee county (two specimens, A. P. Anderson); South Dakota—Mitchell (B. Fink), Spring Creek (L. H. Pammel); Texas—Austin (F. C. Werkenthin), Tarrant county (F. G. Miller); Utah—Farmington canyon (L. H. Pammel and R. E. Buchanan); Logan canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); Wisconsin—Geneva (George W. Carver), La Crosse (L. H. Pammel), Prescott (Mary Edgar); Wyoming—West Black's Fork (L. H. Pammel, C. P. Johnson and R. E. Buchanan).

POLLINATION AND HONEY BEE VISITS

In the greenish yellow flowers the petals are short; the freely exposed nectar is secreted by five orange-colored glands between the bases of the filaments. Sumach is a well known source of honey.

Ames, June 18, 1914. Anthers orange-yellow, connivent opening. Nectar gland large, yellow, at base of flower; adapted to short-tongued visitors. Plants on east slope of hillside. Honey bee frequent on pistillate flowers. In three minutes one honey bee and two other bees on the plant. (L.H.P.)

Dubuque, June 15, 1914. Cloudy, cool. Honey bees abundant, one to three seconds in a flower. (L.H.P.)

Ames, June 17, 1914. College Park. Cloudy, still. Honey bees numerous. Two to three seconds per flower. (Lott.)

June 18, 1914, a.m. College Park. Cloudy, warm, north wind. Honey bees numerous; eight to ten insects on a cluster at once. (G.H.M.)

P.m. College Park. Cloudy, moderate, northwest wind. Honey bees predominated. Other Hymenoptera and Diptera present. More between nine to ten o'clock than between ten-thirty and twelve. (G.H.M.)

June 19, 1914. College Park. Cloudy, cool, northeast wind. No honey bees. Few small flies remain longer on a flower. (G.H.M.)

June 22, 1914. College Park. Cloudy, warm, northwest wind. Very many honey bees. Several Lepidoptera. Bees work flowers rapidly. (Lott.)

June 25, 1914. Partly cloudy. West wind. Two per cluster per minute. (G.H.M.) A plant with a great variety of visitors, both long-tongued and short-tongud.

Dubuque, June 15, 1915. On hillside, east slope. Cloudy, slight breeze. Honey bees numerous on pistillate flowers. Bee one to three seconds in a flower. Not very active. The connivent stamens keep out small insects. (L.H.P.)

Ames, July 1, 1927, 5:30 p.m. Bees abundant. Two, two, two, three, two, four, three, two seconds in a flower. (L.H.P.)

Bees loaded with pollen. Two, two, two, one, two, two, two seconds in a flower. Odor of tannic acid. Many small bees. (L.H.P.)

Campus, July 2, 1927, 10:45 to 11 a.m. Bee makes seven visits to one panicle of the cluster in fifteen minutes. (C.C.L.)

Ames, July 3, 1927, 10:30 a.m. Clear, northerly wind. Bees two, two, three, three, two, three, two seconds in a flower. (L.H.P.)

July 3, 1927, 12 m. No bees on staminate flowers nor on pistillate flowers.

July 6, 1927, 10:30 a.m. Clear, warm. No honey bees. Small bees only. Few flowers left.

Clear Lake, June 22, 1929, 7:30 a.m. Early bloom. No bees. (C.M.K.)

Rhus Toxicodendron L. Poison Ivy

A bushy or trailing woody low shrublike plant. Compound leaves with three large leaflets, taking beautiful colors in fall. Berries cream-colored, nearly round, smooth. Poisonous to some persons.

Along fence rows, borders of woods, in various soils—black sandy soil, clay, loam and black prairie soil, Missouri loess, limestone soils. Very widely distributed in Iowa, in woods and second bottoms.

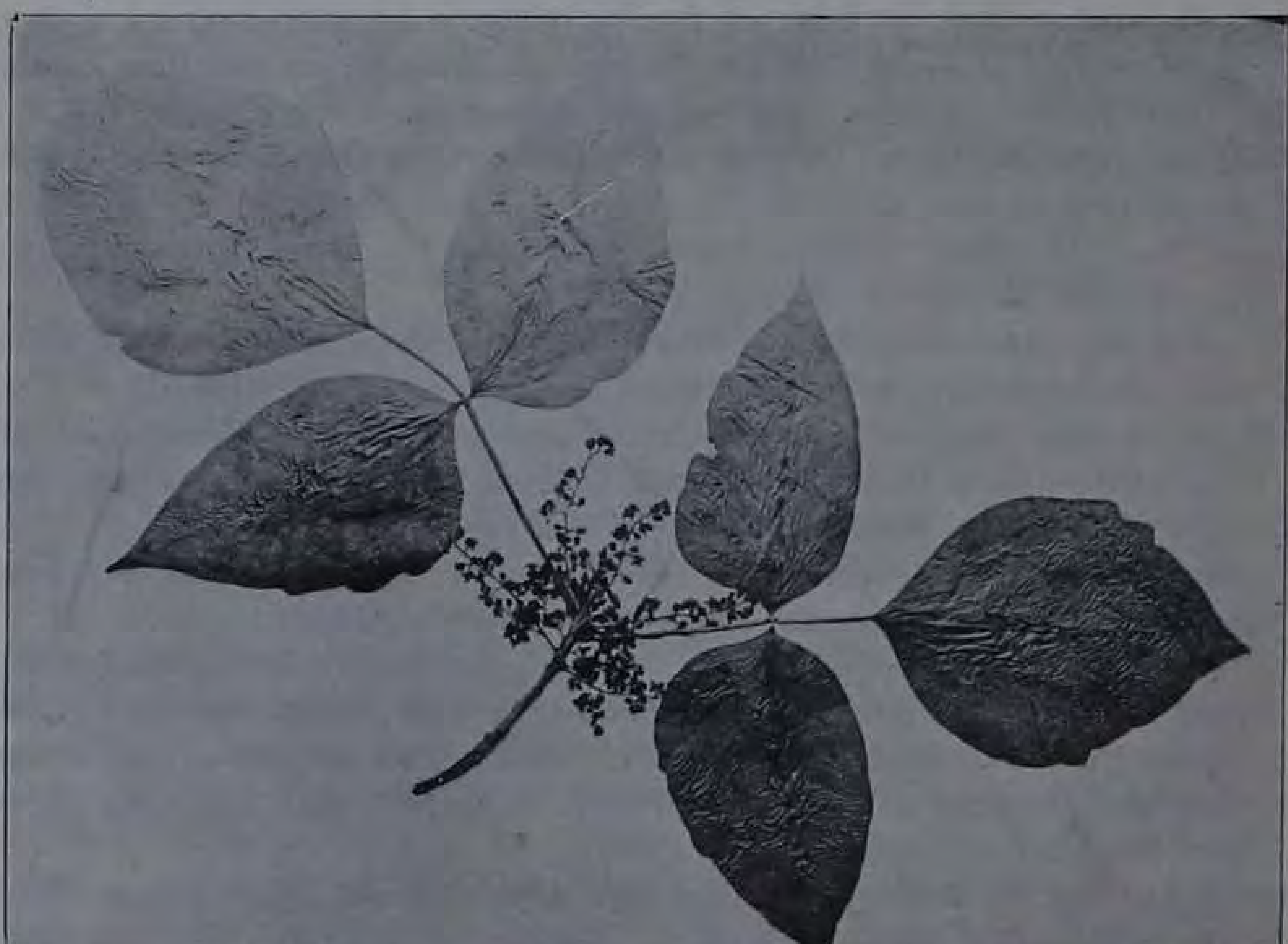

FIG. 224.—Poison ivy with three leaflets and flowers (*Rhus Toxicodendron* L.) *Photo by Colburn.*

The flowers are inconspicuous; they are visited by bees for nectar, which is freely secreted.

Associated with *Prunus virginiana, Juniperus virginiana, Rhus glabra, Vitis vulpina, Psedera vitacea, Solidago rigida.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville, Stratford (L. H. Pammel), Ames (J. R. Campbell, G. W. Carver), Boone (E. E. Hanlon), Clear Lake (R. I. Cratty), Creston (F. C. Stewart), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (Bruce Fink), Ledges (Boone county) (J. V. Ellis), Lee county (Paul Bartsch).

It has been observed (L. H. Pammel) at Adel, Algona, Anamosa, Bellevue, Bloomfield, Burlington, Carroll, Cedar Rapids, Charles City, Cherokee, Clermont, Clinton, Council Bluffs, Cresco, Creston, Dallas Center, Davenport, Denison, Des Moines, Dubuque, Eldora, Emmetsburg, Estherville, Fairfield, Fort Atkinson, Fort Madison, Glenwood, Hamburg, Indianola, Keokuk, Keosauqua, Lake View, Larchwood, Lebanon, Le Mars, Lineville, Little Rock, Logan, Maquoketa, Marshalltown, Mason City, Missouri Valley, Monticello, Moulton, Muscatine, New Albin, New Hampton, Onawa, Pisgah, Rock Rapids, Sac City, Shenandoah, Sioux City, Steamboat Rock, Turin, Union.

General distribution in the United States:

Colorado—Larimer county (L. H. Pammel); Delaware—Ogletown (Wm. M. Canby); District of Columbia—Bennings (G. McCarthy), Rock creek (E. A. Hyde); Florida—Gainesville (L. H. Pammel); Illinois—Utica (Mrs. Joseph Clemens); Indiana—Wells county (Charles C. Deam); Kansas—Wichita (T. L. Andrews); Louisiana—Alexandria (C. R. Ball); Minnesota—Cass Lake (L. H. and H. E. Pammel and P. S. McNutt); Nebraska—Halsey (J. C. Blumer); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Baltimore (Asa Horr); Oklahoma—Muskogee (L. H. Pammel); Pennsylvania—Gettysburg (L. H. Pammel); South Carolina—Oconee county (two specimens, A. P. Anderson); Texas—Kerrville (A. A. Heller); Utah—Farmington canyon (L. H. Pammel and R. E. Blackwood); Wyoming—Evanston (L. H. Pammel and R. E. Blackwood).

Rhus canadensis Marsh. Aromatic Sumach

A straggling bush one to two feet high, on dry rocky banks from New England to Minnesota and southward. Leaves compound, three ovate leaflets. Flowers pale greenish yellow, polygamous; petals short; stamens in the pistillate flower reduced in size and bearing no pollen. Nectar is secreted by five orange-colored glands between the bases of the filaments.

The aromatic sumach is common in southeastern Iowa and in Clinton and Jackson counties, where it occurs in woodlands and borders of woods and on rocky banks, limestone hills and sandy soils.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Fairfield, Farmington, Muscatine, Ottumwa, Tete des Morts (L. H. Pammel), Keokuk (P. H. Rolfs), Keosauqua (L. H. Pammel and G. B. MacDonald), Leon (Walter Osborn), Salem (L. H. Pammel, G. B. MacDonald and H. E. Jaques).

It has also been observed (L. H. Pammel) at Burlington, Clinton, Croton, Des Moines, De Witt, Fort Madison, Lebanon, Montrose, Mount Pleasant.

General distribution in the United States:

Arkansas—Lawrence county (L. H. Pammel); Illinois—Bluff lake, Cheltenham Beach (two specimens), Chicago, Graceland (L. H. Pammel); Indiana—Pine (J. R. Churchill); Kansas—Ottawa (W. E. Castle); Massachusetts—Waltham (L. H. Pammel); Missouri—Columbia, Glenco (L. H. Pammel), Allenton (four specimens, George W. Letterman), northern Missouri (J. P. Anderson), Willard (J. W. Blankenship); Nebraska—Lincoln county (F. G. Miller); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Cedar Point, (E. Wilkinson), Kelley's island (L. H. Pammel); Texas—Dallas (B. F. Bush).

HONEY BEE VISITS

Ames, May 12, 1921, 12 m. Some honey bees. Two, two, two, two, three, two seconds in a flower. (L.H.P.)

May 10, 1923. Bees getting nectar. Not common. Three, five, eight, three, four seconds in a flower. (L.H.P.)

Blooming, Ames, April 16, 1924.

Rhus Cotinus L. Smoke Tree

A tree twenty to thirty feet high, glabrous. Leaves oval, thin, three to five inches long. Flowers in loose full panicles, becoming plumose. Cultivated.

HONEY BEE VISITS

Manhattan, Kansas, May 17, 1927, 10 a.m. Clear. Honey bees abundant. Two, two, two, three, four, two, two seconds in a flower. (L.H.P.)

Ames, June 7, 1927. Clear, warm. No bees. (L.H.P.)

CELASTRACEAE, STAFF TREE FAMILY

Shrubs bearing simple leaves. Flowers small, regular; stamens four or five, inserted on a disk at the bottom of the calyx. The flowers are unisexual, generally inconspicuous and with a shallow nectary. In some genera the flowers are proterandrous. Seed arillate.

Evonymus (Tourn.) L. Spindle Tree

Shrubs with deciduous serrate opposite leaves; loose clusters or cymes of flowers on peduncles springing from the axils. Flowers small, perfect, conspicuous, brownish purple in color; sepals and petals four to five. The exposed nectar is secreted by a fleshy disk surrounding the style. The fruit is scarlet and conspicuous in the woodlands, where our native form ripens in September. Visited occasionally by honey bees.

Evonymus atropurpureus Jacq. Waahoo

A tall shrub, from New York westward and southward, commonly planted. Oval serrate leaves; flowers with four dark-colored petals, smooth, deeply four-lobed red fruit, hanging on long peduncles. Ornamental in autumn when the fruit ripens.

The waahoo is common in Iowa, along borders of woods, sandy

FIG. 225.—Waahoo (*Evonymus atropurpureus*). *Photo by Ada Hayden.*

soils, rocky places and clay soils, second bottoms or high banks in bottomland sometimes subject to overflow.

It is associated with *Prunus americana, Crataegus punctata, C. mollis, Heracleum lanatum, Sanicula marylandica, Cryptotaenia canadensis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park (Delaware county), Eagle Rock, Farmington, Indianola (two specimens), Keokuk, Keosauqua, Liscomb, Madison county, Manchester, Marquette, Marion county, North McGregor, Pisgah, Sioux City, Webster City, Winterset (L. H. Pammel), Ames (F. A. Sirrine, E. R. Hodson, G. W. Carver and L. H. Pammel, Alberta Wolfe), Decatur county (J. P. Anderson), Decorah (R. I. Cratty, E. W. D. Holway), Fayette (two specimens, Bruce Fink), Iowa City (B. Shimek), Ledges (Boone county) (L. H. Pammel and Miller, R. E. Buchanan), Missouri Valley (H. B. Clark), Mount Pleasant (H. E. Jaques), Nodaway river (Adair county) (F. C. Stewart), northeastern Iowa (H. Goddard), Peru (D. E. Hollingsworth), Plymouth county (Olive F. Brown), Shell Rock (E. S. Fyler), Waukon Junction (O. Schultz).

General distribution in the United States:

Indiana—Wills county (Charles C. Deam); Kansas—Wichita (T. L. Andrews); Louisiana— (T. L. Andrews); Missouri—Creve Coeur lake (L. H. Pammel), Rockport (A. O. Simonds); Ohio—Cedar Point, Kelley's island, Put-in-Bay (L. H. Pammel), Pickerington (Asa Horr); Wisconsin—Bloomingdale, Kilbourne City, La Crosse, Madison (L. H. Pammel).

HONEY BEE VISITS

Ames, June 5, 1922. Clear, flowers just opening. No bees.

June 24, 1922. Squaw creek. Partly cloudy. Northwest wind. Small flies, bugs. Honey bees fourteen per hour. (L.A.K.)

Evonymus europaeus L. European Spindle Tree

Shrublike tree, in cultivation. Leaves petioled, oval, pointed. Flowers yellowish. Occasionally cultivated.

Nectar is secreted by a fleshy disc surrounding the style. Bees are not mentioned by Mueller as visitors.

HONEY BEE VISITS

Ames, May 16, 1921, 1:30 p.m. A few bees. One, one, one, three, one seconds in the flower. (L.H.P.)

May 17, 1921, 8:30 a.m. Cloudy, warm. Three bees working on a small bush. One, one, one, two, one seconds in a flower. (L.H.P.)

Evonymus americanus L. American Strawberry Bush

A low shrub, from New York west and south, sometimes cultivated. Leaves thickish, ovate, almost sessile, petals greenish purple, fruit crimson.

The honey bee is a visitor getting nectar. It has been noted on this plant by Loew in Berlin Botanical Gardens.

General distribution in the United States:

Alabama—Tuskegee (L. H. Pammel); Arkansas—Lawrence (P. H. Rolfs), Pike county (L. H. Pammel); Delaware—Wilmington (Wm. C. Canby); District of Columbia—Benniny's (G. McCarthy); Georgia—DeKalb county (John K. Small); Kentucky—Harlan county (T. H. Kearney, Jr.); Louisiana—(T. L. Andrews); Ohio—Mansfield (E. Wilkinson); Put-in-Bay (L. H. Pammel); Worthington (Asa Horr); South Carolina—Oconee county (A. P. Anderson); Pickens county (two specimens); Texas—Houston, Lufkin (Ada Hayden).

Celastrus L. Staff Tree

Woody twiner with alternate, oval, pointed leaves and conspicuous clusters of orange red fruits. Pod three-celled.

Celastrus scandens L. Climbing Bittersweet

A familiar twining woody plant, common in Iowa woodlands and thickets, where it climbs over fences and into trees. The leaves are finely serrate, pointed, thin, turning yellow in autumn. The fruits are globose, scarlet, opening with frost, and disclosing the pulpy scarlet red aril.

Second alluvial bottoms in black prairie, limestone, clay, loess or sandy soils throughout Iowa. Especially common in fence rows where carried by birds.

Associated with *Vitis vulpina, Rhus glabra, Celtis occidentalis, Quercus macrocarpa, Rhus Toxicodendron, Prunus americana, P. serotina, P. virginiana, Solidago ulmifolia, Aster* sp., *Solidago rigida, Viola cucullata, Heracleum lanatum, Verbesina helianthoides, Rudbeckia laciniata, Aster Drummondi, Bromus purgans, Festuca nutans.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Des Moines, Dubuque, Forest City, Fraser, Hawarden (two specimens), Ledges (Boone county), Mason City, Sioux City, Waterville (L. H. Pammel), Clear Lake, Scranton (R. I. Cratty), Hardin county, Steamboat Rock (C. M. King), Ames (Ada Hayden, L. H. Pammel and A. Hess), Charles City (C. L. Webster), Colfax (P. Sipe), Columbus Junction (two specimens, E. B. Watson), Decatur county (T. J. and M. F. L. Fitzpatrick, J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, Bruce Fink), Hamburg (L. H. Pammel and H. B. Clark), Indianola (L. H. Pammel, I. E. Melhus, H. E. Jaques), Keokuk (P. H. Rolfs), Ledges (Boone county) (J. P. Anderson, 3 specimens, R. E. Buchanan), Missouri Valley (L. H. Pammel and H. B. Clark), Ontario (E. R. Hodson), Osage (two specimens, Mrs. Tuttle), Postville (O. Schultz), Winterset (G. W. Carver).

It has been observed (L. H. Pammel) at Algona, Burlington, Carroll, Cedar Rapids, Centerville, Cherokee, Clinton, Cresco, Davenport, De Witt, Eldora, Estherville, Fairfield, Fort Dodge, Jefferson, Marshalltown, Mason City, Mount Pleasant, Muscatine, Shenandoah, Webster City.

General distribution in the United States:

District of Columbia—Soldiers Home, Washington (L. H. Pammel); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Indiana—Bloomingdale (John S. Wright); Maryland—Principio Furnace (F. B. Trenk); Minnesota—Cass Lake, Star island (L. H. Pammel, H. E. Pammel and P. S. McNutt); Missouri—Jefferson Barracks (L. H. Pammel); Nebraska—Pine Ridge (J. C. Blumer), Sheridan county (R. E. Buchanan); New York—Hudson City (A. C. Hexamer and F. W. Maier), Ithaca (Muenscher and Bechtel, H. E. Summers), Niagara Falls (G. H. Frazier); Ohio—Worthington (Asa Horr); Vermont—Peacham (Ferdinand Blanchard); Wisconsin—La Crosse (two specimens, L. H. Pammel), Oshkosh (Mrs. Joseph Clemens).

HONEY BEE VISITS

Ames, May 29, 1922, 7 p.m. Sun still shining. Honey bees abundant and collecting nectar. Bees two, three, two, two, two, three seconds in a flower.

June 4, 1922, 6 p.m. Partly cloudy. Bees abundant. One, two, two, two, one, two seconds in a flower.

June 5, 1922, 11 a.m. Light breeze, clear and bright.

12 m. and 2:30 p.m. No bees.

Bees have been generally observed to work freely on bittersweet.

Blooming, Ames, June 16, 1924.

Celastrus articulata Thunb. Chinese Bittersweet

Climbing shrub. Leaves roundish to obovate, abruptly pointed, crenate, serrate. The variety *punctata* Makino has small leaves which are elliptic-ovate to elliptic-oblong.

HONEY BEE VISITS

Ames, May 28, 1929, 10 a.m. Cloudy, warm. Bees fairly numerous. Two, two, two, two seconds in a flower. (L.H.P.)

STAPHYLEACEAE, Bladdernut Family

Mostly shrubs or small trees with opposite pinnate stipulate leaves and perfect flowers. Stamens as many as the petals. Fruit a bladderly inflated pod.

Staphylea L.

Small upright shrubs, opposite pinnate leaves; greenish white flowers in racemes, calyx deeply five-parted. Five erect spatulate petals; pod large and inflated with one to four bony seeds.

Staphylea trifolia L. Bladdernut

Upright shrubs. Flowers inconspicuous, arranged in racemes, yellowish green in color. Calyx five-parted; petals five, white. Pod large, inflated, three-celled. Leaves opposite, compound, with three to five serrate leaflets.

Shady hillsides, in clay, sandy or limestone soils. Associated with *Podophyllum peltatum*, *Geranium maculatum*, *Hydrophyllum virginicum*, *Hepatica acutiloba*, *Dentaria laciniata*, *Dicentra Cucullaria*, *Viola pubescens*, *V. cucullata*, *Arisaema triphyllum*.

Nectar is secreted at the base of the pistil from a somewhat fleshy disc. Bees sometimes work abundantly upon the flower.

FIG. 226.—Bladder-nut (*Staphylea trifolia*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Dubuque, Lehigh, Lyons, Nashua, Peterson, Saylor (L. H. Pammel), Cedar river, Mitchell county, Osage (F. M. Tuttle), Ames (Trelease and Combs, E. R. Hodson, Bernice Banks, C. M. King, A. G. Hoopes, F. A. Sirrine), Allamakee county (O. Schultz), Chickasaw county (W. D. Spiker), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway, R. I. Cratty), Estherville (B. O. Wolden), Fayette (Bruce Fink), Fraser (Botany Party, L. H. Pammel and G. B. MacDonald), Lake View (E. E. Speaker), Lamont (I. T. Bode), Ledges (Boone county) (L. H. Pammel, C. M. King and R. E. Buchanan), Maquoketa (E. R. Harlan), McGregor (L. H. and Lois Pammel), Mount Pleasant (J. H. Mills), northeastern Iowa (H. Goddard), Wayland (George Carver).

Observed (L. H. Pammel) at Charles City, Clear Lake, Des Moines, Eldora, Marshalltown, Postville, Waukon.

General distribution in the United States:

Connecticut—New Haven (W. H. Mast); Illinois—Chicago (Stella L. Goodspeed), Peoria (F. E. McDonald), Starved Rock (L. H. Pammel and Mark Heavenhill), Utica (Mrs. Joseph Clemens); Indiana—Turkey Run State Park (L. H. Pammel); Missouri—Jefferson City (O. Krause); New York—Ithaca (Muenscher and Bechtel); South Carolina—Oconee county (two specimens, A. P. Anderson); Wisconsin—Holmen, La Crosse (L. H. Pammel).

Blooming, Ames, June 1, 1924; May 10, 1926.

ACERACEAE, Maple Family

Trees or shrubs, with opposite petioled leaves, either simple or compound; flowers regular, polygamous or dioecious, in racemes or corymbs, calyx five- or four-cleft, petals four or five or more; ovary two-celled, two-lobed, forming a winged fruit.

Acer (Tourn.) L. Maple

Trees of the temperate zone with polygamous or dioecious flowers. Leaves opposite, lobed. Petals inconspicuous or absent. Ovary two-celled. The back of each carpel bears a wing. The two-seeded fruit separates into two keys.

The flowers are generally inconspicuous, sometimes reddish and sometimes greenish yellow, more or less crowded. Sometimes the flowers appear before the leaves are out, and in such case the flowers are fairly conspicuous.

Nectar is secreted by a central disc and is fully exposed. A valuable source of honey in early spring.

Acer spicatum Lam. Mountain Maple, Bush Maple

A treelike shrub. The leaves are slightly three-lobed, coarsely notched, downy on under side. The clusters of greenish flowers are upright. Fruit reddish, with small wings.

On shaded slopes, limestone soils or sandy bluffs of northeastern Iowa in rocky woods and along the Mississippi. Associated with *Trillium erectum, Podophyllum peltatum, Phlox divaricata, Dicentra Cucullaria, Caulophyllum thalictroides, Aquilegia canadensis, Campanula rotundifolia, Dodecatheon Meadia, Onoclea Struthiopteris, Rhus typhina, R. glabra, Vitis vulpina, V. bicolor, Betula papyrifera.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clayton county (two specimens, Bruce Fink), McGregor (Ada Hayden), Postville (two specimens, L. H. Pammel), Yellow river (Allamakee county) (three specimens, O. Schultz).

This has been observed (L. H. Pammel) at Bellevue, Decorah, Waterville, Waukon Junction, West Union.

General distribution in the United States:

Michigan—Marietta, Stambaugh, Whitehall (L. H. Pammel), Green (L. H. Pammel and V. C. Fisk), Ironwood (Mrs. Joseph Clemens), Mackinac Island (R. I. Cratty); Minnesota—Cloquet, Itasca State Park (two specimens, L. H. Pammel), Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt), Backus (Ada Hayden), Black Duck (Mrs. Roy Westley), Brainerd (five specimens, E. B. Watson), Duluth (E. W. D. Holway), International Falls (H. S. Kellogg); New York—Ithaca (Muenscher and Bechtel, three specimens, H. E. Summers), Watkins Glen (L. H. Pammel); North Carolina—Haywood county (Biltmore Herbarium), Watauga county (J. K. Small and A. A. Heller); Ohio—Lancaster (Asa Horr); Pennsylvania—Blue Knob (Mrs. Joseph Clemens), Hick's Run (A. A. Heller); Wisconsin—Bloomingdale, Galesville (L. H. Pammel), Merrill (L. H. Pammel and V. C. Fisk).

Acer platanoides L. Norway Maple

Large tree with rounded spreading head. Five-lobed leaves, cordate at the base, dentate. Flowers yellowish green, in corymbs.

The leaves of the variety *Schwedleri* Koch are bright red when young, later becoming green. This species is freely cultivated for ornamental purposes.

Bees have been observed on it in Iowa and honey bees are recorded also by Hermann Mueller in Germany.

Acer Ginnala Maxim. Tatarian Maple

A fine shrub or low tree twenty feet high. Three-lobed leaves, doubly serrate. Flowers yellowish.

This is one of Professor Budd's introductions in Iowa and is not infrequently cultivated. It also is visited by honey bees.

Acer saccharum Marsh. Hard Maple

Leaves three to five-lobed, with rounded sinuses and pointed sparingly toothed lobes, downy on the veins beneath and pale in color; flowers from terminal leaf-bearing buds and lateral leafless buds, greenish yellow, drooping, on slender hairy pedicels; structure much the same as in *A. nigrum*. Wings of the fruit divergent, broad. A large handsome tree of rich northern woods and also on rocky soils; common in Iowa's forested regions, especially in northeastern Iowa, where it is associated with the black maple. The most southwesterly occurrence is at Eldora. Sometimes in river bottoms not subject to long standing water. A fine honey plant, abundantly visited by bees. Pellett says in speaking of this tree that it is visited by bees in great numbers. Associated with *Phlox divaricata,*

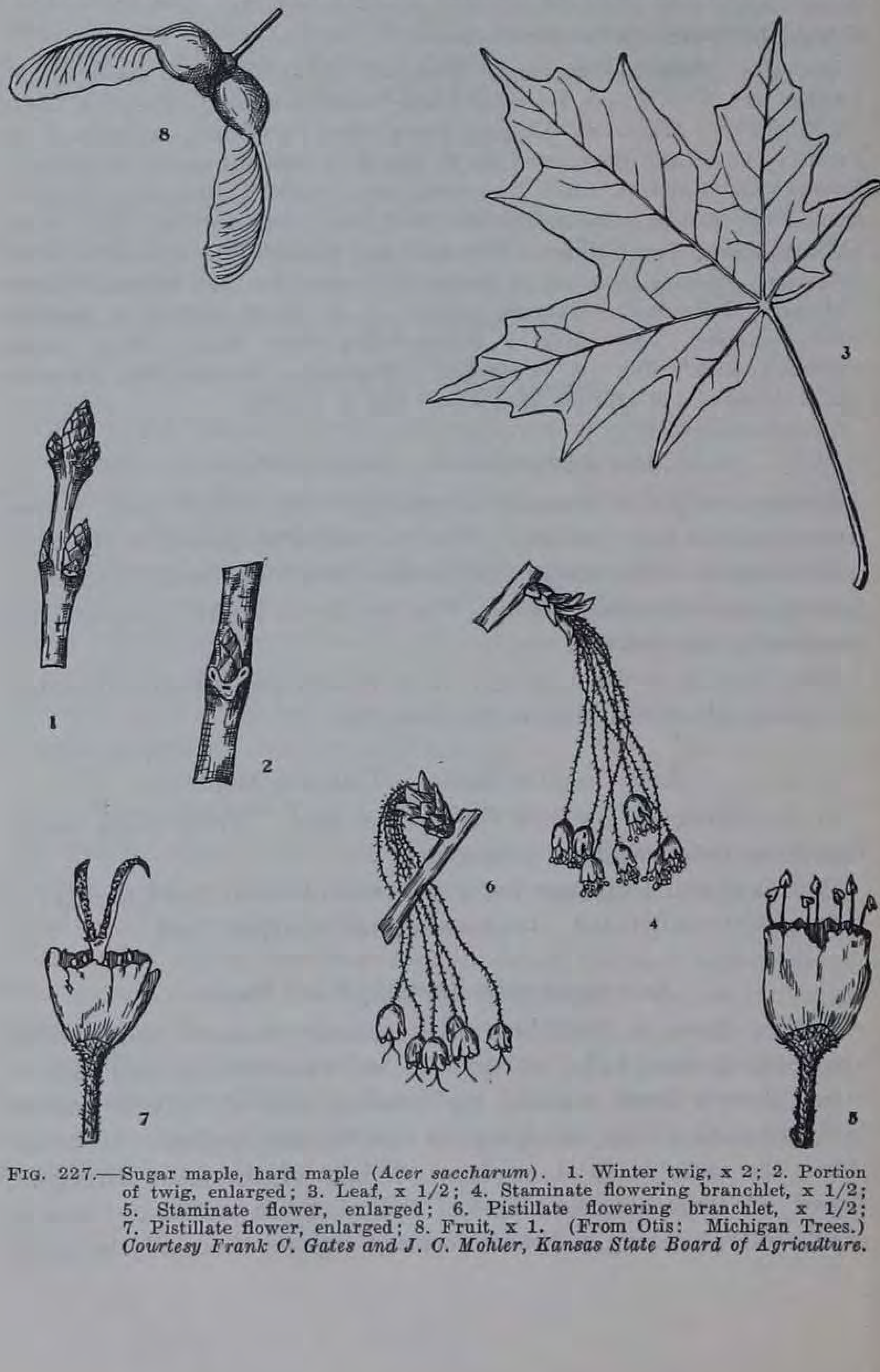

FIG. 227.—Sugar maple, hard maple (*Acer saccharum*). 1. Winter twig, x 2; 2. Portion of twig, enlarged; 3. Leaf, x 1/2; 4. Staminate flowering branchlet, x 1/2; 5. Staminate flower, enlarged; 6. Pistillate flowering branchlet, x 1/2; 7. Pistillate flower, enlarged; 8. Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Pinus Strobus, Betula papyrifera, Tilia americana, Quercus alba, Rhus typhina, Vitis bicolor, V. vulpina.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Buffalo creek, Burlington, Cedar Falls, Cedar Rapids, Denver Junction, Eldora, Estherville, Fayette, Flint creek, Keokuk, Lamont, Lansing, Lyons (two specimens,) Marble Rock, McGregor, Montrose, Muscatine county, Oakland Mills, Onawa, Pine creek, Soldier, Spirit Lake, Toolsboro (two specimens, L. H. Pammel), Big creek (L. H. Pammel, G. B. MacDonald and H. E. Jaques), Delaware county (I. T. Bode), West Union (Emma Hancock and L. H. Pammel).

This plant has also been observed (L. H. Pammel) at Fairfield, Mount Pleasant, Muscatine.

General distribution in the United States:

Delaware—Nanogue (Wm. C. Canby); District of Columbia—Washington (H. E. Pammel); Illinois—Hamilton (L. H. Pammel and F. Pellett), Rockford (L. H. Pammel and V. C. Fisk); Kentucky—Berea (L. H. Pammel), Harlan county (T. H. Kearney, Jr.); Michigan—Muskegon, St. Ignace, Whitehall (three specimens, L. H. Pammel), Green, northern Michigan, Ontonagon (L. H. Pammel and V. C. Fisk), Ann Arbor (F. Roth), Ironwood (Mrs. Joseph Clemens); Minnesota—Cass Lake, Cloquet, Faribault, Howard Lake (two specimens), Itasca State Park, South Huron, Star island, St. Charles, St. Paul (L. H. and H. E. Pammel and P. S. McNutt), Black Duck (Mrs. Roy Westley), Minnehaha Falls (L. H. and H. E. Pammel); Missouri—Columbia (L. H. Pammel); New York—Buffalo, Niagara Falls (L. H. Pammel), Ithaca (H. E. Summers); North Carolina, Florida and Georgia (S. B. Buckley); Ohio—Gambier (L. H. Pammel); Pennsylvania—State College, Tonawanda (L. H. Pammel); Wisconsin—Galesville, La Crosse (two specimens), Nelson Dewey Park, St. Croix Falls (two specimens), Fond du Lac (L. H. Pammel and Elizabeth Waters).

Acer saccharum var. *nigrum* (Mich. f.) Britton. Black Sugar Maple

Resembling previous species, but leaves green and scarcely paler but downy underneath, the lobes wider, the sinus at the base commonly closed; stipules often conspicuous. In rich soil of northern woods, found with previous species in woods in many parts of Iowa, especially in bottoms east of Des Moines river, in localities not subject to standing water, and on slopes of hills. The only species of sugar maple found in Story, Boone and Polk counties.

The hard maples are common in the eastern drainage basin of Mississippi river and as far west as Des Moines river valley and northwestern Iowa, along the Little Sioux and in the Lake region, where they furnish much honey. The flowers appear much later than those of the soft maples. They are greenish yellow, appear with the leaves, and are borne on slender drooping pedicels. They are abundantly visited by insects, especially by bees and other Hymenoptera, which are very numerous on sunny days.

The flowers are arranged in clusters, staminate and pistillate flowers on separate branches on the same trees. Staminate, five

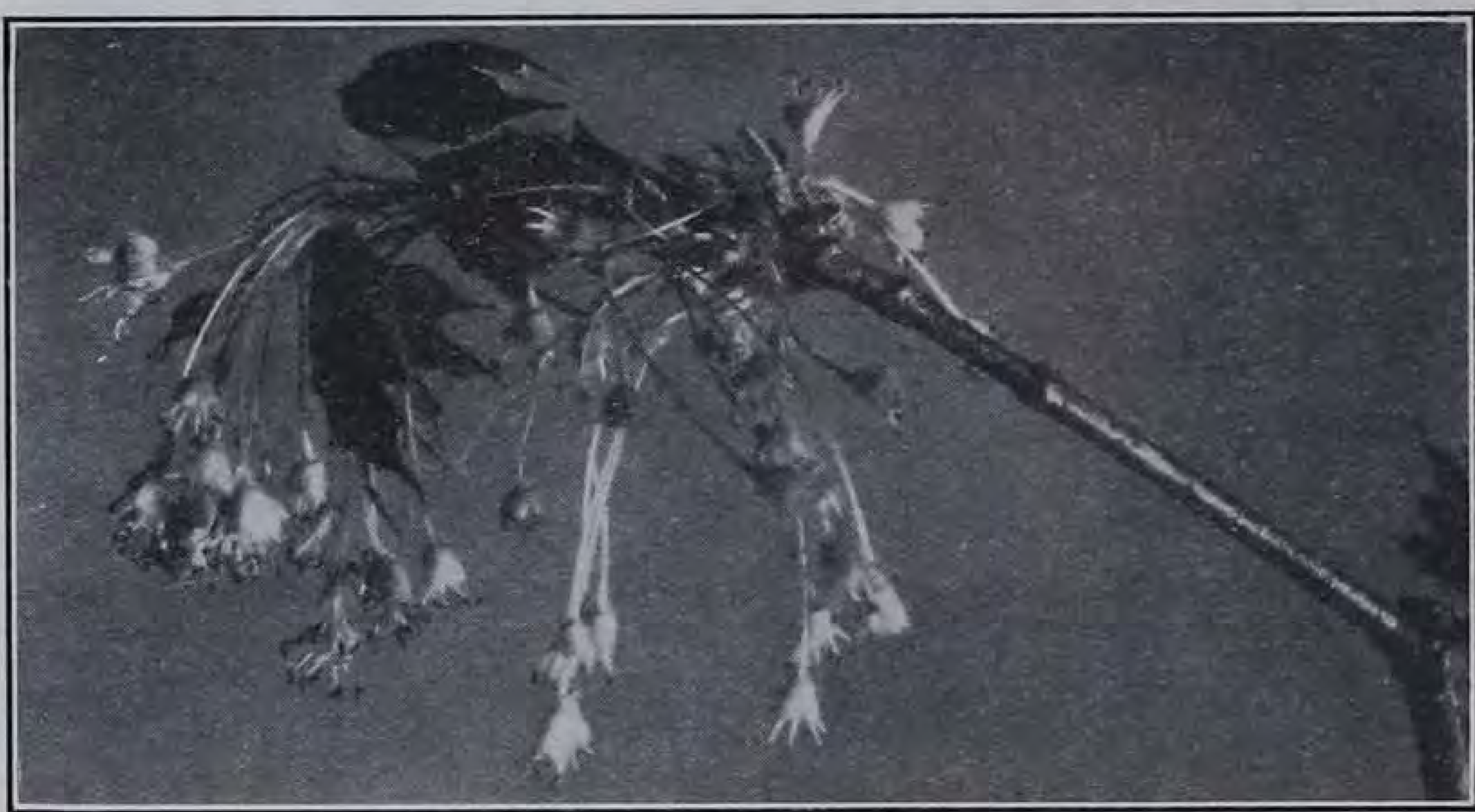

FIG. 228.—Black maple (*Acer saccharum* var. *nigrum*). *Photo by Ada Hayden.*

flowers in a cluster, five stamens, filaments projecting beyond the calyx tube; short rudimentary pistil; five conspicuous nectar glands on the disc. Pistillate flowers in clusters, three or more flowers in a cluster. Each flower with a single pistil and two styles, which are red. The disc bears rudimentary stamens. Calyx-small, five-lobed. Nectaries not conspicuous in pistillate flowers. The young ovary is hairy.

Associated with *Phlox divaricata, Podophyllum peltatum, Pimpinella integerrima, Thalictrum dioicum, Viola pubescens, V. cucullata, Dentaria laciniata, Hepatica acutiloba, Diarrhena diandra, Bromus purgans, Carex pennsylvanica.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Charles City, Clarksville, Eagle Rock, Flint creek, Johnson county, Kilbourne, Madison county, Mud lake, Nashua (three specimens), Quarry, Red Rock, Rochester, Steamboat Rock, Wallingford, Walnut creek (two miles east of Kelley) (L. H. Pammel), Ames (J. C. Blumer), Ledges (Boone county) (R. E. Buchanan), Muscatine (F. Reppert).

It has also been observed (L. H. Pammel) at Algona, Cedar Rapids, Cresco, Dubuque, Eldon, Fort Dodge, Jefferson, Marshalltown, Sioux Rapids, Steamboat Rock.

General distribution in the United States:

Minnesota—Minnehaha (two specimens, L. H. and H. E. Pammel), St. Charles (L. H. Pammel); Missouri—Columbia (two specimens, L. H. Pammel); New York—Ithaca (Muenscher and Bechtel); Ohio—Buckeye Lake (L. H. Pammel and Prof. Griggs), Put-in-Bay (L. H. Pammel); Pennsylvania—Williamsport (J. K. Small and A. A. Heller); Virginia—Smyth county (John K. Small); Wisconsin—La Crosse (L. H. Pammel), Platteville (L. H. Pammel and B. B. Zimmerman).

HONEY BEE VISITS

Cedar Rapids, April 27, 1914. Bees at work. (L.H.P.)

Ames, April 25, 1914. Bees at work. (L.H.P.)

May 2, 1914. Cool. Maples still blooming. Bees getting nectar. (L.H.P.)

May 12, 1917. Partly cloudy, fairly cool. Honey bees common. (L.H.P.)

May 13, 1917. Moderately cool. Honey bees fairly common. (L.H.P.)

May 25, 1917. Cloudy, cool. Trees in splendid bloom. Honey bees common. (L.H.P.)

Cedar Rapids, April 27, 1918. Tree blooming during this period. A rainy week. On May 1 and 2 in spite of cold weather some nectar being gathered.

Ames, April 22, 1919. Some bees. (L.H.P.)

May 20, 1920, 10 a.m. Many bees working among the flowers. (C.M.K.)

April 23, 1922. Day chilly and windy. Almost 32° at night. (Dandelion open until five o'clock.) Very few bees. (L.H.P.)

April 30, 1922. Zumwalt Valley. Trees numerous. Freely blooming. Bright sunny day. Light breeze.

12 to 3 p.m. Many bees briskly working. (C.M.K.)

Trees observed, thirty-five to forty-five years old. Blossoms upon each, from eighty thousand to one hundred twenty-five thousand. (L.H.P.)

May 2, 1922, 3 p.m. Warm, partly cloudy. Bees abundant. Three to ten seconds in a cluster. More than 15,000 flowers on this tree. Similar observations made on trees at Humboldt, Fort Dodge, Redfield and Des Moines, this season.

May 3, 1922, 1 p.m. Sunshiny, warm, south wind. No bees noted upon campus maples. (L.H.P.)

May 4, 1922, 12 m. Sunshiny, west wind. Flowers hang in loose clusters. Evidently difficult for bees to cling to. Visited by some smaller Hymenoptera. Honey bees two, three, two, six seconds in a flower. (L.H.P.)

May 4, 1922, 6:30 p.m. Slight west wind. No bees. Many of the flowers have dehisced. Staminate and pistillate flowers noticed in corymbs in following proportion: 1 staminate, 6 pistillate; 1 staminate, 12 pistillate; 1 staminate, 13 pistillate; 1 staminate, 16 pistillate; 1 staminate, 12 pistillate; 1 staminate, 18 pistillate; 1 staminate, 6 pistillate. (L.H.P.)

April 28, 1924, 2 p.m. Partly cloudy, slight west wind. Honey bees very numerous. Three, two, three, four, three, three, three, two seconds in a flower.

May 3, 1928, 1 p.m. Partly cloudy, dry, windy. Many trees with abundance of flowers. Bees three, five, two, three, four seconds in a flower. The wind interferes with bees alighting on flowers. (L.H.P.)
Keosauqua, May 6, 1928, 9 a.m. Clear, slight breeze. No bees. (L.H.P.)

Acer saccharinum L. Silver Maple

The soft maple occupies a conspicuous place among bee plants because it is the first to appear and for a week at a most important time of year constitutes the only source of nectar and pollen.

FIG. 229.—Soft maple (*Acer saccharinum*). *Photo by Ada Hayden.*

The soft maple is widely distributed as a native plant and is also widely planted for windbreaks and upon woodlots. Native in alluvial bottoms along all of our streams. Most abundant along such streams as the Mississippi, Cedar, Iowa, Des Moines and Wapsipinicon.

It is associated with *Viola cucullata, Claytonia virginica, Lobelia cardinalis, L. siphilitica, Carex Grayii, Impatiens biflora, Ulmus americana, Betula nigra, Populus deltoides, Plantanus occidentalis, Cephalanthus occidentalis.*

The soft maple blooms in late March or early April, while there are still frequent frosts. The flowers are polygamo-monoecious. The staminate flowers have aborted pistils and the pistillate flowers have aborted stamens.

The nectar is secreted in an open disc and is rather abundant.

Throughout its range, from our observations, it is abundantly visited by honey bees. Many bees were observed in Kentucky, Tennessee and Alabama in 1928. It is also visited by other Hymenoptera.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Boone, Buffalo creek, Burlington, Cedar Falls, Chaney lake, Eagle Rock, Granite, Keokuk, Ledges (Boone county), Lime Springs, Lineville, Lost Island lake, Marion county, McGregor, Middle river, Muscatine, Oakland, Squaw creek, Story county, Stratford, Warren county (L. H. Pammel), Ames (J. V. Ellis, Edna C. Pammel), Decorah (E. W. D. Holway), Delaware county (I. T. Bode), Des Moines (G. W. Carver), Fayette (Bruce Fink, C. C. Parker), Muscatine (L. H. Pammel, E. R. Harlan and J. Kelso), Sioux City (Rose Schuster Taylor), Union (J. P. Anderson).

It has also been observed (L. H. Pammel) at Agency, Alden, Algona, Cedar Rapids, Centerville, Charles City, Cherokee, Clinton, Cresco, Davenport, Dubuque, Eldora, Emmetsburg, Estherville, Fort Atkinson, Fort Dodge, Fort Madison, Glenwood, Iowa City, Iowa Falls, Keosauqua, Marquette, Mason City, Missouri Valley, New Albin, Oelwein, Ottumwa, Postville, Rock Rapids, Shenandoah, Steamboat Rock, Wapello, Waukon Junction.

General distribution in the United States:

Colorado—Fort Collins (J. W. Cowan); District of Columbia—Washington (L. H. Pammel); Illinois—Galesburg (L. H. Pammel), Kankakee (R. I. Cratty), St. Clair county (H. Eggert); Kentucky—Berea (L. H. Pammel); Michigan—Belle Isle Park, Detroit (L. H. Pammel); Minnesota—Cannon Falls, Lake City, Monticello (L. H. Pammel), Minnehaha, Taylor's Falls (L. H. and H. E. Pammel); Missouri—Rockport (A. O. Simonds), St. Louis (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel); Ohio—Baltimore (Asa Horr), Buckeye Lake (L. H. Pammel and Prof. Griggs), Put-in-Bay, Sandusky (L. H. Pammel); South Dakota—Sioux Falls (two specimens, L. H. Pammel); Wisconsin—Holmen, Kilbourne City, mouth of Kickapoo river, Muscoda (L. H. Pammel), La Crosse (Edna C. Pammel), Prescott (Mary Edgar.)

HONEY BEE VISITS

Ames, March 27, 1915. Numerous bees on sunny days. Sometimes twenty to thirty to a tree. Seem to visit mostly the staminate flowers.

March 23, 1920, College Campus, 1:30 p.m. Partly cloudy. Flowers open, both staminate and pistillate. A few bees.

2 p.m. Sun shining brightly. Slight southeast wind. Fine day. Some honey bees at work on tree six hundred feet from apiary. (L.H.P.)

March 28, 1920. Fine clear day; strong southwest wind. No bees.

Honey flow of soft maple. O. W. Park

Year	Period of bloom	Full bloom	Period worked on by bees	Period of honey flow
1918	3–17	3–17 to 3–25	3–17 to 3–20	3–17
1919	3–16		3–18	3–18
1920	3–24		3–24	3–24
1921	3–4 to 3–25		3–4	3–25*
1922	3–14		3–14	3–14
1923	4–5 to 4–16		4–5	——

* Bloom interrupted this year by cold weather.

In most localities the soft maple is the first source of both nectar and pollen, often producing large quantities of pollen and some nectar. It is visited by bees about three days. The period of honey flow is about one day.

Date of bloom, March 17, 1927.

Acer rubrum L. Red or Swamp Maple

A medium sized tree with ovate to suborbicular leaves, cordate at the base, hairy when young becoming smooth, white beneath. Flowers in umbel-like clusters preceding the leaves, scarlet, crimson or rarely yellowish.

Occurs in swamps and wet woods in the north and eastward to Florida. Common in the Gulf coastal states. Not native to Iowa although found near Prairie du Chien and La Crosse, Wisconsin. This species is widely cultivated.

It is freely visited by honey bees and considerable honey is often produced when the weather is favorable. Many bees have been observed at Ames and we have also observed honey bees on it in Florida, Mississippi and Alabama.

Acer Negundo L. Box Elder

A small tree, with light green twigs and delicate drooping clusters of small greenish or brownish flowers, coming earlier than the leaves. Leaflets three to nine, pinnate, ovate, pointed. flowers dioecious, petals none, calyx minute, five-cleft. Sterile flowers borne on capillary pedicels, each flower with four or five stamens. Fruit smooth, with large incurved wings.

FIG. 230.—Box elder (*Acer Negundo*). *Photo by Ada Hayden.*

The box elder is native to Iowa and is commonly cultivated, especially near dwellings. It is one of the most widely distributed trees in Iowa along bottoms and in the rich alluvial soil of the ravines among the loess bluffs of western Iowa. It is associated with *Acer saccharinum, Ulmus americana, Quercus bicolor, Fraxinus lanceolata, Cryptotaenia canadensis, Geum canadense, Leersia virginica, Elymus virginicus, Cinna arundinacea.*

This tree is much visited by honey bees, for pollen and honey dew; blooms early while the weather is still cool.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (three specimens), Atlantic, Burlington, Cherokee, Dubuque, Fairfield, Fraser, Granite, Indianola, Jefferson, Lake Mills, Lamont, Lansing, Lime creek, Lime Springs, Lineville, Liscomb, Lost Island lake, Marshalltown (two specimens), Mason City, New Albin, Oakland, Quarry, Waterloo, Whitney (L. H. Pammel), Algona, West Bend (R. I. Cratty), Council Bluffs, Hamburg (two specimens, L. H. Pammel and H. B. Clark), Decatur county (J. P. Anderson), Fayette (C. L. Parker), Mount Pleasant (L. H. Pammel, G. B. MacDonald, H. E. Jaques), Postville (two specimens, O. Schultz), St. Charles (Bruce Fink, H. A. Mueller), Union (J. P. Anderson).

It has also been observed (L. H. Pammel) at Agency, Anamosa, Beaver, Boone, Charles City, Cherokee, Clinton, Council Bluffs, Cresco, Davenport, Decorah, Denison, De Witt, Elkader, Emmetsburg, Estherville, Fairfield, Fort Atkinson, Fort Dodge, Glenwood, Grand Junction, Hampton, Iowa Falls, Keokuk, Keosauqua, Little Rock, Logan, Madrid, Mason City, Missouri Valley, Mondamin, Monticello, Muscatine, New Albin, New Hampton, Oelwein, Ogden, Onawa, Osage, Oskaloosa, Ottumwa, Pisgah, Red Rock, Rock Rapids, Shenandoah, Stratford, Strawberry Point, Tama, Turin, Waukon, Webster City, West Union.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Arizona—Flagstaff (D. T. MacDougal); California—Big Tree, Live Oak, Santa Cruz (two specimens, L. H. Pammel), Berkeley (Katherine Jones), Tocaloma (Michener and Bioletti); Colorado—Cache la Poudre river, Fort Collins (L. H. Pammel), Cache la Poudre (L. H. Pammel and C. P. Johnson), Placerville (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); Illinois—Cahokia (H. Eggert); Kansas —Wichita (T. L. Andrews); Maryland—Forest Glen (L. H. Pammel); Minnesota—Anoka, Graceville (two specimens), Monticello, Ortonville, (L. H. Pammel), International Falls (H. S. Kellogg), Minnehaha Falls (L. H. and H. E. Pammel); Missouri—Rockport (A. O. Simonds); Nebraska—Pine Ridge (J. C. Blumer); New Mexico—Fort Bayard (J. C. Blumer), Pinus Altus (A. Isabel Mulford); New York—Brooklyn (Mrs. L. M. Parker), Geneva (L. H. Pammel), Ithaca (H. E. Summers, Muenscher and Bechtel); Ohio—Worthington (Asa Horr); South Carolina—Bradley (Rev. Davis), Oconee county (two specimens, A. P. Anderson); South Dakota—Brookings, Milbank, Sioux Falls, Sisseton, Spring beach, Yankton (L. H. Pammel), Lake Tetonkeha (N. E. Hansen and L. H. Pammel); Texas—San Antonio (L. H. Pammel); Utah—Camas (L. H. Pammel and E. M. Stanton), Logan (three specimens, A. Isabel Mulford), Logan canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Salt Lake City (L. H. Pammel, E. M. Stanton and R. E. Blackwood); Wisconsin—Madison, Prairie du Chien, Watertown (L. H. Pammel), La Crosse (L. H. and Lois Pammel), Platteville (L. H. Pammel and B. B. Zimmerman); Wyoming—Halleck canyon (Aven Nelson).

HONEY BEE VISITS

Ames, May 3, 1916. College Park. Ten bees with pollen on legs, on a staminate tree. (L.A.K.)

Dunlap, May 3, 1916. Visited by bees for both honey and pollen. (Wm. Mile.)

Ames, May 13, 1916. Ten honey bees on one staminate tree. (L.H.P.)

April 14, 1917. Bees gathering pollen. (L.H.P.)

April 24, 1917. Bees gathering pollen. (L.H.P.)

April 22, 1918. 12 m. No wind. Bees abundant, gathering pollen. On a branch 18 inches long, 480 flowers. About one-fifth of the flowers open. Bees most numerous from 11 a.m. to 12 m. (L.H.P.)

April 20, 1919. A few bees getting honey. (L.H.P.)

April 25, 1919. Fairly favorable day. Some sunshine. The staminate flowers of a few trees opening. Some bees. Prof. Park noted bees on box elder a few days earlier. (A.M.)

Waterloo, April 26, 1919. Frost earlier in day. Stamens out. No bees observed. (L.H.P.)

April 29, 1919. Northwest wind. Three honey bees on a small tree 12 feet high, in two minutes time. About fifty per cent of the flowers open.

April 29, 1923. 10 a.m. Clear, warm. Many bees. Twelve, ten, four, twelve seconds at one flower. (L.H.P.)

April 21, 1926. Warm. Bees abundant on staminate flowers. (L.H.P.)

SAPINDACEAE, Buckeye Family

Many of the family are trees, some shrubs and some herbs, with opposite compound leaves without stipules; many flowers polygamous and some slightly irregular; compound ovary which is three-celled, with two ovules in each cell.

Knuth says, "Nectar secreted and concealed at base of the flowers, which are aggregated in large candelabra-like inflorescences."

Aesculus L. Horse Chestnut and Buckeye

Trees or shrubs, with opposite, palmately compound leaves. Flowers in dense terminal clusters. Fruit a leathery, three-seeded pod. Usually but one or two large seeds develop, with shining brown seed coat and prominent scar.

The flowers of the buckeye and horse chestnut are irregular, of yellowish, reddish or whitish color, and form clusters. Portions of the petals have deeper orange color.

There is an abundance of nectar secreted at the base of the flower and accessible to bees. The flowers are visited by bumble bees and at times by honey bees. The flowers of some species are proterogynous.

Aesculus Hippocastanum L. Common Horse Chestnut

Medium sized trees with palmately compound leaves, seven leaflets. Corolla spreading, white spotted with purple and yellow. Five petals; stamens declined. Flowers polygamo-monoecious; possessing conspicuous nectar guides, at first yellow then becoming reddish in color. Considerable nectar is secreted in the bottom of the calyx between the claws of the upper petals. Some flowers are

FIG. 231.—Horse chestnut (*Aesculus Hippocastanum*). A flowering branch. Upper right-hand corner, flower with stamens and pistil. Upper left-hand corner, single stamen and pistil. Nectar glands shown below. *After Faguet.*

perfect, some male and some female and these are all on the same inflorescence. The insects use the stamens as a resting place.

Loew reports many honey bees in Germany and bees have also been reported by many other investigators.

The horse chestnut is not frequently cultivated in Iowa.

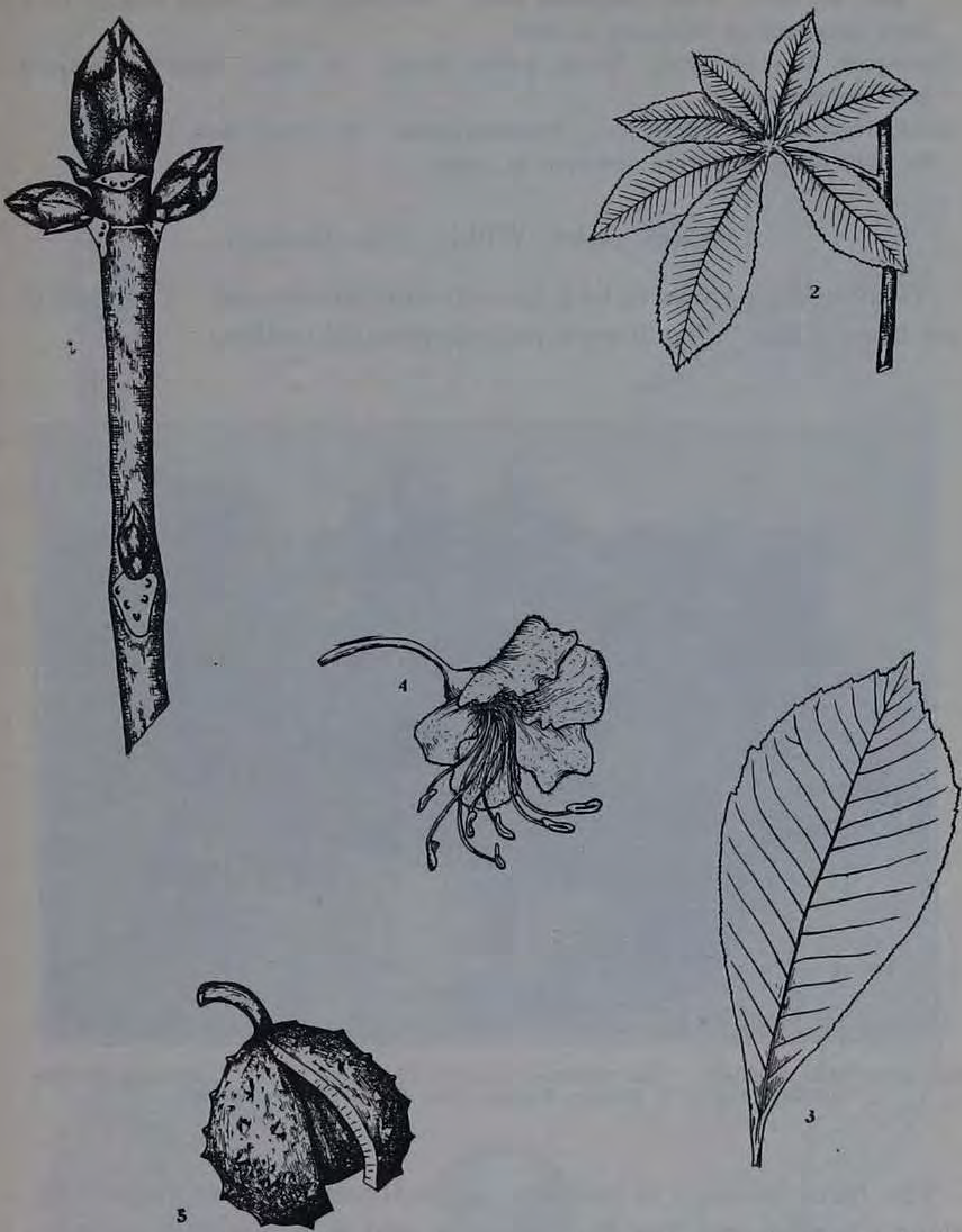

FIG. 232.—Horse chestnut (*Aesculus Hippocastanum*). 1. Winter twig, x 3/4; 2. Leaf, x 1/6; 3. Leaflet, x 1/2; 4. Flower, x 1; 5. Fruit, x 1/2. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

HONEY BEE VISITS

Ames, May 23, 1927, 10 a.m. Bees ten, five, six, six, three, ten, twelve seconds in a flower.

4 p.m. Clear, sunshiny. Bees abundant, also bumble bees. Five, ten, six, six, twelve, four, six seconds in a flower.

May 26, 1927. Cool, northwest wind. No honey bees. Some bumble bees. Bees abundant at Ottumwa in 1927.

Davenport, May 14, 1928. Warm, partly cloudy. No bees. Bees on *Lonicera Morrowi* near by.

Ames, June 1, 1929, 12:10 p.m. Past its prime. No honey bees. (L.H.P.) In 1929 some bees were observed at Ames.

Aesculus glabra Willd. Ohio Buckeye

This buckeye grows to be a tree of considerable size. The leaflets are usually five. The flowers are pale greenish yellow.

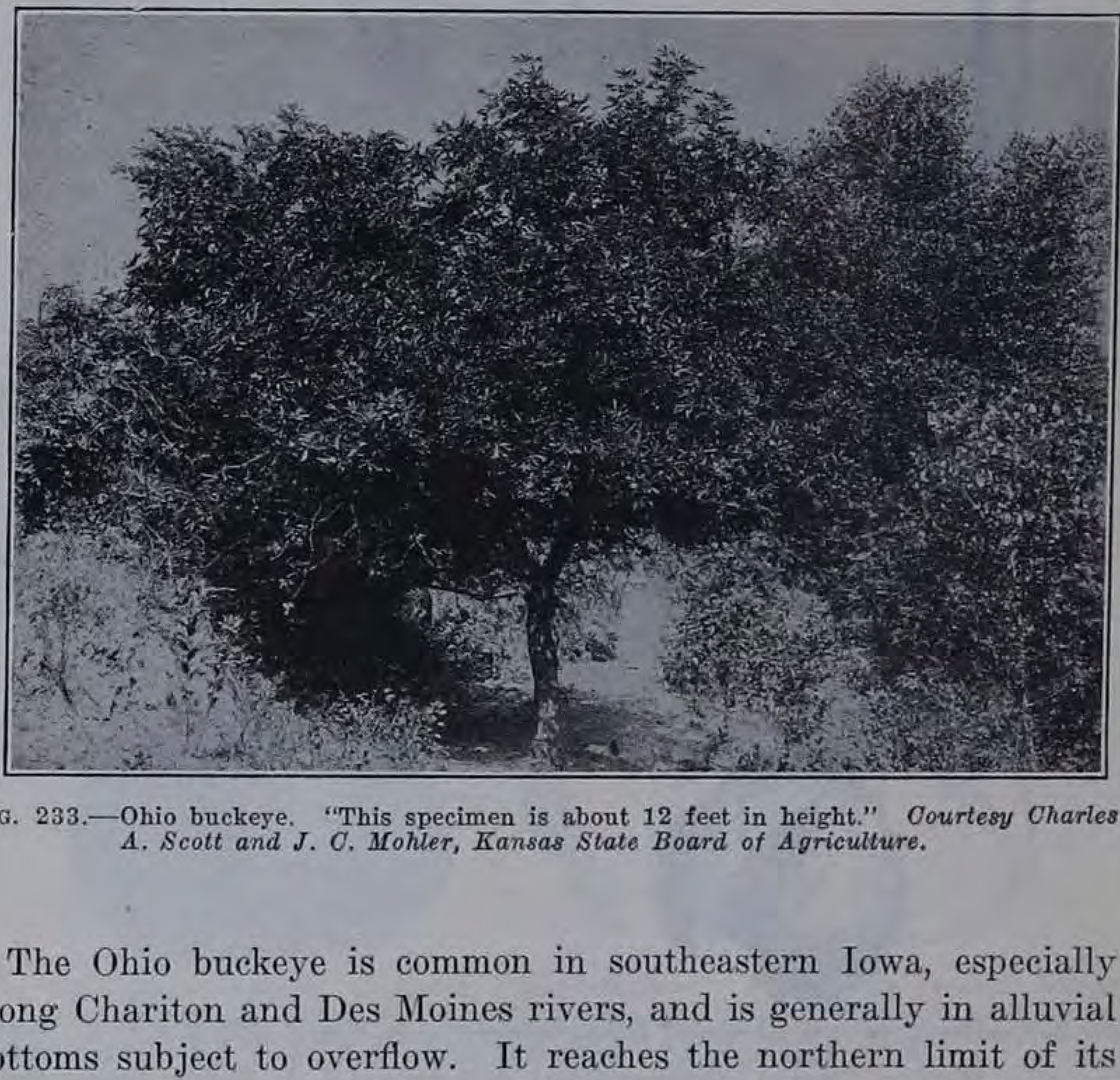

FIG. 233.—Ohio buckeye. "This specimen is about 12 feet in height." *Courtesy Charles A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

The Ohio buckeye is common in southeastern Iowa, especially along Chariton and Des Moines rivers, and is generally in alluvial bottoms subject to overflow. It reaches the northern limit of its range at Fraser where it occurs in upland woods and on slopes of hills. It is associated with *Ulmus americana, Populus deltoides, Fraxinus lanceolata, Betula nigra, Leersia virginica.*

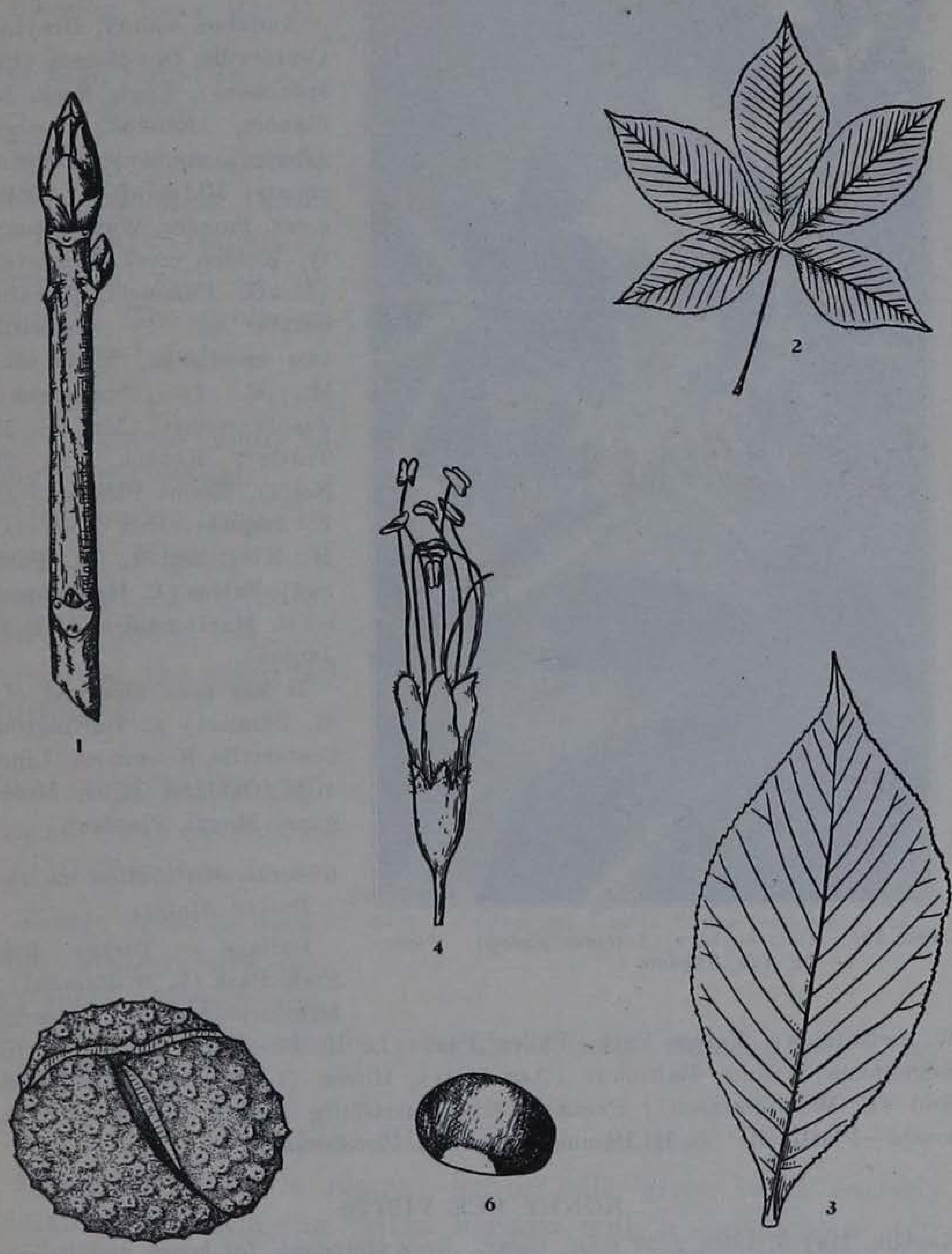

FIG. 234.—Ohio buckeye (*Aesculus glabra*). 1. Winter twig, x 1; 2. Leaf, x 1/6; 3. Leaflet, x 1/2; 4. Flower, x 2; 5. Fruit, x 1/2; 6. Nut, x 1/2. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

FIG. 235.—Ohio buckeye (*Aesculus glabra*). *Photo by Ada Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Audubon county, Brayton, Centerville, Des Moines (two specimens), Eagle Rock, Indianola, Keokuk, Ledges (Boone county), Marion county, Middle River, Otter creek, Sumner, Warren county, Weldon creek, Winterset (L. H. Pammel), Decatur county (J. P. Anderson, two specimens, T. J. and M. F. L. Fitzpatrick), Jasper county (Mrs. F. M. Tuttle), Keokuk (P. H. Rolfs), Mount Pleasant (H. E. Jaques), Red Rock (C. M. King and L. H. Pammel), Salem (L. H. Pammel, G. B. MacDonald and H. E. Jaques).

It has been observed (L. H. Pammel) at Burlington, Centerville, Keosauqua, Lineville, Oakland Mills, Moingona, Mount Pleasant.

General distribution in the United States:

Indiana — Turkey Run State Park (L. H. Pammel); Missouri—Allenton (George W. Letterman), Forest Park, Valley Park (L. H. Pammel), St. Louis (G. Engelmann); Ohio—Baltimore (Asa Horr), Huron (L. H. Pammel), Mansfield (E. W. Wilkinson); Pennsylvania—Harrisburg (L. H. Pammel); Wisconsin—Platteville (L. H. Pammel and B. B. Zimmerman).

HONEY BEE VISITS

Keokuk, May 5, 1923, 2:30 p.m. Clear. Bees abundant, for honey and pollen. Bees swarming about the tree. Six to twenty-four seconds in the flower.

Ames, May 12, 1923. Clear, northwest wind. No bees. (L.H.P.)

May 13, 1923. Clear, southwest wind. Some humble bees. No honey bees. "Bees cannot get the nectar normally." Prominent nectar glands below the pistil. Nectar secreted in abundance. (L.H.P.)

May 13, 1926, 1 p.m. Partly cloudy, north wind, cool, humid. No honey bees. Some bumble bees. (L.H.P.)

Keosauqua, May 6, 1928, 9 a.m. Clear, slight breeze. Bees getting pollen. Ames, May 19, 1922, 2 p.m. Bees six, seven, five seconds in a flower getting pollen. (L.H.P.)

Blooming, Ames, May 10, 1924. Lansing, May 11, 1924.

Aesculus Pavia L. Red Buckeye

Shrubs or small trees with palmately compound leaves, smooth or sometimes soft downy beneath. The corolla, as well as the tubular calyx, is bright red. Petals four; stamens about as long as the corolla.

Distribution from Virginia to Missouri and southward. Only cultivated in Iowa. Bees observed on the plant at Burlington.

FIG. 236.—Red buckeye (*Aesculus Pavia*). *After Chestnut, United States Department of Agriculture.*

BALSAMINACEAE, JEWEL WEED OR TOUCH-ME-NOT FAMILY

Mostly herbs or somewhat shrubby, with watery juice, alternate simple leaves without stipules, irregular flowers, stamens five, ovary five-celled.

Impatiens (Rivinius) L. Balsam

Broad-leaved shade plants; leaves pale green, oval, coarsely dentate. The swinging yellow blossom with a conspicuous spur formed by the posterior sepal. Seed pods explosive, projecting the seeds when they spring open.

The touch-me-not or jewel weed is common in low grounds in woods and along streams. The flowers are irregular, yellow in color, proterandrous. The nectar is secreted at the end of the calyx spur. The North American species are commonly visited by humming birds, while the commonly cultivated European species is visited largely by the bumble bee. Bees are not plentiful upon the flowers.

Impatiens pallida Nutt. Pale Touch-me-not

Plant grows to a height of four feet. In this balsam the flowers are pale yellow, slightly dotted with brown. The early seed is produced from cleistogamous flowers. The conspicuous flowers bloom in July and August.

The pale touch-me-not or jewel weed is widely distributed in Iowa on rich soil banks of small streams, in ravines, rich woods, and borders of lakes, in soils better drained than where the spotted touch-me-not grows; or sometimes in woods in alluvial bottoms.

It is associated with *Cardamine rhomboidea, Caltha palustris, Campanula americana, Aster prenanthoides.* Less restricted distribution than *I. biflora.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cerro Gordo county (two specimens), Dakota City, Indianola, Madison county, McGregor, New Albin, Wheelerwood, Winterset (L. H. Pammel), Ames (Ada Hayden), Backbone Park (Delaware county) (I. T. Bode), Cedar Rapids (R. E. Buchanan), Clear Lake (R. I. Cratty), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Fayette (Bruce Fink), Fort Dodge (F. C. Stewart), Ledges (Boone county) (J. V. Ellis, L. H. Pammel, R. E. Buchanan and C. M. King), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Tama county (V. C. Fisk).

This has also been observed (L. H. Pammel) at Cresco, Dubuque, High lake, Iowa lake, Jefferson, Marquette, Mason City, Postville, Wallingford.

General distribution in the United States:

District of Columbia—(Jesse H. Holmes); Illinois—Peoria (F. E. McDonald); Kentucky—Poor Fork (T. H. Kearney, Jr.); Massachusetts—Tyringham (Anna Murray Vail); Minnesota—Ortonville (L. H. Pammel), St. Cloud (R. Gmelin); New Jersey—Fort Lee (P. A. Rydberg); New York—Haine's Falls (Mrs. L. M. Parker), Ithaca (H. E. Summers, Muenscher and Bechtel), Watkins Glen (L. H. Pammel); Ohio—Pickerington (A. Horr).

Blooming, Ames, September 1, 1924.

Impatiens biflora Walt. Spotted Touch-me-not

A plant three to four feet high with ovate coarsely toothed leaves. Flowers orange color, spotted with brown. The posterior sepal forms a long conical spur.

Found growing near springs, and in shady moist places. Flowering season from June to September.

The spotted touch-me-not is common in many places along the bluffs of the Mississippi from Keokuk to New Albin. It is associated with *Leersia oryzoides, Lobelia siphilitica, Aster umbellatus, A. novae-angliae, Solidago serotina, S. Riddellii, Caltha palustris, Thalictrum dasycarpum, Bromus ciliatus, Cardamine rhomboidea.*

In this flower nectar is secreted in the top of the calyx spur; it is usually regarded as a humming-bird flower, but bees and butterflies also visit it. Bumble bees puncture the flowers and by means of these openings honey bees also obtain nectar. The plant is a source of honey in some places. Regarded by Mr. Pellett as a honey plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Fraser, Hamburg, Marshalltown (L. H. Pammel), Armstrong (Emmet county) (R. I. Cratty), Ames (L. H. Pammel and C. R. Ball, Fred Rolfs), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (Bruce Fink), northeastern Iowa (H. Goddard), Osage (Mrs. Tuttle), Postville (L. H. Pammel, Ellison Orr, D. O. Wilson), Winterset (G. W. Carver).

This has also been observed (L. H. Pammel) at Algona, Buena Vista county, Calhoun county, Cerro Gordo county, Charles City, Clear Lake, Cresco, Dubuque, Eagle lake, Eldora, Emmet county, Emmetsburg, Fertile, Forest City, Hancock county, High lake, Jewell Junction, Lake Okoboji, Lost Island lake, Marshalltown, Mason City, McGregor, Medium lake, Sac county, Silver lake, Spirit Lake, Steamboat Rock, Storm Lake, Story City, Twin lakes, Wallingford, Wall Lake, Webster City.

General distribution in the United States:

Illinois—Bluff lake (H. Eggert), Starved Rock (L. H. Pammel and Mark Heavenhill); Indiana—King's creek (Jessie H. Holmes); Kentucky—Harlan Court House (T. H. Kearney, Jr.); Louisiana— (T. L. Andrews); Minnesota—Black Duck (Mrs. Roy Westley), Cedar island (Cass Lake) (L. H. and H. E. Pammel), Brainerd (three specimens, E. B. Watson), International Falls (H. S. Kellogg); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Ohio—Pickerington (Asa Horr); Virginia—Arlington (C. R. Ball and A. E. Paddock); Wisconsin—Holmen (L. H. Pammel), La Crosse (Dora S. Pammel), Portland (C. M. King and Dora Pammel).

HONEY BEE VISITS

Ames, September 8, 1918. Plant in bloom.

Albert Lea, Minnesota, August 28, 1927. Bees abundant. Two, two, one, one, one, one seconds in a flower. Although a humming-bird flower, bees were seeking it. Common along borders of the lake. (L.H.P.)

Blooming, Ames, September 1, 1924.

Impatiens Balsamina L. Garden Balsam

A low growing plant of gardens, with crowded lanceolate leaves; bearing clusters of large showy short-spurred flowers in their axils; color in shades from white to red and purple.

Honey bees, two species of *Bombus* and *Polistes gallica* observed by Prunet. Honey bees also observed by other European investigators.

Pellett states that it is commonly regarded as a bumble bee flower, but honey bees have been reported from both Michigan and Wisconsin, where the species is quite common in places.

RHAMNACEAE, Buckthorn Family

Shrubs or small trees, leaves simple, stipules falling early. Frequently dioecious, small regular flowers with perigynous stamens. Calyx lobes, petals and stamens four to five. Ovary two- to five-celled. Calyx and disc free from the ovary or adherent to the base. Fruit a berry or capsule.

Rhamnus (Tourn.) L. Buckthorn

Shrublike plants with simple, mostly alternate leaves. Flowers greenish in axillary clusters, frequently dioecious. Drupe berry-like, black.

Inconspicuous proterandrous flowers with exposed nectar secreted by the calyx.

Rhamnus alnifolia L'Her. Alder-leaved Buckthorn

A low shrub. Leaves oval, toothed and pointed. Flowers without petals. Fruit three-seeded, berry-like.

This species occurs on cold limestone bluffs on north slopes and in damp cold woods in Winneshiek, Dubuque and Allamakee counties. There is a large amount on Yellow river on the north slopes in balsam fir woods; in similar situations in Winneshiek county.

It is associated with *Viola blanda, Aconitum noveboracense, Viburnum Opulus, Pinus Strobus, Abies balsamea, Poa Wolfii.*

General distribution in the United States and Canada:

Manitoba—Le Pas (C. A. Hansen); Minnesota—Pikes Bay, Cass Lake (L. H. Pammel); Montana—Bitter Root valley (L. H. Pammel and H. S. Fawcett); New York—Ithaca (Muenscher and Bechtel); Pennsylvania—West Lancaster (John K. Small); Wisconsin—Mercer (Mrs. Joseph Clemens); Wyoming—Obsidian creek (two specimens, Aven and Elias Nelson).

Rhamnus cathartica L. Buckthorn

A shrub or sometimes a tree, twelve or more feet high. Branchlets often tipped with stout spines; oblong, minutely serrate leaves. Calyx four-lobed. Flowers greenish, fragrant, dioecious. The male flowers larger than the female and with a rudimentary pistil. Female flowers have rudimentary stamens. Drupe black, three- to four-seeded.

A not infrequent escape. It has been planted as a hedge plant in many parts of the state. Various places, on prairie and limestone soils. In limestone soils of Dubuque county associated with *Andropogon furcatus, Andropogon scoparius, Bouteloua curtipendula, Quercus macrocarpa.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, Dubuque, Forest City, Monticello (L. H. Pammel).

General distribution in the United States:

Colorado—Fort Collins (J. H. Cowan); Massachusetts—Arlington (H. L. Jones, J. W. Blankinship); Minnesota—McIntire (F. E. Tracy); New York—Geneva (L. H. Pammel); Wisconsin—Janesville (J. N. Dietz), Ripon (W. F. Schriveson).

HONEY BEE VISITS

Ames, May 19, 1929, 8:30 a.m. Bees abundant. Two, two, two, two, one, three seconds in a flower. Valuable honey plant. (L.H.P.)

May 19, 1929, 2:30 p.m. Warm. Just in bloom. Some bees. Two, two, two, two seconds in a flower. (L.H.P.)

May 21, 1929, 1:30 p.m. Few bees, many Diptera. Bees two, two, two, one seconds in a flower. (L.H.P.)

May 22, 1929, 5:15 p.m. Cloudy. No bees. A few Diptera. (L.H.P.)

May 23, 1929, 8 a.m. Bees, one, one, one, two, two seconds in a flower. Three bees in three minutes on stalk ten feet high. One bee went to ten clusters in one minute. Fifty flowers in cluster. Some small Diptera and Hymenoptera.

12:15 p.m. Bees fairly common. Numerous Diptera. Bees two, two, one, one, two, two seconds in a flower.

5 p.m. Warm. Bees numerous. Bees pass rapidly from one flower to another in two clusters. Two, two, one, one, two, two seconds in a flower.

May 28, 1929, 8 a.m. No bees.

Rhamnus lanceolata Pursh. Lance-leaved Buckthorn

This species is common in southern Iowa, from Elkader to Keokuk along Mississippi river and from Davenport westward across the state, apparently extending along the Missouri and Mississippi farther north than in the interior of the state.

Limestone soils, loess or clay soils. Associated with *Symphoricarpos orbiculatus, Eupatorium urticaefolium, Solidago latifolia, S. ulmifolia, Quercus alba, Q. macrocarpa, Corylus americana, Prunus serotina,* etc.

This species furnishes honey, according to many observers.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel (two specimens), Council Bluffs (three specimens), Dubuque (two specimens), Elkader, Indianola, Madrid, Marion county, McGregor, Monmouth, Oskaloosa, Otter creek, Ottumwa, Red Rock, Salem, Shenandoah, Volga, Warren county (L. H. Pammel), Centerville, Cooper creek (L. H. Pammel and G. B. MacDonald).

It has been observed by L. H. Pammel at Boone, Dubuque, Keokuk and Winterset.

It is reported for Sioux City.

Honey bees have been observed by us in Winterset. Dr. S. N. Dietz also reports the honey bee in southern Iowa.

In bloom, Ames, May 17, 1926.

Rhamnus Frangula L. Alder Buckthorn

An unarmed shrub with smooth leaves which are broad, obovate to obovate-oblong, dark green and shiny above. Flowers whitish, perfect, in umbels. Sepals and petals greenish in color. Petals and stamens five. Fruit a berry-like drupe, black, with two to four nutlets. Introduced from Europe.

The receptacle forms a hemispherical fleshy disc which secretes nectar. On account of this open situation, the nectar is accessible to various insects. The flowers are inconspicuous and not much visited; but bees, bumble bees and wasps are mentioned as being among the insects sometimes found working upon them.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (G. W. Carver and F. A. Sirrine), Hull (J. B. and R. D. Mayer).

HONEY BEE VISITS

Four Hymenoptera observed, one honey bee, one Diptera. (H. Mueller).

Manhattan, Kansas, May 16, 1927, 2:30 p.m. Clear. Bees abundant. Two, two, four, three, two, two seconds in a flower. (L.H.P.)

Ames, May 22, 1927. Bees abundant on the plant. (L.H.P.)

May 26 to 30, 1927. Cool. Northeast wind. No bees.

June 29, 1927, 11 a.m. Hot winds, cloudy. Some flowers. No bees.

Ceanothus L. Red-Root

Small shrubs with flowers in umbel-like clusters, forming dense panicles or corymbs. Calyx and pedicels colored like petals. Calyx five-lobed, incurved. Petals hooded, spreading, on slender claws longer than the calyx. Fruit dry, separating into three dehiscent nutlets. Leaves alternate or opposite, petiolate, serrate, pinnately veined.

FIG. 237.—Red-root, New Jersey tea (*Ceanothus americanus*). *Photo by Ada Hayden.*

Ceanothus americanus Desf. New Jersey Tea

Leaves ovate or oblong-ovate, acute, three-ribbed, pubescent. Flowers white.

Widely distributed in the state of Iowa, especially in openings of prairies.

HONEY BEE VISITS

Near Ames, July 17, 1927. Three miles from apiary. Associated with *Melilotus officinalis.* No bees. (L. H.P.)

The New Jersey tea is sometimes visited by bees, but in Iowa it is an unimportant honey plant.

Blooming, Ames, July 1, 1926.

Ceanothus ovatus var. *pubescens* Tor. and Gray. Smaller New Jersey Tea

Like the preceding, but the leaves are narrowly oval or elliptical-lanceolate, finely glandular serrate. Flowers white.

Occurs in dry rocky, sandy soils. Especially common in western Iowa.

This New Jersey tea is sometimes visited by bees but, like the preceding species, is unimportant.

Blooming, Ames, July 1, 1926.

VITACEAE, Grape Family

Shrubby plants, generally climbing by tendrils; leaves alternate, palmately veined or compound. Flowers small, regular, greenish, polygamous; calyx small or obsolete; stamens and petals of the same number, four to five, soon falling. Fruit a two-celled berry. The flowers are generally fragrant.

Psedera Neck. Woodbine

Climbing woody plants. Tendril-bearing with alternate palmately divided leaves. Clusters of flowers compound, resembling those of the grape.

Honey bees have been observed on this species in Europe and are so recorded by Kerner. Knuth states that the flowers are much sought by bees, they being attracted by an odor which is imperceptible to persons. Plateau also noticed *Apis* in Belgium.

Psedera quinquefolia (L.) Greene. Woodbine, Virginia Creeper

A woody climber with digitate leaves, leaflets five, glabrous, dull green, paler below. Tendrils branching, tipped at the ends with adhesive discs. Inflorescence paniculate, fruit subglobose, purple when ripe. Foliage brilliantly colored in autumn just before falling.

The Virginia creeper is widely distributed in woods, climbing over trees, occasionally climbing over sandy and limestone rocks. It is associated with *Celastrus scandens, Vitis vulpina, Celtis occidentalis, Ulmus americana, Quercus alba, Solidago canadensis, Sanicula marilandica, Lactuca pulchella, Euphorbia marginata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Granite, Lake Mills, Otter creek, Palo Alto, Warren county (L. H. Pammel), Clear Lake, Emmet county (R. I. Cratty), Ames (F. Rolfs, E. B. Watson), Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Decorah (E. W. D. Holway), Fayette (B. Fink), Mud lake (Hamilton county) (F. C. Stewart), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson), Rockford (Mr. and Mrs. T. J. Fitzpatrick), Shell Rock (E. S. Fyler), Spirit Lake (L. H. and H. E. Pammel).

It has been observed (L. H. Pammel) at Boone, Burlington, Camanche, Centerville, Charles City, Cherokee, Clinton, Cresco, Davenport, Des Moines, Dubuque, Eldora, Fairfield, Fort Dodge, Glenwood, Hamburg, Indianola, Jefferson, Keokuk, Ledges, Mason City, Missouri Valley, Mount Pleasant, Muscatine, Oakland Mills, Osage, Rock Rapids, Shenandoah, Steamboat Rock, Winterset.

General distribution in the United States:

Arizona—Flagstaff (D. T. MacDougal); Colorado—Fort Collins (J. H. Cowan), La Porte (L. H. Pammel and C. P. Johnson); Florida—Sarasota Key (S. M. Tracy); Kentucky—Poor Fork P. O. (T. H. Kearney, Jr.); Massachusetts—Gloucester (Mr. and Mrs. L. Blundell); Minnesota—Cass Lake, Cedar island (L. H. and H. E. Pammel), Brainerd (E. B. Watson), Sandy lake (J. H. Sandberg), Star island (L. H. and H. E. Pammel and P. S. McNutt); Missouri—St. Louis (L. H. Pammel); Nebraska—Lincoln county (F. G. Miller), Sheridan county (R. E. Buchanan); New Mexico—Fort Bayard (J. C. Blumer), Whitman's Camp (A. Isabel Mulford); New York—Ithaca (Muenscher and Bechtel); Ohio—Worthington (Asa Horr); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood); Wisconsin—Coon Valley (L. H. Pammel).

HONEY BEE VISITS

Knuth says, "Nectar is secreted in minute drops under the base of the ovary. The flower has been observed to be much visited by bees." Kirchner records the honey bee on *Psedera* and Plateau also observed this species in the Alps. The honey bee has been observed on flowers of *Psedera* at Boone during some years. Bees have been noticed to visit the vines so freely at Ames in some years that the air was filled with a humming sound. Generally, however, this is not an important source of honey.

Ames, July 4, 1927, 12 m. Bees pass over the flowers. One, one, one seconds in a flower. (L.H.P.)

Psedera vitacea (Knerr) Greene.

Closely resembles common woodbine. The plant nearly smooth; leaves thin and shining. Tendrils ending in adhesive discs.

Found in moist woods.

HONEY BEE VISITS

Ames, bees observed upon this species. (L.H.P.)

Cissus

Tendril-bearing shrubs with perfect or sometimes polygamous flowers with four or five sepals and petals; petals expanding; disc cup-shaped, surrounding base of ovary; fruit a berry.

Cissus Ampelopsis Pers.

Nearly glabrous perennial with heart-shaped leaves, some truncate at the base; coarsely and sharply toothed; flowers in small panicles; berries one- to three-headed, bluish or greenish. Common on river banks from Virginia to Texas; sometimes cultivated for ornamental purposes.

HONEY BEE VISITS

Ames, July 3, 1927, 12 m. Bees one, one, one, two, two seconds in a flower. Campus, July 7, 1927, 8:30 to 9:30 a.m. Bees working freely. (C.C.L.)

Vitis (Tourn.) L.

Woody vines with tendrils and simple rounded leaves. Flowers in a compound cluster, fragrant. Fruit pulpy. Flowers polygamo-dioecious. Some plants with perfect flowers and others staminate with a rudimentary ovary. Calyx short. Petals separate at base, falling off without expanding.

The nectar glands are exposed and alternate with the stamens. According to Beach, self pollination takes place in the still unopened flowers. The following rather interesting statement is made with regard to *Vitis vinifera* of Europe by Knuth: "The nectar is secreted in very small amounts. The inconspicuousness of the flowers is counterbalanced by their extreme fragrance, which would no doubt serve to attract insects if the booty were in proportion, but the quantity of pollen is small, and according to all available accounts nectar never appears to be secreted, at least not in Europe."

A fact that may well restrain the bees from visiting the flowers is that it blooms at a time when there are so many other fine sources of nectar. Delpino, however, states that in Italy nectar is abundantly secreted. Kirchner states that in the climate of Germany the vine has lost the power of producing nectar in the northern limit where the crop grows.

Notes have been made by us of honey bees on various species of grape, but these bees have never been found abundantly. This applies to *Vitis labrusca* and its hybrids as well as to *V. cordifolia*, *V. bicolor*, *V. cinerea* and *V. vulpina*.

On June 12, 1929, the senior author saw numerous plants of *Vitis labrusca* at Rolfe, but without a single bee visit. However, bees have been observed on the species. They occur more frequently on *Vitis vulpina*, the wild frost grape, than on the others.

Pellett, in commenting upon the grape, states that the nectar yield is not as abundant as in many plants, but that it yields some honey where the plant grows in sufficient quantity. A quantity of pollen is gathered from this source, as well as honey dew from the leaves.

Vitis labrusca L. Cultivated Grape

The flowers are commonly polygamous or dioecious, but greenish, inconspicuous and very fragrant. The ovary bears an adnate fleshy disc of five nectar glands. The stamens and petals are borne on the disc. The petals form a cap over the stamens. When the stamens are released, pollen is thrown upon the visiting insect.

Vitis labrusca is said to be a valuable honey plant in western Tennessee and *Vitis monticola,* also a southern species, is listed at times as a valuable honey plant.

Even though commonly cultivated in this state, it yields little or no honey, though bees have been observed on it.

General distribution in the United States:

Alabama—Auburn, Montgomery (L. H. Pammel); Massachusetts—Plymouth (J. W. Blankinship); New Jersey—Asbury Park (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel); Utah—Salt Lake City, (escape) (L. H. Pammel and R. E. Blackwood); Virginia—Marion (John K. Small).

Vitis bicolor Le Conte. Summer Grape

In this grape the branches are terete. Leaves thickish, pale beneath, with long petioles. The plant is nearly smooth.

This species is common only in northeastern Iowa, in clay soil and rocky woods.

Bees have been observed by us on this species.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clayton county (B. Fink), McGregor (two specimens, L. H. Pammel).

It has been observed (L. H. Pammel) at Lansing, Marquette, New Albin and Waukon Junction.

It occurs also at Chaseburg, La Crosse, Prairie du Chien and Victor, Wisconsin, and at Houston, Minnesota.

General distribution in the United States:

Arkansas—Pike county (L. H. Pammel); Michigan—Muskegon (L. H. Pammel); Ohio—Huron, Kelley's island (L. H. Pammel); Wisconsin—La Crosse (L. H. Pammel), Platteville (L. H. Pammel and B. B. Zimmerman).

Vitis cinerea Engelm. Sweet Winter Grape

In this grape the branchlets are angular. The plant has a whitish pubescence. The berries are in loose clusters, small, dark and without bloom.

In thickets and protected places in the woods.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decatur county (two specimens, J. P. Anderson), Hamburg (L. H. Pammel and H. B. Clark).

This has been observed (L. H. Pammel) at Burlington, Keokuk and Muscatine.

General distribution in the United States:

Alabama—Montgomery (two specimens, L. H. Pammel); Florida—Sarasota Key (S. M. Tracy); Illinois—Red Bud (two specimens, L. H. Pammel), East St. Louis (H. Eggert); Louisiana—Alexandria (C. R. Ball); Missouri—Allerton, Pilot Knob, (L. H. Pammel); Nebraska—Otoe county (Rev. J. M. Bates); Oklahoma—Muskogee (L. H. Pammel).

Vitis cordifolia Michx. Frost Grape

A grape with slightly three-lobed, sharply toothed shining leaves. The flower cluster is large and loose. Berries small, black, shining. Although common in Missouri, this grape is rare in Iowa.

Bees have been observed on this species, but the plant is not common in this state.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Decatur county near the Missouri line (J. P. Anderson).

General distribution in the United States:

Arkansas—Luverne county (P. H. Rolfs); Delaware—Brandywine Gap (Wm. M. Canby); District of Columbia—(Wm. M. Canby); Illinois—Bluff lake (H. Eggert); Kansas—Wichita (T. L. Andrews); Louisiana—Ascension (T. L. Andrews); Missouri—Ivory (L. H. Pammel), Valley Park (two specimens); Texas—Denison (two specimens, L. H. Pammel), Kerrville (A. A. Heller), Tarrant county (Albert Ruth); Virginia—Smyth county (John K. Small), Fort Washington—(G. McCarthy).

Vitis vulpina L. Wild Grape

This grape has shining leaves, usually three-lobed. Flower cluster compact. Berries small, bluish, with a bloom, acid and very juicy. Stream banks—New Brunswick west to North Dakota and Kansas.

The wild grape is widely distributed in every county in the state, especially common in woods in eastern Iowa along streams, growing on fences and along roadsides. It is associated with *Celastrus scandens, Campanula americana, Platanus occidentalis, Betula nigra, Quercus bicolor, Quercus alba, Q. macrocarpa, Smilacina stellata, Prunus americana, Prunus serotina, P. virginiana, Ostrya virginiana, Solidago rigida*, etc.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Centerville, Chaney lake, Clarinda, Dawson, Dubuque (two specimens), Emmetsburg, Granite, Lake Mills, Lansing, Liscomb, Lost Island lake, Marquette, Marshalltown, McGregor (two specimens), Middle River, Moingona, Muscatine county, North McGregor, Sioux City, South River, Warren county (L. H. Pammel), Algona, Clear Lake (R. I. Cratty), Ames (L. Clapper, L. H. Pammel and G. W. Carver, F. Rolfs), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Fraser (Botanical Seminar), Hamburg (L. H. Pammel and H. B. Clark), Keokuk (P. H. Rolfs), Lansing (O. Schultz), Ledges (J. W. Ellis, R. E. Buchanan), Osage (Mrs. F. M. Tuttle), Rockford (Mr. and Mrs. C. L. Webster), Shelby county (T. J. and M. F. L. Fitzpatrick), Shell Rock (E. S. Fyler), West Union (L. H. Pammel and Emma Hancock).

It has also been observed (L. H. Pammel) at Brooklyn, Camanche, Cedar Rapids, Centerville, Charles City, Clinton, Council Bluffs, Davenport, De Witt, Fairfield, Fort Atkinson, Grinnell, Indianola, Iowa City, Mason City, Missouri Valley, Mount Pleasant, New Albin, Postville, Waukon, Waukon Junction.

General distribution in the United States:

Colorado—LaPorte, Littleton (L. H. Pammel), Rist canyon (C. S. Crandall); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Minnesota—Jefferson, Owatonna, South Huron (L. H. Pammel), Cass Lake, Star island (L. H. and H. E. Pammel and P. S. McNutt); Missouri—Cahokia, Crystal City, Jefferson Barracks, Savoy, St. Louis, Washington, Wicks, Valley Park (L. H. Pammel), St. Louis (two specimens, H. Eggert); Nebraska—Halsey (two specimens, J. C. Blumer); New Mexico—Lorenzo Spring, Pleasant Valley (A. Isabel Mulford); New York—Ithaca (Muenscher and Bechtel); Pennsylvania—Towanda (L. H. Pammel); Wisconsin—Galesville, La Crosse (two specimens, L. H. Pammel), Prescott (Mary Edgar).

HONEY BEE VISITS

McGregor, May 3, 1918, 3 p.m. Cloudy. A few bees at work.

Ames, May 21, 1921, 7 a.m. Some bees. One to two seconds in a flower.

Fort Dodge, June 5, 1922, 11 a.m. Partly cloudy. Bees abundant. One, two, one, one, two seconds in a flower. (L.H.P.)

These flowers are decidedly attractive to bees.

Blooming, Lansing, June 14, 1924; Ames, May 10, 1925; Lansing, May 15, 1925; Ames, May 26, 1926.

Vitis vulpina L. var. *praecox* Bailey. Frost Grape

Much like the species, but with fruit ripe in July and early August.

This is associated with *Ipomoea hederacea, Gonolobus laevis* and *Eupatorium urticaefolia.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Hamburg (L. H. Pammel and H. Clark).

HONEY BEE VISITS

Manhattan, Kansas, May 16, 1927, 5 p.m. Clear, sunshiny. Flowers very fragrant. No honey bees.

Boone, May 31, 1927. Plant fragrant. No bees. (L.H.P.)

Vitis rupestris Scheele. Sand or Sugar Grape

A low bushy form. Not many tendrils, leaves small, shining, broad, with short point at tips. Berries small and sweet, in small clusters.

This grape is common in Missouri and just reaches Iowa at Keokuk. Found in southeastern Iowa on limestone soils. It is associated with *Fraxinus quadrangulata, Ostrya virginica, Quercus stellata, Q. marylandica, Smilacina stellata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Keokuk (L. H. Pammel).

General distribution in the United States:
Oklahoma—Norman (W. E. Bruner); Texas—Houston (Dr. Ada Hayden), Tarrant county (Albert Ruth).

This grape is reported as being visited by honey bees.

TILIACEAE, BASSWOOD FAMILY

Generally trees with fibrous bark, alternate simple stipulate leaves, regular, perfect flowers; sepals five, deciduous, petals five, imbricated in the bud; stamens numerous. Fruit dry, woody. The European lime tree (*Tilia europaea*) is known as a valuable honey plant.

Knuth states in regard to the pollination of basswood: "The flowers are pendent, the nectar secreted by the hollow sepals is protected from rain. The yellowish flowers smell strongly of honey. The exposed nectar lies in two little pits on the bases of the sepals, and is accessible to even very short-tongued insects. Besides the honey bee, which visits the flowers in thousands and collects honey only, not pollen, other Apidae as well as Syrphidae and Muscidae are very frequent visitors."

Tilia americana (Tourn.) L. Basswood, Linden

Fine trees of northern regions, with soft white wood. Leaves somewhat heart-shaped, serrate, with deciduous stipules. The flowers are in small clusters hanging by the peduncle, which is borne on a large membranous bract. The flowers are cream-colored and valuable to bees.

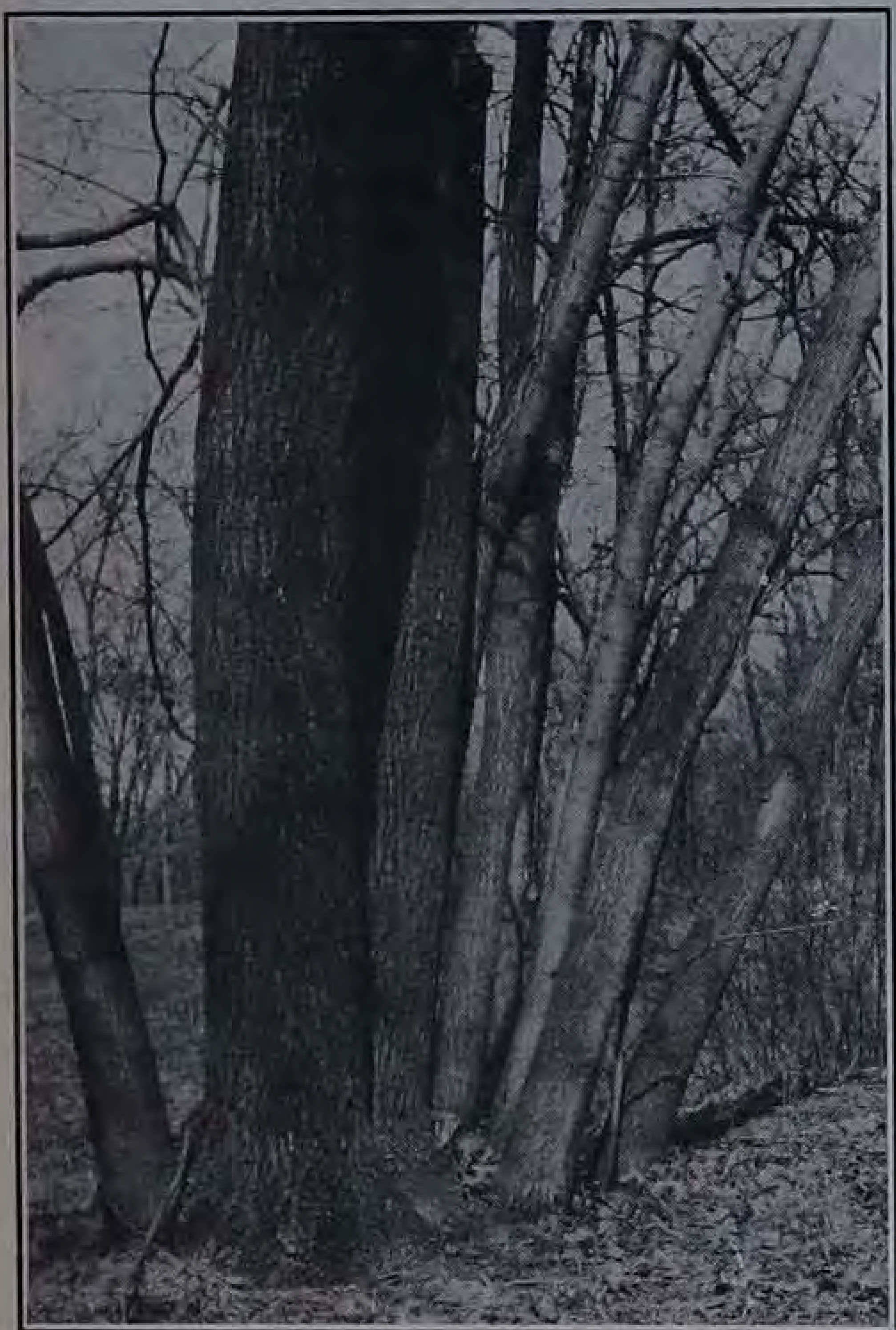

FIG. 238.—Trunk and young trunks of basswood (*Tilia americana*). *Photo by Vernon Fisk.*

Widely distributed in rich upland woods, clay, calcareous, or sandy soils, on shaded slopes. In Iowa most abundant in northeastern part. Associated with *Aquilegia canadensis, Podophyllum peltatum, Arisaema triphyllum, Phlox divaricata, Hepatica acutiloba, Diarrhena diandra, Leersia virginica, Thalictrum dioicum, Trillium nivale, Polemonium reptans, Anemonella thalictroides.*

Distribution in Iowa, as shown by specimens in the I.S.C. Herbarium:

Adel, Algona, Allamakee county, Ames (two specimens), Atlantic, Beaman, Bellevue (two specimens), Burlington, Camanche, Cedar, Centerville, Chaney lake, Cherokee, Clarinda, Clarksville, Dawson, Decorah, Eagle Rock, Estherville, Fairfield, Farmington, Fayette, Granite, Green Island (two specimens), High lake, Indianola (two specimens), Jefferson, Johnson county, Keosauqua (two specimens), Lake Mills, Lansing, Lake Okoboji (two specimens), Lime Springs, Little Sioux, Lost Island lake, Mahaska county, Mason City, Marion county, Middle River, Muscatine county, Nashua, New Albin, Osage, Oskaloosa,

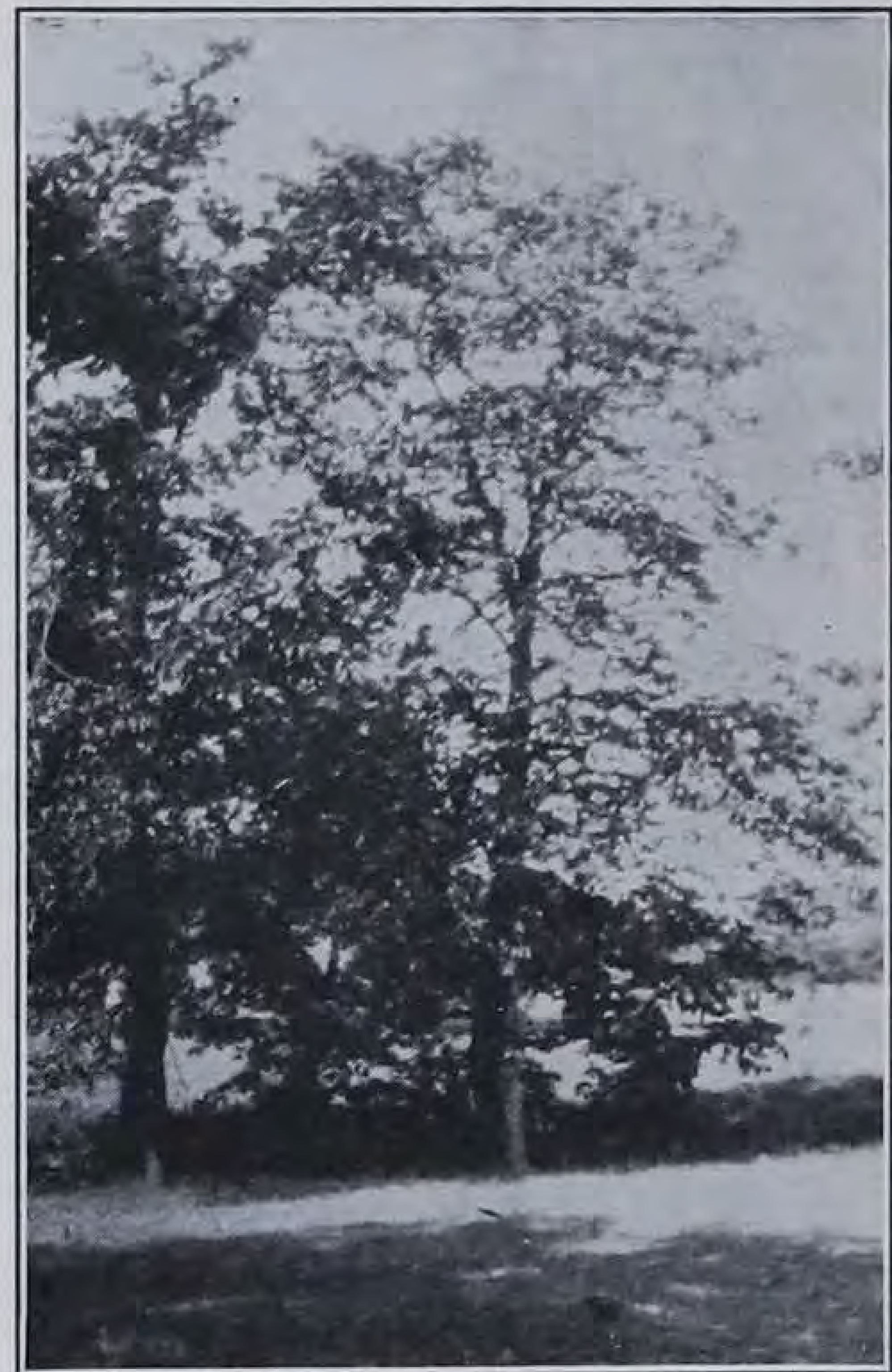

FIG. 240.—Basswood tree near Story City. *Photographed by L. H. Pammel.*

Insect collections made July 5 to July 10, 1915, indicate that honey bees were rather rare, small bees and flies being the dominant insects. Among collections of five different periods, only three contain honey bees.

Ames, June 24, 1917. Honey bees abundant. (L.H.P.)

Iowa City, July 13, 1917. Bees abundant on basswood. The vicinity fairly humming. (L.H.P.)

Ames, June 29, 1920. Bees abundant on basswood. (C.M.K.)

June 30, 1920. Tree most fragrant in the evening.

July 2, 1920, 6:30 p.m. Cool breeze. One bee about the flowers. (C.M.K.)

July 3, 1920, 7:30 a.m. Mild breeze. No bees.

12 m. Sunshiny. Many bees working industriously.

6:30 p.m. A few bees. (C.M.K.)

July 4, 1920, 8 a.m. Mild, damp, light breeze. Two or three bees about the tree.

12 m. Cool, clear. Several bees.

6 p.m. A few bees. (C.M.K.)

July 5, 1920, 8 a.m. Rainy. No bees.

6 p.m. Rainy. A few bees. (C.M.K.)

July 6, 1920, 8 a.m. Cloudy, not wet, mild. A few bees.

12 m. Warmer, 77°. A few bees. Flowers beginning to age. (C.M.K.)

July 7, 1920, 9:15 a.m. Bright, sunshiny. Slight shower previous day. Time in flower, two, three, five, three, three seconds. One bee in one small cluster in one minute. Many other Hymenoptera present. (L.H.P.)

July 8, 1920, 12:15 p.m. Four bees in 150 flowers in one minute. Time in flower, four, four, four, four, three seconds. (L.H.P.)

Algona, July 4, 1920, 7 p.m. Cloudy. Time in flower, two, three, two seconds. Some bees. Two bees observed in 100 flowers in one minute. (L.H.P.)

Beaman, July 4, 1920, 7 p.m. Street tree loaded with bloom. (L.H.P.)
Ledges (Boone), June 22, 1921, 2 p.m. Third day of bloom. Bees numerous. Three bees on 300 flowers, five, six, six, eight, six seconds in flower. (L.H.P.)
Kelley, June 28, 1922, 4 p.m. Bees six, six, three, three seconds in flower. Not as many bees as earlier when flowers are just opening. (L.H.P.)
Des Moines, June 24, 1922, 3:30 p.m. Bees abundant. Six, eight, nine, six, eight seconds in a flower. (L.H.P.)
Ames, June 29 and July 1, 1923, 2 p.m. Six, seven, two, four, six seconds. One bee visits fifty flowers. Trees in a row. Many flowers open at same time.
July 4, 1923, 5:30 a.m. Tree in a yard. Bees abundant. Three, four, four, three, seven, eight seconds.
1:30 p.m. Tree in timber. Bees abundant. Three, four, three, seven, five, three, four seconds in a flower.
3:30 p.m. Clear and warm. Three to five seconds. Bees abundant.
July 7, 1923, 9:30 a.m. Flowers fading. (L.H.P.)
3:30 p.m. Clear and warm. Three, five, three, four, four, three seconds in a flower. Bees abundant. (L.H.P.)
Ames, June 27, 1926, 6 p.m. Bees abundant. Ten, twelve, eight, five seconds in a flower. (L.H.P.)
July 3, 1927, 6 p.m. Bees abundant. Two, three, three, two, two, three, three seconds in the flower. (L.H.P.)
July 4, 1927, 10 a.m. Clear, cool, raw east wind. Bees abundant. Two, two, three, three, three, two, three seconds in a flower. (L.H.P.)
July 10, 1927. Clear, warm. Flowers advanced. Some bees. Six, two seconds in a flower. (L.H.P.)
Eldora, July 10, 1927, 4 p.m. Just in bloom. No bees. (L.H.P.)
Bumble bees also visit the basswood.
Ames, June 29, 1928, 5:30 p.m. Clear, warm. Early flowers very fragrant. No bees, but numerous bees on *Melilotus alba* just under the tree. (C.M.K.)
July 12, 1928. Cool, cloudy. Some bees, also on white and yellow sweet clover. (L.H.P.)
June 28, 1929, 1 p.m. Clear. Not many bees. Four, three, three, three, two seconds in a flower. Bumble bees visit the flowers. (L.H.P.)
July 9, 1929, 7 p.m. Bees five, six, seven seconds in a flower. (Frances Middleton.)
(Of a group of five trees only one in bloom.)
In bloom, Ames, June 15, 1925; June 20, 1926.

Basswood flowers are arranged in cymes; the flowers are fragrant, and nectar is copiously secreted in the hollow sepals.

Mueller says, "Honey is secreted and lodged in the hollow sepals and is accessible to insects with short proboscides. The lime attracts great numbers of insects by the number and strong scent of its flowers and the accessible position of their honey. Limes when in flower are the resort of thousands of bees in fine weather. I found none with pollen in their baskets but they all seemed to come for the honey."

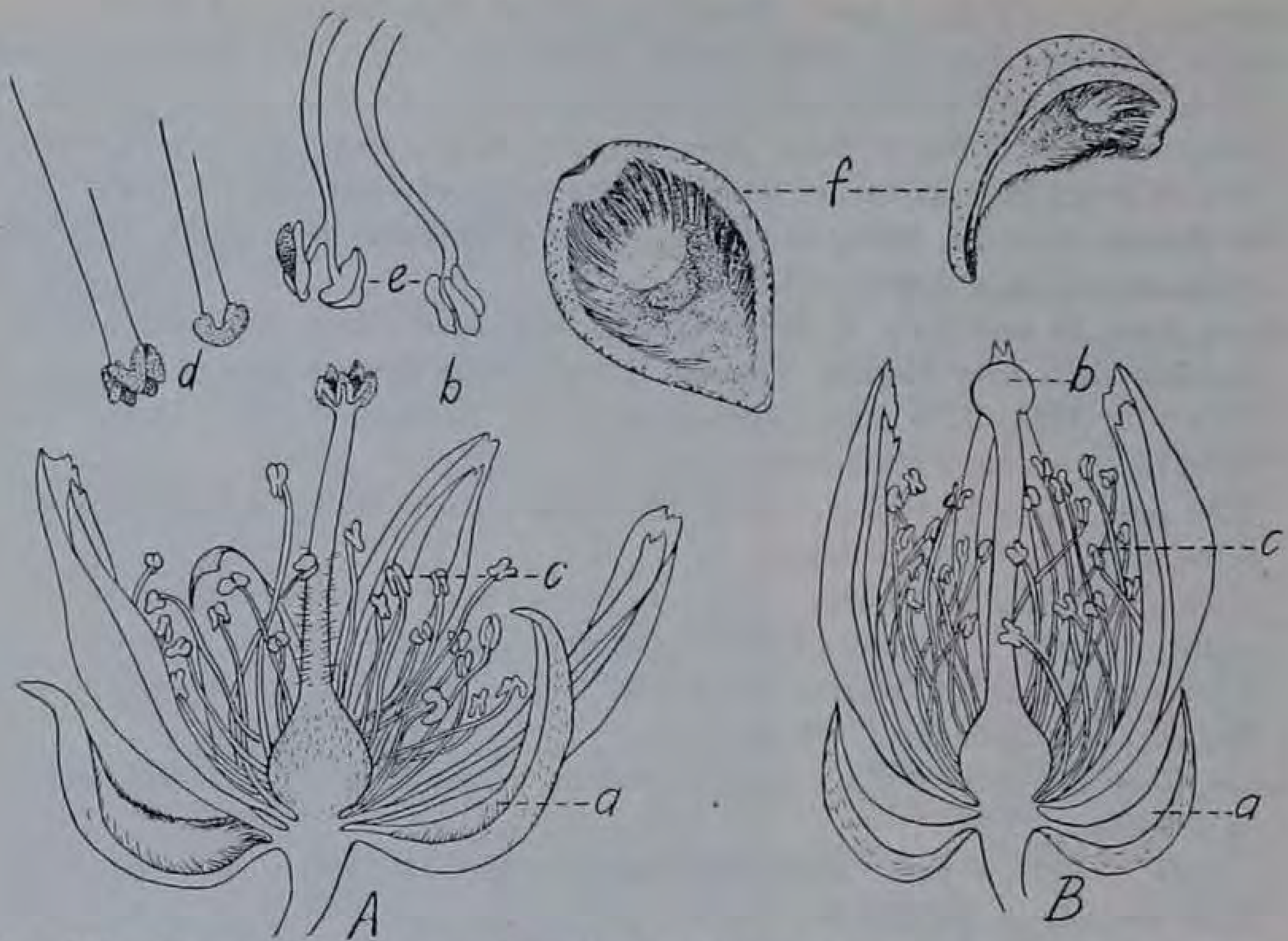

FIG. 241.—Basswood (*Tilia americana*). A. Mature flower; a. nectary, b. receptive pistil. B. Immature flower; a. nectary, b. pistil, c. proterandrous stamens, d. stigmas, e. stamens (various stages), f. calyx bearing nectary. *Drawn by A. Hayden.*

The basswood blooming period is rather short but while it lasts a large amount of nectar flows. It is our own observation that the yield, though somewhat irregular, is fairly good every year.

The basswood is one of the best sources of honey in the eastern states. The blooming period is from ten days to two weeks; Mr. Pellett finds that the honey flow can be depended upon about two or three years out of every five.

Basswood secretes copious amounts of nectar and yields best in the northern part of its range. Bonney says it failed to yield in 1914, after blooming for six successive years.

The conditions for pollination during the basswood season were not favorable in 1929, and comparatively little seed was produced on the trees observed.

We have observed in a number of cases, basswood trees in full bloom one season, and without bloom the succeeding year.

Dr. O. W. Park finds as follows, "Wherever basswood is plentiful it is the source of an abundant yield of honey of excellent quality some years, while in other seasons it yields practically nothing. The flow from this source seldom lasts more than ten days or two weeks but a strong colony will sometimes store from ten to fifteen pounds per day from this source."

FIG. 242.—Iowa hardwoods with maples and basswood.

Honey production in basswood. O. W. Park.

Year	Period of bloom	Full bloom	Period worked by bees	Period of honey flow	Notes
1918	6/17		6/22	6/22-7/3	Medium yield of nectar
1920	6/29	6/30-7/15	6/29	6/30-7/4	Bees working moderately on basswood
1923	6/22-7/12	6/30-7/8	6/27-7/11	6/29-7/10	More on white sweet clover, some on white clover

*Blooming dates for Tilia americana in Iowa**

	Northern section			Central section						Southern section	
	Lansing	Armstrong	Emmet Co.	Ames	Boone	Anamosa	LeGrand	Avoca	Cedar Rapids	Lamoni	Keokuk
1878				6/27							
1902							7/6				
1904				7/8							
1905				6/18						6/12	
1906											5/16
1907		7/15			6/11			7/15	7/11		
1908					6/21	7/13			7/1		4/29
1909					6/19						5/5
1910					6/10						
1911	6/25				6/15						5/17
1912	7/3				6/16						5/14
1913			7/12		6/28						
1914	7/2			6/12 to 6/26							
1915				7/15							
1917	7/2			7/10							
1918				6/20							
1919	6/23			7/1							
1920				7/1							
1921	6/5			6/16							
1922	6/27			6/16							
1923	6/29			7/1							

* Exceptionally early or late seasons show corresponding variations in blooming period of basswood.

MALVACEAE, Mallow Family

The plants of this family are herbs or shrubs with mucilaginous juice and alternate stipulate leaves; flowers regular with five sepals and five petals; stamens monadelphous, anthers six-celled. Nectar is secreted at the base of the petals.

There are several plants in this family which yield nectar abundantly. The bright color of many of the flowers renders them quite conspicuous and the stamens yield an abundance of pollen. Many plants of this family are markedly proterandrous. Visited by a miscellaneous lot of beetles and flies, many Hymenoptera and some Diptera and Lepidoptera. Some of the species are visited also by humming-birds.

Althaea L. Hollyhock

Herbs with regular flowers and alternate leaves. The numerous monadelphous stamens are arranged in a column with anthers at the top. The calyx is surrounded by six to nine bractlets.

Althaea rosea Cav. Hollyhock

An herbaceous plant, biennial to perennial, with alternate palmately veined leaves. Stem tall and simple, hairy. Leaves rugose, rounded, angled; flowers large, bright, conspicuous, proterandrous, forming a long spike. Corolla in various shades of rose, purple, yellow, sometimes white; single or double, three to four inches broad. Cultivated from the Levant. In wide cultivation in clay, black loam and sandy soils.

FIG. 243.—Hollyhock (*Althaea rosea*). *Photo by Ada Hayden.*

Nectar is secreted by five yellow areas at the bottom of the calyx between the bases of the petals.

The nectar is protected from rain by hairs near the base of each petal. The insect visitors effect cross-pollination. However, self-pollination can take place by the curving back of the stigmas, which brings them in touch with the anthers. Knuth states, "Automatic self-pollination takes place if insect visits fail, the stigmas curving back among the anthers that have not yet lost all their pollen." He and Loew report honey bees as frequent visitors upon it in Germany. Other European investigators also report the honey bee as a pollinator.

The hollyhock is one of the valuable honey plants, secreting much nectar. It is much frequented by bees in season of bloom, especially in the morning. The bees spend considerable time in the flowers collecting nectar. They also gather much pollen, which is abundant.

Observations of insect visitors upon the hollyhock at Ames covered the period from June to September, 1914, and parts of June and July in 1919. The plants were in favored, sunny situations, in garden soil.

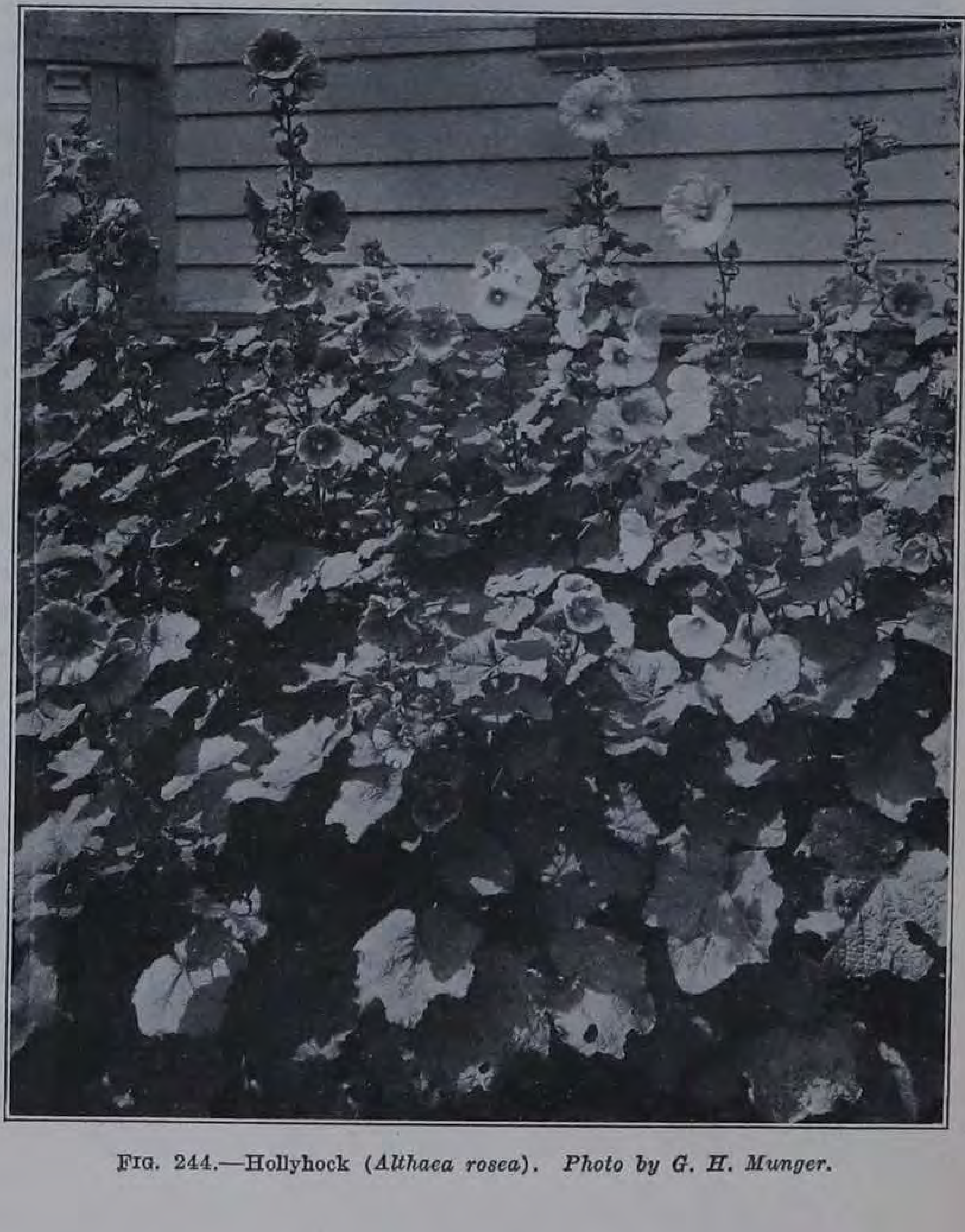

FIG. 244.—Hollyhock (*Althaea rosea*). *Photo by G. H. Munger.*

The bees worked freely in either calm, breeze or strong wind, and on clear, cloudy, warm or cool days, coming in considerable numbers. They seemed to prefer the dark colored flowers. One bee visited five flowers in four minutes, spending forty seconds in a flower, ten seconds to one nectary. Again bees spent four to fourteen seconds in a flower, depending upon the amount of nectar available. Frequent observations were made of these flowers; three to five bees were usually at work on the cluster at one time. The bee alights on the petal, crawls down to the passage-way to the nectar and thrusts in its proboscis, repeating the process at the four other nectaries. Pollen is not gathered intentionally as a rule, but becomes scattered over the back of the bee. Mr. Munger observed bees scraping this pollen from the body and putting it into the pollen baskets.

Honey bees were most abundant upon the hollyhock during the warm bright days of the latter part of June and early July. There is a little suspension of general bloom of other nectar-bearing flowers at this time. In September, also, they did not visit the hollyhock, being active upon other flowers. Mr. Pellett says of the hollyhock, "Wherever found, the bees seek it eagerly and apparently it secretes nectar freely."

J. H. Paarmann of Davenport found the five-year average date for beginning bloom of hollyhock to be June 20.

General distribution in the United States:

Iowa—Iowa City (A. S. Hitchcock); New York—Geneva (L. H. Pammel); Utah—Salt Lake City (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. W. Lummis).

HONEY BEE VISITS

Ames, June 21, 1914. Clear, light wind. Five honey bees in four minutes. (G.H.M.) Forty seconds in one flower, ten seconds in each nectary. Other insects; two small bees. (G.H.M.)

June 22, 1914, 8 p.m. Partly cloudy. South side of house. Three honey bees. Other insects; one small bee. (G.H.M.)

June 23, 1914, 8 a.m. Five honey bees, other insects; two small bees.

June 24, 1914, 7:45 a.m. Cloudy. South side of house. Bee four, six, eight, fourteen seconds in a flower. Eight honey bees observed in three minutes on the cluster of plants. (L.H.P.)

June 27, 1914. Cloudy, gale from west. Five flowers visited in one hour. (G.H.M.)

June 28, 1914, 3 p.m. South side of house. Warm, two flowers visited per hour. Other insects present; seven small bees. (G.H.M.)

June 30, 1914. Campus. Cloudy, south breeze. No honey bees. Other insects; 30 green bees (*Augochlora*) per flower per hour. (L.A.K.)

In 1914 by far the most abundant insect found was the metallic green *Augochlora*, attracted, no doubt, by the abundant pollen yielded by the many stamens of the flower.

July 6, 1915, 7:30 a.m.; July 8, 5:30 p.m.; July 11, 3 p.m.; July 15, 7:30 a.m. No honey bees.

September, 1915. Very few insect visitors.

July 11, 1917. Clear. Bees common on hollyhock. (L.A.K.)

June 26, 1919, 8 a.m. Clear and warm. Honey bees abundant, dusted with pollen, gathering honey. Twenty bees on one small clump of hollyhocks; they go from one nectary to another. Thirty to forty seconds in one flower. (L.H.P.)

June 28, 1919. Sunny, bright, southeast wind, pleasantly cool. Honey bees abundant; drain one nectary, then pass to another. Forty seconds in a flower. Back of bee covered with pollen. (L.H.P.)

June 30, 1919, 5:45 p.m. Five honey bees on fifty flowers in five minutes. Five, fifteen, twenty seconds in a flower. The bee inserts its proboscis beneath the hairs and secures the nectar. (L.H.P.)

July 4, 1923, 11 a.m. Several bees. Eight, ten, twelve, eleven, twelve seconds in the flower. (L.H.P.)

June 28, 1924. Small Hymenoptera abundant. No bees. (L.H.P.)

July 5, 1924, 8 a.m. Cool, clear, dew. The bees twenty, nineteen, twenty-five seconds in a flower. (L.H.P.)

July 6, 1924, 12:15 p.m. Bees thirty-five, forty-eight, fifty-two seconds in a flower. Backs covered with pollen. (L.H.P.)

Eldora, July 8, 1924, 4 p.m. Bees three, five, ten seconds in a flower. (L.H.P.)

Ames, July 10, 1924, 7:30 a.m. Cloudy. A few bees. Fifty-five, sixty-five seconds in a flower.

July 14, 1924, 6 p.m. Warm. The bee fifty, fifty-five, sixty, twenty-five seconds in flower. (L.H.P.)

July 15, 1924. Sultry. Bees fifteen, twenty-five, fifteen seconds in flower.

July 17, 1924. Cool, windy. Bees seventeen to sixty seconds in a flower.

Giard, July 28, 1925, 9 a.m. Partly clear. Bees abundant. Bees twenty-five, thirty, thirty-five seconds in the flower.

Ames, July 30, 1925, 10 a.m. Partly cloudy, hot. Few bees. Ten, eleven, twelve, ten seconds in the flower. (L.H.P.)

June 27, 1927. Bees common. Ten, fifteen, twenty seconds in a flower.

July 6, 1927, 10:30 a.m. Clear, warm. Bees three, one, five, four, forty, thirty seconds in a flower. Sometimes two bees in a flower. (L.H.P.)

July 13, 1927. Hot, dry, clear. Bees five and fourteen seconds in a flower.

July 14, 1927, 8:30 to 10 a.m. Very dry, warm and sunny. One bee fourteen seconds in a flower. In fifteen minutes one to three flowers were visited. (C.C.L.)

Eldora, July 10, 1927, 4:30 p.m. Clear, warm. Bees abundant. Fifteen, twenty-five, twenty seconds in a flower. (L.H.P.)

Bloomfield, July 25, 1927, 10:30 a.m. Partly cloudy; shower during night. Bees twenty-five, twenty, fifteen seconds in a flower. (L.H.P.)

No bees on *Cichorum Intybus*, *Lycium halimifolium*, pumpkin, *Teucrium*.

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary.) Bees abundant. Forty-five, fifty, fifty-five, thirty-five seconds in a flower. (L.H.P.)

Ames, Formal Gardens, I.S.C., June 30, 1929, 12:15 p.m. Bees frequent. Two to twelve seconds in a flower. (Mrs. I. O. Webber.)

July 19, 1929. Bees fifteen to thirty-five seconds in a flower.

Dana, July 27, 1929, 10:30 a.m. Bees ten, ten, twelve, fourteen, twelve, fourteen, sixteen seconds in a flower. Gathering pollen. (L.H.P.)

Boone, Ledges, July 23, 1929. Bees abundant. (C. F. Henning.)

September 26, 1929. Clear and warm. Bees abundant. Nine, ten, eight, eleven, twelve seconds in a flower getting pollen and nectar. (L.H.P.)

October 7, 1929, 2 p.m. Bees two to fourteen seconds in a flower.

Ames, October 16, 1929, 9:30 a.m. Clear and cool. Bees abundant. Twenty-one, ten, nineteen, sixteen, four seconds in a flower. (L.H.P.)

Malva. Mallow

Herbs, with alternate leaves. Corolla folded in the bud. Seeds round kidney shape.

Malva Moschata L. Musk Mallow

A low perennial stem, leaves palmately five-parted. Flowers rose-colored.

HONEY BEE VISITS

Ames, July 31, 1929. No honey bees. *Bombus* and solitary bees. (L.H.P.)

September 11, 1929. Partly cloudy. Bees in flower twenty-six, twenty-four, twenty seconds. (L.H.P.)

July 30, 1929, 11 a.m. No honey bees. Some solitary bees and *Bombus.*

Hibiscus L. Rose Mallow

Stamens in a column, pistils united. Seeds several in each cell. Herbs or shrubs with large and showy flowers.

Hibiscus Moscheutos L. Swamp Rose Mallow

Tall perennials, with ovate pointed leaves. Petals rose-colored, capsule glabrous, beaked. Grows on river banks. Cultivated at Ames.

HONEY BEE VISITS

Ames, July 9, 1929. No honey bees observed but one of the wild bees identified by Dr. H. H. Knight as *Tetralonia speciosa* Cress was abundant, collecting pollen and nectar.

Callirhoe Nutt. Poppy Mallow

Mallow-like plants; petals wedge-shaped.

Callirhoe involucrata (T. and G.) Gray

A procumbent plant with rounded leaves, five- to seven-cleft, the segments incised. Peduncle one-flowered. Petals reddish.

Commonly cultivated in central Iowa and native to the loess bluffs of western Iowa, and sometimes extending eastward one hundred miles.

General distribution in the United States:

Kansas—Morris (Kenneth K. Mackenzie), Wichita (T. L. Andrews); Nebraska—Holdrege (J. G. McMillan), Kearney (I. C. Brownlie), Wilcox (Mrs. Joseph Clemens); Oklahoma—Norman (W. E. Bruner); Texas—College Station (L. H. Pammel), Corpus Christi bay (A. A. Heller), Tarrant county (Albert Ruth).

Mr. G. H. Cole writes, "In some years the poppy mallow bloom is heavier than in others. We have observed bees working on it frequently but have never traced honey from the source in our supers until the summer of 1924. During a particularly dry spell, when the mint was in full bloom, one of our yards east of Carthage about 10 miles, with no other apparent source of nectar, had supers partly full of a straw-colored, minty tasting honey which gave off an odor quite like that which comes from the mint. There were several large fields near this apiary and visiting them, we found the bees working heavily on the blossoms, and by pressure we were able to secure drops from individual workers which were evidently taken from the blossoms of this flower."

HONEY BEE VISITS

Ames, July 22, 1929, 9:30 a.m. Bees six to fourteen seconds in a flower.
July 24, 1929, 1:30 p.m. Heavy rain in the morning. No honey bees.

Lavatera. Tree mallow

Herbs, shrubs or trees, cultivated in gardens. Leaves maple-like. Flowers variously colored.

Lavatera trimestris L.

Branching annual. Leaves roundish. Flowers solitary, rose pink.

HONEY BEE VISITS

Ames, October 16, 1929, 9:30 a.m. Clear and cool. Bees one, one, one, one, one seconds in a flower. (L.H.P.)

VIOLACEAE, Violet Family

Herbs with irregular spurred flowers. Corolla with five petals; sepals five, distinct or nearly so. Petals often spurred. Ovary one-celled. Fruit a capsule. Leaves alternate with stipules.

Viola (Tourn.) L. Violet, Heart's-ease

Petals somewhat unequal, the lower one spurred at the base. Stamens closely surrounding the ovary, the two lower spurs projecting into the spur of the corolla.

A large genus of many species in the United States. Knuth says, "Most species of violets are bee flowers."

Viola papilionacea Common Blue Violet

With violet or blue flowers which are peduncled. Capsule ovoid-cylindric, green. This violet is widely distributed in the state and in the northern United States.

HONEY BEE VISITS

East of Bloomfield, May 7, 1928, 11:30 a.m. Clear and warm. Bees two, two, two, three, two, three seconds in a flower. (L.H.P.)

Viola pedata L. Bird-foot Violet

Nearly glabrous plant with three deeply divided leaves. Occurs on sunny slopes or gravelly soil.

Fig. 245.—Blue violet (*Viola papilionacea*). *Photo by Ada Hayden.*

Viola pedatifida G. Don.

Plants with a short rootstock. Leaves palmately divided. Occurs on gravelly soil.

Viola scabriuscula Schwein. Smooth Yellow Violet

Leaves and stems only sparingly pubescent. Flowers yellow.

FIG. 246.—At left—Yellow violet (*Viola scabriuscula*). (fl.) flower, (2) spurred petals, (n') nectariferous spur.
At right—(3 and 4) flower of pansy (*Viola tricolor*). (3)—(s) calyx, (p) pistil, (p') petal, (s) stamens.
(4)—(h) Groove to the nectary, (a) Anther spurs.
After C. M. King and Hermann Mueller.

TAMARICACEAE, Tamarisk Family

Shrubs or small trees or rarely herbs, with alternate sessile leaves, often scalelike, without stipules. Flowers regular, perfect, solitary or in spikes. Sepals and petals four or five. Stamens four. Ovary superior, one-celled with two to many ovules.

Small family of handsome shrubs, only one of which is extensively cultivated in Iowa.

Tamarix gallica L. French Tamarisk

Shrubs or small trees with slender branches, small leaves usually scalelike. Flowers small, on short stalks or sessile, in dense racemes or in panicles.

HONEY BEE VISITS

Ames, June 13, 1927, 12:30 p.m. Flowers with fine odor. Few bees. (L.H.P.) Cloudy, cool. Some bees. One to three seconds in a flower.

June 17, 1927, 10 a.m. Sunshiny. Bees abundant. One, one, one, one, one, one seconds in a flower. Flowers with odor of almond.

FIG. 247.—Tamarisk (*Tamarix gallica*). *Photo by Ada Hayden.*

June 24, 1927, 12 m. A few flowers left. No bees. (L.H.P.)

June 9, 1929, 12:30 p.m. Fairly warm. No bees. Many small Hymenoptera. (L.H.P.)

June 10, 1929, 8 a.m. Warm. No bees. Many small Hymenoptera.

Tamarix pentandra Pall. Asiatic Tamarisk

Introduced from southeastern Europe. Shrubs or small trees about ten to twelve feet high. Leaves lanceolate to ovate, acute, somewhat glaucous. Flowers pale pink in large open panicles. The flowers have a pleasing odor resembling that of vanilla. They are adapted to short-tongued insects and are visited by many flies and small Hymenoptera, occasionally some honey bees.

In 1929 we made a good many observations on the species at Ames and Des Moines, but in no case did we find honey bees. In previous years we have recorded honey bees.

Mr. W. Kuhn on June 10, 1929, observed large numbers of honey bees visiting the flowers, in Nebraska.

ELAEAGNACEAE, Oleaster Family

Shrubs or small trees with silvery-scurfy leaves; perfect or dioecious flowers, apetalous, in axillary clusters. Calyx tube with

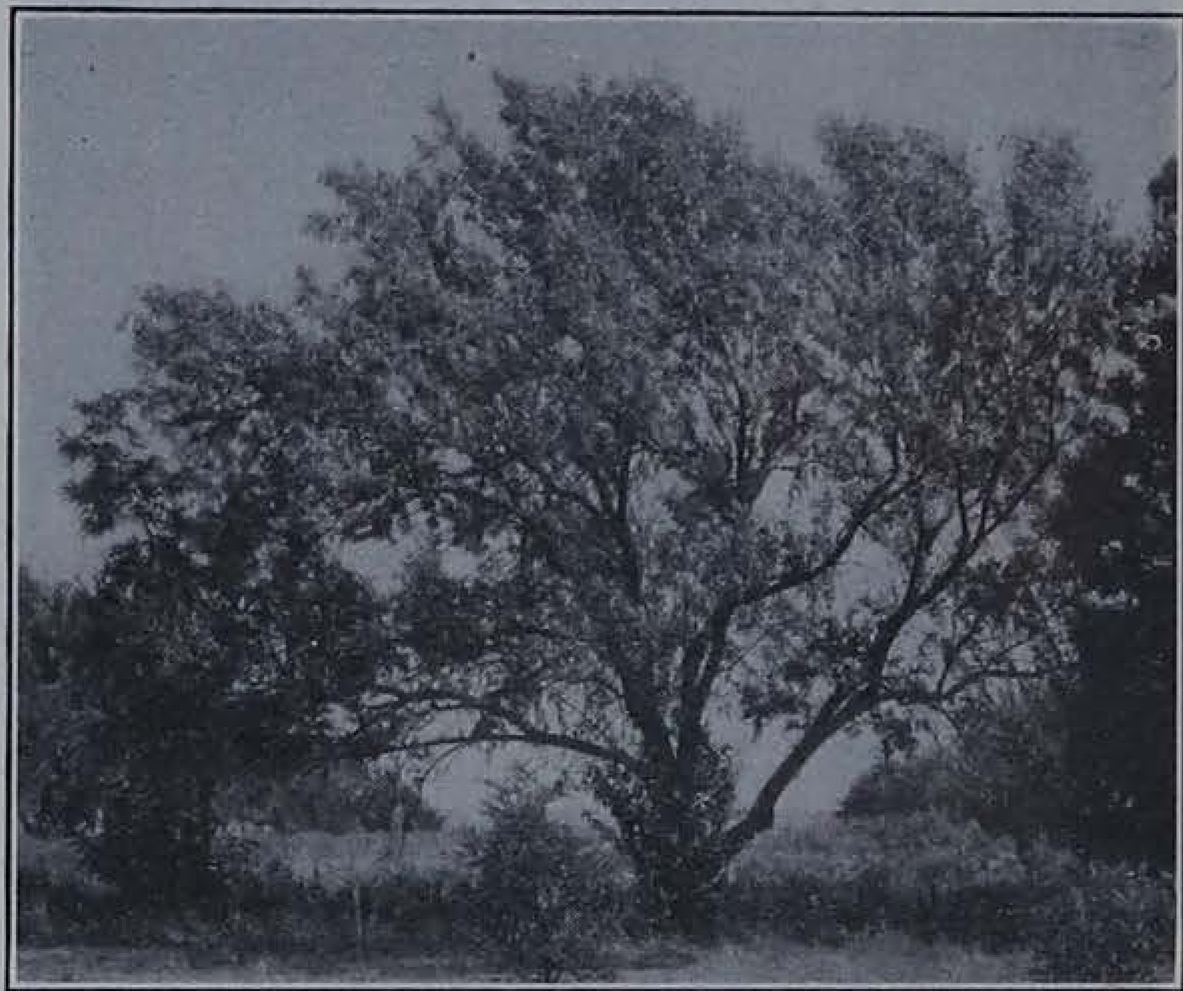

Fig. 248.—A Russian olive. This tree is 30 feet in height. Its spread of limbs exceeds its height. (By Scott.) *Courtesy Chas. A. Scott and J. C. Mohler, Kansas State Board of Agriculture.*

Fig. 249.—Oleaster or Russian olive (*Elaeagnus angustifolia*). *Photo by Ada Hayden.*

FIG. 250.—Russian olive (*Elaeagnus angustifolia*). 1. Winter twig, x 1; 2. Leafy branchlet with flower, x 1 1/2; 3. Peltate scale from the leaf, enlarged; 4. Vertical section of flower, enlarged; 5. Mature fruit, x 2; 6. Portion of a twig, showing bud and leaf scar, x 1 (original); 7. Portion of a leafy branch, reduced (original). (From Pool: Nebraska Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

a prominent disc. Stamens as many or twice as many as calyx lobes. Ovary superior, one-celled, one-ovuled. Fruit drupelike.

Elaeagnus (Tourn.) L.

Deciduous shrubs or trees, often spiny, with alternate leaves, short petioles. Dotted leaves, silvery or scurfy. Flowers axillary, solitary, perfect or polygamous, apetalous. Calyx tube bell-shaped or tubular, four-lobed. Fruit drupelike.

Elaeagnus angustifolia L. Wild Olive, Russian Oleaster

A tree of low branching form with alternate silvery, slender, lanceolate, scurfy leaves, which remain on tree; dark-colored bark. Fruit round, ovoid, mealy, nonedible.

The calyx is cylindrical with four spreading lobes. The lemon yellow lobes of the calyx advertise the flower. This later becomes paler in color. Pistils and stamens mature at the same time. Stamens four. The opening of the calyx tube is small. The lower part of the pistil is enlarged; abundant nectar is secreted at the base of the pistil.

The honey bee or other insect lights on the tip of the flower and thrusts its proboscis into the calyx cup. The flowers have a pleasant odor and while blooming are sought by bees all day. The blooming period is about five days and the yield of nectar is good. Honey bees are so numerous in time of bloom that their murmur is audible for some distance.

This handsome plant was widely distributed by Professor J. L. Budd and is one of his valuable introductions. It is naturalized in a few places in the state—in the vicinity of Ames, also in Pocahontas and Webster counties. The oleaster should be planted more than it is and be more generally recognized as a valuable honey plant.

HONEY BEE VISITS

Ames, May 31, 1914. Northwest wind. Tree in yard. Ten Hymenoptera on three hundred flowers. Flower at first bright yellow, later paler. First bloom May 1. Bee in flower five, four, six, eight seconds.

June 3, 1914. Partly cloudy. Ten honey bees, two *Bombus*, two butterflies to two hundred fifty flowers. Visit, seven seconds. (L.H.P.)

1 to 3 p.m. Southeast wind. Six honey bees and an occasional *Bombus* to one hundred flowers. Visit, one to ten seconds. Very few bees observed.

June 3, 1914, 3:30 p.m. Campus. South wind, partly cloudy. Honey bees five, seven, six, eight seconds in a flower. On two hundred fifty flowers in one minute, five bees, one bumble bee, one butterfly.

1:30 to 3 p.m. Southeast wind. Six honey bees on one hundred flowers. Bee in flower one to ten seconds. (L.H.P.)

June 1, 1917, 6:30 p.m. Honey bees abundant. (L.H.P.)

June 8, 1920, 3 p.m. Clear. Bees abundant. (L.H.P.)

June 13, 1920, 7 p.m. Three bees at work on twenty-five flowers in two minutes. (L.H.P.)

June 18, 19, 1920. Bees observed at 6:30 p.m. Flowers very fragrant.

June 2, 1922. Early bloom. 11 a.m. Sunny. Bees collecting nectar.

12 m. Partly cloudy. Numerous bees active about the tree. (C.M.K.)

June 5, 1922, 11 a.m.; 12 m.; and 2 p.m. Bees collecting nectar, as well as pollen. (L.H.P.)

June 6 and 7, 1922. As on 5th. Tree very fragrant.

June 9, 1922, 4 p.m. Sunshiny, light breeze. Many bees. Two, three, two, one seconds in a flower.

June 10, 1922, 7 a.m. Bright, windy. No bees.

6 p.m. Numerous bees. (L.H.P.)

June 1, 1923, 1:30 p.m. Cool, cloudy. Only a few bees. Three, four, three, two, two, three seconds in a flower. (C.M.K.)

May 20, 1926. Bright, sunny. Flowers abundant. Freely visited by bees.

Manhattan, Kansas, May 16, 1927, 5:15 p.m. Clear, sunshiny. Bees abundant. Three, four, three, four, five, five, four, three seconds in a flower. (L.H.P.)

May 17, 1927, 2 p.m. Warm. Bees two to four seconds in a flower.

Ames, June 4, 1927, 11 a.m. Warm, sunny. Just in flower. Some bees. Six, five, six, five, six, six seconds in a flower. (L.H.P.)

June 5, 1927, 10 a.m. North wind. No bees. (L.H.P.)

June 9, 1927. Clear, south wind. Only a few bees. (L.H.P.)

June 10, 1927, 2 p.m. Bees abundant. Four, four, three, five, four seconds in a flower. (L.H.P.)

June 13, 1927, 12:30 p.m. Flowers fragrant. No bees. (L.H.P.)

June 16, 1927, 10 to 11 a.m. Windy, cool, hazy. Bees made twenty-seven visits to one cluster of bloom in one hour. Bloom very fragrant. (C.C.L.)

June 17, 1927, 10 a.m. Sunshiny. A few flowers still left. No bees.

June 3, 1929, 12:30 to 2 to 5:30 p.m. No bees present though abundant on *Melilotus officinalis* near by.

June 5, 1929, 2 p.m. Warm. No bees. 2:15 p.m. Few bees. Six, seven, eight seconds in a flower. (L.H.P.)

Date of bloom, 1925, Ames, May 26.

Shepherdia Nutt. Buffalo Berry

Shrubby plants with opposite leaves and sessile flowers. Flowers dioecious, sterile. Four-parted calyx. Stamens eight. Style slender.

Shepherdia argentea Pursh. Silverberry

A thorny shrub. The flowers are dioecious; the staminate flowers with a four-parted calyx and eight stamens; the pistillate with an urn-shaped, four-cleft calyx. Fruit berry-like.

The buffalo berry occurs native only in western Iowa. It is sometimes cultivated.

Freely visited by bees, at Ames.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, cultivated (three specimens, F. A. Sirrine), Sioux City (four specimens, L. H. Pammel, Mrs. H. J. Taylor).

General distribution in the United States:

Colorado—Cache la Poudre river (L. H. Pammel), Montrose (Edwin Payson); Minnesota—Crookston (three specimens, Mrs. Roy Westley), Pipestone; Montana—Billings (L. H. Pammel); Nebraska—Halsey (J. C. Blumer), Willow Island (Joseph Wahl), Scott's Bluff (T. G. Miller); Nevada—Reno (A. A. Heller); South Dakota—Watertown (L. H. Pammel).

LYTHRACEAE, Loosestrife Family

Herbaceous plants. Leaves opposite and without stipules; flowers in axillary or whorled clusters; campanulate calyx; petals four to seven or wanting, enclosing the many-seeded ovary.

Lythrum L. Loosestrife

Slender herbs with opposite entire leaves. Petals six, stamens six to twelve. Flowers nearly regular, pinkish.

Knuth says, "Flowers are red, with concealed nectar secreted at the bottom of the tubular receptacle."

Lythrum alatum Pursh. Loosestrife

A smooth, slender, perennial herb; the leaves small, oblong; deep purple flowers borne in the axils. Petals six, stamens six.

The purple loosestrife is common in swamps, bogs and low grounds, in sandy or gravelly moist places, and on shores of lakes, from Ontario westward to Minnesota and southward. It is widely distributed in Iowa in bottom lands, near ponds and ditches, and in sloughs and low places in prairies.

It is associated with *Cicuta maculata, Ranunculus pennsylvanicus, Anemone pennsylvanica, Thalictrum dasycarpum, Melanthium virginicum, Lobelia siphilitica, Carex vulpinoidea, Phalaris arundinacea, Geum macrophyllum, Cornus Amomum, Salix discolor, S. longifolia, S. rostrata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

De Witt, Des Moines, Fairbanks, Fertile, Forest City, Mason City, Ogden, Otter creek, Postville, Riverside, Warren county, Wheelerwood (L. H. Pammel), Cedar Rapids, Eagle Grove (R. E. Buchanan), Ames (R. E. Jeffs), Cerro Gordo county (M. Jones), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Fraser (Botany Party), Kelley (Pearl Clayton), Osage (Mrs. Tuttle), Peru (D. E. Hollingsworth), Pocahontas (J. Meehan), Skunk river (Paul Bartsch), Slater (two specimens, W. D. Tener, H. S. Fawcett, C. Reinbott), West Bend (R. I. Cratty).

It has been observed (L. H. Pammel) at Centerville, Cherokee, Clinton, Dubuque, Fort Dodge, Keokuk, Lake Okoboji, Mount Pleasant, Muscatine, New Albin, Waukon.

General distribution in the United States:

Illinois—Rantoul (H. A. Gleason), Chicago (two specimens, L. H. Pammel), Fox (L. H. Pammel and V. C. Fisk); Indiana—Wells county (Charles C. Deam); Kansas—Quindaro, Wichita, (Kenneth K. Mackenzie); Louisiana—Alexandria (C. R. Ball); Minnesota—Benson, Graceville (L. H. Pammel), Backus (Ada Hayden), St. Cloud (R. Gmelin); Nebraska—Halsey (J. C. Blumer); Ohio—Lancaster—(Asa Horr); Oklahoma—Little River (A. W. Van Vleet); South Dakota—Brookings (L. H. Pammel); Tennessee— (T. L. Andrews); Texas—Corpus Christi (A. A. Heller), Austin (B. C. Thorpe), Hempstead (L. H. Pammel); Wisconsin—Devil's Lake (Mr. and Mrs. L. H. Pammel), St. Croix Falls, La Crosse, Madison (L. H. Pammel, J. R. Heddle), Geneva (George W. Carver).

HONEY BEE VISITS

The flowers grow in large masses and are very attractive to insects. Nectar is concealed at the bottom of the tubular receptacle.

Bee keepers report that bees work upon it freely during its long period of bloom.

Robertson does not mention the honey bee on this *Lythrum*, although a number of different bees are recorded.

Ames, July 17, 1914, a.m. Clear, northwest wind. Many wild bees. Few Diptera seeking nectar. Thirty of these insects visit a flower each hour. They change between this plant and *Melilotus*. (G.H.M.)

July 25, 1924, 5 p.m. Clear. Honey bees abundant. Two seconds in a flower, getting honey, which is freely secreted.

Lythrum Salicaria L. Spiked Lythrum

An erect, much branched perennial attaining a height of three feet. Leaves smooth or pubescent, opposite, in whorls of three, lanceolate. Flowers purple, in whorls, trimorphic—that is, flowers on one plant with long styles, medium length stamens and short stamens; second type with short style, medium length stamens and long stamens, and third type with short style, medium length stamens and short stamens.

POLLINATION AND HONEY BEE VISITS

The studies of Darwin on trimorphism were made on this species.

Delpino investigated the mechanism of the flower and found that in order to get seed the pollen must come from a stamen of the same length as the pistil; that is, the pollen from short stamens must be taken to a short style, the pollen from long stamens to a long style, and pollen from a medium long stamen to a medium long style. That is to say, when pollen from a long stamen is placed upon a short style, seed will not be produced, etc. The nectar is secreted by the fleshy disc of the receptacle surrounding the short stalk of the ovary and filling the space between this and the receptacular wall. The red inner surface of the calyx and the dark veins of the petals (which converge to the middle of the flower) serve as nectar-guides. The lower petals are directed obliquely upward, while the upper pairs spread out vertically. The insect uses the stamens and style as a resting place to get the nectar.

Ames, July 17, 1927, 11:30 a.m. Bees abundant. Two, two, two, three, two seconds in a flower. Near apiary. (L.H.P.)

July 22, 1927, 11 to 12 a.m. After rain. Cloudy, warm. Several bees collecting honey. Two, four seconds in a flower. (C.C.L.)

5 to 6 p.m. Dry, warm, windy. Bees two to four seconds in each flower. (C.C.L.)

July 31, 1927, 10:30 a.m. Clear, warm, northwest wind. Bees abundant. Two to three seconds in a flower. *Pieris rapae* also frequent.

July 21, 1928, 4:20 p.m. Bees two seconds in a flower.

August 4, 1928. One, one, one, one, one second in a flower. (L.H.P.)

In 1928 bees were very active on this species.

June 27, 1929. Bees two, two, three, two, two seconds in a flower.

July 1, 1929, 1:30 p.m. Bees two, two, two, two, one seconds in a flower.

July 4, 1929. No bees. This species was in the same vicinity as *Veronica spicata*, *Anchusa italica*, and crimson rambler rose, all of which were visited by bees. Some days bees are abundant on *Lythrum Salicaria*.

July 19, 1929, 1:15 p.m. Bees abundant. Two, two, two, two, three, one seconds in a flower. This is one of the most consistent honey plants.

July 22, 1929. Bees two, two, two, three, two, one seconds in a flower.

July 26, 1929, 2 p.m. Bees two seconds in a flower.

July 30, 1929. Some bees. One, one, two, two, two seconds in a flower.

August 1, 1929, 10:30 a.m. Bees two seconds in a flower.

August 2, 1929, 2:30 p.m. Warm, partly cloudy. Bees two, two, two, three, one, two seconds in a flower. (L.H.P.)

Blairstown, September 28, 1929, 2 p.m. Some bees. Two, three, two, three seconds in a flower.

ONAGRACEAE, Evening Primrose Family

Herbs having simple leaves without stipules, or with mere traces, and with perfect symmetrical flowers usually in fours, borne in spikes, racemes or solitary; style single, slender, two- to four-lobed, ovary wholly inferior; fruit a capsule, many-seeded, seeds naked, sometimes with a tuft of hairs.

Epilobium L. Willow-herb

Perennial two to three feet tall. Leaves lanceolate, pinnately-veined. Flowers magenta-colored. Fruit a capsule with tufted seeds.

Epilobium angustifolium L. Fireweed

Not abundant in Iowa. Found in a few places in the northeastern part of the state—Clayton, Allamakee and Winneshiek counties, and occasionally in Delaware county. Very widely distributed in eastern North America and in the Rocky Mountain and Pacific coast regions.

This is one of the very valuable honey plants of North America, especially in burnt-over areas.

It is mentioned by Pellett as a valuable honey plant. He states that it is a source of much nectar from Canada to the Pacific coast. He also states that nectar may be secreted two or three years in abundance and then there will likely not be a surplus for several years, owing to the shifting condition of the flora.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Emmet county, Waukon (R. I. Cratty), Decorah (E. W. D. Holway), Oneida Junction (L. H. Pammel).

General distribution in the United States:

Arizona—San Francisco mountains (D. T. MacDougal); Colorado—Arapahoe National Forest, Camp Uray, Fraser, Larimer county (L. H. Pammel), Berthoud Pass (D. S. Jeffers), Fall river (H. I. Featherly), Fort Collins (Ada Hayden), Fraser (L. H. Pammel, R. A. Pearson), Manitou (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank Raney), Ward (R. E. Buchanan); Idaho—Big Boulder creek (Kaing and Woods); Massachusetts—Concord (Blankinship), Hammond's Pond (L. H. Pammel); Michigan—Lake Au Train, Stambaugh (L. H. Pammel), Iron county (Watkins and Rolfe), Mackinac Island (R. I. Cratty); Minnesota— Cass Lake, Itasca State Park, Leech Lake, Walker (L. H. Pammel), Backus (Ada Hayden), Black Duck, International Falls (Mrs. Roy Westley), Brainerd (E. B. Watson), Minneapolis (R. I. Cratty), St. Cloud (R. Gmelin); New Mexico—Las Vegas (Bro. G. Arene); New York—Durant (R. S. Horner), Ithaca (H. E. Summers), Oregon—Crook county, Redmond (Kirk Whited), on the coast (L. H. Pammel, W. S. Dudgeon); Utah—Red Banks (A. Isabel Mulford), Peterson (L. H. Pammel, R. E. Blackwood); Vermont—Peacham (Ferdinand Blanchard); Washington—Seattle (Miss S. L. Goodspeed); Wisconsin—Bloomingdale, La Crosse, Moose lake, Mormon coulee (L. H. Pammel), Merrill (L. H. Pammel and V. C. Fisk), Portland (L. H. Pammel and C. M. King); Wyoming—Garfield Peak, Nash's Fork (Aven Nelson), Medicine Bow mountains (Reppert and Witter), Yellowstone canyon (Aven and Elias Nelson), Yellowstone Park (R. O. White).

John Lovell states that this plant usually blooms in July and August, but is affected by latitude, altitude and rainfall. The nectar is secreted by the ovary, where it is protected from rain and yet is easily accessible to insects.

Lovell reports bumble bees, solitary bees and butterflies. Knuth and Loew both report honey bees as frequent visitors in Germany.

In burnt over lands of some northern states it has a long blooming period and is important as a honey source where bees are kept.

Blooming, Escanaba, Michigan, to Milwaukee, Wisconsin.
August 12, 1927. No bees. (L.H.P.)

Gaura L. Gaura

Herbs with many-seeded pod. Leaves alternate, sessile; flowers pinkish, small.

Gaura biennis L. Gaura

A downy plant about three feet high; leaves oblong-lanceolate. Spikes of flowers wandlike, fruit downy, four-angled, acute at both ends, ribbed. Dry banks, western Quebec to Connecticut, Minnesota, Nebraska and southward.

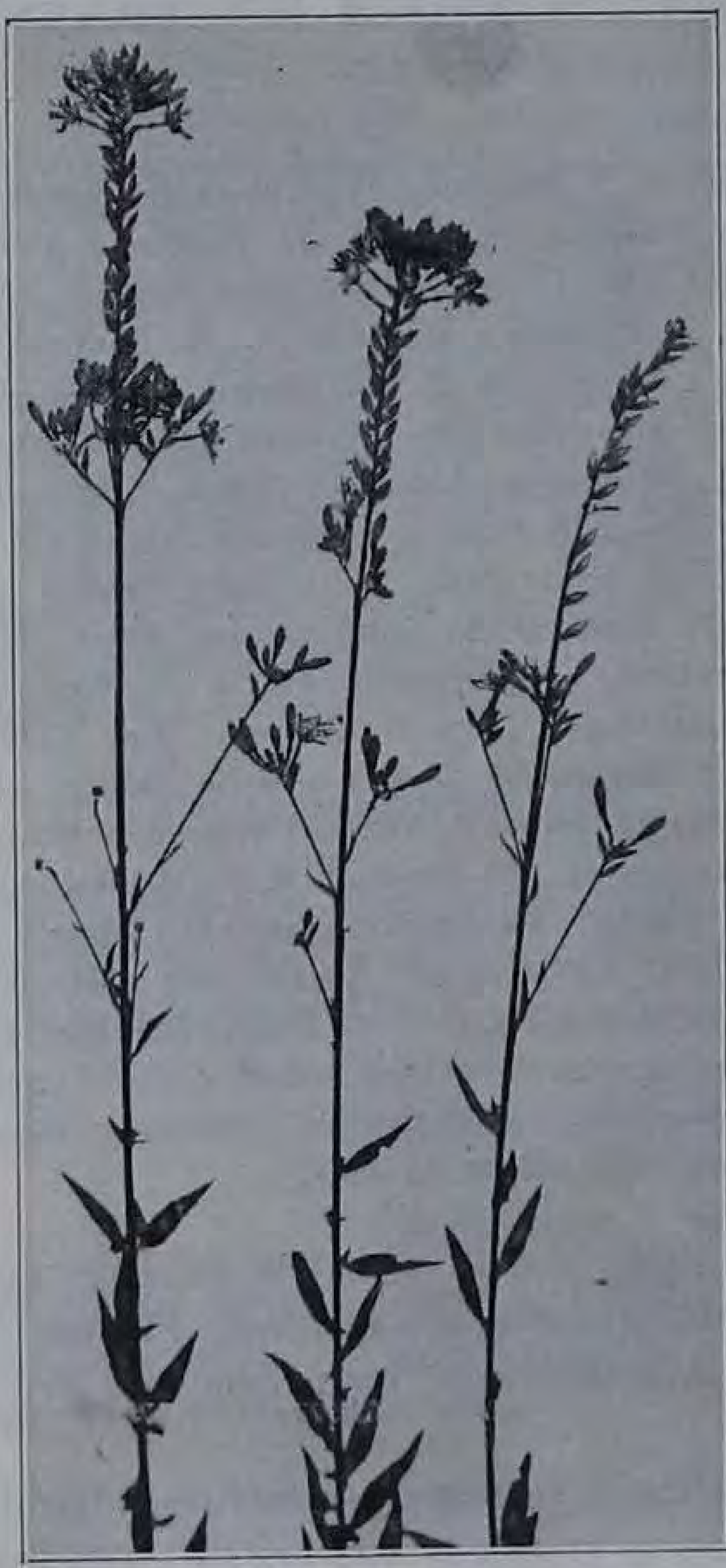

FIG. 251.—Biennial gaura (*Gaura biennis*). *Photo by G. H. Munger.*

This is a common plant of clay soils throughout southern Iowa. Associated with *Salvia lanceaefolia, Oenothera biennis, Solidago canadensis, Aster multiflorus.*

John Lovell reports that this flower is visited by bees in some seasons. Robertson reports the honey bee upon this plant. We have observed it also in Iowa.

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:
Arcadia, Camanche, Carroll, Coon Rapids, Des Moines, Indianola, Marion county, Onawa, Winterset (L. H. Pammel), Cedar Rapids (R. E. Buchanan, E. O. Arnold), Clinton (Violet Blake), Davenport (C. C. Parry), Decatur county (J. P. Anderson), Dexter (Mrs. B. C. Hemphill), Fremont county (T. J. and M. F. L. Fitzpatrick), Keokuk (Iza Mitchell), McGregor (A. Hayden), Muscatine (F. Reppert), Ontario (R. Burgess), Skunk river valley (P. Bartsch).

FIG. 252.—Biennial gaura (*Gaura biennis*) in an oat field two miles west of Oskaloosa, July 17, 1927. *Photo by Harry Nichols.*

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Arkansas—Lawrence county (P. H. Rolfs); Colorado—Fort Collins (C. S. Crandall); Illinois—Pullman (L. H. Pammel), Rantoul (H. Gleason); "Indian Territory"—eastern Oklahoma (L. H. Pammel); Missouri—St. Louis (H. Eggert); Nebraska—Sheridan county (R. E. Buchanan); New York—Ithaca (Muenscher and Bechtel); North Dakota—Bismarck (Sadie Lauterman); Ohio—Mansfield (E. Wilkinson); Oklahoma—Norman (W. E. Bruner); Virginia—Great Falls of the Potomac (C. R. Ball).

HONEY BEE VISITS

Keokuk, Illinois side. June 14, 1914. Collected in flower. (L.H.P.)
Clinton, Illinois side, June 14, 1914. Ten flowers on one plant were visited in thirty-five seconds. (L.H.P.)
Keokuk, June 16, 1914. Blooming. Bees abundant. (L.H.P.)
September 9, 1918. Bees gathering pollen. (L.H.P.)
Walnut, Illinois, September 14, 1918. Common in the woods. Bees abundant.

Gaura coccinea Pursh. Red Gaura

This species is gray, pubescent; may grow to be two feet tall, leafy. Leaves lanceolate, nearly entire. Flowers in spikes, rose-colored. There are four unequal, clawed petals. Lobes of calyx reflexed. Fruit fusiform, four-angled and acute at both ends.

Is fairly abundant. Occurs on the loess bluffs in western Iowa and westward and is freely visited by bees. Some observations were made in 1928.

Associated with *Oxytropis Lamberti, Dalea laxiflora, Dalea* *alopecuroides, Pentstemon grandiflorus, Yucca glauca, Sporobolus brevifolius, Bouteloua oligostachya, B. curtipendula, Phlox pilosa.*

This plant is the source of some nectar. In regard to *Gaura coccinea* Pellett makes the statement that it is much sought by bees for both nectar and pollen. The nectar is abundant, but is not common enough to be important. "A good stimulant."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Turin (two specimens, L. H. Pammel).

It has been observed (L. H. Pammel) at Council Bluffs, Hamburg, Hawarden, Missouri Valley, Pisgah, Sioux City.

Gaura parviflora Dougl.

Puberulent plant 3 to 5 feet high. Leaves ovate-lanceolate. Spikes dense. Fruit 4-nerved, narrowed at ends.

Also found in western Iowa. Observed (L. H. Pammel) at Council Bluffs, Hamburg and Glenwood. This may be included with honey plants. Pellett mentions it as a source of nectar in Texas.

General distribution in the United States:

Arizona—Flagstaff (D. T. MacDougal); Colorado—Fort Morgan, Manitou (L. H. Pammel), Denver (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Fort Collins (Reppert and Witter), Greeley (C. S. Crandall), Trail Glen (F. E. and C. E. Clements), Trinidad (A. Isabel Mulford); Kansas—Tribune (A. P. Anderson); Montana—Anaconda (J. C. Witham), Billings (I. S. Hunt); Nebraska—Alma, Grand Island (L. H. Pammel), Scott's Bluff (F. G. Miller), Sheridan county (R. E. Buchanan), Wilcox (Mrs. Joseph Clemens); New Mexico—Fort Bayard (A. Isabel Mulford), Towana county (F. W. Werkenthin); North Dakota—Mandan (John Craig); Oklahoma—Caddo county (W. E. Bruner); South Dakota—Brookings (D. Griffiths, E. C. Pammel), Mount Vernon (B. Trenk), Spearfish canyon (C. M. King); Wyoming—Carbon (L. H. Pammel), Kimball (L. H. Pammel and Ira C. Brownlie), Sybille, Ura (Aven Nelson).

UMBELLIFERAE, Carrot Family

Herbaceous plants, stem generally hollow, petioles often dilated; leaves alternate, generally compound. Flowers in simple or compound umbels or capitate, small, proterandrous, with rather strong pleasing odor. Calyx entire or five-toothed, the tube wholly adnate to the ovary, petals five, stamens five, inserted on the epigynous disc; fruit dry, consisting of two seedlike cohering carpels.

The carrot family is interesting with reference to what is known as geitonogamy, or fertilization by pollen from neighboring flowers. Knuth has the following to say:

"When the filaments elongate their pollen-covered anthers come in contact with the mature stigmas of neighboring flowers, in consequence of the divergence of the styles. In *Sanicula, Astrantia* and *Laserpitium,* there is a deviation from this form of geitonogamy owing to the fact that pollen flowers as well as hermaphrodite ones are present; but here again the same thing happens, because the elongating stigmas can take up pollen."

Honey bees are not numerous on members of this family. Hermann Mueller records them on several of the European species of *Eryngium.* Kerner reports the honey bee upon *Conium maculatum* or poison hemlock. Honey bees are reported on the carrot by Knuth and other European investigators, also on *Anthriscus* by Loew. Generally speaking, the small Diptera and Hymenoptera are abundant.

Mr. Charles Robertson, who has studied the pollination of many of these plants, states, "Bees also appear to be equally common throughout, only *Zizia* and *Pastinaca* showing more species than *Erigenia.* The flowers with concealed nectar and those blooming in early spring are most favorable to them."

Robertson reports Apidae upon the following species: *Zizia aurea, Osmorrhiza longistylis, Sanicula marilandica, Heracleum lanatum, Pastinaca sativa, Cicuta maculata, Eryngium yuccaefolium.*

Knuth says of the carrot family, "The Umbelliferae have small flowers aggregated into larger inflorescences. Nectar is secreted by an epigynous disk and lies freely exposed in the middle of the flower." Charles Robertson says, "The Umbelliferae have remarkably uniform flowers, the nectar being generally exposed, or at most only slightly concealed by the incurved petals."

Pellett states that the cultivated parsnip is a valuable honey plant in a few places and that the common carrot yields some honey. Root also mentions the parsnip as having some value, as well as celery and carrot. This latter plant is widely naturalized in this state, but we have not had opportunity of noticing honey bees on it.

The carrot is mentioned as a honey plant by Lovell in "Honey Plants of North America," especially in the Sacramento valley, but the statement is made that the plant yields nectar only about once in ten years.

Eryngium (Tourn.) L.

Perennials with toothed, cut leaves. Calyx teeth prominent, rigid and persistent.

Eryngium amethystinum L.

A cultivated form.

HONEY BEE VISITS

Ames, July 9, 1929, 2 p.m. One, one, one, one, one seconds in a flower.
July 11, 1929, 12:15 p.m. Some honey bees. (L.H.P.)
July 18, 1929, 8:30 a.m. Flies and other Diptera. No honey bees.
July 25, 1929, 8:30 a.m. Some bees. One, one, one, one, one seconds in a flower. Many Diptera. (L.H.P.)

Pastinaca L. Parsnip

Yellow-flowered biennial plants with grooved stems.

FIG. 253.—Wild parsnip (*Pastinaca sativa*). *Photo by Ada Hayden.*

Pastinaca sativa L. Wild Parsnip

A tall, stout, glabrous biennial with grooved stem; leaves pinnately compound, cut-toothed; flowers yellow, small; calyx teeth obsolete; fruit oval, flattened dorsally, the lateral ribs with broad wings.

Wild parsnip is widely distributed in all parts of the state, in roadsides, fence rows, gardens, vacant lots and wood-lots.

Naturalized everywhere in clay and black humus, sandy and calcareous soils. Associated with *Arctium major, Lactuca scariola, Ambrosia trifida, Zizia aurea, Rumex crispus.*

Charles Robertson says, "The large umbels of yellow flowers are very attractive to insects. The nectar is freely exposed."

He records no bees.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, Harlan, Sac City (two specimens, L. H. Pammel), Ames (L. H. Pammel and M. Clapper), Dubuque county (T. J. and M. F. L. Fitzpatrick), Kelley (Pearl Clayton), Winneshiek county (Holway).

It has been observed (L. H. Pammel) at Algona, Burlington, Cedar Rapids, Center Point, Centerville, Cherokee, Clinton, Council Bluffs, Cresco, Davenport, Des Moines, Eldora, Emmetsburg, Estherville, Fairfield, Fort Atkinson, Fort Dodge, Glenwood, Granite, Hamburg, Hampton, Indianola, Iowa City, Keokuk, Keosauqua, Little Rock, Marshalltown, Mason City, McGregor, Missouri Valley, Mount Pleasant, Muscatine, New Albin, New Hampton, Onawa, Pisgah, Postville, Rock Rapids, Shenandoah, Sioux City, Union, Wapello, Waukon, West Liberty.

General distribution in the United States:

Illinois—Blackberry (B. Fink), Pecatonica (L. H. Pammel and V. C. Fisk); Indiana—Crawfordsville (W. H. Evans); Minnesota—International Falls (L. H. Pammel); New York—Ithaca (H. E. Summers); Utah—Logan (A. Isabel Mulford); Wyoming—Sheridan (Ferdinand Reppert, A. Estella Paddock and Sarah Ellis).

HONEY BEE VISITS

Ames, June 27, 1914. Roadside. Partly cloudy, strong west wind. Two bees per umbel per minute. (G.H.M.)

June 29, 1914. Cloudy, southwest wind. Two per umbel per minute. (G.H.M.)

Pilot Mound, June 16, 1929, 12:30 p.m. Only a few honey bees. One, one, one, one second in a flower. Many Diptera and small Hymenoptera. (L.H.P.)

Des Moines, June 24, 1929. No bees. One thousand feet from an apiary.

Honey bees are not commonly seen upon wild parsnips in Iowa. The small yellow flowers of the parsnip are borne in widely spread clusters and the nectar is unprotected. The bloom is visited by a great number of visitors, including honey bees. Mr. Robertson records 375 insects, of which forty species are beetles. There is a slight amount of honey, but the plant is not an important honey plant, even though there are enormous quantities of wild parsnip in the state.

We have had occasion to examine a good many flowers, but have

Anethum graveolens L. Dill

Erect, smooth branching plant, leaves finely dissected, fennel-like. Garden annual. Occasionally found on waste ground.

HONEY BEE VISITS

Des Moines, June 24, 1929. No bees. One thousand feet from an apiary.

CORNACEAE, Dogwood Family

This group is not of importance to beekeepers. Some honey is occasionally obtained from them.

Cornus L. Cornel, Dogwood

Our species, shrubs with perfect flowers, small two-seeded drupe. Leaves opposite. Flowers in open clusters.

Knuth states that the nectar is exposed, secreted in a ring surrounding the style. Several species in Europe have apparently not been widely investigated with reference to pollination.

Cornus Amomum Mill. Silky Cornel

A shrub three to nine feet high with purplish branches, the young branches silky. Leaves elliptical, pointed, silky, downy beneath. Flowers white in flattened cyme. Fruit blue.

This species is widely distributed in eastern and central North America. Common along streams in Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Auburn, Ankeny, Beaver Junction, Belle Plaine, Bellevue, Boone county, Centerville, Charles City, Clayton, Colfax, Davenport, Estherville, Forest City, Jackson Junction, Lake Mills, Lake View, Lost Island lake, Lyons, Madison county, Minerva, Muscatine county, Nashua, New Albin, Oelwein, Ottumwa, Palo Alto county, Rochester, Spirit Lake, State Center, Traer, Waukon, Warren county, Wheelerwood (L. H. Pammel), Bloomfield (C. G. Koebke), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson), Emmet county (R. I. Cratty, B. O. Wolden), Fayette (Bruce Fink), Fort Dodge (F. W. Paige), Grundy Center (L. H. Pammel and B. B. Zimmerman), Keokuk (F. H. Rolfs), Lamont (I. T. Bode), Oto (H. B. Clark), Volga (Hazel E. King), Waukon Junction (O. Schultz).

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Colorado—Minnehaha (F. E. and E. S. Clements); Connecticut—Wethersfield (Charles Wright); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Massachusetts—Ipswich (Thomas Murray); Michigan—Muskegon, St. Ignace (L. H. Pammel); Minnesota—Clear Lake, Jefferson, Leech Lake, Walker (L. H. Pammel), Anoka, Coleraine (R. I. Cratty); Missouri—St. Louis (H. Eggert); Nebraska—Pine Ridge (J. C. Blumer), Willow Island (J. C. Wahl); New York—Ithaca (H. E. Summers), Renwick Flats (Muenscher and Bechtel); South Carolina—Oconee (A. P. Anderson); South Dakota—Sioux Falls (L. H. Pammel); Wisconsin—Bangor, Kilbourne, Madison, Prairie du Chien (L. H. Pammel).

HONEY BEE VISITS

Ames, June 16, 1927, 8 a.m. No bees.

10:30 a.m. Bees abundant, getting pollen and nectar. Bees two, two, two, one, two, two, three, two seconds in a flower. (L.H.P.)

June 17, 1927, 12 m. A few bees, many flies. Bees eight, six, ten seconds in a flower getting nectar. (C.M.K.)

June 17, 1927. Odor of flower strong, not unpleasant. Bees abundant. Number of flowers in one cluster from sixty to seventy-five. Two bees on one flower in five minutes, or at the rate of about 160 visits per day of eight hours. (L.H.P.)

4 to 5 p.m. Warm, cloudy, windy. Bees freely at work. (C.C.L.)

6 p.m. Clear. Bees two to four seconds in a flower. Very numerous.

Ames, June 18, 1927, 12 m. Bees abundant. Two seconds in a flower.

June 19, 1927, 8 a.m. Several bees, getting nectar.

10 a.m. Clear, sunshiny, warm. Bees abundant. Two to three seconds in a flower.

6:30 p.m. Warm showers at 4:30 p.m.m Bees one to two seconds in a flower.

June 21, 1927, 8 a.m. Bees one to two seconds in a flower.

12:30 p.m. Bees one to two seconds in a flower. (C.M.K.)

6 p.m. Warm, sunny. Some bees. One second in a flower.

June 22, 1927, 8 a.m. and 12 m. Cloudy, damp. No bees. (L.H.P.)

June 23, 1927, 1 p.m. Few flowers left. Few bees. Bees two, two, two, two, one, one, two seconds in a flower.

Story City, June 19, 1927, 3 p.m. Warm, sunshiny. No bees. Bee hives near by. (L.H.P.)

Davenport, May 14, 1928. Warm, partly cloudy. No bees. Bees working on *Lonicera Morrowi* near by. (L.H.P.)

Ames, June 14, 1928, 11 a.m. Bees, two, two, two, two, two seconds in a flower. Near *Ligustrum vulgare*, which had more visitors. (L.H.P.)

June 15, 1928, 9 a.m. Clear, cool. Bees two seconds in a flower.

June 16, 1928, 2 p.m. Warm, windy. Bees common. Two, three, two, three, two, two seconds in a flower. (L.H.P.)

June 17, 1928, 11:30 a.m. Bees two, two, two, two seconds in a flower. Flowers fragrant. (L.H.P.)

May 23, 1929, 5 p.m. Clear, windy. Bees abundant. One, one, one, one seconds in a flower. (L.H.P.)

June 15, 1929, 8:30 a.m. No honey bees. (L.H.P.)

Cornus paniculata L'Her. Dogwood

Branches gray, smooth. Leaves ovate-lanceolate, whitish beneath. Fruit white, on red pedicels.

Widely distributed in Iowa and in eastern North America.

FIG. 255.—Dogwood (*Cornus paniculata*). *Photo by Ada Hayden.*

HONEY BEE VISITS

Ames, June 20, 1927. Some bees. Honey on receptacle at base of petals.
Boone and Ogden, June 25, 1927, 10 a.m. Clear, warm. A few bees. (L.H.P.)
Ames, June 25, 1927, 6 p.m. No bees. (C.M.K.)
July 1, 1927. Bees common. One, one, one, one seconds in a flower.
July 3, 1927, 12 m. Cool, east wind. Bees common. One, one, two, two, two seconds in a flower. (L.H.P.)
July 4, 1927, 12 m. Bees one to two seconds in a flower.

Blooming Ames, May 10, 1925.

Cornus sp.

Ames, Campus, near water tower, June 27, 1927, 4 to 5 p.m. Warm, dry, windy. Fragrant. Bees frequent. Twenty-one visits in one hour to a cluster of bloom. (C.C.L.)
Ames, 1929. No bees observed on a plant under observation for a week.

Cornus sanguinea Forsk. Blood-red Dogwood

Shrubs ten to twelve feet high. Branches red, leaves broadly elliptical or often pointed, slightly pubescent beneath. Flowers greenish white, in dense cymes. Commonly cultivated for ornamental purposes. Occasionally visited by honey bees.

According to Mueller in speaking of *Cornus sanguinea*: "The stamens and stigmas develop simultaneously. The anthers are introrse and at the same level as the stigma."

Quoting from Knuth, Mueller says, "The larger insects that alight on the inflorescence or on a single flower will, therefore, when licking the nectary, usually touch an anther or two with one side of their heads and the stigma with the other. Should they creep further on the same inflorescence or visit another, cross-pollination will be favored."

Cornus florida L. Flowering Dogwood

Tree from fifteen to twenty-one feet in height, ovate; pointed leaves, with an acute base; clusters surrounded by four showy corolla-like white involucral bracts sometimes tinged with pink; fruit ovoid; common from Maine to Florida and Texas; native as far north as Missouri; sometimes cultivated in southeastern Iowa.

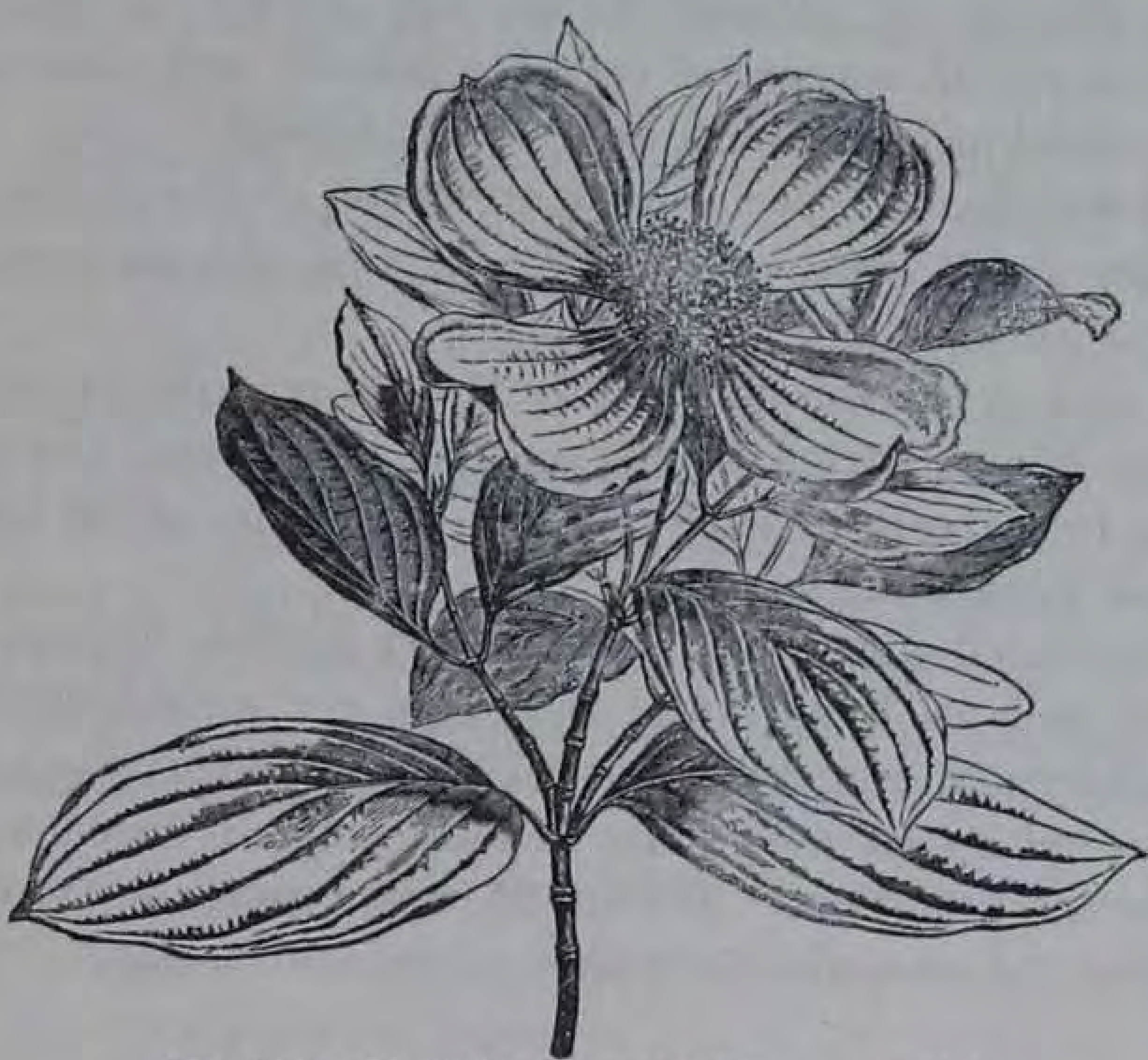

FIG. 256.—Flowering dogwood (*Cornus florida*).

Frequently visited by bees in the south, particularly in Florida. We have not been in southeastern Iowa when the plant was in bloom and therefore do not know whether it is visited by honey bees there, but presumably it is, at Davenport, Burlington and Keokuk.

ERICACEAE, Heath Family

Shrubs or occasionally trees or herbs. Opposite verticillate leaves; flowers regular or nearly so. Stamens as many or twice as many as the lobes of the corolla, inserted on the disc. Anthers commonly with appendages. Pollen of four united grains. Ovary two- to five-celled. Fruit a berry, drupe or capsule.

Few members of the family are native to Iowa.

Gaylussacia baccata (Wang.) C. Koch. Black Huckleberry

Shrub, lightly pubescent when young. Oval leaves with shining resinous globules; flowers in short racemes. Corolla more or less conical. Fruit black. Occurs in the southeastern part of the state.

Vaccinium pennsylvanicum Lam. Dwarf Blueberry

Green warty stems; branches smooth or pubescent. Leaves lanceolate or oblong, serrulate, bright green. Corolla short and bell-shaped. Found in northeastern Iowa in Jackson county.

Several species of *Rhododendron* are grown in cultivation. Among these are *R. maximum* (greater laurel), and sometimes the mountain laurel or calico bush of the same family.

Of the herbs several species of wintergreen or *Pyrola* are native. Among these are *P. americana* and *P. elliptica,* also the Indian pipe (*Monotropa uniflora* and *M. Hypopitys*).

Several species furnish honey. Mr. Pellett records that a surplus of honey is obtained from four species of *Vaccinium,* and we have seen honey bees freely in some parts of Wisconsin on the blueberry (*Vaccinium pennsylvanicum*).

Mr. John Lovell states that the blueberry in New England yields fine honey, and we have found that bees get considerable honey from blueberries and huckleberries in Florida and northward.

Arctostaphylos Uva-ursi occurs in southwestern Wisconsin a few miles from the Iowa line. Doctor Shimek reports it from northeastern Iowa. *Azalea* also furnishes pollen and nectar.

PLUMBAGINACEAE, Leadwort Family

Plants without stems. Leaves in rosettes or on elongated scapes. Flowers in spikes, heads or panicles; 5 petals or lobes; stamens 5. Ovary free, 1-celled.

No native plants of this family occur in the state. However, one species is more or less frequently cultivated, namely, the sea-pink, thrift or *Statice plantaginea.*

Statice plantaginea All. Thrift

Perennial herb one-half foot to three feet high. Linear-lanceolate leaves. Flowers in globular heads with long bracts. Pink to crimson.

HONEY BEE VISITS

Ames, June 16, 1928, 2 p.m. Warm, windy. Bees abundant. Average of two seconds in a flower.

June 20, 1929. Bees observed. Two and three seconds in a flower.

PRIMULACEAE, PRIMROSE FAMILY

Herbs with simple undivided leaves, perfect regular flowers in racemes or umbels, commonly with 5 petals and 5 sepals or rarely without corolla; stamens 4 or 5, ovary 1-celled, a single style and stigma. Fruit a capsule.

Several genera and species occur in the state, including *Primula, Androsace occidentalis, Trientalis americana* and *Dodecatheon Meadia.*

As to pollination, several members of this family are dimorphic. In *Primula* one plant will produce short stamens and long style; another will produce long stamens with a short style. Fertilization cannot be brought about unless the pollen comes from a stamen that corresponds in height to the stigma of another flower. The work of Darwin, Knuth, Mueller and others shows the importance of insects in the pollination of these plants and the effect of pollen from a short stamen upon a long style and vice versa. Pollen from a short stamen on a long style will not produce seed, nor will that from a long stamen on a short style. The pollen grains of the short stamens are smaller than the pollen from a long stamen.

Lysimachia (Tourn.) L. Loosestrife

A tall or medium sized branching plant. Leaves ovate-lanceolate; flowers five- to six-parted, yellow.

Lysimachia Fortunei Maxim. White Loosestrife

Erect glabrous plant about one and a half feet high. Leaves ovate-lanceolate; flowers white, in a dense raceme.

HONEY BEE VISITS

Ames, July 9, 1929, 2 p.m. Bees about one second in a flower.
July 22, 1929. Just a few bees; average two to three seconds in a flower.
July 24, 1929, 2:30 p.m. No bees. Many Diptera and small Hymenoptera.

Steironema Raf. Loosestrife

Glaucous perennial. Herbs with simple leaves and perfect regular flowers. Corolla rotate. Capsules 10- to 20-seeded. Stems leafy, leaves opposite.

FIG. 257.—Loosestrife (*Steironema ciliatum*). *Photograph by Ada Hayden.*

Steironema ciliatum (L.) Raf. Fringed Loosestrife

A perennial herb with erect stems 1 foot to 3 feet high; leaves ovate, acute pointed, heart-shaped at base. Petioles with long ciliated hairs. Flowers with rotate corolla; nodding, on slender peduncles, light yellow.

The yellow loosestrife is widely distributed in prairies, meadows, springy places, in woods and in low grounds. It is associated with *Phlox divaricata, P. pilosa, Podophyllum peltatum, Bromus ciliatus, Corylus americana, Prunus americana, P. serotina.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls (two specimens), Lake Mills, Lake Okoboji, Lamont, Rock Rapids (two specimens), Story City (L. H. Pammel); Emmet county (two specimens), Osceola, West Bend (R. I. Cratty), Ames (G. W. Carver, Fred Rolfs, R. E. Jeffs), Cedar Rapids (R. E. Buchanan), Charles City (L. H. Pammel and E. M. Sherman), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Greenfield (F. C. Stewart), Kelley (Pearl Clayton), Ledges (Boone county) (three specimens, L. H. Pammel, C. M. King and R. E. Buchanan), northeast Iowa (H. Goddard), Osage (F. M. Tuttle), Rock Valley (W. Newell, J. F. Jansen and L. H. Pammel).

It has been observed (L. H. Pammel) at Algona, Burlington, Cherokee, Clinton, Des Moines, Dubuque, Fort Dodge, Hamburg, Indianola, Keokuk, Mason City, Missouri Valley, Mount Pleasant, New Albin, Postville, Rock Rapids, Sioux City.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall); Illinois—Lincoln (Judith B. Mills), Bluffs and Railway (H. Eggert), Fox (L. H. Pammel and Mark Heavenhill); Indiana—Wells county (Charles C. Deam); Kentucky— (T. H. Kearney, Jr.); Massachusetts—Adams (M. A. Day); Michigan—Whitehall (L. H. Pammel); Minnesota—Cass Lake (L. H. and H. E. Pammel), Itasca Lake State Park (L. H. Pammel), St. Cloud (E. B. Watson), St. Paul (R. Gmelin); Black Duck (Mrs. R. Westley); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Cedar Point (two specimens, L. H. Pammel), Pickerington (Asa Horr); South Dakota—Spearfish canyon (C. M. King); Tennessee— (T. L. Andrews); Utah—Peterson (two specimens, L. H. Pammel and R. E. Blackwood); Logan canyon (L. H. Pammel); Wisconsin—La Crosse (R. Gmelin, L. H. Pammel), Bloomingdale (L. H. Pammel); Wyoming—Halleck canyon, Laramie Peak (Aven Nelson), Sheridan county (F. Reppert, A. E. Paddock, Sarah Ellis).

HONEY BEE VISITS

Ames, July 13, 1914, a.m. Railroad. Partly cloudy, north wind. Twenty per flower per hour. Small bees predominate. Flies change from this to others.

Steironema lanceolatum (Walt.) Gray. Lance-leaved Loosestrife

The characteristics of this species are erect stems, lanceolate leaves with tapering base, flowers yellow, corolla longer than calyx. Fairly common in meadows and prairies. The plants are commonly assembled in small patches. They grow to a height of 12 to

18 inches. Associated with *Carex vulpinoides, Melanthium virginicum, Thalictrum dasycarpum, Cicuta maculata, Lythrum alatum.*

Robertson reports this plant as visited for honey and pollen by *Macropis steironematis.*

Honey bees have been observed on it in Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Grand Junction, Hamilton county, Indianola, McGregor (L. H. Pammel); Decatur county (J. P. Anderson), Emmet county (R. I. Cratty), Guttenberg (R. Gmelin), Pisgah (O. S. Swim), Ringgold (T. J. and M. F. L. Fitzpatrick), Wild Cat Den (Muscatine county) (F. Reppert).

It has been observed (L. H. Pammel) at Charles City, Cherokee, Dubuque, Fort Dodge, Postville, Spirit Lake.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Illinois—Makanda (H. A. Gleason), Red Bud (L. H. Pammel); Indiana—Liberty (J. N. Rose); Maine— (M. L. Fernald); Missouri—Forest Park, St. Louis (H. Eggert), Adams, Pleasant Grove (Kenneth K. Mackenzie); Nebraska—Wilton Island (James Wahl); Ohio—Lancaster (Asa Horr); South Dakota—Sisseton (L. H. Pammel); Wisconsin—Beaman Island, near McGregor, Galesville, Holmen, North Bend (L. H. Pammel).

Steironema quadrifolium (Sims) Hitchc. Prairie Moneywort

This species has erect stems and grows to a height of 3 feet. The stem leaves are sessile, long and slender; the lowest leaves are oblong; corolla longer than the calyx. This species resembles the preceding but is taller. It occurs in low situations, especially in northern and northeastern Iowa. It is associated with *Cirsium muticum, Pedicularis lanceolata, Gentiana crinita, G. Andrewsii, Salix candida, S. rostrata, S. pedicularis.*

The only visitor reported by Robertson is *Macropis steironematis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clinton, Dubuque, Mason City, Mount Carmel (L. H. Pammel); Armstrong, Emmet county, Estherville, West Bend (R. I. Cratty), Ames (G. W. Carver, C. E. Bessey, R. E. Jeffs), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Kelley (three specimens, Pearl Clayton), Ontario (E. R. Hodson), Story City (L. H. Pammel and F. C. Stewart), Winneshiek county (H. Goddard).

It has been observed (L. H. Pammel) at Iowa Lake, Lake Okoboji, Turtle Lake, Twin lakes.

General distribution in the United States:

Illinois—Chicago (L. H. Pammel); Missouri, Bay Mills, Ripley county (Kenneth K. Mackenzie), Blue Spring (H. Eggert); Ohio—Lancaster (Asa

Horr); Tennessee—Knoxville (Albert Ruth); Wisconsin—La Crosse (L. H. Pammel), Madison (J. R. Heddle).

No doubt visited by honey bees as are some of the other species.

Anagallis (Tourn.) L. Pimpernel

Corolla wheel-shaped. Stamens with bearded filaments. Capsule many-seeded. Low spreading herbs.

Anagallis linifolia L. Pimpernel

Leaves opposite or verticillate, linear. Flowers blue on slender pedicels. Lobes of corolla entire.

HONEY BEE VISITS

Ames, October 14, 1929, 1:30 p.m. Bees three to six seconds in a flower.

Dodecatheon L. American Cowslip

Perennial smooth herb, with a cluster of basal leaves and a nodding umbel of rose-colored flowers.

Dodecatheon Meadia L. American Cowslip

Smooth perennial herb, leaves clustered at the base. A single scape bearing an umbel of showy rose-colored flowers. Woods, prairies. A rather rare plant in Iowa.

HONEY BEE VISITS

Sheffield, May 28, 1929, 1:30 p.m. Many small Hymenoptera. No honey bees.

OLEACEAE, Olive Family

Trees or shrubs; leaves simple or compound; flowers variable, conspicuous or inconspicuous; calyx regular, four-cleft, corolla four-petaled or sometimes wanting; stamens few; ovary superior; two-celled; style one; fruit a samara (ash), capsule (lilac), drupe (olive).

The flowers of this family are entomophilous. They attract insects by the color of the flowers and by the odor, which is often very strong. Nectar is secreted by the ovary and contained in the more or less elongated corolla tube.

Syringa L. Lilac

Familiar dooryard ornamentals. Leaves opposite, simple, entire. Flowers in large fragrant clusters. These are among our very desirable ornamental shrubs.

Syringa vulgaris L. Common Lilac

A common ornamental bush, with heart-shaped leaves and large fragrant clusters of lilac- or pale violet-colored flowers. Widely cultivated in clay, black, sandy and calcareous soils.

Sparingly naturalized or spreading from the roots. The common lilac occurs in every county in the state and is perfectly hardy; it

FIG. 258.—Common lilac (*Syringa vulgaris*). *Photograph by A. Hayden.*

occasionally persists for many years after planting, being found in the neighborhood of old dwellings.

Distribution for Iowa:

It has been observed (L. H. Pammel), at Ames, Belle Plaine, Boone, Burlington, Carroll, Cedar Rapids, Centerville, Charles City, Cherokee, Clinton, Council Bluffs, Cresco, Davenport, Decorah, Denison, Des Moines, De Witt, Eldora, Fairfield, Fort Dodge, Fort Madison, Glenwood, Hamburg, Hampton, Indianola, Iowa Falls, Jefferson, Keokuk, Larchwood, Le Mars, Lineville, Little Rock, Marion, Marshalltown, Mason City, Missouri Valley, Mount Pleasant, Mount Vernon, Muscatine, New Albin, Onawa, Postville, Rock Rapids, Shenandoah, Sioux City, Steamboat Rock, Tipton, Turin, Waukon.

General distribution in the United States:

Colorado—Fort Collins (J. H. Cowan); Illinois—Champaign (B. Fink), Fox (L. H. Pammel and Mark Heavenhill); Minnesota—Crookston (Mrs. Roy Westley); Utah—Salt Lake City (two specimens, L. H. Pammel and R. E. Blackwood); Virginia—Staunton (W. A. Murrill).

HONEY BEE VISITS

Knuth says, "Flowers are aggregated, with concealed nectar, secreted at the base of the corolla tube by the ovary."

Mueller says, "Honey is secreted by the ovary and occupies 2 to 4 mm. of the tube, which is 8 to 10 mm. long; it is sheltered from the rain by the two stamens, which to a great extent fill up the mouth of the tube.

Honey bees have been observed abundant upon it—all collecting pollen."

Ames, May 13, 1920, 11 a.m. Two bees at work. (L.H.P.)

May 18, 1920, 9 a.m. Light wind. Some bees.

May 7 to 15, 1924, 5 p.m. Cool, cloudy. No bees.

May 20, 1924, 2 p.m. Clear. Slight north breeze. A bee two to four seconds in a flower.

May 8 and 9, 1926. Dry and warm. No honey bees. No nectar. Dry weather checks honey flow.

Blooming, Ames, April 8, 1925; May 5, 1926. Lansing, May 12, 1926.

Syringa Persica L. Persian Lilac

A slender lilac, blooming a little later than the common lilac. The leaves are lance-ovate; the clusters of flowers are lilac-purple. The separate flower smaller than in common lilac.

Hardy but less widely cultivated than the common lilac, in black sandy, calcareous soils. Seldom spontaneous.

It has been observed (L. H. Pammel) at Ames, Cedar Rapids, Clinton, Des Moines, Marshalltown, etc.

HONEY BEE VISITS

Ames, June 1, 1920, 1:14 p.m. Partly cloudy. No honey bees. Bumble bee one to two seconds in a flower.

May 8, 1926, 1:30 p.m. No honey bees. No nectar.

May 17, 1929, 4:30 p.m. Adjacent to wild crab. No bees.

Honey bees were observed on it in 1928. It is, however, not much frequented by bees.

Syringa amurensis var. *japonica* Franch and Star. Japanese Lilac

A treelike form; leaves broadly ovate-acuminate, dark glossy green above, paler beneath. Flowers later than common lilac, in large tufts of creamy white flowers.

Occasionally cultivated in black and clay soils.

HONEY BEE VISITS

Ames, June 18, 1919. Many wild bees and flies; a few honey bees about the plant.

June 19, 1919. Bees abundant. Time in a flower, one second.

June 14, 1928, 5:30 p.m. Plant near *Ligustrum vulgare.* A very few bees. Two seconds in a flower. Tree in full bloom.

Ligustrum (Tourn.) L. Privet

Ornamental shrubs with entire short-petioled leaves and small white flowers in terminal panicles; flowering in early summer.

Knuth says "with concealed nectar secreted by the ovary."

Ligustrum vulgare L. Privet

An ornamental shrub valuable for hedges; inflorescence panicled. Flowers white; leaves elliptic-lanceolate; fruit black. Common hedge plant, wild in eastern Europe. Frequently cultivated in clay and black soils. The west European form scarcely hardy; the east European more hardy.

Honey is secreted by the ovary and collects at the base of the tube.

Fig. 259.—Privet (*Ligustrum vulgare*). *Photograph by A. Hayden.*

Knuth reports bees getting nectar from this flower.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Fayette (B. Fink).

It has been observed (L. H. Pammel) at Ames, Davenport, Des Moines, Keokuk, Marshalltown, Muscatine, etc.

General distribution in the United States:

California—Balboa (Fidelia Woodcock); Massachusetts—Belmont (Walter Deane), Boston (L. H. Pammel), Cambridge (B. Fink); North Carolina—Watonaga county (J. K. Small and A. A. Heller); Ohio—Pickerington (Asa Horr); Pennsylvania— (John K. Small); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood).

HONEY BEE VISITS

Ames, June 19, 1919. Honey bees numerous; time spent in a single flower, one second.

April 27, 1927. Bees obtaining pollen and nectar. Many other Hymenoptera present.

June 14, 1927, 8 and 11 a.m. Bees abundant. One to three seconds in a flower. Three bees in five minutes on one cluster. Some flies also on the flowers. One bee visited twelve flowers out of a cluster of fifty.

June 15 to 19, 1927. Clear, moderate. Bees abundant. One to three seconds in a flower. Flowers fragrant. Bees visit four to five flowers in a cluster.

June 27, 1927, 3 to 4 p.m. Warm, windy, dry. Honey bees working busily. (C.C.L.)

June 12 to 16, 1928. Warm. Bees abundant. Average two to three seconds in a flower.

June 17, 1928, 11:30 a.m. No bees. Some on dandelion.

Denison, June 25, 1928, 4:20 p.m. No bees. (L.H.P.)

Ames, June 6 and 11, 1929, 2 p.m. Warm. Some bees. Four seconds in a flower.

Ligustrum amurense Carr. Chinese Privet

Shrubs sometimes attaining a height of 15 feet. Branches pubescent when young. Leaves oval or oblong. Flowers white, short peduncled. Fragrant.

Quite widely cultivated and distributed as an ornamental shrub.

HONEY BEE VISITS

Ames, June 15, 1929, 8:30 a.m. and 5:30 p.m. Bees fairly common. Three to four seconds in a flower.

Ligustrum Ibota Sieb. Japanese Privet

Shrubs 10 feet in height. Branches pubescent. Elliptic or oblong-obovate leaves. Flowers in nodding panicles. Fruit black.

Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

Ames, May 25, 1925, 6 p.m. Bees one to two seconds in a flower.

June 16, 1928, 2 p.m. Warm, windy. Bees fairly common. Four to six seconds in a flower.

5 p.m. Warm. Bees getting pollen and nectar. Three to four seconds in a flower. Flower tubes longer than in *L. vulgare*.

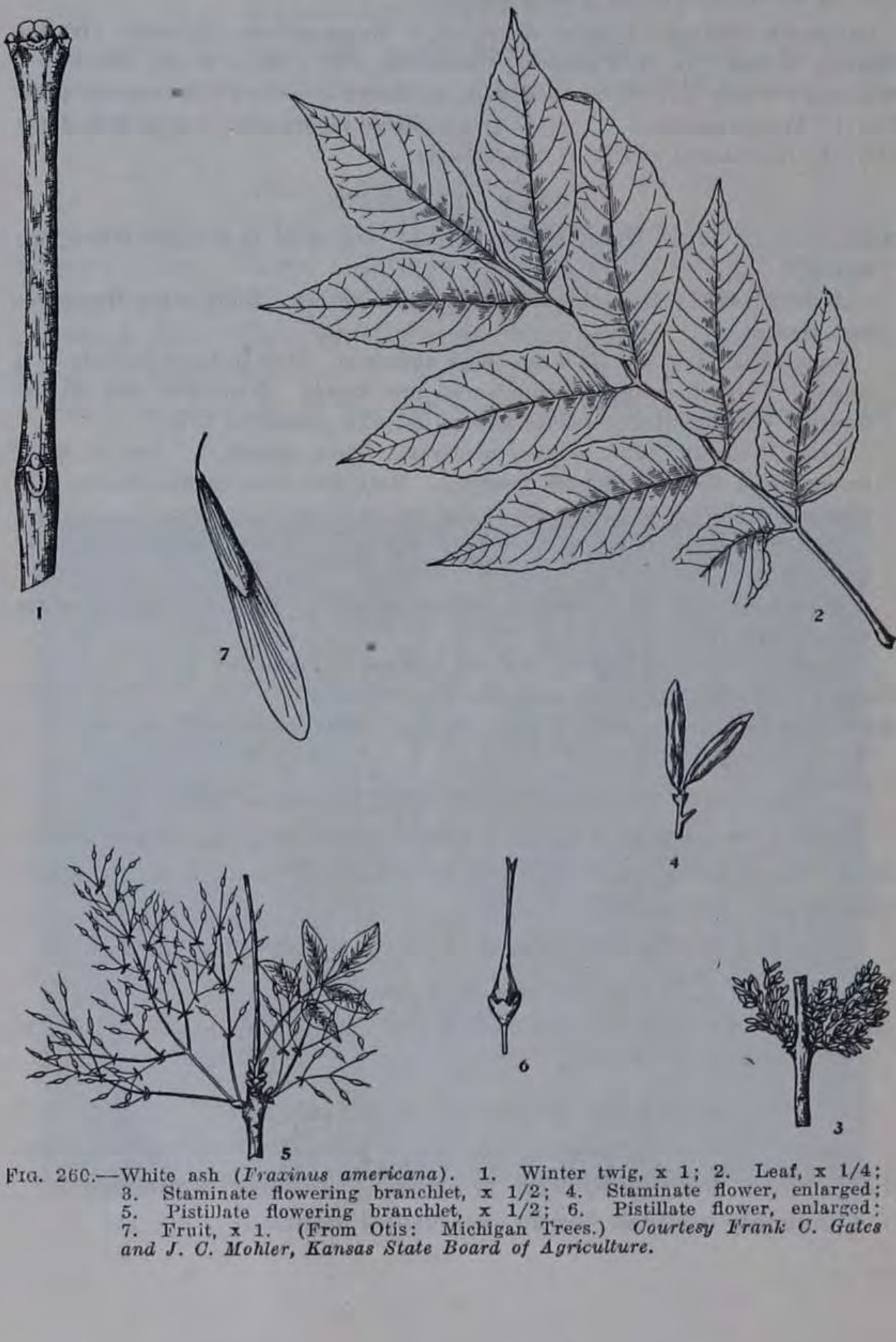

FIG. 260.—White ash (*Fraxinus americana*). 1. Winter twig, x 1; 2. Leaf, x 1/4; 3. Staminate flowering branchlet, x 1/2; 4. Staminate flower, enlarged; 5. Pistillate flowering branchlet, x 1/2; 6. Pistillate flower, enlarged; 7. Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

June 17, 1928, 11:30 a.m. Bees numerous, getting pollen. Four to three seconds in a flower.

Forsythia Vahl. Golden Bells

Deciduous shrub with opposite leaves, simple or ternate, smooth. Flowers axillary, yellow.

Several species are cultivated, namely *F. suspensa* Vahl and *F. viridissima* Lindl. Honey bees were observed on *F. viridissima* in Texas and Kansas.

Fraxinus (Tourn.) L. Ash

Trees with pinnate leaves; the winged fruit a samara. Flowers mostly apetalous, sometimes lacking calyx, dioecious, polygamous, or monoecious. Petals when present 4; stamens usually 2, anthers linear, large. Style single, two-cleft, the small flowers in crowded panicles or racemes from axils of the last year's leaves.

Fraxinus americana L. White Ash

Fine tree. Pinnately compound leaves, petiolate. Branches and petioles glabrous, pale beneath. Fruit abruptly dilated. Bark furrowed, gray. This species occurs in central Iowa and as far north as Allamakee county in northeastern Iowa.

Fraxinus pennsylvanica Marsh. Red Ash

Branches and petioles with a velvety pubescence. Leaflets 5-9, ovate or oblong-lanceolate. Fruit dilated into the linear or spatulate wing.

Common in the lake region of northern Iowa.

Fraxinus pennsylvanica var. *lanceolata* (Borkh.) Sarg. Green Ash

Fine tree of alluvial bottoms, with wedge-shaped leaflets, bright green both sides.

Fraxinus nigra Marsh. Black Ash

Branches and petioles smooth. Leaflets 7-11, oblong-lanceolate. Green and smooth on both sides. Fruit linear-oblong.

Common in moist and swampy places throughout eastern and central Iowa.

Fraxinus quadrangulata Michx. Blue Ash

Branches square. Leaflets seven to eleven, short-stalked, pointed, sharply serrate. Fruit oblong. Along dry banks and rocky places

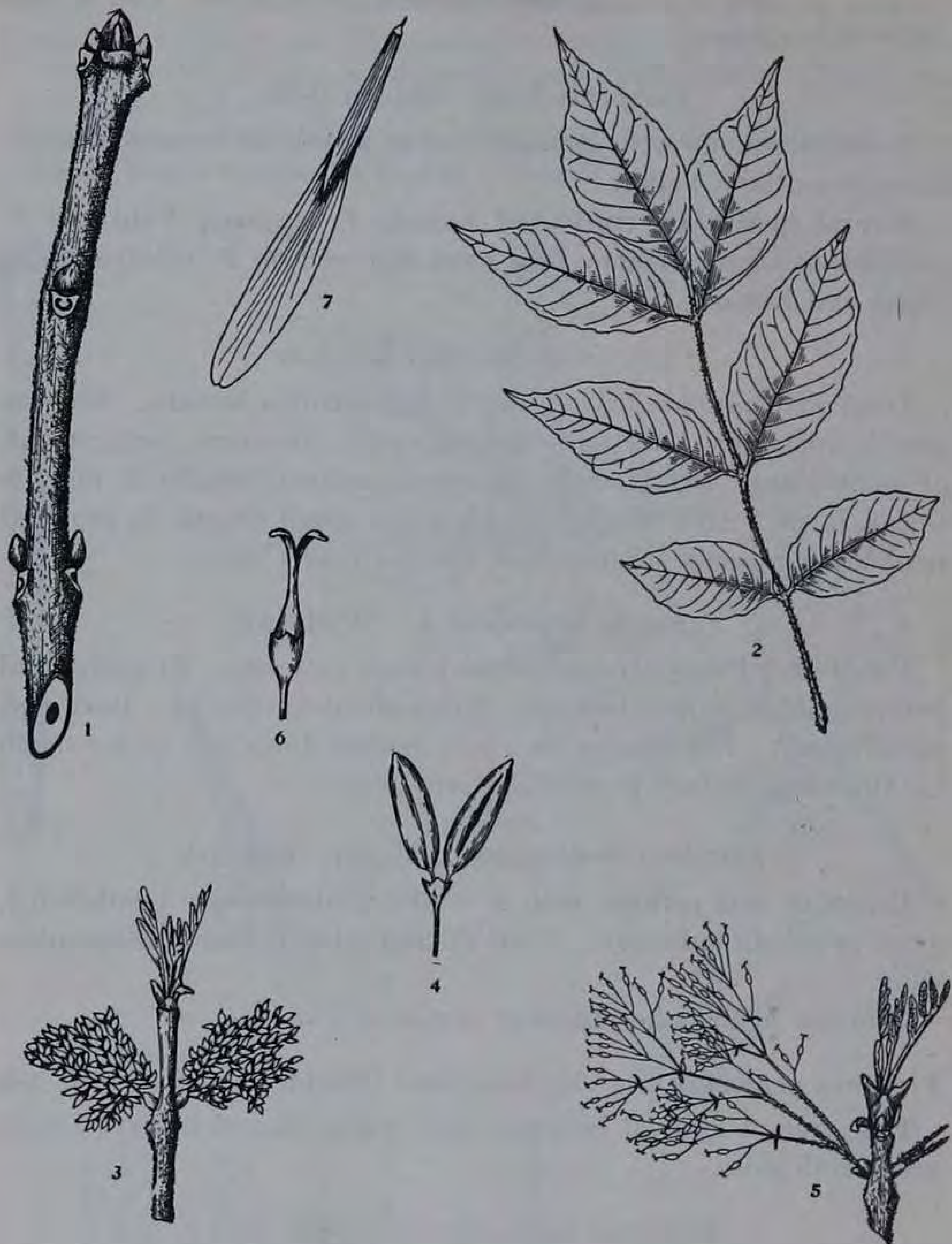

FIG. 261.—Red ash (*Fraxinus pennsylvanica*). 1. Winter twig, x 1; 2. Leaf, x 1/2; 3. Staminate flowering branchlet, x 1/2; 4. Staminate flower, enlarged; 5. Pistillate flowering branchlet, x 1/2; 6. Pistillate flower, enlarged; 7. Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

in southeastern Iowa. This is called blue ash because inner bark yields a blue color in water.

The flowers are entomophilous but so far as we have observed in Iowa they are not visited by honey bees.

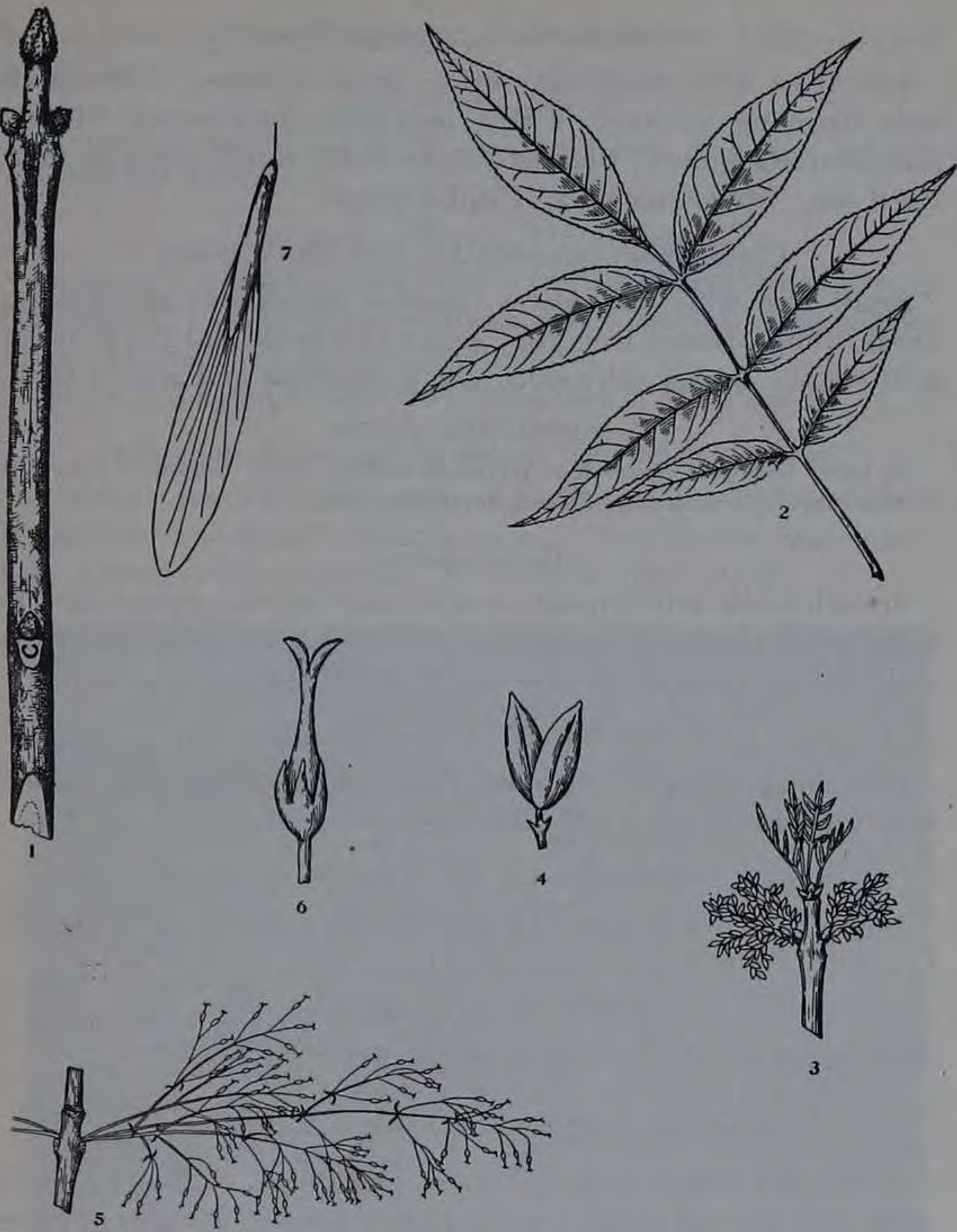

FIG. 262.—Green ash (*Fraxinus pennsylvanica* var. *lanceolata*). 1. Winter twig, x 1; 2. Leaf, x 1/3; 3. Staminate flowering branchlet, x 1/2; 4. Staminate flower, enlarged; 5. Pistillate flowering branchlet, x 1/2; 6. Pistillate flower enlarged; 7. Fruit, x 1. (From Otis: Michigan Trees.) *Courtesy Frank C. Gates and J. C. Mohler, Kansas State Board of Agriculture.*

Pellett reports that the flowers of some species are visited by honey bees for pollen.

The senior author saw honey bees on one southwestern species (*Fraxinus Berlandieri ?*) at Brownsville, Texas, and several other places in the Rio Grande Valley.

Chionanthus L. Fringe Tree

Low trees with deciduous, entire, petioled leaves. Flowers in loose drooping panicles. Calyx persistent, four-parted. Petals four, scarcely united; stamens two or more, rarely three or four. Pistil one. Stigma notched. Fruit a drupe.

Chionanthus virginica L. Old Man's Beard

Small tree with oval leaves; flowers paniculate; petals long, linear, white. Native from New Jersey to Florida and Texas, north to Missouri. Occasionally cultivated in southern and central Iowa.

HONEY BEE VISITS

No honey bees were observed at Winterset in May, 1929. Bees were abundant on this plant at Gainesville, Florida, February, 1928.

Gentianaceae

Smooth herbs with opposite sessile entire leaves; regular flowers with stamens as many as lobes of the corolla and inserted on the tube. Ovary 1-celled, with two persistent placentae.

Centaurium Hill. Centaury

Branching annuals with rose-colored, purple or reddish flowers with funnel-form or salver-form corolla.

Centaurium spicatum (L.) Fernald. Centaury

Upright plant, 6 inches to 1 foot in height, corymbosely branched. Cymes flat-topped, flowers sessile, purple-rose.

HONEY BEE VISITS

Ames, August 4, 1928. Some bees. Average one second in a flower.

APOCYNACEAE, Dogbane Family

Representatives in Iowa are herbaceous plants with milky acrid juice and opposite simple leaves; flowers regular, 5 sepals or lobes and 5-lobed corolla; 5 stamens borne on corolla, ovaries 2; seeds with tuft of silky hairs.

Amsonia Walt. Amsonia

Perennial herbs with alternate leaves and pale blue flowers in terminal clusters. Pods long, slender, many-seeded.

Amsonia Tabernaemontana Walt. Amsonia

Leaves lanceolate, taper-pointed; tube of bluish corolla slightly longer than the lobes. Low grounds, Pennsylvania to Missouri and westward.

HONEY BEE VISITS

Ames, May 30, 1929, 11 a.m. and 3 p.m. Some bees. Two, three and four seconds in a flower.

Apocynum (Tourn.) L. Dogbane

Perennial herbs with opposite leaves. Small pale pinkish flowers, bell-shaped. Pods long and slender. Seeds bearing a tuft of silky hairs. The bark is tough and fibrous.

Nectar is concealed and stored at the base of the pistil.

Apocynum androsaemifolium L. Spreading Dogbane

A smooth, perennial, ascending herb, with small bell-shaped pinkish flowers in terminal spreading cymes. Branches widely spreading. Leaves ovate, petiolate. Dry thickets, open woods.

FIG. 263.—Spreading Dogbane (*Apocynum androsaemifolium*). *Photograph by G. H. Munger.*

FIG. 265.—Indian Hemp (*Apocynum cannabinum*). *U. S. Dept. of Agr.*

Indian hemp is widely distributed in Iowa in open fields, borders of woods, clay, sandy, gravelly and prairie soils or in woods. It is associated with *Lithospermum canescens, Cassia Chamaecrista, Asclepias verticillata, Verbena stricta, Poa pratensis, Amaranthus retroflexus.*

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Backbone Park, Boone, Granite, Jefferson, McGregor, Postville (two specimens), Slater, Pammel Park (L. H. Pammel); Ames (two specimens, G. W. Carver, J. F. Jensen and W. Newell), Cedar Falls (G. W. Carver), Decatur county (T. J. and M. F. L. Fitzpatrick), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Fraser (Botany Seminar), Guttenberg (R. Gmelin), Hamburg (L. H. Pammel and H. B. Clark), Kelley (two specimens, Pearl Clayton), northeastern Iowa (three specimens, H. Goddard), Ontario (R. E. Buchanan), Slater (Botanical Party), Wild Cat Den (Muscatine county) (F. Reppert).

It has also been observed (L. H. Pammel) at Algona, Centerville, Cherokee, Clinton, Davenport, Des Moines, Dubuque, Fairfield, Forest City, Fort Dodge, Keokuk, Missouri Valley, Mount Pleasant, New Albin, Rock Rapids.

General distribution in the United States:

Colorado—Cache la Poudre river (L. H. Pammel and C. P. Johnson), Fort Collins (C. S. Crandall); Illinois—Hamilton (L. H. Pammel); Maryland—(G. M. McCarthy); Massachusetts—Deerfield (T. R. Churchill); Minnesota—Benson, Cass Lake, Star Island (L. H. Pammel), Cedar Island (P. S. McNutt), Coleraine (R. I. Cratty); Nebraska—Halsey (J. C. Blumer), McCook (L. H. Pammel), Wilcox (Mrs. James Clemens), Willow Island (James Wahl); New York—Ithaca (Muenscher and Bechtel); Ohio—Castalia, Cedar Point, Huron (L. H. Pammel); South Dakota—Watertown (L. H. Pammel); Texas—Tarrant county (Albert Ruth); Utah—Ogden (L. H. Pammel), Peterson (two specimens, L. H. Pammel and R. E. Blackwood); Washington—West Klickitat

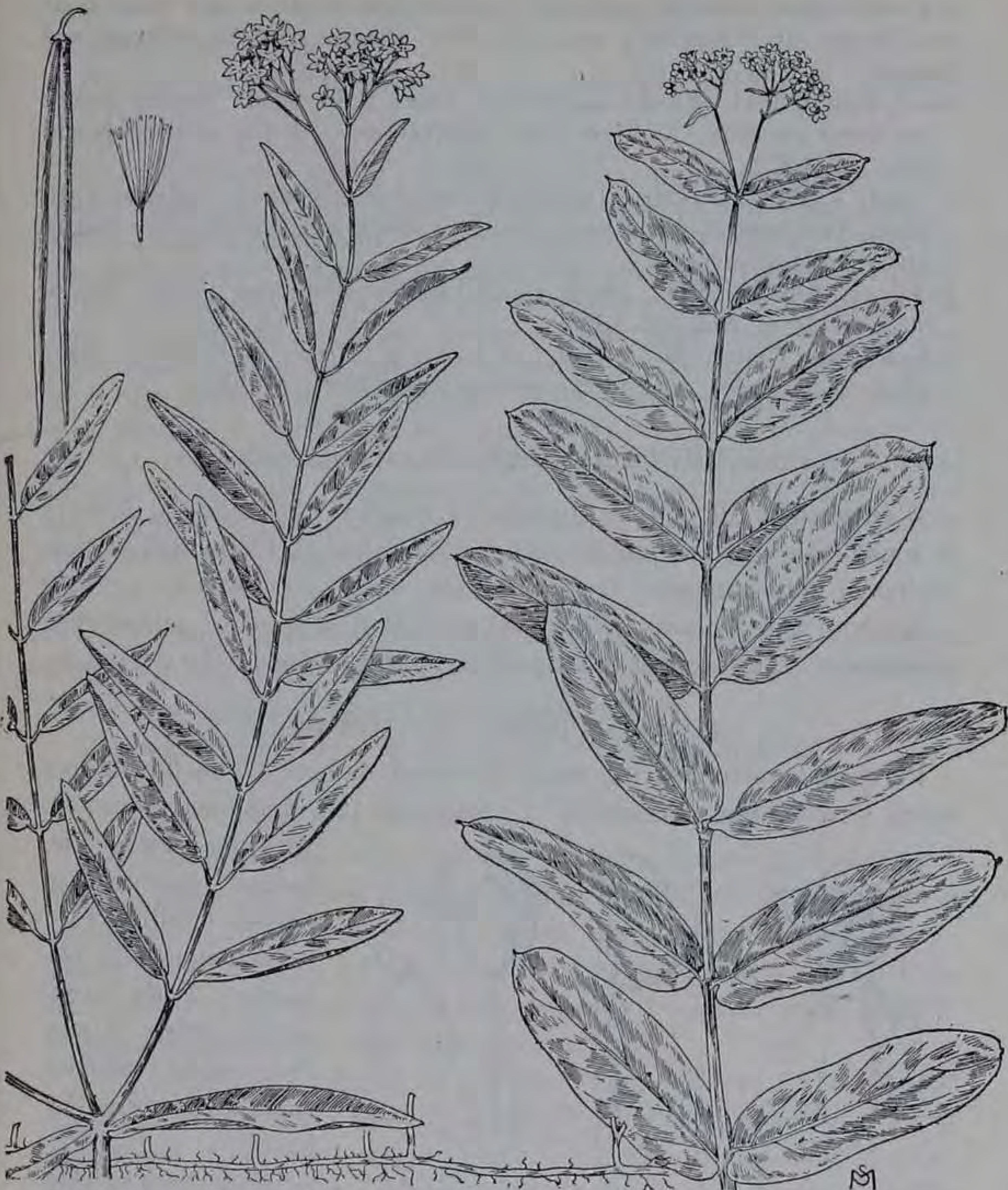

FIG. 266.—A. Indian Hemp (*Apocynum cannabinum*). B. (*Apocynum cannabinum* var. *hypericifolium*) low growing variety with broader leaves. *Mich. Agr. Exp. Sta.*

county (W. Suksdorf); Wisconsin—Portland (C. M. King and D. S. Pammel); Wyoming—Yellowstone National Park (R. P. White, L. H. Pammel and W. S. Dudgeon).

HONEY BEE VISITS

Flowers yellowish white, odor disagreeable; visited freely by honey bees. John H. Lovell states that an acre of this plant near Cleveland, Ohio, was constantly visited by bees and other insects from June until frost.

Frank Pellett states in regard to dogbane that at times bees work on it very freely. It is especially abundant along Missouri river in Missouri and Kansas.

Ames, July 1, 1914. Stream on campus. Clear, south wind. Twenty insects per flower per hour. No honey bees. Mostly wasps. A few Andrenidae and flies. (L.A.K.)

July 4, 1914. All day. Interurban track. Partly cloudy. Warm, north wind. One honey bee, one small bee, four wasps, one butterfly, two flies in whole day's observation.

Pickering, July 27, 1914. Partly cloudy, sultry. Four honey bees. Wasps, black and green flies. (L.A.K.)

Colo to State Center, July 24, 1927, 1 to 4 p.m. Damp, cool, cloudy, slight wind. A few bees. One to two seconds in a flower. (C.C.L.)

ASCLEPIADACEAE, Milkweed Family

Plants with milky juice, opposite or whorled entire leaves, flowers in umbel-like clusters, calyx and corolla 5-lobed and 5 hooded bodies, pollen in pollen masses; fruit a follicle.

Some of these plants (*Stapelia*) attract flies fond of putrefying substances. These effect cross-pollination by means of the proboscis.

Asclepias (Tourn.) L. Milkweed

Perennial herbs bearing many-flowered umbels. The flower has many unusual characteristics. Corolla reflexed, five-lobed; stamens forming a ring. The pollen coheres in masses (pollinia).

Leaves mostly opposite. Pods large, ovoid, with many flat seeds bearing tufts of long silky hairs.

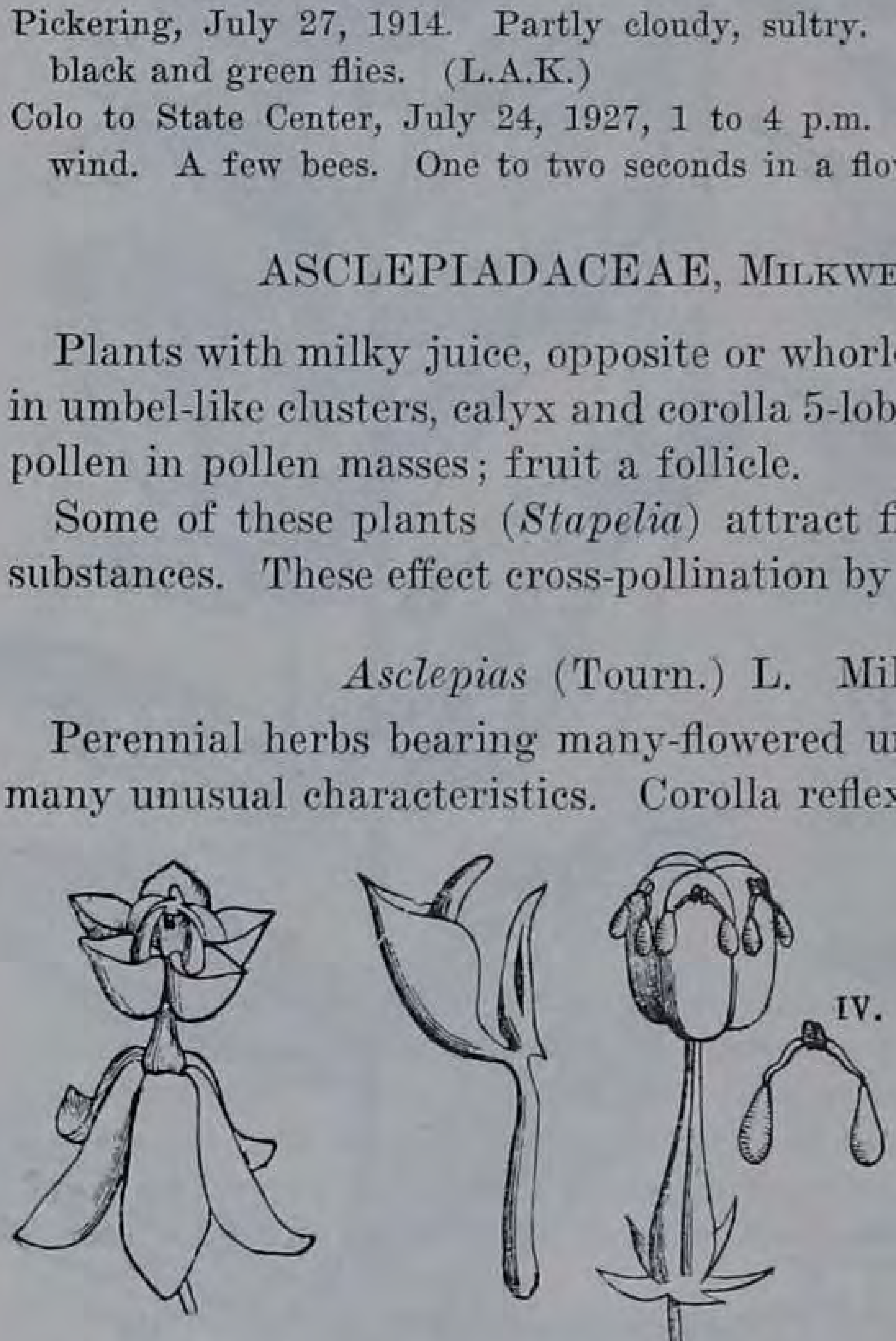

Fig. 267.—Flowers of *Asclepias*, details, IV. Pollinia. *After Thomé.*

The flowers secrete nectar. Knuth says, "The extremely specialized flower mechanisms are adapted to insect visitors in a very perfect manner." They are pinch-trap flowers, catching and holding the legs of insects.

While many varieties of milkweed are valuable honey plants, several species are quite injurious as bees are entrapped by their pollinia. This was fully described by Charles Robertson in the

Botanical Gazette many years ago. He observed the honey bee upon all our species.

The method of pollination is fully described by Knuth, Mueller and Delpino.

Knuth states as follows: "The five filaments are broadened, generally fused into a tube, and provided with external appendages which make up a corona, anthers usually with terminal membranous appendages; pollen aggregated into pollinia, attached in pairs to the clip-glands of the large capitate stigma. The clips grasp the legs of insect-visitors when the nectar-secreting spots are on the same radii as the stamens (*Asclepias*), or the proboscis if these spots alternate with the stamens (*Vincetoxicum, Stapelia, Bucerosia, Araujia*). The clips are thus drawn out of their recesses by the legs or proboscis of visitors and transferred to other flowers. (Pinch-trap flowers.) The extremely specialized flower mechanisms are adapted to insect visitors in a very perfect manner, so that a comparison may be made with orchids though in this case there is nothing like the same variety."

Mr. Pellett states that remarkable yields of honey are sometimes secured from milkweeds and they are of some value everywhere. The honey is light colored and of good quality.

There are several species of *Asclepias* common in Iowa.

Asclepias tuberosa L. Butterfly-weed

A spreading herb, with alternate slender leaves, juice scarcely milky, stems and leaves hairy. Flowers with 5 lobed sepals and 5 lobed petals, in umbels, bright orange, odor pleasant, pods hoary. There are 5 nectaries by which nectar is copiously secreted. A brilliant flower of the prairies, probably of only moderate value to bees. Dry fields and banks, New England westward.

This species is common on prairies, rights-of-way of railroads, gravel or sandy soil. Associated with *Pedicularis canadensis, Vicia americana, Geranium maculatum, Astragalus canadensis, Andropogon scoparius, Phlox pilosa, Baptisia bracteata, Panicum Scribnerianum, Lobelia spicata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Arcadia, Coon Rapids, Lost Island lake (L. H. Pammel); Ames (G. W. Carver, Fred Rolfs, L. H. Pammel and C. R. Ball, R. E. Jeffs), Creston (F. C. Stewart), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Eagle Grove (R. E. Buchanan), Kelley (two specimens, Pearl Clayton), northeastern Iowa (H. Goddard), Peru (D. E. Hollingsworth), Pocahontas (J. Meehan).

FIG. 268.—Butterfly weed (*Asclepias tuberosa*). *Photograph by A. Hayden.*

It has been observed (L. H. Pammel) at Algona, Bellevue, Boone, Burlington, Cedar Rapids, Cherokee, Clinton, Dana, Denison, Dubuque, Eldora, Forest City, Fort Dodge, Hamburg, Indianola, Keokuk, Livermore, Marshalltown, Mason City, Missouri Valley, Mount Pleasant, Muscatine, Rock Rapids, Shenandoah, Sioux City, Steamboat Rock.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Arizona—Walnut canyon (D. T. MacDougal); Colorado—Manitou (F. E. and E. S. Clements); Connecticut—Cornwall (T. L. Andrews); Illinois—Champaign (B. Fink), Makanda (H. A. Gleason); Kansas—Wichita (T. L. Andrews); Louisiana—Ascension (T. L. Andrews); Michigan—Tecumseh (U. S. National Herbarium); Minnesota—St. Cloud (E. B. Watson), St. Paul (R. Gmelin); Missouri—Pilot Knob (L. H. Pammel); New Jersey—Youngstown (Asa Horr); New Mexico—Fort Bayard (two specimens, A. Isabel Mulford); New York—Bedford Park, New York City (Percy Wilson), Niagara Falls (G. H. Frazier), Ithaca (H. E.

Summers, Muenscher and Bechtel); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Kelley's Island, Cedar Point, Huron (Castalia) (L. H. Pammel), Fairfield county (Asa Horr); Oklahoma—Norman (W. E. Bruner); Tennessee—Clarksville (T. L. Andrews); Texas—Austin (B. C. Thorpe), Tarrant county (Albert Ruth); Wisconsin—Muscoda (L. H. Pammel).

HONEY BEE VISITS

Ames, July 9, 1914, 2 to 5 p.m. Hot, dry. (L.A.K.)

August 10, 1914, 3 to 6 p.m. Clear, southeast wind. One honey bee observed, several small wasps, butterfly, fly. Two insects per umbel per minute. (G.H.M.)

Ames to Nevada, July 10, 1927. Hot and dry. Bees freely at work. Four seconds in each flower.

Lancaster, Missouri, July 25, 1927, 12 m. Warm, sunshiny, shower previous night. Bees abundant. Five, four, three seconds in a flower.

August 2, 1927, 12:30 p.m. Clear. Bees abundant. Five to three seconds in a flower.

Charles Robertson observed honey bees upon *Asclepias tuberosa.*

Asclepias purpurascens L. Purple Milkweed.

A slender milkweed about 3 feet in height. The leaves are elliptical, smooth above, finely velvety underneath, short petiole. Corolla dark purple.

This species is not common in the state. Most commonly found in southern Iowa in woodlands on dry sandy or gravelly soils. Associated with *Cassia Chamaecrista, Polygala verticillata, Polygala incarnata, Polygala sanguinea, Scutellaria parvula, Lithospermum canescens.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Pammel Park, Winterset (L. H. Pammel), Decatur county (J. P. Anderson), Osceola (F. C. Stewart).

General distribution in the United States:

Illinois—Peoria (F. E. McDonald), Red Bud (L. H. Pammel); Missouri—Jackson county (Kenneth K. Mackenzie); New Jersey—Morristown (Mrs. L. M. Barker); Tennessee—Clarksville (T. L. Andrews).

HONEY BEE VISITS

Honey bees work on this flower.

Asclepias incarnata L. Swamp Milkweed

A perennial leafy herb, with opposite leaves and many-flowered umbels; plant $2\frac{1}{2}$ to 5 feet tall, smooth. Leaves oblong-lanceolate, acute, narrowed at base; flowers rose-purple, blooming through July and August. The swamp milkweed is common in

FIG. 269.—Swamp milkweed (*Asclepias incarnata*). *Photograph by A. Hayden.*

peat bogs and marshy places in many parts of Iowa, associated with *Carex vulpinoides, Lobelia siphilitica, Pedicularis lanceolata, Parnassia caroliniana, Gentiana Andrewsii, Leersia oryzoides, Spartina Michauxiana.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belle Plaine, Centerville, Charles City, Clinton county, De Witt, Indianola, Keystone, Lake Mills, McGregor, Rockwell City, Spirit Lake (L. H. Pammel); Cedar Rapids, Eagle Grove (R. E. Buchanan), Adel (Charles F. Clark), Ames (L. H. Pammel and C. R. Ball, Fred Rolfs, W. E. Robb), Creston (five specimens, T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Hull (W. Newell), Kelley (Pearl Clayton), Ledges (J. V. Ellis), northeastern Iowa (H. Goddard), Pocahontas (J. Meehan), Polk county (C. E. Bessey), Rockford (Mr. and Mrs. C. L. Webster), Sioux City (J. R. Hanson), Spirit Lake (L. H. and H. E. Pammel), West Bend (R. I. Cratty).

It has also been observed (L. H. Pammel) at Algona, Burlington, Clinton, Cresco, Davenport, Dubuque, Fort Atkinson, Fort Dodge, Hamburg, Jewell Junction, Keokuk, Madison, Mason City, Missouri Valley, Mount Pleasant, Nevada, Oelwein, Postville, Shenandoah, Waukon.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall); District of Columbia—(W. J. Canby); Illinois—Champaign (B. Fink, H. Gleason); Kansas—Wichita (T. L. Andrews); Massachusetts—Dedham (Walter Deane); Michigan—Gogebic (Mrs. Joseph Clemens); Nebraska—Halsey (J. C. Blumer), Lincoln (R. Gmelin), Sheridan county (R. E. Buchanan), Willow Island (James Wahl); New York—Ithaca (H. E. Summers, Muenscher and Bechtel); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Baltimore (Asa Horr); South Dakota—Brookings, Watertown (L. H. Pammel); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood); Wisconsin—La Crosse (Dora S. Pammel), Wauzeka (L. H. Pammel).

HONEY BEE VISITS

Charles Robertson records honey bees abundant on *Asclepias incarnata* from July 22 to August 21.

Tama, 3:30 p.m. Honey bees abundant. One clump of blossoms visited by 12 bees in one minute. (L.A.K.)

Dubuque, July 14, 1914. Clear, west wind. Honey bees, others, wasps (*Vespa*), flies, beetles. One insect per flower per minute. (G.H.M.)

Pickering, July 27, 1914. Mainly wasps. (L.A.K.)

Escanaba, Michigan, to Milwaukee, Wisconsin, August 12, 1927. Freely blooming. Some honey bees observed. (L.H.P.)

Des Moines, August 3, 1929, 1 p.m. Bees two to three seconds in a flower. Five hundred feet from apiary.

August 4, 1929, 2 p.m. Bees numerous. Bees could not withdraw readily from the flower because of the pollen masses. Three and two seconds in a flower.

August 5, 1929. Abundant from Ames to Jewell, Blairsburg, Iowa Falls, Hampton, Allison, Maynard, Strawberry Point and McGregor. No honey bees observed at any of these points, though there was an abundance of nectar secretion.

This is a valuable honey plant in certain swampy regions.

Bees sometimes caught by the corpuscula of the pollen masses of this milkweed.

Blooming, Ames, May 23, 1924.

Asclepias speciosa Torr. Showy Milkweed

This milkweed is perennial, with large broad, short-petioled leaves. The flower clusters are dense, purplish green. The tops of the hoods of the corolla each bear a low appendage.

This species is not uncommon in the northwestern part of the state in the lake region, in gravel and black prairie soils. It is associated

FIG. 270.—Showy milkweed (*Asclepias speciosa*). *Photograph by Colburn.*

with *Zygadenus elegans, Lilium philadelphicum, Smilacina stellata, Panicum Scribnerianum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Emmet county (two specimens, R. I. Cratty).

Observed (L. H. Pammel) at Spirit Lake, Estherville, and Emmetsburg. Also at Spencer (C. M. King).

General distribution in the United States:

Arizona—Bill Williams Mountain (D. T. MacDougal); California—Yosemite valley (L. H. Pammel); Colorado—Fort Collins (two specimens, A. H. Fry, J, H. Cowan); Nebraska—Cadawa (J. M. Bates), Halsey (J. C. Blumer), Holdrege (W. B. Miller), Kearney (L. H. Pammel), Larsen (F. G. Miller), Sheridan county (R. E. Buchanan); Utah—Logan (A. Isabel Mulford), Salt Lake (L. H. Pammel).

HONEY BEE VISITS

Honey bees visit this species, but are frequently caught by the corpuscula. It is, therefore, a detrimental plant to the honey bee.

Asclepias syriaca L. Common Milkweed

A tall, stout perennial 2 to 5 feet high, with fine soft pubescence. Leaves oblong, broad, downy beneath, opposite. Corolla dull purple to white; flowers in loose umbels. Pods ovoid, with soft spinous

FIG. 271.—Common milkweed (*Asclepias syriaca*). *Photograph by C. M. King.*

processes. Seeds flat, margins bearing a tuft of long silky hairs. Rich ground. New England to Saskatchewan and southward.

A common weed everywhere in black, sandy, limy and clay soils. Associated with *Radicula palustris, Polygonum pennsylvanicum, Convolvulus sepium.*

The deeply 5-parted corolla is of purple color. Next to the corolla is a crown of five hooded bodies seated on the tube of the stamens. The 5 stamens are attached to the corolla, the filaments are united in a tube which encloses the pistil, and the anthers adhere to the stigma.

FIG. 272.—Seed pod of common milkweed (*Asclepias syriaca*). *Photograph by A. Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Algona (E. B. Watson), Ames (L. H. Pammel), Charles City (Fred Rolfs, C. L. Webster), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (G. W. Carver), Fayette (two specimens, B. Fink), Fraser (Botany Seminar), Kelley (Pearl Clayton), Lawler (P. H. Rolfs), Osage (Mrs. Flora May Tuttle), West Bend (R. I. Cratty).

This has also been observed (L. H. Pammel) at Bellevue, Boone, Burlington, Carroll, Cedar Rapids, Centerville, Cherokee, Clarinda, Clinton, Corning, Council Bluffs, Cresco, Dallas Center, Davenport, Dubuque, Eldora, Emmetsburg, Forest City, Fort Atkinson, Fort Dodge, Fort Madison, Glenwood, Glidden, Greene, Hamburg, Indianola, Jefferson, Kanawha, Keokuk, Lineville, Marshalltown, Mason City, Missouri Valley, Moulton, Mount Pleasant, Muscatine, Oelwein, Onawa, Postville, Rock Rapids, Shenandoah, Sioux City, Waukon.

General distribution in the United States:

Connecticut—Cornwall Creek (T. L. Andrews); Illinois—East St. Louis (H. Eggert); Kansas—Wichita (T. L. Andrews); Minnesota—St. Cloud (E. B. Watson); Missouri—Washington (L. H. Pammel); New York—New Castle (New York Botanical Garden), Ithaca (Muenscher and Bechtel); Tennessee—Clarksville (T. L. Andrews); Wisconsin—La Crosse (L. H. Pammel).

ECOLOGY

Pollen grains of milkweed consist of a pair of pollinia. These pollen masses are taken out by the insects as they suck nectar from the glands and become attached to the insect's hairs, legs and tongue.

FIG. 273.—Common milkweed (*Asclepias syriaca*). *Photograph by A. Hayden.*

Lovell has the following to say with regard to the milkweed: "Milkweed flowers are called pinch-trap flowers because they possess a remarkable clip-mechanism found in no other family of plants. Two club-shaped masses of pollen are attached by flexible bands to a small, dry, triangular disc placed midway between them. In this membranous disc there is a wedge-shaped slit at one end. In its efforts to obtain a foothold on the smooth flowers an insect is likely to thrust a claw, leg, antenna, or tongue into one of the slits. If one of these organs is drawn upward in the slit, the dry disc becomes tightly clamped to it. When the insect flies away it carries with it the disc and the two masses of pollen strapped to it. Exposed to the air, the straplike stalks dry and draw the pollinia close together. As the bee alights on another flower, they are easily thrust between two anther wings, where they come in contact with the stigma; but, once inserted and pulled upward, they can not again be withdrawn. The insect can obtain its liberty only by breaking the connecting bands. If it cannot do this, it perishes slowly of starvation. Disc after disc may thus become attached to an insect, until it is crippled or helpless."

The common milkweed is rated as one of the good honey plants. Many bees are caught by the legs in the slits of the staminal column of these flowers and are held to die. Nectar is secreted by the five hoods that surround the staminal column. Charles Robertson records a honey bee caught in the flower while collecting pollen in *Asclepias syriaca.*

Great yields are sometimes obtained from some milkweeds, which are important honey plants in many localities.

John H. Lovell states that the honey is light in color and that in the northern part of the southern peninsula of Michigan the flow lasts about 30 days and that as a honey plant *Asclepias syriaca* is important in that part of the state, where it is one of the chief honey producing plants.

HONEY BEE VISITS

Ames, June 14, 1914, all day. Chicago & North Western Railway right-of-way. Partly cloudy, warm. North wind. Bees none to ten, averaging about one. (L.A.K.)

June 18, 1914. College car line. Partly cloudy, north wind. Bumble bees, other bees, beetles. Thirty per flower per hour. (G.H.M.)

June 24, 1914, 5 p.m. Near Campus. Cloudy, humid, northwest wind. Insects frequent. (L.A.K.)

July 5, 1925. The bee eleven to eighteen seconds in a flower. Movements of bees sluggish. Ten bees in twelve minutes about the flowers. (L.H.P.)

July 3, 1927. Cool, showery. Bees at work. (C.C.L.)

July 13, 1927. I.S.C. Formal Gardens. Hot, dry, clear. Bees very abundant. Five to ten seconds in a flower. (C.C.L.)

July 14, 1927, 8:30 to 10 a.m. Very dry, warm and sunny. Bees very numerous, getting nectar. Fourteen visits to one flower in fifteen minutes. (C.C.L.)

Lancaster, Mo., July 25, 1927, 12 m. Warm, sunshiny, shower previous night. Bees getting pollen; not entangled in flowers.

August 25, 1927, 12:30 p.m. Clear. Bees three to six seconds in the flower.

Bloomfield, July 27, 1927. Sixty-three to sixty-five flowers in an umbel. One to two umbels to one plant. No bees.

Asclepias Sullivantii Engelm. Sullivant's Milkweed

A tall smooth milkweed, leaves cordate at base, nearly sessile. Flowers purple, large. The pod is quite smooth, slightly spiny at beak.

In low black sandy soils of eastern Iowa, rather rare. Associated with *Asclepias verticillata, Lithospermum canescens, L. hirta, Pedicularis canadensis, Geranium maculatum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (Fred Rolfs), Creston (F. C. Stewart), Decatur county (J. P. Anderson), Emmet county (five specimens, R. I. Cratty), Kelley (Pearl Clayton), West Bend (R. I. Cratty).

This has been observed (L. H. Pammel) at Bellevue, Camanche, Clinton, Council Bluffs, Fort Madison, Mason City, Missouri Valley, Muscatine, New Albin.

General distribution in the United States:

Illinois—Pullman (L. H. Pammel), Shabbona (B. Fink); Kansas—Wichita (T. L. Andrews); Missouri—Jackson county (Kenneth K. Mackenzie), St. Louis (L. H. Pammel).

Charles Robertson records honey bees found hanging to flowers of *Asclepias Sullivantii* while collecting pollen.

We have observed honey bees on this species.

Asclepias amplexicaulis Sm. Blunt-leaved Milkweed

This milkweed grows to a height of 3½ feet. The leaves are cordate at base, clasping. Flower is pale greenish purple.

This milkweed is evidently not common in the state; occurs in sandy woods and fields.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Decorah (E. W. D. Holway).

Asclepias Meadii Torr. Mead's Milkweed

Height about 4 feet, slender; leaves ovate, flower greenish white.

Sandy soil. Associated with *Mollugo verticillata, Cassia Chamaecrista, Scutellaria parvula, Tephrosia virginiana, Lithospermum canescens, Asclepias tuberosa, Asclepias purpurascens.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Armstrong, Emmet county (R. I. Cratty), Decatur county (J. P. Anderson).

Asclepias phytolaccoides Pursh. Poke Milkweed

About 3 feet in height; leaves broad-ovate, short-petioled, almost smooth. Pedicels of flower stems loose, nodding. Flowers greenish in color.

In rich, black, sandy woods of northeastern Iowa. Not uncommon. Associated with *Arisaema Dracontium, Tilia americana, Acer saccharum, Aster sagittifolius, Staphylea trifolia*, etc.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clermont (E. R. Walker), Decorah (E. W. D. Holway), Fayette (B. Fink), Ledges (Boone county) (J. V. Ellis), northeastern Iowa (H. Goddard), Osage (F. M. Tuttle), southern Iowa (C. R. Ball).

General distribution in the United States:

Illinois—Fox (two specimens, L. H. Pammel and Mark Heavenhill); Louisiana—(T. L. Andrews); New York—Ithaca (Muenscher and Bechtel); Ohio—Put-in-Bay (L. H. Pammel), Worthington (Asa Horr).

HONEY BEE VISITS

Honey bees have been reported on this species.

Asclepias ovalifolia Dcne. Oval-leaved Milkweed

Soft downy plant 4 to 5 feet high. Leaves ovate, short-petioled, acute. Umbels 10 to 18-flowered. Hoods of flowers yellowish, corolla lobes greenish white, purplish outside. Prairies of Iowa.

HONEY BEE VISITS

Ames, July 3, 1927. Cool, showery. Bees at work (C.C.L.)

Asclepias verticillata L. Whorled Milkweed

A smooth plant 1 to 2 feet high; stem very leafy; leaves narrow-linear, in whorls of 3-6. Flowers greenish white, in lateral and terminal umbels. Prairies and open woods. Massachusetts to Saskatchewan and southward.

The whorled milkweed is especially common in loess soil, western Iowa, on Missouri loess bluffs, and in sandy or gravelly soils in many other sections of the state. It is associated with *Silene stellata, Asclepias tuberosa, Geranium maculatum, Vicia americana.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Arcadia, Cherokee, Clarinda, Coon Rapids, Eddyville, Hawarden, Indianola, Mahaska county, Missouri Valley, Oskaloosa, Sioux City, Turin (L. H. Pammel); Armstrong, Emmet county (R. I. Cratty), Adel (two specimens, C. F. Clark), Ames (C. R. Ball, G. W. Carver, J. Jensen and W. Newell, C. E. Bessey, E. R. Hodson), Battle Creek (E. T. Preston), Cedar Rapids (Mae Cutler), Creston (three specimens, T. L. Andrews), Dallas Center (C. R. Brenton), Decatur county (J. P. Anderson), Des Moines (two specimens, A. L. Bakke), Fayette (B. Fink), High Bridge (Boone county) (G. M. Lummis), Kelley (Pearl Clayton), Madrid (C. L. Goodville), Muscatine (L. H. Pammel and F.

FIG. 274.—Whorled milkweed (*Asclepias verticillata*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Reppert), northeastern Iowa (H. Goddard), Osage (Mrs. Tuttle), Rock Valley (James Jensen and W. Newell).

It has been observed (L. H. Pammel) at Bellevue, Cherokee, Clinton, Forest City, Fort Dodge, Fort Madison, Rock Rapids.

General distribution in the United States:

Alabama—Birmingham (L. H. Pammel); Colorado—Fort Collins (Ada Hayden), Hotchkiss (L. A. Vertull), Naturita (Edwin Payson); Florida—Sanibel Island (S. M. Tracy); Illinois—Utica (Mrs. Joseph Clemens), Berwyn (two specimens, H. S. Fawcett), Sadonis (H. A. Gleason); Minnesota—Graceville (L. H. Pammel); Missouri—Westport (Kenneth K. Mackenzie); Nebraska—Alma (L. H. Pammel), Callaway (J. M. Bates); New Mexico—Messilla Park (L. H. Pammel); Ohio—Erie county (Asa Horr); Oklahoma—Norman (W. E. Bruner); South Dakota—Armour (Mrs. N. E. Hansen), Brookings (Edna C. Pammel), Highmore (Quick), Opposite Hawarden (L. H. Pammel); Texas—College Station (L. H. Pammel); Virginia—Glencarlyn (Lyster H. Dewey).

HONEY BEE VISITS

Charles Robertson records bees on *Asclepias verticillata* as follows at Carbonville, Illinois:

"July 11-Aug. 21. Honey bees, *Apis mellifica.*"

Ames, July 21, 1914. Railroad right-of-way. Clear, south wind. Honey bees, one observed. Many bumble bees and wasps, few flies, two insects per umbel per minute. (G.H.M.)

July 22, 1914. All day. Railway right-of-way. Partly cloudy, hot west wind. One bee observed in one day. One bumble bee in day, ten to thirty wasps, none to five small bees, none to five flies, occasional Lepidoptera. (G.H.M.)

Aug. 7, 1915. Clear, moderate. One observed in one day. Many wasps (three or four kinds), sucking nectar. (L.A.K.)

Aug. 21, 1915. Pasture. Clear, rather warm. Wasps, butterflies. (L.A.K.)

Sept. 9, 1915. Pasture. Clear, rather warm. *Bombus, Polistes, Sphex.* (L.A.K.)

July 9, 1922. A beautiful moderate day. Partly cloudy. Group of *A. verticillata* in full early bloom on campus. Numerous bees at work; butterflies and wasps also. (C.M.K.)

August 5, 1927, 9:30 a.m. No bees. Bees abundant on white sweet clover.

Iowa City, August 2, 1928. Bees two seconds in a flower. Some wasps present. (L.H.P. and Adams).

August 5, 1929. Common from Jewell to Hampton, Iowa Falls, Allison, Waverly, Maynard, Strawberry Point and McGregor.

Des Moines, August 3 and 20, 1929, p.m. Bees two to three seconds in a flower.

"This flower secretes more nectar than even red clover, 11.6 mg. sugar being found on one gm. flowers. But for reason it is favored by wasps and neglected by honey bees. The former were more numerous, sometimes forming a veritable swarm on a clump of flowers. Insects are captured less frequently by this plant than by the common milkweed." (L.A.K.)

Gonobolus Michx. Angle-pod

Twining plants, smooth, with opposite ovate leaves, heart-shaped, on long petioles. Flowers on slender peduncles, in clusters. Pods lanceolate, smooth.

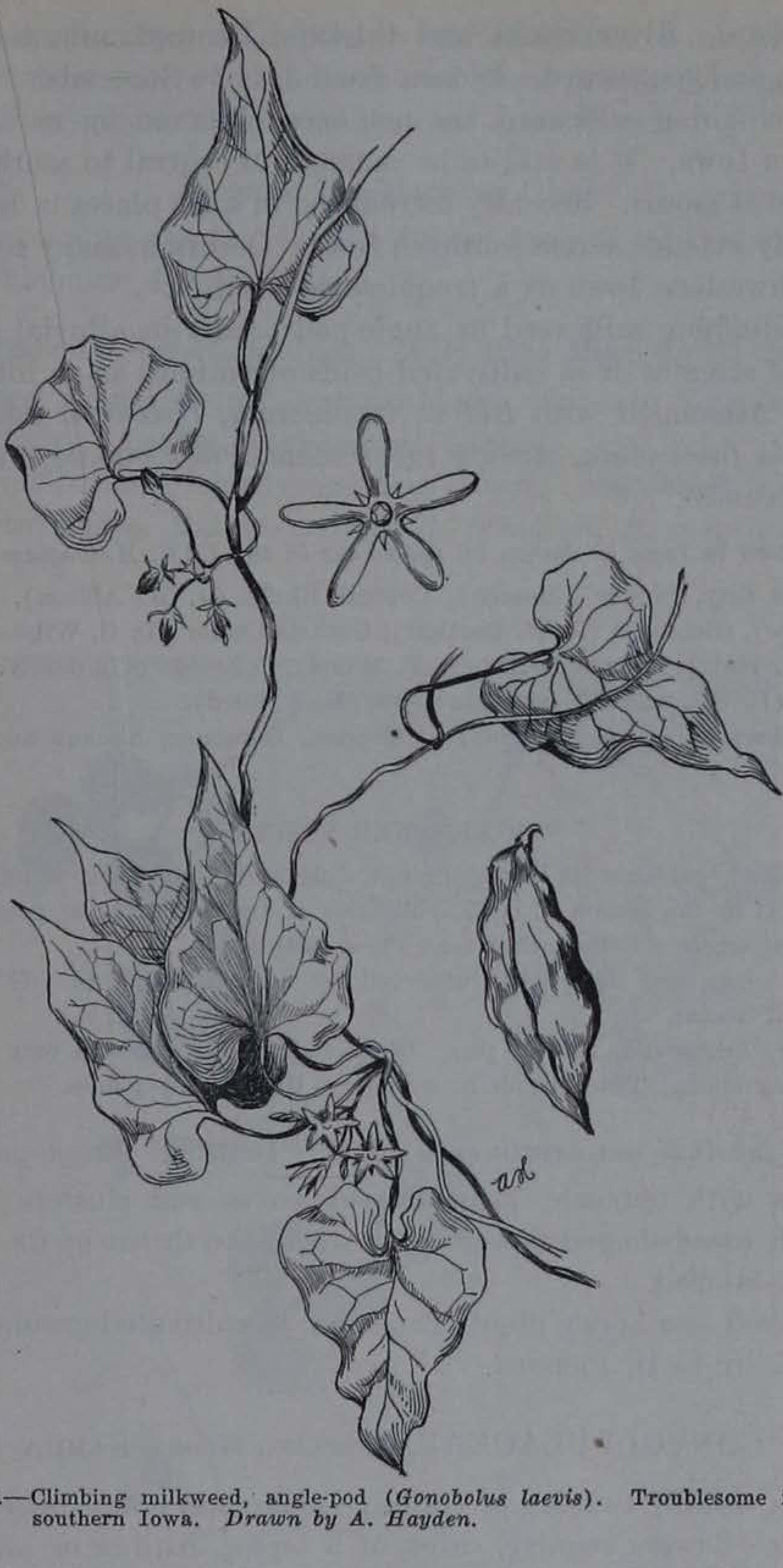

FIG. 275.—Climbing milkweed, angle-pod (*Gonobolus laevis*). Troublesome in fields in southern Iowa. *Drawn by A. Hayden.*

Gonobolus laevis Michx. Angle-pod, Climbing Milkweed

A perennial climbing herb, smooth, with heart-shaped leaves; flowers whitish, in a raceme-like cluster, angled pods with soft warty projections. River banks and thickets, Pennsylvania to Illinois, Kansas, and southward. Blooms from July to September.

The climbing milkweed has not been observed by us except in southern Iowa. It is said to be common in central to southern Illinois and Missouri. Recently introduced in some places in Iowa, and evidently extends across southern Iowa. Occurs in many corn fields in southwestern Iowa as a troublesome weed.

The climbing milkweed or angle-pod occurs in alluvial bottoms, banks of streams or in cultivated fields of bottoms as an introduced plant. Associated with *Bidens involucrata, Helenium autumnale, Vernonia fasciculata, Acnida tuberculata, Pilea pumila, Parietaria pennsylvanica.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City, Sidney (Heezen), Council Bluffs (J. H. Allison), Eddyville (J. Moore), Glenwood (J. W. Bartlett), Guthrie Center (D. G. Wilson), Carson (Paul W. Watt), Council Bluffs (B. F. Myers), Jefferson (Charles W. Martin), Keokuk (L. H. Pammel), southern Iowa (E. E. Reed).

Also observed (L. H. Pammel) at Creston, Hamburg, Keokuk and Shenandoah.

HONEY BEE VISITS

This plant continues its bloom through July and August. It is regarded by Mr. Pellett as the source of large quantities of surplus honey of good quality. This plant comes a little earlier than the smartweed.

Many honey bees have been observed by us. It seems to yield a large amount of nectar.

Hamburg, August 25, 1928, 1 p.m. Clear and warm. Flowers very fragrant. Bees abundant. Two seconds in a flower. Good honey plants.

Vincetoxicum carolinense (Jacq.) Britton. Angle-pod

Herbs with opposite, heart-shaped leaves and clusters of dark purplish wheel-shaped flowers. Crown in the throat of the corolla, obtusely 5-lobed.

Observed as a honey plant, Thurman, in cultivated grounds, July 12, 1925, by L. H. Pammel.

CONVOLVULACEAE, Morning Glory Family

Herbs, usually twining or trailing; some with milky juice; leaves alternate; flowers regular, calyx of 5 sepals distinct or nearly so, corolla more or less bell-shaped, of 5 shallow lobes, stamens 5, ovary compound, styles 2 or 3, usually two-celled or of two separate pistils. The flowers are usually brightly colored.

The morning glory is adapted to various classes of insects. Some of the flowers are proterandrous and some proterogynous. Some night-flying insects, like the moth, visit these flowers.

Ipomoea L. Morning Glory

Leafy twining plants. Corolla funnel-form to salver-form. The capsule globular, 4- to 6-seeded.

Ipomoea hederacea Jacq. Wild Blue Morning Glory

Flowers funnel-shaped, campanulate, white to purple; calyx densely hairy. Leaves heart-shaped, 3-lobed.

Alluvial bottoms, chiefly southern Iowa. Associated with *Vernonia fasciculata, Bidens cernua, B. frondosa, B. involucrata, B. vulgata,* etc.

FIG. 276.—Blue field morning glory (*Ipomoea hederacea*). Fields. Common in southern Iowa and Missouri. *Photograph by Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ledges (Boone county), West Burlington (L. H. Pammel).

Other observations not represented by specimens (L. H. Pammel), Eddyville, Fort Madison, Hamburg, Keokuk, Keosauqua, Ottumwa, Sidney.

General distribution in the United States:

Florida—Jacksonville (two specimens, A. H. Curtiss); Illinois—Cairo (L. H. Pammel), Mahomet (H. A. Gleason); Indiana—Upton (MacDougal and Wright); Kansas—Wichita (T. L. Andrews); Missouri—St. Louis (L. H. Pammel); New Jersey—Highland Park (Halsted's American Weeds); New Mexico—Florida mountains—(A. Isabel Mulford).

HONEY BEE VISITS

Honey bees have been observed by us.

Convolvulus (Tourn.) L. Bindweed

Usually herbs, twining or prostrate. Corolla funnel-form. Capsule globose, 2- to 4-valved.

Convolvulus sepium L. Hedge Bindweed

A freely twining, perennial herb, spreading by running rootstocks. Leaves triangular arrow-shaped, pointed. Corolla white to rose color, large.

FIG. 277.—Morning glory (*Convolvulus sepium*). *After Vasey, U. S. Dept. Agr.*

In alluvial soils; now widely naturalized in prairie black soils, clay or sandy loamy soils. Common in waste places everywhere. It is associated with *Physalis pubescens, Asclepias syriaca, Helianthus tuberosus, H. grosseserratus, Digitaria sanguinalis,* etc.

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Emmet county, Rockwell City (R. I. Cratty), Ames (E. B. Watson, H. I. Power, J. R. Campbell, F. C. Stewart, G. W. Carver, S. W. Beyer), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Fayette (B. Fink), Gillett Grove (L. H. Pammel).

FIG. 278.—European morning glory (*Convolvulus arvensis*). *After Fletcher and Clark.*

It has been observed (L. H. Pammel) at Algona, Burlington, Carroll, Centerville, Cherokee, Clinton, Council Bluffs, Cresco, Davenport, Denison, De Witt, Dubuque, Estherville, Fairfield, Fort Dodge, Glenwood, Hamburg, Indianola, Jefferson, Keokuk, Lake Mills, Marshalltown, Mason City, McGregor, Missouri

Valley, Mount Pleasant, Muscatine, New Albin, Onawa, Red Oak, Rock Rapids, Shenandoah, Sioux City, State Center, Turin, Wallingford, Waukon.

General distribution in the United States and Canada:

Canada—Manitoba (L. H. Pammel); Colorado—Colorado Springs, Miller (Stella L. Goodspeed), Fort Collins (J. H. Cowan, L. H. Pammel); Kansas—Wichita (T. L. Andrews); Minnesota—Black Duck (Mrs. Roy Westley); New York—Ithaca (H. E. Summers, Muenscher and Bechtel); Nova Scotia—Pictou (C. D. Howe and W. F. Lang); Ohio—Mansfield (E. Wilkinson), Worthington (Asa Horr); Wisconsin—Prescott (Mary Edgar).

FIG. 279.—European morning glory (*Convolvulus arvensis*). *Photograph by A. Hayden.*

HONEY BEE VISITS

Knuth says, "The flowers are large, white and odorless. Nectar is secreted by the orange-yellow base of the ovary and covered by the broadened lower ends of the filaments, leaving five narrow nectar passages. The hawk moth is the characteristic visitor."

Ames, July 14, 1914. Car line. Partly cloudy. Northeast wind. No bees. (G. H. M.)

August 24, 1914. Campus. Clear, southeast wind. Few honey bees, many bumble bees, few small bees. Nectar is secreted by a pad or disc on which the pistil rests. (L.A.K.)

August 27, 1923, a.m. Clear, bright. One bee two seconds in each flower.

Blooming, Ames, July 30, 1924.

Convolvulus arvensis L. Field Bindweed

Perennial, creeping or twining plant with halberd-shaped leaves, acute-lobed at base. Peduncles 1-flowered, white or pinkish blossoms salver-shaped, about 1 inch across.

Introduced in various types of soils, clay, gravel or black prairie soil; widely naturalized in pastures, gardens, roadsides and fields. It is associated with *Poa pratensis, Medicago lupulina, Asclepias syriaca, Trifolium repens,* etc.

HONEY BEE VISITS

Honey bees are reported on the morning glory in Europe by Mueller. We have seen honey bees on it in Iowa. The fragrant flowers close during bad weather and at night and in different parts of Europe at various times the flower lasts but a single day.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel, C. E. Maxwell and E. Elijah, G. W. Carver, H. E. Pammel and B. Knapp, C. R. Ball, E. R. Hodson), Fayette (B. Fink), Fremont county (T. J. and M. F. L. Fitzpatrick, J. P. Anderson), Kelley (Pearl Clayton), Lamoni (J. P. Anderson).

It has been observed (L. H. Pammel) at Carroll, Clinton, Council Bluffs, Hawarden, Lamoille, Marshalltown, Orange City.

General distribution in the United States:

California—(T. L. Andrews); Colorado—Fort Collins (C. S. Crandall), Montrose (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); District of Columbia—Washington (L. H. Pammel); Florida—Pensacola (A. H. Curtiss); Illinois—Peoria (F. E. McDonald); Missouri—Kansas City (L. H. Pammel); Nebraska—York (Mrs. Joseph Clemens); Oregon—Redmond (K. Whited); Texas—Tarrant county (L. H. Pammel).

Mueller says, "The orange-red structure under surface of the ovary secretes honey which is lodged in the lowest, narrowest part of the corolla and is sheltered by the broad bases of the stamens. The honey bee is very abundant upon the flower, getting both nectar and pollen. To suck, it creeps down into the base of the flower, dusting its head and back with pollen, which it transfers to the stigmas of the next flower which it visits."

Cuscuta (Tourn.) L. Dodder

Parasitic plants with slender, twining, threadlike stems winding about the host plants. Leaves represented by scales. Flowers and fruits generally in clusters.

Capsule mostly 4-seeded, seeds usually roundish with roughened surfaces. Soon after germination the young plants attach themselves by suckers to neighboring shrubs or herbs after which the part below attachment dies and the plant derives food for future existence from its host. Plants largely distinguished from each other by flower characters.

A number of different species found in Iowa, both introduced and native.

Flowers of the various species small, inconspicuous, aggregated in-

FIG. 280.—Left hand figure. Field dodder (*Cuscuta arvensis*). Middle figure. A. Flax dodder (*Cuscuta Epilinum*). Right hand figure. B. Lesser clover dodder, thyme dodder (*Cuscuta Epithymum*). *Mich. Agr. Exp. Sta.*

to clusters. Nectar is concealed, secreted by the base of the ovary. M. Richter records dodders as honey plants not known to yield a surplus in California.

Cuscuta Epithymum Murr. Lesser Clover Dodder

Stems very slender, flowers whitish. Stamens exserted. Found on clover.

The stamens mature at the same time as the stigmas, and are considerably longer than the two styles. Knuth states that cross pollination by means of insects is favored, for the anthers and stigmas are generally touched by opposite sides of the proboscis.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel), Blencoe (F. D. Crane), Dow City (E. L. Thomas), Varina (J. W. Ziegler).

HONEY BEE VISITS

Honey is secreted by the lower part of the ovary and is sheltered by scale-like appendages of the corolla.

Cuscuta obtusiflora (HBK). Smartweed Dodder

A plant with coarse orange-colored stems and white flowers. Often on *Polygonum*. Likes wet places.

Bees have been observed on this species.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Audubon county, Brayton, Lake Mills (L. H. Pammel), Emmet county, Iowa Lake (R. I. Cratty), High Lake (B. O. Wolden).

General distribution in the United States:

District of Columbia—Washington (E. S. Stelle); Nebraska—Callaway (Rev. J. M. Bates).

Cuscuta arvensis Beyrich. Field Dodder

Stems pale and slender. In rather dry soil, on various plants.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (J. R. Campbell), Creston (M. Smith), Dallas Center (H. E. Collins), Earlham (M. Nellis), Madison county (M. Nellis).

HONEY BEE VISITS

This plant yields honey in California.

Cuscuta Cephalanthi Engelm. Button-bush Dodder

Stem coarse and yellow, rather high climbing. On tall herbs and shrubs.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Little Rock, Wheelerwood (L. H. Pammel), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), McGregor (A. Hayden), northeast Iowa (H. Goddard).

General distribution in the United States:

South Dakota—Brookings (L. H. Pammel); Wisconsin—La Crosse (L. H. Pammel).

Cuscuta Coryli Engelm. Hazel Dodder

Stems coarse. Climbing high. Capsule globose. Our commonest species.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decatur county (two specimens, J. P. Anderson), Fairfield (Matrey), Fayette (four specimens, B. Fink), Rice Lake (L. H. Pammel), Tipton (E. L. Kirkpatrick).

Cuscuta Gronovii Willd. Gronovius' Dodder

Stems coarse. Open woods and dry prairies, on shrubs or coarse herbs.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Emmet county, High Lake (B. O. Wolden), northeastern Iowa (H. Goddard), Postville (O. Schultz).

General distribution in the United States:

Connecticut—Pine Cottage (Louise Merritt Stabler); Massachusetts—Deerfield (M. A. Day), Waverley (J. W. Blankinship); New Jersey—Barnegat Bay (J. R. Churchill); New York—Ithaca (Muenscher and Bechtel).

Cuscuta glomerata Chois. American Dodder

A very common species in Iowa. Stems slender, yellowish white. Flowers in dense clusters closely encircling the stem of the host plant.

In low moist places, on *Helianthus grosseserratus* chiefly.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Des Moines, McGregor (L. H. Pammel); Ames (S. W. Beyer), Crawford county (T. A. Allen), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway, H. Goddard), Manson (C. W. Hyde), Wapello (H. P. Kelley).

General distribution in the United States:

Kansas—Wichita (T. L. Andrews).

Cuscuta planiflora Tenor. Alfalfa Dodder

Flowers in dense clusters. Resembles *C. Epithymum.* Parasitic on alfalfa. Introduced from southern Europe. Native of Spain.

General distribution in the United States:

Montana—Billings (two specimens, L. H. Pammel); Utah—Logan (E. D. Ball).

POLEMONIACEAE, Phlox Family

Phlox L. Phlox

Herbs with opposite entire leaves and showy flowers in cymelike clusters.

Phlox paniculata L. Perennial Phlox

Stout erect plants. Flowers in a pyramidal panicle, pink-purple, about one inch across.

HONEY BEE VISITS

Mount Pleasant, September 8, 1929. Bees gathering pollen. (S. M. Helmick.)

Phlox Drummondii Hook. Drummond's Phlox

The annual phlox of gardens.

HONEY BEE VISITS

Ames, October 16, 1929, 9:30 a.m. Clear and cool. Bees two to three seconds in a flower, getting pollen.

Gilia R. and P.

Corolla tubular, calyx tube scarious. Leaves alternate. Mostly herbs.

Gilia capitata Dougl. Gilia

Stems erect, flowers blue to whitish, funnel-shaped, cultivated, wide western distribution.

HONEY BEE VISITS

Ames, July 17, 1927, 11:30 a.m. Bees abundant. One to two seconds in a flower. Near apiary.

Iowa State College Formal Gardens, July 30, 1927, 9 to 10 a.m. Cool, dry, cloudy. Bees collecting pollen. One second to the flower. (C.C.L.)

Ames, July 31, 1927, 10:30 a.m. Bees abundant. Two and one seconds in a flower.

Polemonium (Tourn.) L. Greek Valerian

Perennials with alternate pinnate leaves and flowers in corymbose clusters, bell-shaped or short funnel-form corolla.

FIG. 281.—Greek valerian (*Polemonium reptans*). *Photograph by A. Hayden.*

Polemonium reptans L. Saint Jacob's Ladder, Greek Valerian

A smooth or slightly pubescent perennial 12 to 14 inches tall; leaflets 5 to 15, ovate-lanceolate. Flowers light blue, nodding, in corymbose clusters.

HONEY BEE VISITS

Eldora, June 5, 1927, 4 p.m. Clear, warm. Only a few flowers left. No bees.

Polemonium humile Willd. Low Phlox

Pubescent, low growing plant, with creeping rootstocks. Leaflets 15 to 21. Corolla blue or purplish. Cultivated.

HONEY BEE VISITS

Ames, June 26, 1929, 2:30 p.m. Warm, cloudy. Bees three, four, five seconds in a flower.

HYDROPHYLLACEAE, WATERLEAF FAMILY

Ours, herbs with opposite or alternate leaves. Flowers regular, blue or whitish, and complete, 5 calyx lobes and 5-lobed corolla; stamens 5, inverted on corolla near its base; ovary compound, style 1, often 2-cleft, or 2 separate styles. Fruit a 1-celled capsule.

FIG.282.—Waterleaf (*Hydrophyllum virginianum*). *Photograph by A. Hayden.*

Hydrophyllum L. Waterleaf

Perennial herbs, with large leaves and bluish purple cymose-clustered flowers. Leaves smooth or hairy, pinnately divided. In rich, sandy woods and shady places.

Hydrophyllum virginianum L. Waterleaf

The corolla in this species is bell-shaped, the tube being furnished with 5 longitudinal appendages opposite the lobes, forming nectar-bearing grooves.

The lavender flowers are borne in cymose clusters. Associated with *Claytonia virginica, Hepatica acutiloba, Podophyllum peltatum, Dicentra Cucullaria, Sanguinaria canadensis, Aster sagittifolius.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dubuque, Madrid, McGregor, Moingona, Postville, Webster City (L. H. Pammel); Ames (E. D. Ball), Boone (J. V. Ellis), Dakota City (F. C. Stewart), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Fraser (L. H. Pammel and R. I. Cratty), Nora Springs (W. D. Goble), northeastern Iowa (H. Goddard), Ontario (E. R. Hodson), Postville (L. H. Pammel, Ellison Orr, D. O. Wilson), Woodman's Hollow (Webster county) (F. Horton), Yellow river (L. H. Pammel, Ellison Orr, Orville Schultz, two specimens).

It has also been observed (L. H. Pammel) at Burlington, Davenport, Forest City, Fort Dodge, Fort Madison, Keokuk, Oelwein, Peterson.

Knuth says regarding this plant, "Nectar is secreted at the base of the flower and rises in a series of tubes, each bounded by a pair of longitudinal folds and the midrib of a petal."

The waterleaf is frequently visited by bees. The nectar (in the grooves) is easily accessible to the honey bees.

Charles Robertson says, "On account of the erect corolla lobes and the hairy filaments the nectar can be obtained most conveniently by a tongue about nine mm. long." The honey bee is not mentioned by him.

Pellett says, "It blooms abundantly and grows luxuriantly in moist woods. The bees have been so eager for the blossoms of the plant in the writer's wild garden, and in the surrounding woods for several years past that he has come to regard it as a valuable honey plant."

Loew reports the honey bees vainly trying to get honey out of this flower at the Berlin Botanical Gardens and considers that the hawk moth is the true pollinator.

HONEY BEE VISITS

We have seen numerous bees on the blossoms of this plant and consider it a normal bee flower.

Ledges, Boone county, May 21, 1921. Both honey bees and bumble bees at work on this flower.

Ames, May 30, 1925, 6 p.m. The bees two to four seconds in a flower.

Bangor, May 30, 1925, 4 p.m. The bee four, two, three seconds in the flower.

Britt, June 3, 1926, 9:30 a.m. Bees ten to five seconds in a flower.

Forest City, June 3, 1926, 5:30 p.m. Bees five to ten seconds in a flower.

Lake Mills, June 3, 1926, 10:30 a.m. Bees six to twelve seconds in a flower.

Boone, May 31, 1927. Abundant bees. Bees visit this flower freely, neglecting *Rosa blanda* near at hand. Bees two to six seconds in a flower.

Hydrophyllum appendiculatum Michx. Waterleaf

A somewhat hairy plant resembling the preceding. Leaves palmately 5-lobed. Calyx with a small reflexed lobe in each cleft.

The flowers are pale blue with white centers, and arranged in loose cymes. The throats are not hairy. Nectar is easily accessible.

Common in northern Iowa. It is associated with *Fragaria vesca, Ribes Cynosbati, Mitella diphyllum, Geranium maculatum, Tilia americana, Acer nigrum, A. spicatum, A. saccharum, Aquilegia canadensis, Viola pubescens.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Waukon Junction, Winterset (L. H. Pammel); Elkader (R. M. Hempel), Fayette (two specimens, B. Fink), Howard county (F. M. Tuttle), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), Marion county (L. H. Pammel and C. M. King), northeast Iowa (H. Goddard).

FIG. 283.—Waterleaf (*Hydrophyllum appendiculatum*). *Photograph by A. Hayden.*

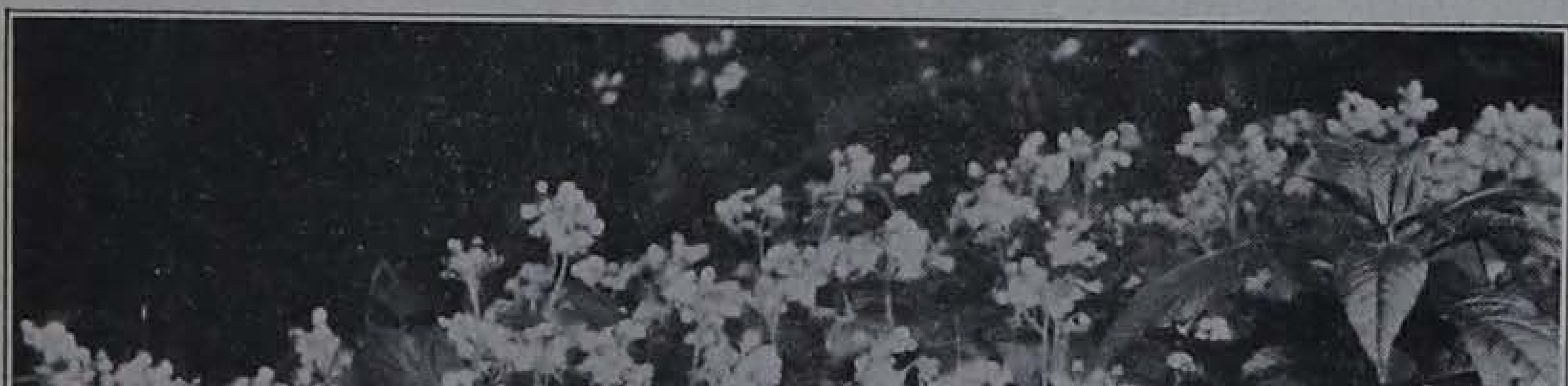

FIG. 284.—Waterleaf (*Hydrophyllum appendiculatum*). *Photograph by A. Hayden.*

HONEY BEE VISITS

Knuth says, "Nectar is concealed at the base of the flower."

Charles Robertson says, "The flowers are proterandrous. They are pale blue with white centers. The throat is more widely open than in *H. virginianum* and the filaments are not hairy. There is, therefore, less difficulty in reaching the nectar. Accordingly, we find more short tongued insects, though the bumble bees remain by far the most numerous guests.

"The flowers and flower clusters are much more conspicuous and the plants grow in larger patches."

On May 13, 14 and 16, he observed honey bees abundantly collecting pollen and nectar. This species is a better honey plant than *H. virginianum*.

Boone, May 5, 1927, 6 p.m. Good honey plant. Bees abundant. Six to eighteen seconds in a cluster.

May 30, 1927, 6 p.m. Warm, clear. Bees abundant. Ten to sixteen seconds in a cluster.

Columbia, Missouri, May 31, 1927, 1:30 p.m. Clear, warm. Honey bees abundant. One to two seconds in a flower.

Ames, June 7, 1927. "North Orchard" (Horticultural Dept. I.S.C.) Fifty-one visits of bee to flower cluster in one and one-half hours. About one minute to the cluster. (C.C.L.)

BORAGINACEAE, Borage Family

Herbs, generally rough, with alternate entire leaves, regular symmetrical flowers, 5-parted calyx and 5-parted corolla, 5 stamens and a single style. Four-lobed ovary in fruit, four one-seeded nutlets.

This family contains the puccoons, heliotrope, hound's tongue, stickseed, bugloss, comfrey and lungwort. Not many of the plants are valuable as honey producers.

The flowers are collected in cymes often scorpioid in character. The flowers are rotate or somewhat so. The nectar is secreted in the receptacle immediately above the ovary and is stored in the corolla tube. There are a few plants in the family which do not secrete much nectar, like some of the puccoons (*Lithospermum*).

Borago L. Borage

Annual or perennial herbs. Erect, hispid. Alternate leaves and loose, leafy cymes of blue flowers. Corolla rotate or campanulate. Stamens five.

Borago officinalis L. Common Borage

Coarse hairy annual, petioled. The leaves often 4 to 6 inches long. Stamens exserted.

A plant frequently cultivated from Europe as an ornamental and as a bee plant. Flowers in loose racemes, blue or purplish.

HONEY BEE VISITS

This is one of the best of our honey plants. Pellett records it as a honey plant and Mr. Fisk Bangs records it as blooming from June 20 to cold weather, which gives it a long period of bloom. Lovell states that it is commonly visited by honey bees. He reports it as blooming from midsummer until frost. Blairstown, September 28, 1929, 2 p.m. Bees two, three seconds in a flower.

Anchusa L. Alkanet

Annual or perennial herbs which are hispid or villous. Alternate leaves. Flowers on scorpioid cymes or racemes; blue, violet or white. Calyx becoming inflated.

Several species of this genus are cultivated for ornamental purposes.

Anchusa capensis Thunb. Cape Bugloss

About one and one-half feet high. Narrow, lanceolate leaves. Calyx inflated. Native to the Cape of Good Hope region.

HONEY BEE VISITS

Ames, July 22, 1927, 11 to 12 a.m. After rain. Cloudy, warm. Bees one and one-half to two seconds in a flower. (C.C.L.)

July 31, 1927, 10:30 a.m. Bees very abundant. Two seconds in a flower.

August 25, 1927, 4 p.m. Bees two to three seconds in a flower.

July 21, 1928, 4:30 p.m. Bees two to three seconds in a flower.

October 14, 1929, 1:30 p.m. Bees two to three seconds in a flower.

Anchusa azurea Mill.

Ames, May 30, 1929, 11 a.m. Warm. Some honey bees for pollen. *Bombus pennsylvanica*. Flowers not adapted to honey bees but to bumble bees. Honey bees gather pollen.

June 3, 1929, 10:30 a.m. Bumble bees common. Honey bees fairly common. Pollen. Four seconds in a flower.

Heliotropium (Tourn.) L. Heliotrope

Corolla salver-form. Herbs or low shrubby plants. Leaves entire.

Heliotropium peruvianum L. Common Heliotrope

Leaves oval, much veined. Flowers one-eighth inch long, violet to purple, vanilla-scented, in a close cyme.

Ames, October 16, 1929, 8:30 a.m. Clear and cool. Bees three and two seconds in a flower.

Mount Pleasant, September 8, 1929. Bees gathering nectar and pollen. (S. M. Helmick.)

Cynoglossum (Tourn.) L. Hound's Tongue

Corolla funnel-shaped, the tube about equaling the 5-parted calyx. Nutlets roughened with short barbed prickles. Coarse herbs. Flowers panicled.

Cynoglossum amabile Stapf and Drummond

A hairy herb, 1 to 3 large leaves. Numerous blue flowers as in forget-me-not. From India.

HONEY BEE VISITS

Ames, July 22, 1927, 11 to 12 a.m. After rain, cloudy, warm. Bees getting honey. One to two seconds in a flower. (C.C.L.)

July 31, 1927, 10:30 a.m. Clear, warm, northwest wind. Bees abundant. Two and one seconds in a flower.

July 21, 1928, 4:30 p.m. Bees two to three seconds in a flower.

FIG. 285.—Hound's tongue (*Cynoglossum officinale*). In pastures. The burs are scattered by sheep. *Photograph by Ia. Agr. Exp. Sta.*

Cynoglossum officinale L. Common Hound's Tongue

Pellett mentions it as a valuable honey plant, quoting an Indiana beekeeper to the effect that there are few plants which yield more honey than it does, coming between fruit bloom and sweet clover and extending into the latter.

HONEY BEE VISITS

Abundantly visited by honey bees in Iowa.

Waukee, May 31, 1929, 5:30 p.m. Bees abundant. Four to six seconds in a flower.

Amsinckia Lehm.
Amsinckia

Annuals with rough, hairy herbage, yellow flowers in elongated spike; sepals usually five, corolla salver-form or somewhat funnel-form; nutlets rough, dull, ovoid.

Amsinckia lycopsoides Lehm. Amsinckia

A loosely branched annual one to two feet high; leaves oblong with erose-sinuate, or entire margins; flowers in loose racemes.

Distribution in Iowa:

Naturalized in a few places.

FIG. 286.—Hound's tongue (*Cynoglossum officinale*). From *Darlington's Weeds and Poisonous Plants.*

General distribution in the United States:

California—Monterey (T. L. Andrews), Patterson (L. H. Pammel and Alice-Marie Needham); Idaho—Nez Perces (J. H. Sandberg); Illinois—Rantcul (H. A. Gleason).

HONEY BEE VISITS

Freely visited by honey bees.

Lycopsis L. Bugloss

Annual herbs with funnel-shaped corolla, slightly unequal limb, with five bristly scales opposite the lobes of the corolla; nutlets rough, wrinkled.

Lycopsis arvensis L. Small Bugloss

A rough bristly annual, lanceolate leaves; flowers racemose, corolla blue. Occasionally spontaneous. Freely visited by honey bees in formal garden.

Myosotis (Rupp.) L. Scorpion-Grass, Forget-me-not

Low soft-hairy herbs, leaves entire, small flowers in naked racemes.

FIG. 287.—Forget-me-not (*Myosotis scorpioides*). *Photograph by A. Hayden.*

Myosotis scorpioides L. True Forget-me-not

Perennial, stems ascending, loosely branched, smoothish. Leaves lanceolate, pubescent. Calyx lobes shorter than its tube. Corolla broad, sky blue with a yellow eye. In moist ground.

HONEY BEE VISITS

Ames, June 17, 1928, 11:30 a.m. Visited by honey bees.

Onosmodium Michx. False Gromwell

Coarse perennial herbs, whitish or greenish yellow flowers and bony nutlets. Leaves oblanceolate. Calyx silky and sparingly hirsute. Flowers in raceme-like clusters.

Onosmodium molle Michx. False Gromwell

Finely grayish pubescence, perennial hispid rigid stem, greenish white flowers with grayish pubescence.

Sandy and gravelly soils. Associated with *Lithospermum canescens, Pedicularis canadensis, Viola pedata,* and *Stipa spartea.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ankeny, Backbone Park (Delaware county), Cedar Falls, Granite, Mason City, Ogden, Wheelerwood (L. H. Pammel); Armstrong, Estherville (R. I. Cratty), Gilbert, Winterset (G. W. Carver), Ames (F. Jensen and W. Newell), Cerro Gordo county (M. Jones), Colfax (F. P. Sipe), Creston (T. L. Andrews), Fayette (B. Fink), Little Rock (C. R. Ball), northeastern Iowa (H. Goddard).

HONEY BEE VISITS

It is visited by honey bees.

VERBENACEAE, Verbena or Vervain Family

Ours, herbs with opposite or whorled leaves. Regular complete or sometimes more or less 2-lipped flowers, calyx 5-toothed, persistent, stamens 4 in 2 pairs, ovary superior, single style, stigma 2 or 1.

Knuth says, "Verbenaceae are bee flowers with nectar secreted by the base of the ovary and stored at the bottom of the short corolla tube. Within the corolla tube is a ring of hairs, to keep out unbidden insects."

Vitex (Tourn.) L. Chaste Tree

Slender shrubs with pliant branches. Used, but not commonly, as ornamentals.

Vitex Agnus-Castus L. Chaste Tree or Hemp Tree

Leaflets 5 to 7, lanceolate, entire, whitened underneath. Flowers bluish, in sessile clusters, forming an interrupted spike at the end of the branches. Plants of the Mediterranean region. Cultivated in various soils. Hardy throughout Iowa.

General distribution in the United States:

Texas—(B. C. Thorpe).

HONEY BEE VISITS

Ames, August 24, 1914. Horticultural Garden. Clear, southeast wind. One bee per minute. Six seconds on one flower. Six bees, six other Hymenoptera. (G.H.M.)

Good honey plant in Florida.

Vitex incisa Wall. Chaste Tree, Hemp Tree

Leaflets incisely serrate, three-fourths inch to three inches long. A graceful shrub with handsome foliage and not very showy bluish flowers.

Cultivated in various soils; fairly hardy. Not generally grown. It is cultivated at Ames. The following interesting letter from Prof. Beach gives the history of the plant at Ames:

"Replying to your inquiry of February 10 will say that the specimen of *Vitex* which we grew in the Plant Introduction Garden here on the Campus came from Lug Tung, China, and was sent to the Upper Mississippi Valley Introduction Garden under S.P.I. No. 21976, is *Vitex incisa*. *Vitex Agnus-castus* is also grown in gardens. There are two or three other less common types of *Vitex* which are included in collections of plant materials, but so far as I know these are not usually found in gardens."

HONEY BEE VISITS

It is freely visited by honey bees.

Verbena (Tourn.) L. Vervain

Herbs with flowers in heads or spikes. Stems usually decumbent, clustered. Fruit a 4-seeded group of nutlets. Leaves opposite.

In this genus nectar is secreted at the base of the ovary and stored at the base of the short corolla tube.

Only one of the verbenas is a good honey plant, namely *Verbena stricta*, which is common in all parts of the state on gravel knolls and sandy soil in pastures. This plant is sometimes a source of surplus honey.

FIG. 288.—White vervain (*Verbena urticaefolia*). *Photograph by Photo Section Ia. Agr. Exp. Sta.*

Bees are abundant at times, depending upon the weather and soil. When the season is very dry, the plant does not yield as much nectar; after a rain it yields abundantly. At Ames and at Garner, bees have been observed on this plant in great numbers.

The garden verbena is rarely visited by bees and the same is true of *Verbena hastata.*

Verbena urticaefolia L. White Vervain

Perennial, minutely pubescent, 2 to 5 feet high. Leaves oval-oblong, acute, petioled, coarsely serrate. Spikes much elongated. Flowers white. Roadsides, thickets.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Churdan, Dawson, Des Moines, Fredonia, Iowa City, Lost Island, Manti, Norwalk, Oxford Junction, Saratoga, Steamboat Rock, St. Olaf, Stratford (L. H. Pammel); Armstrong, Ottumwa (R. I. Cratty), Ames (A. S. Hitchcock), Bloomfield (L. H. Pammel and I. E. Forbes), Colfax (S. P. Sipe), Commerce (L. H. Pammel, Mrs. Frankel and Mrs. G. Rieman), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Delaware county (I. T. Bode), Fayette (B. Fink), Fort Dodge (J. C. Blumer, F. W. Paige), Fraser (Botanical Seminar), Kelley (Pearl Clayton), Keokuk (Iza Mitchell), Ledges (L. H. Pammel, C. M. King, R. E. Buchanan, T. Macklin), Marshalltown (L. H. Pammel and E. Fogel), Montezuma (Mrs. Hill), Muscatine (L. H. Pammel, J. Kelso and E. R. Harlan), New Hampton (L. H. Pammel and C. J. Spiker), northeastern Iowa (H. Goddard), Osage (F. M. Tuttle), Slater (H. S. Fawcett, W. I. Tener, G. Reinbott), Tama county (V. C. Fisk).

FIG. 289.—White vervain (*Verbena urticaefolia*). *Photograph by A. Hayden.*

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); Illinois—Champaign (B. Fink), Hamilton (L. H. Pammel); Kansas—Wichita

(T. L. Andrews), Massachusetts—Franklin (K. M. Weigand); Minnesota—Albert Lea (L. H. Pammel), Black Duck (Mrs. R. O. Westley), Minneapolis (R. I. Cratty); Missouri—St. Louis (H. Eggert); Nebraska—Callaway (J. N. Bates); New Jersey—Perth Amboy (L. H. Pammel); New York—Renwick Flats (Muenscher and Bechtel); Oklahoma—"River Bottoms" (W. E. Bruner); South Dakota—Sisseton (L. H. Pammel); West Virginia—Tucker county (A. H. Moore); Wisconsin—Muscoda (L. H. Pammel), Portland (C. M. King and D. Pammel).

HONEY BEE VISITS

McGregor, August, 1924, 4 p.m. Bees common. One to two seconds in a flower.

Verbena angustifolia Michx. Narrow-leaved Vervain

Low growing, one to two feet high; leaves narrow, lanceolate, spikes few; purple flowers, crowded.

Massachusetts westward and southward. In dry, sandy and gravelly soils, especially in eastern Iowa, as near Hampton and Cedar Falls. It is associated with *Cassia Chamaecrista, Scutellaria parvula, Eragrostis pectinacea, Cenchrus tribuloides, Anemone patens* var. *Wolfgangiana, Panicum virgatum, Verbena bracteosa, Plantago Purshii, Euphorbia corollata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Cedar Falls (two specimens), Charles City, Granite (L. H. Pammel); Iowa City (three specimens), Waterloo (A. S. Hitchcock), Camanche (C. R. Ball).

It has also been observed (L. H. Pammel) at Clinton, Dubuque, Fort Madison, Muscatine.

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); Georgia—Ringgold (John K. Small); Illinois—Rockford (L. H. and H. E. Pammel); Missouri—Rolla (S. E. Meek); Ohio—Kelley's Island, Sandusky (L. H. Pammel); Texas—Galveston Island (S. M. Tracy).

HONEY BEE VISITS

Ames, August 11, 1915. Cloudy, northwest wind. No bees.

Verbena hastata L. Blue Vervain

Stiff plant one and one-half to three feet high. Leaves lanceolate, taper-pointed, cut-serrate, petioled, lower leaves often lobed. Spikes linear, erect, panicled. Flowers violet-blue.

FIG. 290.—Blue vervain (*Verbena hastata*). *Photograph by A. Hayden.*

In alluvial bottoms, shores of lakes, sandy moist soils. Associated with *Verbena urticaefolia, Scirpus atrovirens, Carex vulpinoidea, Salix longifolia, S. cordata, S. nigra, Eupatorium perfoliatum, E. purpureum, Scutellaria lateriflora, Mimulus ringens.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dubuque, Eddyville, Lost Island lake, Mason City, Palo Alto (L. H. Pammel); Armstrong, Clear Lake, Osage, West Bend (R. I. Cratty), Ames (S. W. Beyer, A. S. Hitchcock, R. Jeffs), Decatur county (two specimens, J. P. Anderson), Fayette (two specimens, B. Fink), Hull (W. Newell), Kelley (three specimens, Pearl Clayton, L. H. Pammel, and C. E. Maxwell), Lamont (I. T. Bode), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), Muscatine (Pammel, Kelso and Harlan), New Hampton (P. H. Rolfs), New Liberty (H. Hull), Steamboat Rock (C. M. King).

It has been observed (L. H. Pammel) at Algona, Burlington, Cedar Rapids, Centerville, Davenport, Forest City, Garner, Hamburg, Indianola, Keokuk, Little Rock.

General distribution in the United States:

California—Francis county (Stella L. Goodspeed); Colorado—Fort Collins (C. S. Crandall); Kansas—Wichita (T. L. Andrews); Minnesota—Brainerd

(E. B. Watson); Cass Lake (H. E. and L. H. Pammel); Grand Rapids (J. H. Sandberg), Kelley's lake (Lyle Clapper), Jackson county (R. I. Cratty); Missouri—Hannibal (R. Gmelin), St. Louis (H. Eggert); Nebraska—Halsey (J. C. Blumer); Spade Ranch (two specimens, R. E. Buchanan); Willow Island (Joseph Wahl); New Jersey—New Market (J. A. Kelsey); New York—Ithaca (Muenscher and Bechtel, H. E. Summers), Niagara Falls (G. H. Frazier); Ohio—Pickerington (Asa Horr); Tennessee—Clarksville (T. L. Andrews); Utah—Farmington canon (two specimens, L. H. Pammel and R. E. Buchanan), Virginia—Blackberry (W. A. Murrill); Wisconsin—Holmen (L. H. Pammel), Madison.

HONEY BEE VISITS

Ames, July 17, 1927, p.m. Warm, clear, dry and windy. Bees three seconds in a flower. (C.C.L.)

McGregor, August 15, 1928, 8 a.m. Bees one to two seconds in a flower. (T. Thomson.)

Des Moines, August 3, 1929. Bees one to two seconds in a flower. Five hundred feet from apiary.

Wauzeka, Wisconsin, August 15, 1929, 10 a.m. Bees one second in a flower. (Alluvial bottoms.)

Verbena stricta Vent. Hoary Vervain

Herbaceous plants with opposite leaves. Flowers large, purple, in spikes. The plant downy with soft whitish hairs. Common in pastures. Native to barrens and prairies. Ontario westward and southwestward.

Sandy, gravelly knolls, rocky, limestone soils. It habitat has been greatly modified, the plant now being common in pastures. Associated with *Solidago missouriensis, Ceanothus americanus, C. ovatus, Lespedeza capitata, Panicum virgatum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls, Cherokee, Coon Rapids, Dawson, Fairfield, Granite, Jefferson, Lawler, Mason City, Moravia, Muscatine, New Albin, Oakland, Ottumwa, Sioux City, Spirit Lake, Steamboat Rock (L. H. Pammel); Armstrong, West Bend (R. I. Cratty), Ames (G. W. Carver, two specimens, C. E. Bessey, two specimens, A. S. Hitchcock, S. W. Beyer, Harold and Violet Pammel, two specimens, H. Fawcett, R. E. Jeffs, H. A. Stafford), Algona (E. B. Watson), Arnold's Park (L. H. and H. E. Pammel), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Dunlap (H. Kellogg), Fayette (two specimens, B. Fink), Humboldt (J. O. Hask), Kelley (two specimens, Pearl Clayton), La Crosse (L. H. Pammel), Little Rock (C. R. Ball), northeastern Iowa (H. Goddard), Osage (F. M. Tuttle).

It has also been observed (L. H. Pammel) at Carroll, Cedar Rapids, Centerville, Cherokee, Clinton, Council Bluffs, Dana, Denison, Dubuque, Fairfield, Forest City, Fort Dodge, Hamburg, Huxley, Ida Grove, Indianola, Iowa City, Keokuk, Marshalltown, Missouri Valley, Mount Pleasant, Muscatine, Shenandoah, Turin, Waukon.

General distribution in the United States:

Arkansas—Lawrence county, Fort Smith (P. H. Rolfs); Florida—Orange county (A. Fredholm); Illinois—Berwyn (H. S. Fawcett), Blackberry (B. Fink), Hamilton (L. H. Pammel), Peoria (F. E. McDonald); Kansas—Wichita (T. L. Andrews); Missouri—Jefferson Barracks, Pilot Knob, Washington (L. H. Pammel), Allenton (George W. Letterman); Nebraska—Holdrege (J. G. McMillan), Lincoln county (two specimens), Scott's Bluff (F. G. Miller), Sheridan county (R. E. Buchanan); New Mexico—Las Vegas (A. Isabel Mulford); New York—Ithaca (Muenscher and Bechtel); Oklahoma—Norman (W. E. Bruner); Pennsylvania—Lancaster (John K. Small); South Dakota—Brookings, Yankton (L. H. Pammel); Wisconsin—La Crosse (C. M. King and Dora Pammel), Mazomanie, Dane county (J. R. Heddle).

FIG. 291.—Hoary vervain (*Verbena stricta*). *Photograph by A. Hayden.*

HONEY BEE VISITS

Ames, July 2, 1914. Pastures. Clear, southwest wind. Bees visiting three spikes in one minute. (L.A.K.)

July 6, 1914, p.m. Pasture. Cloudy, light east wind. One bee visited twenty-two flowers on twelve spikes each minute. (L.A.K.)

July 9, 1914, p.m. Pasture. Clear, southeast wind. Very dry and warm. Bees abundant. (L.A.K.)

July 22, 1914. All day. Pasture. Partly cloudy, hot, dry. A few bees. no other insects except an occasional Lepidoptera.

August 7, 1915. Pasture. Clear, moderate. Fewer bees than last summer. (L.A.K.)

August 10, 1915. Pasture. Clear, warm. Five bees. A few Lepidoptera. (L.A.K.)

August 21, 1915. Pasture. Clear, warm. Blooming season passing. Few bees. (L.A.K.)

September 6, 1915. Pasture. Clear, moderately warm. No bees. (L.A.K.)

F. L. Kenoyer reported that bees worked this plant very much in pastures

FIG. 292.—Hoary vervain (*Verbena stricta*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

in southeastern Kansas in 1914. *V. hastata*, and *V. hastata* and *V. stricta* hybrids were worked in 1914, practically as much as was *V. stricta*.

Le Mars, 1918. "An abundance of honey" from *V. stricta*. (E. G. Brown.)

La Crosse, Wisconsin, July 29, 1918. Some honey bees at work.

Marshall, Minnesota, July 29, 1918, 7 p.m. Clear and cool. Bees numerous.
8 p.m. Still a few at work. Forty-five flowers visited by one bee in two minutes.

Rockwell City, July 15, 1920. Clear. Honey bees numerous. Two bees work three hundred flowers in one minute. Just as common as on white clover. Time in flower one to two seconds.

Polk county, July 15, 1920. *V. stricta* in full bloom for one week.

Ames, July 15, 1920, 8:45 a.m. Time in flower four to three seconds.

July 25, 1920, 6 p.m. Cloudy, cool. One bee over an area of five hundred fifty flowers. Time in one flower four to three seconds.

Coon Rapids, June 27, 1921. Cloudy. Some bees. One second in one flower.

Ames, July 13, 1921, 4 p.m. Clear, warm. On four hundred flowers one honey bee. One second in a flower.

July 27, 1923. No bees. Plants growing next to white sweet clover.

July 10, 1924. No bees seen upon the flowers although plants abundant at Lake View, Sac City, Fort Dodge, Rockwell City, Webster City, Jewell, Marshalltown, Nevada, Colo, Kelley, Ankeny, Des Moines.

State Center (two miles west), July 24, 1927, 1 to 4 p.m. Damp, cool, cloudy, slight wind. Bees at work in this plant in a pasture, averaging two seconds in each bloom. (C.C.L.)

FIG. 293.—Prostrate vervain (*Verbena bracteosa*). A. Drawing of trichome. *Photograph by Quade.*

Grand View, August 5, 1927, 3:30 p.m. Bees two to three seconds in a flower.
Prairie du Chien, Wisconsin, August 8, 1929, 10:30 a.m. Abundant bloom. Flowers about half gone. Sandy soil. Bees one second in a flower.
McGregor, August 8, 1929, 2 p.m. No honey bees.
Prairie du Chien, Wisconsin, August 15, 1929. No bees on this species, though they were abundant on *Monarda punctata* and *Melilotus alba* and six days previous bees were common on this plant in the same vicinity.
Mason City, August 18, 1929, 6 p.m. Past prime of bloom. No bees observed, although they were common on *Melilotus alba.*
Fruitland (sandy soil), August 5, 1927, 4 p.m. Bees abundant. Two to three seconds in a flower.
Churdan, July 29, 1928, 3 p.m. Bees numerous. Two seconds in a flower.
Eldora, July 30, 1928, 4 p.m. Bees two seconds in a flower.
Iowa City, August 2, 1928, 3 p.m. Warm and clear. Two and one seconds in a flower.
Chelsea, August 6, 1928, 12:30 p.m. Bees one and two seconds in a flower.
McGregor, August 8, 1928. Bees two seconds in a flower.
Boone, July 27, 1929. Some bees. Two and one seconds in a flower.
Ames, Aug. 25, 1930. Bees two seconds in a flower gathering pollen.
Sept. 3, 1930. Bees gathering pollen, fairly common. A dry season.

There is a great variation in honey bee visits to the hoary vervain. Much depends upon the moisture in the soil and the humidity of the atmosphere. We have found in some places bees abundant and in others none, which is entirely due to different soil and climatic conditions.

Blooming, Ames, July 5, 1924; Lansing, July 3, 1925; Ames, July 3, 1926.

Verbena bracteosa Michx. Bracted Vervain

A spreading procumbent hairy annual, very leafy. Spikes single, remotely and numerously flowered. Bracts large, longer than the purple flowers.

Sandy prairies, gravel knolls, black or clay soils, waste places. Common. Habitat greatly changed, the plant having become a troublesome weed associated with *Euphorbia corollata, E. maculata, Verbena stricta, Cassia Chamaecrista, Amaranthus blitoides.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, Steamboat Rock, Wheelerwood (L. H. Pammel); Ames (C. E. Bessey, two specimens, H. S. Fawcett, two specimens, G. W. Carver, C. R. Ball), Creston (T. L. Andrews), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Iowa City (A. S. Hitchcock), Kelley (two specimens, Pearl Clayton), Lamont (I. T. Bode), Lawler (P. H. Rolfs), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), Mount Pleasant (J. H. Mills), northeastern Iowa (H. Goddard).

It has also been observed (L. H. Pammel) at Algona, Boone, Carroll, Cedar Rapids, Centerville, Cherokee, Clinton, Council Bluffs, Cresco, Dana, Decorah, Des Moines, Dubuque, Forest City, Hamburg, Indianola, Mason City, McGregor, New Albin, Postville, Rock Rapids, Sioux City, Spirit Lake, Story City.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Arizona—Flagstaff (D. T. MacDougal); Colorado—Golden, Lookout Mountain (L. H. Pammel), Fort Collins (J. H. Cowan), La Porte (L. H. Pammel and C. P. Johnson), Manitou (F. E. and E. S. Clements), New Windsor (George E. Osterhout); Florida—(S. B. Buckley); Georgia—Stone Mountain (John K. Small); Illinois—East St. Louis (H. Eggert), Harvard (H. A. Gleason); Kansas—Greeley county (J. P. Anderson), Wichita (T. L. Andrews); Minnesota—Brainerd (E. B. Watson), Jackson county (R. I. Cratty), Minneapolis (J. H. Sandberg), St. Cloud (R. Gmelin); Montana—Glendive (L. H. Pammel); Nebraska—Holdrege (J. G. McMillan), Kearney (L. H. Pammel and I. C. Brownlie), York (Mrs. Joseph Clemens); New Mexico—Cuba (A. D. Read); Oklahoma—Norman (W. E. Bruner); South Dakota—Brookings (Edna C. Pammel, C. D. Gunn), Hot Springs (J. C. Witham), Spearfish canyon (C. M. King); Tennessee—Clarksville (T. L. Andrews); Texas—Tarrant county (Albert Ruth); Utah—Peterson, Salt Lake City (L. H. Pammel and R. E. Blackwood); Wisconsin—La Crosse (L. H. Pammel); Wyoming—Laramie (Aven Nelson), Sheridan (F. Reppert, Estella Paddock and Sarah Ellis).

HONEY BEE VISITS

Ames, Old Athletic field, July 8, 1914. Clear, north wind. One bee per flower each thirty minutes. Several small bees. (G.H.M.)

Verbena Hybrid forms

Hybrids have been noted as somewhat freely occurring as a result of various crossings of *Verbena stricta, V. hastata, V. bracteosa, V. angustifolia* and *V. urticaefolia.*

Verbena hastata x *V. stricta*

A hybrid which has the aspect of both the parent species. The flowers are white or purple and the leaves sometimes resemble *V. urticaefolia* or *V. hastata.* The spikes are smaller than those on *V. stricta.*

An occasional hybrid in sandy soils. Associated with *V. hastata* and *V. stricta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dawson, Garner, Oxford Junction, Palo Alto county, Steamboat Rock (L. H. Pammel).

General distribution in the United States:

Illinois—Cairo (H. Eggert); Missouri—Pacific, St. Louis (H. Eggert), Allenton (Geo. W. Letterman); Wisconsin—La Crosse, Trempealeau (L. H. Pammel).

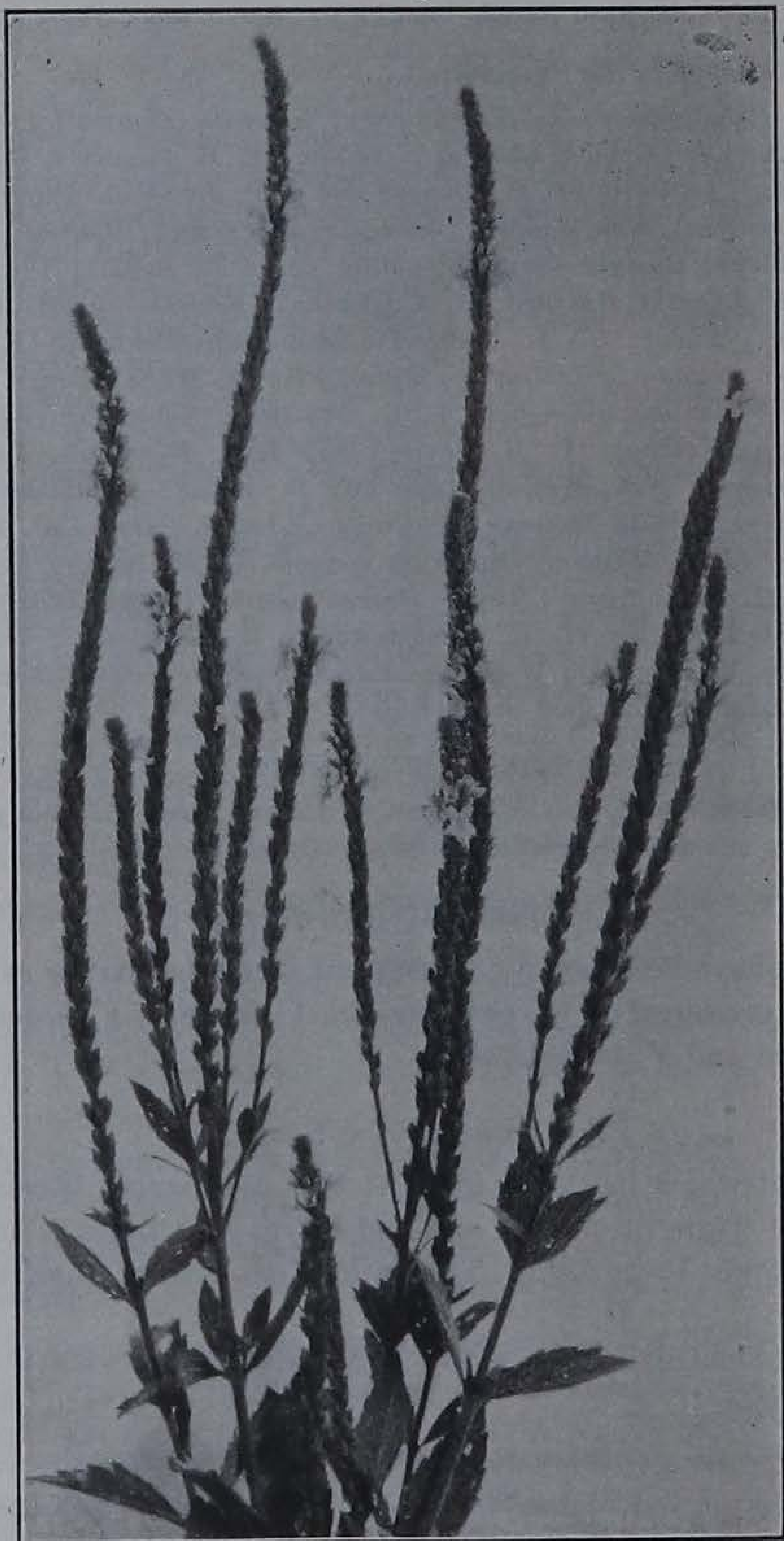

FIG. 294.—Hybrid blue vervain (*Verbena hastata* and *V. stricta*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

HONEY BEE VISITS

This hybrid is visited by honey bees.

Verbena hastata x *V. urticaefolia*

Exhibits characters of both parents.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Iowa Falls (M. E. Peck), Muscatine (L. H. Pammel, J. Kelso and E. R. Harlan), Sioux City (L. H. Pammel).

HONEY BEE VISITS

It is visited by honey bees.

Verbena hastata x *V. bracteosa*

This hybrid is more or less erect in habit with the leaves of *V. bracteosa.* Flowers of the same color.

An occasional hybrid; in sandy soils. Associated with *V. stricta* and *V. bracteosa, Euphorbia corollata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Steamboat Rock (L. H. Pammel).

HONEY BEE VISITS

It is visited by honey bees.

Verbena stricta x *V. bracteosa*

This is an erect plant with leaves sometimes lobed. Flowers in spikes; not as large as those of *V. stricta* but larger than *V. bracteosa.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Ames (L. H. Pammel), Cedar Falls (G. W. Carver).

Verbena stricta x *V. angustifolia*

The leaves of this hybrid are smoother than those of *Verbena stricta.* The flowers are intermediate between the two species *V. stricta* and *V. angustifolia.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Camanche, Oxford Junction (L. H. Pammel).

HONEY BEE VISITS

It is visited by honey bees.

Verbena bracteosa x *V. urticaefolia*

Exhibits characters of both parents.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Hamburg, Iowa City (A. S. Hitchcock), Decatur county (J. P. Anderson).

HONEY BEE VISITS

It is visited by honey bees.

Lippia (Houston) L. Fog-fruit

Herbs with opposite leaves and flowers in spikes. Fruit splitting into two nutlets. Flowers with flattened three-lipped calyx; corolla 2 lipped, upper smaller than lower.

Lippia lanceolata Michx. Fog-fruit

A low spreading green plant, lanceolate toothed leaves, long slender peduncles, bearing solitary heads of bluish white flowers.

Along alluvial banks of streams, as the Mississippi, Skunk, Des Moines, Iowa and Cedar rivers. Associated with *Mimulus ringens, Leersia oryzoides, L. lenticularis, Verbena hastata, Mentha arvensis* var. *canadensis, Lycopus sinuatus.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone county (two specimens), Cedar Falls, Clinton, Glenwood (L. H. Pammel); Decatur county, Fremont county, (J. P. Anderson), Ames (R. I. Cratty, C. R. Ball), Cedar Rapids (R. E. Buchanan), Clayton county (B. Fink), Iowa City (A. S. Hitchcock), Kelley (Pearl Clayton), McGregor (Ada Hayden).

It has been observed (L. H. Pammel) at Algona, Boone, Centerville, Clinton, Davenport, Decorah, Des Moines, Dubuque, Fairfield, Iowa City, Indianola, Jefferson, Keosauqua, Marquette, Marshalltown, Mason City, Missouri Valley, McGregor, Mount Pleasant, Muscatine, New Albin, Story City.

General distribution in the United States:

Alabama—Selma (G. McCarthy); Illinois—Fish Lake, Savanna (L. H. Pammel), Peoria (F. E. McDonald); Kansas—Manhattan (D. G. Fairchild), Wichita (T. L. Andrews); Louisiana—Ascension (T. L. Andrews), (C. R. Ball); Missouri—Newburg (two specimens, S. E. Meek); Nebraska—Lincoln (R. Gmelin); North Carolina—; Ohio—Ross county (Asa Horr); Oklahoma—Norman (W. E. Bruner); Texas—Austin (F. C. Werkenthin).

HONEY BEE VISITS

It is frequently visited by honey bees. Many were observed near McGregor and Lansing.

LABIATAE, Mint Family

In most cases herbs, commonly with square stems, opposite simple aromatic leaves; corolla more or less two-lipped. Flowers in cymose clusters, often terminating the stem; calyx bilabiate, five-toothed; corolla bilabiate, upper lip with two lobes, lower with three lobes; stamens four in two pairs inserted in tube of corolla, style two-lobed, ovary superior, separating into four nutlets.

In the Labiatae nectar is secreted by a disc-shaped gland under the deeply four-lobed ovary. The nectar secreting tissue may readily be distinguished. The inflorescences are usually showy and attract bees, butterflies and other insects. In most species nectar is freely secreted and often rises in the tube of the more vertically placed flowers to a height of several millimeters. Bergamot, motherwort, catnip and many other labiates are valuable honey plants. In sandy soil, in locations where it is common, *Monarda punctata* yields a large amount of nectar. Labiates are freely visited by many insects, especially Hymenoptera.

There are two flower types. One is the butterfly type in which the corolla is in front, and the stamens and styles are on the lower lip. In this way, according to Knuth, secretion of nectar sometimes takes place in the upper side of the flower and pollen is then scattered on the legs and under sides of insects. The typical labiate flowers are pollinated by bees. In these species nectar is secreted in the lower side of the flower and pollen is scattered on the insect's back. We have also a group of plants pollinated by birds, like the species of *Salvia, S. gesneraeflora* and *S. splendens*. A number of the flowers are perfect and some are gyno-monoecious or gyno-dioecious. The visitors belong to all groups of insects; beetles are rare, bees are more common, followed by butterflies.

Species of insects visiting Labiates. Listed by Charles Robertson

	Bees	Other Hymenoptera	Diptera	Lepidoptera
Scutellaria versicolor	1			
Nepeta Glechoma	13		2	4
Brunella vulgaris	10	1	2	7
Marrubium vulgare	4		1	1
Stachys palustris	10		3	3
Teucrium canadense	4			
Leonurus Cardiaca	8		3	1
Nepeta Cataria	14		3	3
Hedeoma pulegioides	2			
Monarda mollis	8		1	15
Lophanthus nepetoides	8	1	3	2
Lophanthus scrophulariaefolius	4		1	
Blephilia hirsuta	17	1	5	1

Teucrium (Tourn.) L. Germander

Corolla with the four upper lobes nearly equal, the lower lobe much larger, stamens four, anther cells confluent.

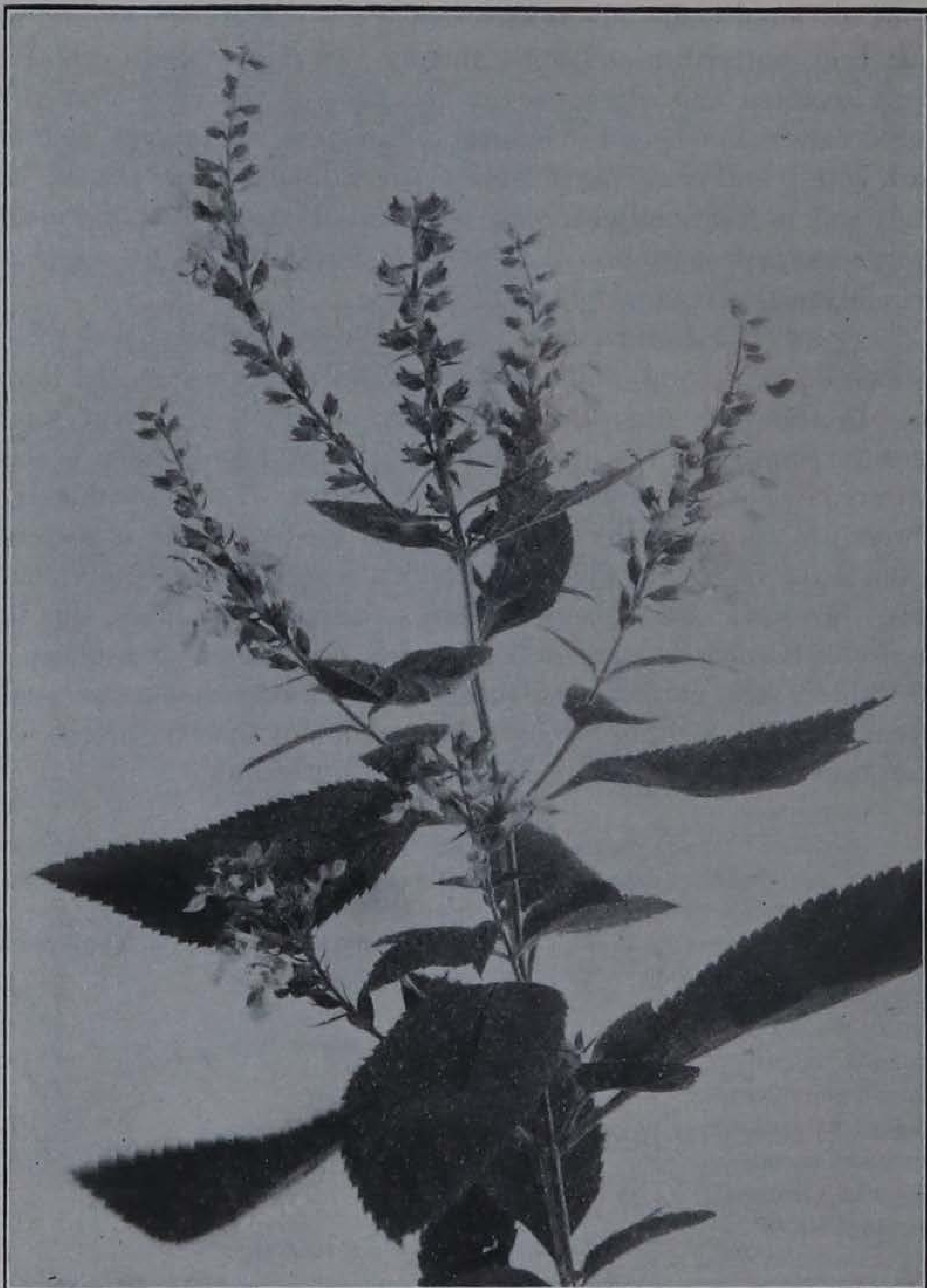

FIG. 295.—Germander (*Teucrium canadense*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Teucrium canadense L. American Germander, Wood Sage

A perennial with serrate, lanceolate to ovate leaves, flowers in spikes, usually purplish pink.

In first and second alluvial bottoms, or black prairie soil. Found also as a weed in various soils. Associated with *Silene nivea, Heracleum lanatum, Polygonum pennsylvanicum, P. incarnatum, Geum macrophyllum.*

FIG. 296.—Germander (*Teucrium canadense*). *Photograph by A. Hayden.*

Charles Robertson says, "The perfect flower is proterandrous. The flowers project nearly horizontally. The tube is cleft on the upper side. The stamen and style are not protected, except by the flowers above them. It is not easy for the insects to land directly upon them."

On these flowers, July 6 to 10, bees were abundant, collecting nectar.

The germander has a long blooming period. Although it does not produce a great amount of nectar, it is a valuable addition to the honey plant flora.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Anamosa, Burlington, Cedar Falls, Clinton, Fort Dodge, Hamburg, Linn county, McGregor, Muscatine county, Oxford Junction, Redfield, Sidney, Spirit Lake, St. Olaf, Thurman, Traer (L. H. Pammel); Decorah (E. W. D. Holway), Adel (R. E. Buchanan), Ames (two specimens, J. R. Campbell, L. H. Pammel and C. R. Ball, L. H. Pammel and H. S. Fawcett, Ada Hayden), Cedar Falls (L. H. Pammel, V. C. Fisk and Miss W. Gilbert), Chickasaw county (W. D. Spiker), Clear Lake (R. I. Cratty), Correctionville (H. J. Ives), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Denison (Clara Blume), Fayette (three specimens, B. Fink), Kelley (Pearl Clayton), Keokuk (L. H. Pammel and Miss Mitchell, P. H. Phelps), Lamont (I. T. Bode), Ledges (L. H. Pammel, R. E. Buchanan, C. M. King, T. Macklin and L. H. Pammel, J. V. Ellis), northeast Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Peru (D. E. Hollingsworth), southern Iowa (J.

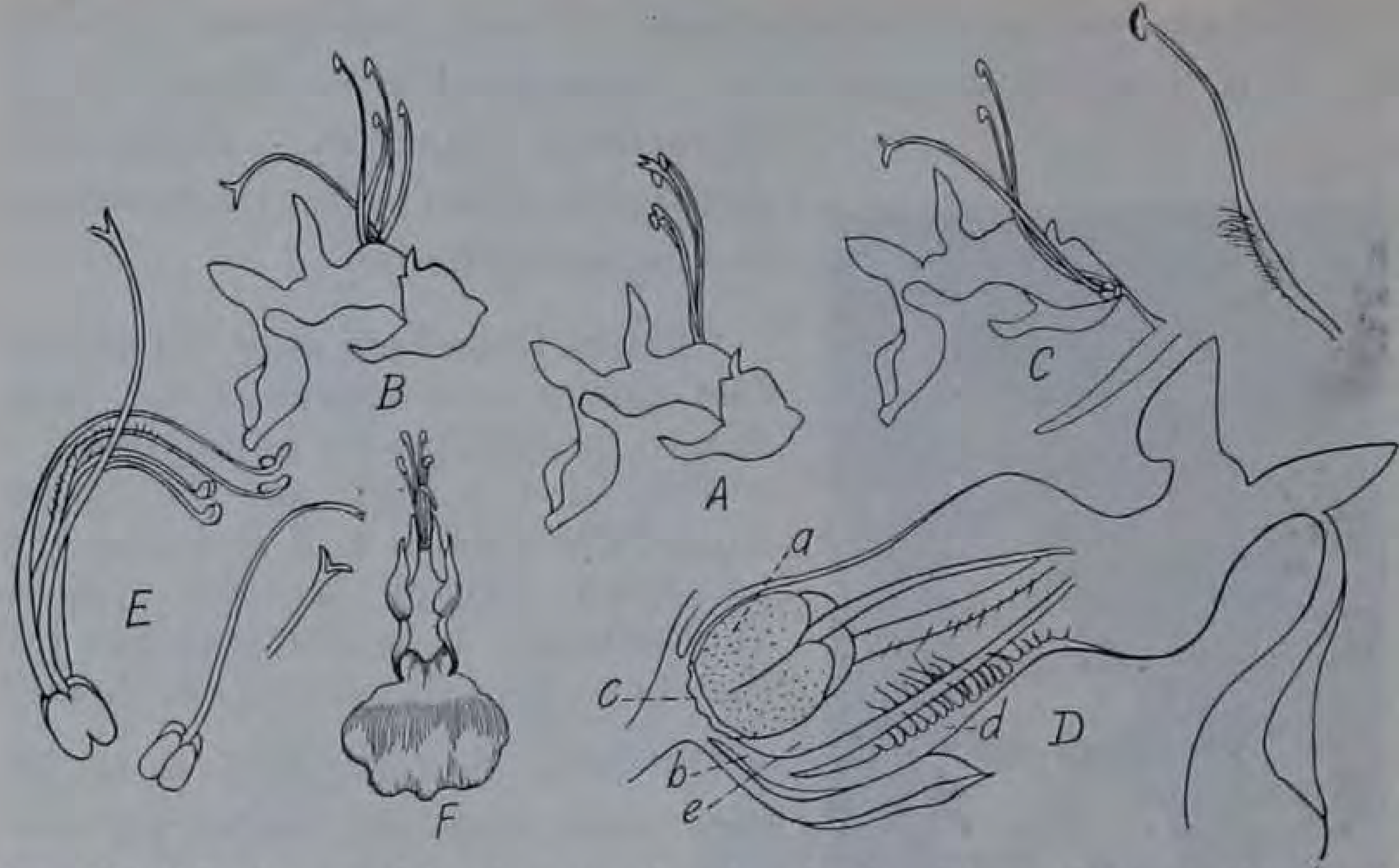

FIG. 297.—Wood sage (*Teucrium canadense*). A. B. Views of flower showing the stamens and pistil exserted through the split upper lip. The forward movement of the pistil as the stigma expands separates it from proximity with the stamens. C. Longitudinal section of flower showing stamen-pistil arrangement at time of dehiscence of stamens. D. Longitudinal section of flower showing (a) nutlets of pistil, attachment of stamens (b) to receptacle, (c) nectar gland, (d) hairy groove leading toward nectary. E. Expansion of stigmatic surface. Proterandrous condition. F. Mouth of flower showing entrance to throat. *Drawing by Ada Hayden.*

P. Anderson), Spirit Lake (L. H. and H. E. Pammel), Tama (V. C. Fisk), Traer (J. W. Provan).

It has also been observed (L. H. Pammel) at Albia, Algona, Brooklyn, Camanche, Cedar Rapids, Centerville, Chariton, Charles City, Clayburn, Clinton, Council Bluffs, Davenport, Des Moines, Dubuque, Dyersville, Eldora, Elkader, Estherville, Fairfield, Glenwood, Grinnell, Hamburg, Indianola, Iowa City, Iowa Falls, Keokuk, Keosauqua, Lansing, Lineville, Maquoketa, Marshalltown, Mason City, McGregor, Moulton, Mount Pleasant, Newton, Sac City, Shenandoah, Sidney, Sioux City, Steamboat Rock, Waukon.

General distribution in the United States:

Arkansas—Northwestern Arkansas (P. H. Rolfs); Illinois—Cahokia (H. Eggert), Fox (L. H. Pammel and Mark Heavenhill), Hamilton, La Salle (L. H. Pammel); Kansas—(Kenneth K. Mackenzie); Louisiana—(T. L. Andrews); Minnesota—Granite Falls (L. H. Pammel), St. Paul (R. Gmelin); New York—Ithaca (H. E. Summers), Niagara Falls (G. H. Frazier); Ohio—Pickerington, Worthington (Asa Horr); Oklahoma—Camanche county (A. H. Van Vleet), Muskogee (L. H. Pammel); Texas—Bracken (B. H. A. Groth), College Station (L. H. Pammel), Tarrant county (Albert Ruth); Wisconsin—Bluff Siding, Galesville, Holmen (L. H. Pammel).

HONEY BEE VISITS

Ames, July 17, 1927, p.m. Warm, clear, dry, windy. Bees one and one-half to two seconds in a flower. (C.C.L.)

Bloomfield, June 25, 1927, 10:30 a.m. Clear, sunshiny. Past height of bloom. No bees.

McGregor Heights, August 10, 1927, 3:00 p.m. Bees abundant. Two to three seconds in a flower.

Central Iowa, July 18 and 20, 1929. Commonly observed at Sac City, Webster City, Fort Dodge, Marshalltown, Nevada, Colo, Kelley, Ankeny, Des Moines, Auburn, Rockwell City, Lake View.

Blooming, Ames, June 25, 1924.

Teucrium occidentale Gray. Western Germander

A hairy-stemmed plant with lance-shaped leaves, white villous beneath, calyx and bracts bearing viscid hairs and stalked glands.

In marshes surrounding lakes and lake beds. Associated with *Phragmites communis, Gentiana quinqueflora, Gentiana crinita, Polygonum acre, Scirpus atrovirens, Veronica virginica, Asclepias incarnata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Badger, Belmond, Boone county (two specimens), De Witt, Lake Mills, North Branch, Onawa, Rockwell City, Sac City, Sioux City (L. H. Pammel); Algona, Armstrong, Emmet county (two specimens), Emmetsburg, Iowa lake, West Bend (three specimens, R. I. Cratty), Ames (R. E. Jeffs), High lake (B. O. Wolden), Kelley (three specimens, Pearl Clayton), Ledges (L. H. Pammel and J. P. Anderson), Osage (F. M. Tuttle), Spirit Lake (H. E. and L. H. Pammel).

Also observed (L. H. Pammel) but not represented by specimens—Argyle, Cerro Gordo county, Dakota City, Forest City, Fort Dodge, Garner, Gilmore City, Humboldt, Lost Island lake, Mallard, Mason City, Peterson, Rolfe, Ruthven, Sibley, Sheldahl, Sheldon, Spencer.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall), New Windsor, Wells county (George E. Osterhout); Minnesota—Marshall (L. H. Pammel); Missouri—Jackson county (Kenneth K. Mackenzie); New York—Ithaca (Muenscher and Bechtel); South Dakota—Brookings (L. H. Pammel and N. E. Hansen), Clear Lake (Edna C. Pammel).

Scutellaria L. Skull-cap

Perennial herbs with bitter taste, having square stems. Corolla two-lipped, the upper lip arched, stamens four, calyx two-lipped with helmet-like projections.

Recorded by Knuth as nectar-bearing bee flowers.

Scutellaria lateriflora L. Mad-dog Skull-cap

A smooth, upright, branching plant, with lance-shaped, pointed, coarsely-toothed leaves, flowers blue, rarely pink.

Skull-cap is common in moist woods near brooks, in sandy or gravelly soil. Associated with *Scirpus lacustris, Typha latifolia, Thalictrum dasycarpum, Acorus Calamus.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Boone, Forest City, Granite, Iowa lake, Lake Mills, McGregor, Turin (L. H. Pammel), Ames (C. R. Ball, F. Rolfs, Alice Caughey), Appanoose county (T. J. Fitzpatrick), Decorah (E. W. D. Holway, H. Goddard), Fayette (two specimens, B. Fink), Guttenberg (R. Gmelin), Osage (two specimens, F. M. Tuttle).

Observed (L. H. Pammel) but not represented by specimens in the Herbarium—along streams and springs and in moist places, Cedar Rapids, Clinton, Dubuque, Eldora, Emmetsburg, Estherville, Forest City, Fort Dodge, Jefferson, Marshalltown, Mason City, Muscatine, New Albin, Steamboat Rock.

General distribution in the United States:

Illinois—East St. Louis (H. Eggert), Red Bud (L. H. Pammel); Minnesota—Duluth (L. H. and H. E. Pammel), International Falls (Harriette Kellogg), Lake City (L. H. Pammel), St. Cloud (R. Gmelin); Missouri—Jefferson Barracks, Mansfield (L. H. Pammel), Dodson (Kenneth K. Mackenzie); Nebraska—Niobrara (R. E. Buchanan), Otoe county (J. P. Anderson); Ohio—Baltimore (Asa Horr); Pennsylvania—Wells (Charles C. Deam); South Dakota—Brookings (L. H. Pammel), Lake Tetonkeha (N. E. Hansen and L. H. Pammel); Wisconsin—Holmen (L. H. Pammel), La Crosse (Dora Pammel).

Scutellaria versicolor (Nutt.) Heart-leaved Skull-cap

Plant soft-hairy, hairs of inflorescence partly viscid, leaves ovate, rugose, racemes simple, corolla blue.

Limestone rocky soil in shady places. Common in northeastern and eastern Iowa, growing with *Camptosorus rhizophyllus, Campanula rotundifolia, Onoclea Struthiopteris, Hydrophyllum appendiculatum, Aquilegia canadensis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decatur county (T. J. and M. F. L. Fitzpatrick, J. P. Anderson), Denison (Clara Blume), Farmington (Mrs. Leuckel), Wadena (B. Fink).

General distribution in the United States:

Illinois—Cahokia (H. Eggert), Grand Tower (H. A. Gleason), Oquawka (Harry N. Patterson), Peoria (T. E. McDonald); Indiana—Wells county (Charles C. Deam); Louisiana—(T. L. Andrews); Minnesota—Lake City (L. H. Pammel); Missouri—Allenton (George W. Letterman), Eagle Rock (Kenneth K. Mackenzie), Pilot Knob (L. H. Pammel); Ohio—Cedar Point (L. H. Pammel).

Scutellaria galericulata L. Skull-cap

An herbaceous plant, underground stolons not tuber-bearing, leaves almost sessile, plant slightly downy, flowers solitary in axils of upper leaves, violet-blue.

Marshes and peaty soil. Associated with *Thalictrum dasycarpum, Cirsium muticum, Gentiana quinqueflora, Aster novae-angliae, A. ptarmicoides.*

In this species Knuth describes the lower lip of the bluish corolla as broad and shallow and marked by a nectar guide, which consists of a white spot crossed by three deep violet lines.

The bee forces itself head first into the flower, separating the folds of the upper lip to allow the entrance of the insect's body.

Flowers are often found perforated. The pollen grains are white, ellipsoidal and delicately tuberculate; size about 31 mm. in length and 18 to 21 mm. in breadth. Knuth records the honey bee for this flower.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park, Delaware county, Fertile, Lake Mills, Mason City (L. H. Pammel); Ames (E. R. Hodson), Armstrong (R. I. Cratty), Fayette (B. Fink), High lake (B. O. Wolden), Kelley (Pearl Clayton), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson).

General distribution in the United States and Canada:

Colorado—Fort Collins (W. F. N.); Idaho—Sand Point (L. H. Pammel); Illinois—Chicago, Pullman (L. H. Pammel); Indiana—Wells county (Charles C. Deam); Massachusetts—Waverly (H. L. Jones); Michigan—Whitehall (L. H. Pammel); Minnesota—Cass Lake, South Huron (L. H. Pammel), Black Duck (Mrs. Roy Westley), Kelley's Lake (Lyle Clapper), Star Island (Cass Lake) (L. H. and H. E. Pammel and P. S. McNutt); Nebraska—Spade Ranch (Sheridan county) (R. E. Buchanan), Willow Island (James Wahl); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Nova Scotia—Sunny Brae (Harold St. John); Ohio—Cedar Point (L. H. Pammel), Lancaster (Asa Horr); Ontario—Lake Huron, Sandy Hills (R. Burgess); Oregon—La Pine, Tumalo (K. Whited); South Dakota—Spring Creek (L. H. Pammel); Utah—Peterson (L. H. Pammel and R. E. Blackwood); Wisconsin—Madison (J. R. Heddle); Wyoming—Jackson's Lake (Aven and Elias Nelson), Laramie river (Albany county) (Aven Nelson), Sheridan (Ferdinand Reppert, A. E. Paddock, Sarah Ellis).

Scutellaria parvula Michx. Small Skull-cap

Pubescent, tuber-bearing with underground stolons, plant dwarf, flowers in axils of leaves.

Sandy and gravelly sandy soil. Associated with *Monarda punctata, Oenothera serrulata, P. rhombipetala, Panicum virgatum, Euphorbia corollata, E. polygonifolia, E. glyptosperma, Eragrostis pectinacea, Stipa spartea, Aristida tuberculosa.*

Charles Robertson states that this is one of the earliest blooming of the indigenous Labiates.

The flowers are solitary in the axils of the opposite leaves, the corolla measures about 9 mm., the tube being about 7 mm. long. The corolla is blue, the lower lip being marked by a large squarish white spot dotted with purple and with streaks above leading into the throat.

The mode of pollen contact is of the most definite sort, the anthers touching the upper part of the bee's head and thorax.

Hymenoptera are numerous but the honey bee was not recorded as numerous.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Dolliver Park (Fort Dodge) (L. H. Pammel); Ames (G. W. Carver, Robert Combs and C. R. Ball), Chickasaw county (W. D. Spiker), Decatur county (J. P. Anderson), Emmet county (B. O. Wolden, R. I. Cratty), Fayette (B. Fink), Kelley (Pearl Clayton), Mount Pleasant (J. H. Mills), northeastern Iowa (H. Goddard), Peru (D. E. Hollingsworth), West Union (Emma Hancock and L. H. Pammel).

General distribution in the United States:

Arkansas—Mt. Ida (S. E. Meek); Illinois—Red Bud, Irvington (L. H. Pammel), Oquawka (Harry Patterson), Peoria (F. E. McDonald), Rantoul (H. A. Gleason); Minnesota—St. Cloud (R. Gmelin); Missouri—Jackson county (Kenneth K. Mackenzie), Jefferson City (O. Krouse); Oklahoma—Arbuckle mountains (Dora Pitts); Texas—Central (L. H. Pammel); Nevada (L. H. Pammel); Wisconsin—Madison, Mount Horeb (J. R. Heddle).

Marrubium (Tourn.) L. Horehound

Whitish-woolly perennial herbs, branching at the base. Leaves deeply cut, flowers in axillary clusters, points of the calyx lobes oval-tipped.

Marrubium vulgare L. Common Horehound

Whitish-woolly perennial with rugose and crenate leaves and many-flowered axillary whorls. Flowers small, white. Waste places, Maine to Ontario, westward and southward. Blooms in June, July and August. Naturalized from Europe.

Naturalized in various soils, clay and Missouri loess and black prairie soil in central and western Iowa. Associated with *Nepeta Cataria, Verbena stricta, Polygonum pennsylvanicum.* In western Iowa associated with *Gaura coccinea, Chrysopsis villosa, Aplopappus spinulosus.*

Horehound is a recent introduction, probably more widely distributed than the specimens indicate.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (cult.), Hamburg, Sac City (L. H. Pammel); Fayette (B. Fink), Hamburg (L. H. Pammel and H. Clark), Red Oak (Ruth Ossian).

Observed (L. H. Pammel) at Council Bluffs, Denison, Glenwood, Keokuk, Keosauqua, Madison county, Marshalltown, Missouri Valley, Shenandoah, Sidney, Sioux City.

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); California—Merced, San Diego, Yuba City (L. H. Pammel); Colorado—Fort Collins (C. S. Crandall), Golden (L. H. Pammel); Idaho—American Falls (L. H. Pammel and W. S. Dudgeon); Illinois—Chicago, Grand Tower (H. Gleason), Hamilton (L. H. Pammel); Nebraska—Cass county (J. P. Anderson); New Jersey—Mickleton (B. Heritage); Ohio—Castalia, Put-in-Bay (L. H. Pammel), Worthington (Asa Horr); Utah—Farmington canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Helper Mountain, Salt Lake City (L. H. Pammel and E. M. Stanton).

HONEY BEE VISITS

Nectar is concealed. The tube is about five mm. long. Bees visit the flowers freely for nectar.

There is a long season of bloom; the flowers secrete some honey and even yield a surplus in some localities, making horehound a valuable honey plant, although the honey is not of the best quality.

Bees were observed by us at Hamburg in 1928.

Agastache Clayt. Giant Hyssop

Tall, erect herbs with ovate, petioled notched leaves. Flowers clustered in terminal spikes.

Agastache nepetoides (L.) Ktze. Giant Hyssop

Tall, perennial herbs with petioled serrate leaves, and terminal spikes of greenish yellow flowers. Leaves ovate, coarsely crenate-toothed. Calyx teeth obtuse. Borders of woods eastern Massachusetts west to Minnesota and southward.

This species is rather widely distributed in the state in clay or sandy soil on borders of rich woods. Associated with *Hydrophyllum appendiculatum, Helianthus strumosus, Rudbeckia triloba, Eupatorium urticaefolium.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche, Fairfield, Gillett Grove, Liscomb, Marshalltown, Pilot Mound (L. H. Pammel); Page county, Van Buren county (T. J. and M. F. L. Fitzpatrick), Ames (A. S. Hitchcock, Fred Rolfs, L. H. Pammel and C. R. Ball), Charles City (E. M. Sherman), Decatur county (J. P. Anderson), Fayette (B. Fink), High Bridge (Botanical party), Winneshiek county (H. Goddard).

Observed (L. H. Pammel) at Chariton, Dubuque, Eldora, Lake Okoboji, Lansing, Maquoketa, Mason City, McGregor, Spirit Lake, Waukee.

General distribution in the United States:

Illinois—Hamilton (L. H. Pammel); Indiana—Crawfordsville (W. H. Evans); Louisiana (T. L. Andrews); Missouri—St. Louis (H. Eggert and L. H. Pammel); Ohio—Cedar Point (L. H. Pammel).

Charles Robertson states, "In *Lophanthus* (*Agastache nepetoides*) the corolla is greenish yellow. The stamens and styles are exserted. The tube of the corolla is about seven mm. long. The visitors consist mainly of bees. On days between August 7 and September 9 the honey bee was abundant, collecting nectar."

Lovell reports this plant as blooming about six weeks and much visited by honey bees. We have seen it much visited by bees in Iowa. The nectar is secreted abundantly by the small nectar glands below the ovary and is held in the lower part of the corolla tube.

HONEY BEE VISITS

Spirit Lake, August 28, 1918. Clear. Plants abundant. No honey bees. Numerous bumble bees. "Not a good year for honey." (Wm. Sawhill.)

Walnut, Illinois, September 14, 1918, 6:30 p.m. Two hundred flowers on a good sized plant. Bees visited thirty-five blossoms in fifteen seconds.

Allamakee county, August 18, 1929, 8 a.m. Bees two seconds in a flower.

Agastache scrophulariaefolia (Willd.) Ktze. Figwort, Giant Hyssop

Similar plant to *A. nepetoides.* Somewhat heart-shaped leaves, slightly pubescent on under side; calyx teeth acute, corolla purplish. New Hampshire to Kentucky and Virginia.

In clay or sandy soils on borders of woods, or in woods. Associated with *Helianthus strumosus, Claytonia virginica, Rudbeckia triloba, Verbesina helianthoides.*

This species is widely distributed in Iowa but most common in northern Iowa across the state from McGregor to Estherville and south along Mississippi river. Especially common in open woods.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clinton, Estherville, Lake Mills, Marion county, McGregor (two specimens), Wheelerwood (L. H. Pammel); Ames (A. S. Hitchcock, Fred Rolfs), Decatur county (T. J. and M. F. L. Fitzpatrick, two specimens, J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Osage (Mrs. Tuttle).

The Decatur county specimens are more or less intermediate between the species and *A. nepetoides.*

This has been observed (L. H. Pammel) at Adel, Burlington, Cedar Rapids, Council Bluffs, Dallas Center, Davenport, Des Moines, Estherville, Indianola, Keokuk, Keosauqua, Marshalltown, Missouri Valley, Muscatine, Sioux City.

General distribution in the United States:

Idaho—Missoula river divide (L. H. Pammel and W. S. Dudgeon); Indiana—Crawfordsville (W. H. Evans); Louisiana—(T. L. Andrews); Missouri—St. Louis (H. Eggert, L. H. Pammel); Nebraska—Lincoln (R. Gmelin); Ohio—Cedar Point (L. H. Pammel); Wisconsin—Kickapoo river, La Crosse, Wauzeka (L. H. Pammel).

HONEY BEE VISITS

The numerous crowded flowers are reported by Knuth as attractive to bees. The nectar is secreted as in *A. nepetoides.* It is abundantly visited by honey bees.

C. P. Dadant of Hamilton, Illinois, finds that this plant yields abundantly and is a good honey plant.

Charles Robertson says (in *Lophanthus scrophulariaefolia*) that the anthers are purplish tipped; the tubes are about three mm. long. The honey bee is a frequent visitor, getting nectar.

Agastache Foeniculum (Pursh.) Ktze. Giant Hyssop

A smooth, tall herb; ovate, acute leaves, glaucous white underneath with minute down; calyx teeth acute. Foliage with scent of anise. Found in woods Lake Superior, south and westward.

Drift soils, gravel knolls, borders of woods. Associated with *Silene stellata, Helianthus strumosus, Aster Drummondii, Solidago latifolia.*

This species, though abundant in Minnesota, is rare in Iowa. Mr. Cratty found it in a wooded ravine near Estherville, and it was found by L. H. Pammel on a wooded slope on Spirit lake near the Minnesota line. It was collected also by Miss King at Lake Okoboji.

General distribution in the United States and Canada:

Colorado—Fort Collins (C. S. Crandall), Larimer county (L. H. Pammel); Minnesota—Bemidji, Itasca State Park, Norway Beach, Ortonville, Richdale, Wadena (L. H. Pammel); Backus (Ada Hayden), Brainerd (E. B. Watson), Cass Lake (L. H. and H. E. Pammel), Douglas county (George B. Alton), Minneapolis (R. I. Cratty), Star Island (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (R. Gmelin); New Mexico—Redstone (A. Isabel Mulford); Saskatchewan—Shellbrooke (C. A. Hansen); South Dakota—Sisseton (L. H. Pammel), Spearfish canyon (C. M. King); Wisconsin—St. Croix Falls (L. H. and H. E. Pammel).

HONEY BEE VISITS

We have observed honey bees on this plant in northwest Iowa.

Pellett in speaking of the value of this as a honey plant said, "In the '70's when planting for honey was quite a fad this species received some attention."

H. A. Terry in the "Beekeepers' Journal" for March, 1912, wrote, "It produced honey in the greatest abundance, which possesses in a slight degree the same fragrance of the plant, which renders it exceedingly pleasant to the taste. It commences to bloom in May or early June and blooms incessantly until late in autumn. I firmly believe an acre of this plant well established would be ample pasturage for 100 colonies of bees.

"In manner of growth the plant somewhat resembles common catnip. On clear ground it may be sown broadcast, and when established will take care of itself, or it may be sown in drills and cultivated. The flowers are purple, and it is well worthy of a place in the flower garden. The seeds may be sown in autumn or spring and when mature will self-sow so as to produce plants in greatest abundance. I find my bees work stronger on this plant than on any wild plant in this part of the country. (Iowa.)''

The authors found this species much visited by bees in the region about Winnipeg, Manitoba, and there it is apparently the source of considerable honey.

Nepeta L. Catnip

Branching aromatic herbs, with notched, somewhat downy leaves, and small white or pale colored pinkish flowers in clusters. Fruit of ovoid, smooth nutlets.

The flowers are proterandrous. Nectar is secreted in the fleshy outgrowth below the pistil and is stored in the tube of the corolla.

Nepeta Cataria L. Catnip

Perennial branching downy herbs. Leaves heart-shaped deeply crenate. Corolla dilated in the throat, whitish dotted with purple. A common weed, near dwellings.

An established plant in various soils, clay, sandy clay and black prairie soils. Associated with *Verbena stricta, Polygonum pennsylvanicum, Bidens frondosa, B. vulgata, Anthemis Cotula, Urtica gracilis, Chenopodium album,* generally forming solid colonies.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Eddyville, Mason City, Nevada, Steamboat Rock (L. H. Pammel); Ames (Violet Pammel, H. E. Pammel), Armstrong (R. I. Cratty), Arnold's Park (L. H. and H. E. Pammel), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Dubuque (Asa Horr), Fayette (B. Fink), Fraser (Botany Seminar), Kelley (Pearl Clayton), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson).

It has been observed (L. H. Pammel) at Algona, Boone, Burlington, Cedar Rapids, Centerville, Cherokee, Clinton, Cresco, Dallas Center, Davenport, Fairfield, Fort Dodge, Grinnell, Hamburg, Indianola, Iowa City, Keokuk, Lake Okoboji, Mason City, Missouri Valley, Muscatine, Newton, Shenandoah, Sioux City, Wallingford, Waukon.

General distribution in the United States:

Colorado—Fort Collins (J. H. Cowan); Illinois—Bluff Lake (L. H. Pammel); Michigan—St. Ignace (L. H. Pammel); Minnesota—St. Cloud (E. B. Watson), St. Paul (R. Gmelin); New York—Willet's Neck, Long Island (A. C. Hexamer), Watkins Glen (L. H. Pammel); South Dakota (Edna C. Pammel), Elk Point (V. Fisk); Washington—Seattle (L. H. Pammel and W. S. Dudgeon); Wisconsin—La Crosse (two specimens, L. H. Pammel), Prescott (Mary Edgar).

HONEY BEE VISITS

In catnip the flowers are borne in clustered cymes. The nectar is accessible to many short-tongued insects. This flower is commonly visited by the honey bee, some species of *Bombus,* some Diptera and Hymenoptera, and yields much nectar. The plant has a long season of bloom.

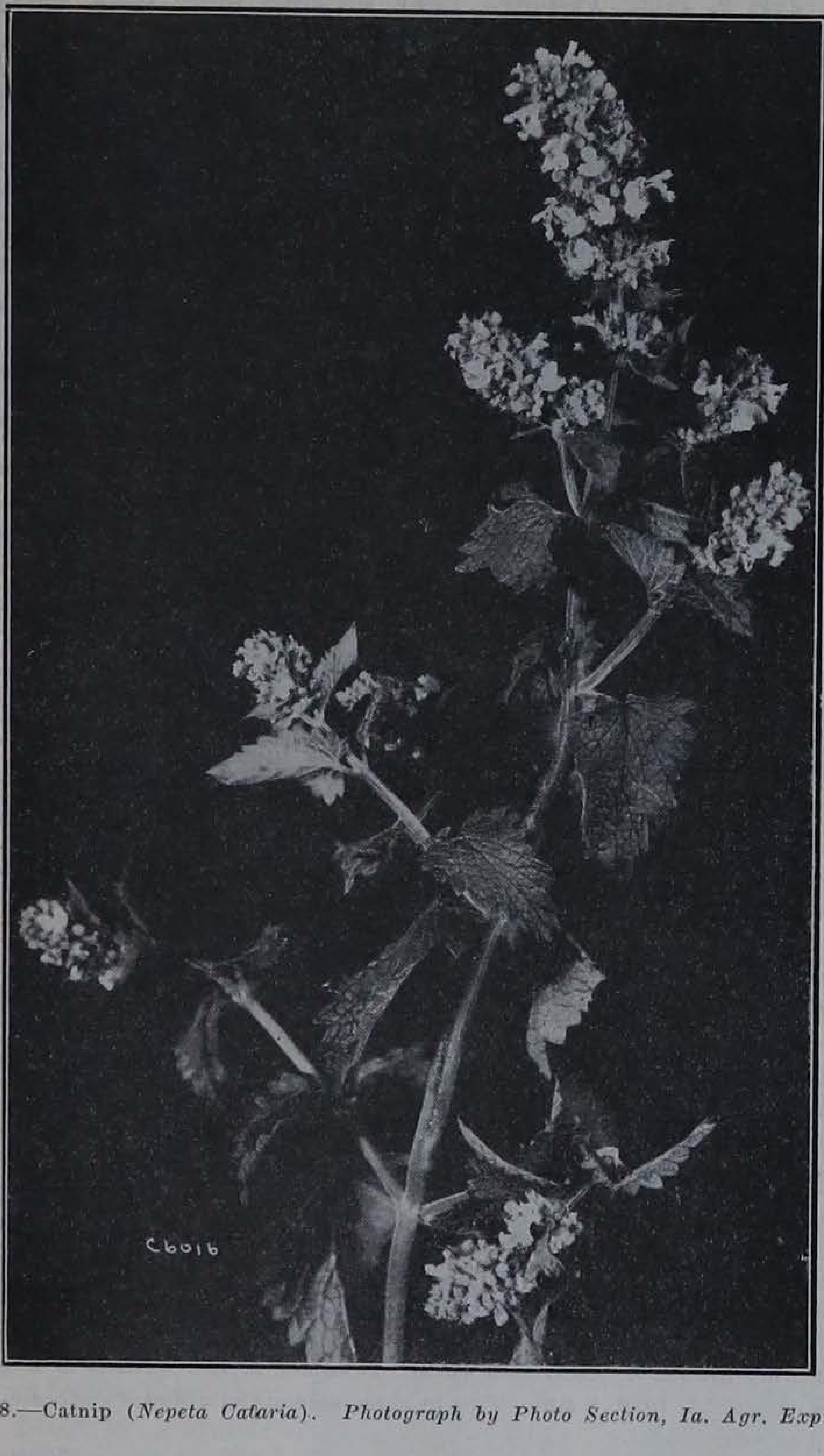

FIG. 298.—Catnip (*Nepeta Cataria*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Charles Robertson states, "The proterandrous flowers are arranged in crowded spikelike clusters. The corolla tube is about five mm. deep, so that short-tongued bees can reach some of the nectar, and those with mid-length tongues can exhaust it." He observed the bee abundant getting nectar.

Ames, July 9, 1914. Pastures. Clear, southeast wind, warm. Many bees. (L.A.K.)

July 16, 1914. Roadside. Clear, northwest wind. Many bees and flies, some wasps. One insect per flower per minute. Alternate between this and mustard. (G.H.M.)

Des Moines, July 16, 1914. Hot, dry. Numerous bees. Hardly any elsewhere. (L.A.K.)

Squaw creek, September 9, 1914. Clear. Southeast wind, moist. Many small Hymenoptera; some flies. Fifteen insects per flower each hour. (G.H.M.)

Ames, August 11, 1915. Damp, cloudy, northwest wind. Five bees. (L.A.K.)

Ledges, August 15, 1915. Partly cloudy, sultry. Two bees. (L.A.K.)

Ames, September 1, 1915. Clear, moderately cool, damp. Plants well matured. Eight bees at work. (L.A.K.)

Kilbourne, Wisconsin, July 12, 1919, 7 a.m. Partly cloudy, no wind. Twenty-two flowers visited by one bee in a minute. Five thousand flowers in a clump.

Ames, July 13, 1921. Clear, warm. Four bees visiting five hundred flowers in one clump. Bees one to two seconds in a flower.

Mormon Ridge, Marshall county, July 4, 1922, 5 p.m. Bees abundant. Two seconds in a flower.

Clayton, August 4, 1923. Clear, sunshine. Bees one to three seconds in a flower.

Eldora, July 8, 1924, 4 p.m. Bees one second in a flower.

Hubbard, July 8, 1924, 11:30 a.m. Bees one second in a flower.

Giard, July 28, 1924, 9 a.m. and 2 p.m. Clear. Bees abundant. Two seconds in a flower.

McGregor, August 13, 1924, 4 p.m. Bees abundant. Two seconds in a flower.

Ames, July 5, 1925. The bees two seconds in a flower. Over five hundred flowers, three bees were working in one-half minute.

Colo to State Center, July 24, 1927, 1 to 4 p.m. Damp, cool, cloudy, slight wind. Bees at work, averaging two seconds in each flower. (C.C.L.)

McGregor Heights, August 9, 1927, 9:30 a.m. Bees abundant. Two to three seconds in a flower.

Norwalk, September 7, 1927, 3 p.m. Clear, warm. Low grounds. No bees, nor on *Salvia lancaefolia* and other blooming fall honey plants. Many on plants on high ground.

McGregor, September 11, 1927, 9 a.m. Bees abundant. Two to three seconds in a flower.

Churdan, July 29, 1928, 4 p.m. Bees two to three seconds in a flower.

Iowa City, August 2, 1928, 3 p.m. Bees two to three seconds in a flower.

McGregor, August 8, 1928, 3 p.m. Bees two to three seconds in a flower.

Decorah, August 19, 1928, 2 p.m. Bees three to four seconds in a flower.

Dana, July 27, 1929. Clear and warm. Bees one to two seconds in a flower.

Ames, August 4, 1929, 8 a.m. Two to three seconds in a flower gathering pollen and nectar.

"Yields very well but the flavor is not pleasant." W. S. Pangburn, Center Point.

Catnip is eagerly sought by honey bees under all conditions. It might be planted on uncultivable soils with profit.

Lansing, August 17, 1929, 3 p.m. Bees abundant. Two to three seconds in a flower.

Nepeta hederacea (L.) Trevisan. Ground Ivy

A perennial creeping plant, pubescent. Leaves green on both sides, crenate, roundish. Blue flowers in small axillary clusters. Blooms in early spring.

An established plant in various soils, clay, limestone, sandy and Missouri loess soils. Associated with *Stellaria media*, *Poa pratensis*, *Trifolium repens*, etc.

Nectar is secreted by the fleshy nectar glands below the ovary. It is not copious and furnishes but little nectar in Iowa.

The blue-violet flowers are marked with purple blotches on the middle lobe of the lower lip which serve as a nectar guide.

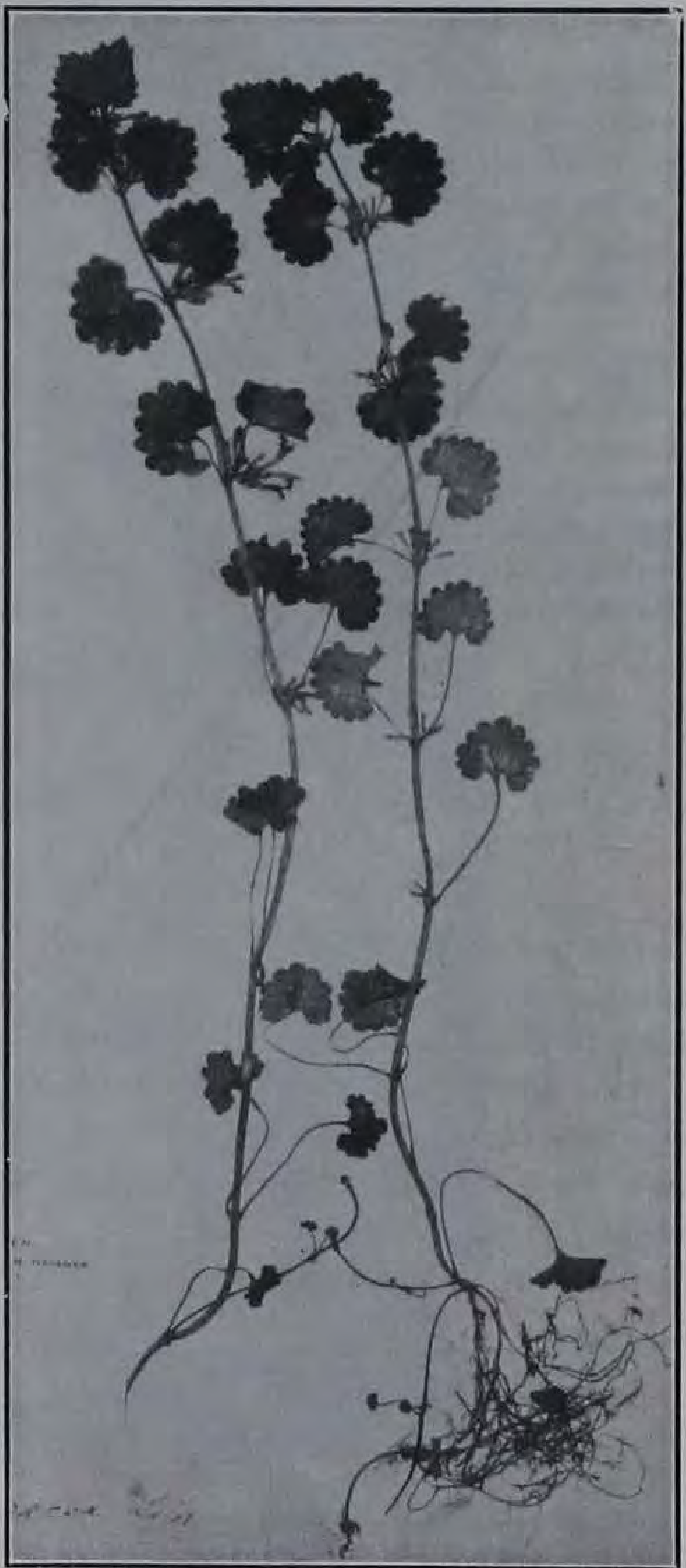

FIG. 299.—Ground ivy, creeping Charley (*Nepeta hederacea*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Hermann Mueller has the following to say regarding this plant, "In the large hermaphrodite flowers (corolla-tube 13-16 mm. broad at the entrance) the anthers as they dehisce downwards during the first stage of anthesis shed their pollen on the backs of visitors. At this time the style projects beyond the anthers and the front margin of the upper lip, with its stigmatic branches still apposed. When the pollen has been scattered, the style elongates and the two stigmatic branches diverge, the lower one still inclining downwards. Self-pollination is therefore excluded, as it is inevitable that the older flowers should be dusted with the pollen of the younger ones. The honey bee and short-tongued bumble bees frequently perforate the large flowers in order to steal nectar."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Harlan, Ledges (two specimens) (L. H. Pammel); Ames (Bernice Banks), Cerro Gordo county (M. Jones), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (F. H. Linn), Osage (Mrs. F. M. Tuttle).

It has been observed (L. H. Pammel) at Algona, Cedar Rapids, Cherokee, Clinton, Council Bluffs, Creston, Davenport, Dubuque, Fort Dodge, Hamburg, Indianola, Marshalltown, Mason City, Missouri Valley, Muscatine.

General distribution in the United States:

Illinois—Champaign (B. Fink); Indiana—Crawsfordville (W. H. Evans); Missouri—Newburgh (S. E. Meek); New York—Geneva (L. H. Pammel), Ithaca (two specimens, H. E. Summers), Long Island (Elsie Tribly); Ohio—Cambridge (E. R. Beyer), Worthington (Asa Horr); Pennsylvania—Spruce creek (L. H. Pammel); Wisconsin—Geneva (George W. Carver), Kilbourne, Madison (L. H. Pammel).

Prunella L. Self Heal

Low growing herbaceous perennial plants with densely bracted clusters of flowers, purple or white.

Prunella vulgaris L. Heal-all

Low perennial, leaves ovate-oblong, petioled. Flowers in clusters, corolla violet, sometimes flesh-colored. Woods and fields Newfoundland to Florida, westward. Blooming period June to September.

This species is widely distributed in woodland tracts in eastern, southeastern and northeastern Iowa, apparently showing a preference for a clay soil. Unrestricted, however, as to soils. Associated with *Apocynum androsaemifolium, Solidago ulmifolia, S. latifolia, Aster sagittifolia* and *A. Drummondii.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Des Moines, Indianola, Keystone, Lamont, Lost Island lake, Mahaska county, Marion county near Knoxville (L. H. Pammel); Clear Lake, Decorah, Osage (R. I. Cratty), Ames (L. H. Pammel and C. R. Ball, F. Rolfs, A. S. Hitchcock), Cedar Rapids (R. E. Buchanan), Colo (J. F. Hicks), Creston (T. L. Andrews), Decatur county (two specimens, J. P. Anderson), Decorah (E. W. D. Holway), Delaware county (I. T. Bode), Des Moines (A. L. Bakke), Fayette (B. Fink), Hampton (N. B. Claypool), Kalona (J. N. Arnold), Lawler (P. H. Rolfs),

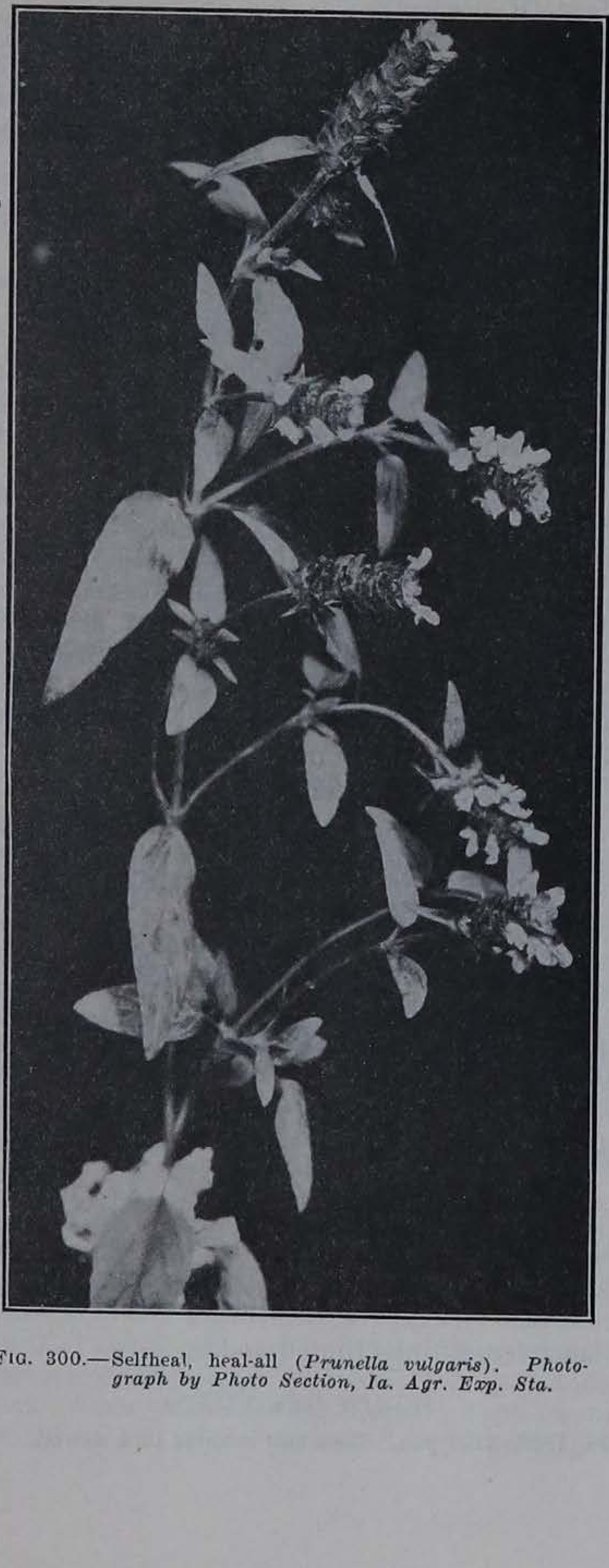

FIG. 300.—Selfheal, heal-all (*Prunella vulgaris*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), northeastern Iowa (H. Goddard).

It has been observed (L. H. Pammel) at Albia, Algona, Burlington, Carroll, Clinton, Council Bluffs, Dubuque, Fairfield, Fort Dodge, Hamburg, Harvey, Keosauqua, Lansing, Mason City, McGregor, Missouri Valley, Mount Pleasant, Neola, New Albin, Oskaloosa, Sidney, Sioux City, Waukon.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); California—Wauwona (L. H. Pammel), Yosemite Valley (L. H. Pammel); Illinois—Fox (L. H. Pammel and Mark Heavenhill); Louisiana— (T. L. Andrews); Massachusetts—Brainfield (H. E. Pammel); Minnesota—Cannon Falls (L. H. Pammel), Hibbing (Lyle Clapper), St. Cloud (R. Gmelin); Missouri—Pilot Knob (L. H. Pammel); New York—Buffalo (L. H. Pammel), Ithaca (Muenscher and Bechtel), Long Island (A. C. Hexamer and F. W. Ma'er), Niagara Falls (G. W. Frazier), St. Regis Falls (E. R. Hodson); North Carolina—Highlands (C. H. Boynton); Nova Scotia—Pictou county (Harold St. John); Ohio—Cedar Point (L. H. Pammel); Oklahoma—Tecumseh (A. H. V.); Oregon—Crook county, LaPine, Redmond (K. Whited); Pennsylvania—Towanda (L. H. Pammel); Texas—San Antonio (Mr. and Mrs. J. Clemens); Utah—Farmington canyon, Salt Lake City (L. H. Pammel and R. E. Blackwood), Duchesne river (L. H. Pammel and E. M. Stanton), Uintah canyon (L. H. Pammel and R. E. Blackwood); Vermont—East Corinth (H. S. Kellogg); Washington—Langley (J. M. Grant), Skamania county, West Klickitat county (W. N. Suksdorf); Wyoming—Mammoth Hot Springs (Aven and Elias Nelson); Wisconsin—La Crosse (R. Gmelin).

HONEY BEE VISITS

Charles Robertson says, "The flowers approach the typical form, the anthers being protected by the galea. The flowers are purplish. They are adapted to bumble bees, although often visited by other long-tongued bees and by butterflies."

The bluish flowers furnish considerable honey in some years, especially in clay soil. The nectar is secreted by the pouches below the ovary.

Mr. Bonney of Buck Grove says, "It is a great honey plant. It generally begins to yield nectar about the time white clover ceases, and lasts ten days to thirty. Average for the past four years, sixteen days, in this location."

McGregor, August 5, 1923. Clear, dry. Clay soil. No honey bees. One bumble bee observed.

Lavandula L. Lavender

Perennial herbs. Fragrant flowers in whorls.

Lavandula Spica L. Lavender

Flowers lavender, in interrupted spikes.

HONEY BEE VISITS

Ames, July 24, 1929, 2:30 p.m. Bees two seconds in a flower.

Physostegia virginiana Benth. False Dragon Head

Stem two to four feet in height. Flowers in spikes. Leaves rather thick. Calyx tubular-campanulate, with teeth half the length of the tube, sharp pointed. Purple corolla one-half inch to one inch long. In wet grounds.

FIG. 301.—False dragon head (*Physostegia virginiana*). *Photograph by A. Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Cedar Falls, Chariton, Dakota City, Fertile, Hazleton, islands of Mississippi, Liscomb, Madison county, Mason City, Rock Rapids, Steamboat Rock, Strawberry Point (L. H. Pammel); Armstrong (R. I. Cratty), Cedar Rapids (R. E. Buchanan), Chickasaw county (W. D. Spiker), Delaware county (I. T. Bode), Emmet county (B. O. Wolden), Fayette (B. Fink), Fremont county (J. P. Anderson), Guttenberg (R. Gmelin), Ledges (L. H. Pammel and C. R. Ball), McGregor (Ada Hayden), Mount Pleasant (J. H. Mills), northeastern Iowa (H. Goddard), Olin (H. A. Pike), Osage (Mrs. F. M. Tuttle), Tama (V. C. Fisk), Woodbine (G. N. Young).

General distribution in the United States:

Florida—Jacksonville (A. H. Curtiss); Illinois—Bath (H. A. Gleason), Bluff Lake (L. H. Pammel), Cheltenham (L. H. Pammel), Shabbona (B. Fink); Kansas—Argentine (Kenneth K. Mackenzie); Minnesota—Cass Lake (L. H. and H. E. Pammel), International Falls, Itasca county, St. Cloud (R. Gmelin); Missouri—Springfield (S. E. Meek); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (Muenscher and Bechtel); North Carolina—Wilmington (Biltmore Herbarium); Ohio—Lancaster (Dr. Bigelow); Texas—Grape-land (B. C. Thorpe), Hemstead (L. H. Pammel); Wisconsin—Bergman Island, Dalles of Wisconsin, Holmen, Muscoda (L. H. Pammel), La Crosse (two specimens, Dora S. Pammel).

HONEY BEE VISITS

Ames, August 27, 1927, 10:30 a.m. Bees getting pollen and nectar. Three to ten seconds in the flower. Nectar deep seated. Bees creep into the flower. No bees on *Lythrum alatum*, *Euphorbia corollata* nor *Eschscholtzia* in same vicinity.

September 5, 1927, 9 a.m. Bees getting pollen and nectar. Three to five seconds in a flower.

McGregor, August 15, 1928, 10:30 a.m. Bees two to three seconds in a flower. (D. Thomson.)

Leonurus L. Motherwort

Tall, erect herbs, with palmately-cleft leaves. Flowers white or pink, clustered in axils of leaves. The five lobes of the calyx awl-pointed.

FIG. 302.—Motherwort (*Leonurus Cardiaca*). A common weed in waste places and gardens. *At left, photograph by Photo Section, Ia. Agr. Exp. Sta. At right, photograph by A. Hayden.*

Leonurus Cardiaca L. Common Motherwort

A tall perennial. Leaves with long petioles, the lower rounded, palmately-lobed, the floral wedge-shaped at the base. Upper lip of the pale purple corolla bearded.

Widely distributed in this state, especially in waste places around dwellings and in fence rows. Naturalized from Europe. Common in clay or sandy soil. Associated with *Nepeta Cataria, Urtica gracilis, Malva rotundifolia, Anthemis Cotula, Plantago major* and *P. Rugelii.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eddyville, Jefferson, Marquette, North McGregor, Rochester, Steamboat Rock (L. H. Pammel); Clear Lake, Osage (R. I. Cratty), Ames (E. B. Watson, R. Combs, J. C. Blumer, Fred Rolfs, J. S. Jensen and W. Newell), Charles City, Iowa City (A. S. Hitchcock), Fayette (B. Fink), Fostoria (F. P. Hawk), Kelley (Pearl Clayton), Moingona (L. H. Pammel and C. R. Ball), northeastern Iowa (H. Goddard), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson).

It has also been observed (L. H. Pammel) at Burlington, Cedar Rapids, Clinton, Council Bluffs, Dana, Davenport, Des Moines, Dubuque, Fort Dodge, Hamburg, Keokuk, Keosauqua, Marshalltown, Missouri Valley, Muscatine, Sidney, Sioux City.

General distribution in the United States:

Connecticut—Cornwall (T. L. Andrews); Indiana—South Bend (Mrs. Joseph Clemens); Louisiana (T. L. Andrews); Michigan—Decatur (Lyster W. Dewey), Farwell (Ida Grillette), St. Ignace (L. H. Pammel); Minnesota—Granite Falls (L. H. Pammel), Rochester (Mrs. George Ainslie), St. Paul (R. Gmelin); Missouri—St. Louis (L. H. Pammel); New York—Elmira (T. F. Lucy), Ithaca (H. E. Summers, Muenscher and Bechtel); Ohio—Put-in-Bay (L. H. Pammel), Worthington (Asa Horr); Vermont—Groton (Ferdinand Blanchard); Wisconsin—La Crosse, Coon Valley (L. H. Pammel), Platteville (L. H. Pammel and B. B. Zimmerman).

HONEY BEE VISITS

Charles Robertson says, "The corolla is whitish, the upper lip being pale purplish beneath and the lower being marked with brownish and purple.

"The flower is properly fertilized by bees in search of honey, and the pollen is applied to their backs."

McGregor, August 5, 1929. The honey bee abundant, getting nectar.

Bert Brown of Des Moines reports that this plant blossoms for several months and that bees work it persistently from early morning till late evening.

Motherwort is one of the very dependable honey plants at all times when it is in bloom. It is especially important during the dry season, during the part of August when the nectar flow may be scarce on account of drouth. The purple flowers are attractive and the nectar is secreted by the fleshy outgrowth below the ovary.

Ames, July 9, 1914, p.m. Clear, southeast wind. Bees rather abundant. (L.A.K.)

Des Moines, July 10, 1914. Bees abundant. A splendid honey plant with long blooming period.

Mormon Ridge, July 4, 1922, 5 p.m. Plants numerous. Bees abundant. Two and three seconds in one flower.

Ames, July 4, 1923, 3:30 p.m. Clear and warm. Many bees. Time in flower three seconds.

Prairie du Chien, Wisconsin, 1925, 10:30 a.m. Partly cloudy. Sandy soil. Over nine hundred flowers, on three plants. Six bees were working actively during a period of two minutes. The bee six to three seconds in a flower.

Colo, September 16, 1927, 1:15 p.m. Bees two seconds in a flower. (C.C.L.)

Jordan's Grove, June 29, 1928, 12:30 p.m. Bees abundant. Five seconds in a flower. No bees on *Trifolium hybridum*.

Stachys (Tourn.) L. Hedge Nettle

Annual or perennial herbs of varied appearance. The clusters of flowers few to many-flowered. The calyx bell-shaped, nutlets rounded at the top. Distinguished mainly by certain characteristics of the stamens.

Stachys tenuifolia Willd. Slender Hedge Nettle

A perennial with slender rootstock, leaves lanceolate, taper-pointed, sharply toothed, short-petioled, color of flowers pale purplish.

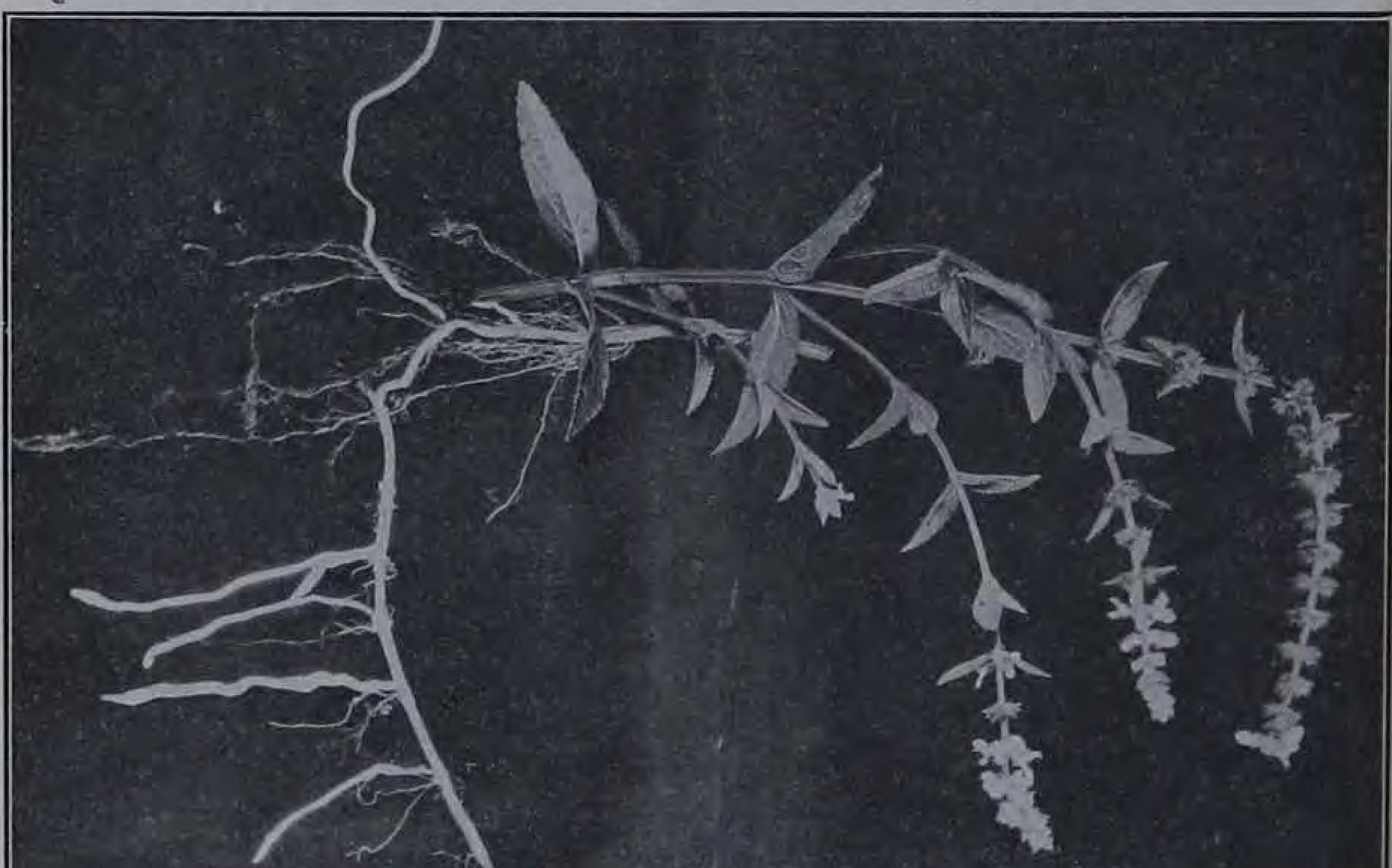

FIG. 303.—Smooth hedge nettle (*Stachys tenuifolia*) showing root system. *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

FIG. 304.—Slender hedge nettle (*Stachys tenuifolia*). *Photograph by A. Hayden.*

Distributed from Massachusetts westward. Time of bloom July and August. This is a species of alluvial woods along streams. Associated with *Leersia oryzoides, Mentha arvensis* var. *canadensis, Lycopus rubellus, Lippia lanceolata, Cinna arundinacea.*

Considerable nectar is furnished by this plant. The nectar is secreted by the somewhat fleshy glands below the nectary.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Appanoose county (T. J. and M. F. L. Fitzpatrick), Cedar Rapids (R. E. Buchanan), Des Moines (two specimens, A. L. Bakke), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King, L. H. Pammel and C. R. Ball), Osage (two specimens, Mrs. F. M. Tuttle), Skunk river (Mount Pleasant) (L. H. Pammel and H. E. Jaques).

This has also been observed (L. H. Pammel) at Burlington, Indianola and Keokuk.

General distribution in the United States:

Illinois—Savanna (L. H. Pammel); Michigan—northern Michigan (L. H. Pammel); Minnesota—Cass Lake (L. H. Pammel); North Carolina—Grandfather Mountain (J. K. Small and A. A. Heller); Ohio—Pickerington (Asa Horr); Virginia—Washington county (John K. Small); Wisconsin—Bloomingdale, Wauzeka (L. H. Pammel).

HONEY BEE VISITS

Tama, July, 1923, 3:30 p.m. Twenty-six to twenty-eight bees visiting one head of flowers in one minute.

Onawa, July 14, 1923, 11:30 a.m. Bees one to two seconds in a flower.

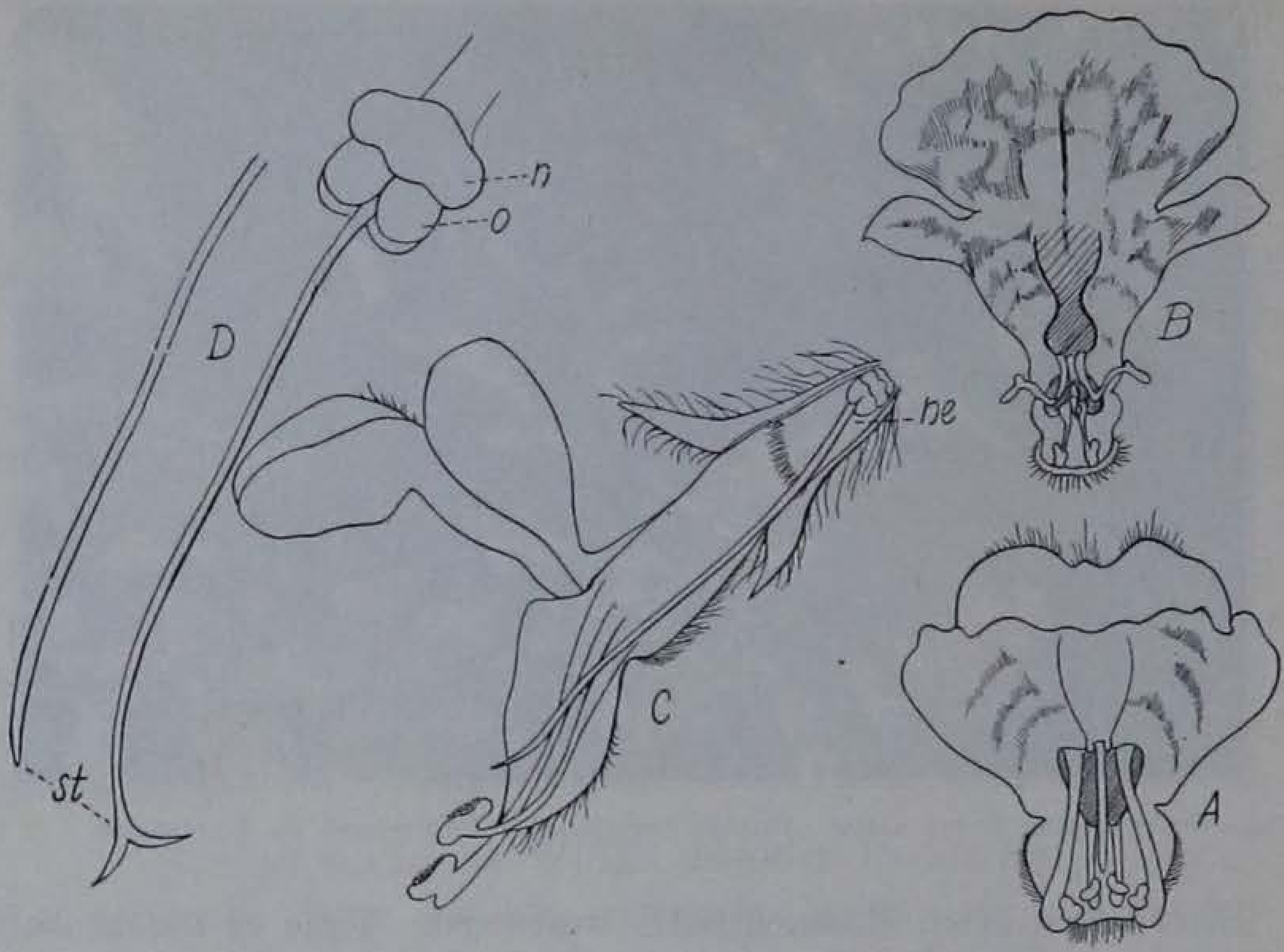

FIG. 305.—Woundwort (*Stachys palustris*). A. Face view of young flower, stamen-pistil arrangement and entrance to throat of flower. B. A more mature flower showing the reflexed position of the dehiscing stamens. Two downward pointing indehiscent stamens. C. Longitudinal section of flower showing the proterandry. Nectary (ne). D. Stages in development of the stigma. Nectar gland below the nutlets of the ovary, (n). *Drawing by Ada Hayden.*

FIG. 306.—Hedge nettle (*Stachys palustris*). *Photograph by A. Hayden.*

FIG. 307.—Slender hedge nettle (*Stachys palustris*). *Photograph by A. Hayden.*

Stachys tenuifolia var. *aspera* (Michx.) Fernald. Hedge Nettle

Bees were observed on this in 1928 but not in abundance.

Stachys palustris L. Woundwort

In this perennial herb the stem is leafy, becoming 3 or 4 feet tall. Leaves are almost always sessile. Flowers in whorls. The angles of the stem are beset with spreading hairs.

Common throughout the state in low grounds, lake beds and moist prairie meadows. Associated with *Mimulus ringens, Spartina Michauxiana, Carex vulpinoides.*

Charles Robertson says, "The corolla is pale purplish. The lip affords a convenient horizontal landing place six mm. in extent.

"The tubes are from six to eight and eight-tenths mm. long, which indicates an adaptation to long or medium length tongues, but rather short tongues can reach the nectar when the insects force their heads into the throat.

The plant blooms from June twenty-second to October seventh." (Southern Illinois.)

Nectar is secreted by the much thickened base of the ovary. Bees are rather abundant on the flowers at times.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong (two specimens), De Witt, Marathon, Mason City, Polk City, Rice Lake, Turin, Wheelerwood (two specimens) (L. H. Pammel); Adel (Chas. Clark), Alden (C. T. Stevens), Ames (C. E. Bessey, R. E. Jeffs), Cedar Falls

(G. W. Carver), Creston (F. C. Stewart), Fayette (two specimens, C. C. Parker), Garner (L. H. Pammel and Winifred Gilbert), Kelley (two specimens, Botany Party, Pearl Clayton), Little Rock (C. R. Ball), Osage (R. I. Cratty, Mrs. F. M. Tuttle), Peru (D. E. Hollingsworth), Rock Valley (W. Newell and J. T. Jensen), Spirit Lake (C. R. Ball).

It has also been observed (L. H. Pammel) at Algona, Cresco, Des Moines, Fort Dodge, Mason City, Postville, Webster City.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall, Reppert and Witter), Greely (L. H. Pammel), New Windsor (George E. Osterhout); Illinois—Urbana (H. A. Gleason); Minnesota—Brainerd (E. B. Watson), Cedar Island (Cass Lake) (L. H. and H. E. Pammel), Jackson (A. A. Crozier), Lake City, Norway Beach (L. H. Pammel), Star Island (Cass Lake) (two specimens, L. H. and H. E. Pammel and P. S. McNutt), Winona (John M. Holzinger); Missouri—St. Louis (L. H. Pammel); Nebraska—Cass county (J. P. Anderson), Sheridan county (R. E. Buchanan); Newfoundland—Topsail (C. D. Howe and W. F. Lang); New York—Shallow Lake (E. R. Hodson); Ohio—Huron (L. H. Pammel); Oregon—Redmond (K. Whited); Prince Edward Island—Charlestown (M. L. Fernald and Harold St. John); South Dakota—Hartford Beach (L. H. Pammel); Washington—Clarke county (W. N. Suksdorf); Wyoming—Black Fork (L. H. Pammel, C. P. Johnson, G. M. Lummis and R. E. Blackwood), Sybille (Aven Nelson).

Salvia (Tourn.) L. Sage

Our species are herbs with snowy flowers in spikes, racemes or whorls. Chiefly characterized by distinction in calyx, corolla and peculiar arrangement of anthers. Anther-bearing stamens 2, long connective; the sterile one-half anther in throat of the flower.

Knuth says, "Usually bumble bee or bee flowers with two stamens, of which the connective is modified into a two-armed lever. The upper anther-like lobe containing pollen is generally concealed under the upper lip and thus protected from rain. A bumble bee probing for the nectar secreted at the bottom of the flower by the base of the ovary, strikes its head against the generally sterile anther-lobe which is situated in the mouth of the corolla. Thus the fertile anther-lobe is brought down on the back of the insect which is using the lower lip as a platform and dusts it with pollen. This is transferred to the stigma of a flower in the second stage where the diverging stigmatic branches with mature papillae are situated in the entrance of the flower and must be touched first by visitors."

This is the mechanism which, with modifications, is found in the various species of *Salvia*.

The pollination of the European sage (*Salvia pratensis*) was first studied by Sprengel, later by Hildebrand and Mueller. The irregular blue labiate flowers are arranged in a raceme. The upper lip is arched. The flowers are proterandrous. In their first stage the stigmas are folded together and protrude from the upper lip; later they unfold and point downward. The opening of the tube of the corolla is guarded by two oblique processes which are the sterile, transformed half anthers. Attached to these are extremely long connectives. The other part of the anther cell is under the arched lip of the corolla. When a bumble bee lights on the under lip and thrusts its proboscis downward into the tube of the corolla, it comes in contact with the processes which close the throat of the corolla. When these sterile anther cells are touched, they lift upwards and backward, forward and downward and in this way the pollen is brushed off on the bee's back. The presence of nectar is indicated to the insect by the odor and the purplish spot on the lower lip. Nectar is found in abundance in the lower part of the tube of the corolla and is secreted by the yellow, fleshy portion underneath the ovary.

Sage honey has a delicious flavor and is a peculiar product of California. John Lovell said that the yield of honey secured from black sage during twenty-five years has been so immense that sage honey has often been selling in many cities of the north. There are several species of these sages in California. The honey flow lasts from the middle of March to the first of April.

Pellett states: "In the western Missouri river bottom they have become sufficiently common so that an appreciable amount of honey might be expected in many localities."

Richter in "Honey Plants of California" speaks quite favorably of white sage as a very valuable honey plant, also the black sage. However, the sage, so far as the several cultivated species are concerned, does not enter appreciably into our honey products in the state of Iowa.

Salvia azurea Lam. var. *grandiflora* Benth.

Branching perennial, lanceolate leaves, petiole short. Inflorescence spikelike. Calyx with broad upper lip. Corolla deep blue, ranging to white, without a hairy ring inside, from one-half to five-eighths inch long. Showy, inflorescence dense. Sometimes cultivated.

HONEY BEE VISITS

Ames, August 27, 1927, 4 p.m. Some bees.
September 15, 1927, 9 a.m. Bees two seconds in a flower.

June 26, 1928, 2 p.m. Clear, warm. Bees abundant. Two seconds in a flower.

September 15, 1930. A few honey bees and many bumble bees were observed.

Salvia pratensis L. Salvia

Herbaceous perennial one foot to three feet high. Leaves often spotted with red. Basal leaves petiolate, stem leaves sessile. Flowers in simple racemes, the whorls distant, six-flowered; corolla bright blue. Gardens.

"The pollinators," says Knuth, "are long-tongued bees," but he records the honey bee as sometimes visiting them.

Nectar is secreted by the fleshy base of the ovary.

Knuth says, "The bee visitor can easily reach between the diverging filaments to the nectar."

HONEY BEE VISITS

McGregor, September 11, 1927, 9 a.m. (Clay soil.) Bees abundant. Three seconds in a flower.

Ames, June 16, 1928, 2 p.m. Warm, windy. Bees two to three seconds in a flower.

Salvia splendens Sellow. Scarlet Sage

The large showy salvia of gardens. Leaves ovate, pointed. Calyx and corolla bright scarlet. Often visited by humming birds.

Cultivated only in various garden soils.

The scarlet sage is widely distributed as an ornamental plant. It has been observed (L. H. Pammel) at Ames, Boone, Burlington, Cedar Rapids, Clinton, Council Bluffs, Davenport, Des Moines, Dubuque, Forest City, Fort Dodge, Keokuk, Missouri Valley, Muscatine, Postville, Sioux City, Waukon.

HONEY BEE VISITS

Ames, August 21, 1915. Campus. Partly cloudy. Honey bees crawl into corolla tube, forcing themselves far enough so that the proboscis will reach the nectar near the base of the tube where the two sides touch one another, then wriggle out. Process occupies one-half minute. (L.A.K.)

August 27 to September 5, 1915. Cloudy, cool, then warmer. A few bees. (L.A.K.)

September 29, 1922, 11 a.m. Some bees apparently getting nectar out of perforations. Pollen also collected.

Pella, October 11, 1924, 9:30 a.m. Bees quite common, collecting nectar.

Mount Pleasant, September 4, 1929. Bees numerous, gathering pollen. Six and five seconds in a flower.

September 9, 1929. Bees gathering pollen. (S. M. Helmick.)

Ames, September 28, 1929, 2 p.m. Clear. Five to three seconds in a flower. Pollen.

Blairstown, September 28, 1929. Clear. Five to three seconds in a flower.

Ames, October 20, 1929, 12:15 p.m. North wind. Clear. Honey bees numerous. Three seconds to a flower. Much time was lost where the bees would go to the red colored calyx. In some cases three and four of these brightly colored calyces were visited before going to corolla of a flower. Honey bees get only pollen.

This flower is pollinated by humming birds as noted by Dr. William Trelease. The lower lip is small as the humming birds do not need a platform. Nectar is secreted abundantly in the fleshy part underneath the pistil. The style and stigma project beyond the corolla. The filaments are inserted at the joint of separation between the upper and lower lips, which Knuth speaks of as a lever with arms of equal length; the front end of this lever bears the fertile anther lobes, while the other lies on the inner surface of the corolla and is devoid of lobes. Bees and bumble bees are too small for this mechanism. Their proboscides cannot reach the nectar; butterflies are too weak to set the lever apparatus in motion.

Fritz Mueller observed bees on this species in Brazil.

Salvia officinalis L. European Sage

A low, erect hoary plant; leaves oblong-lanceolate, pubescent, veining very distinct, margins finely crenate. Flowers clustered in whorls near the top of the stem. Cultivated in various types of soils—clay, sandy and black.

The European sage is not infrequent in cultivation in Iowa. It has been observed (L. H. Pammel) at Ames, Carroll, Clinton, Dubuque, Postville, Waterloo.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Fayette (cult.) (B. Fink).

Knuth says, "The violet colored flowers of this species are marked on the lower lip with dark violet and whitish streaks serving as nectar guides. A ring of hairs in the corolla tube lies immediately above the nectar. The upper lip of the flower is short but broad, keeping out rain."

Mr. Pellett reports the sages as good honey plants though not large producers. The honey from garden sage is white and good, resembling that of catnip.

This is a most excellent honey plant. We have observed bees numerous on the flowers in July.

Salvia nemorosa Crantz. Purple Sage

Branching perennial, stems roughish, leaves lanceolate. Corolla bright violet.

HONEY BEE VISITS

October 14, 1929, 1 p.m. Bees three seconds in a flower.

Salvia lanceaefolia Poir. Wild Blue Sage

An annual nearly glabrous plant, one-half foot to 3 feet high; leaves lanceolate, somewhat serrate, tapering to the slender petiole. Flowers in clusters; inflorescence somewhat spiked. Corolla blue.

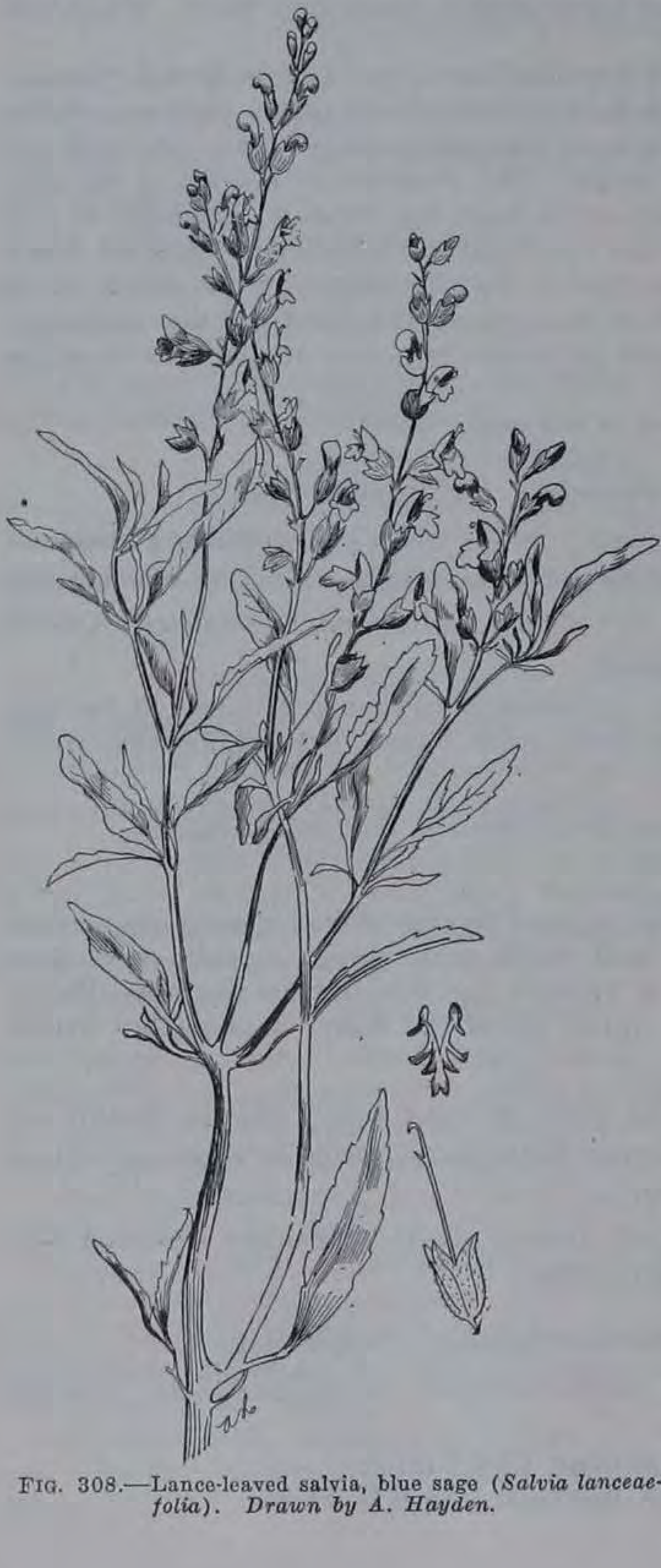

FIG. 308.—Lance-leaved salvia, blue sage (*Salvia lanceaefolia*). *Drawn by A. Hayden.*

Plains and open soil, Indiana, Nebraska and southward. Originally in Missouri loess bluffs; now naturalized; common in sandy, clay or black soils, waste places, railway ballast, etc. Associated with *Gaura coccinea, Euphorbia marginata, Dalea laxiflora, D. alopecuroides, Oxytropis Lamberti, Dyssodia papposa, Aplopappus spinulosus, Aster sericeus, A. laevis, Solidago nemoralis, S. missouriensis.*

Salvia lanceaefolia is a common plant in western Iowa, also naturalized in other parts of the state. The blue flowers are conspicuous. The nectar-secreting tissue, a fleshy yellowish structure under the four-lobed ovary, is readily distinguished. The presence of nectar is indicated to the insect by the odor of the flower and the dark marking on the lower lip. Nectar occurs abundantly in the lower part of the tube of the corolla and is secreted below the ovary.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Coon Rapids, Des Moines, Harlan, Jefferson, Palo Alto county (L. H. Pammel); Harrison county, Missouri Valley (R. Burgess), Ames (G. W. Carver, C. R. Ball and Robert Combs), Creston (T. L. Andrews), Fremont county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick).

It has been observed (L. H. Pammel) at Boone, Carroll, Cherokee, Des Moines, Fort Dodge, Glenwood, Hamburg, Jefferson, Madison county, Marshalltown, Missouri Valley, Sioux City. At Audubon, Boone, Grinnell, Hubbard, Iowa Falls, McGregor in 1930.

General distribution in the United States:

Colorado—Boulder (George E. Osterhout), Engelmann canyon (F. E. and E. L. Clements), Fort Collins (J. H. Cowan, L. H. Pammel), Julesburg (L. H. Pammel and R. E. Blackwood), Petersburg (L. H. Pammel, C. P. Johnson and G. W. Lummis); Illinois—Peoria (F. E. McDonald); Kansas—Wichita (T. L. Andrews); Missouri—Allenton (two specimens, George W. Letterman), Green county (J. W. Blankinship); Nebraska—Callaway (Rev. J. M. Bates), Hastings (L. H. Pammel); New Mexico—Santa Fe (A. Isabel Mulford); South Dakota—Hot Springs (J. C. Witham); Texas—Bracken (B. H. A. Groth), Kerrville (A. A. Heller).

HONEY BEE VISITS

Bees have been observed on *Salvia lanceaefolia* in western Iowa, and while not as valuable as some of the other species of *Salvia* it has some value as a honey plant.

Sidney, July, 1925. Many honey bees observed.

Salvia virgata Hort. Blue Salvia

Branching perennial 2 to 3 feet high; leaves lanceolate to oblong, crenate, glabrous above, pubescent beneath. Racemes long, slender, whorls 6-flowered. Calyx purplish; corolla violet, about one-half inch long, swollen at throat, without a hairy ring inside. Commonly cultivated.

HONEY BEE VISITS

Ames, June 24, 1927, 8 a.m. Fine honey plants. Bees abundant. Two seconds in a flower.

June 27, 1927. Bees abundant. Two seconds in a flower. Six flowers of the spike visited; fifteen flowers open. Two bees on same flower in three minutes.

Formal Gardens, I.S.C., July 13, 1927. Hot, dry, clear. Bees very abundant. Two to four seconds in a flower. (C.C.L.)

July 17, 1927. Bees abundant. Two seconds in a flower.

July 27, 1927, 11 a.m., 12 m. After rain, cloudy, warm. Good plant for honey. Bees one to one and one-half seconds in a flower. (C.C.L.)

July 31, 1927, 10:30 a.m. Bees abundant. Two seconds in a flower.

August 31, 1927, 12:30 p.m. Bee spends one to two seconds in a flower. Visits one to five flowers in a spike.

September 5, 1927, 9:30 a.m. Bees abundant. One to two seconds in a flower.

October 2, 1929. Bees two to three seconds in a flower.

September 15, 1930, 1 p.m. Bees one to two seconds in a flower.

Salvia Sclarea L. Clary

A gray-hairy plant two feet high. Leaves oblong, wavy-margined, petiolate. Flowers in a long interrupted spike of whorls. Bracts showy, broad, concave, veined with red.

Cultivated.

HONEY BEE VISITS

Ames, June 23, 1929, 3:35 p.m. Bees three seconds in a flower.

July 24, 1929, 2:30 p.m. Heavy rain in morning. No honey bees. Plant has a strong odor.

September 14, 1930, 1 p.m. Some bees.

Monarda L. Horse Mint

Tall herbs, our species all perennial. Leaves with odor, margins usually toothed. Attractive flowers in large clusters surrounded by bracts.

Monarda mollis L. Wild Bergamot

A branching aromatic plant 2 to 3 feet in height, soft, downy; leaves oblong-ovate, slightly heart-shaped at base. Flower clusters large, terminal. Corolla rose color, purple or white. In dry soils from New England westward.

Common in black prairie, sandy, gravelly drift soil, in borders of woods, clay and calcareous soils, in all parts of the state. Associated with *Desmodium canadense, Petalostemum purpureum, P. candidum, Lespedeza capitata, Andropogon furcatus, A. scoparius,* etc.

Charles Robertson says, "The plant is very common, the branches terminated by large heads of uniform rose color. Insects can approach the flowers with equal convenience from almost any side, and can receive the pollen on almost any part of their bodies." He does not record the honey bee, although many Hymenoptera were present.

FIG. 309.—Horse mint, wild bergamot (*Monarda mollis*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

The numerous branches bear light purple flowers in terminal glomerate heads. The nectar is secreted by the fleshy disc below the ovary and is protected from unbidden guests by small hairlike projections. It is reported that the bees are able sometimes to get considerable nectar, although the corolla tubes are deep.

Dr. L. A. Kenoyer says, "Although the flower has a very long tube, the honey bees acted as though they were getting some nectar from it, in 1914. Perhaps they get nectar by capillary action along the side of the tube. A single test of bees collected from *Monarda* indicated less sugar than that of bees from *Melilotus.*"

He also says, "Aromatic oils secreted by hairs on the corolla may be an attraction to the honey bees; it seems to be to small bees. Occasionally a honey bee can be seen to suck through a hole which has been made by some insect, but far more often they alight on the top and thrust their proboscides as deep as possible. In 1915 they were less frequent as visitors."

Miss Iza Mitchell of Keokuk tells us that she observed honey bees on this plant. She thinks that the honey may have been forced up the tube after a dew.

Frank Pellett notes that in the case of *Monarda mollis* the corolla tube is so deep that bees are unable to reach the nectar although sometimes reported as getting considerable nectar from this species. The explanation seem to us to be that under cloudy conditions with plenty of moisture the nectar is drawn up by capillarity and insects can get the nectar.

The senior author for a long time had been of the opinion that bees did not get nectar out of this flower, but when he saw bees visiting the flower in the vicinity of McGregor he became convinced that it yielded considerable nectar at times.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Estherville (two specimens), Fairfield, Garner, Gillett Grove, Glenwood, Hawarden, Jackson county, Keystone, Kossuth county, Lamont, Lansing, Lost Island lake, Marshalltown, McGregor, New Albin (two specimens), Ottumwa, Palo Alto, Polk City, Rock Rapids, Sioux City, Solon, Spirit Lake, Tete Des Morts, West Burlington (L. H. Pammel); Armstrong (two specimens), Clear Lake (R. I. Cratty), Adel (C. F. Clark), Ames (F. Rolfs, G. W. Carver, Mina Belle Lynch, L. H. Pammel and C. R. Ball), Boone county (L. H. Pammel and O. F. Miller), Charles City (E. M. Sherman; C. L. Webster), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines county (Paul Bartsch), Fayette (two specimens, B. Fink), Kelley (Pearl Clayton), Ledges (Boone county) (R. E. Buchanan, T. Macklin and L. H. Pammel), Marshalltown (L. H. Pammel and Estelle D. Fogel), northeastern Iowa (H. Goddard), Peru (D. E. Hollingsworth), Slater (two specimens, W. I. Tener, C. Reinbott and H. S. Fawcett).

It has been observed (L. H. Pammel) at Albia, Cedar Rapids, Charles City, Clear Lake, Clinton, Eldora, Estherville, Fort Dodge, Hamburg, Hampton, Indianola, Iowa Falls, Keokuk, Keosauqua, Lansing, Mason City, Muscatine, Postville, Red Oak, Sidney, Sioux City, Waukon.

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); Colorado—Fort Collins (L. H. Pammel and C. P. Johnson), Rist canyon (C. S. Crandall); Illinois—Blackberry (B. Fink), Fox (L. H. Pammel and Mark Heavenhill), Hamilton (L. H. Pammel); Louisiana—(two specimens, T. L. Andrews); Michigan—Grand Rapids (A. A. Crozier), St. Ignace (L. H. Pammel), Whitehall (Mrs. K. G.

Smith; Minnesota—Bemidji, Faribault, Minneapolis, Wilmer (L. H. Pammel), Brainerd, St. Cloud (E. B. Watson), Crookston (Mrs. Roy Westley), Norway Beach (Cass Lake) (L. H. and H. E. Pammel), Richdale (L. H. Pammel and W. S. Dudgeon), St. Paul (R. Gmelin); Missouri—(P. T. Barnes), Valley Park (L. H. Pammel); Nebraska—Halsey (J. C. Blumer), Scott's Bluff (F. G. Miller); New Mexico (A. Isabel Mulford); New York—Ithaca (H. E. Summers), White Plains (Mrs. L. M. Park); North Dakota—Minot (J. C. Blumer); Ohio—Worthington (Asa Horr); Oklahoma—Codds county (W. E. Bruner), Muskogee (L. H. Pammel); South Dakota—Brookings, Lake Tetonkeha, Milbank, Sioux Falls, Sisseton, Watertown (L. H. Pammel), Dell Rapids (N. E. Hansen); Virginia—Farmer Mountain, Marion (John K. Small); Wisconsin—Easton, Galesville, La Crosse, Lynxville, Muscoda (three specimens, L. H. Pammel), Stevens Point (L. H. Pammel and V. C. Fisk).

HONEY BEE VISITS

Ames, July 14, 1914. Interurban car track. Partly cloudy, warm, northwest wind. Honey bees all day, especially evening. Six to twenty. *Bombus* none to two, small flies two to eleven. Wasps, butterflies and flies occasional. (L.A.K.)

Interurban car tracks. Warm. Honey bees. Few *Bombus*, small bees, flies. Honey bees act as though sucking from a tube. Two per head per minute. (G.H.M.)

Dubuque, July 15, 1914. Clear, northwest wind. Honey bees, other Hymenoptera, seeking nectar. One per head per minute. Honey bees and *Bombus* change between *Solidago* and *Monarda*. (L.A.K.)

Ames, July 29, 1914. Interurban car track. Clear, southeast wind. Honey bees. *Bombus* several, other Hymenoptera many, flies few. Three per head or thirty-five per quadrat per minute. Honey bee works persistently, sucking from a tube. (L.A.K.)

Atlantic, August 1, 1914. Hot and dry. Several species *Bombus* and butterflies. (L.A.K.)

Ames, August 3, 1914. Hot and dry. Two per head per minute. (G.H.M.)

August 10, 1915. Pasture. Clear, moderate. One honey bee, one *Bombus*. (L.A.K.)

August 21, 1915. Pasture. Clear, following a cool night. An occasional honey bee, mostly on old head. (L.A.K.)

Pilot Knob, Hancock county, July 28, 1918. No bees on this plant. Frank Pellett states that he has not observed honey bees upon the plant; others report having observed them.

McGregor, August 18, 1923. Species abundant. Bees hover about the flower, but do not enter.

Clayton, August 4, 1923. East slope of hill. Honey bees frequent. Bees two to three seconds in one flower. A bee examined and honey found.

Boscobel, Wisconsin, August 13, 1924, 4 p.m. Bees two to three seconds in a flower getting nectar.

McGregor, August 13, 1924, 11 a.m. Bees seven to three seconds in a flower.

Iowa City, August 4, 1927, 3 p.m. Clay soil. Clear, warm. No bees. Bees preferring white sweet clover.

Conesville, August 5, 1927, 1 p.m. Bees abundant. Two to three seconds in a flower.

Lamoille, August 7, 1927, 11 a.m. and 12 m. Warm, cloudy, dry. Bees working vigorously, two and three seen on each floret.

Practically all other plants in bloom on prairie at side of road south of Lamoille between Lincoln Highway and Lamoille were being visited by bumble bees. Other plants in bloom were *Cassia* and *Desmodium,* which bumble bees were working vigorously. They also worked horse mint in places. (C.C.L.)

McGregor, August 8, 1928. Bees abundant. Five seconds in a flower.

Wauzeka, Wisconsin, August 25, 1928, 5 p.m. Bees abundant. Two to four seconds in a flower.

McGregor, August 8, 1929, 2 p.m. Bees two to three seconds in a flower. Pollen and nectar. Somewhat sandy soil.

Monarda punctata L. Horse Mint

A perennial minutely hairy plant 2 to 3 feet in height. Leaves petioled, lanceolate, narrowed at base. Bracts lanceolate, teeth of the downy calyx short and awnless, rigid, soon spreading. Clusters of flowers axillary, corolla yellowish, the upper lip spotted with purple, notched at the apex, tube scarcely exceeding the calyx. Sandy ground, New York westward. Blooms from July to September.

FIG. 310.—Horse mint (*Monarda punctata*). *Photograph by R. S. Kirby.*

The species is common in eastern Iowa in sandy soil, on sand hills and adjacent to Skunk, Cedar and Iowa rivers. Associated with *Tephrosia virginiana, Scutellaria parvula, Anemone caroliniana, A. nemorosa, A. patens* var. *Wolfgangiana, A. cylindrica, Silene stellata, Hedeoma hispida.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, New Albin (L. H. Pammel), Des Moines county (Skunk river valley) (Paul Bartsch), Johnson county (T. J. and M. F. L. Fitzpatrick), McGregor (Ada Hayden).

This has also been observed (L. H. Pammel) at Ames, Clinton, Dubuque, Fort Madison, Leland, Montrose, Muscatine, Wapello.

General distribution in the United States and Canada:

Arkansas—Hot Springs (S. E. Meek); Canada—Calgary (L. H. Pammel); Colorado—La Porte (L. H. Pammel); District of Columbia—Washington (Carrie Harrison); Florida—Jacksonville, River Junction (A. H. Curtiss); Illinois—Chicago (L. H. Pammel, George Vasey); Michigan—Muskegon (L. H. Pammel); Missouri—Eagle Rock (B. F. Bush), St. Louis (L. H. Pammel); New Jersey—Mickleton (B. Heritage), South Amboy (L. H. Lighthipe); Texas—Clay Station, Houston (L. H. Pammel), Palestine (B. C. Thorpe); Wisconsin—Bergman Island, near McGregor, Galesville, Holmen (three specimens), Muscoda, Onalaska, Wauzeka (L. H. Pammel), Fountain City (R. Gmelin), La Crosse (Dora S. Pammel).

HONEY BEE VISITS

This plant may be depended upon to yield nectar and is a valuable contribution in regions where it grows.

John Lovell states that this is a valuable species to the beekeeper. He says that it yields nectar abundantly and is very attractive to honey bees. The following notes do not indicate the importance of this plant as a honey plant for the reason that we have not made observations where the plant is common, but in all places indicated it is an important source of honey. Moreover, the soil on which the plant occurs is not of very great agricultural importance except for the growing of Jack pine, melons and other vegetables.

Muscoda, Wisconsin, August 12, 1924, 12:30 p.m. Bees two to three seconds in a flower.

La Crosse, Wisconsin, August 12, 1927. Common also at Onalaska and Prairie du Chien, Wisconsin, Bellevue and Dubuque, Iowa.

Grand View, August 5, 1927, 3 p.m. Bees abundant. Two to three seconds in a flower.

Fruitland, August 5, 1927. Sandy soil. Bees abundant. Two seconds in a flower.

La Crosse, Wisconsin, August 7, 1927, 9:30 a.m. Sandy soil. Bees abundant. Partly cloudy, fairly warm.

McGregor, August 8, 1928. Bees abundant. Three to five seconds in a flower.

Prairie du Chien, Wisconsin, August 8, 1929. Bees abundant. Three seconds in a flower. Sandy soil.

La Crosse, Wisconsin, August 10, 1929, 4 p.m. Bees four to three seconds in a flower. Abundant bloom and bees numerous. Plant occurs on sandy soil.

McGregor, August 11, 1929, 8 a.m. Bees abundant. Four to three seconds in a flower. Abundant bloom of virgin's bower 100 feet away, but no bees on this flower. They were observed on the same plant in 1928.

Prairie du Chien, Wisconsin, August 15, 1929, 8:30 a.m. Four to five seconds in a flower. Sandy soil.

Blue Mound, Wisconsin, August 25, 1928, 2 p.m. Bees three seconds in a flower.

In Texas a related species *M. clinopodioides* is the source of large quantities of surplus honey, light and clear in appearance.

Blephilia Raf. Wood Mint

Perennial herbs somewhat resembling the horse mint. Flowers bluish purple, in crowded clusters.

Blephilia ciliata (L.) Raf. Downy Blephilia

Somewhat downy perennial. Leaves nearly sessile, oblong, ovate, narrow at base, whitish-downy beneath; outer bracts ovate, colored, ciliate, as long as the calyx. Found in dry open places. Associated with *Geranium maculatum, Hepatica acutiloba, Hydrophyllum virginianum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Mount Zion (L. H. Pammel).

General distribution in the United States:
California—(T. L. Andrews); District of Columbia—Piney Branch road (C. R. Ball); Illinois—Rantoul (H. A. Gleason); Indiana—Crawfordsville (W. H. Evans); Michigan—Green, northern Michigan (L. H. Pammel and V. C. Fisk), St. Ignace (two specimens, L. H. Pammel); Missouri—Columbia, Valley Park (L. H. Pammel), Kansas City, Ripley county (Kenneth K. Mackenzie), Allenton (George W. Letterman), Creve Coeur (H. Eggert); Ohio—Worthington (Asa Horr); Wisconsin—La Crosse (L. H. Pammel).

HONEY BEE VISITS

Mouth of Yellow river, Allamakee county, August 18, 1929. No bees although bees were abundant upon the Simpson honey plant.

Nectar secretion as in other species of *Blephilia*. Attractive to honey bees.

Blephilia hirsuta (Pursh.) Benth. Wood Mint

This is not uncommon in rich woods, especially along Mississippi river.

In this form the ovate leaves are long petioled, pointed, heart-shaped at base, the lower ones similar, the upper ones linear-awl-shaped. Flower is pale purplish. Borders of woods, sandy and loamy soils.

Associated with *Agastache nepetoides, Silene stellata, Hystrix patula, Aquilegia canadensis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Bellevue, Lost Island lake (L. H. Pammel); Boone (A. S. Hitchcock), Decorah (E. W. D. Holway), Des Moines (G. W. Carver, A. S. Hitchcock), Fayette (B. Fink), Lamont (I. T. Bode), Lebanon (A. F. Sample), Ledges (Boone county) (two specimens, L. H. Pammel, R. E. Buchanan, C. M. King), northeastern Iowa (H. Goddard).

It has also been observed (L. H. Pammel) at Burlington, Cedar Rapids, Clayton, Clinton, Decorah, Elkader, Farmington, Fort Madison, Keokuk, Keosauqua, Lansing, Manchester, Postville, Strawberry Point.

General distribution in the United States:

California—(T. L. Andrews) (probably an error); Michigan—Lake Au Train, St. Ignace (L. H. Pammel), northern Michigan, Green (L. H. Pammel and V. C. Fisk); Missouri—Kansas City (K. Mackenzie), St. Louis (H. Eggert); Ohio—Vermillion (Ex. Herb. Oberlin), Worthington (Asa Horr); Washington, D. C.—Piney Branch road (C. R. Ball).

HONEY BEE VISITS

Bees have been observed getting nectar from this plant. Nectar is secreted as in other mints—from the glands situated below the ovary. We have observed many bees on these flowers in sections of the state where it is native.

Charles Robertson says, "Flowers are white, the lower lip dotted with purple. The flowers are often visited by bees which land upon the lower lip, suck the nectar in a legitimate way and receive the pollen upon their backs."

Hedeoma Pers. Mock Pennyroyal

Low-growing annual aromatic herbs, with small entire leaves and small purplish flowers in clusters at the axils.

Hedeoma pulegioides (L.) Pers. American Pennyroyal

An erect, branching, low hairy plant. Whorls with few bluish flowers. Leaves petioled, oblong, serrate, with odor nearly that of true pennyroyal. In dry soils, Nova Scotia to Dakotas and southward.

This is an upland, clay, woodland species, quite widely distributed in the state but more especially in upland woodlands along the streams of eastern Iowa. Associated with *Eupatorium urticaefolium, Aster sagittifolius, Solidago ulmifolia, S. latifolia.*

Charles Robertson says, "The pale purplish flowers are arranged in small axillary clusters, one or two being open in each cluster at a time. They are adapted to small bees."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Pammel Park, Eddyville, Madison county (L. H. Pammel); Ames (A. Hayden, G. W. Carver, A. S. Hitchcock), Decatur county (three specimens, E. M. Sherman), Keosauqua (L. H. Pammel and A. F. Sample), Ledges (Boone county) (two specimens, L. H. Pammel and O. F. Miller).

It has also been observed (L. H. Pammel) at Albia, Burlington, Carlisle, Centerville, Des Moines, Dubuque, Fairfield, Fort Dodge, Indianola, Keokuk, Keosauqua, Marshalltown, Moulton, Winterset.

General distribution in the United States:

Arkansas—Black Rock, Lawrence county (P. H. Rolfs); Colorado—Denver (L. H. Pammel), Fort Collins (C. S. Crandall); District of Columbia—Washington—U. S. Soldiers Home (H. E. Pammel, three specimens, C. R. Ball and A. E. Paddock); Illinois—Chicago, Evanston, Graceland, East St. Louis (L. H. Pammel), Champaign (B. Fink), Havana (H. A. Gleason), Iuka (H. I.

Featherly); Kentucky—Poor Fork Post Office (T. H. Kearney, Jr.); Missouri—St. Charles, St. Louis (L. H. Pammel), Hannibal (R. Gmelin), Sheffield (Kenneth K. Mackenzie); New Jersey—New Market (Halsted's American Weeds); New York—Ithaca (Muenscher and Bechtel); Ohio—Kelley's Island (L. H. Pammel), Pickerington (Asa Horr); South Carolina—Arlington (two specimens, C. R. Ball and A. E. Paddock), Oconee county (A. P. Anderson).

HONEY BEE VISITS

Bees have been observed upon this plant. The flowers furnish some nectar. This plant has an extremely strong odor which may be evident to honey bees.

Hedeoma hispida Pursh. Hairy Pennyroyal

A low, somewhat hispid plant. Leaves linear, crowded. Bracts spreading or reflex, upper flowers crowded. Flower bluish. Plains and rocky banks. New York westward.

This species is widely distributed in Iowa in sandy and gravelly soils. Associated with *Monarda punctata, Anemone cylindrica, Silene stellata, Scutellaria parvula.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche (two specimens), Dev'l's Backbone, Dubuque, Eagle Rock, Ledges

FIG. 311.—Hairy pennyroyal (*Hedeoma hispida*). *Photograph by A. Hayden.*

(Boone county) (two specimens), Madison county, Marion county, Red Rock, Winterset (L. H. Pammel); Ames (C. R. Ball), Charles City (two specimens, A. S. Hitchcock), Decatur county (T. J. and M. F. L. Fitzpatrick, J. P. Anderson, three specimens), Decorah (R. I. Cratty, E. W. D. Holway), Fayette (three specimens, B. Fink), Kelley (Pearl Clayton), northeastern Iowa (H. Goddard).

It has been observed (L. H. Pammel) at Algona, Bellevue, Burlington, Centerville, Cherokee, Clinton, Dubuque, Forest City, Fort Madison, Mason City, Muscatine, Postville, Spirit Lake, Wallingford, Waukon Junction.

General distribution in the United States:

Arkansas—Northern Arkansas (P. H. Rolfs); Kansas—Wichita (T. L. Andrews); Illinois—Oquawka (Harry N. Patterson), Peoria (F. E. McDonald), Red Bud (L. H. Pammel), Rockford (L. H. Pammel and V. C. Fisk); Minnesota—Winona (J. M. Holzinger); Missouri—Pixley (Kenneth K. Mackenzie), St. Louis (H. Eggert); Nebraska—Sheridan county (R. E. Buchanan); Texas—Tarrant county (Albert Ruth); Wisconsin—Cross Plains (J. R. Heddle), Holmen (L. H. Pammel), La Crosse (R. Gmelin).

HONEY BEE VISITS

Honey bees have been observed on this plant although bees are not common. This plant does not furnish much nectar.

Pycnanthemum Michx. Mountain Mint

Perennial erect aromatic herbs. Whitish flowers in terminal or axillary capitate clusters. Corolla two-lipped, upper lip notched. Leaves linear, almost entire to ovate.

Pycnanthemum flexuosum (Walt.) B.S.P. Mountain Mint

Smooth branching perennial, linear leaves. Flowers in somewhat downy corymbose clusters. The bracts are rigid, lance-subulate calyx-teeth; corolla short, white.

Clay and sandy soil, borders of woods and roadsides of southern and southeastern Iowa. Associated with *Monarda mollis, Corylus americana, Solidago nemoralis, Helianthus grosseserratus, Cassia Chamaecrista, Andropogon furcatus.*

The narrow-leaved mountain mint, or basil, occurs in dry woodlands in southern Iowa with pennyroyal, white oak and hickory. The specimen from Jackson county by Bartsch apparently is referable to this species. If so, it is somewhat out of the range.

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Fairfield, Farmington, Indianola, Otter Creek, Ottumwa (two specimens), Rochester, Warren county (L. H. Pammel); Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson), Jackson county (P. Bartsch), Keosauqua (L. H. Pammel and G. B. MacDonald), Osceola (F. C. Stewart), Salem (L. H. Pammel and H. E. Jaques).

This has been observed (L. H. Pammel) at Burlington, Centerville, Chariton, Denmark, Fairfield, Fort Madison, Keokuk, Mount Pleasant, West Burlington.

General distribution in the United States:

Arkansas—Ashley county (R. E. Fennell), Fort Smith (P. H. Rolfs), Tobe (L. H. Pammel); District of Columbia—(W. J. Canby); Illinois—Glen Rock (L. H. Pammel and Mark Heavenhill), Makanda (H. A. Gleason); Massachusetts—Arlington (J. W. Blankinship), Yarmouth (M. L. Fennell, F. K. Butters, Harold St. John); Missouri—Benton, St. Charles (L. H. Pammel), Big Sac (J. W. Blankinship), Sheffield (B. F. Bush), St. Louis (H. E. Eggert), New Jersey—Clifton (George V. Nash); New York—Ithaca (Muenscher and Bechtel); North Carolina—Biltmore (Biltmore Herbarium); South Carolina—Anderson (Davis); Texas—Houston (L. H. Pammel), Kingville (three specimens, E. R. Hodson), Texarkana (A. A. and E. Gertrude Heller).

HONEY BEE VISITS

Bloomfield, July 25, 1927, 10:30 a.m. Clear, sunshiny. Bees fairly common. One to two seconds in a flower.

Pycnanthemum virginianum (L.) Durand and Jackson. Mountain Mint

More or less aromatic scented perennial herbs, 1 foot to 3 feet in height; very leafy, quite smooth. Leaves clustered, lance-linear, rigid, sessile. Flowers small, in numerous globular close-heads, in crowded corymbs. Massachusetts westward and southwestward.

This species is common in many parts of Iowa; once more common than now. Found in depressions in prairies, where it is abundant; sometimes also in peat bogs and in moist uplands, and on borders of lakes. Other species in woods. Associated with *Scutellaria galericulata, Scirpus atrovirens, Thalictrum dasycarpum, Melanthium virginicum, Phlox glaberrima, Festuca Shortii, Vicia americana, Galium coccineum, Lilium canadense, Lilium philadelphicum* var. *andinum.*

The flowers are gathered in rather close clusters. The nectar, which is secreted by the fleshy disc below the ovary, is not abundant. It may be said that in some seasons more nectar is produced than in others. None of the *Pycnanthemums* in Iowa are very important as honey plants.

Honey bees have been reported on this though personally we have not observed any.

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Centerville (two specimens), Charles City, Emmetsburg, Fairbanks, Fertile, Garner, Goldfield, Indianola, Marathon, Marion county, Mason City, Riverside, Sac City, Wheelerwood (L. H. Pammel); Clear Lake, Decorah, West Bend (R. I. Cratty), Le Claire, Scott county (C. LeBuhn), Ames (Violet Pammel, L. H. Pammel and C. R. Ball), Charles City (F. M. Tuttle), Decorah (E. W. D.

Holway), Eagle Grove (R. E. Buchanan), Fayette (B. Fink), Fraser (Botany Seminar), Kelley (Pearl Clayton), Lake Okoboji (Miller's Bay) (H. S. Coe and L. H. Pammel), Marshalltown (L. H. Pammel and Estelle Fogel), northeastern Iowa (H. Goddard), Northwood (Mrs. Tuttle), Osage (L. H. Pammel and Mrs. Tuttle), Ontario (E. R. Hodson), Slater (three specimens, H. S. Fawcett, W. I. Tener, C. Reinbott).

General distribution in the United States:

Arkansas—Lawrence county (P. H. Rolfs); Illinois—Blackberry (B. Fink), Fox (L. H. Pammel and Mark Heavenhill), Hamilton (L. H. Pammel), Ogle county (R. I. Cratty), Pullman (L. H. Pammel); Minnesota—St. Cloud (Rudolph Gmelin), St. Paul (L. H. Pammel); Missouri—Allenton (George W. Letterman), Little Blue Tank (Kenneth K. Mackenzie); New Hampshire—Alstead (W. W. Eggleston); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Lancaster (Dr. Bigelow); Wisconsin—Madison (J. R. Heddle), Galesville, La Crosse (two specimens, L. H. Pammel).

HONEY BEE VISITS

Charles Robertson says, "The flowers (*Pycnanthemum virginianum*) are erect and the lips are so widely expanded that the stamens are fully exposed and the tubes are about equally accessible from any side." He records the honey bee as being abundant upon the flower, getting nectar.

Des Moines, August 4, 1929, 1:30 p.m. Two seconds in a flower. Eight hundred feet from apiary.

August 5, 1929. Common from Jewell to Blairsburg, Iowa Falls, Allison, Waverly and Strawberry Point. No bees observed.

Pycnanthemum pilosum Nutt. Downy Mint

This is a pubescent form growing to a height of 2½ feet. The lanceolate leaves are long pointed. The flowers are in crowded, bracted, terminal heads.

Nectar is secreted by the fleshy disc below the ovary. It is not abundant.

This species occurs in borders of woods, or open places adjacent to woods in southeastern Iowa. Sandy open woods or light clay soil. Associated with *Quercus marylandica, Q. alba, Q. velutina, Carya ovata, Geranium maculatum, Hedeoma pulegioides, Phlox divaricata.*

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Burlington (two specimens), Pammel Park, Fairfield, Rochester, Winterset (L. H. Pammel); Centerville (L. H. Pammel and G. B. MacDonald), Decatur county (J. P. Anderson), Muscatine (L. H. Pammel and F. Reppert).

This species has also been observed (L. H. Pammel) at the following additional localities: Fort Madison, Keokuk, Mount Pleasant, Oakland Mills and Salem.

General distribution in the United States:

Arkansas—Lawrence county (two specimens, P. H. Rolfs); Florida—Jacksonville (A. H. Curtiss); Illinois—Havana (H. A. Gleason); Missouri—Benton

(L. H. Pammel), Hannibal (R. Gmelin), Springfield, J. M. Blankinship; Oklahoma—Muskogee (L. H. Pammel).

HONEY BEE VISITS

Honey bees have been reported on this species, though personally we have not observed any.

Coleus Lour.

Cultivated herbs, with variously colored foliage.

Coleus Blumei Benth.

A tender perennial herb, with ovate leaves, sometimes sharply toothed, variously colored yellow, dull red and purplish. Flowers dark blue, or whitish.

HONEY BEE VISITS

Ames, October 2, 1929, 10:30 a.m. One to three seconds on a flower.

Mentha (Tourn.) L. Mint

A perennial with the odor of mint. Flowers in clusters from axillary whorls. Calyx bell-shaped or tubular. Corolla with a short included tube. Stamens four.

FIG. 312.—Peppermint (*Mentha piperita*). In some gardens. *Photograph by Ia. Agr. Exp. Sta.*

Mentha piperita L.
Peppermint

Glabrous pungent herb with ovate-oblong leaves, sharply serrate, hirsute. Naturalized in many parts of the state.

HONEY BEE VISITS

Postville, September 11, 1927, 4:30 p.m. Bees abundant. One to three seconds in a flower.

Oskaloosa, September 6, 1930. Bees abundant. Three seconds in a flower.

FIG. 313.—Mint (*Mentha arvensis* var. *canadensis*). *Photograph by A. Hayden.*

Mentha canadensis L.
American Wild Mint

Perennial. Flowers in axillary whorls. Calyx pubescent. Odor like pennyroyal.

HONEY BEE VISITS

Richter reports bees active upon this plant from July to October.

Mentha arvensis var. *canadensis* (L.) Briquet.
Mint

Lanceolate pubescent leaves. Pink or violet flowers in whorls. A common native species, found frequently in low grounds.

HONEY BEE VISITS

Montrose, September 2, 1929. Bees one to two seconds in a flower.

SOLANACEAE, Nightshade Family

Herbs or rarely shrubs. Alternate leaves regular or irregular. Corolla, 5 sepals and 5 petals, stamens 5, pistil 1; compound, usually rank-smelling herbs.

Knuth says that in this family nectar is secreted below the ovary.

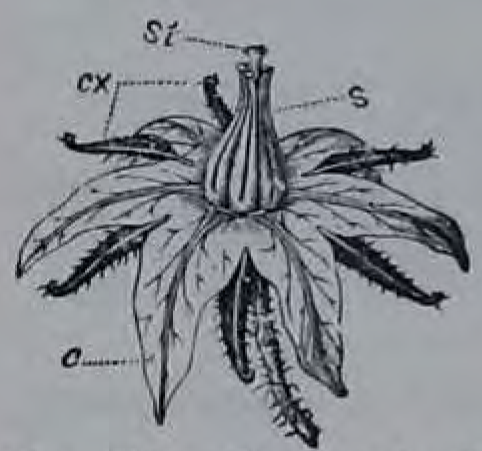

Fig. 314.—Flower of *Solanum*: c. corolla, cx. calyx, s. stamens, st. style and stigma. *After Thomé.*

The flowers of the family belong to several distinct groups—those which generally furnish pollen, like the species *Solanum*, and those with concealed nectar, and a class, pollinated by night-flying Lepidoptera, with concealed nectar which is stored in the tube.

Honey bees have been reported on *Lycium halimifolium*, *Solanum Dulcamara* and *Atropa Belladonna*, in Europe.

Lycium L. Matrimony Vine

Shrubby, often spiny plants with alternate small entire leaves. Axillary flowers. Corolla 5-lobed, funnel-shaped. Berry small, 2-celled.

Lycium halimifolium Mill. Matrimony Vine

Low trailing shrubs, usually somewhat spiny. The lateral spines bear clusters of leaves and small purplish flowers. Duration of bloom throughout early summer. Branches long and slender. Fruit scarlet. A common hardy ornamental.

Widely cultivated and naturalized in various soils.

We have noticed it in Ames, Burlington, Cedar Rapids, Des Moines, Fort Dodge, Indianola, Keokuk, Keosauqua, Marshalltown, Mount Pleasant, Tingley, Webster City, McGregor.

General distribution in the United States:

Delaware—Wilmington (Wm. M. Canby); Illinois— Quincy (L. H. Pammel); New York—Ithaca (H. E. Summers); Ohio—Castalia (L. H. Pammel); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood).

HONEY BEE VISITS

Knuth says, "The lighter throat of the dull red corolla is marked with dark violet lines serving as nectar guides."

Nectar is easily accessible to the bee. The small flowers, clustered in the axils of the leaves, are much frequented by bees. The plant is sometimes of considerable importance. It has a long blooming season, flowering until frost. Ames, July 8, 1922, 8 a.m. Clear, cool, dew present. A bee one to four seconds in a flower.

September 22, 1922, 8:30 a.m. Partly cloudy. Bees two seconds in a flower. On one hundred fifty flowers eight bees in three minutes.

Iowa City, September 22, 1922, 12 m. Bees about two seconds in a flower.

Ames, September 23, 1922, 12:15 p.m. Clear, cool. Few bees. Five seconds in a flower.

September 29, 1922, 11 a.m. Bees four seconds in a flower.

September 1, 1923. Day warm and bright. Bees numerous and active all day, getting nectar.

September 13, 1923, 2:30 p.m. Sunshine. Bees two to six seconds in a flower.

September 21, 1923, 12 m. Warm. Flowers freely open. Bees numerous, active.

September 25, 1923, 2 p.m. Foggy, warm. Some bees. Numerous other insects.

Prairie du Chien, Wisconsin, June 17, 1925, 10:30 a.m. Partly cloudy. Sandy soil. Honey bees gathering nectar only.

Ames, July 3, 1927. Cool, showery. Bees at work. (C.C.L.)

September 20, 1929, 1 p.m. Cool, cloudy. Bees gathering pollen. Three seconds in a flower. Also *Bombus*.

September 25, 1929, 3 p.m. Some bees. Three seconds in a flower.

September, 1929. Bees one second in a flower. (A. L. Hershey.)

Blooming, Ames, May 18, 1925.

Capsicum L. Red Pepper

Woody or annual smooth plants with ovate, elliptic or narrow lanceolate, simple entire leaves; flowers white or greenish white, calyx short, 5-lobed, corolla rotate, usualy 5-lobed, stamens usually 5, ovary 2- to 3-celled, style simple, stigma capitate, fruit a many-seeded berry.

Capsicum annuum L. Cayenne Pepper

Annual with ovate or ovate oblong smooth leaves. Flowers greenish white, pedicelled, solitary or in twos or threes, short calyx, corolla rotate, anthers opening longitudinally, fruit a berry, 2- or 3-celled, conelike, roundish, of pungent or sweetish flavor.

HONEY BEE VISITS

During some years there are few visitors, but owing to the drouth in 1930 the honey bee visited flowers not ordinarily visited by it. Mr. C. C. Lounsberry reported as follows concerning honey bee visits to cayenne pepper:

September 15, 1930, 2:30 p.m. Honey bee abundant, two to ten seconds in a flower. The cabbage butterfly as well as *Syrphus* flies were abundant.

September 12, 1930, 9:00 a.m. Watched honey bees. Very busy working *Capsicum annuum*. They made four visitations to the same flower in fifteen minutes, on the following varieties: Sunnybrook, California wonder, World beater, Harris earliest.

Solanum (Tourn.) L. Nightshade

Perennials or annuals, herbs or shrubs, smooth, hairy or spiny stems and leaves, flowers wheel-shaped or 5-cleft, corolla white, purple or yellow, stamens exserted, anthers converging around style opening by two pores, fruit a berry.

Solanum Melongena L. Eggplant

Herb or somewhat shrubby with gray scurfy leaves and stem, occasionally the leaves are slightly spiny. Flowers single, violet, fruit a berry, usually purple.

HONEY BEE VISITS

Mr. C. C. Lounsberry on September 15, 1930, noted that at Ames the bumble bee was rather common and remained from two to five seconds on the flowers. No honey bees came to the flowers.

Petunia Juss. Petunia

Showy flowers—garden annuals.

Petunia hybrida Vilm. Common Garden Petunia

Variable. Flowers 2 to $3\frac{1}{2}$ inches long, with funnel-shaped tube and broad spreading corolla. Color ranges from white to deep purple.

HONEY BEE VISITS

Ames, October 16, 1929, 8:30 a.m. Clear and cool. Bees observed by Dorothy M. Johnson.

SCROPHULARIACEAE, Figwort Family

Mostly herbs with simple leaves. Flowers complete, regular or irregular. Stamens 4, in 2 pairs, or 1 pair, sterile, inserted on the corolla; style single, ovary superior, compound; fruit a 2-celled, 2-valved capsule.

The brightly colored corollas often make the flowers conspicuous. The species mentioned herein all bear nectar at the bases of the filaments.

The common mullein (*Verbascum Thapsus*), a widely scattered weed, has a pollen-producing flower. We have never found any bees on it, although Mueller reports honey bees in Germany. It is possible that in Iowa it is ocasionally visited by honey bees. This is a very troublesome weed in thin soils.

Verbascum thapsiforme Shrad. has been under observation this spring (1929), but in no case have we found honey bees, although the flowers are more conspicuous than in the common mullein.

Linaria (Tourn.) Hill. Toadflax

Persistent, deep-rooted perennial herbs. Leaves opposite or whorled, sessile. Flowers showy, numerous, winged. Bloom extends from June to October.

Knuth says, "The flowers are adapted to visits of bees or bumble bees. Nectar is secreted by the fleshy base of the ovary and stored in a spur."

Linaria vulgaris Hill. Butter and Eggs

Glabrous erect perennial herbs with extremely numerous mostly alternate leaves. Showy yellow and orange flowers in a dense raceme. Fields and roadsides. Generally distributed. Of European origin. An introduced plant. Especially common in clay soils. Associated with *Trifolium pratense* but usually in solid patches.

FIG. 315.—Butter and eggs, toadflax (*Linaria vulgaris*).

Toad flax is a common naturalized weed in many parts of the state, though it is more common in northeastern Iowa than elsewhere, where it may be found in streets and along rights-of-way of railroads.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Aurelia, Boone, Cedar Falls, Dillon, Harlan, Moingona, Polk City (L. H. Pammel); Ames (S. W. Beyer, F. C. Stewart, L. H. Pammel and C. R. Ball, G. W. Carver), Cedar Rapids (Burgess), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Elkader (L. H. Kramer), Fayette (B. Fink), Fraser (Botany Seminar), New Hampton (P. H. Rolfs), Osage (two specimens, Mrs. F. M. Tuttle), Story county (A. S. Hitchcock), Toledo (J. W. Pendry), Winneshiek county (H. Goddard).

It has been observed (L. H. Pammel) at Algona, Cedar Rapids, Charles City, Clayton, Clinton, Dana, Davenport, Des Moines, Dubuque, Fairfield, Fort Dodge, Gilbert, Marquette, Mason City, McGregor, New Albin, Newton, Nora Springs, Postville, Waukon, Winterset.

FIG. 316.—Toadflax (*Linaria vulgaris*). *After Fletcher and Clark.*

General distribution in the United States:

Illinois—Champaign (B. Fink); Michigan—St. Ignace, Whitehall (L. H. Pammel); Minnesota—St. Cloud (R. Gmelin); New Mexico—Las Vegas (A. Isabel Mulford); New York—Burdette (L. H. Pammel), Ithaca (two specimens, H. E. Summers), Lockport (Stella L. Goodspeed); Virginia—Blacksburg (W. A. Murrill); Wisconsin—Genoa (L. H. Pammel), Grand Rapids (B. M. Vaughn).

HONEY BEE VISITS

In toad flax (butter and eggs) the nectar is secreted by a prominent enlargement at the base of the ovary. The nectar, as it is secreted, passes down a smooth, narrow groove which is lined by short stiff hairs, and thence to the top of the spur. This groove is an excellent nectar guide. The bee alights on the lower lip and creeps into the tube, thrusting its head into the entrance of the spur, which it empties down to a depth of two or three millimeters.

Charles Robertson says, "That the flower is adapted to long-tongued bees is indicated not only by the sizes of the tube and the length of the spur, but by the fact that only the larger bees are able to open the flower with ease.

"When a bumble bee lights upon the palate its weight opens the flower, and all it has to do is to enter. But the other bees observed by me are not heavy enough to open the flower by their own weight, and so can only enter by squeezing in between the lips. I have seen the hive-bee enter so as to strike the stamens with its ventral surface or with its side.

"Between June and October I observed bees collecting nectar and pollen."

Mueller records the honey bee as a frequent visitor in Europe.

Dillon, October 30, 1915. Six bumble bees in ninety seconds over a quadrat containing four hundred sixty flowers. Time in a flower one to three seconds. Honey bees occasionally visit it in Iowa.

Digitalis (Tourn.) L. Foxglove

Herb with long leaves often crowded at its base. Flowers in long showy terminal racemes, purple, yellowish or white. Corolla declined. Tube inflated.

Digitalis purpurea L. Foxglove

Commonly cultivated for ornamental purposes. Has large reddish or spotted flowers in conspicuous racemes. The nectar guides appear in the form of dark purple blotches with white margins. The nectar is secreted by a little swelling below the ovary and occurs in the base of the corolla tube. The flowers are proterandrous. They are adapted to bumble bees. Honey bees have been reported on this flower, but they are hardly the pollinators.

HONEY BEE VISITS

We found honey bees this spring (1929) in the formal garden on the campus of Iowa State College. Bees were observed also in the late summer.

Veronica (Tourn.) L. Speedwell

Principally herbs. Leaves mostly opposite; corolla wheel-shaped, almost regular; capsule flattened.

Knuth says, "Flowers usually blue in color, with concealed nectar secreted by a disc below the ovary, and stored in the lower part of the short corolla-tube."

Veronica virginica L. Culver's Root

A smooth-stemmed perennial 2 to 3 feet high; leaves whorled in fours to sevens, short-petioled, pointed, finely serrate, spikes panicled; flowers small, white. Rich soil. Massachusetts and westward.

FIG. 317.—Culver's root (*Veronica virginica*). *Photograph by A. Hayden.*

Culver's root is widely distributed in low grounds, borders of woods and in woods and prairies in many parts of the state. Once much more common than it is now. Associated with *Eupatorium purpureum, Thalictrum dasycarpum, Solidago serotina, Aster novae-angliae, S. Ridellii, Gerardia aspera, Gentiana Andrewsii, Liatris scariosa.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Fairbanks, Garner, Hanlontown, Lamont, Lost Island lake, Madison county, Marathon, McGregor, Palo Alto, Rochester, Winterset (L. H. Pammel), Osage, West Bend (R. I. Cratty), Ames (R. E. Jeffs, A. Hayden, two specimens, A. S. Hitchcock, Natural History Society, L. H. Pammel and C. R. Ball), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Fayette (B. Fink), Fraser (Botany Seminar), Hamilton county (P. H. Rolfs), Hull (W. Newell), Kelley (Pearl Clayton), Lamont (I. T. Bode), Marshalltown (F. C. Stewart), Muscatine (F. Reppert), northeastern Iowa (H. Goddard), Osage (two specimens, Mrs. F. M. Tuttle), Ontario (E. R. Hodson), Winterset (G. W. Carver).

It has been observed (L. H. Pammel) at Boone, Carroll, Cedar Rapids, Cherokee county, Clinton, Council Bluffs, Davenport, Dubuque, Fort Dodge, Iowa City, Muscatine, New Albin, Ogden, Postville, Waukon.

General distribution in the United States:

Arkansas—Northwestern Arkansas (F. L. Harvey); Illinois—Champaign (B. Fink), Fox (L. H. Pammel and Mark Heavenhill), Peoria (F. E. McDonald); Minnesota—Pipestone, St. Charles, St. Cloud, St. Paul (L. H. Pammel), Brainerd (E. B. Watson), Minneapolis (J. L. Sandberg); Missouri—Hannibal (R. Gmelin); Pennsylvania—Nescopeck (Mrs. Joseph Clemens); Texas—Texarkana (Ada and E. Gertrude Heller); Wisconsin—Galesburg, Holmen, St. Croix Falls (L. H. Pammel), La Crosse (R. Gmelin), Madison (J. R. Heddle).

HONEY BEE VISITS

Charles Robertson says, "The corolla tubes measure five mm. and the nectar is sought by mid-length and long tongues."

He observed the honey bee upon this flower, collecting nectar.

Ames, July 22, 1915. All day. Partly cloudy, hot, west wind. Two to four honey bees, as many solitary bees and wasps. *Bombus* and flies rare. Sweet scented. A good honey plant. (L.A.K.)

Pipestone, Minnesota, August 3, 1922, 5:30 p.m. Bees one second in a flower.

McGregor, August 6, 1922, 2 p.m. Bees one to two seconds in a flower. Twenty-five flowers open on a single spike, ten spikes on one plant, 250, altogether 1200 to 1500 flowers to one plant.

August 5, 1923. Cloudy, dry. Bees abundant. One or two seconds in a flower. Clay soil, top of hills. Over a clump of 1500 flowers in the space of five minutes four bees were working.

Iowa City, near, August 4, 1927, 4 p.m. Height of bloom. Bees abundant. One second in a flower. Some bees flew from this plant to *Melilotus alba*. No bees on *Petalostemum candidum*, *P. purpureum*, *Vernonia Baldwini*, *Verbena stricta*, *Euphorbia corollata*.

McGregor, August 4, 1929. Honey bees abundant. (Frances Middleton.)

August 5, 1929. Abundant Jewel to Blairsburg, Iowa Falls, Hampton, Allison, Waverly, Strawberry Point. Bees fairly common.

McGregor, August 7, 1929. Bees two and one seconds in a flower.

Veronica Anagallis-aquatica L. Water Speedwell

Smooth creeping perennial herbs, rooting at base and then becoming erect; 1 foot to 3 feet in height. Leaves sessile, most of them clasping at base. Pedicels spreading, corolla pale blue with purple stripes. Blooms in July and August.

This species, though widely distributed, is not common anywhere in Iowa. It occurs in brooks and ditches in shallow water or in moist places, especially in northern and eastern Iowa.

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Story City, Webster county (L. H. Pammel); Sac county, Wall Lake (C. E. Bessey), Ames (three specimens, A. S. Hitchcock, G. W. Carver), Decorah (E.

W. D. Holway), Fayette (two specimens, B. Fink), Winneshiek county (three specimens, H. Goddard).

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall), Kempton (L. H. Pammel), Palmer Lake (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank Raney); Illinois—Rantoul (H. A. Gleason); Minnesota—Sandy lake (J. H. Sandberg); North Carolina—Cranberry (John K. Small and A. A. Heller); Ohio—Lackburne (Asa Horr); Texas—Austin (F. C. Werkenthin, B. C. Thorpe); Wisconsin—Avalanche, Bloomingdale, La Crosse (two specimens), Madison (L. H. Pammel).

HONEY BEE VISITS

Honey bees are said to visit it in Iowa, although we have not observed any on plants at Decorah and Ames.

Veronica americana Schwein. American Brooklime

First creeping and rooting, then erect herb, from a foot to $2\frac{1}{2}$ feet in height. Leaves lanceolate to ovate, acute, serrate, short petioled. In brooks and ditches from Newfoundland westward. Blooms in June and July.

Rare in the state; in moist soils, borders of brooks. Associated with *Bidens cernua, Leersia oryzoides.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Independence (J. H. Muncie).

It has been observed (L. H. Pammel) at Ames, Dubuque, Lansing, Manchester, Maquoketa and McGregor.

General distribution in the United States:

Alaska—Hyder (Kirk Whited), Lehwein road (K. Whited); British Columbia—Between Stewart and Hyder; California—Blairsden (two specimens, L. H. Pammel), Mariposa Grove (L. H. Pammel and R. A. Needham), Portola (Mr. and Mrs. L. H. Pammel); Colorado—Frasier, Larimer county (L. H. Pammel), Breckenridge (J. P. Anderson), Fort Collins (C. S. Crandall, Reppert and Witter), La Porte (L. H. Pammel and Fred Rolfs), Palmer Lake (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank Raney); Idaho—Horse Creek (L. H. Pammel and H. S. Fawcett); Michigan—Clifton (Frank E. and Floy J. Wood); New York—Ithaca (Muenscher and Bechtel), Onondaga valley (Lucien M. Underwood), Poughkeepsie (Miss Shattuck); Oregon—Crook county (Kirk Whited), Portland (L. H. Pammel and W. S. Dudgeon); Southern states—L. B. Buckley; Utah—East Fork of the Weber (L. H. Pammel and E. M. Stanton), Emigrant canyon (L. H. Pammel and R. E. Blackwood), Fillmore Forest (W. B. Miller), Peterson canyon (L. H. Pammel and R. E. Blackwood), Utah Lake (Mrs. Lois Catlin); Washington—Cold Creek (J. S. Cotton), Elma (J. M. Grant), Seattle (Stella Goodspeed), Skamania county (W. N. Suksdorf); Wisconsin—Avalanche, La Crosse (L. H. Pammel).

HONEY BEE VISITS

It is sometimes visited by honey bees.

Veronica peregrina L. Neckweed

A smooth annual erect herb, 4 to 9 inches in height, branched. Lowest leaves petioled, oval-oblong, the others sessile, obtuse. Flowers almost sessile, white capsule orbicular, many-seeded. In waste

FIG. 318.—Speedwell (*Veronica peregrina*). Common in gardens and fields in the early spring. *Photograph by Quade.*

and cultivated grounds New Brunswick, southward and westward. Blooms from May to October.

A common weed in fields, clay and black prairie soils, cultivated soils, abundant. Associated with *Capsella Bursa-pastoris, Lepidium apetalum, Oxalis corniculata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Marshalltown, Pisgah, Waukon Junction (L. H. Pammel); Osceola, Webster City (F. C. Stewart), Ames (two specimens, A. S. Hitchcock, Fred Rolfs, B. D. Halsted, C. E. Bessey), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Muscatine (F. Reppert), Shelby county (T. J. and M. F. L. Fitzpatrick).

It has also been observed (L. H. Pammel) at Algona, Cedar Rapids, Council Bluffs, Des Moines, Dubuque, Forest City, Fort Dodge, Mason City, Rolfe, Sioux City, Waterloo.

General distribution in the United States:

Alaska—Juneau (J. P. Anderson); Arizona—Mormon Lake (D. T. MacDougal); Arkansas—............................... (F. L. Harvey); California—Portola (L. H. Pammel); Colorado—Fort Collins (C. S. Crandall, L. H. Pammel); Illinois—Cahokia (H. Eggert), Oquawka (Harry N. Patterson), La Salle county (J. W. Harett); Kansas—Wichita (T. L. Andrews); Louisiana—New Orleans (two specimens, L. H. Pammel); Massachusetts—Wellesley (Carrie Harrison); Michigan—Ironwood (Mrs. Joseph Clemens); Minnesota—Cloquet (L. H. Pammel), Hibbing (Lyle Clapper); Missouri—St. Louis, Webster (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel), Poughkeepsie (Miss Shattuck); Ohio—Worthington (Asa Horr); Oklahoma—Oklahoma City (W. E. Bruner); Oregon—La Pine, Redmond (two specimens, K. Whited); Texas—Austin (two specimens, B. C. Thorpe); Utah—Peterson, Bear River (L. H. Pammel and R. E. Blackwood); Wyoming—Nez Perces creek (Aven and Elias Nelson).

HONEY BEE VISITS

Sometimes but rarely visited by honey bees.

Blooming, Ames, April 20, 1924.

Veronica arvensis L. Corn Speedwell

A simple or diffusely branched annual 2 to 5 inches in height, hairy. Lower petioles ovate, crenate, uppermost sessile, entire. Capsule inversely heart-shaped, with rounded lobes. In cultivated grounds in clay soil, Nova Scotia westward and southward. Not common. Naturalized from Europe.

The sky blue corolla is marked by a whitish nectar guide with darker streaks.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Iowa City (two specimens, A. S. Hitchcock), Muscatine (F. Reppert), Wayland (G. W. Carver).

General distribution in the United States:

Illinois—Peoria (F. E. McDonald); Missouri—Allenton (two specimens, George W. Letterman); New York—Ithaca (Muenscher and Bechtel), Poughkeepsie (Miss Shattuck); North Carolina—Statesville (M. E. Ryams); Ohio—Cambridge (R. Burgess), Cedar Point, Kelley's Island (L. H. Pammel), Pickerington (Asa Horr).

HONEY BEE VISITS

We have not seen honey bees on this, though they have been reported to us.

Veronica longifolia L. Blue Speedwell

An upright, smooth or slightly pubescent perennial; leaves sharply serrate. Flowers in densely flowered racemes, lilac color. Commonly cultivated for ornamental purposes, frequently under the name of *Veronica spicata.*

This is a valuable honey plant, freely visited by bees. The flowers are proterogynous, developing from below upwards, Knuth notes, so that the lower ones mature and set fruit before the upper ones open.

Knuth states, "At the apex are buds (the uppermost still surrounded by the calyx), below which are to be found flowers in the female stage and finally those in which the sexual organs have withered and fruit is ripening.

"The stigma projects from the flower before it has fully opened, and the unripe anthers are still covered by the unexpanded portions of the corolla."

Honey bees are reported by Knuth and Mueller as frequent visitors in Germany.

HONEY BEE VISITS

Ames, July 1, 1923, 2 p.m. Bees abundant. Good honey plant. Two seconds in one flower.

June 27, 1927. Few flowers. Bees two seconds in a flower. Each bee visits three to five flowers in a spike. Forty flowers open.

Formal Gardens, I.S.C., July 13, 1927. Hot, dry, clear. Bees numerous. One and three seconds in a flower.

July 31, 1927, 10:30 a.m. Clear, warm, northwest wind. Maximum bloom. Bees fairly common. Two seconds in a flower.

September 24, 1927, 2:30 p.m. Warm, cloudy. Bees two seconds in a flower.

June 26, 1928, 2 p.m. Clear, moderate. Bees abundant. Two seconds in a flower.

June 23, 1929, 12:30 and 3 p.m. Bees abundant. Three seconds in a flower.

July 9, 1929. Honey bees common. One second in a flower. A most consistent honey plant. The following visitors also are reported by Dr. H. H. Knight: Diptera; *Eristalis flavipes* Walk. Hymenoptera; *Bombus, Halictus Provancheri* D. T., *H. variatus* Robt., *H. tegularis* Robt.

July 12, 1929, 8 a.m. Plants moist from rain. Some honey bees. Two and one seconds in a flower.

July 19, 1929, 9 a.m. and 1:15 p.m. One of the best of our honey plants. Bees present though only a few flowers are left. One to two seconds in a flower.

July 24, 1929, 1:30 p.m. Clear, after heavy rain. Some honey bees. Two seconds in a flower.

2:30 p.m. (Near apiary.) Some bees. Two seconds in a flower. No bees on *Trifolium repens, T. hybridum* or *Melilotus officinalis.*

July 30, 1929. Partly cloudy. Only a few flowers left. No honey bees.

September 11, 1929. Many bees. Two seconds in a flower.

September 18, 1929, 10:30 a.m. No bees. Many bees on *Aster novae-angliae*. (Near an apiary, temperature 60°.)

September 26, 1929. Warm, clear. Many bees. Two seconds in a flower. Dr. H. H. Knight reported the following insects: Coleoptera. Yellow beetle (*Chauliognathus pennsylvanicus* De G.). Diptera. *Syrphus* fly. Hymenoptera. (*Halictus* sp.) Lepidoptera. Skipper (*Polites cernes* B. and L.).

September 30, 1929. Cool, slight north breeze. Some bees. Two seconds in a flower.

October 16, 1929, 9:30 a.m. Clear and cool. Bees two to three seconds in a flower.

September 15, 1930. Commonly visited by honey bees and bumble bees.

FIG. 319.—Simpson honey plant (*Scrophularia marilandica*). *Photograph by A. Hayden.*

Scrophularia (Tourn.) L. Figwort

Perennial usually strong-scented herbs with opposite leaves. Flowers greenish to purplish in terminal panicled clusters. Capsules many-seeded.

Scrophularia marilandica L. Simpson Honey Plant

This slender species grows to a height of 3 to 5 feet. Leaves thin, broad, finely notched with slender petioles. Flowers greenish purple. Capsule roundish. Many small dark seeds.

Simpson honey plant is widely distributed in woods, usually in uplands and in clay soil. Associated with *Heracleum lanatum*, *Bromus purgans*, *Phlox divaricata*, *Geranium maculatum*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cheney lake, Dubuque, Gillett Grove, McGregor, Muscatine county, Rochester, Steamboat Rock (L. H. Pammel); Osage, West Bend (R. I. Cratty), Adel (C. F. Clark), Ames (A. S. Hitchcock, G. W. Carver, A. Hayden, S. W. Beyer), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Fayette (three specimens, B. Fink), Fraser (Botany Seminar), Kalona (D. N. Arnold), Little Rock (C. R. Ball), northeastern Iowa (H. Goddard), Spirit Lake (H. E. and L. H. Pammel).

General distribution in the United States:

Colorado—Gulch west of Soldier canon, Rist canyon (C. S. Crandall); Kentucky—Bell county (T. H. Kearney, Jr.); Michigan—........................ (J. E. Wood), Ontonagon (L. H. Pammel); Missouri—Pixley's (Kenneth K. Mackenzie), St. Charles, St. Louis (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel), Piedmont (Louise Merritt Stabler); Ohio—Mansfield (E. Wilkinson); Utah—Ogden (L. H. Pammel).

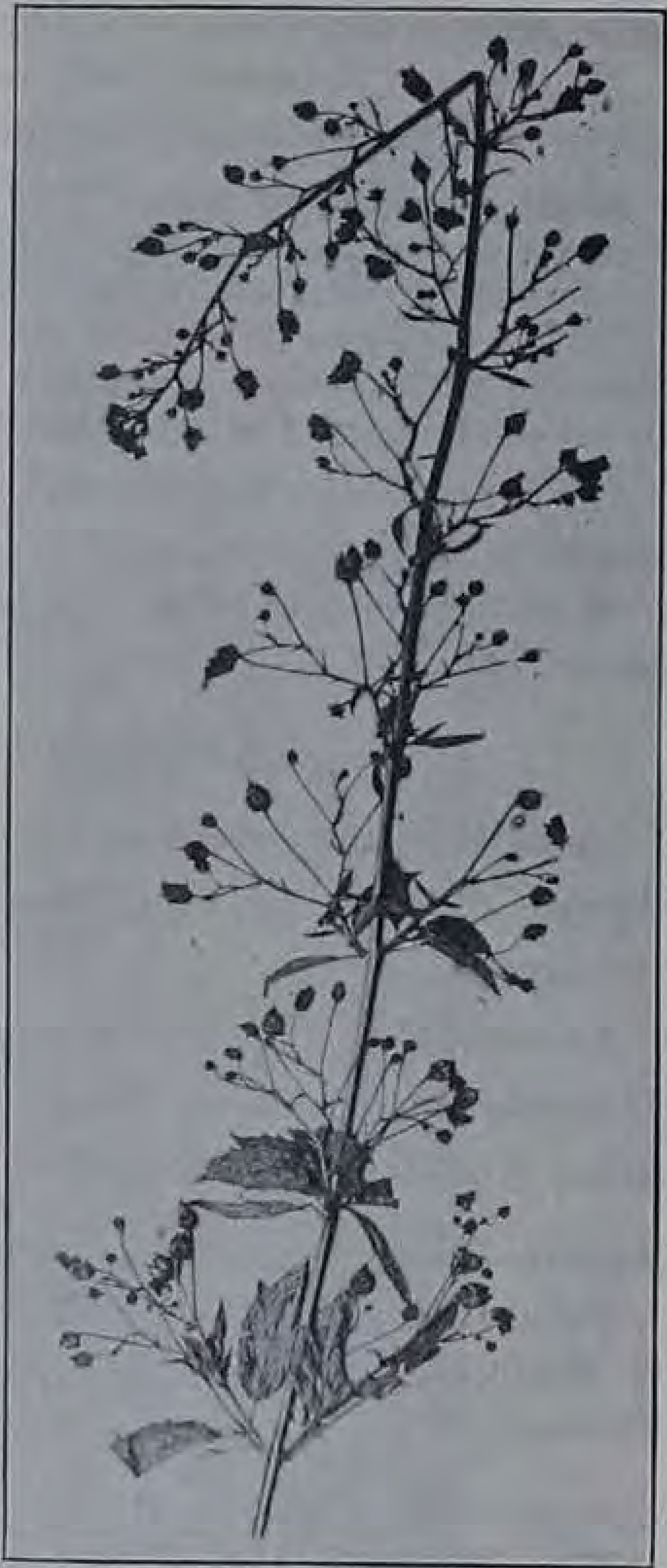

FIG. 320.—Simpson honey plant (*Scrophularia marilandica*). Woods and waste places. *Photograph by Ia. Agr. Exp. Sta.*

POLLINATION AND BEE VISITS

This is generally regarded as a wasp flower. Mueller observed wasps as very frequent visitors about this flower. He says, "The wide globular corolla is about five mm. in diameter; at its base near the superior side two large drops of honey may be seen, which are secreted by the yellowish base of the ovary."

Dr. Trelease has given us an interesting account of the pollination of Simpson honey plant. It is especially adapted to wasps. Mueller records six Vespidae. He says, "The fact that they hold a proportion of over one-third in the list of *Scrophularia* is sufficient evidence that the flower especially favors wasps. I know of no bee flower on which so many wasps occur as intruders."

The small greenish purple irregular flowers are proterogynous. In its earlier stages the stigma only protrudes; it is inclined over the lobe. Honey bees and wasps, which largely pollinate the flowers, approach from the front and come in contact with the stigma, leaving some of the pollen on it. The following day the stamens come in view and the style becomes flabby and rests on the lower lip. An insect in going to the flower for the nectar is dusted with pollen from the later flowers. Self-pollination cannot occur.

Knuth and Robertson both report observing honey bees steadily collecting nectar and pollen, a contribution to late summer harvest.

Charles Robertson says, "The flower is interesting on account of its special adaptation to wasps. Although more bees were observed on the flowers, the proportion of wasps is remarkable.

"It is certainly true that the flowers are not easily discovered by bees, and that the nectar is not attractive to them. Sometimes the hive-bees are present in great numbers, and are about the only visitors to be seen."

On fifteen days between July 12 and September 1 the honey bee was observed to be abundant, getting nectar and honey.

It is not an important honey plant in Iowa, although bees have been observed upon it.

Scrophularia leporella Bicknell. Figwort

A tall, square-stemmed perennial with ovate, pointed leaves. The flower cluster slender, elongated; capsule ovoid, conical, of firm texture.

Common in rich, open woods, clay or sandy soil. Associated with *Heracleum lanatum, Zizia aurea, Taenidia integerrima, Silene stellata, Aquilegia canadensis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decatur county (J. P. Anderson), Greenfield (F. C. Stewart), Iowa City (A. S. Hitchcock), Lake Okoboji, Liscomb, Miller's Bay, Palo Alto county (L. H. Pammel).

General distribution in the United States:

New York—Floyd (J. V. Haberer), Ithaca (Muenscher and Bechtel).

HONEY BEE VISITS

We have seen bees on this very rarely in central Iowa, although it is reputed to be a valuable honey plant. However, forty years ago bees were observed on it at La Crosse, Wisconsin, and occasionally bees have been observed elsewhere on this species but not in recent years.

Allamakee county, mouth of Yellow river, August 18, 1929, 8 a.m. Bees abundant. Three seconds in a flower.

Pentstemon (Mitchell) Ait. Beard-tongue

Pentstemon gloxinoidis. Hybrid between *P. Martivegii* x *P. Cobaea.*

HONEY BEE VISITS

Ames, Ocotober 14, 1929. Bees about twelve seconds on a flower. Pollen and nectar.

BIGNONIACEAE, Bignonia Family

Woody plants, compound or simple, alternate or opposite leaves; flowers large and showy; calyx 2-lipped, 5-cleft or entire; corolla tubular or bell-shaped, 5-lobed; stamens 5, of which one or a pair may be sterile, inserted on corolla; ovary free, bearing a long style with a two-lipped stigma.

Tecoma radicans (L.) Juss. Trumpet Creeper

Leaves pinnate; leaflets 7 to 11, ovate, pointed, toothed; flowers corymbed, coral colored, tubular, funnel-formed. Stamens do not extend beyond the corolla tube.

HONEY BEE VISITS

Jefferson, September 2, 1927, 3 p.m. Some bees collecting pollen.

FIG. 321.—Catalpa (*Catalpa speciosa*). *Photograph by A. Hayden.*

Catalpa Scop. Catalpa

Our species are trees with large opposite, simple, petioled leaves. Flowers large, showy, with white or mottled corolla; inflated flowers in terminal clusters. Capsule long, slender. Seeds flat-winged.

FIG. 322.—Catalpa (*Catalpa speciosa*). *Photograph by A. Hayden.*

FIG. 323.—Flower of catalpa (*Catalpa speciosa*). A. Face view of flower showing grooves and coloration converging toward nectar gland. Also stamen-pistil arrangement. B. Side view of flower showing orientation markings and stamen-pistil arrangement. C. Tetrad pollen grains showing topographic markings. D. Changes in position and length of pistil, in relation to proterandrous stamens. E. Stages in dehiscence of stamens. F. Undehisced fertile stamens with recurved filaments and short sterile stamens. G. Dehiscing stamens and short sterile stamens attached near margin of nectary. H. Pistils with unexpanded and expanded stigma. Nectar gland at base of ovary. *Drawing by Ada Hayden.*

Catalpa speciosa Warder. Catalpa, Catawba Tree

A tall tree with thick bark; large heart-shaped leaves; corolla nearly white, inconspicuously spotted. Long slender pod.

Cultivated as a shade tree or in groves in various soils: clay, black, prairie, sandy and calcareous. It is rarely an escape from cultivation. This species is generally hardy in all parts of the state. Some winters, however, it is somewhat injured by freezing, especially the bark.

The flowers are fragrant, producing much nectar. They are frequently visited by smaller Hymenoptera, and by bees, which crawl into the large bell-shaped corolla. Stamens are bilobed and sensitive.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (Edna C. Pammel, L. Clapper), Decatur county (J. P. Anderson), Marcus (J. A. Rowlet), Montrose (L. H. Pammel), Sioux City (two specimens, Mrs. H. J. Taylor).

This species has been observed cultivated (L. H. Pammel) at the following points: Algona, Boone, Carroll, Cedar Rapids, Cherokee, Council Bluffs, Dana, Denison, Des Moines, Dubuque, Forest City, Fort Dodge, Iowa City, Marshalltown, Mason City, Mount Ayr, Orange City, Rolfe, Waukon.

General distribution in the United States:

Arkansas—Pike county (L. H. Pammel); Colorado—Fort Collins (J. H. Cowan); Illinois—Quincy (L. H. Pammel); Ohio—Cedar Point, Put-in-Bay (L. H. Pammel); Texas—Austin (two specimens, F. C. Werkenthin); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood).

HONEY BEE VISITS

Ames, June 26, 1927. Bees about twenty-five seconds in a flower; abundant; three bees in ten minutes visited ten flowers of a cluster. One bee visited one to four flower clusters.

June 27, 1927, 3 to 4 p.m. Warm, windy, dry. Bee in the flowers ten or more seconds. Twenty-two visits to one bloom in an hour. (C.C.L.)

June 16, 1928, 9 a.m. Cool, cloudy. Bees twelve to fifteen seconds in a flower.

Tingley, June 20, 1929, 10:30 a.m. Some bees.

PLANTAGINACEAE, Plantain Family

Stemless herbs with heads of greenish flowers borne in terminal spikes.

Knuth says, "Pollen collecting or pollen devouring insects may (though rarely) be seen on these flowers, so that entomophily may occasionally be effected. Flies are the most frequent visitors; the delicate scent of *P. media* so adds to its attractiveness that bumble and honey bees also visit it.

"Pollination, however, is much more frequently effected by the wind. Pollen-collecting bees damp the dry pollen grains with regulated nectar."

Plantago (Tourn.) L. Plantain

Stemless or short-stemmed herbs bearing ribbed leaves, spikes or heads of small, inconspicuous flowers on long scapes. Fruit membranous, mostly 2-celled.

Plantago lanceolata L. English Plantain, Buckhorn or Ribgrass

A low biennial to perennial herbaceous plant; leaves apparently parallel-veined, all from the ground, lanceolate, hairy, purple-stemmed. Rootstocks short; scapes stiff, tall, bearing thick, close spikes of flowers. The pod circumcissile below the middle. Seeds hollowed on face. A weedy plant in grass lands.

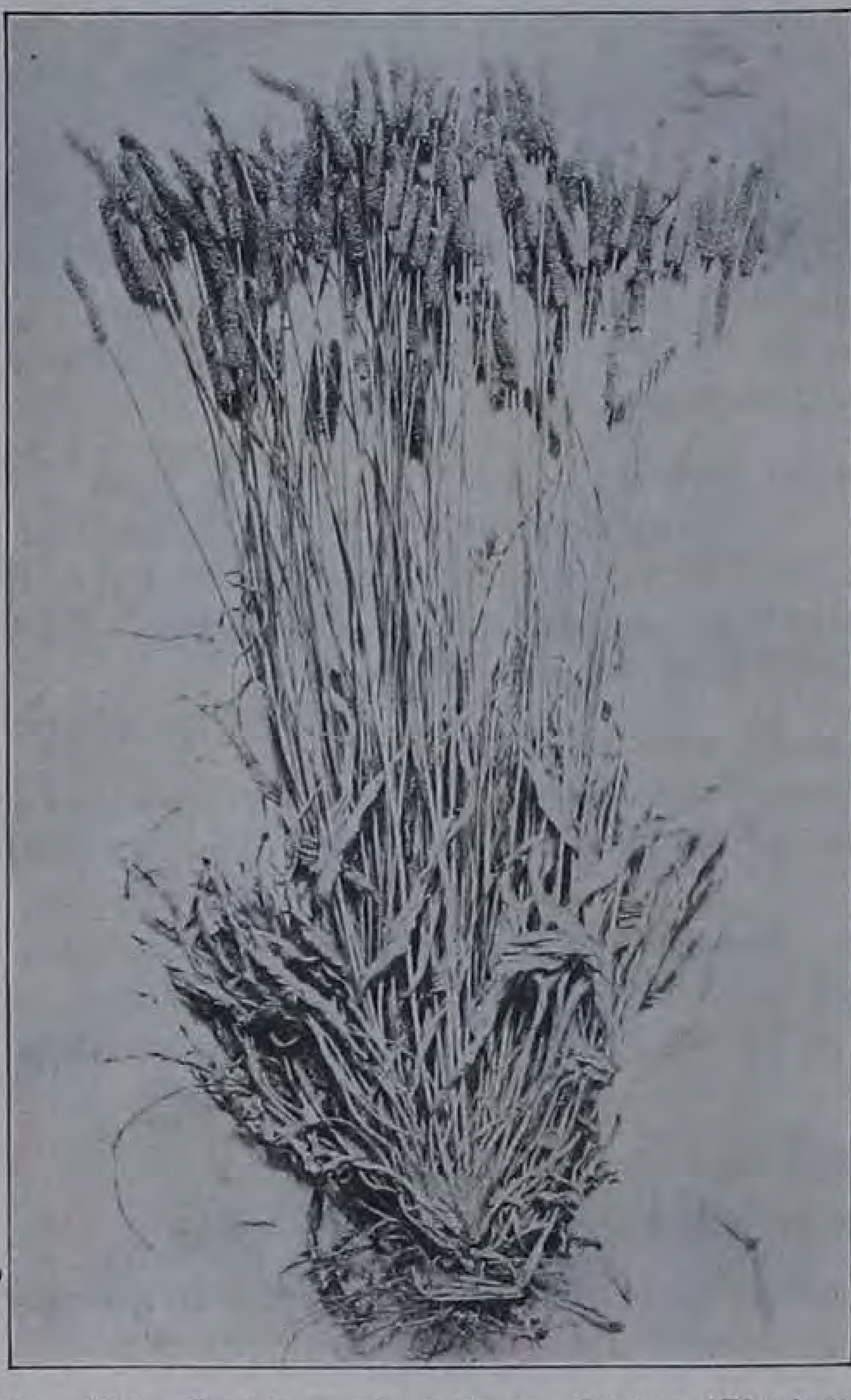

FIG. 324.—Buckhorn plantain or ribgrass (*Plantago lanceolata*). Common in clover meadows. *Photograph by Ia. Agr. Exp. Sta.*

Widely naturalized in many parts of Iowa in sandy clay, and in calcareous soils. Associated with *Poa pratensis, Trifolium repens, T. pratense, Phleum pratense.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. Clapper, F. A. Sirrine, G. W. Carver, E. R. Hodson, M. Clapper, two specimens), Audubon (A. H. Edwards), Burlington (P. Bartsch), Coin (G. H. Whitman), Corydon (J. M. Kellogg), Decatur county (J. P. Anderson), Farragut (Carl Coleman), Fayette (B. Fink), Hartley (W. B. Elliott), Maynard (A. F. Crawford), Mount Sterling (T. H. Madden), Sac City (L. H. Pammel), Sioux Rapids (H. L. Farmer).

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Alaska—Juneau (J. P. Anderson); California—Santa Cruz (L. H. Pammel and R. A. Needham), Yosemite Valley, Santa Cruz (L. H. Pammel); Colorado—Fort Collins (W. F. M.) District of Columbia—Washington (L. H. Pammel); Illinois—Champaign, Kanesville (B. Fink); Kansas—Wichita (T. L. Andrews); Michigan—Whitehall (L. H. Pammel); Missouri—St. Louis (H. A. Gleason, L. H. Pammel); New Jersey—Perth Amboy (L. H. Pammel); New York—Ithaca (H. E. Summers); Ohio—Columbus (Freda Detmers); Oregon—Corvallis (Otto Elmer), Portland (L. H. Pammel and W. S. Dudgeon), Redmond (Kirk Whited); South Carolina—Oconee county (A. P. Anderson).

HONEY BEE VISITS

Ames "Olson's", July 15, 1914, 12 m. Partly cloudy, south wind. *Halictus* gathering pollen. Three on a spike per minute. (G.H.M.)

We have not observed honey bees on this species in town.

Mueller observed honey bees in great numbers, gathering pollen. He describes the interesting procedure as follows: "The honey bee flies buzzing to a spike and while it hovers in the air spits a little honey on the exserted anthers. Then, still hovering and buzzing, it brushes pollen with the tarsal brushes of its forefeet off the anther, the tone of its humming suddenly becoming higher; in the same instant one sees a cloud of pollen rise from the shaken anthers. After placing the pollen on its hind legs the bee repeats the operation on the same or other spikes."

RUBIACEAE, Bedstraw Family

Shrubs or herbs with opposite or whorled leaves; flowers perfect or polygamous, often dimorphic; 4 sepals, 4 petals, 4 stamens, except in *Sherardia*; ovary 2- to 5-celled; styles 1 and 2.

Knuth says, "Nectar is usually sparingly secreted by a fleshy disc on the ovary."

In some exotic species the nectar is deeply concealed and accessible only to hawk moths and humming birds. A few of the plants of this family are dimorphic. The dimorphic flowers have been discussed by a number of botanists, notably Darwin.

Asperula odorata is sometimes cultivated for ornamental purposes and Hermann Mueller records bees on this plant.

Galium L. Bedstraw

Slender woodland herbs with clusters of small flowers. Stems square; leaves in whorls, often roughish.

HONEY BEE VISITS

The Galiums are not recorded as honey plants by Frank Pellett or John Lovell, nor are honey bee visits recorded by Hermann Mueller for any of the species of *Galium*.

Observations were made on *Galium* at several different points in 1929—at Eldora, Steamboat Rock and Iowa Falls, but honey bees were not observed, nor does the senior author recall having seen any in the vicinity of La Crosse, Wisconsin. Honey bees, however, have been reported on some species.

Galium boreale L. Northern Bedstraw

A smooth plant, white slender leaves in fours. Flowers white, in compact panicles. Fruit usually bristly.

In clay, calcareous and sandy soils in woods of northeastern Iowa. Associated with *Lathyrus ochroleucus, L. venosus, Cladonia rangiferina, Polygala Senega, Corylus americana, Diervilla trifida, Geranium maculatum, Pedicularis canadensis, Prunus americana, Betula papyrifera, Quercus velutina, Q. alba, Q. rubra, Carya ovata, Aster sagittifolius, Solidago nemoralis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Bellevue (two specimens), Carroll, New Albin, Postville (three specimens) (L. H. Pammel); Boone, Humboldt (C. E. Bessey), Cedar Rapids (three specimens, R. E. Buchanan), Coggon (McTavish), Decorah (H. Goddard, E. W. D. Holway), Fayette (two specimens, B. Fink), Greene (Lavinia Price), Howard county (two specimens, F. M. Tuttle), Ledges (J. V. Ellis), Little Rock (C. R. Ball), Winneshiek county (T. J. Fitzpatrick).

Other observations not represented by specimens (L. H. Pammel): Cresco, Dubuque county, Fort Dodge, Forest City, Forest Mills, Lansing, Mason City, Marquette, McGregor, Pine Creek, Pilot Knob, Postville, Rice Lake, Waterville, Waukon.

HONEY BEE VISITS

Honey bees have been reported.

Galium Mollugo L. Bedstraw

A slender perennial herb, with very numerous white cymes of flowers, numerous nearly smooth square stems and whorled, almost linear leaves in eights. Roadsides and fields from Newfoundland westward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Marshalltown (Mrs. E. W. Harmon).

General distribution in the United States:

Connecticut—Middlefield (C. A. Kofoid); Massachusetts—West Falmouth (J. R. Churchill); Vermont—Peacham (Ferdinand Blanchard).

NECTAR SECRETION AND HONEY BEE VISITS

At the base of the style in this flower surrounding the ovary lies a fleshy disc which secretes nectar, which adheres to the disc in a thin layer.

Diptera are said by Mueller to be the chief visitors. He does not mention the honey bee.

Knuth says, "The small, white flowers, like all of our native Rubiaceae, secrete nectar in a disc above the ovary, and surrounding the base of the style. The quantity is small."

Ames, July 5, 1914. Olson's. Partly cloudy, south wind. One per flower per minute. *Apis mellifica*, flies, butterfly. (G.H.M.)

Cephalanthus L. Button Bush

Small trees or shrubs. Flowers white, clustered in dense heads.

Cephalanthus occidentalis L. Button Bush

A tall shrub. Leaves lance-oblong, in pairs of threes with short stipules. The head of white flowers about 1 inch in diameter. New Brunswick westward and southward.

FIG. 325.—Buttonbush (*Cephalanthus occidentalis*). *Photograph by A. Hayden.*

Common along shores of rivers subject to overflow and along lakes, in low swampy, peaty soils. It is most abundant along the Mississippi and its immediate tributaries. Associated with *Lobelia cardinalis, L. siphilitica, Mentha arvensis* var. *canadensis, Lycopus americana, Scutellaria galericulata, Spartina Michauxiana, Steironema quadrifolium, Betula nigra, Acer saccharinum, Fraxinus lanceolata, Ulmus americana.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium: Centerville, Chariton riv-

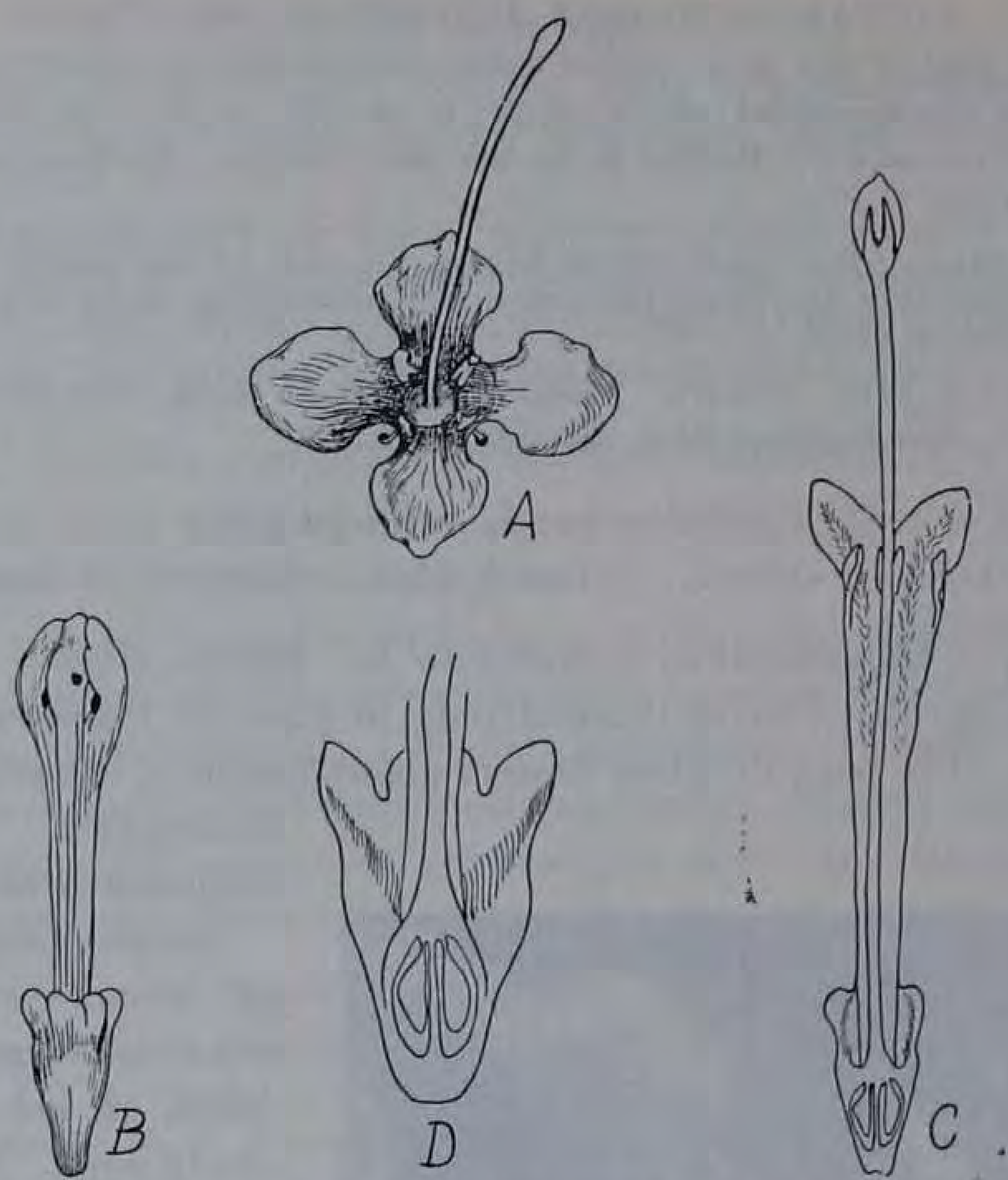

FIG. 326.—Flower of Buttonbush (*Cephalanthus occidentalis*). A. General aspect showing exserted pistil and short stamens. B. Unopened bud with exserted stamens. C. Longitudinal section of ovary and calyx showing nectar cup. D. Longitudinal section of flower showing epigynous ovary and nectar cups. *Drawn by A. Hayden.*

er bottoms, Polk City (L. H. Pammel); Muscatine Island, Wild Cat Den (L. H. Pammel and F. Reppert), Ames (Mrs. Whitney, C. E. Bessey, Anne C. Gilchrist), Clayton county (B. Fink), Decatur county (T. J. and M. F. L. Fitzpatrick, two specimens, J. P. Anderson), Hamburg (L. H. Pammel and H. B. Clark), Iowa City (two specimens, A. S. Hitchcock), Keokuk (P. H. Rolfs), Lebanon (A. F. Sample), Moulton (two specimens, C. R. Ball), Ottumwa (Jesse Peters), Story City (E. L. Ericson).

This has also been observed (L. H. Pammel) at Cedar Rapids, Clinton, Decatur county, Keokuk, Lineville, McGregor, Marshalltown, New Albin, Shenandoah, Story City, Wapello, Wayne county.

General distribution in the United States:

Alabama—Montgomery (two specimens, L. H. Pammel); Arkansas—Hot Springs (L. H. Pammel), Lawrence county (P. H. Rolfs); California—Patterson (L. H. Pammel), Butte county (A. A. Heller); Connecticut—Cornwall (T. L. Andrews); Indiana—South Bend (Mrs. Joseph Clemens), Crawfordsville (W. H. Evans); Kansas—Wichita (T. L. Andrews); Kentucky—Pine Mountain (T. H. Kearney, Jr.); Maryland—Princess Ann (Fred E. Trenk); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (H. E. Summers), Taughannack

Point (Muenscher and Bechtel); Ohio—Buckeye Lake, Cedar Point (two specimens, L. H. Pammel), Worthington (Asa Horr); Oklahoma—Norman (W. E. Bruner); South Carolina—Pickens county (two specimens, A. P. Anderson); Texas—Bracken (B. H. A. Groth); Wisconsin—Bergman island, Holmen (two specimens, L. H. Pammel), La Crosse (Dora S. Pammel), Wauzeka (L. H. Pammel).

HONEY BEE VISITS

Frank Pellett states that the bees seek it eagerly when it is in bloom, and in places where the plant is common it is of considerable value as a honey plant. Texas Agricultural and Mechanical College reports it of considerable value as a honey plant in Texas and Richter reports it of considerable value in California.

In 1928 I saw a large number of honey bees on it in the vicinity of McGregor, Iowa, and La Crosse, Wisconsin. Lovell also speaks of it as a valuable honey plant, making this rather interesting comment on the plant in Mayfield, Massachusetts, where there is a large swamp where button bush blooms profusely in August: "At about 11:00 in the morning the bees usually leave buckwheat, which is in bloom at this time, and start for the great swamp, where they work button bush until night. The honey greatly improves that of buckwheat with which it is mixed."

Lovell, who has measured the tube of the corolla, states that it is nine mm. long and that a bee's tongue is only six mm. long, but because the tube of the corolla flares the bees can probably get all of the nectar.

Atlantic, July 31, 1914. Hot, dry. Late in season. Some moths. Many honey bees. (L.A.K.)

Ames, 1926. Bees abundant. Two to three seconds in a flower.

CAPRIFOLIACEAE, Honeysuckle Family

Shrubs or rarely herbs with opposite simple and compound leaves without stipules; flowers with calyx and corolla, the calyx tubes adnate to the ovary, corolla regular or irregular; 5-lobed stamens generally as many as the lobes of the corolla; ovary 2- to 5-celled; style 1, fruit a pod, berry or drupe.

Mueller says, "The members of this order are extremely variable in regard to their flower mechanism."

Many flowers of the family are pollinated by birds, as the honeysuckle *Lonicera Caprifolium* and *Lonicera sempervirens*. *Lonicera Caprifolium,* which is sometimes cultivated, is adapted to hawk moths. Also some of the flowers, such as *Symphoriçarpos,* are regarded by Hermann Mueller as wasp flowers. Short-tongued insects like flies freely visit the elderberry, which is said to be without nectar.

Diervilla (Tourn.) Mill. Bush Honeysuckle

Early flowering ornamental shrubs. Leaves ovate, serrate. Flowers in loose clusters.

Many observations have been made upon *Diervilla rosea* and *Diervilla japonica* and its hybrids. Observations were made in the spring of 1929.

Diervilla Lonicera Mill. Bush Honeysuckle

A form with oblong leaves, 3-flowered peduncles and yellow flowers, deepening in color with age.

Coal measure sandstone, clay, limestone soils. Associated with *Lathyrus venosus, Galium boreale, Phegopteris Dryopteris, Aspidium marginale, Lycopodium lucidulum, Betula lutea, B. papyrifera, Quercus velutina, Dicentra Cucullaria, Dentaria laciniata, Sanguinaria canadensis, Podophyllum peltatum, Pinus Strobus.*

General distribution in the United States:

Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Indiana—Steuben county (Charles C. Deam); Massachusetts—Brimfield (H. E. Pammel); Michigan—Gogebic (Mrs. Joseph Clemens), Ontonagon (L. H. Pammel and V. C. Fisk), Stambaugh (two specimens), Whitehall (L. H. Pammel); Minnesota—Cass Lake, Itasca State Park, Pike's Bay (L. H. Pammel), Black Duck (Mrs. Roy Westley), Brainerd (E. B. Watson), Coleraine (R. I. Cratty), Hibbing (Lyle Clapper), International Falls (H. S. Kellogg), Lake Pokegama islands (J. H. Sandburg), St. Paul (R. Gmelin); New York—Ithaca (H. E. Summers, Muenscher and Bechtel), Watkins Glen (L. H. Pammel); Nova Scotia—Pictou (C. D. Howe and W. F. Lang); Vermont—East Corinth (H. S. Kellogg); Wisconsin—Kilbourne, Galesville, Brule River (L. H. Pammel).

The plant blooms freely and the flowers, while not showy, are rich in nectar. Blooming season from June to August.

HONEY BEE VISITS

Ames, July 3, 1927, 12 m. A valuable honey plant. No bees.

We observed honey bees in 1928 and 1929.

Diervilla sessilifolia Buckley. Bush Honeysuckle

A shrub growing to a height of 5 feet; ovate-lanceolate leaves 2 to 6 inches long, sessile, serrate; cymes 3- to 7-flowered, crowded into dense panicles; corolla yellow. Introduced from southeastern part of the United States.

HONEY BEE VISITS

Ames, June 27, 1927, 5 to 6 p.m. Warm, very windy, dry. Bees frequent. Much hindered by the wind. Twenty-nine visits to one cluster of bloom. (C.C.L.)

Diervilla hybrida Dipp. Various hybrid species

Des Moines, May 28, 1929. Bees abundant, getting honey. Sixteen seconds in a flower.

Diervilla cultivated species

Ames, June 2, 1929, 5:30 p.m. Very fragrant. No bees.

Lonicera L. Honeysuckle

Erect or climbing form with entire leaves. Flowers showy, fragrant. Corolla tubular or funnel-shaped. Berry several-seeded.

The flowers are either proterogynous or proterandrous. Nectar is secreted by the receptacle, or in a pouch of the corolla, as observed by Knuth. Among the very best of our early honey plants are found in this genus.

Although rich in nectar, most species have corolla tubes too deep for the length of the honey bee.

Lonicera Morrowi Gray. Bush Honeysuckle

A shrub 4 to 6 feet high, soft, downy. Branches spreading. Leaves oblong, dark green above, pale beneath. Corolla lobes nearly equal, spreading, white or cream-colored. Berries bright red. Widely cultivated in gardens in clay, drift and black prairie soils.

FIG. 327.—Bush honeysuckle (*Lonicera Morrowi*). *Photograph by A. Hayden.*

This honeysuckle is valuable as a honey plant. The flowers are in axillary two-flowered clusters. The nectar is secreted at the base of the corolla and lodged in the shallow cup. The plant blooms regularly each year so that the nectar flow is certain. It is visited by many insects, the most important of which is the honey bee.

This is one of our very best early honey plants and though widely cultivated should be more extensively used.

May 29, 1929. No bees. Many Hymenoptera. Still many flowers to be pollinated.

Blooming, Ames, May 9, 1924; April 25, 1925.

Lonicera tatarica L. Tartarian Honeysuckle

Upright bush, 8 to 10 feet high. Flowers appearing after the leaves, conspicuously peduncled. A strong growing tall shrub. Leaves cordate-oval; flowers whitish or pinkish, followed by red berries in twos. A Siberian species widely cultivated.

Cultivated in various soils; black, sandy, Missouri loess and drift soils, calcareous soils. Sometimes spontaneous. Associated with *Prunus serotina, P. virginiana, Corylus americana.*

Nectar is secreted in the shallow pouch at the base of the tube. The flowers of the Tartarian honeysuckle are quite noticeable to insects by the reddish color and the distinct fragrance. The flowers are grouped in clusters of two. The blooming season covers eight or more days.

FIG. 328.—Tartarian honeysuckle (*Lonicera tatarica*). *Photograph by A. Hayden.*

Honey bees are most important insect visitors. They start work early in the morning and continue more or less actively till dark, depending upon the character of the weather; when this is cold they come less frequently than when the day is warm.

The Tartarian honeysuckle is a dependable plant each year although of less value than *L. Morrowi.*

H. Mueller says, "The bright red flowers are homogamous; the anthers project a little beyond the stigma. Insects, while probing for nectar, touch the stigma with one side of their heads and the pollen-covered anthers with the other.

"When visits are repeated, crossing is favored, though self-pollination may also be effected, and it is not unusual to find flowers in which the stigma touches one or two of the anthers."

Fruit setting of *Lonicera tatarica* under natural conditions in the garden

Observations made May 22, 1929

Number of flowers on bunches	Number of fruits set
22	18
19	17
24	20
20	17
20	17
20	15

This may be regarded as the average result in the usual season, and shows a high average of flower fertilization.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (F. A. Sirrine), Fayette (B. Fink), Osage (R. I. Cratty).

General distribution in the United States:

Colorado—Fort Collins (J. H. Cowan); Illinois—Galena (L. H. Pammel); Massachusetts—Cambridge (George C. Deane); Michigan—.................................... (F. E. Wood); Missouri—Rockport (A. O. Simonds).

HONEY BEE VISITS

Mueller says, "The corolla tube is six to seven mm. long and secretes nectar in a shallow pouch at its base."

Ames, May 23, 1914, 2:30 to 5 p.m. Southwest wind. No bees. Several other insects. One large *Bombus*.

May 25, 1917, 5:30 p.m. Southwest wind. A number of insects.

June 11, 1917. Cool, cloudy. Bees abundant.

May 12, 1918. Cool, windy. Few bees.

May 27, 1919, 9:45 a.m. One bee from three to four seconds on each pink colored honeysuckle, gathering pollen chiefly. One bee visits as many as seventy flowers. Many flowers visited by the same bee three or four times. Bumble bees numerous. Thirty-five flowers in one minute.

10:45. Bees numerous, gathering nectar. One bee visits fifteen to sixty groups, working ten to fifty seconds in each group.

May 10, 1920, 10 a.m. Sun after shower. Slight southeastern breeze. *Lonicera Tatarica* flowers just about to open.

May 19, 1920. Sunshiny, moderate east wind, pleasantly cool. A few bees. (C.M.K.)

May 23, 1920, 10:30 a.m. Honey bees one to three seconds in a flower. Three honey bees visiting fifty flowers in three minutes.

May 26, 1920. Many bees getting pollen and nectar. Bee in flower three seconds, 150 flowers in two minutes. Some bumble bees.

Boone, May 26, 1920. Honey bees about three seconds in a flower, getting pollen and nectar.

Ames, May 4, 1921, 8:30 a.m. and 2 p.m. Cool, clear, north wind. Some honey bees getting pollen and nectar. Two to six seconds in one flower. Two bees on one bush.

May 9, 1921, 2 p.m. Foot of Stanton Hill. Cloudy, slight wind. Eight bees.

2:30 p.m. Eight bees. Two seconds to one flower. One bee visited a dozen flowers of the area. Area considered above was a cluster of bushes with about 500 square yards of blooming surface. One yard had about 1000 flowers. About 500,000 flowers on bush.

May 10, 1921, 2:45 p.m. Bush at foot of Stanton Hill. Cloudy. On one square yard of flowers five bees. Hundreds on entire bush.

May 11, 1921, 2:30 p.m. Warm, clouds with some sunshine. One square yard of flowers had ten bees. Each flower repeatedly visited by bees. Yellow colored flowers also visited.

May 12, 1921. Bush at foot of Stanton Hill. 7:30 to 10:30 a.m. One square yard of blossoms being visited by six to ten bees. The bee passes from flower to flower, two to five seconds in each. One flower visited repeatedly by different bees.

May 23, 1921, 2:30 p.m. Little wind. One bumble bee on one plant. No other insects.

May 6, 1922, 8:30 a.m. Bees three seconds in a flower, very abundant, loaded with pollen. Plant fragrant, flowers very numerous.

May 14, 1922, 10 a.m. Partly cloudy. Some flowers still wet from rain. Bees abundant, collecting both nectar and pollen. One to four seconds in a flower. A shrub of seven feet height, number of flowers estimated as one million.

May 18, 1923, 1:30 p.m. Clear, rather cool. Relatively few bees. In two minutes two bees visited eighty flowers. One to four seconds in a flower.

May 20, 1923, 2:30 p.m. Some bees, collecting, for the most part, pollen.

May 24, 1923, 5:30 p.m. Bees getting nectar. Three to seven seconds in a flower.

June 25 and 26, 1923, p.m. Clear and warm. About four seconds in a flower.

Blairsburg, May 12, 1924. Some bees.

May 18 and 20, 1924, 12 m. and 2 p.m. Clear, sunshiny, slight north breeze. Bees getting pollen. Three to six seconds in a flower.

Ames, May 20, 1924, 3 and 6 p.m. Bright, clear, moderate, light breeze. A bee visits ten flowers. Three seconds in a flower.

May 23, 1924, 9 a.m. Rain during night. Cloudy, damp. No bees.

May 9 and 10, 1926. Clear, warm, north breeze. No bees. Dry weather influencing honey flow.

May 17, 1926, 12 m. Warm, sultry. Bees abundant. Two seconds in a flower.

May 21, 1926, 10 a.m. Cool, cloudy. Some bumble bees. No honey bees.

May 13, 1927, a.m. and p.m. Westerly wind. Bees collecting pollen and honey. Two to five seconds in a flower.

May 14 to 19, 1927. Cold, strong wind. No bees or only a few.

May 23, 1927, 12 m. and 5 p.m. Clear, windy. Bees abundant. About three seconds in a flower.

May 24, 1927, 8 a.m. Bees abundant, collecting mostly pollen. Two to four seconds in a flower.

Keosauqua, May 6, 1928, 6:45 p.m. Clear, cool. Bees four seconds in a flower.

Ames, May 9, 1929, 2:30 p.m. Few bees. Less than on *Lonicera Morrowi.*

May 13 to 16, 1929. Clear. Few bees though abundant on *Lonicera Morrowi* and *Berberis.* Four seconds in a flower.

May 17 and 19, 1929. Bees abundant. From three to six seconds in a flower.

May 22, 1929, 12:30 p.m. Cloudy, westerly wind. Bees two or three seconds on a flower.

Eldora, May 25, 1929, 2 p.m. Bees abundant. Four seconds in a flower.

Lonicera japonica Thunb. (*L. Halliana*) Japanese Honeysuckle

Halliana of gardens, yellow-flowered honeysuckle. Twining or trailing woody stemmed shrub, pubescent. Leaves oblong, entire, thickish; corolla white, pink or yellow; berries black. Cultivated as an ornamental in black prairie, clay, sandy and calcareous soils.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Florida—Jacksonville (A. H. Curtiss); North Carolina—Biltmore (L. H. Pammel); Texas—Lufkin (Ada Hayden).

HONEY BEE VISITS

Ames, May 23, 1914. Numerous bees. (C.M.K.)

May 25, 1914, 3:45 p.m. 80° to 90° temperature. Flowers fragrant. Numerous bees. (C.M.K.)

5 p.m. 55°, strong south wind. Honey bees, solitary bees, etc. (L.A.K.)

May 13, 1919. Bees abundant.

June 24, 1927, 12 m. A few bees.

Lonicera Sullivantii Gray. Sullivant's Honeysuckle

A woody vinelike shrub, leaves large, smooth, oval, sessile; most of them on the flowering stems connate, glaucous. Flowers pale yellow, slightly gibbous below, in a loose cluster. Ohio west and south.

Calcareous soils, or sandy soil. St. Peter and St. Croix sandstones. Associated with *Aquilegia canadensis, Arabis lyrata, Heuchera villosa, Hydrophyllum virginicum, H. appendiculatum, Geranium maculatum, Trillium erectum, Tilia americana, Physocarpus opulifolius* var. *intermedius.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Marquette, McGregor, north of Iowa City, Waukon Junction (L. H. Pammel); Decorah (E. W. D. Holway), Fayette (B. Fink), Iowa City (A. S. Hitchcock), northeastern Iowa (H. Goddard), Rockford (C. L. Webster).

General distribution in the United States:

Illinois—Fox (L. H. Pammel and Mark Heavenhill); Ohio—Columbus (W. A. Kellerman); Wisconsin—Bloomingdale, Prairie du Chien (L. H. Pammel).

HONEY BEE VISITS

Honey bees have frequently been found obtaining nectar from this honeysuckle by means of perforations through the wall of the tubular portion of the corolla.

Ames, June 7, 1917, 12:30 p.m. Honey bees apparently getting both nectar and pollen out of the flower. Flowers yellowish when first open, turning brick-reddish. Some bumble bees. Two to four seconds in a flower.

June 5, 1919. Both honey bees and bumble bees abundant.

June 11, 1919. Intermittent showers. Bees getting nectar.

June 10, 1920. Clear. Honey bees collecting pollen.

May 25, 1921, 12 m. Pollen being collected by honey bees. Two seconds in a flower. Bumble bees and one butterfly also noted.

June 5, 1922, 5 p.m. Bees three seconds in a flower. Apparently obtaining nectar. The tube of the corolla is too long for honey bees but perforations were not noticed.

Lonicera dioica L. Wild Honeysuckle

A glabrous twining shrub 3 to 10 feet high. Leaves oblong, glaucous and glabrous beneath, several upper pairs connate into discs. Corolla greenish to purplish, the tube short. Rocky grounds. Maine westward. Blooms in May and June.

In clay, Carboniferous sandstone, gravelly ground in woods. Associated with *Ribes Cynosbati, Fragaria vesca, Quercus rubra, Q. alba, Carya ovata, Antennaria plantaginifolia, Trillium nivale, Galium boreale, Viola cucullata, V. pubescens, Hepatica acutiloba, Mitella diphylla, Geranium maculatum, Dirca palustris, Carex assiniboinensis, Prunus pennsylvanica, P. virginiana.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Armstrong, Backbone Park, Manchester, Pilot Mound, Webster county (L. H. Pammel); Fort Dodge, Webster City (F. C. Stewart), Ames (F. A. Sirrine, C. R. Ball, E. G. Preston, two specimens, L. H. Pammel and R. Combs), Charles City (C. L. Webster), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Emmet county (R. I. Cratty), Fayette (B. Fink), Hardin county (C. M. King), Kalona (J. N. Arnold), Ledges (Wilbur Hurst), Marshalltown (E. R. Hodson), northeastern Iowa (H. Goddard), Postville (L. H.

Pammel, Ellison Orr and D. O. Wilson), West Union (Emma Hancock and L. H. Pammel), Woodman's Hollow (F. Anton).

General distribution in the United States:

Michigan—Muskegon (L. H. Pammel); Minnesota—Brainerd (three specimens, E. B. Watson), Minneapolis (C. M. King), Minnetonka (J. H. Sandberg), St. Cloud (R. Gmelin), St. Paul (R. Gmelin); New York—Ithaca (Muenscher and Bechtel); North Carolina—Buncombe county (Biltmore Herbarium); Ohio—Put-in-Bay (L. H. Pammel); South Dakota—Spring creek (L. H. Pammel).

HONEY BEE VISITS

Not one of the honey bee flowers. Bees sometimes collect pollen.

Lonicera sp. Hybrid related to *L. tatarica.*

HONEY BEE VISITS

Ames, May 24 and 25, 1927, 1 p.m. North wind. Bees abundant. Two to four seconds in a flower.

May 27 and 28, 1927, 8 a.m. and 12 m. Cloudy. No bees.

Symphoricarpos (Dill.) Ludwig. Snowberry, Indian Currant, Coralberry

Low shrubs with slender upright branches. Flowers pinkish white, in close clusters. Corolla bell-shaped, 4- or 5-lobed, with as many stamens inserted within the throat. Berry 2-seeded, clustered. Seeds bony.

The bell-shaped reddish flowers have nectar secreted by a hair-covered enlargement on one side of the corolla. Bonnier says that all parts of the flower are very rich in sugar.

Symphoricarpos orbiculatus Moench. Indian Currant, Buckbrush

Low branching shrub 2 to 4 feet in height. Oval, wavy-margined leaves. Flowers white, bell shaped, tinged with rose color, in clusters, in the axils of the leaves. Berries small, red. Rocky banks, New York to Dakotas and south. Cultivated in gardens.

Clay soil, alluvial bottoms, Missouri loess. Associated with *Corylus americana, Fraxinus lanceolata, Carya ovata, C. laciniosa, Quercus palustris, Q. rubra, Q. alba, Juglans nigra, Betula nigra, Vernonia fasciculata, Aster Tradescanti, A. salicifolius, Solidago serotina, Eatonia Pennsylvanica, Eupatorium urticaefolium, Euphorbia marginata, Helianthus tuberosus, Bidens cernua, Sambucus canadensis.*

The corolla of the bell-shaped flower is sparingly bearded. Nec-

FIG. 329.—Indian currant (*Symphoricarpos orbiculatus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

tar is secreted as in other members of the genus. Although the blossoms are small they are much sought by bees. In some localities where buckbrush abounds it has been found to yield good surplus. At Ames we have seen many bees gathering nectar, which, however, is not always copious.

"*Symphoricarpos orbiculatus* saved the bees in 1914 when everything else failed at Cantril."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Atlantic, Burlington, Centerville, Clarinda, Des Moines (three specimens), Eagle Rock, Fairfield, Farmington, Glenwood, Hamburg, Happy Hollow, Harvey, Indianola, Keokuk, Keosauqua, Missouri Valley, Monroe county, Moravia, Ottumwa, Perry, Polk City, Sioux City, Warren county (L. H. Pammel), Cooper creek (L. H. Pammel and D. C. Poshusta), Council Bluffs (L. H. Pammel and

H. B. Clark), Decatur county (J. P. Anderson), Des Moines (G. W. Carver), Hamburg (L. H. Pammel and H. B. Clark), Keokuk (P. H. Rolfs), Lee county (Paul Bartsch), Osceola (F. C. Stewart), Polk City (C. L. Krantz).

General distribution in the United States:

British Columbia—Victoria (L. H. Pammel); Illinois—Hamilton (two specimens, L. H. Pammel); Michigan—Green (L. H. Pammel and V. C. Fisk); Minnesota—Crookston (Mrs. Roy Westley); Missouri—Wicker (L. H. Pammel); Ohio—Cincinnati (L. H. Pammel); Oklahoma—Norman (W. E. Bruner), west of Fort Smith (two specimens, P. H. Rolfs, L. H. Pammel); Pennsylvania—State College (L. H. Pammel); Texas—Tarrant county (Albert Ruth); Wisconsin—La Crosse, cult. (L. H. Pammel).

HONEY BEE VISITS

John H. Lovell states that the flowers are smaller than those of the snowberry and bloom for two or three weeks, secreting a large amount of nectar.

Pellett states that this plant is an important source of honey in woodland borders throughout Arkansas and Missouri.

He also states that in southeastern Iowa 1914 was a very poor year for bees and that many colonies required feeding to get them through the winter. In a few localities, where buckbrush abounds, they not only were well prepared for winter but stored some surplus.

Des Moines, July 15, 1914. Hot, very dry. Freely visited by bees. (L.A.K.)

Ames, August 15, 1917. Clear. Honey bees common.

July 14, 1920, 8:45 a.m. Bees abundant. Time in flower two to five seconds.

September 22, 1922, 12 m. to 5:40 p.m. Few flowers left. Partly cloudy. A few bees. One to four seconds in a flower.

August 26, 1923, 7:45 a.m. Sky slightly overcast, still, warm. Bees numerous, getting nectar. Flowers opening freely along the racemes. Each bee visits several flowers; one second in a flower. (C.M.K.)

August 27, 1923, 7:45 a.m. and 4 p.m. Clear, warm, light south wind. Bees very active and numerous.

6 p.m. Bees as above. Sudden dark clouds ended the bees' work.

August 29, 1923, 7 a.m. and 6 p.m. Cool, bright, slight wind. Bees on the buckbrush; observed on no other plant.

August 30, 1923. Rain at intervals. Bees active early and late.

September 1, 1923. Damp, cool, still, no rain. Bees at work at 7 a.m. and all day. Day warm and favorable. Bees very numerous, actively collecting nectar.

September 11, 1923. Work of bees checked by spell of very cool, rainy weather.

September 12, 1923. Bright. A few bees returning to the buckbrush; on almost no other plant. (C.M.K.)

September 25, 1923, 9:30 a.m. to 4 p.m. Foggy, warm. Still a few flowers. A few bees visiting them.

Lancaster, Missouri, July 25, 1927, 12 m. Some honey bees at work.

August 25, 1927, 12:30 p.m. Clear. Bees two seconds in a flower.

Ames, August 26, 1927, 10:30 a.m. Some bees. Two seconds in a flower. Hamburg, August 25, 1928, 5 p.m. Bees two to five seconds in a flower.

J. M. Cate, a beekeeper at Centerville, states that he has had a ton of honey from the buckbrush (*Symphoricarpos orbiculatus*). On September 1, 1929, the plants were no longer blooming.

Symphoricarpos occidentalis Hook. Wolfberry

Upright branching shrub with clusters of pinkish flowers in dense terminal and axillary spikes. Rocky ground, Michigan westward and southward.

This species is common in rocky and gravelly soils and along lakes and smaller streams of northern Iowa. Abundant in Missouri loess of western Iowa from Fremont to Lyon counties. Associated with *Euphorbia marginata, Solidago rigida, S. nemoralis, S. missouriensis, Aster laevis, A. sericeus, A. obtusifolius, Cleome serrulata, Oxytropis Lamberti, Corylus americana, Amelanchier spicata, A. canadensis, Betula papyrifera, Quercus alba, Q. velutina, Prunus pennsylvanica, Aquilegia canadensis, Campanula rotundifolia, Andropogon scoparius, Comandra umbellata, Silphium laciniatum, Echinacea purpurea.*

The corolla is funnel-formed, pinkish and much bearded within. The flowers secrete an abundance of nectar, and the plant is considered one of the very best of honey plants, much better than the coral berry.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Armstrong, Carroll, Eagle Grove, Garner, Gillett Grove, Glenwood, Greene, Iowa lake, Lake Mills, Lake Okoboji, Lime creek, Little Rock (two specimens), Lost Island lake (two specimens), Mason City, Missouri Valley, Oto, Palo Alto, Rock Rapids, Sioux City, South Dakota opposite Hawarden, Willow creek (L. H. Pammel), Plymouth county, Woodbury county (Olive F. Brown), Clear Lake, Goldfield (R. I. Cratty), Algona (Watson), Battle Creek (E. G. Preston), Cedar Falls (G. W. Carver), Decorah (R. Brown), Fayette (B. Fink), Fremont county (J. P. Anderson), Hamburg (L. H. Pammel and H. B. Clark), Spirit Lake (H. E. and L. H. Pammel), St. Ansgar (Mrs. F. M. Tuttle), Winneshiek county (H. Goddard).

General distribution in the United States:

Colorado—Denver (I. W. Clokey), Englemann canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Fort Collins (A. Hayden), Manitou (L. H. Pammel), Petersburg (G. M. Lummis), Stone Prairie Hill near Fort Collins (C. S. Crandall); Minnesota—Anoka, Canyon Falls, Clear Lake, Graceville (two specimens), Granite Falls, Howard, Wadena (L. H. Pammel), Brainerd (E. B. Watson), Clinton (J. C. Witham), Spear Rock (C. A. Hansen), St. Paul (R. Gmelin); Missouri—St. Louis (H. Eggert); Montana—Glendive, Livingston (L. H. Pammel), Missoula (J. E. Kirkwood); Nebraska—Lincoln, Scott's Bluff county (F. G. Miller), Halsey, Pine Ridge (J. C. Blumer), Sheridan county (R. E. Buchanan); New York—Niagara Falls (G. H. Frazier); North Dakota—Minot (J. C. Blumer); South Dakota—Brookings, Dell Rapids, Spring Rock, Watertown (L. H. Pammel), Spearfish canyon (C. M. King); Utah—Salt Lake City (L. H. Pammel and R. E. Blackwood); Wisconsin—La Crosse (L. H. Pammel); Wyoming—Granger (Aven Nelson), Laramie Hills (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. W. Lummis), Sheridan (Ferdinand Reppert, A. Estella Paddock, Sarah Ellis), Yellowstone Park (R. P. White).

HONEY BEE VISITS

John A. Lovell states that this plant secretes nectar freely. It is very attractive to wasps and hence is called a wasp flower. The white berries are eaten by pheasants and cattle. It is abundant in western Iowa, where it yields well in dry weather.

We have found honey bees on this quite frequently.

Buck Grove, June 18, 1914. Excellent honey plant. Fine fall honey plant. (A. F. Bonney.)

Payne, July 5, 1914, 8 a.m. Partly cloudy, south wind. Bees abundant, remaining but a short time in flower. More on sweet clover in the same vicinity.

Ames, August 21, 1915, a.m. Clear, following a cool night. Six bees. (L.A.K.)

August 30, 1915, a.m. and p.m. Clear, following frost. Six bees. (L.A.K.)

September 4 and 5, 1915. Clear, warmer. Ten bees. (L.A.K.)

Des Moines, June 21, 1919. Honey bees four seconds in a flower.

Ames, July 2, 1920, 2 p.m. Bee visits thirty flowers in one minute. On 1500 flowers. Two bees in two minutes.

July 7 to 23, 1920. Some days partly cloudy. Bees abundant. Time in flowers two to five seconds.

July 27, 1920, 9 a.m. Dry and clear. Three bees in one minute on one plant. Perhaps 300 flowers. Time in flower three to six seconds.

Pella, July 26, 1927, 10:30 a.m. Bees abundant. Three to five seconds in a flower.

Hamburg, August 25, 1928, 5 p.m. Bees abundant. Missouri loess soil. Three to five seconds in a flower.

Blooming, Ames, May 7, 1924.

Symphoricarpos racemosus var. *laevigatus* Fernald. Snowberry

Shrub two to five feet high. Leaves oblong or roundish, green on both sides, pilose beneath. Flowers in short spikes at ends of branches. Corolla campanulate. Dry limestone ridges and banks, from Quebec westward. In various soils in Iowa, black prairie, clay and sandy soils.

This is a handsome ornamental. It might be used much more extensively than it is. It is one of the very valuable honey plants.

FIG. 330.—Snowberry (*Symphoricarpos racemosus* var. *laevigatus*). *Photograph by A. Hayden.*

Knuth says, "The flowers are pendulous, slightly fragrant, conveniently large to receive the head of a wasp or bee, which are the most frequent visitors. At the widest point within the bell-shaped flowers, the surface bears numerous long hairs stretching from the corolla lobes to the middle of the bell. These help to collect the nectar."

General distribution in the United States:

Colorado—Fort Collins, Howe's Gulch (W. F. M.), Salida (L. H. Pammel, R. L. Barrett, L. V. Lee, and Frank Raney), Silver Plume (L. H. Pammel); Illinois—Utica (Mrs. Joseph Clemens); Michigan—Mackinac Island (R. I. Cratty); Minnesota—Cass Lake (four specimens), Leech Lake, Norway Beach, Star Island, Walker (L. H. Pammel); Montana—Bitter Root Valley Mountain (L. H. Pammel and H. S. Fawcett); New Mexico—Cuba (A. D. Read); New York—Ithaca (Muenscher and Bechtel), Niagara Falls (Thomas Morong, Herbarium Walter Deane); North Carolina—Biltmore Estate (H. M. Packard and Carrie Harrison); Ohio—Worthington (Asa Horr); Oregon—Smith Rock (Kirk Whited); South Dakota—Milbank (L. H. Pammel); Utah—Logan canyon (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney), Ogden (two specimens, L. H. Pammel); Virginia—Smyth county (John K. Small); Washington—Easton (L. H. Pammel and W. S. Dudgeon), Seattle (Stella L. Goodspeed); Wisconsin—St. Croix Falls (L. H. and H. E. Pammel), Elkhart Lake (J. H. Schuette), La Crosse (two specimens, L. H. Pammel); Wyoming—Woods Postoffice (Reppert and Witter).

HONEY BEE VISITS

Ames, July 1, 1920, 2 p.m. Honey bees two seconds in a flower.

August 28, 1920, 2 p.m. Southeast breeze. A few flowers remaining. No bees.

June 9 to 15, 1921, 9 a.m. Clear, warm. Bees abundant. Two to three seconds in a flower.

June 1, 1922. Cloudy, warm. Abundance of rain preceding week. Bees two to four seconds in a flower.

June 29, 1922, 8:30 a.m. and 12:30 p.m. Bees two to four seconds in a flower. Pass by certain flowers. Twenty-five bees on 2,000 flowers.

June 30, 1922, 8 a.m. Bees three seconds in a flower. In these plants, as in others, the bees are most numerous at early bloom. As the flowers pass their prime, bees are less numerous, or absent, even upon favorite flowers like white clover.

July 6, 1922, 4 p.m. Bees two to six seconds in a flower. In moist weather bees remain longer in the flowers; supply of nectar increased. Bees abundant.

July 4, 1923, 11 a.m. Warm, some dew. Bees one to four seconds in a flower.

5:30 p.m. Plants in shady place. Bees three seconds in a flower.

July 10, 1924, 1:15 p.m. Clear, northwest wind. Bees three to five seconds in the flower.

Eldora, July 8, 1924, 6 p.m. Clear. Bees about four seconds in a flower.

Ames, July 18, 1926. Sunshiny. Bloom abundant. Bees numerous getting nectar. Four to twelve seconds in the flowers.

July 20, 1926, 1 p.m. Moderately warm, clear. Flowers becoming less numerous. Bees six to ten seconds in a flower.

May 7 and 8, 1927, 1 p.m. Warm, slight wind. Bees abundant. Two to six seconds in a flower.

June 13, 1927. Cloudy, cool. Bees abundant. Collecting nectar.

July 1, 1927, 10 a.m. Partly cloudy, north wind. Bees abundant. Four to two seconds in a flower. Two bees on one flower in five minutes.

July 6, 1927, 1 p.m. Very dry. Bees common. Five to seven seconds in a flower.

Des Moines, June 20, 1928, 11 a.m. Clear and warm. Bees abundant. Four to six seconds in a flower.

Ames, June 5, 1929, 2 p.m. Bees abundant. Six seconds on a flower.

Hampton, August 5, 1929. Some honey bees. Three seconds in a flower.

Blooming, Ames, June 1, 1925; Ames, June 1, 1926; Lansing, June 1, 1926.

Viburnum (Tourn.) L. Arrow-wood, Laurestinus

Fine ornamental upright shrubs or sometimes small trees. Simple opposite leaves with or without stipules. Flowers small, in terminal paniculate or umbel-like cymes. Calyx five-toothed. Corolla deeply five-lobed. Stamens five. Pistils one to three. Fruit a one-celled, one-seeded drupe.

Viburnum Opulus var. *americanum* (Mill.) Ait. Cranberry Tree

Deciduous shrub 10 to 12 feet high. Leaves 3- to 5-ribbed, strongly 3-lobed, broadly wedge-shaped, the lobes pointed. Petioles with 2 glands at the apex. Marginal flowers sterile, with flat corollas, the other flowers fertile; stamens exserted; fruit red, acid. This plant is widely cultivated as an ornamental, and is native in a few places in the state, particularly in Allamakee county, where it occurs upon northern, cool, limestone slopes. Occasionally found on the borders of peat bogs. Common throughout the northern United States.

HONEY BEE VISITS

Ames, May 30, 1927, 11:30 a.m. to 3:30 p.m. Sunshine, warm. Bees numerous.
June 1 to 3, 1927. Cloudy, damp, cool. No bees.
June 4, 1927, 1 p.m. Bees fairly common. One second in a flower.
June 6, 1927, 9 a.m. and 10 a.m. No bees. Flowers with *Crataegus* odor, only a few left.
June 18, 1927. First cluster had 86 blossoms and 52 fruits. Second cluster 25 blossoms and 10 fruits. Third cluster 56 blossoms and 25 fruits.
May 29, 1929, 8 a.m. Many Hymenoptera. No bees. Odor of cumarin.
May 30, 1929. Only a few bees. One second in a flower. Odor of cumarin.

Viburnum dentatum L. Arrow-wood

A smooth shrub with light colored leaves, broadly ovate, smooth or sometimes with hairy tufts at the axils, sharply toothed. Flowers white. Widely distributed in eastern North America and commonly cultivated.

HONEY BEE VISITS

Ames, June 4, 1927, 1 p.m. Bees fairly common. One second in a flower.

Viburnum molle Michx. Soft-leaved Arrow-wood

A shrub 1 foot to 6 feet in height with gray exfoliating bark; leaves coarsely dentate, smooth above, pale and somewhat pubescent beneath. Black fruit. This is found in Iowa as well as *Viburnum pubescens*, which is known as the downy arrow-wood. This is a low, straggling shrub; leaves ovate or oblong-ovate. Petioles more or less downy. Occurs on calcareous ridges in northern Iowa.

Viburnum Lentago L. Sheep-berry

Shrubs or sometimes trees 10 to 14 feet in height with ovate leaves sharply and coarsely serrate. Petioles winged. Cyme sessile, 3- to 4-rayed; drupe bluish black, ovoid or ellipsoid. Common in woods.

HONEY BEE VISITS

Ames, May 18, 1926, 2 p.m. Bees one second in a flower.

Blooming, Ames, May 12, 1926.

Viburnum prunifolium L. Black Haw

This is a tall shrub or small tree with oval leaves which are slightly pointed, finely and sharply serrate, with winged petioles; cyme 3- to 5-rayed. Fruit ellipsoid, black.

Commonly cultivated, but has also been reported on low ground. Bees are reported on the species.

Blooming, Ames, June 1, 1925, May 15, 1926. Lansing, June 5, 1926.

Sambucus (Tourn.) L. Elder

Shrubby plants with pinnately serrate leaflets. Flowers very numerous, white, in compound cymes or flat clusters. Fruit a small juicy berry-like drupe. Generally has an odor of vanilla. Stamens and pistils mature at the same time or in some cases the pistils mature first. Several species are cultivated, like *Sambucus nigra*.

FIG. 331.—Common elder (*Sambucus canadensis*). *Photograph by A. Hayden.*

Sambucus racemosa L. Red-berried Elder

A shrubby plant with woody stems, 2 to 10 feet high, the bark warty, the pith brown. Leaflets 5 to 7, ovate-lanceolate, downy underneath, cymes convex or pyramidal. Flowers yellowish white, or tinged with crimson. Fruit bright red.

Sandy soil on St. Peter and St. Croix sandstone. Associated with *Hydrophyllum appendiculatum, H. virginicum, Podophyllum peltatum, Geranium maculatum, Dodecatheon Meadia, Physocarpus opulifolius* var. *intermedius, Prunus virginiana, Vitis vulpina, Betula papyrifera, Tilia americana, Acer saccharum, A. nigra, Aquilegia canadensis, Cornus alternifolia, C. circinnata.*

Rocky woods Newfoundland and westward across the continent and southward. Blooms in May. Fruit ripens in June.

The stamens and pistils of this flower mature at the same time. Sometimes slightly proterandrous and sometimes slightly proterogynous. Kerner notes that the odor is like herring brine, while Kirchner describes it as meal-like; to us it is something like vanilla, quite strong and perceptible in passing the plant.

Kirchner made this interesting comment, "After the flowers have opened the tips of the petals sometimes bend right back, and the stamens diverge so much as to be almost in one plane; their anthers, however, are still unripe while the three short stigmas are fully mature. The tips of their petals then grow to some extent, and assume a yellowish color; the anthers dehisce downwards and outwards, the stigmas remaining receptive."

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dubuque, Green Island, Postville (three specimens) (L. H. Pammel); Decorah (two specimens, E. W. D. Holway), northeastern Iowa (H. Goddard).

This species has also been observed (L. H. Pammel) at Clear Lake, Hardin City, Howard county, Lansing, Marquette, McGregor, New Albin, Postville, Waukon.

General distribution in the United States:

Alaska—Hyder (two specimens, Kirk Whited); Arizona—Tucson (L. H. Pammel); British Columbia—Vancouver (Kirk Whited); Colorado—Fraser (L. H. Pammel and D. S. Jeffers), Fraser river (L. H. Pammel and C. G. McLaren), Jack brook (F. E. and E. S. Clements), Mount Logan (L. H. Pammel and R. L. Barrett, L. V. Lee, Frank Raney); Illinois—Starved Rock (L. H. Pammel and Mark Heavenhill); Indiana—Steuben county (Charles C. Deam); Michigan—Whitehall (L. H. Pammel); Minnesota—Faribault, Itasca State Park (two specimens), St. Paul (L. H. Pammel), Cass Lake (L. H. and H. E. Pammel and P. S. McNutt, L. H. Pammel and T. R. Truax), Duluth (L. H. and H. E. Pammel), Marion county (R. I. Cratty), Minnehaha Falls (L. H.

and H. E. Pammel); Montana—Bitter Root Valley (L. H. Pammel and H. S. Fawcett); New Hampshire—Dublin (J. R. Churchill); New York—Ithaca (H. E. Summers, Muenscher and Bechtel); South Dakota—Spearfish canyon (C. M. King); Utah—Ogden (two specimens, L. H. Pammel), Peterson (two specimens, L. H. Pammel and R. E. Blackwood); Vermont—Peacham (Ferdinand Blanchard); Wisconsin—Bloomingdale, Kilbourne, La Crosse (L. H. Pammel).

Sambucus nigra L. European Elder

Taller and more woody than common elder. Leaves usually golden; leaflets usually 5, oblong-oval. Flowers large, faintly sweet-scented. Fruit black. A cultivated ornamental, variegated or cut-leaved. Cultivated in gardens in various soils—clay, sandy, black and black prairie soils.

Mueller says that these are nectarless flowers, visited sparingly by bees.

HONEY BEE VISITS

Ames, June 26, 1917. Cloudy. A few honey bees on flowers.

DIPSACEAE, Teasel Family

Perennial, biennial or annual herbs with opposite or rarely whorled leaves. Flowers in dense heads, surrounded by an involucre. Calyx adnate to the ovary, which is simple and one-celled. Stamens inserted on the corolla tube. Only a few genera of these are cultivated.

Scabiosa L. Mourning Bride

Herbs, grown in flower gardens. Leaves entire or divided. Heads ovoid-conical on long peduncles. Flowers blue, white or rose-colored. Corolla 4- to 5-cleft.

Scabiosa atropurpurea L. Sweet Scabious

Flowers dark purple, rose or white. Basal leaves lyrate, coarsely dentate.

HONEY BEE VISITS

Ames, July 27, 1927, 11 a.m., 12 m. After rain. Cloudy, warm. A few bees collecting pollen. One-half and two seconds in a flower. (C.C.L.)

August 4, 1929. Bees abundant. One second in a flower.

October 13, 1929, 12:30 p.m. Clear. A slight north breeze. Bees one second in a flower.

CUCURBITACEAE, GOURD FAMILY

Herbs with tendrils, alternate palmately lobed leaves, dioecious or monoecious flowers; calyx tubes adhering to the compound 1- to 3-celled ovary; stamens united by their anthers, one with 1-celled anther and two with 2-celled anther; stigmas 2 or 3; fruit a pepo, dry or fleshy.

Knuth says, "The staminate flowers of Cucurbitaceae are more conspicuous than the pistillate flowers, and usually are first visited by the bees. Nectar is secreted in the bottom of a naked fleshy cup formed by the fusion of the lower parts of the calyx and corolla. The nectaries consist of a layer of secretory tissue about one mm. thick, and are provided with water stomata."

Cucurbita (Tourn.) L. Pumpkin, Squash

Flowers monoecious. Large, with wheel-shaped corolla. Anthers united; style 3-lobed. The fruit is fleshy, enclosed in a firm rind; seeds many. Herbs with large, angled leaves.

The Cucurbits are usually said to be moneocious or dioecious, although G. O. Miller says they are occasionally polygamous. It has

A B
FIG. 333.—Field pumpkin (*Cucurbita pepo*). A. Staminate flower. B. Pistillate flower. *Photograph by A. Hayden.*

been known for some time that some species have perfect flowers and others monoecious, and mainly the latter. Crozier says in regard to the watermelon: "In making some crosses today on the Volga watermelon, a variety from southern Russia, I discovered that the so-called pistillate flowers possessed stamens."

The flowers of the cucumber are also commonly visited by bees, but the striped cucumber beetle may also cause pollination. The flowers are monoecious; the staminate flowers far outnumber the pistillate. The male flowers appear before the pistillate. Cross-fertilization is the rule so far as the experiments of Mr. F. C. Stewart and the senior author could determine.

Studies* have also been made and reported by E. F. Castetter and A. T. Erwin on the structure of the flower of the cucumber, also by Fred C. Werkenthin and published in the Proceedings of the Iowa Academy of Science.

Cucurbita pepo L. Pumpkin

This species has numerous cultivated forms. The chief types are common field pumpkins, the bush scallop squashes, the summer crookneck squash, and gourds. The stalks and somewhat lobed leaves are rough-bristly. Hollow interior of the fruit is traversed by coarse soft threads; flower tube flaring. Cultivated in various soils.

The common pumpkin is frequently cultivated in Iowa throughout the state, usually in cornfields. The following localities may be noted: Algona, Ames, Boone, Carroll, Cedar Rapids, Centerville, Cherokee, Clarinda, Clinton, Council Bluffs, Davenport, Decatur county, Decorah, Forest City, Fort Dodge, Iowa City, Jefferson, Le Mars, Little Rock, Mason City, McGregor, Missouri Valley, Muscatine, New Albin, Rock Rapids, Sioux City, Spirit Lake.

HONEY BEE VISITS

Both kinds of flowers secrete nectar freely and are attractive to insects. The staminate flowers mature earlier than the pistillate.

The odor of the flower is not as pleasant as that of the squash. The insect reaches the nectar in the staminate flowers by putting its proboscis between the filaments of the monadelphous stamens. The flowers open early in the morning. A large amount of nectar and pollen is produced.

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* Pammel, L. H., and Beach, Alice M. Pollination of Cucurbits. Ia. Acad. Sci. 2: 146-152. pl. 11-14.

Werkenthin, Fred C. Origin of *Cucurbita* Species. Proc. Ia. Acad. Sci. 29: 281-290. f. 1-3.

Castetter, Edward F. Further species Crosses in the Genus *Cucurbita*. Proc. Ia. Acad. Sci. 33: 120-121.

Castetter, Edward F. Microsporogenesis in *Cucurbita maxima* (abs.) Proc. Ia. Acad. Sci. 32: 265-266.

Erwin, A. T., and Haber, E. S. Species and varietal Crosses in Cucurbits.

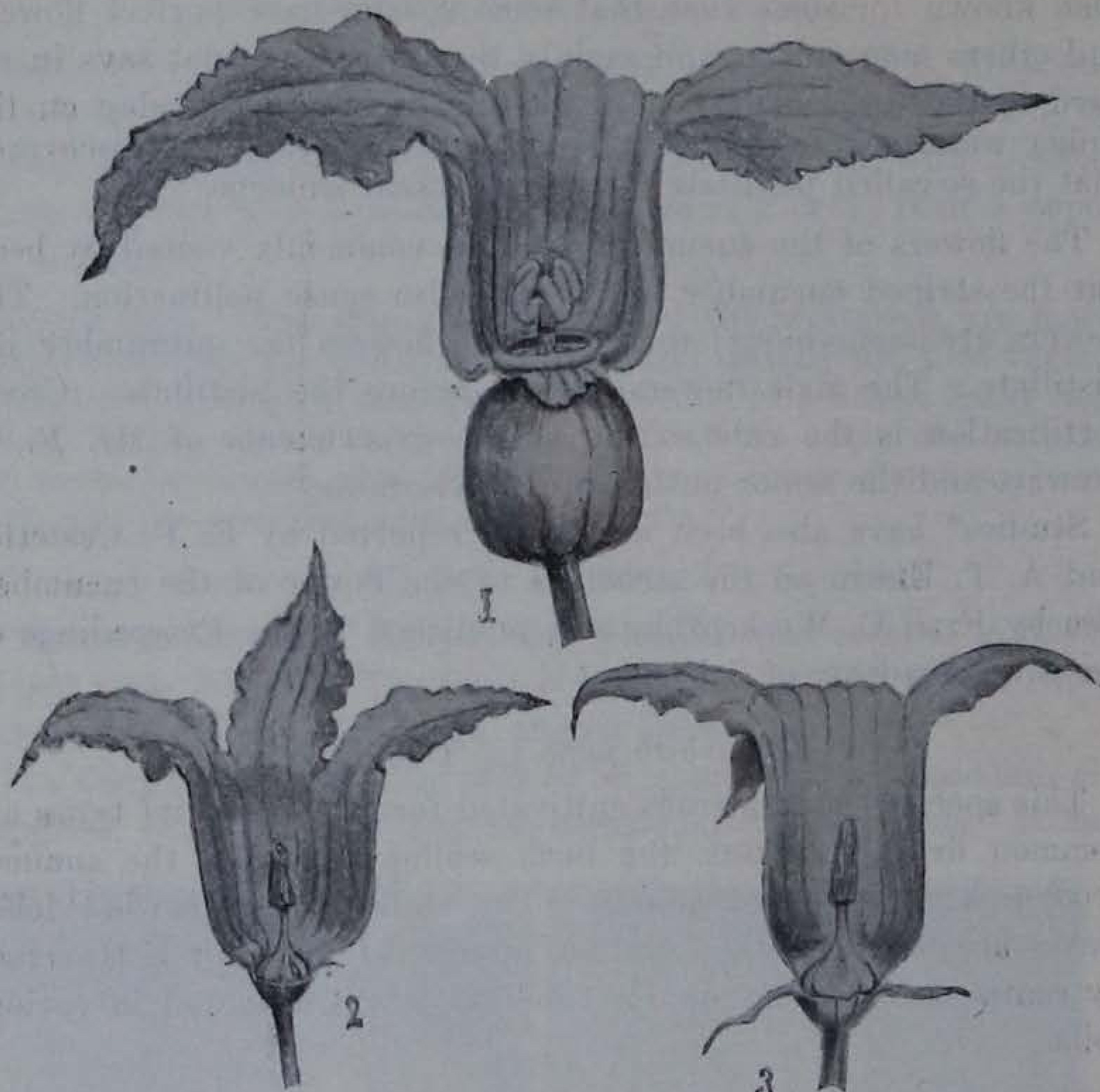

FIG. 334.—Perfect gem squash (*Cucurbita pepo*). 1. Pistillate flower. 2, 3, staminate flowers. *Drawn by C. M. King.*

The following insects were observed on the pumpkin at Ames: *Melissodes* sp., *Bombus pennsylvanicus, B. fervidus, Xenoglossa pruinosa,* and *Augochlora similis.*

Pellett states that the pumpkin blooms are very attractive to bees. The plants yield an abundance of pollen as well as nectar.

Lovell states that the pumpkin yields a large amount of amber-colored honey, which candies quickly.

Centerville (three miles north), August 5, 1927, 11 a.m. No bees on this, nor on Pennsylvania smartweed, catnip nor *Cucumis melo*. No apiary near by.

Cucurbita maxima Duchesne. Squash

The flowers are large, open, somewhat cylindrical, yellow. The corolla is 5-cleft and adherent to the bell-shaped tube of the calyx. The stamens are monadelphous. Fruit rounded or ovate, and pointed. The flesh hard, yellow. The Hubbard and Boston Marrow belong in this group. Cultivated in various soils.

FIG. 335.—Bush scallop squash (*Cucurbita pepo*). Upper, pistillate flower. 5. Staminate flower. *Drawn by C. M. King.*

The squash is widely cultivated in Iowa though not as extensively as the pumpkin. The following places may be noted: Boone, Cedar Rapids, Centerville, Cherokee, Clarinda, Clinton, Council Bluffs, Creston, Dallas Center, Davenport, Decorah, Des Moines, Dubuque, Eagle Grove, Fairfield, Forest City, Fort Dodge, Hamburg, Iowa City, Keokuk, Le Mars, Lineville, Little Rock, Manchester, Marshalltown, Mason City, McGregor, Missouri Valley, Mount Pleasant, Muscatine, Rock Rapids, Rockwell City, Shenandoah, Spirit Lake, Strawberry Point, Waukon, Webster City.

FIG. 336.—Hubbard squash (*Cucurbita maxima*). Pistillate flower, showing shallow nectary. *Drawn by C. M. King.*

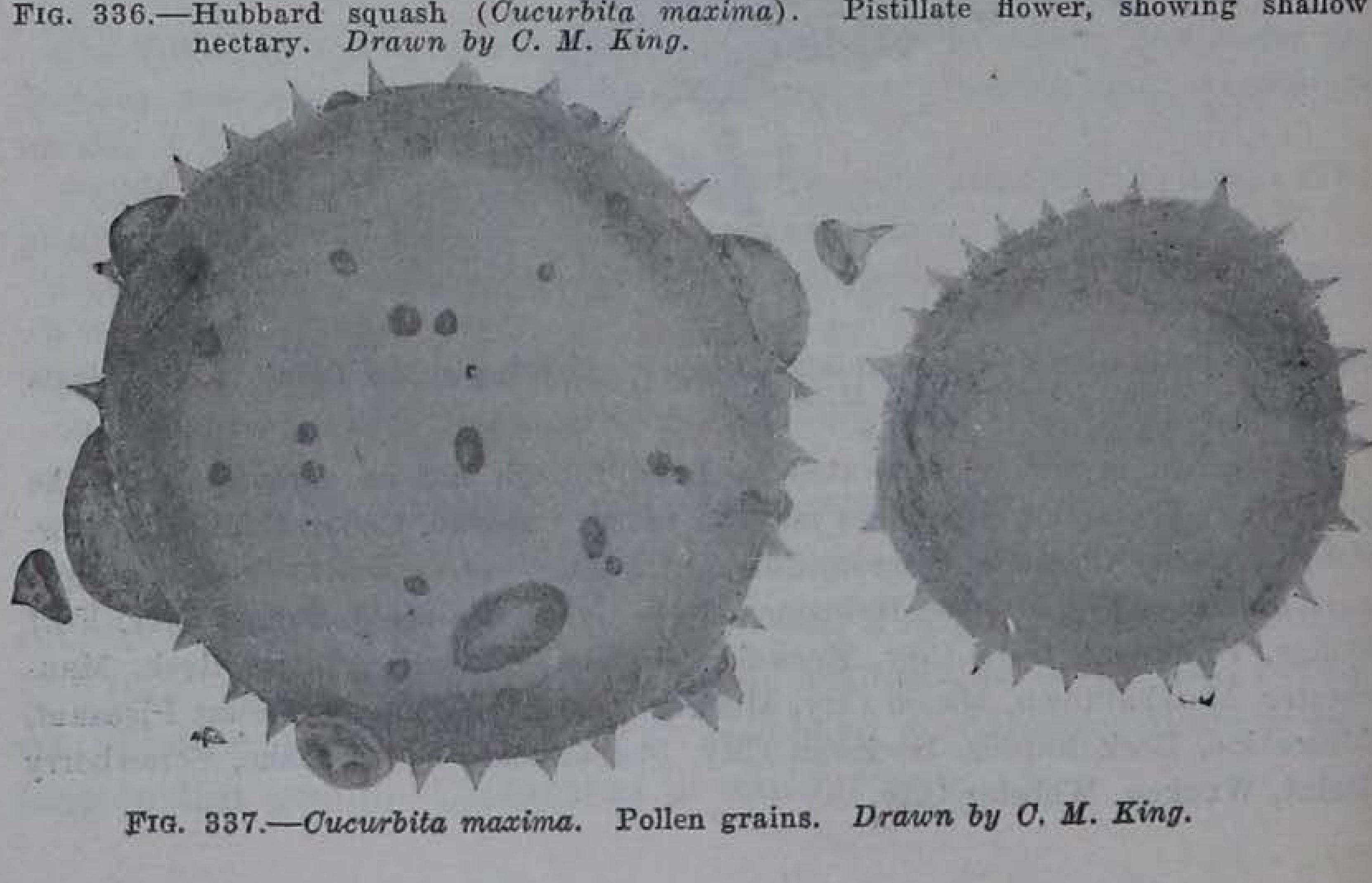

FIG. 337.—*Cucurbita maxima.* Pollen grains. *Drawn by C. M. King.*

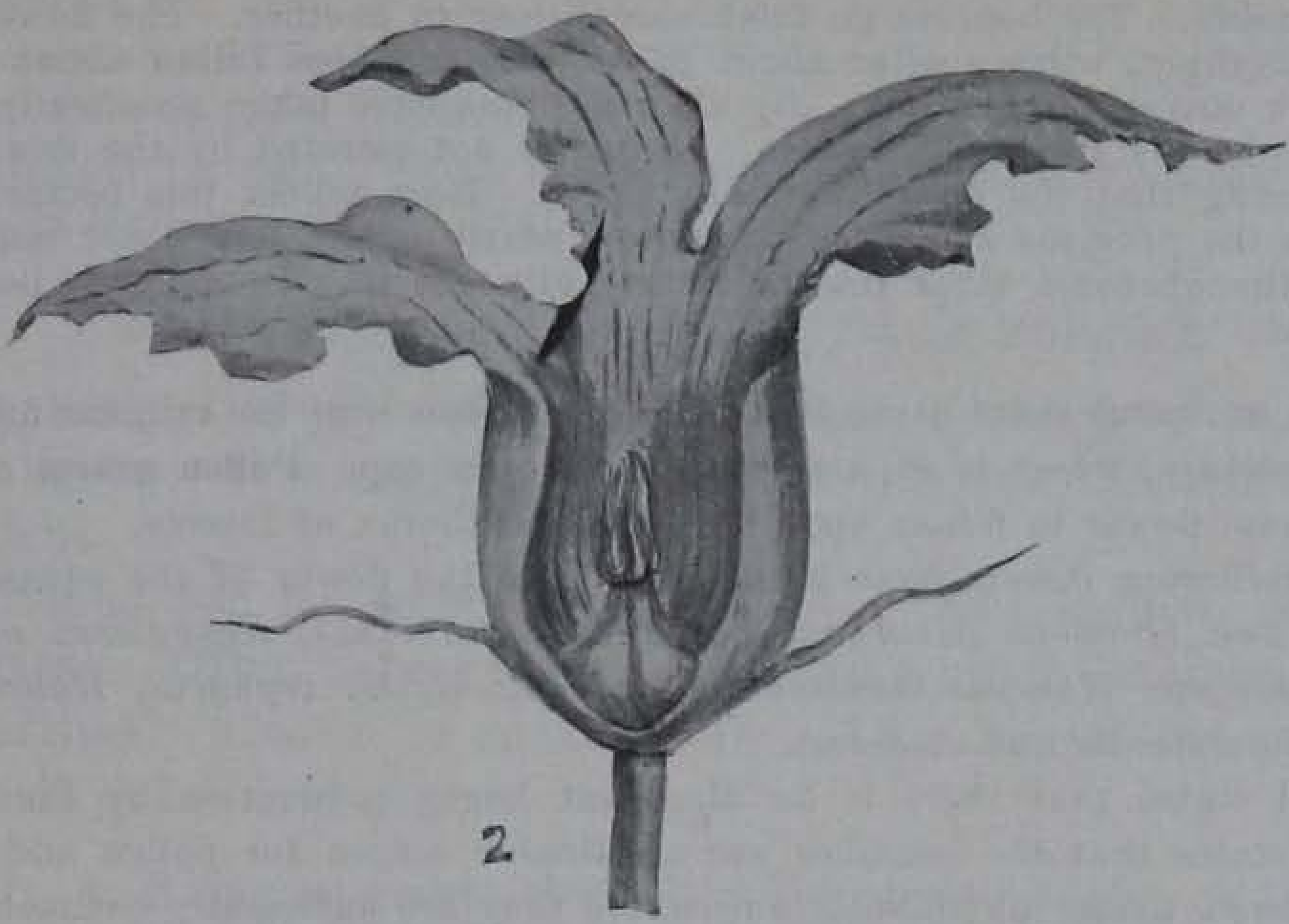

FIG. 338.—*Cucurbita maxima.* Staminate flower. *Drawn by C. M. King.*

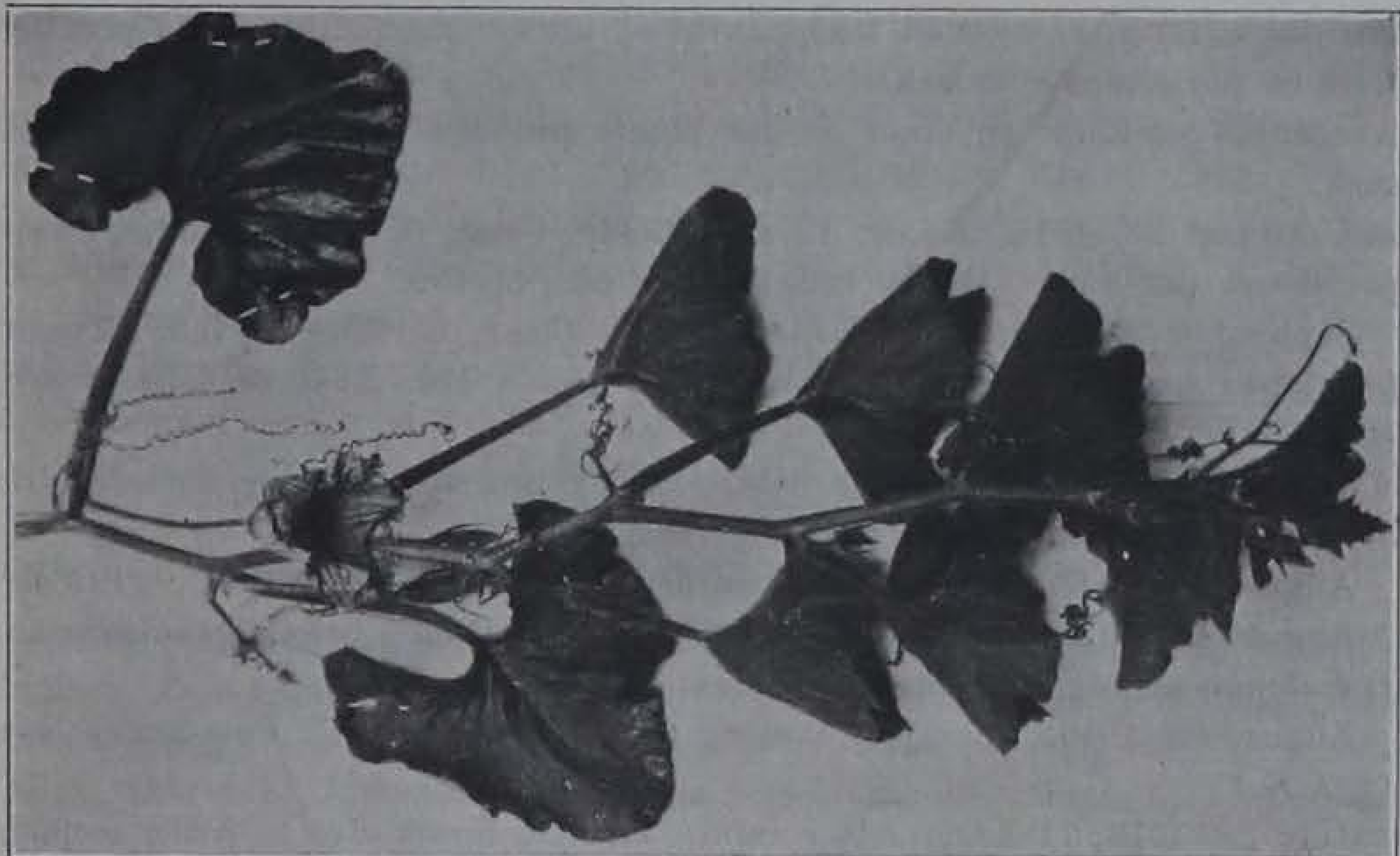

FIG. 339.—Squash (*Cucurbita maxima*). *Photograph by R. S. Kirby.*

POLLINATION AND HONEY BEE VISITS

In the common squash the flowers are large and have a very pleasant odor. In the case of the staminate flowers the nectar is contained in the lower part of the staminal tube and an insect in its search must pass over the stamens down along the grooves of the united filaments. The insect thrusts its tongue into the slit at the lower end.

In regard to pollination of pumpkins and squashes and insect behavior, Dr. E. F. Castetter says:

"There is a crossing among some varieties of certain species of pumpkins and squashes. The bees do go from one variety to another. The flowers open before daylight, wilting after about 12 o'clock, and bees follow about sunrise, and work during the morning. By noon the bees have taken practically all the pollen from the staminate flowers. Nectar is not secreted by the flower until the morning that the flower normally opens. Bees collect this nectar. Very often in the previous afternoon the flower partly opens, but is not noticed by bees, although some other insects occasionally get in. In general, bees were abundant.''

When an insect visits a pistillate flower it passes over the stigmas and down to the nectary, which is in the form of an open cup. Pollen grains are conveyed from flower to flower upon the head and thorax of insects.

The following insects have been noted upon the flower of the squash: the bumble bee (*Bombus pennsylvanicus* and *B. fervidus*), *Xenoglossa pruinosa*, *Melissodes* sp., *Halictus coriaceous*, *H. tegularis*, *H. zephyrus*, *Halictus* sp., *Augochlora similis* and *Andrena*.

Lovell states that there is an abundant honey production by the squash. Pellett states that the squashes are a valuable source for pollen and nectar. They secrete nectar abundantly and where they are sufficiently common a considerable quantity of honey is produced.

During some years when investigations were made by us on the growing of Cucurbits as much as a small teaspoonful of honey was found in the pistillate flowers of the common squash.

As far as we know no other of our plants produces as much nectar as the squash.

Ames, August 26, 1914, 9 a.m., 12 m. Field. Clear, 65°, east wind. Twelve per flower per hour. Honey bee, solitary bee, beetles. (G.H.M.)

September 2, 1914, a.m. College field. Clear, northwest wind. Twenty per flower per hour. Begin work at 9 a.m. Honey bee. *Bombus*, solitary bees. (G.H.M.)

September 3, 1914. College field. Honey bee, *Bombus*, *Synhalonia*, *Diabrotica 12-punctata* and *D. vittata*. (L.A.K.)

August 17, 1915. After rain. Garden. One bee per quadrat. (L.A.K.)

August 19, 1915. College field. Clear, cool. Honey bees, *Synhalonia* and *Petralonia*, seemingly gathering nectar. (L.A.K.)

August 25, 1915. Sunny, following cool night. Active. Few honey bees. (L.A.K.)

July 28, 1918, 11 a.m. After rain. Time in flower five to seven seconds, first on one side then on the other. Two bees in same flower at same time.

August 13, 1918, 12 m. to 3 p.m. Hot day, slight northeast wind. Abundance of bees. Flowers closed later in the day.

August 14, 1918, 2 p.m. Partly cloudy, cool. Bees abundant on cucumber and sugar melon also.

August 18, 1918. Bees abundant on cucurbits, *C. pepo*, *C. maxima*, cushaw, winter crookneck, *C. moschata*. The flowers remain open longer in cloudy weather.

Spirit Lake, August 18, 1918. Clear day. Black and Italian bees on cucumber and pumpkin. Time of bee in pumpkin flower one, one-fourth, one-half minutes. The bees collected only nectar but became covered with pollen. Bee visited first one side of the nectary then went to the other side.

Ames, August 27, 1923, 8 a.m. Clear, bright. Several bees getting pollen. Ten to twelve seconds in a flower.

2 p.m. Flower closed. (C.M.K.)

September 10, 1923. Warm, bright days. Bees numerous, actively getting pollen in large quantities. (C.M.K.)

Cucurbita moschata Duchesne. Sweet Pumpkin

This species, though widely cultivated, is not as common as the field pumpkin. It is sometimes cultivated with corn, though usually in gardens.

Cultivated for its edible fruit, which is club-shaped, or long cylindrical. Often large with a glaucous-whitish surface, often green striped. Grown in various soils. All varieties are valuable sources of pollen and nectar.

Dr. L. A. Kenoyer makes the following observations: "In 1914 it was noted that nectar accumulated in those staminate flowers which have stamens entirely monadelphous and enclosing the nectary. Some have stamens naturally partly separate at the base and nectar either evaporates or is taken by insects. In 1915 secretion was much less copious, only small droplets being evident. It was noticed that the nectaries secreted much more freely when brought from the cool outside air into a warm room. The most abundant bees on cucurbits are species of *Synhalonia*, a solitary bee about the size of a honey bee. They are sluggish and seem mainly interested in pollen. Sometimes the flower wilts and entraps these bees. Four were thus found captured by a single blossom. To test the color sense of bees, pumpkin corollas were laid on the leaves of the vine. *Synhalonia honesta* would stop momentarily at two or three such profitless corollas in succession."

Widely cultivated in Iowa. Common at Muscatine, Conesville, Wapello, Fort Madison, Des Moines, Ames, Marshalltown, Cedar Rapids, Fort Dodge, Manchester, Osage, Dubuque, Mason City, New Albin, Council Bluffs, Missouri Valley, Clarinda, Audubon, Centerville, Rock Rapids, Sioux City, Le Mars, Hamburg, Shenandoah, Fairfield, Mount Pleasant, Tipton, McGregor, etc.

HONEY BEE VISITS

Ames, August 14, 1918. Cloudy, cool, dry. Bees abundant.

Citrullus Neck.

Monoecious, with long vines running along the ground. Plants hairy, with branched tendrils. Leaves deeply pinnatifid. Flowers of medium size, light yellow, solitary in the axils. Corolla 5-parted nearly to the base, anthers free, stigmas 3.

Pellett in "American Honey Plants" states, "Where grown on a commercial scale the watermelon is the source of some honey. The bees visit the blossoms eagerly for both pollen and nectar."

Citrullus vulgaris Schrad. Watermelon

Hairy annual. Leaves cordate at base, pinnately divided into 3 or 4 pairs of lobes. A form with 2 or 3 forked tendrils. Calyx bell-shaped, corolla deeply 5-cleft, widely spread, pale yellow. Fruit large, globular or elongated. Seeds white or black, flat, smooth.

The pale yellow corollas of the watermelon are widely spreading. Nectar is secreted at the base of the flower. The bee uses the petals as a resting place while obtaining nectar. It first brushes to one side and then passes over the stamens to the opposite side of the flower, from which the nectar is taken, and then visits another flower. The visits are confined to the watermelon. In other words, the insects do not pass from the watermelon to the nutmeg or cantaloupe. Also noted other Hymenoptera and Diptera.

It is frequenty stated that watermelons and pumpkins will mix, but experiments made by the senior author, E. F. Castetter and A. T. Erwin indicate that this is not true.

HONEY BEE VISITS

Honey bees pollinate the flower. They are not infrequent.
Muscatine, Aug. 5, 1927. Honey bees noted.

Cucumis (Tourn.) L.

Tendrils simple. Sterile flowers in clusters, the fertile ones solitary in the axils. Fruit with a fleshy rind.

Cucumis Melo L. Cantaloupe

Leaves round, heart-shaped, the lobes, where present, and sinuses rounded. Fruit with a smooth rind and sweet flesh, the edible part being the inner portion of the pericarp. From southern Asia. Widely cultivated in sandy, black and clay soils.

The largest areas under cultivation occur in the sandy bottoms of the lower Des Moines, Skunk, Iowa and Cedar rivers. Grown at Wapello, Muscatine, Conesville, Cedar Rapids, Ames, Marshalltown, Tama, Iowa City, Boone, Fort Dodge, Algona, Le Mars, Rock Rapids, Sioux City, Council Bluffs, Hamburg, Shenandoah, Clarinda, etc.

HONEY BEE VISITS

Bees were observed abundantly on this species at Conesville and Muscatine on August 5, 1928.
Conesville, August 5, 1927, 11:30 a.m. Several bees. Three seconds in a flower.

Bees have also been observed at Ames, Marshalltown, Clinton and other places.

Cucumis sativus L. Cucumber

Leaves more or less lobed, the lobes acute. The fruit rough or muricate when young, smooth when mature. Cultivated in various soils, sandy, clay and black prairie soils.

The cucumber is dependent upon bees for pollination of its flowers, since the pistillate and staminate flowers are in separate flowers of the same plant, that is, monoecious. Cucumbers are an important source of honey in some localities.

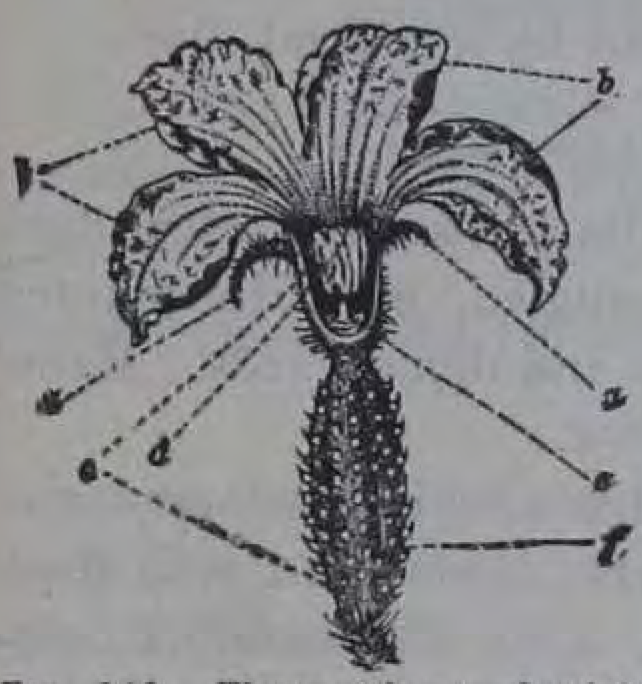

FIG. 340.—Flower of cucumber (*Cucumis*) (*After Thomé*). a. sepal; b. pistil; d. stigma; e. style; f. ovary. *Pieters U. S. Dept. of Agr.*

A. I. and E. R. Root state that in the vicinity of pickling factories it yields quite a harvest of honey.

Frank Pellett states that where pickles have been grown under glass they have proved unfruitful until bees are given access to the bloom. According to B. N. Gates, one grower had 40 acres under glass in Massachusetts and the industry required about three thousand colonies of bees annually to serve in the cucumber greenhouses.

Dr. Miller of Marengo, Illinois, reports the cucumber as a honey plant.

The cucumber is widely cultivated. The chief regions of its culture are the Cedar, the lower Des Moines, Iowa and Skunk rivers, Algona, Ames, Boone, Carroll, Cedar Rapids, Centerville, Cherokee, Clarinda, Council Bluffs, Creston, Decorah, Des Moines, Dubuque, Forest City, Fort Dodge, Hamburg, Jefferson, Le Mars, Little Rock, Manchester, Marshalltown, Mason City, McGregor, New Albin, Osage, Rock Rapids, Shenandoah, Sioux City, Strawberry Point.

HONEY BEE VISITS

Ames, July 20, 1918. Clear day. Visited by both black and Italian bees. Bees abundant on both.

August 13, 1918, 12 m. to 3 p.m. Hot day, slight northwest wind. Abundance of bees. Flowers closed later in the day.

August 14, 1918. Dry, warm, cloudy. Honey bees abundant on cucumber and sugar melons.

Spirit Lake, August 18, 1918. Clear day. Visited by both black and Italian bees.

Wisconsin—Galesville, Wauzeka (L. H. Pammel), Oshkosh (Mrs. Joseph Clemens).

HONEY BEE VISITS

The honey from this plant is reputed to be white and of pleasant flavor.

Honey bees are rather frequent on the plant in Iowa. They were observed commonly at McGregor and Clayton, Iowa, and La Crosse, Wisconsin.

CAMPANULACEAE, Bellflower Family

Small herbs with milky juice, alternate simple leaves, regular campanulate flowers which are usually blue; calyx tube adnate to ovary, limb 5-parted, stamens usually free, style one, stigma 2 or more; fruit a capsule.

Campanula (Tourn.) L. Bellflower

Annual, biennial or perennial herbs with root leaves often unlike those of the stem. Flowers in spikes, racemes, or paniculate. Calyx 5-cleft; corolla generally bell-shaped, 5-lobed; stamens 5, separate, stigmas generally 3, flowers generally blue.

The flowers are markedly proterandrous. The nectar is secreted by a yellow fleshy disc situated on the ovary and surrounding the style. When the anther dehisces the style elongates and pushes the pollen out and the stamens contract so that bees creep into the flower. They first come in contact with the brush hairs, and then leave the pollen on the stigma of an older flower.

Honey bees have been reported on quite a number of species. In Europe Knuth reports honey bees on *Campanula rotundifolia*, the common harebell or bluebell.

This is native to northeastern Iowa on limestone rocks, extending westward, for instance, to Iowa Falls.

Campanula americana L. Tall Bellflower

An annual plant with simple stem about 3 feet high. Ovate, serrate, tapering leaves. A spike-shaped raceme with flowers clustered or solitary in the axils of the upper leaves. Corolla rotate,

FIG. 341.—Bellflower (*Campanula americana*). *Photograph by Geo. H. Munger.*

light blue, 2.5 inches broad; capsule opening by pores at the summit.

Moist rich soil, Ontario and New York to Nebraska, Arkansas and Georgia. It blooms from June to August.

Bottoms and second-bottom ravines, moist soil. Associated with *Verbesina helianthoides*, *Heracleum lanatum*, *Impatiens pallida*, *Ulmus americana*, *Quercus rubra*, *Acer saccharinum*, *A. nigrum*, *Cryptotaenia canadensis*, *Osmorrhiza longistylis*, *O. brevistylis*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium: Des Moines, Farmington, Liscomb, Lost Island lake, Madison county, Palo Alto county (L. H. Pammel); Algona, Armstrong, Clear Lake, Decorah (R. I. Cratty), Lake Okoboji, Milford (L. H. Pammel and H. S. Coe), Ames (G. W. Carver, S. W. Beyer, C. R. Ball and L. H. Pammel, Fred Rolfs), Cedar Rapids (R. E. Buchanan), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Kalona (D. N. Arnold), Ledges (Boone county) (two specimens, L. H. Pammel, C. M. King and R. E. Buchanan), Muscatine (L. H. Pammel, J. Kelso and E. R. Harlan), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Peru (D. E. Hollingsworth).

General distribution in the United States:

Illinois—Starved Rock, Fox (L. H. Pammel and Mark Heavenhill), Champaign (B. Fink); Missouri—Rolla (S. E. Meek); Minnesota—St. Cloud, St. Paul (R. Gmelin); Ohio—Kelley's Island (L. H. Pammel), Pickerington (Dr. Bigelow); Oklahoma—Muskogee (L. H. Pammel); Utah—Uintah Mountains (L. H. Pammel); Virginia—Marion (John K. Small); Wisconsin—La Crosse (two specimens), Wauzeka (L. H. Pammel).

HONEY BEE VISITS

Ames, College Park, July 25, 1914. Clear, southeast wind. Wild bees gathering pollen. (G.H.M.)

August 11, 1915. Partly cloudy, northwest wind. One bumble bee. (L.A.K.)

September 8, 1918. Still blooming.

"A good honey plant," Louis Dadant.

Campanula medium L. Canterbury Bells

Stout, erect, hispid-hairy biennial with root leaves oblanceolate. Flowers erect, ascending, showy, on stout peduncles. Violet-blue in color. Commonly cultivated.

HONEY BEE VISITS

Ames, July 22, 1927, 11 a.m. to 12 m. After rain, cloudy, warm. Some bees. Seven and seventeen seconds in a flower. (C.C.L.)

Campanula Rapunculoides L. Rampion

Biennial, erect, glabrous plant. Radical leaves many, 4 to 8 inches long; petiole long, margin crenulate. Flowers in long, erect, narrow racemes. Corolla open-bell-shaped, about one half inch long, lilac-colored. Commonly cultivated.

HONEY BEE VISITS

Ames, June 17, 1929, 2 p.m. Some honey bees. Twelve to fourteen seconds in a flower. The bee passes over the stigma and then down to the base of the flower. In the younger flowers it comes in contact first with the stamens, and in an older flower with the stigmas. Honey bees go to the flower chiefly for the pollen.

LOBELIACEAE, Lobelia Family

Annual herbs with milky juice; simple entire leaves; flowers in racemes, perfect, somewhat irregular, stamens 5 with anthers and filaments usually in a tube around the style; ovary 2-celled, style 1; fruit a united capsule.

Lobelia (Plumier) L. Lobelia

Herbs with alternate leaves. The flower with short tube and 5-cleft calyx. Axillary or in bracted racemes.

The flowers are proterandrous. The pollen is dehisced on the cylinder before the flower opens. When it is dehisced the style elongates and the pollen becomes attached to the brush hairs. Fertilization cannot take place except by pollen from a younger flower. Several of the species of *Lobelia* are humming-bird flowers. It is seldom they are pollinated by bees, though Knuth records the honey bee on *Lobelia* in Germany.

Studies have been made on the pollinations of this by Trelease and by Robertson.

Lobelia cardinalis L. Cardinal Flower

A tall, smooth, slender perennial. Flowers in racemes, intensely red. Low grounds and shores of streams. Associated with *Carex vulpinoidea, Cephalanthus occidentalis, Mentha canadensis, Lycopus sinuatus, Scutellaria galericulata, Veronica virginica, Thalictrum dasycarpum, Aster novae-angliae, A. ptarmacoides, Solidago serotina.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Falls, McGregor (two specimens) (L. H. Pammel); Ames (A. Hayden, S. W. Beyer), Bremer county (B. Fink), Guttenburg (R. Gmelin), Lee county (Paul Bartsch).

Other observations not represented by specimens were made by L. H. Pammel at Bellevue, Centerville, Clinton, Davenport, Des Moines, Dubuque, Iowa City, Lansing, Marquette, Marshalltown, McGregor, Mississippi river, Muscatine, New Albin.

FIG. 342.—Cardinal flower (*Lobelia cardinalis*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

General distribution in the United States:

Illinois—Cahokia (H. Eggert), Champaign (B. Fink), Iuka (H. I. Featherly), Utica (Mrs. Joseph Clemens); Indiana—Wells county (Charles C. Deam); Kansas—Wichita (T. L. Andrews); Kentucky—Poor Fork Post Office (T. H. Kearney, Jr.); Louisiana—(C. R. Ball); Massachusetts—Holyoke (Mrs. L. M. Parker); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (Muenscher and Bechtel), New Castle (New York Botanical Garden); Oklahoma—Norman (W. E. Bruner); Ohio—Baltimore (Augusta Shoeman), Buckeye Lake (L. H. Pammel); Wisconsin—Bluff Siding, Holmen, La Crosse (two specimens), Muscoda (L. H. Pammel).

Largely pollinated by humming-birds. Honey bees have been observed in the flowers. The nectar is too deep seated for them.

Robertson says, "Trelease saw this flower visited by humming-birds (*Trochilus colubris* L.). I have never failed to find them about the flowers, and there is no doubt that the flowers are specially adapted to them. The pendent lip shows that the flower is intended to be visited by a bird or insect which is in the habit of sucking the sweets from flowers without resting upon them."

Blooming, Boone, August 14, 1926.

Lobelia siphilitica L. Great Lobelia

A perennial herb, $1\frac{1}{2}$ feet high, with numerous ovate to lanceolate leaves. Flowers large, spicate, racemose, light blue, irregular; with long corolla tube and hirsute calyx. Low grounds, Maine westward.

Moist springy places in prairie, swamps, swampy places in alluvial bottoms. Associated with *Chelone glabra, Eupatorium perfoliatum, E. purpureum, Impatiens biflora.*

FIG. 343.—Great blue lobelia (*Lobelia siphilitica*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Charles City, Fertile, Forest City, Lime creek, Mason City, Rockwell City, Wheelerwood (L. H. Pammel); Big creek, Mount Pleasant, Skunk river (G. B. MacDonald and L. H. Pammel), Ames (R. E. Jeffs), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Fraser (two specimens, Botany Seminar), Iowa lake (L. H. Pammel and R. I. Cratty), Keokuk (P. H. Rolfs), Ledges (Boone county) (L. H. Pammel and O. F. Miller), northeastern Iowa (H. Goddard), Ontario (E. R. Hodson), Osage (Mrs. F. M. Tuttle), Scott county (C. LeBuhn), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

It has been observed (L. H. Pammel) at Burlington, Clear Lake, Clinton, Des Moines, Dubuque, Emmetsburg, Estherville, Jewell Junction, Keosauqua, Lansing, Maquoketa, Mason City, Postville, Spirit Lake, Story City, Waukon.

General distribution in the United States:

Colorado—Cache la Poudre river (L. H. Pammel), Laramie county (J. H. Cowan); Illinois—Hamilton (L. H. Pammel and F. Pellett), Peoria (F. E. McDonald); Kentucky—Bell county (T. H. Kearney, Jr.); Louisiana—(T. L. Andrews); Maryland—High Island (Lyster H. Dewey); Minnesota—Cass Lake, Star island (H. E. and L. H. Pammel and P. S. McNutt), Clear Lake (L. H. Pammel), Leech Lake (Walker); Missouri—Marion county near Mark Twain's Cave (two specimens), St. Louis (P. T. Barnes); Nebraska—Callaway (J. M. Bates), Scott's Bluffs county (F. G. Miller), Sheridan county (R. E. Buchanan); Ohio—Pickerington (Dr. Bigelow); Texas—Tarrant county (Albert Ruth); Washington—eastern Washington (Stella L. Goodspeed); Wisconsin—La Crosse, Portland (Emma Pammel, C. M. King and Dora Pammel), Fond du Lac (L. H. Pammel).

FIG. 344.—Great blue lobelia (*Lobelia siphilitica*). *Drawn by C. M. King.*

HONEY BEE VISITS

The large blue flower is especially adapted to bumble bees, by which it is visited. It is not usually one of the honey bee flowers.

Ames, near Skunk river, August 21, 1914, 2 to 5 p.m. Clear, north wind. One honey bee, many *Bombus*, two other Hymenoptera getting nectar and pollen. Bees go to base of flower, have pollen on legs. Twenty per flower per hour. Pass from this plant to *Cirsium*. (G.H.M.)

Norwalk, September 7, 1927, 4:20 p.m. (near apiary). The flowers are perforated. Bees thirty to twenty seconds in a flower.

COMPOSITAE, Composite Family

Flowers with the corolla either strap-shaped or tubular. The tubular flowers are mostly 5-lobed. Stamens 5 or 4, inserted on the corolla, their anthers united into a tube (syngenesious). Calyx tube adnate to the ovary. This is in the shape of bristles, awns, scales or cup-shaped. Flowers are monoecious, dioecious or polygamous. Fruit dry, an achene containing a single seed. Heads either discoid or strap-shaped or all discoid. The flowers with a strap-shaped corolla are called ray flowers. The tubular flowers are called disc flowers. The receptacle is sometimes chaffy.

This is a large family, of which few plants have any agricultural importance. Widely distributed over the earth's surface. A large number of the species are honey plants.

History. The family has been studied by many authors and much has been written on the subject of pollination. Koelreuter[1] as early as 1766 observed the sensitive stamens. Hermann Mueller[2] in 1873 gave a review of the mechanisms for pollination. Hildebrandt[3] in 1869 made an exhaustive study of the style with reference to Com-

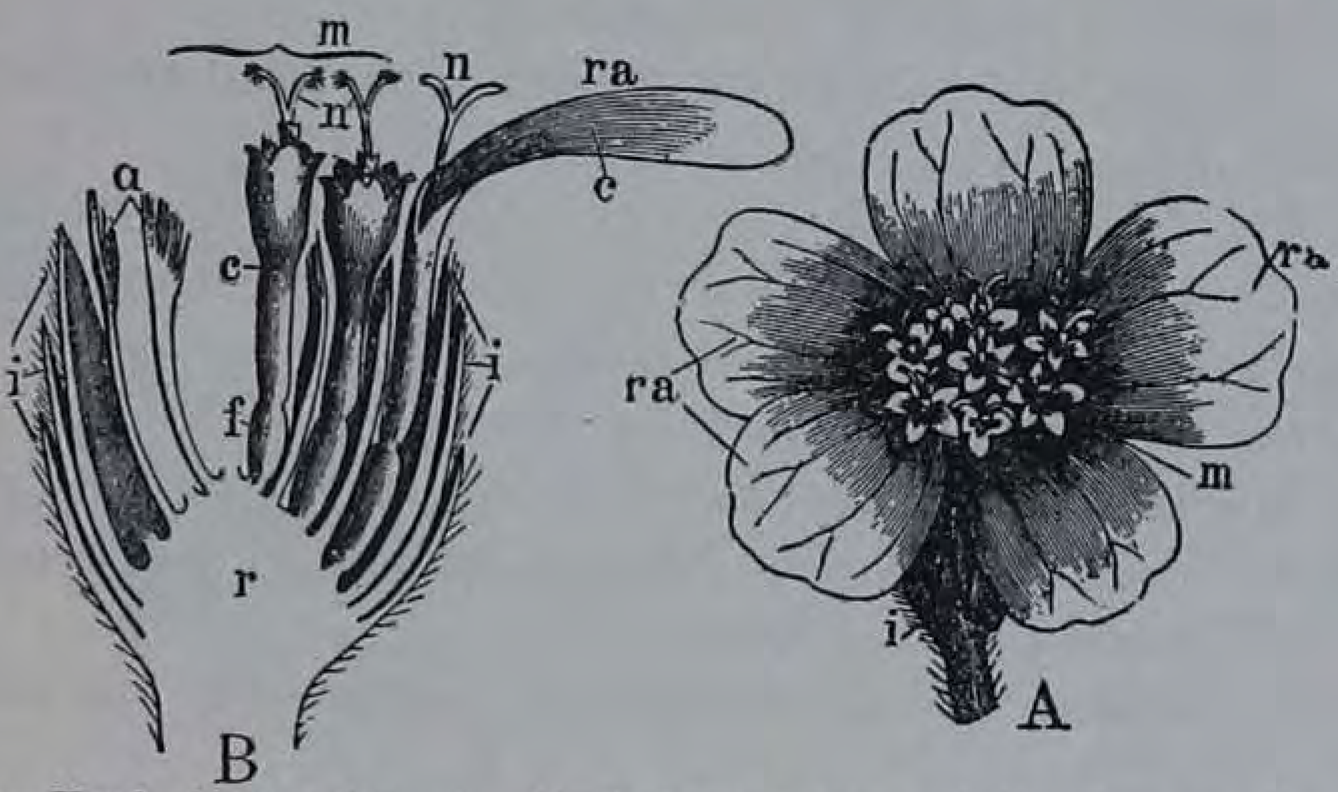

FIG. 345.—Head of composite. A. Head showing rays and disc flowers. B. Showing head in section, with disc and ray flowers. *After Thomé.*

positae. Delpino[4] in 1870, earlier than Mueller, discussed methods of pollination in the Compositae. Sir John Lubbock[5] contributed to the knowledge of pollination. Paul Knuth[6] in his Handbook of Flower Pollination collected the material on the family. Loew[7] and other European botanists have described in detail the pollination of the family. MacLeod[8] made many important contributions.

Many American studies have been made. Of these mention may

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1 Fortsetzung der vorläufigen Nachricht, 199.

2 Befruchtung der Blumen, (Fertilization of Flowers), 315.

3 Geschlechts verhaltniss bei den Compositen.

4 Ulteriori osservazioni sulla dicogamia nel regno vegetale.

5 On British wild flowers considered in relation to Insects.

6 Handbook of Flower Pollination, 2:568. English translation.

7 Beobachtungen uber den Blumenbesuch von Insekten au Freilandpflanzen des Botanischen Gartens zu Berlin.

Weitere Beobachtungen uber den Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin.

8 Bot. Jaarb. Dodonea Ghent.

corollas, or by the production of a limb of each into a long outer lobe.

"Nectar is secreted by a ridge surrounding the base of the style. It is so abundant as to rise in the corolla-tube and is protected from rain by the filaments which converge above it. It is accessible to both long-tongued and short-tongued insects. It is advantageous to nectar production, also, that the heads close in unfavorable weather."

The plants of this family are so widely distributed and so common everywhere in Iowa that the Composite group must be considered an important source of honey. Most of the plants come

FIG. 347.—Ironweed (*Vernonia fasciculata*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

into bloom in July and August and continue until frost. However, a few, like the dandelion, are early bloomers, beginning soon after frost is out of the ground and continuing through May; they then disappear and again bloom in September until cold weather. The different species occur on a variety of soils—clay, sandy, rocky, calcareous, drift and alluvial.

Vernonia Schreb. Ironweed

Perennial herbs, with leafy stems several in a group, and alternate leaves. Flowers rose-colored, in close cymes. Heads discoid, 15- to many-flowered, perfect.

The flowers are proterandrous. Branches of the style are long and threadlike, minutely bristly-hairy all over. The styles push open, the brush hairs gather the pollen, then the styles curve back. The insect in taking nectar out of the flower comes in contact with the brush hairs and then when it goes to another flower it leaves some of the pollen upon the stigma.

Vernonia fasciculata Michx. Ironweed

A bushy perennial herb 3 to 5 feet in height, with leafy stems. Leaves ascending, narrow, green and nearly glabrous beneath; heads rather small in a close cyme, about 20-flowered. Flowers reddish purple. Prairies, Ohio westward.

Alluvial bottoms, alluvial soils along shores of lakes and ponds, moist sandy soils or in decomposed peat. Associated with *Carex vulpinoidea, Polygonum acre, P. Muhlenbergii, P. lapathifolium, Thalictrum dasycarpum, Mimulus ringens, Aster Tradescanti.*

In the middle west these flowers are common in pastures, and are conspicuous in late summer.

Honey bees collect some honey from this plant. At Ames, after rains, there is considerable honey flow.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

(Specimens identified by Gleason), Adel, Des Moines, Eagle Grove, Hawarden, Lost Island lake, Marshalltown, New Albin, Oakland, Wheelerwood (L. H. Pammel); Algona (E. B. Watson), Ames (M. Reynolds, Herb. Nat. Hist. Soc., A. S. Hitchcock, Fred Rolfs), Charles City (L. H. Pammel and E. M. Sherman), Clinton (Lyons), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Floyd county (Mrs. F. M. Tuttle), Iowa City (A. S. Hitchcock), Kelley (Botanical Seminar, Pearl Clayton), Lawler (P. H. Rolfs), Lee county (Skunk River bottom) (Paul Bartsch), Manchester (C. R. Ball), Marshalltown (F. C. Stewart), Muscatine (F. Reppert), Newton (G. Drew), northeastern Iowa (H. Goddard), Ontario (E. R. Hodson), Story county (a biological form with wide leaves) (Nettie Bannister), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

Observed by L. H. Pammel at Adel, Burlington, Dallas Center, Keosauqua, Missouri Valley (common type), Pammel Park, Sioux City, Tama, Wapello.

General distribution in the United States:

Illinois—Chicago (Dr. Stennett), Kankakee (R. I. Cratty), Walnut (L. H. Pammel); Louisiana—(T. L. Andrews); Michigan—Whitehall (L. H. Pammel); Nebraska—Galloway (J. M. Bates), Holdrege (J. G. McMillan), Lincoln county (F. G. Miller); Oklahoma—Muskogee (L. H. Pammel); South Dakota—Brookings, Wahpeton (L. H. Pammel), Highmore (Mr. Quick); Wisconsin—Galesville, Holmen, La Crosse (two specimens), Madison (L. H. Pammel).

HONEY BEE VISITS

Ames, August 4, 1914. Clear, south wind. Three bees on each cluster per minute. (G.H.M.)

Hamburg, August 25, 1928, 3 p.m. Bees one second in a flower.

Bees have since been observed upon this species in the vicinity of Ames. During some years it probably yields considerable nectar.

Loew and Knuth observed the honey bee in Germany.

Vernonia missourica Raf. Missouri Ironweed

Tall, stout perennial herb. Leaves large. Heads medium sized, 35- to 50-flowered. Involucre greenish, bracts narrow, appressed. Pappus tawny or slightly purple. Prairies, Illinois southward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

(Specimens identified by Gleason)—Des Moines county (Paul Bartsch), Indianola (L. H. Pammel), Keokuk (P. H. Rolfs).

General distribution in the United States:

Illinois—Champaign (two specimens, B. Fink), Starved Rock (L. H. Pammel and Mark Heavenhill); Indian Territory—West of Fort Smith, Arkansas (P. H. Rolfs); Missouri—St. Louis (two specimens, P. T. Barnes), Wicks (two specimens), St. Louis (two specimens, L. H. Pammel); Nebraska—Lincoln (R. Gmelin); Texas—Pierce (Green), Texarkana (A. A. and E. G. Heller).

HONEY BEE VISITS

Honey bees have been observed upon this species in Keokuk.

Vernonia Baldwini Torr. Baldwin's Ironweed

Perennial herbs with leafy stems. Surface of the plant tomentulose; heads medium-sized, about 30-flowered; leaves lanceolate-oblong; involucre arachnoid, greenish, the bracts squarrose, acuminate.

Found upon prairies and barren hills from Iowa to Texas. Clay soils, uplands, or less commonly in alluvial bottoms. Associated with *Solidago ulmifolia, S. latifolia, Hedeoma pulegioides, Aster Drummondii, Poa compressa, Aristida gracilis, Vitis vulpina, Celastrus scandens, Quercus alba, Q. macrocarpa, Carya ovata.*

FIG. 348.—Ironweed (*Vernonia Baldwini*). *Photograph by Colburn.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Adel, Centerville, Cooper creek, Des Moines, Glenwood, Hamburg, Henry county, Indianola, Nevada, Sioux City (L. H. Pammel); Creston (T. L. Andrews), Decatur county (J. P. Anderson), Des Moines (A. L. Bakke, G. W. Carver, A. S. Hitchcock), Greenfield (F. C. Stewart).

General distribution in the United States:

Kansas—Wichita (three specimens, T. L. Andrews); Illinois—Utica (Mrs. Joseph Clemens); Missouri—Little Blue Tank (Kenneth K. Mackenzie), St. Louis (P. T. Barnes); Nebraska—Callaway (J. M. Bates), Holdrege (G. M. McMillan), Simeon (J. M. Bates); Oklahoma—Muskogee (L. H. Pammel), Yale (A. H. Van Vleet); Texas—Kerr county (A. A. Heller), San Marcus (L. H. Pammel).

HONEY BEE VISITS

Lancaster, Missouri, July 25, 1927, 12 m. Flowers in full bloom. No bees.

Winterset, August 28, 1928, 12:30 p.m. Bees one second in a flower.

Des Moines, August 28, 1929, 11 a.m. Bees fairly common. One second in a flower.

FIG. 349.—Baldwin's ironweed (*Vernonia Baldwini*). *Photograph by the Eckerman Studio.*

Keokuk, September 2, 1929. No bees. (Near apiary.)
Bees have been seen abundantly on this plant at Centerville and Keosauqua.

Ageratum L. Ageratum

Annual garden herbaceous plants. Leaves opposite, ovate. Heads tassel-like, clustered.

Ageratum conyzoides L. Garden Ageratum

Heads about one-fourth inch across, flowers blue or white. Blooms throughout the summer.

HONEY BEE VISITS

Shenandoah, August 27, 1928, 11 a.m. Warm, partly cloudy. Bees one second in a flower.
Centerville, September 1, 1929, 9 a.m. Warm. Rain night before. Bees one second in a flower.

Eupatorium (Tourn.) L. Thoroughwort

Perennial herbs, mostly erect, with alternate leaves and white or purple flowers in clusters. Heads discoid, 3- to many-flowered. Flowers perfect.

FIG. 350.—Baldwin's ironweed (*Vernonia Baldwini*). *Photograph by the Eckerman Studio.*

POLLINATION

History. The pollination of this genus (the type species *Eupatorium cannabinum* L.) was studied by Hermann Mueller,[1] Kerner,[2] MacLeod,[3] Knuth[4] and Loew.[5] Robertson[6] studied several other members of this genus.

1 Fertilization of Flowers, 318. Alpenblumen, 450.

2 Natural History of Plants.

3 Bot. Jaarb. Dodonaea.

4 Bloembiol Bijdragen.

5 Beobachtungen über den Blumenbesuch von Insekten an Freilandpflanzen des Botanischen Gartens zu Berlin.

6 Flowers and Insects, Rosaceae and Compositae. Trans. Acad. Sci. of St. Louis, VI:452-453.

The flowers are proterandrous. The branches of the style are thickened upward or club-shaped, minutely pubescent. The style pushes up the pollen as it lengthens out. The brush hairs are conspicuous and densely clothe the style.

Eupatorium purpureum L. Joe-Pye Weed

Stout herbs with whorled finely crenate leaves; flower heads cylindrical, in paniculate clusters, pale pink to whitish. Low grounds, New England westward and southward.

FIG. 351.—Joe-Pye weed (*Eupatorium purpureum* var. *maculatum*). *Photograph by Roger Preston.*

In peaty swamps and marshes and low woods. Associated with *Eupatorium perfoliatum, Aster umbellatus, Veronica virginica, Thalictrum dasycarpum, Cardamine rhomboidea.*

Robertson states, "The purplish color of the florets and the slender tubes seem to indicate an adaptation to butterflies." He records the honey bee on this plant. Loew reports the honey bee on this species in Germany.

The Joe-Pye weed is frequently reported as yielding honey and is listed by John Lovell as a good honey plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dakota City, Estherville, Glenwood, Hanlontown, Indianola, Lansing, McGregor, Saratoga (L. H. Pammel); Adel (C. F. Clark), Ames (L. H. Pammel and C. R. Ball, F. Rolfs, Mina Belle Lynch), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Fayette (B. Fink), Kelley (Pearl Clayton), Lamont (I. T. Bode), Oakland Mills (H. E. Jaques), Osage (Mrs. F. M. Tuttle).

It has also been observed (L. H. Pammel) in marshy, boggy places, springs, borders of lakes and brooks, in drift areas—Algona, Anamosa, Bellevue, Belmond, Cedar Rapids, Cherokee, Clear Lake, Clinton, Cresco, Decorah, Delhi, Dubuque, Eagle Grove, Eldora, Elkader, Emmetsburg, Fertile, Forest City, Fort Dodge, Hardin county, Jefferson, Jewell, Lake Okoboji, Lake View, Lehigh, Mallard, Manchester, Marshalltown, Mason City, Monticello, New Albin, New Hampton, Nora Springs, Palmer, Peterson, Pine creek, Pocahontas, Postville, Rock Rapids, Ruthven, Sac City, Spencer, Storm Lake, Waukon, Webster City, Wheelerwood, Worth county.

General distribution in the United States:

Arkansas—Fayetteville (two specimens, P. H. Rolfs); Colorado—Fort Collins (C. S. Crandall); District of Columbia—Pine Branch road (C. R. Ball and A. E. Paddock); Illinois—Fox (L. H. Pammel and Mark Heavenhill), Peoria (F. E. McDonald); Kentucky—Poor Fork Post office (T. H. Kearney, Jr.); Louisiana—(two specimens, T. L. Andrews); Maryland—Principio Furnace (F. E. Trenk); Massachusetts—Deerfield (M. A. Day); Michigan—Muskegon (L. H. Pammel); Minnesota—Cloquet, Itasca State Park (L. H. Pammel), Duluth (L. H. and H. E. Pammel), Cass Lake, Star Island (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (R. Gmelin); Nebraska—Shenandoah county (R. E. Buchanan); New Jersey—Asbury Park (L. H. Pammel); New York—Ithaca (H. E. Summers), Niagara Falls (G. H. Frazier); Ohio—Columbus (J. S. Hines); South Carolina—Abbeville (M. F. Hexamer), Pickens county (three specimens, A. P. Anderson); Wisconsin—Forest county, St. Croix (L. H. Pammel), St. Joseph's Ridge (R. Gmelin), Kankauna (J. H. Schuette), La Crosse (L. H. and Gladys Pammel).

HONEY BEE VISITS

A showy sweet scented composite which attracts many insects.

Ames, July 25, 1914. College Park. Clear, southeast wind. Two bees on a cluster each minute. Other insects at work, wild bees, flies, beetles. (G.H.M.)

July 27, 1914. Clear, west wind. Four insects per cluster per minute. A few bees, *Bombus*, flies, several moths. Many small bees and wasps. (G.H.M.)

McGregor, August 9, 1922, 1:30 p.m. Plants abundant. Average of 1500 flowers to each plant. Honey bee one second in each flower.

This species furnishes some honey in some localities. Honey bees visit it rather freely.

Eupatorium purpureum var. *maculatum* (L.) Darl. Spotted Joe-Pye Weed

This plant resembles *E. purpureum* but is more pubescent; the leaves are thicker, more rugose, and more coarsely toothed. The flat-topped panicles are rose-colored to pale purplish and more crowded. Found generally in drier places than the species. Newfoundland westward and southward.

Fig. 352.—Joe-Pye weed (*Eupatorium purpureum* var. *maculatum*). *Photograph by G. H. Munger.*

In moist upland woods. Associated with *Verbesina helianthoides*, *Heracleum lanatum*, *Rudbeckia laciniata*, *Cryptotaenia canadensis*, etc.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City, Forest City, Madison county, McGregor (L. H. Pammel); Ames (Mina Belle Lynch, L. H. Pammel and C. R. Ball), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Osage (Mrs. F. M. Tuttle), Winneshiek county (H. Goddard).

It has been observed (L. H. Pammel) at Algona, Boone, Cedar Rapids, Clinton, Des Moines, Dubuque, Fort Dodge, Hampton, Iowa Falls, Marshalltown, Mason City, New Hampton, Webster City.

General distribution in the United States:

Minnesota—Brainerd (E. B. Watson); Cass Lake (L. H. and H. E. Pammel), Norway Beach (L. H. Pammel); South Dakota—Sisseton (L. H. Pammel); Wisconsin—St. Croix Falls (L. H. Pammel).

HONEY BEE VISITS

McGregor, August 5, 1923, 12 m. Dry, cloudy. Bees one or two seconds. Clay soil. Top of hill.

August 8, 1923. (Rain on preceding day). Bees present.

It furnishes considerable nectar at times. In 1926 many bees were observed upon this plant near McGregor after a rain.

FIG. 353.—Joe-Pye weed (*Eupatorium purpureum* var. *maculatum*). *Photograph by A. Hayden.*

Eupatorium serotinum Michx. Late-flowering Thoroughwort

Stout herb with cylindrical heads in corymbs, leaves long-petioled. Stem pubescent, 1 meter to 2 meters high, leaves ovate-lanceolate, pointed, triple-veined, serrate. Alluvial ground, Maryland to Minnesota and southward. Associated with *Vernonia fasciculata, Lycopus rubellus.*

Robertson says, "The tubes are shorter and broader than in *E. purpureum,* and consequently there are many more short-tongued species on the flowers." He records the honey bee sucking and collecting pollen.

FIG. 354.—Joe-Pye weed (*Eupatorium purpureum* var. *maculatum*). *Photograph by G. H. Munger.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche (L. H. Pammel).

General distribution in the United States:

Florida—Jacksonville (A. H. Curtiss); Illinois—Peoria (F. E. McDonald); Kentucky—Bell county (T. H. Kearney, Jr.); Louisiana—(two specimens, T. L. Andrews); Minnesota—Leech Lake, Walker (L. H. Pammel); Missouri—Wicks (L. H. Pammel), Sheffield (Kenneth K. Mackenzie); New Jersey—Asbury Park (L. H. Pammel); Oklahoma—Kingfisher (M. A. Carleton); Texas—Pierce (S. M. Tracy), Seguin (B. H. A. Groth), Tarrant county (Albert Ruth).

HONEY BEE VISITS

C. P. Dadant considers this a honey plant. It blooms abundantly from the middle of August to the middle of September. Honey bees visit the flowers freely for nectar and pollen, especially after showers and in localities where there is considerable moisture in the soil.

Lovell states that in Todd county, Kentucky, 75 per cent of the flow of honey comes from this plant.

Walnut, Illinois, September 14, 1918. Common in the woods. Bees common.

Eupatorium altissimum L. Tall Boneset

A tall, stout, downy plant; leaves three-nerved, tapering at both ends; flower clusters dense, white.

Favors dry rocky limestone soils, prairies. Associated with *Aster* *sericeus, Bouteloua curtipendula, Andropogon scoparius, Triodia seslerioides.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche, Centerville, Charles City, Dakota City, Decorah, Eagle Grove, Madison county, Marion county, Shenandoah (L. H. Pammel); Ames (R. E. Jeffs), Decatur county (J. P. Anderson), Fayette (B. Fink), Mount Pleasant (H. E. Jaques), northeastern Iowa (H. Goddard).

It has also been observed (L. H. Pammel) at Burlington, Clinton, Davenport, Des Moines, Fort Dodge, Keokuk, Keosauqua, Mason City, McGregor, Mount Pleasant, Oakland Mills.

HONEY BEE VISITS

Montrose, September 2, 1929. Bees numerous. One second in a flower.

Eupatorium perfoliatum L. Thoroughwort

A stout perennial with opposite leaves united at the base about the stem, tapering, serrate, veiny, downy beneath. The numerous heads crowded in a dense 10- to 30-flowered corymb. Flowers white. Low wet grounds, peaty soil, borders of lakes and springy places. Generally distributed. Associated with *Aster umbellatus, A. novae-angliae, Eupatorium purpureum, Polygonum sagittatum, Scirpus atrovirens, Cirsium muticum, Gentiana crinita, Poa triflora, Calamagrostis canadensis.*

Robertson records the honey bee upon this plant.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, Charles City, Clinton, Eagle Bluff, Emmetsburg, Hanlontown, Lake Mills, Ogden, Saratoga, Spirit Lake, Waterloo (L. H. Pammel); Ames (P. H. Rolfs, Mina Belle Lynch), Clear Lake (R. I. Cratty), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (G. W. Carver), Fayette (B. Fink), Kelley (Pearl Clayton), Iowa lake (L. H. Pammel and R. I. Cratty), Osage (Mrs. F. M. Tuttle), Salem (L. H. Pammel and H. E. Jaques), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

It has also been observed (L. H. Pammel) at Forest City, Fort Dodge, Garner, Hampton, Humboldt, Jefferson, Jewell, Marshalltown, Mason City, McGregor, New Hampton, Perry, Postville, Waukon, Webster City.

General distribution in the United States:

Illinois—Peoria (F. E. McDonald); Massachusetts—Deerfield (M. A. Day), Gray Herbarium, Winchester (M. L. Fernald and C. A. Weatherby); Michigan—Muskegon (L. H. Pammel); Nebraska—Callaway (J. M. Bates), Halsey (J. C. Blumer); Minnesota—Cass lake, Howard lake, Leech lake, Walker (L. H. Pammel), Cedar Island (L. H. and H. E. Pammel), Minneapolis (R. I. Cratty), Star Island (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (R. Gmelin); North Carolina—Highlands (C. H. Boynton); New York—Ithaca (Muenscher and Bechtel, H. E. Summers), Niagara Falls (G. H. Frazier); Oklahoma—Norman (W. E. Bruner); Virginia—Arlington (C. R.

Ball and A. E. Paddock); Wisconsin—Muscoda, St. Croix Falls, Wauzeka (L. H. Pammel), La Crosse (L. H. and Gladys Pammel).

HONEY BEE VISITS

The boneset blooms throughout the later summer and its honey is usually found mixed with that of the other fall plants. Honey bees are frequent on the species and it is a good safe honey plant. John H. Lovell states that the odor and flavor of the honey are at first very rank and strong and that it retains its flavor for some time. Pellett states that it is one of the honey plants in the northern states and Canada.

Ames, Sept. 3, 1914. College Park. Clear, southeast wind. Twelve per head per hour. Honey bees, wasps, *Bombylius*, beetles, Diptera predominate. (G.H.M.)

Escanaba, Michigan, to Milwaukee, Wisconsin, August 12, 1927. In bloom.

Bees were noted on this plant at the Iowa-Minnesota border line north of Mason City in 1927.

Eupatorium urticaefolium Reichard. White Snakeroot

A smooth, branching perennial 1 foot to 2½ feet high. Leaves opposite, thin, broad, ovate, pointed, with sharp, coarse teeth, long petioles. Heads 8- to 30-flowered in compound corymbs. Frequent throughout the region, in rich woods.

FIG. 355.—White snakeroot (*Eupatorium urticaefolium*). *Drawn by Lois Pammel.*

In woods, clay and gravel soils, or black sandy soil. Associated with *Aster sagittifolius*, *A. Drummondii*, *Prunella vulgaris*, *Solidago latifolia*, *S. ulmifolia*, *Viola cucullata*, *V. pubescens*, *Claytonia virginica*.

The pollination of this species has been described by Charles Robertson, who reports the honey bee as getting pollen and nectar.

These plants are visited freely by honey bees, which collect both pollen and honey. The species is one of the very reliable honey plants of our woodlands. Though the plant is toxic to animals there is no evidence that the honey is poisonous.

Pellett states that bees visit this species freely and he is authority for the statement that though the plant is common over the state of Tennessee it

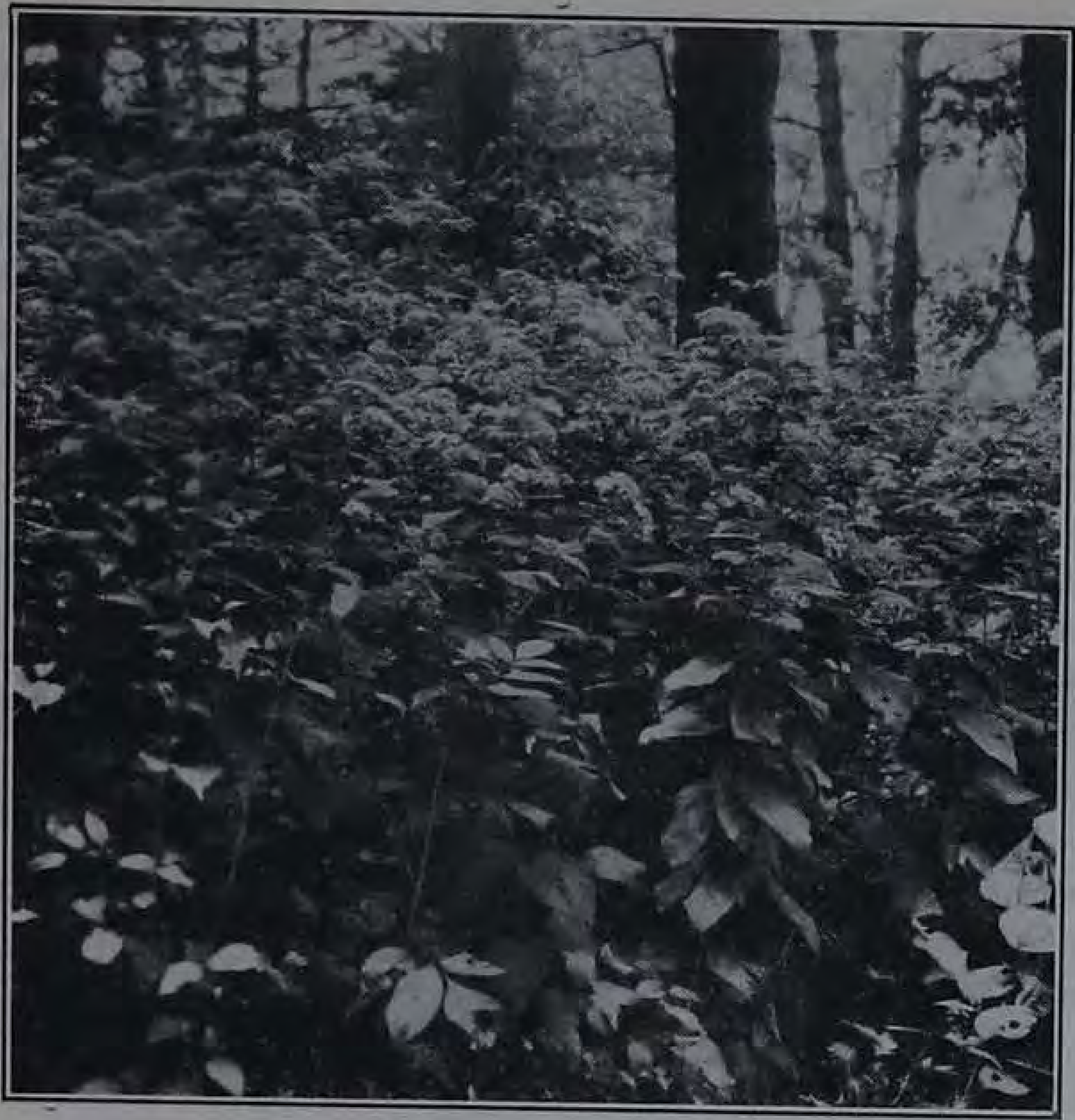

FIG. 356.—White snakeroot (*Eupatorium urticaefolium*). *Photograph by the Ia. Agr. Exp. Sta.*

yields only in the northern part. This same species, according to Lovell, yields much honey in Alabama.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche, Forest City, Gillett Grove, Glenwood, Greene, Hamilton county, Lime Springs, Nashua, Perry, Rochester, Spirit Lake, Wallingford, Waterville (L. H. Pammel); Armstrong, Clear Lake (R. I. Cratty), Lake Okoboji, Milford (H. S. Coe), Ames (Ada Hayden, L. H. Pammel and C. R. Ball, Mina Belle Lynch), Atlantic (F. G. Pellett), Belmond (G. C. Clark), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Fraser (Botany Seminar), Harlan (W. M. Bomberger), Keokuk (P. H. Rolfs), northeastern Iowa (H. Goddard), Ontario (E. R. Hodson), Rockford (C. L. Webster), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott), Waterville (I. Stang), Westchester (S. L. Goodspeed).

This plant has been observed (L. H. Pammel) at Burlington, Clinton, Council Bluffs, Davenport, Des Moines, Dubuque, Fairfield, Fort Dodge, Fort Madison, Hamburg, Iowa City, Keokuk, Keosauqua, Lake Mills, Marshalltown, McCallsburg, Mount Pleasant, Nevada, Oakland Mills, Sioux City, Story City, Webster City.

General distribution in the United States:

Illinois—Chicago (Stella L. Goodspeed); Kentucky—Bell county (T. H. Kearney, Jr.); Massachusetts—Deerfield (M. A. Day); Minnesota—Granite

Falls, Lake City, Monticello, Ortonville (L. H. Pammel), Rochester (Mrs. George Ainslie), St. Cloud (R. Gmelin); Missouri—Allenton (George W. Letterman); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (Muenscher, Bechtel, H. E. Summers), Watkins Glen (L. H. Pammel); Ohio—Pickerington, Worthington (Floyd, M. D., J. N. Floyd), (Asa Horr Herbarium); Oklahoma—Norman (W. E. Bruner); South Dakota—Sioux Falls (L. H. Pammel); Virginia—Great Falls of the Potomac (C. R. Ball); Wisconsin—Holmen, Galesville, Muscoda, Wauzeka (L. H. Pammel), La Crosse (Dora S. Pammel).

HONEY BEE VISITS

Ames, September 8, 1918. Bees observed on this plant. "Considered a good honey plant"—(C. P. Dadant).

September 17, 1929, 1:30 p.m. Cool, west wind, clear. No bees. Near *Bidens cernua.*

September 26, 1929, 10:30 a.m. Warm and clear. Bees a few only. Moment only.

3:30 p.m. No honey bees although abundant on New England aster adjacent.

Dr. H. H. Knight reports the following insect visitors:

Coleoptera: Yellow flower beetle (*Chauliognathus pennsylvanicus* De G.).

Hemiptera: Tarnished plant bug (*Lygus pratensis* L.).

Kuhnia L. Kuhnia

Perennial herbs, with resinous dotted leaves, and paniculate-corymbose heads of cream-colored flowers. Heads discoid with 10 to 25 perfect proterandrous flowers. The branches of the style are thickened upward, minutely pubescent. Abundant upon hills.

Kuhnia eupatoroides L. False Boneset

A perennial slightly pubescent plant about two to four feet tall. Leaves various. Flowers cream-colored.

Drift soils, sandy knolls. Associated with *Aster laevis, A. multiflorus, Ceanothus americana, Astragalus caryocarpus, Cirsium Hillii, Oenothera serrulata, Andropogon furcatus, A. scoparius, Sorghastrum nutans.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City, Cherokee, Gillett Grove, Granite, Greene, Lake Mills, Madison county, McGregor (two specimens), Missouri Valley, Rock Rapids, Sioux City, Spirit Lake (L. H. Pammel); Adel (C. F. Clark), Ames (S. W. Beyer), Armstrong (R. I. Cratty), Decatur county (two specimens, J. P. Anderson), Des Moines (G. W. Carver, A. L. Bakke), Fayette (Parker, B. Fink), Fraser (A.

Hayden), Lansing (O. Schultz), Osage (Mrs. F. M. Tuttle), Winneshiek county (H. Goddard).

It has also been observed (L. H. Pammel) on gravel knolls, drift soil, sandy soil—Algona, Battle Creek, Burlington, Cedar Rapids, Centerville, Chariton, Cherokee, Clarinda, Council Bluffs, Cresco, Eldora, Estherville, Fairfield, Forest City, Fort Madison, Garner, Gifford, Gilbert, Grinnell, Hampton, Iowa City, Indianola, Jewell Junction, Keokuk, Lake Okoboji, Le Mars, Leon, Marshalltown, Mason City, Missouri Valley, Montrose, Mount Pleasant, Muscatine, New Albin, New Hampton, Newton, Nora Springs, Oakland Mills, Ontario, Ottumwa, Shenandoah, Sioux City, Spirit Lake, Steamboat Rock, Story City, Turin, Union, Webster county.

General distribution in the United States:

Colorado—Fort Collins, Hotchkiss (J. H. Cowan); Illinois—Hamilton (L. H. Pammel and Frank Pellett), Walnut (L. H. Pammel); Kansas—Wichita (three specimens, T. L. Andrews); Minnesota—Lake City, Ortonville, St. Paul (L. H. Pammel); Missouri—Allenton (two specimens, George W. Letterman), St. Louis (H. Eggert); Nebraska—Callaway (J. M. Bates), Sheridan county (R. E. Buchanan); North Carolina—Biltmore (Biltmore Herbarium); South Dakota—opposite Hawarden, Sioux Falls, Sisseton (L. H. Pammel), Clear Lake (Edna Pammel).

Liatris Schreb. Blazing Star

Perennial herbs with simple stems, resinous dotted leaves and spicate rose-colored flowers. Stems erect, simple. The pappus of plumose or capillary bristles. Blooming in late summer, preferring sandy soil. Root tuberous or cormlike.

The flowers are proterandrous. The branches of the style are thickened upward, pubescent. The brush hairs gather the pollen copiously as the pollen pushes through the anther tube.

Liatris squarrosa Willd. Blazing Star

A hairy form about a foot tall, with long, rigid linear leaves; heads few. Bracts with leaf-like spreading tips.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel), Decatur county (J. P. Anderson), Osage (Mrs. Tuttle), Page county (T. J. and M. F. L. Fitzpatrick).

It has been observed (L. H. Pammel) at Cedar Rapids, Clinton, Fort Dodge, Marshalltown, Polk county, Taylor county, Webster City.

HONEY BEE VISITS

Bees visit these flowers for pollen. Some nectar is furnished.

Iowa City, August 12, 1927, 3 p.m. Clay soil. No bees. Bees preferring white sweet clover.

Liatris cylindracea Michx. Blazing Star

A smooth form about a foot high; leaves linear, heads few, bracts with short abruptly-pointed appressed tips. Found in open dry places, Ontario westward to Missouri.

FIG. 357.—Cylindrical-headed blazing star (*Liatris cylindracea*). *Photograph by A. Hayden.*

In open prairie soils. Associated with *Petalostemum candidum, P. purpureum, Helianthus occidentalis, Andropogon scoparius.*

Bees visit the flowers, and some pollen and nectar is furnished.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decorah (E. W. D. Holway), Fayette (B. Fink). (This species occurs on gravelly knolls and limestone bluffs of northern and northeastern Iowa).

It has been observed (L. H. Pammel) at Charles City, Cresco, Hampton, Mason City, New Hampton.

General distribution in the United States:

Illinois—Champaign (A. Gilkerson, H. A. Gleason Herbarium), Peoria (Alice J. Heading), (Walter Deam Herbarium); Missouri—Allenton (two specimens, George W. Letterman), Springfield (S. E. Meek).

Liatris punctata Hook. Dotted Button Snakeroot

A stout form, about 1 foot high; leaves narrowly linear, rigid; heads many in a dense spike. Pappus very plumose. Found from Minnesota southward and westward.

Dry gravelly knolls. Associated with *Oxytropus Lamberti, Dalea alopecuroides, D. laxiflora, Euphorbia marginata, Callirhoë involucrata, Yucca glauca, Sporobolus cuspidatus, Aster laevis, Aplopappus spinulosus, Pentstemon grandiflorum, Dyssodia papposa, Gaura coccinea.*

Most abundant in loess soil in western Iowa and gravelly knolls in northwestern Iowa and in drainage areas adjacent to the Missouri loess area, from Hamburg to Sioux City and Lyon county.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cherokee, Granite, Missouri Valley, Sioux City, Turin (L. H. Pammel); Armstrong, Emmet county (R. I. Cratty).

It has been observed (L. H. Pammel) at Council Bluffs, Hamburg, Rock Rapids, Sioux City, Turin.

General distribution in the United States:

Colorado—Eaton, Golden, La Porte, Livingston, Silver Plume (two specimens), Yellowstone Valley (L. H. Pammel), Boulder, Denver (C. P. Johnson), Louisville, Superior (Ferdinand Reppert and Witter), Cache la Poudre river (L. H. Pammel and C. P. Johnson), Fort Collins (C. S. Crandall), Lookout Mountain (L. H. Pammel and D. S. Jeffers), Manitou (F. E. and E. S. Clements), New Windsor (George E. Osterhout); Minnesota—Granite Falls, Monticello, St. Paul (two specimens, L. H. Pammel); Montana—Glendive (L. H. Pammel); Nebraska—Holdrege (J. G. McMillan), McCook (two specimens, L. H. Pammel), Sioux county (two specimens, F. G. Miller); North Dakota—Minot (J. C. Blumer); South Dakota—Belle Fourche (Ada Hayden), Hot Springs (A. Estelle Paddock and F. Reppert), Sisseton (L. H. Pammel); Wyoming—Centennial, Cottonwood canon (Aven Nelson), Cheyenne, Laramie (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. M. Lummis).

HONEY BEE VISITS

It furnishes some pollen and nectar. Honey bees have been observed on the flowers near Hamburg.

Liatris scariosa (L.) Willd. Large Button Snakeroot

Perennial herbs with simple stem; rigid, narrow alternate leaves, and spicate, handsome rose-purple flowers. Height 2 to 4 feet. Heads 8- to 12-flowered, crowded. Bracts of involucre oblong, obtuse, appressed with slight margins. Moist grounds. Massachusetts westward and southward. Involucre usually resinous.

Prairies, sandy and gravelly knolls, dry soil. Associated with *Lilium philadelphicum, Aster sericeus, A. laevis, Solidago missouri-*

ensis, S. speciosa, S. nemoralis, Rosa pratincola, Anemone cylindrica, A. patens var. *Wolfgangiana, Comandra umbellata, Cirsium Hillii.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Alton, Carroll, Charles City, Cherokee, Eagle Grove, Eagle Rock, Fairfield, Fertile, Gillett Grove, Granite, Hancock county, Hawarden, Madison county, Mason City, Ortonville, Rock Rapids, Slater, Spirit Lake, Waterville (L. H. Pammel); Ames, Ontario (E. R. Hodson), northeastern Iowa, Winneshiek county (H. Goddard), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Jefferson (T. A. Allen), Kelley (Botany Party), Keokuk (L. H. Pammel and Iza Mitchell), Ledges (Boone county) (R. E. Buchanan), New Hampton (L. H. Pammel and W. D. Spiker), Newton (G. Drew), Riceville (Mrs. Tuttle), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott), Wild Cat Den (Muscatine county) (L. H. Pammel, F. Reppert).

It has been observed (L. H. Pammel) at Burlington, Clinton, Fairfield, Hampton, Keosauqua, Marshalltown, Mason City, Mount Pleasant, New Hampton, Oakland Mills.

General distribution in the United States:

Arkansas—Texarkana (A. A. and E. Gertrude Heller); Colorado—Table Rock (G. F. B.); Illinois—Graceland, Hanover (L. H. Pammel), Peoria (F. E. McDonald), Walnut (L. H. Pammel and H. A. Gleason); Minnesota—Cass Lake, Cannon Falls, Clear Lake, Leech lake, Minneapolis, Richdale, St. Cloud, Walker (two specimens) (L. H. Pammel), Crookston (Mrs. Roy Westley), Star island (L. H. and H. E. Pammel and P. S. McNutt); Missouri—Swope Park (Kenneth K. Mackenzie); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Lancaster (Dr. Bigelow), Norwalk (Asa Horr); South Dakota—Brookings (two specimens, L. H. Pammel and Edna C. Pammel); Wisconsin—Bluff Siding, La Crosse, Onalaska, St. Croix Falls (L. H. Pammel).

HONEY BEE VISITS

The species is visited by honey bees, which go to the flowers for nectar and pollen.

Liatris pycnostachya Michx. Prairie Blazing Star

A stout, usually hairy, leafy plant, with dense spike of flowers. Found growing upon prairies.

Common in black, prairie soils. Associated with *Vicia americana, Astragalus canadensis, Sorghastrum nutans, Andropogon pro-*

vincialis, Eryngium yuccaefolium, Cirsium iowense.

These prairie plants often grow in conspicuous patches. One of the several species of blazing star of the prairies of Iowa. It blooms ten days to two weeks earlier than *L. scariosa.*

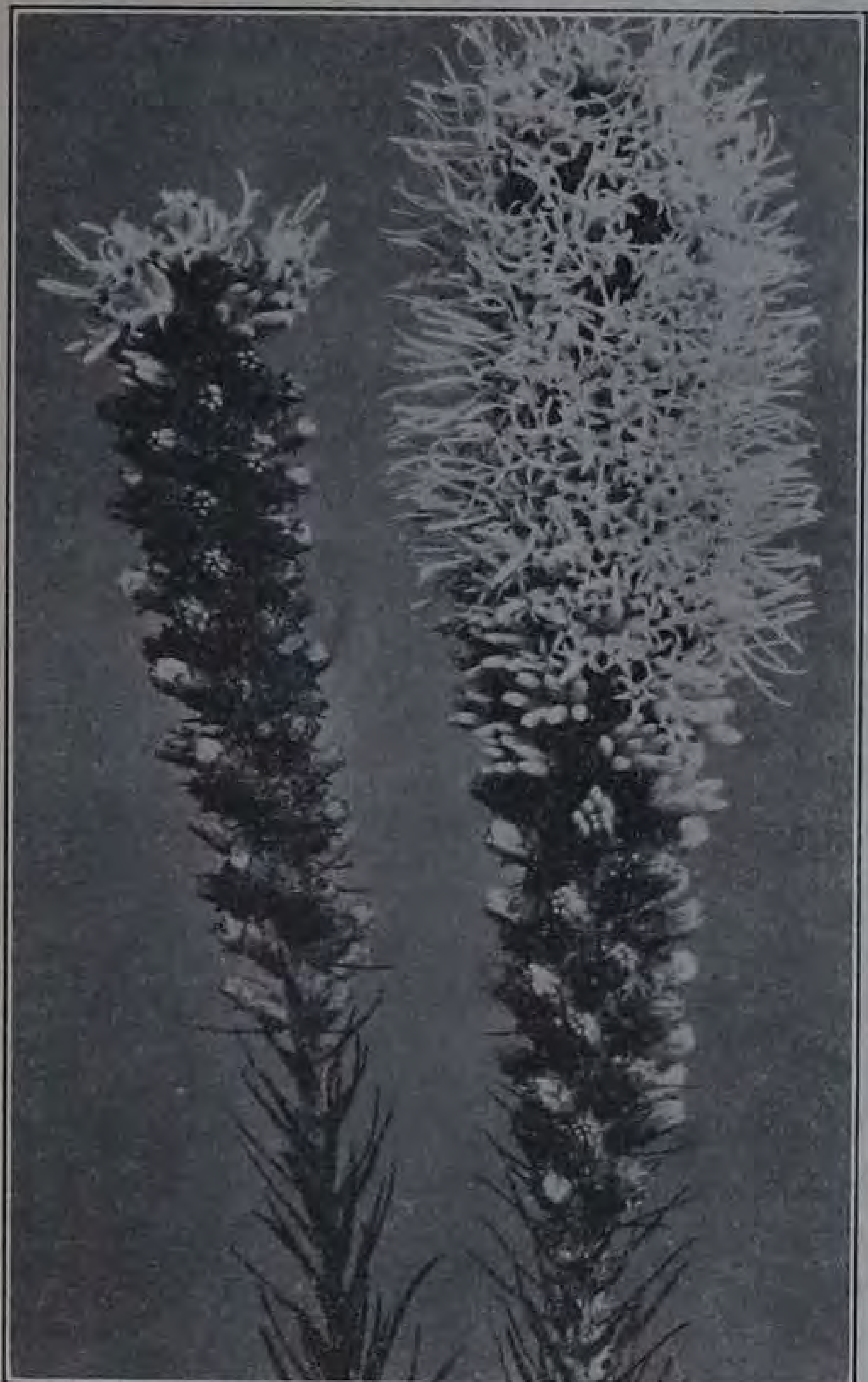

FIG. 358.—Dense-flowered blazing star (*Liatris pychnostachya*). *Photograph by A. Hayden.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Garner, Wheelerwood (L. H. Pammel); Ames (L. H. Pammel and C. R. Ball, S. W. Beyer), Armstrong (R. I. Cratty), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Johnson county (T. J. and M. F. L. Fitzpatrick), Kelley (Pearl Clayton), Ontario (E. R. Hodson, Mrs. F. M. Tuttle), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

It has been observed (L. H. Pammel) at Algona, Cedar Rapids, Charles City, Marshalltown, Mason City, Nevada, New Hampton, Story City, Webster City.

General distribution in the United States:

Illinois—Berwyn (H. S. Fawcett), Carson (H. Eggert); Minnesota—Benson, Howard, Graceville (L. H. Pammel); Nebraska—Lincoln county (F. G. Miller); Oklahoma—Dixie (A. H. Van Vleet); Soutn Dakota—Brookings(L. H. Pammel); Texas—San Antonio (L. H. Pammel); Wisconsin—La Crosse (R. Gmelin).

HONEY BEE VISITS

Honey bees have been observed upon this plant gathering pollen. Apparently the nectar is out of reach for the honey bees.

Robertson says regarding the pollination, "Pollen is carried out and exposed on the long divisions of the style. The corolla tubes are from 7 to 8 millimeters long. The visitors are long-tongued bees and flies, and butterflies."

He does not record bees upon this plant.

Liatris spicata (L.) Willd.

Stems leafy, stout. Leaves linear. Heads cylindrical in shape. Bracts of involucre appressed. Massachusetts to Minnesota and southward.

HONEY BEE VISITS

Ames, July 21, 1929, 4:30 p.m. Bees one to two seconds in a flower.

Grindelia Willd. Tarweed

Coarse perennial or biennial herbs, usually resinous-viscid, clasping leaves, and conspicuous heads of yellow flowers, terminating leafy branches. Heads many-flowered, with pistillate rays.

Grindelia squarrosa (Pursh.) Dunal. Tarweed

This is a prairie form with spatulate to oblong leaves. Flowers yellow; the top of the involucre is spreading.

In Missouri loess soil in western Iowa. In sandy soil in eastern and central Iowa. Associated with *Dalea alopecuroides, D. laxiflora, Helianthus Maximiliani, Helianthus annuus, Sporobolus cuspidatus, Andropogon scoparius, Bouteloua curtipendula, Euphorbia marginata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Boone, Cedar Falls, Council Bluffs, Delhi, Granite, Hawarden, Moingona (L. H. Pammel); Centerville (G. H. Munger), Clear Lake (L. H. Pammel and Mrs. J. S. Naylor), Emmet county (B. O. Wolden), Henry county (J. H. Mills), McGregor (Ada Hayden).

It has been observed (L. H. Pammel) at Clinton, Des Moines, Glenwood, Hamburg, Missouri Valley, Polk City, Rock Rapids, Sioux City, Tabor, Turin.

General distribution in the United States and Canada:

Arizona—Central Arizona (T. L. Andrews); Canada—Winnipeg (L. H. Pammel); Colorado—Cache la Poudre, Golden, LaSalle, Lookout Mountain, Solidago (L. H. Pammel), Fort Collins (C. S. Crandall); Manitoba—Emerson (L. H. Pammel); Minnesota—Minneapolis (two specimens, L. H. Pammel); Montana—Glendive (L. H. Pammel); Nebraska—Scott's Bluff county (F. G. Miller); North Dakota—Portal (L. H. Pammel); South Dakota—Belle Fourche (Ada Hayden), Brookings (Edna C. Pammel), Spearfish canyon (C. M. King), Wahpeton (L. H. Pammel); Wisconsin—Dresser Junction, Onalaska, Prairie du Chien, St. Croix Falls (L. H. Pammel); Wyoming—Cheyenne (L. H. Pammel, C. P. Johnson, R. E. Buchanan, G. M. Lummis), Granite canyon (L. H. Pammel and R. E. Blackwood).

HONEY BEE VISITS

Honey bees have been observed on this species. It is more important in western Iowa than eastward as the plant is indigenous along the Missouri river.

Frank Pellett states that it blooms in August and is much sought by bees. The honey is yellow and of inferior flavor. In the West where it is common it is said to spoil the honey.

Mr. Pellett makes this interesting statement: "The honey is yellow and of inferior flavor. It is often mixed with light honey in the super and the grade spoiled as a result. In Colorado it is well known by the name of "rosin weed." There the comb-honey producers complain that it often spoils the quality of their product through being mixed with the honey from alfalfa and sweet clover. Honey from gum weed candies very quickly, so quickly in fact that Colorado beekeepers say that the bees have to hurry home with the load to prevent it becoming candied in their sacs. Comb honey which candies cannot readily be restored, hence in localities where gum weed is abundant the beekeeper may find it to his advantage to produce extracted honey. Even this does not solve the problem entirely, since the gum weed honey candies in the combs so readily as to make it difficult to extract. There are few reports of large surplus from this source. In most cases it is mixed with other honey and only in such quantity as to make it rather a nuisance than otherwise. The tendency to candy in the combs makes it undesirable for winter stores."

Lovell states that many acres of dry plains in Manitoba and Minnesota are covered by its yellow flowers, which the honey bees visit in great numbers.

Creston, September, 1928. Bees one to two seconds in a flower. Apiary 500 feet away.

Chrysopsis Nutt. Golden Aster

Low perennial woolly or hairy with many-flowered discoid heads; the flowers all alike; rays numerous, yellow. The outer pappus of chaffy bristles, the inner pappus of copious hairlike bristles.

Chrysopsis villosa Nutt. Golden Aster

A pubescent plant with branching stems, the branches ending in single short-peduncled heads. Leaves narrow, hoary. Achenes 3- to 5-nerved.

Sandy soil. Associated with *Anemone patens* var. *Wolfgangiana, Viola pedata, V. pedatifida, Panicum virgatum, Mollugo verticillata, Polygala verticillata, Scutellaria puberula.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche, Granite (L. H. Pammel); Muscatine (Flora Reppert).

Observed (L. H. Pammel) at Council Bluffs, Hamburg, Hanlontown, Linn county, Lyon county, Missouri Valley, Plymouth county, Sioux City, Turin.

General distribution in the United States:

Arizona—Pine (D. T. MacDougal), Walnut canyon; California—Patterson, San Diego (two specimens, L. H. Pammel); Colorado—Eaton, Forks Junction, Fort Collins, Golden (five specimens), Greeley, Idaho Springs, Littleton (L. H. Pammel), Empire (H. N. Patterson), Farmington canyon (L. H. Pammel and R. E. Buchanan), Petersburg (L. H. Pammel, C. P. Johnson and G. M. Lummis); Ward (L. H. Pammel, R. E. Buchanan and G. M. Lummis); Idaho—

Bear lake (A. Isabel Mulford); Illinois—Peoria (F. E. McDonald); Minnesota—Leech lake, Ortonville, Walker (L. H. Pammel); Montana—Billings (I. S. Hunt), Glendive (L. H. Pammel); Nebraska—Alma, Grand Island (L. H. Pammel), Callaway (G. M. Bates), Halsey (two specimens, J. C. Blumer), Sheridan county (L. H. Pammel, T. H. Kearney, Jr., and Jessie Holmes), Sioux county (F. G. Miller); New Mexico—Santa Fe (A. Isabel Mulford); South Dakota—Belle Fourche (Ada Hayden), Bracken (B. H. A. Groth), Brookings (L. H. Pammel and N. E. Hansen), Custer (J. C. Whitman); Utah—Farmington (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. M. Lummis), Peterson canyon (L. H. Pammel and R. E. Blackwood), Salt Lake City (L. H. Pammel, R. L. Barrett, L. V. Lee and Frank Raney); West Black's Fork (L. H. Pammel, C. P. Johnson, R. E. Buchanan); Washington—Fall Bridge (Kirk Whited); Wyoming—Laramie Hills (L. H. Pammel).

HONEY BEE VISITS

This plant is visited by bees for nectar and pollen. The honey is accessible.

Solidago L. Goldenrod

Perennial autumn flowering herbs with wandlike stems and sessile leaves. Flowers of disc and rays yellow; ray flowers pistillate.

The pollination of members of this genus has been worked out by Hildebrand,[1] Hermann Mueller,[2] Knuth,[3] and Charles Robertson.[4]

The flowers are proterandrous and the lobes of the corolla expand. In the second or female stage the style pushes the pollen out of the syngenesious anthers. The brush hairs collect the pollen, which is transferred to the insect when it takes the nectar out of the tubular corolla. When the insect visits an older flower it leaves the pollen on the stigmatic papillae on the margin of the style.

Knuth records the honey bee as a pollinator of *Solidago fragrans* (observed by Loew).

The genus *Halictus* of the Hymenoptera is most frequently reported on the genus *Solidago*; the Diptera and Coleoptera also are frequent.

John H. Lovell mentions the following species, *Solidago squarrosa, occidentalis, rigida, graminifolia, rugosa, juncea, nemoralis, caesia, rupestris, neglecta, sempervirens* and *canadensis*, as furnishing nectar in different sections of the country. No doubt the soil has very much to do with the nectar secreted by these plants. Pellett also mentions the above species and several more like *Solidago uliginosa, puberula* and *hispida*. Some years they no doubt do

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1 U. d. Geschlechtsverhält u. d. Compositen.

2 Fertilization of Flowers, 320-321.

3 Blutenbiol Herbstbeob.

4 Flowers and Insects. Trans. Acad. of Sci., St. Louis. 6:454-458.

furnish a large amount of nectar. Northeastern Iowa is much more favorable than central Iowa for the production of nectar from these species. From September 10 to 24, 1930, we had under observation *S. nemoralis* without seeing a single honey bee on the plant.

Solidago speciosa Nutt. Showy Goldenrod

A stout-stemmed goldenrod 1 foot to 2 feet high, smooth below, often roughish above; leaves rather thick, smooth, ovate; margins serrate, rough. Heads somewhat crowded in numerous erect racemes, forming a pyramidal panicle. Rays about 5, large. Dry open woods and thickets, local from Massachusetts to Minnesota and southwest.

Sandy prairies, gravel knolls, drift rock. Associated with *Solidago missouriensis, Andropogon scoparius, Aster sericeus, Anemone cylindrica, A. patens* var. *Wolfgangiana, Astragalus caryocarpus.*

Distribution in Iowa as shown by specimens in the I. S. C. Herbarium:

Iowa City (A. S. Hitchcock), McGregor (Ada Hayden), Muscatine (F. Reppert), Perry (L. H. Pammel), Steamboat Rock (C. M. King).

Observed (L. H. Pammel) at Ames, Boone, Burlington, Clermont, Clinton, Fort Dodge, Hampton, Marshalltown, Mason City, Postville, Webster City, West Union.

General distribution in the United States:

Colorado—Stone City (L. H. Pammel); Illinois—Chicago (L. H. Pammel); Massachusetts—Brookline (Walter Deane); Minnesota—Cass Lake (L. H. and H. E. Pammel); Missouri—Hodson (Kenneth K. Mackenzie); Nebraska—Holdrege (J. G. McMillan); Wisconsin—La Crosse (Emma Pammel), Madison (L. H. Pammel).

HONEY BEE VISITS

This plant is frequently visited by honey bees and furnishes a large amount of nectar in some years.

On certain types of clay soils it is more valuable as a honey plant than in central Iowa on drift or common prairie soil.

Mary Rolfs reports bees as being quite abundant, sucking nectar from flowers of the plant. Other Hymenoptera also were visiting the plant.

Cassville, Wisconsin, October 4, 1918. Observed. Some honey bees.

Postville, Clermont, West Union, October 4, 1918. Honey bees observed at these places.

Solidago speciosa var. *angustata* T. and G. Narrow-leaved Showy Goldenrod

Not so tall as the showy goldenrod, less than 3 feet in height. The leaves lanceolate, and the flower clusters smaller than in the preceding species.

Black sandy soil, gravel knolls. Associated with *Solidago nemoralis*, *S. missouriensis*, *Aster sericeus*, *Anemone patens* var. *Wolfgangiana*, *A. cylindrica*, *Stipa spartea*, *Astragalus caryocarpus*, *Phlox pilosa*, *Viola pedata*, *Panicum Scribnerianum*.

FIG. 359.—Showy goldenrod (*Solidago speciosa* var. *angustata*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park, Delaware county, New Hampton, Sioux City (L. H. Pammel); Armstrong, Emmet county (R. I. Cratty), Lawler, Sioux City (P. H. Rolfs), Ames (C. E. Bessey), Charles City (J. C. Arthur), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Greenfield (F. C. Stewart), Iowa City (A. S. Hitchcock), Johnson county (T. J. and M. F. L. Fitzpatrick), Kelley (Botany Department), Ledges (Boone county) (R. E. Buchanan), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

It has also been observed (L. H. Pammel) at Cedar Rapids, Eldora, Marshalltown, Mason City, Perry.

FIG. 360.—Showy goldenrod (*Solidago speciosa* var. *angustata*). *Photograph by A. Hayden.*

General distribution in the United States:

District of Columbia—Brightwood (C. R. Ball); Illinois—Chicago (H. F. Munroe), Hanover (H. A. Gleason); Michigan—Whitehall (L. H. Pammel); Minnesota—Anoka, Clear Lake, Lake City, Leech lake, Walker (L. H. Pammel), St. Cloud (R. Gmelin); Wisconsin—Galesville, La Crosse (L. H. Pammel).

HONEY BEE VISITS

Is frequently visited by honey bees. It produces an abundant amount of nectar under favorable conditions.

Solidago ulmifolia Muhl. Elm-leaved Goldenrod

A slender, smooth-stemmed goldenrod 2 to 7 feet high. Leaves thin, elliptical ovate, pointed, tapering to the base, loosely veined, beset with soft hairs beneath. Racemes loosely recurved, spreading. Found growing in dry and rocky woods New England westward.

Black sandy or clay soils in woods. Associated with *Solidago latifolia, Claytonia virginica, Dicentra Cucullaria, Sanguinaria canadensis, Hepatica acutiloba, Anemonella thalictroides, Eupatorium ageratoides, E. purpureum* var. *maculatum, Isopyrum biternatum, Thalictrum dioicum, Vernonia Baldwini, Geranium maculatum, Festuca nutans, Bromus purgans, Ulmus fulva, Quercus alba, Q. rubra, Tilia americana.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Atlantic, Boone, Clarinda, Clinton, Des Moines, Eagle Rock, Fairfield, Ham-

FIG. 361.—Elm-leaved goldenrod (*Solidago ulmifolia*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

burg, Lyons, Madison county, Marion county, McGregor, Red Rock, Rochester (L. H. Pammel); Clear creek, Fairfield, Keosauqua (L. H. Pammel and G. B. MacDonald), Ames (Herb. Nat. Hist. Soc., J. C. Arthur, Ada Hayden, C. E. Bessey), Cedar Rapids (R. E. Buchanan), Charles City (Mrs. F. M. Tuttle, C. L. Webster, F. C. Stewart), Decatur county (J. P. Anderson), Des Moines (A. L. Bakke), Fayette (B. Fink), Iowa City (A. S. Hitchcock), Keokuk (P. H. Rolfs), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan, C. M. King), Marshalltown (L. H. Pammel, Estelle Fogel, F. C. Stewart), Mount Pleasant (J. H. Mills), Muscatine (F. Reppert), Newton (Gilman Drew), northeastern Iowa (H. Goddard).

It has been observed (L. H. Pammel) at Burlington, Dubuque, Keosauqua, Sioux City.

HONEY BEE VISITS

It furnishes a good quality of honey, and in considerable quantity when moisture conditions are favorable. It has been observed at the following places: Cassville, Wisconsin, October, 1918. McGregor, October, 1918. Rock Island, Illinois, September 12, 1927, 3 p.m. Clay soil. Clear, warm. Bees common. One second in a flower.

Solidago missouriensis Nutt. Missouri Goldenrod

Smooth, about 1 foot to 3 feet in height. Leaves firm and rigid, linear-lanceolate, 3-ribbed. Margins rough, dense, racemes recurved. Involucre straw-colored, blunt. Rays 6 to 13, small.

Dry prairies and open woods. Tennessee to Manitoba and westward. Associated with *Solidago nemoralis, S. speciosa* var. *angustata, Baptisia leucophaea, B. leucantha, Phlox pilosa, Astragalus caryocarpus, Andropogon scoparius, Bouteloua curtipendula.*

The pollination of this species was studied by Robertson, who observed the honey bee upon it as an infrequent visitor.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cherokee, Gillett Grove, Granite, Hawarden, Keystone, Marathon, Sioux City, Turin, Webster City (L. H. Pammel); Iowa City, Hawarden (A. S. Hitchcock), Armstrong, Dickinson county (R. I. Cratty), Ames (P. H. Rolfs), Decatur county (J. P. Anderson), Fayette (B. Fink), Hancock county (J. C. Arthur), Harrison county (R. Bürger), Kelley (Pearl Clayton), Muscatine (F. Reppert).

It has been observed (L. H. Pammel) at Burlington, Charles City, Clinton, Davenport, Des Moines, Dubuque, Fort Dodge, Grinnell, Hamburg, Hampton, Keosauqua, Larchwood, Mason City, McGregor, Missouri Valley, Muscatine, New Hampton, Rock Rapids, Rockwell City, Sioux City, Sioux Rapids.

General distribution in the United States:

Arizona—Flagstaff (D. T. MacDougal); Colorado—Cache la Poudre river (L. H. Pammel, C. P. Johnson), Empire (H. N. Patterson), Fort Collins (two specimens, C. S. Crandall), Littleton (L. H. Pammel); Idaho—Challis (Laing and Woods); Illinois—Oquawka (Harry N. Patterson), Peoria (F. E. McDonald); Minnesota—Leech lake, Wadena, Walker (L. H. Pammel), Cass Lake (two specimens, L. H. and H. E. Pammel), Missouri—Kimmswick (H. Eggert), Waldo Park (Kenneth K. Mackenzie); Nebraska—Callaway (J. M. Bates), Holdrege (J. G. McMillan), Scott's Bluff (F. G. Miller); Oregon—Tumalo (Kirk Whited); South Dakota—Brookings (two specimens), LaBolt, Lake Poinsett, Sisseton, Watertown (L. H. Pammel), Brookings (Edna C. and L. H. Pammel and N. E. Hansen), Spearfish canyon (two specimens, C. M.

King); Utah—Peterson (two specimens, L. H. Pammel and R. E. Blackwood); Washington—Peshastin (J. H. Sandberg and J. B. Leiberg); Wisconsin—La Crosse (two specimens), Muscoda, Onalaska, Trempealeau county (L. H. Pammel); Wyoming—Laramie (Aven and Elias Nelson), Laramie Peak (Aven Nelson).

HONEY BEE VISITS

Bees are not infrequent and the species furnishes some honey and a considerable amount of pollen.

Solidago nemoralis Ait. Gray Goldenrod

Grayish hoary with soft pubescence. Stem simple or corymbed above, 1 to 3 feet high. Leaves oblanceolate, the lower longer, the upper greatly reduced. Racemes numerous, forming a crowded compound raceme or panicle which is turned to one side. Firm yellowish bracts of the involucre appressed. Rays bright yellow. Dry open soil, Canada southward.

Sandy, gravel knolls, sandy soil, limestone soils. Associated with *Solidago missouriensis, Phlox pilosa, Astragalus caryocarpus, Panicum Scribnerianum, Aster sericeus, A. multiflorus.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bixby Park, Boone, Centerville, Clinton, Dakota City, Eagle Rock, Fairfield, Gillett Grove, Granite, Hamburg, Hanlontown, High Bridge, Kelley, Keokuk, Madison county, Manchester, Mason City, McGregor, Oelwein, Red Rock, Rock Rapids, Sioux City, Story City, Turin, Wheelerwood (L. H. Pammel); Cedar Rapids, Iowa City (A. S. Hitchcock), Ames, Boone (Geo. W. Carver), Armstrong (R. I. Cratty), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Emmet county (R. I. Cratty and L. H. Pammel), Greenfield (F. C. Stewart), Ledges (Boone county) (L. H. Pammel and Miller), Muscatine (F. Reppert), northeastern Iowa (H. Goddard), New Hampton (P. H. Rolfs), Osage (Mrs. F. M. Tuttle), Slater (H. S. Fawcett, W. I. Tener and C. Reinbott).

It has also been observed (L. H. Pammel) at Algona, Burlington, Charles City, Dubuque, Emmetsburg, Forest City, Fort Madison, Keosauqua, Lyon county, Mount Pleasant, Postville, Webster City.

General distribution in the United States:

Arkansas—Northwestern Arkansas (F. L. Harvey); Colorado—Fort Collins (C. S. Crandall); District of Columbia—(G. McCarthy); Illinois—Olney (Robert Ridgeway); Kentucky—Bell county (T. H. Kearney, Jr.); Maryland—Principio Furnace (two specimens, F. B. Trenk); Massachusetts—Adams (M. A. Day); Minnesota—Anoka, Clear Lake, Leach Lake, Minneapolis, Ortonville, Walker (two specimens) (L. H. Pammel), Cass Lake (two specimens), Duluth (L. H. and H. E. Pammel), Sandy Lake (J. H. Sandberg); Missouri—Allenton (George W. Letterman), Old Orchard (L. H. Pammel), Raytown (Kenneth K. Mackenzie); Nebraska—Halsey (J. C. Blumer); New Mexico—Las Vegas (G. R. Vasey); New York—Ithaca (Muenscher and Bechtel), Watkins Glen (L. H.

Pammel); Ohio—Painsville (H. C. Beardslee); Rhode Island—Greenwich (New York Botanical Garden); South Carolina—Oconee county (A. P. Anderson); South Dakota—Custer (J. C. Witham); Pennsylvania—Towanda (L. H. Pammel); Wisconsin—Madison (three specimens), Onalaska (L. H. Pammel), La Crosse (L. H. and H. E. Pammel, Dora S. Pammel); Wyoming—Laramie (L. H. Pammel, C. P. Johnson, R. E. Buchanan, G. M. Lummis), Yellowstone National Park (John Craig).

HONEY BEE VISITS

Visited in September and October by honey bees for nectar. It is an excellent honey plant when the plant grows in moist somewhat sandy or loamy soil.

Bees were abundant in the flowers of this species near La Crosse, Wisconsin. Robertson reports the honey bee upon this species.

McGregor, Postville, October 4, 1918. Bees on this plant.

Bees were observed upon this species in 1928 at McGregor.

Solidago canadensis L. Canada Goldenrod

A rough, hairy, pubescent perennial 3 to 6 feet high. A slender goldenrod with thin, long, slender leaves, sharp, serrate, glabrous below. Heads small, crowded in recurved racemes, forming dense pyramidal panicles. Involucral bracts linear, greenish straw-color. In thickets and rich open soil. Along roadsides and edges of fields. New England westward and southward. Associated with *Helianthus grosse-serratus*, *H. Maximiliani*, *Aster multiflorus*, *Veronica virginica*, *Corylus americana*.

FIG. 362.—Canadian goldenrod (*Solidago canadensis*). *Photograph by Colburn.*

Robertson observed bees and other insects abundant upon this goldenrod from August 8 to October 10. It is visited by honey bees and many other small Hymenoptera.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belmond, Boone, Cedar Rapids, Charles City, Cherokee, Clear Lake, Dawson, Des Moines, Eagle Grove, Eagle Rock, Emmet county, Emmetsburg, Fairfield, Gillett Grove, Granite, Greene, Hamburg, Hawarden, High lake, Lake Mills, Little Rock, Marshalltown, McGregor, Nevada, New Hampton, Oelwein, Plymouth county, Rock Rapids, Salem, Saratoga, Sioux City, State Center, Stratford, Turin, Waukon (L. H. Pammel); Fraser, Kelley (Botany Seminar), Ames (C. E. Bessey, J. F. Schulte, L. H. and H. E. Pammel, M. Reynolds, S. W. Beyer), Armstrong (R. I. Cratty), Cedar Rapids (R. E. Buchanan), Cres-

FIG. 363.—Canada goldenrod (*Solidago canadensis*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

ton (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Floyd Springs (Mrs. F. M. Tuttle), Kelley (Pearl Clayton), Keokuk (P. H. Rolfs), Marshalltown (F. C. Stewart), McGregor (A. Hayden), Mount Pleasant (H. E. Jaques), Muscatine (F. Reppert), Newton (Gilman Drew), northeastern Iowa (H. Goddard), Scott county (C. LeBuhn), Slater (W. I. Tener, C. Reinbott, H. S. Fawcett), Split Rock (C. A. Hansen).

It has been observed (L. H. Pammel) at Britt, Carroll, Clinton, Council Bluffs, Davenport, Des Moines, Dubuque, Emmetsburg, Estherville, Fairfield, Forest City, Fort Dodge, Garner, Greenfield, Guthrie Center, Hamburg, Hampton, Indianola, Keokuk, Keosauqua, Lansing, Lyon county, Manson, McGregor, Mount Pleasant, New Hampton, Onawa, Postville, Sioux City, Turin, Webster City, Winterset.

General distribution in the United States and Canada:

Colorado—Engelmann canyon, Fort Collins (F. E. and E. S. Clements), Palmer Lake (C. S. Crandall); District of Columbia—Georgetown (E. S. Steele), Piney Branch road (C. R. Ball and A. E. Paddock), Washington (Carrie Harrison); Illinois—Walnut, Zearing (L. H. Pammel), Berwyn (H. S. Fawcett); Indiana—Wells county (Charles C. Deam); Kansas—Wichita (T. L. Andrews); Louisiana—(T. L. Andrews); Maryland—Baltimore (Jessie H. Holmes, Herb. U. S. Dept. Agr.); Massachusetts—Adams (M. A. Day), Pine Grove (Grace Gilgore, Gray Herbarium), West Falmouth (J. R. Churchill); Minnesota—Granite Falls, Howard Lake, Itasca Lake, Minneapolis (two specimens), Ortonville, South Huron, St. Paul (two specimens), Wildwood (Lois Pammel), Cass Lake, Star Island (L. H. and H. E. Pammel and P. S. McNutt), Black Duck (Mrs. Roy Westley), Duluth (L. H. and H. E. Pammel), Rochester (Mrs. George Ainslee), St. Cloud (R. Gmelin).

HONEY BEE VISITS

Ames, August 28, 1914. Railroad. Clear, northwest wind. Few honey bees. Diptera, *Bombylius*. Many beetles, twelve per hour. (G.H.M.)

August 2, 1915, a.m. College Park. Clear, moderate. Twenty-five honey bees. (L.A.K.)

September 4, 1915, p.m. College Park. Clear, warmer. Fifteen honey bees. (L.A.K.)

September 6, 1915, a.m. College Park. Clear, warmer. No honey bees. The best of the goldenrods in 1915.

September 15, 1917. Clear. Bees common.

Hamilton, Illinois, September 9, 1918. Honey bees visiting the plant.

Sioux City, September 9, 1918. Honey bees visiting this plant.

La Crosse, Wisconsin, September 23, 1918. Warm afternoon. The honey bee abundant, visits 37 flowers in a minute. Came from hives one-fourth of a mile away.

Boone, August 25, 1927, 3 p.m. Bees abundant. One second in a flower. Visiting two to three flowers in a head.

Grand Junction, September 2, 1927, 4:30 p.m. Bees one second in a flower. Visit two to three flowers in a head.

Ames, September 5, 1927, 9:30 a.m. and 4 p.m. Clear, warm. Bees one second in a flower. Visiting three to five flowers in a head.

August 27, 1929, 10:30 a.m. No bees. Many beetles.

Des Moines, August 28, 1929. No bees. (Near an apiary.)

Ames, September 17 and 26, 1929. No bees. Near *Aster novae-angliae,* on which bees are abundant.

September 15 to 24, 1930. No bees observed although common on New England aster adjacent.

Solidago serotina Ait. Late Goldenrod

Stem stout and smooth. Leaves smooth on both sides, lanceolate, taper-pointed. The panicle full and large, the bracts linear, subherbaceous; rays 7 to 14, rather long. This plant grows in thickets in rich soil throughout the state. Its blooming season is August and September.

Low grounds, swamps and peaty soils or low upland moist places along streams. Associated with *Vernonia fasciculata, Eupatorium perfoliatum, Cyperus esculentus, Scirpus atrovirens, Glyceria nervata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone county, Cedar Rapids, Charles City, Dawson, Des Moines, Estherville, Fraser, Hancock county, Indianola, Keokuk, Keystone, Lime Springs, Madison county, Manchester, Marion county, Marshalltown, Mason City, New Albin, Oelwein, Postville, Red Rock, Rock Rapids, Rochester, Spirit Lake, Steamboat Rock, Wapsipinicon river, Wheelerwood (L. H. Pammel); Armstrong, Clear Lake, Emmet county (R. I. Cratty), Ames (Fred Rolfs, C. E. Bessey, C. L. Spencer, E. S. King, L. Emerson, F. C. Stewart, F. A. Sirrine, L. H. Pammel and C. R. Ball), Charles City (J. C. Arthur, C. L. Webster), Decatur county (J. P. Anderson), Des Moines (C. E. Bessey, A. L. Bakke), Fayette (B. Fink), Fort Dodge (O. M. Oleson), Fraser (Botanical Seminar), High Bridge (G. M. Lummis), Iowa City (A. S. Hitchcock), Kelley (Botany Party), Lawler (P. H. Rolfs), Ledges (J. P. Anderson), Marshalltown (F. C. Stewart), northeastern Iowa (H. Goddard), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

It has been observed (L. H. Pammel) at Algona, Davenport, Des Moines, Dubuque, Emmetsburg, Estherville, Fort Dodge, Goldfield, Guthrie Center, Humboldt, Indianola, Jefferson, Keosauqua, Rock Rapids, Sioux City, Spencer, Winterset.

General distribution in the United States:

Colorado—Denver (I. W. Clokey), Littleton (L. H. Pammel), Poudre Flats (C. S. Crandall); Illinois—Chicago (three specimens), Galena, Graceland (L. H. Pammel), Berwyn (two specimens, H. S. Fawcett); Louisiana—(T. L. Andrews); Michigan—Mackinac Island, Whitehall (L. H. Pammel); Minnesota—Cass Lake, Five creek, Graceville, Itasca Lake, La Porte City, Monticello, Norway Beach, Ortonville (two specimens), Pipestone, St. Paul, Welliver (L. H. Pammel), Duluth (L. H. and H. E. Pammel), Flat Island (L. H. and H. E. Pammel and P. S. McNutt); Missouri—(Dr. Krause), Old Orchard, St. Charles, Wicks (L. H. Pammel); Montana—Billings (T. S. Hunt); Nebraska—Lincoln, Scott's Bluff (F. G. Miller), Sheridan county (R. E. Buchanan), Willow Island (Jos. Wahl); New Hampshire—Laconia (Miss Prince); New

York—Geneva (L. H. Pammel), Ithaca (Muenscher and Bechtel, Carrie Harrison); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Gambier (L. H. Pammel); Pennsylvania—Towanda (L. H. Pammel); South Dakota—Brookings, Milbank, Sisseton, Watertown (L. H. Pammel), Spearfish canyon (two specimens, C. M. King); Texas—Sherman (L. H. Pammel); Tarrant county (Albert Ruth); Virginia—Ingleside (E. S. Steele); Washington—Easton (L. H. Pammel and W. S. Dudgeon), Langley (G. M. Grant); Wisconsin—Holmen, La Crosse, Madison (L. H. Pammel), Bloomingdale (C. M. King); Wyoming—Cheyenne (L. H. Pammel), Smoot (E. Payson, George M. Armstrong).

HONEY BEE VISITS

This is a good honey plant and is much visited by bees for the honey.

Ames, September 9, 1915. Clear. Honey bees common.
September 15, 1917. Clear. Honey bees common.
September 2, 1919. Partly cloudy. Honey bees at work.

Pilot Mound, July 28, 1918. Bees at work.

Keokuk, September 9, 1918. Bees at work.

Hamilton, September 9, 1918. Bees at work.

La Crosse, Wisconsin, September 23, 1918, p.m. Warm. Bees came to the flowers from apiary one-fourth mile away and over a hill 350 feet high.

Ames, August 31, 1927, 2:30 p.m. Bee spends one second in a flower. Visits two flowers in a head.

Boone, August 25, 1927, 3 p.m. Bees abundant. One second in a flower. Visits two or three flowers in a head.

Ames, September 1, 1927, 2:30 p.m. Bees one second in a flower. Visiting two to three flowers in a head.

Norwalk, September 7, 1927, 4:30 p.m. Bright, clear, warm. Bees one second in a flower. Visits two to four flowers in a head. Apiary one-fourth mile away.

Rock Island, Illinois, September 12 and 13, 1927, a.m. and p.m. Clay soil. Clear, warm. Bees common. One second in a flower. Visit two to four flowers in a head. Near apiary.

Honey bees were found on this plant at Sioux City in 1927. It is one of the most common of our goldenrods and is visited most frequently. Furnishes nectar.

Ames, October 2, 1929, 1:30 p.m. No bees though abundant on New England aster.

In bloom, Ames, August 15, 1925; Lansing, August 17, 1925.

Solidago rigida L. Stiff Goldenrod

A rough and hoary perennial plant, stem leafy, stout, 1 foot to 5 feet high. Leaves oval but not 3-veined, feather-veined, thick and rigid, the lower petioled, the upper closely sessile. Heads more than 30-flowered in a compound corymb terminating the simple stem.

FIG. 364.—Stiff goldenrod (*Solidago rigida*). *Photograph by Colburn.*

Black prairie soils, gravel knolls, sandy soil, Missouri loess. Associated with *Solidago nemoralis*, *S. missouriensis*, *Astragalus caryocarpus*, *Baptisia leucantha*, *Aster sericeus*, *Silphium laciniatum*, *Brauneria purpurea.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cedar Rapids, Charles City, Cherokee, Estherville, Fairfield, Gillett Grove, Granite, High lake, Little Rock, Madison county, Oelwein, Sioux City, Sioux Falls, Spirit Lake, Stratford, Waterloo (L. H. Pammel), Greenfield, Marshalltown (F. C. Stewart), Hamilton, Lawler (P. H. Rolfs), Armstrong (R. I. Cratty), Ames (R. E. Jeffs, C. E. Bessey, S. W. Beyer), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Iowa City (A. S. Hitchcock), Jewell Junction (J. A. Rolfs), Ledges (Boone county) (R. E. Buchanan), Mason City (C. M. King), Muscatine (F. Reppert), Newton (G. Drew), northeastern Iowa (H. Goddard), Slater (H. S. Fawcett), Traer (J. W. Provan).

Observed (L. H. Pammel) at Algona, Burlington, Carroll, Davenport, Des Moines, Dolliver, Dubuque, Estherville, Fort Dodge, Guthrie Center, Hamburg, Hampton, Indianola, Keokuk, Keosauqua, McGregor, Missouri Valley, Mount Pleasant, Nevada, Onawa, Postville, Rock Rapids, Sioux City, Story City, Turin, Winterset.

FIG. 365.—Stiff goldenrod (*Solidago rigida*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

General distribution in the United States:

Colorado—Boulder (George Osterhout), Leyden Junction (I. W. Clokey); Illinois—Berwyn (two specimens, H. S. Fawcett), Bloomington (B. L. Robinson), Pullman (L. H. Pammel), Rantoul (H. A. Gleason); Kansas—Wichita (T. L. Andrews); Minnesota—Clear Lake, Minneapolis, Morris, Richdale, South Huron, St. Paul (L. H. Pammel), Crookston (Mrs. Roy Westley), Duluth (L. H. and H. E. Pammel); Missouri—Old Orchard (L. H. Pammel), Sheffield (Kenneth K. Mackenzie); Nebraska—Halsey (two specimens, J. C. Blumer), Lincoln (F. G. Miller), Sheridan county (two specimens, R. E. Buchanan); North Dakota—Fargo, Pembina (L. H. Pammel); South Dakota—Belle Fourche (Ada Hayden), Brookings (Edna C. Pammel); Texas—Tarrant county (Albert Ruth); Wisconsin—La Crosse (L. H. Pammel and C. M. King), Madison (L. H. Pammel).

HONEY BEE VISITS

This species under some conditions furnishes considerable nectar, especially on moist loamy soil and after showers. At La Crosse, Wisconsin, on the moist east slopes, bees were abundant.

Dubuque, July 14, 1914, p.m. Clear, northwest wind. Honey bees, small bees, wasps, flies. One sort gathering pollen, all others nectar. Thirty per flower per hour. (G.H.M.)

Ames, September 18, 1917. Open sunshine. A few bees at work.

Postville, October 4, 1918. Bees observed.

Ames, August 25, 1927, 3 p.m. Bees abundant. One second in a flower. Visiting two to three flowers in a head.

September 1 and 2, 1927, a.m. and p.m. Dry. Some bees. One to two seconds in a flower. Visiting two to four flowers in a head.

Grand Junction, September 2, 1927, 4:30 p.m. Bees one second in a flower. None on *Helianthus Maximiliani.*

Cherokee, September 21, 1928, 3 p.m. Bees one second in a flower.

Solidago graminifolia (L.) Salisb. Bushy or Fragrant Goldenrod

Much branched; heads small, in little clusters crowded in flat-topped corymbs; rays short, more numerous than the disc flowers. Leaves narrow, entire, sessile. Moist soil, Quebec westward, south to Missouri.

Upland prairie soils, common along fences. Associated with *Solidago serotina, Silphium integrifolium, Aster novae-angliae, A. salicifolius, Sorghastrum nutans, Salix discolor.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Cedar Rapids, Hanlontown, Manchester, Oelwein, West Burlington, Wheelerwood (L. H. Pammel); Ames (Ada Hayden, P. H. Rolfs, M. Reynolds, Herb. Nat. Hist. Soc.), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Fayette (C. C. Parker), Iowa City (A. S. Hitchcock), Kelley (Pearl Clayton), Muscatine (F. Reppert), Osceola (L. H. and H. E. Pammel).

Observed (L. H. Pammel) at Charles City, Hampton, Mason City, New Hampton, Story City.

General distribution in the United States:

Illinois—Berwyn (H. S. Fawcett); Minnesota—Cass Lake, Leach Lake, Monticello, Walker (L. H. Pammel), Brainerd (E. B. Watson), Duluth (L. H. and H. E. Pammel), Star Island (L. H. and H. E. Pammel and P. S. McNutt), St. Cloud (R. Gmelin); Missouri—Hodson (Kenneth K. Mackenzie); Nebraska—Halsey (J. C. Blumer); Newfoundland—Grand Falls (M. L. Fernald and K. M. Wiegand); New Jersey—Raritan Ledge (J. A. Kelsey); New York—Bronx Park (George V. Nash), Ithaca (Muenscher and Bechtel); Niagara Falls (G. H. Frazier, Carrie Harrison); North Carolina—Biltmore (Biltmore Herbarium); Ohio—Mansfield (E. Wilkinson); Pennsylvania—Towanda (L. H. Pammel); South Dakota—Sisseton (L. H. Pammel); Wisconsin—Dells of Wisconsin river (L. H. Pammel), Holmen (three specimens, L. H. Pammel), La Crosse (two specimens, L. H. Pammel).

HONEY BEE VISITS

This species furnishes nectar in clay soils and where there is sufficient moisture in the soil.

Solidago latifolia L. Broad-leaved Goldenrod

A smooth plant, with zigzag stem. Leaves broadly ovate, sharply serrate, thin. Petioles winged. Heads in axillary clusters. Moist shady places.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dallas county, Edgewood, Eldora, Estherville, Fayette, Fort Dodge, Hamburg, Lake Mills, Madison county, Manchester, Marion county, Newton, Strawberry Point (L. H. Pammel); Algona (L. H. Pammel and Paul Halloway), Clear Lake (L. H. Pammel and Mrs. J. S. Naylor), Decorah (E. W. D. Holway), Denison (Clara Blume), Eldora (L. H. Pammel and Raymond Torrey), Johnson county (T. J. and M. F. L. Fitzpatrick), Osage (Mrs. F. M. Tuttle).

General distribution in the United States:

District of Columbia—Washington (H. S. Henshaw); Illinois—Bluff Lake (L. H. Pammel), Chicago (H. H. Babcock), Glencoe (H. F. Munroe), Peoria—(F. E. MacDonald); Kentucky—Southeastern part (T. H. Kearney, Jr.); Massachusetts—Greylock Mountain (M. A. Day); Minnesota—Cass Lake (L. H. and H. E. Pammel and P. S. McNutt), Ortonville (L. H. Pammel); New York—Bedford Park (vicinity of New York City) (Percy Wilson), Ithaca (Muenscher and Bechtel, H. E. Summers), Niagara Falls (G. H. Frazier), Watkin's Glen (L. H. Pammel); Ohio—Columbus (H. A. Gleason); South Dakota—Sioux Falls (L. H. Pammel); Vermont—Barnet (F. Blanchard); Wisconsin—Bloomingdale, Kilbourne City, Madison (four specimens, L. H. Pammel). "North Carolina to Georgia and Florida" (S. B. Buckley).

HONEY BEE VISITS

Cherokee, September 22, 1928, 10 a.m. Bees one second in a flower.

Boltonia L'Her. Boltonia

Perennial, branching, aster-like plants of low grounds, usually with bluish-rayed flowers, with yellow discs. Achenes flat, winged with bristly pappus. Autumn flowering. Heads many-flowered; rays numerous, pistillate.

Boltonia asteroides (L.) L'Her.

Stems from a foot to 7 feet in height; leaves thickish, lanceolate, involucral bracts acuminate; pappus of few or many bristles and 2 awns or none. Heads many-flowered, disc yellow, rays white or purplish.

Low alluvial bottoms, shores of lakes. Associated with *Vernonia fasciculata, Polygonum Muhlenbergii, Glyceria nervata, Helianthus grosse-serratus, Polygonum acre, Leersia lenticularia, L. oryzoides, Cephalanthus occidentalis, Penthorum sedoides, Thalictrum dasycarpum.*

Loew records the honey bee as being rather common upon the plant and getting nectar.

Robertson states as follows: "The plants are often collected in rather large patches in moist places, and are quite attractive to insects. The heads have yellow disc florets and white rays, and expand 15 millimeters or more. The rays are pistillate, the disc florets being perfect. Nectar and pollen are supplied by the latter. The tubes of the disc florets are only about 1 millimeter deep, so that numerous short-tongued insects can obtain the nectar."

He does not record bees upon these plants in September and October.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Marshalltown, Turin (L. H. Pammel); Ames (C. E. Bessey), Armstrong (R. I. Cratty), Centerville (L. H. Pammel, G. B. MacDonald), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Des Moines county (P. Bartsch), Fraser (Botany Seminar), Kelley (Pearl Clayton), McGregor (Ada Hayden), Slater (W. I. Tener, C. Reinbott, H. S. Fawcett).

Observed (L. H. Pammel) at Algona, Burlington, Charles City, Clinton, Davenport, Dubuque, Emmetsburg, Fort Dodge, Indianola, Keokuk, Keosauqua, Mason City, McGregor, Missouri Valley, Muscatine, Onawa, Postville, Rockwell City, Sioux City, Story City, Webster City, Winterset.

General distribution in the United States:

Illinois—Chicago (J. R. Churchill), Urbana (A. Gilkerson, Herbarium of H. A. Gleason); Minnesota—Granite Falls (L. H. Pammel), International Falls (H. S. Kellogg), Minneapolis (George B. Alton); Missouri—Adams (Kenneth K. Mackenzie); Ohio—Cedar Point (E. Wilkinson); Lancaster (Dr. Bigelow);

Wisconsin—La Crosse (L. H. Pammel); Wyoming—Laramie county (F. G. Miller).

HONEY BEE VISITS

Ames, August 8, 1917. Cool. A few bees, flies, white butterflies and wasps.
Central Iowa, August 29, 1917, 3 p.m. Clear. Some bees, some moths.
Ames, September 4, 1917. Dry. No bees on plants on hillsides.

July 2, 1918. No bees. Some other insects.

August 27, 1929, 10:30 a.m. Some bees gathering pollen. One second in a flower.

September 17, 1929. Pollen and nectar. One second in a flower.

September 18, 1929, 10:30 a.m. No bees. (Temperature 60°.) Near an apiary. Many bees on *Aster novae-angliae.*

September 23 and 25, 1929, 10:30 a.m. Clear and warm. Some honey bees.

September 26, 1929. Clear and warm. Some bees. Many Diptera and Coleoptera. Bees one second in a flower.

September 15 and 17, 1930, 4 p.m. Some bees. Sept. 20, 2 p.m. Some bees. *Bombus* numerous. Sept. 24, 8 a.m. Cloudy and sultry. No bees.

Dr. H. H. Knight reports the following insect visitors at Ames:

Coleoptera: *Diabrotica longicornis* Say. *D. 12-punctata* Fabr. Yellow beetle (*Chauliognathus pennsylvanicus* De G.).

Diptera: Tachinid fly (*Archytas aterrima* Desv.).

Lepidoptera: Cabbage beetle butterfly (*Pieris rapae* L.). Red Admiral (*Vanessa atalanta* L.). American Copper (*Chrysophanus hypophlaas* Bdv.). Clouded Sulphur (*Eurymus philodice* Godt.).

ASTERS

Asters are perennial herbs, flowering chiefly in the autumn, with heads arranged in corymbs, panicles or racemes. The heads are many-flowered, each flower with a single row of white, purple, blue or pink rays; the ray flowers are fertile; the disc is yellow, often changing to purple.

The genus *Aster* is well represented in Iowa. These flowers are freely visited by honey bees during some seasons and in parts of Iowa every season for their nectar; and there are several species of asters which contribute an important amount to the fall honey crop.

The seasonal range for the blooming of asters in Iowa is from the middle of August to the middle of October, when the heavy frosts are deferred, with September as the month of continuous harvest of nectar.

Whoever visits in the field or woodland a group of asters during the period of full bloom witnesses a scene of interesting and beautiful activities, opening his eyes to the myriad inter-relationships in nature. No more lovely sight may be found than the insect visitors busily at work upon a softly-brilliant mass of aster bloom on a bright September day.

Asters as a Source of Honey

Beekeepers generally report the asters as good honey plants. Frank Pellett says, "Some species produce nectar much more abundantly than others, and it is probable that the flow from all kinds is more or less affected by soil or climatic conditions.

"In most localities the aster honey is mixed with that from goldenrod, and the two sources are usually spoken of together.

"It is probable that most of the species are of more or less value for honey under favorable conditions." However, the amount of nectar produced varies with the season, soil and climate. A few years ago, we made a study of asters in central Iowa and later in northeastern Iowa late in August and early in September. The species *Aster multiflorus, A. Tradescanti, A. azureus* and *A. laevis,* though common in central Iowa prairie soil, were visited very little by honey bees. A short distance north of McGregor, in the region about La Crosse, all of these and other species were common on the sandy and calcareous soil. Honey bees were abundant. Every plant of the various species coming under our observation was abundantly visited by bees.

It is apparent that the woodland species like *A. Drummondii, A. sagittifolius* and *A. cordifolius* are much more valuable for honey than are the prairie species like *A. azureus* and *A. laevis.*

Species of alluvial bottoms like *A. Tradescanti* and *A. lateriflorus* of the white-flowered species are much more important than the prairie species *A. multiflorus.*

The New England aster *A. novae-angliae,* growing in rather moist places, cannot be compared with some of the other species; its honey production varies greatly in different seasons, as also is the case with *A. salicifolius* and *A. paniculatus.* In 1929 and 1930 it was abundantly visited by honey bees during its entire blooming season.

Some Characteristics of the Flower of Aster

Complete studies have been made by Loew,[1] and by Knuth,[2] Mueller[3] and Kerner.[4]

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1 Blütenbiol. Floristic.

2 Handbook of Flower Pollination, Eng. Trans.

3 Fertilization of Flowers.

4 The Natural History of Plants.

Ray flowers in one row, pistillate, usually differently colored than the yellow disc flowers. Branches of the style broadened, covered with brush hairs above, and beset by numerous stigmatic papillae laterally and internally, their tips almost always inclined together in the perfect flowers. The brush hairs remove the copious pollen.

FIG. 366.—Aster, visited by bee. *Photograph by H. E. Jaques.*

Nectar in asters is secreted by a ring surrounding the style at the base of a narrow tubular corolla, and as it accumulates it rises up into the wider part of the corolla, where it is accessible to most of the short-tongued insects.

In many composites, especially in asters and goldenrod, as well as in many other species of the family, like yarrow, ragwort, the tubular florets are so arranged in the center of the head that the pollen is expelled from the younger, proterandrous inner flowers, falling then on the stigmas of the adjacent outer, older flowers without the aid of any special elongation or curvature of the style.

Aster oblongifolius Nutt. Aromatic Aster

Minutely glandular, branched above, stiff, 1 foot to 2 feet high. Leaves lanceolate, sharp-tipped, partly clasping, firm, entire-margined. Rays violet-purple. Heads of middle size.

Dry hills, sandy soil, gravel knolls and Missouri loess. Associated with *Bouteloua oligostachya, Sporobolus cuspidatus, Andropogon scoparius, Lespedeza capitata, Brauneria purpurea, Solidago nemoralis, Petalostemum purpureum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Charles City, Dubuque, Gillett Grove, McGregor, Rock Rapids, Sioux City, Turin (L. H. Pammel); Fayette (B. Fink), Keokuk (L. H. Pammel and P. H. Rolfs).

This aster is common in western Iowa, especially on loess soil. It has been observed at Missouri Valley, Council Bluffs, Storm Lake, Cherokee and Spirit Lake, Hamburg, Sac City, Ames, Marshalltown, Webster City, Fort Dodge, Emmetsburg.

General distribution in the United States:

Minnesota—Granite Falls (L. H. Pammel), Minneapolis (J. H. Sandberg); Missouri—Davis, Hannibal (Herbarium of University of Texas), Hodson (Kenneth K. Mackenzie), St. Louis (H. Eggert); Nebraska—Callaway (J. M. Bates); North Dakota—Minot (J. C. Blumer).

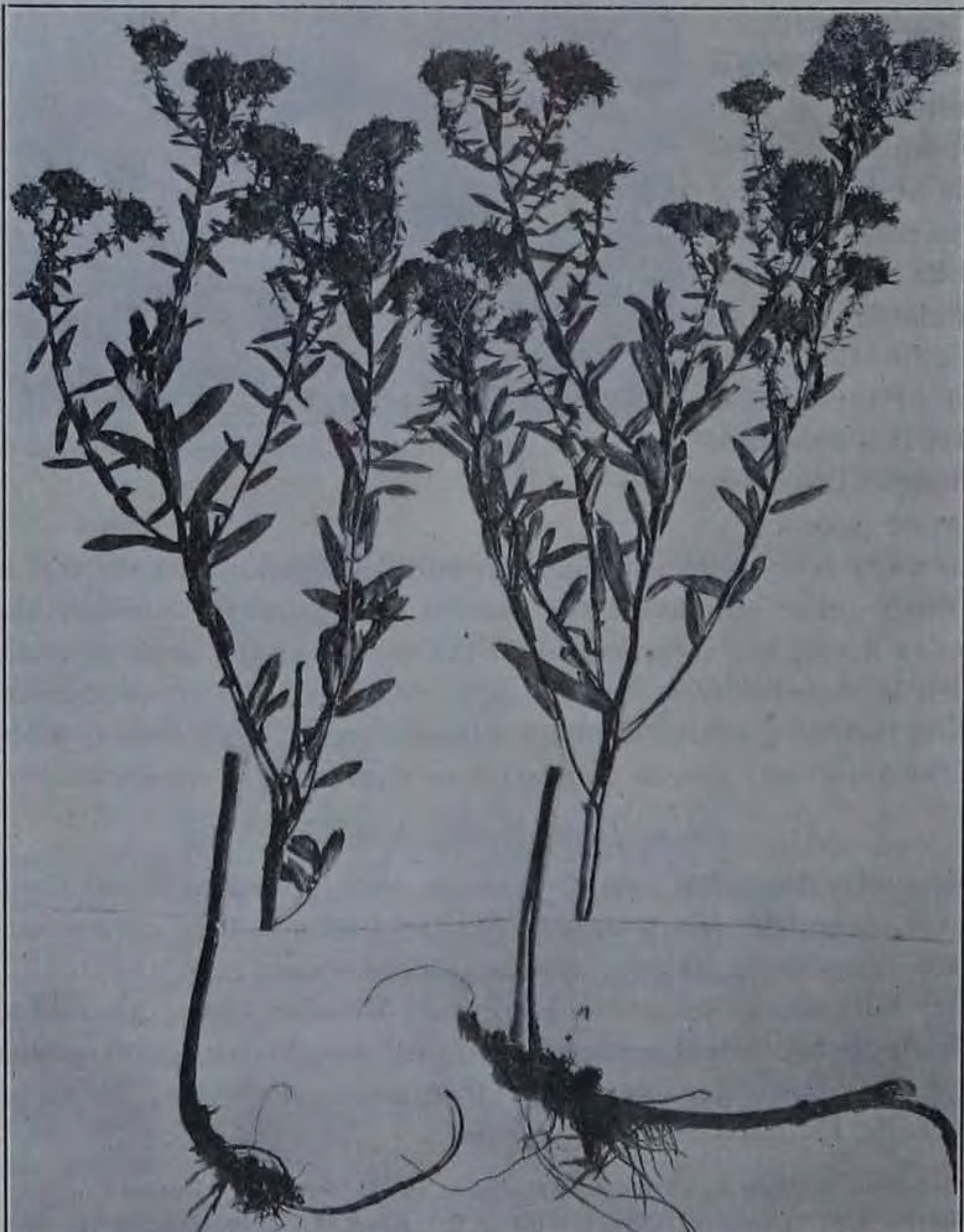

FIG. 367.—Oblong-leaved aster (*Aster oblongifolius*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

HONEY BEE VISITS

Armstrong, September 6, 1907. (R. I. Cratty.)

McGregor, October 4, 1918. Late bloom, September to October. In bloom after frost.

East Dubuque, Illinois, October 4, 1918. Twenty-five flowers in forty seconds.

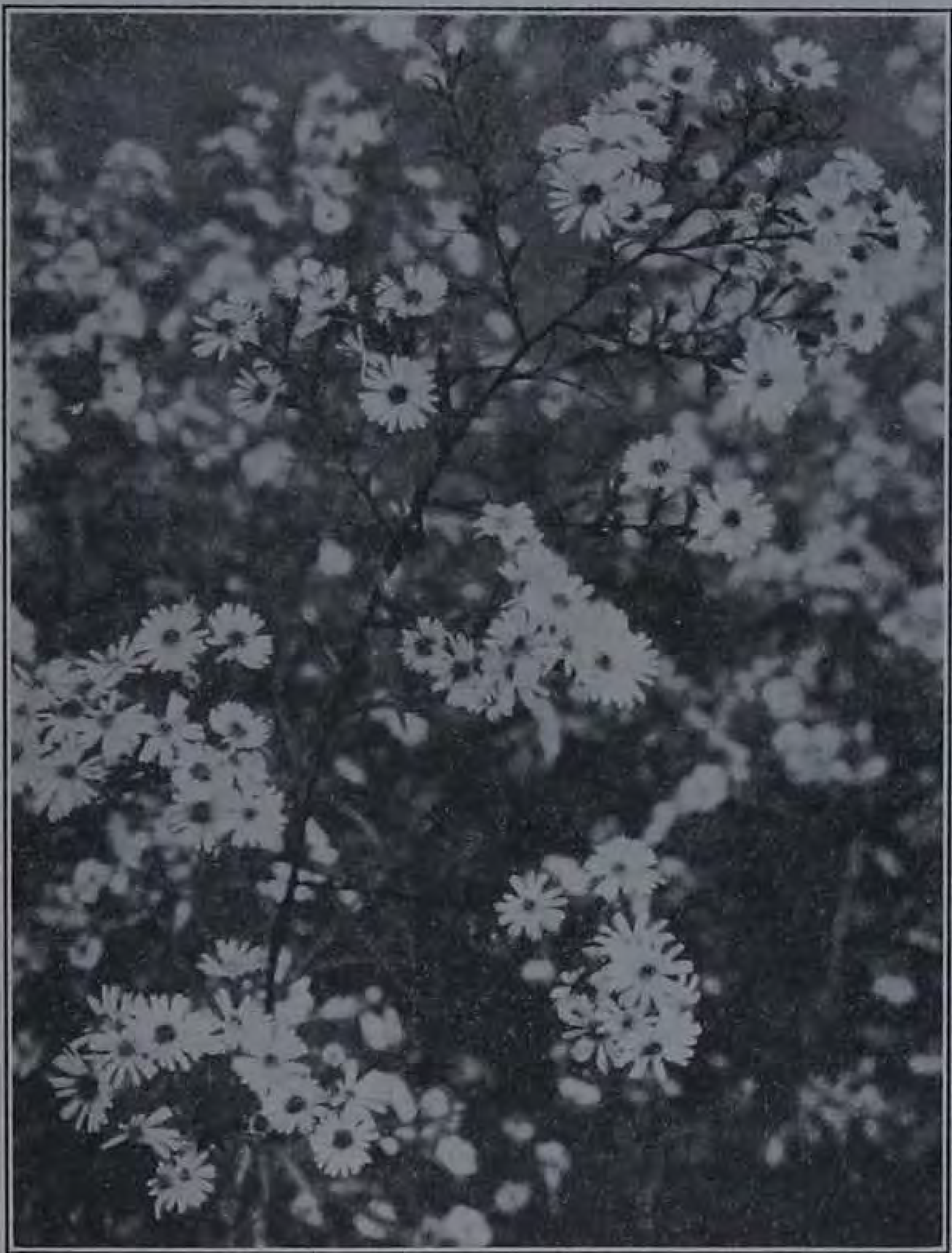

FIG. 368.—Long-leaved aster (*Aster longifolius*). *Photograph by Ada Hayden.*

Ames, September 17, 1929, 1:30 p.m. Cool, west wind, clear. Bees abundant.

September 18, 1929. No bees. Many bees on *Aster novae-angliae* (near apiary). Temperature 60°.

September 20 and 23, 1929, 10:30 a.m. Some bees. One second in a flower. Beetles, yellow butterfly, *Pieris rapae, Bombus,* Diptera.

September 20, 1930, 2 p.m. A few bees. *Bombus* more numerous.

Dr. H. H. Knight reports the following insect visitors:

Diptera.

Tachina fly (*Archytas aterrima* Desv.).

Lepidoptera.

Yellow Butterfly (*Eurymus philodice* Godt.). Cabbage Butterfly (*Pieris rapae* L.). Dingy cutworm moth (*Feltia ducens* Walk.).

FIG. 369.—Long-leaved aster (*Aster longifolius*). *Photograph by Ada Hayden.*

Aster novae-angliae L. New England Aster

A stout, roughish perennial plant with clusters of large, many-rayed purple heads toward the top. Disc flowers numerous, yellow. Flowers faintly fragrant. Leaves entire-margined, lanceolate, clasping, slightly lobed at base. Often found in large patches. Blooms late, August to October. Widely distributed.

Chiefly in moist calcareous soils in many places, especially in low moist grounds along upland streams, in upland prairie soils and in wet, peaty, partly drained marshes. Associated with *Solidago*

FIG. 370.—New England aster (*Aster novae-angliae*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

serotina, Helianthus grosse-serratus, Aster salicifolius, A. prenanthoides, Gentiana quinquefolia.

The faintly fragrant flowers are in purple heads. Knuth calls attention to the fact that the blue ray florets fold in, closing over the yellow disc florets in the evening and during wet weather.

The honey bee is a very common visitor found upon the flower during the period of bloom. The disc flowers supply both nectar and pollen.

Charles Robertson says, "The plants grow in rather large patches

Fig. 371.—New England aster (*Aster novae-angliae*). *Photograph by Ada Hayden.*

and bear numerous showy heads with yellow discs and violet purple rays. The heads expand two and three centimeters. Nectar and pollen are supplied by the disc florets. The tubes of these measure three or four millimeters in length."

Honey bees were observed collecting pollen and nectar among the many insect visitors October 2 to 10.

The flower mechanism in *A. novae-angliae* is the same as in other species of aster; the tips of the stylar branches as they grow through the anther-cylinder brush out the pollen by means of small sweeping hairs and subsequently papillae are exposed.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Beulah, Centerville, Des Moines, Edgewood, Emmet county, Fertile, Fort Dodge, Fraser, Hawarden, Little Rock, Marion county, Mason City, Rock Rapids, Shenandoah, Toledo, Twelve Mile lake, Wheelerwood, Willow creek (L. H. Pammel); Ames (C. E. Bessey, Ada Hayden), Armstrong (R. I. Cratty), Belmond (G. C. Clark), Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson), Fayette (B. Fink, two specimens), Fraser (Botanical Party), High lake (B. O. Wolden), Johnson county (T. J. and M. F. L. Fitzpatrick), Ledges (Boone county) (R. E. Buchanan, L. H. Pammel and C. M. King), Mount Pleasant (H. E. Jaques), Ontario (R. Burgess), Pilot Knob (L. H. Pammel and Miss W. Gilbert), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott, Botanical Party), Traer (J. W. Provan), West Chester (S. L. Goodspeed), Winneshiek county (H. Goddard).

It has been observed (L. H. Pammel) at Algona, Burlington, Charles City, Clinton, Emmetsburg, Estherville, Fairfield, Guthrie Center, Hamburg, Hampton, Indianola, Keokuk, Keosauqua, Lake Mills, Lyon county, Mason City, Oakland Mills, Postville, Sioux City, Waukon, Webster City, Winterset.

General distribution in the United States:

Connecticut—Pine Cottage (Mrs. L. M. Parker); District of Columbia—Brightwood (C. R. Ball); Illinois—Berwyn (H. S. Fawcett); Minnesota—St. Cloud (R. Gmelin), Winona (John M. Holzinger); Missouri—St. Louis (P. T. Barnes, M. B. L. and P. B.); Nebraska—Lincoln (R. Gmelin); New York—Bedford Park and vicinity; New York—New York City (Percy Wilson), Ithaca (Muenscher, Bechtel and H. E. Summers), Niagara Falls (G. H. Frazier); Ohio—Columbus (H. A. Gleason), Lancaster (Dr. Bigelow); Wisconsin—La Crosse (Dora Pammel and C. M. King).

HONEY BEE VISITS

Knuth records visits of honey bees to these flowers as late as October 16. In general the New England aster is in bloom in Iowa from late August to late September until frost; it is freely visited by bees during this period.

Robertson records this aster as being visited by honey bees during the first week of October.

Toledo, September 24, 1914. Clear, recent rain. Three bees, rather more *Bombus*, wasps, flies, beetles. Probably nectar and pollen. One honey bee visits fifty flowers per minute on six heads. (L.A.K.)

La Crosse, Wisconsin, September 23, 1918. Warm afternoon. Bees came from the apiary one-fourth mile away, over a hill 350 feet high. Some bees at work on the plant. A bee visits 45 flowers in one minute.

Macoupin county, Illinois, McGregor, Postville, October 4, 1918. Many bees.

Clermont, October 4, 1918. Some bees. One bee visited 48 flowers in one minute.

Ames, September 29, 1922, 11 a.m. Clear, warm. Bees abundant. One second in a flower.

September 21, 1923, 12 m. Warm, sunny. Bees freely working on this aster.

I.S.C. Hort. Garden, October 2, 1923, 10 a.m. Bright, cool, clear. A few bees. One second in a flower. Numerous other insects.

Ames, September 5, 1927. Bees one second in a flower. Visit five to fifteen flowers in one head.

Rock Island, Illinois, September 12, 1927, 3 p.m. (Clay soil.) Clear, warm. Bees common. One second in a flower.

Ames, September 24, 1927, 2:30 p.m. Warm, cloudy. Bees abundant. One second in a flower.

September 11, 1928. Bees fairly common. One second in a flower. No bees on *Boltonia asteroides*, *Heliopsis scabra*, nor *Helenium autumnale*.

November 28 and 29, 1929. Cool. Bees fairly common.

September 16, 1930, 1 p.m. Strong north wind. Bees common. Sept. 17, 4 p.m. Cloudy. Bees numerous. Sept. 20 and 24. Some bees, also *Bombus* sp., Monarch and cabbage butterflies and *Colias*.

Oskaloosa, September 30, 1928. Bright. Bees one second in a flower.

Winterset, August 8, 1929. Bees one second in a flower.

Ames, August 27, 1929, 10:30 a.m. Clear, cool. Some bees. One second. Gathering pollen.

September 11, 1929. Bees numerous. One second in a flower. (Near apiary.) Beetles, *Pieris*, Monarch butterfly present.

September 16 and 18, 1929. Bees abundant. One second in a flower. Ray flowers partly closed. (Temperature 60°.)

September 23 to 28, 1929. Clear and warm. Bees abundant. One second in a flower.

Dr. H. H. Knight reports other insect visitors as follows:

Coleoptera: *Diabrotica longicornis* Say. Yellow beetle (*Chauliognathus pennsylvanicus* De G.).

Hymenoptera: *Halictus* sp. *Agapostemon texanus* Cress.

Lepidoptera: Black Moth (*Ctenucha virginica* Charp). Yellow butterfly (*Eurymus philodice* Godt.). White butterfly (*Pieris protodice* Bdv. Lic.). Cabbage butterfly (*Pieris rapae* L.). Monarch butterfly (*Danais archippus* Auct.)

Ames, September 30, 1929. Bees numerous. Bees one second in a flower. No bees on *Eupatorium urticaefolium* adjacent.

October 5, 1929, 11 a.m. Clear. One second on a flower.

Booneville, October 5, 1929, 12:30 p.m. One second on a flower.

Ames, October 16, 1929, 8:30 a.m. Clear and cool. Bees one second in a flower. (L.H.P. and Dorothy Johnson.)

Aster azureus Lindl. Sky-blue Aster

Stems somewhat rough, compound clusters borne near the summit, the branches slender and stiff. Leaves rather rough, the lower oblong, heart-shaped, on long petioles; the other leaves lanceolate to linear, sessile, those on the branches bractlike. Leaves entire or slightly serrate. Heads middle-sized; rays bright blue. Copses and prairies; wide distribution.

FIG. 372.—Sky-blue aster (*Aster azureus*). *Photograph by A. Hayden.*

Upland prairies in rather dry soils. Associated with *Aster laevis*, *A. multiflorus*, *Andropogon scoparius*, *A. furcatus*, *Bouteloua curtipendula*, *Polygala verticillata*, *Astragalus caryocarpus*.

Distribution in Iowa as shown by specimens in I.S.C. Herbarium:

Ames, Wheelerwood (L. H. Pammel); Cedar Rapids (R. E. Buchanan), Charles City (L. H. Pammel and E. H. Sherman), Decatur county (J. P. Anderson), Kelley (Botanical Party), Lawler (P. H. Rolfs).

Observed (L. H. Pammel) at Carroll, Clermont, Estherville, Fort Dodge, Guthrie Center, Keokuk, Keosauqua, Lyon county, Marshalltown, Missouri Valley, Rockwell City, Sioux City, Webster City.

General distribution in the United States:

Illinois—Berwyn (H. S. Fawcett), Chicago (L. H. Pammel), Havana (H. A. Gleason), Peoria (F. E. McDonald); Indiana—Shore of Lake Michigan, "Millers" (J. R. Churchill), Posey county (John S. Wright); Kansas—Nuncey (Kenneth K. Mackenzie); Minnesota—Brainerd (E. B. Watson), Crow Wing county (J. H. Sandberg), Minneapolis (L. H. Pammel); Missouri—Jackson county, Jones creek (Kenneth K. Mackenzie); Nebraska—Lincoln (R. Gmelin); Wisconsin—Brown county (J. H. Schuette), La Crosse (four specimens, L. H. Pammel).

HONEY BEE VISITS

Pellett quotes a statement from the *American Bee Journal* that this aster, known as the stickweed, is one of the best asters for producing honey in the

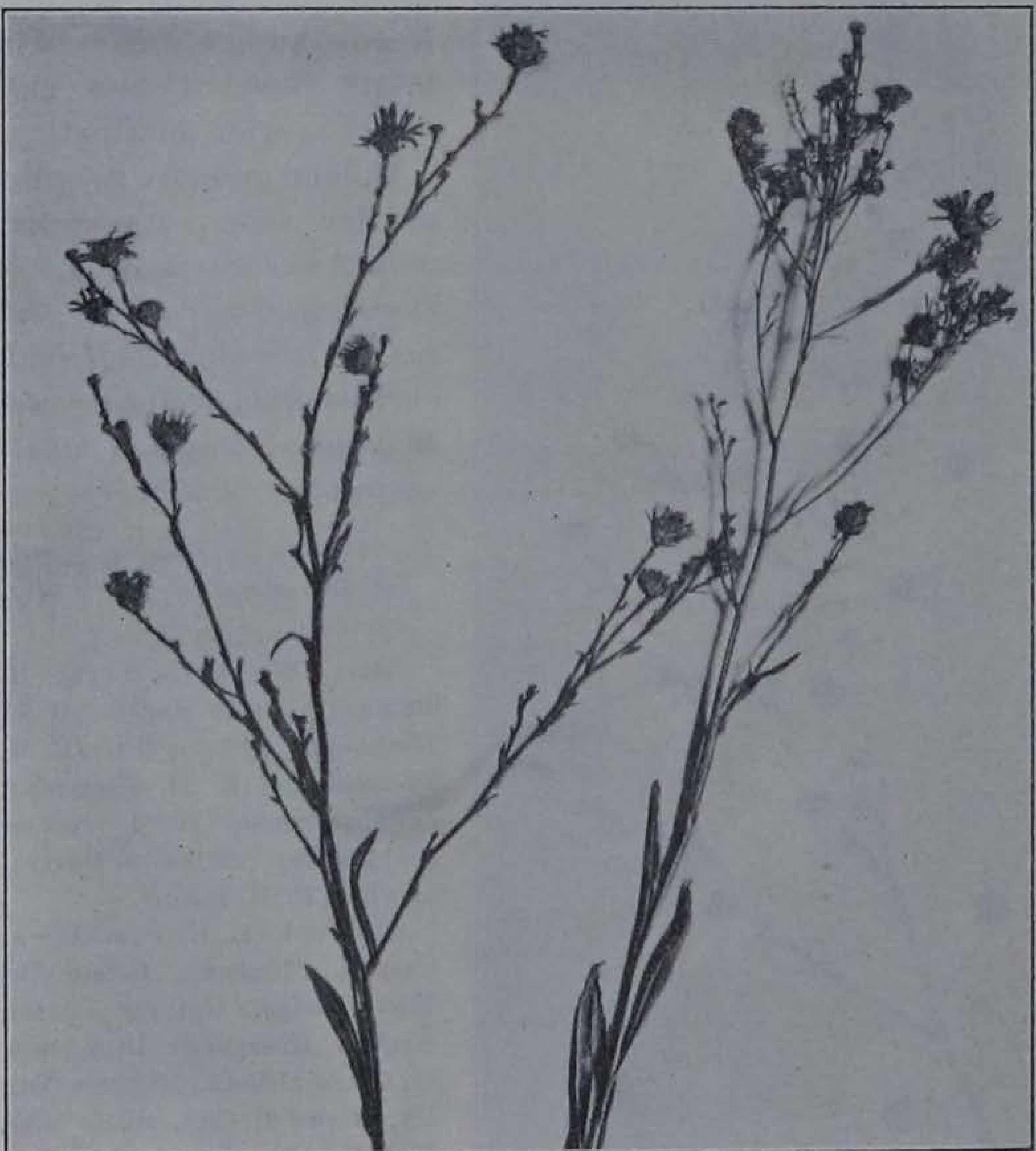

FIG. 373.—Sky-blue aster (*Aster azureus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

fall of the year. The bloom lasts until about the middle of October in West Virginia.

La Crosse, Wisconsin, September 23, 1918. Warm afternoon. Apiary located a quarter of a mile from the orchard where the asters were growing, on the opposite side of a bluff. Soil, sandy loam. This aster blooms from the last of August throughout September, and is attractive to bees.

McGregor, October 4, 1918. Bees abundant. Also at Clermont and Postville, same day.

Rock Island, Illinois, September 12, 1927, 9 a.m. Clear, warm. Some bees. One second in a flower. Near apiary.

This is an excellent honey plant.

FIG. 374.—Heart-leaved aster (*Aster cordifolius*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Aster cordifolius L. Common Blue Wood Aster

Stem nearly smooth, widely branching above, the diverging branches bearing numerous panicled heads; leaves thin, sharply saw-toothed, roughened above; the lower all heart-shaped on slender petioles; the upper chiefly cordate at base. Bracts of the involucre all appressed, with very short green tips; rays bluish; heads small. Woods and thickets in clay soils. Not common in Iowa.

Robinson and Fernald give the distribution as follows: Quebec to Iowa, south to Georgia and Missouri.

FIG. 375.—Heart-leaved aster (*Aster cordifolius*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decorah (E. W. D. Holway), Fayette (B. Fink).

Also observed (L. H. Pammel) at Clinton, Dubuque and Marshalltown.

General distribution in the United States:

Massachusetts—Waltham (J. W. Blankinship); New York—Ithaca (H. E. Summers); Ohio—Buckeye Lake, Licking county (H. A. Gleason); Virginia—Park Lane (E. S. Steele), Row creek (Lester F. Ward).

HONEY BEE VISITS

Blooms from August to October. It is reported by Pellett as a valuable honey plant in favorable seasons. Mr. Pellett quotes Mr. F. W. L. Sladen of Canada as saying that this is a good honey plant. In one year 12,000 pounds of honey were obtained from this plant in a restricted district in Canada.

This plant is not of sufficient importance in Iowa to make it a valuable honey plant.

FIG. 376.—Arrow-leaved aster (*Aster sagittifolius*). *Photograph by Fryklund.*

FIG. 377.—Sagittate-leaved aster (*Aster sagittifolius*) and goldenrod (*Solidago*). *Photograph by Fryklund.*

Aster sagittifolius Wedemeyer. Arrow-leaved Aster

Stem erect, stiff, nearly smooth, with ascending branches with numerous racemose clusters of heads. Leaves thin, serrate, lanceolate, pointed; the lower heart-shaped at the base, with margined petioles. The upper lanceolate or linear, pointed at both ends. Bracts of the involucre linear, with loose awl-shaped tips. Heads small; flowers pale blue or nearly white, not showy. Blooms from August to October.

Clay woods, sandy or somewhat gravelly soils. Associated with *Quercus alba, Q. rubra, Ulmus fulva, Tilia americana, Prunus serotina, Hepatica acutiloba, Anemone nemorosa, Hydrophyllum virginianum, Dicentra Cucullaria, Sanicula marylandica.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Allamakee county, Centerville, Des Moines, Marion county, Red Rock, Steamboat Rock, Wall Lake, Yellow river (L. H. Pammel); Ames (C. E. Bessey), Charles City (C. L. Webster), Decatur county (J. P. Anderson), Fayette (B. Fink), Fraser (Botany Seminar), Ledges (Boone county) (Botanical Party), Marshalltown (L. H. Pammel and Estelle Fogel), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Salem (L. H. Pammel and H. E. Jaques), Spirit Lake (L. H. and H. E. Pammel).

It has been observed (L. H. Pammel) at Algona, Boone, Burlington, Council Bluffs, Des Moines, Eldora, Fairfield, Fort Dodge, Guthrie Center, Indianola, Keosauqua, Marshalltown, Rockwell City, Sioux City, Winterset.

FIG. 378.—Arrow-leaved aster (*Aster sagittifolius*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

General distribution in the United States:

Massachusetts—Wellesley (Grace Gilbert); Minnesota—Lake City, Leech Lake, Walker (L. H. Pammel), Cass Lake, Star Island (L. H. and H. E.

Pammel and P. S. McNutt), Cedar Island (L. H. and H. E. Pammel), Minneapolis (R. I. Cratty); Missouri—Allenton (George W. Letterman), Eagle Rock, Kansas City (Kenneth K. Mackenzie), St. Louis (H. Eggert); New Jersey—Clifton (George V. Nash); New York—Ithaca (Carrie Harrison), Niagara Falls (two specimens, G. H. Frazier); Ohio—Columbus (H. A. Gleason); Pennsylvania—Williamsport (John Small and A. A. Heller); Wisconsin—La Crosse (Dora S. Pammel).

HONEY BEE VISITS

At La Crosse, Wisconsin, on the east slopes in moist sandy soil honey bees were abundant and obtaining much nectar in some seasons; also much visited by other bees.

La Crosse, Wisconsin, September 23, 1918. The average number of flowers visited by one bee per minute was 36 to 40. Bees came from an apiary one-fourth of a mile away on the opposite side of bluffs.

McGregor, Postville, Clermont, October 4, 1918. Warm. Bees working at 5 p.m.

La Crosse, Wisconsin, September 23, 1919. Some bees on these flowers observed as late as 5 p.m.

Cassville, Wisconsin, September 22, 1920, 5:45 p.m. Warm, cloudy. Some bees.

Cherokee, September 22, 1928, 10 a.m. Bees one second in a flower.

Ames, September 17, 1929, 1:30 p.m. Cool, west wind, clear. Not many bees. Near *Bidens cernua*.

This late blooming aster is followed by bees until November, even after a slight frost.

Loew observed honey bees on this aster in the Berlin Botanical Gardens.

Aster Drummondii Lindl. Drummond's Aster

Pale, with fine gray pubescence. Leaves heart-shaped to lanceolate, mostly with margins, the uppermost lanceolate and sessile. Bracts sharp-pointed. Rays pale blue or nearly white. Similar to preceding, with which it is often confused. Open ground, of general distribution.

Upland woods. Clay or somewhat sandy soil. Associated with *Ulmus fulva, Tilia americana, Acer nigrum, Prunus virginiana, Dicentra Cucullaria, Sanguinaria canadensis, Hydrophyllum virginicum, Solidago ulmifolia, S. latifolia, Festuca nutans, Diarrhena diandra, Helianthus tuberosus.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Atlantic, Cherokee, Clarinda, Des Moines, Eddyville, Edgewood, Fairfield, Fayette, Forest City, Fraser, Gillett Grove, Keokuk, Lake Mills, Lime Springs, Manchester, Marion county, Mason City, Red Rock, Strawberry Point, Wapsipinicon river (L. H. Pammel); Centerville, Cooper creek, (L. H. Pammel and G. B. MacDonald), Adel (Chas. Clark), Armstrong (R. I. Cratty), Mount Pleasant (H. E. Jaques), Pilot Knob (L. H. Pammel and Winifred Gilbert).

It has been observed (L. H. Pammel) at Algona, Boone, Burlington, Cedar

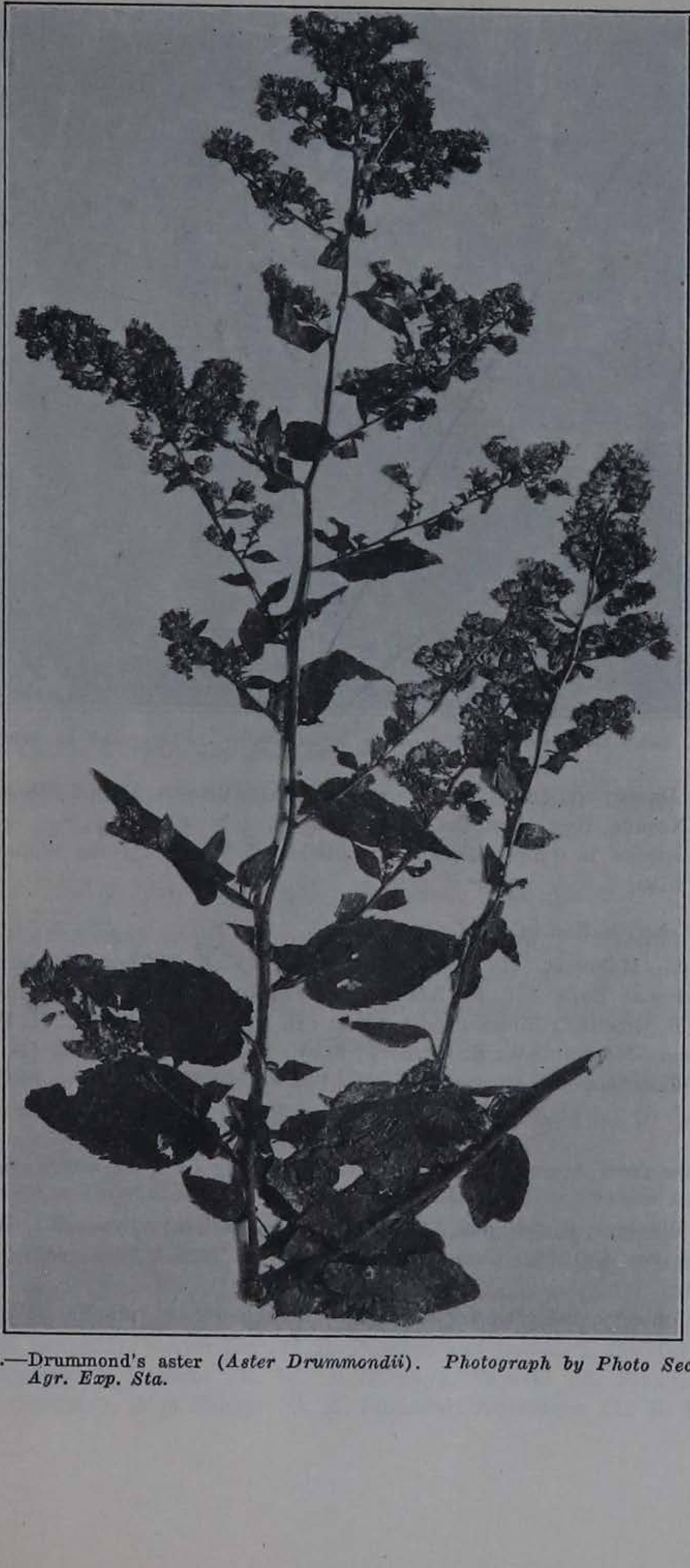

FIG. 379.—Drummond's aster (*Aster Drummondii*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

FIG. 380.—Drummond's aster (*Aster Drummondii*). *Photograph by Fryklund.*

Rapids, Davenport, Indianola, Keosauqua, Marshalltown, Mount Pleasant, Muscatine, Nevada, New Hampton, Winterset.

This species is quite widely distributed in Iowa, and is as common as *A. sagittifolius.*

General distribution in the United States:

Illinois—Mahomet (H. A. Gleason), Peoria (F. E. McDonald); Minnesota—International Falls (H. S. Kellogg), Rochester (Mrs. George Ainslie), St. Cloud (R. Gmelin); Missouri—St. Louis (H. Eggert), Wicks (L. H. Pammel); Oklahoma—Norman (W. E. Bruner); South Dakota—Sioux Falls (L. H. Pammel); Wisconsin—La Crosse, Madison (two specimens, L. H. Pammel).

HONEY BEE VISITS

Blooms from August to October. Bees working on these asters observed as follows:

Mount Pleasant, Keosauqua, August 29, 1917. McGregor, Cassville, Wisconsin, September 4, 1918. Cherokee, September 22, 1928. Bees one second in a flower.

It is of some value as a honey plant, though not as valuable as *A. sagittifolius.*

Aster Lindleyanus T. and G. Lindley's Aster

Somewhat stout, 1 foot to 3 feet high, nearly smooth. Radical and lowest leaves ovate, somewhat cordate, the uppermost without petioles, pointed at both ends. Heads middle sized, in a loose panicle or cluster, the slender bracts loose. Rays blue-violet. Thickets and open places, of ordinary general distribution, north and east.

Limestone bluffs of eastern Iowa. Associated with *Fraxinus americana, F. quadrangulata, Ulmus fulva, Aster sericeus, A. multiflorus, Solidago nemoralis.*

It is of considerable value as a fall honey plant in northeastern Iowa. We have no plants in the herbarium, although the species is fairly common about McGregor and in other parts of northeastern Iowa.

Has been observed (L. H. Pammel) at Clermont, Clinton, Dubuque, Keokuk, Marshalltown and McGregor.

HONEY BEE VISITS

La Crosse, Wisconsin, September 23, 1918. A bee visited 15 flowers in 18 seconds.

McGregor, Postville, Clermont, October 4, 1918. Bees working on these asters. One bee visits 40 to 50 flowers in one minute.

Blooms from August to October. Visited by Hymenoptera. Honey bees not mentioned by Loew, Berlin Botanical Garden.

Aster laevis L. Smooth Aster, Blue Aster

A rather robust plant, about two feet in height. Heads closely panicled, leaves firm, lanceolate, mostly entire, the upper usually clasping by lobed base. Involucre hemispherical, bracts with short green tips. Rays blue-violet. Dry soils.

Of wide distribution in the northern states, extending southward. A variable and beautiful species. Blooms from August to October. Visited by many Hymenoptera.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belmond, Cherokee, Des Moines, Edgewood, Emmetsburg, Garner, Gillett Grove, Hanlontown, Keokuk, Lebanon, Manchester, Mason City, Shenandoah, Sheldahl, Sioux City, Slater, Stratford, Walnut, Watertown (L. H. Pammel); Ames (C. M. King), Armstrong (R. I. Cratty), Boone county (L. H. Pammel and G. M. Lummis), Centerville (L. H. Pammel and Deming), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Fraser (Botany Seminar), High Bridge (G. M. Lummis), Keosauqua (L. H. Pammel

FIG. 381.—Blue aster (*Aster laevis*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

and G. B. MacDonald), Ontario (E. R. Hodson), Osage (Mrs. F. M. Tuttle), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott), southern Iowa (J. P. Anderson).

It has been observed (L. H. Pammel) at Carroll, Chariton, Denison, Forest City, Fort Dodge, Guthrie Center, Hamburg, Indianola, Marshalltown, Missouri Valley, Nevada, Rock Rapids, Rockwell City, Shenandoah, Winterset.

This species occurs in all parts of Iowa especially upon prairies and along roadsides.

FIG. 382.—Blue aster (*Aster laevis*). *Photograph by Ada Hayden.*

General distribution in the United States:

Colorado—Engelmann canyon (F. E. and E. S. Clements), Fort Collins (C. S. Crandall), Jefferson county (I. W. Clokey); Illinois—Peoria (F. E. McDonald); Massachusetts—Stoneham (J. W. Blankinship); Minnesota—Cass Lake, Graceville, Granite Falls, Minneapolis (L. H. Pammel), Crookston (two specimens, Mrs. Roy Westley), Hennepin county (J. H. Sandberg), Star Island (L. H. and H. E. Pammel and P. S. McNutt), Norway (L. H. and H. E. Pammel); New York—Geneva (L. H. Pammel), Ithaca (two specimens, Carrie Harrison); North Dakota—Minot (J. C. Blumer); South Carolina—Oconee county (A. P. Anderson); South Dakota—Brookings, Sioux Falls (L. H. Pammel); Wisconsin—Bay Settlement, Brown county (J. H. Schuette), Hudson (L. H. Pammel), Portland (C. M. King and Dora Pammel); Wyoming—Laramie (Edwin Payson).

HONEY BEE VISITS

Ames, September 18, 1917. Bright, clear. In timber. Bees abundant.

Keosauqua and Mount Pleasant, September 19, 1917. A few bees working.

La Crosse, Wisconsin, September 23, 1918. Warm. Apiary one-fourth of a mile away. Many bees were observed visiting this species.

Ames, September 28, 1917. Warm, south wind. A few bees, but many small Hymenoptera were at work.

September 29, 1922, 11 a.m. Bees abundant. One second in a flower.

This is one of the most valuable species of the genus as a honey plant. Evi-

FIG. 383.—Heath-like aster (*Aster ericoides*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

dently the amount of nectar flow depends on weather conditions and moisture in the soil.

Aster ericoides L. White Heath Aster, Frost Aster

Smooth, 1 foot to 3 feet high, the simple branchlets racemose along the upper side of the slender spreading branches. Lowest leaves broad, oblong, some of them serrate, the others linear-lanceolate or linear awl-shaped. Heads small, one-fourth inch high or less. Rays white, rarely purplish. Dry open places. Of wide distribution in alluvial ground. Blooms from August to October.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Camanche, Des Moines, Dubuque, Hamburg, Little Rock, Mount Pleasant, Quarry, Webster county (L. H. Pammel); Decatur county (J. P. Anderson), Henry county (J. H. Mills), Keokuk (L. H. Pammel and Iza Mitchell).

It has been observed (L. H. Pammel) at Burlington, Clinton, Davenport, Keosauqua, Oakland Mills, Winterset.

General distribution in the United States:

Cuba—Cienfuegos (Robert Combs); District of Columbia—Soldiers Home (C. R. Ball and A. E. Paddock); Georgia—Camp Gordon (D. C. Poshusta); Illinois—Graceland, Hamilton (L. H. Pammel); Indiana—Posey county (John S. Wright); Maryland—Below Great Falls (Lester F. Ward); Minnesota—Clear Lake, Lake City, Ortonville (two specimens, L. H. Pammel); Missouri—Crystal City (H. Eggert), Eagle Rock (Kenneth K. Mackenzie), Fountain City (R. Gmelin), Wicks (L. H. Pammel); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (Muenscher and Bechtel); South Carolina—Oconee county (A. P. Anderson); Texas—.......................... (H. Winslow) (Herb. Eli Lilly and Co.); Wisconsin—La Crosse (L. H. Pammel).

HONEY BEE VISITS

Frank Pellett is the authority for the statement that it is a valuable honey plant in Missouri.

Bees work vigorously upon this plant, although it is a late bloomer. It furnishes a good deal of honey, but its flow is dependent on climatic conditions. The flow is more copious after showers.

Aster multiflorus Ait. Dense-flowered Aster

Pale or hoary with minute close pubescence, 1 foot to 3 feet high, much branched and bushy; the small head much crowded on the spreading branches. Leaves stiff, crowded, spreading, with rough margins. Heads one-fourth inch long; rays white or occasionally purplish, 10 to 20. Dry sandy and prairie soil. Widely distributed. Associated with *Aster laevis*, *Helianthus occidentalis*, *H. scaberrimus*, *Brauneria purpurea*, *Stipa spartea*, *Andropogon scoparius*,

FIG. 384.—Dense-flowered aster (*Aster multiflorus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

A. furcatus, Bouteloua curtipendula, Aster laevis, A. azureus, Baptisia leucophaea, Rosa pratincola, Solidago missouriensis.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Belle Plaine, Charles City, Des Moines, Eagle Rock, Emmetsburg, Fraser, Garner, Hamilton county, Little Rock, Marion county, Oelwein, Spirit Lake, Stratford (L. H. Pammel); Ames (P. H. Rolfs, A. Hayden, C. E. Bessey and L. H. Pammel), Armstrong (R. I. Cratty), Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson), Eagle Rock (L. H. Pammel and E. R. Harlan), Floyd Springs (Mrs. F. M. Tuttle), Fraser (Botanical Seminar), Kelley (L. H. Pammel and C. E. Maxwell), Plymouth county (L. H. Pammel and Brown), Salem (L. H. Pammel and H. E. Jaques), Slater (H. S. Fawcett, W. I. Tener and C. Reinbott), Steamboat Rock (C. M. King), Traer (J. W. Provan), Winneshiek county (H. Goddard).

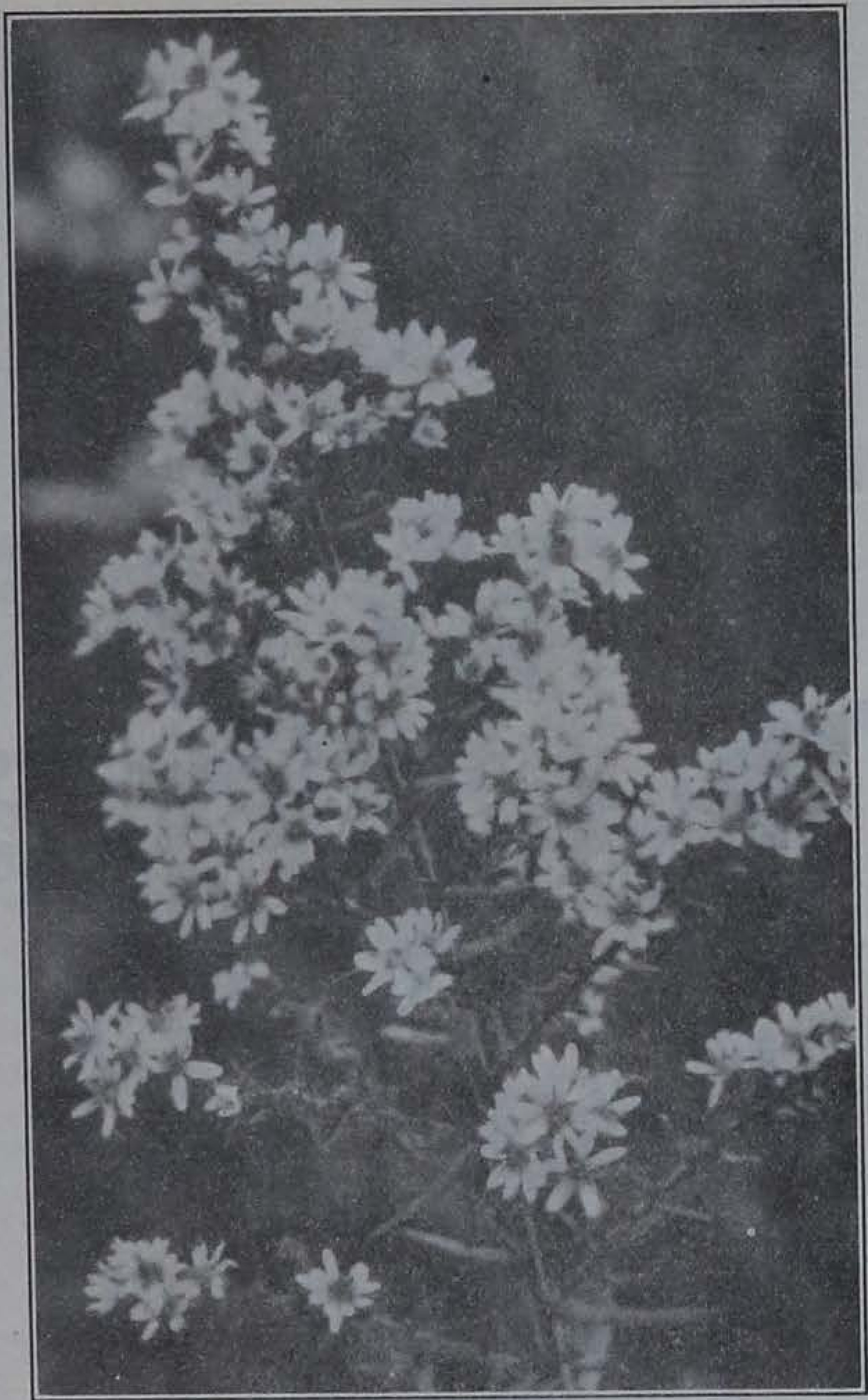

FIG. 385.—Dense-flowered aster (*Aster multiflorus*). *Photograph by A. Hayden.*

It has been observed (L. H. Pammel) at Carroll, Chariton, Clinton, Davenport, Denison, Estherville, Fairfield, Guthrie Center, Hamburg, Hampton, Indianola, Iowa City, Keosauqua, Missouri Valley, New Hampton, Oakland Mills, Rock Rapids, Shenandoah, Sioux City, Winterset.

General distribution in the United States:

Colorado—Arvada (I. W. Clokey), Fort Collins (L. H. Pammel and C. P. Johnson); Illinois—Berwyn (H. S. Fawcett), Peoria (F. E. McDonald); Massachusetts—Malden (J. W. Blankinship); Minnesota—Graceville, Lake City (L. H. Pammel), Minneapolis (J. S. Sandberg, J. M. Holzinger—U. S. National Herbarium); Missouri—(L. H. Pammel); Nebraska—Callaway (J. M.

FIG. 386.—Aster (*Aster lateriflorus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Bates), Crete, Holdrege (L. H. Pammel), Sheridan county (R. E. Buchanan); South Dakota—Brookings (Edna C. Pammel), Hot Springs (J. G. McMillan); Texas—Bracken (B. H. A. Groth), Tarrant county (Albert Ruth); Wisconsin—Fountain City (R. Gmelin), La Crosse (two specimens, Dora Pammel and C. M. King); Wyoming—Laramie county (two specimens, F. G. Miller), Laramie (L. H. Pammel, C. P. Johnson, R. E. Buchanan and G. M. Lummis).

Aster lateriflorus (L.) Britton. Starved Aster

Somewhat pubescent, branching. Leaves lanceolate to oblong-lanceolate, both ends tapering, sharply serrate in the middle. Bracts of involucre slender, sharp pointed, leafy branchlets. Rays short, white or pale bluish. Thickets, fields, etc.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Allamakee county, Council Bluffs, Edgewood, Fairfield, Hamburg, Madison county, McGregor, Rochester, Rock Rapids, Spirit Lake, Steamboat Rock, Turin, West Chester, Yellow river (L. H. Pammel); Ames (C. E. Bessey, A. Hayden), Belmond (C. F. Clark), Boone county (G. M. Lummis), Cedar Rapids (R. E. Buchanan), Decatur county (T. J. Fitzpatrick), Des Moines (G. W. Carver), Fairfield (L. H. Pammel and G. B. MacDonald), Fayette (B. Fink), Fraser (Botany Seminar), Mount Pleasant (H. E. Jaques), Osage (Mrs. F. M. Tuttle).

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Illinois—Hamilton (L. H. Pammel), Peoria (F. E. McDonald), ... (J. W. Wolf U. S. Nat. Herb.); Kansas—Argentine (Kenneth K. Mackenzie); Kentucky—Bell county (T. H. Kearney, Jr.); Maine—Bangor (M. L. Fernald); Maryland—Bladensburg (two specimens, G. McCarthy), Principio Furnace (F. E. Trenk); Massachusetts—Concord (J. W. Blankinship); Minnesota—Granite Falls (two specimens, L. H. Pammel), Monticello (L. H. Pammel); Missouri—near St. Louis (L. H. Pammel); Nebraska—Lincoln (R. Gmelin); New Jersey—Clifton (George V. Nash); New York—Ithaca (Muenscher and Bechtel); Nova Scotia—Partridge Island (G. V. N. Dearborn); Pennsylvania—Long Pond (John K. Small and A. A. Heller); South Dakota—Sioux Falls (L. H. Pammel); Texas—Tarrant county (Albert Ruth).

HONEY BEE VISITS

Blooms from August to October. This species is one of the valuable honey plants. Much visited by bees and furnishes much nectar. It is reported as a valuable honey plant in Canada and also is recorded as a honey plant by John H. Lovell.

Mount Pleasant and Keosauqua, August 29, 1917. Bees at work.

McGregor, September 4, 1918. Bees at work.

Aster Tradescanti L. Tradescant's Aster, Michaelmas Daisy

Stem very branching, 1½ to 4 feet high. The numerous middle-sized heads in raceme-like clusters. Leaves slender, lanceolate, tapering to a long, slender point; the lower leaves somewhat serrate in the middle. Involucre about one-fourth inch long, bracts linear, sharp-pointed, with green line along the back. Rays short and narrow, mostly white, rarely purplish.

Low alluvial bottoms. Associated with *Ulmus americana, Populus deltoides, Betula nigra, Cephalanthus occidentalis, Boltonia asteroides, Vernonia fasciculata, Carex Grayii, Cyperus esculentus, Lobelia cardinalis, Leersia lenticularis, Quercus bicolor, Q. palustris, Carya laciniosa, Salix nigra, S. amygdaloides.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville, Clinton, Marion county, Marshalltown, McGregor, Quarry (L. H. Pammel); Keosauqua, Mount Pleasant (L. H. Pammel and G. B. MacDonald), Algona (E. B. Watson), Ames (C. E. Bessey), Boone county (G. Lummis), Salem (L. H. Pammel and H. E. Jaques).

It has been observed (L. H. Pammel) at Charles City, Davenport, Des Moines, Eldora, Fairfield, Iowa Falls, Keokuk, Lansing, Mason City, Nevada, Postville, Waukon.

HONEY BEE VISITS

This is no doubt one of the valuable honey plants. In some places bees have been observed but the honey production seems to vary with the locality and soil. It is recorded as a honey plant by John H. Lovell and Frank Pellett. Mr. Pellett considers this as "the most important among asters as a source of surplus honey." It blooms from August to October, contributing much toward fall nectar supply in some places.

McGregor, October 4, 1918. Bees at work on these flowers.

Iowa City, September 22, 1922. Bees one second in a flower.

Norwalk, September 7, 1927, 4:30 p.m. Bright, clear, warm. Bees one second in a flower. Apiary one-fourth mile away.

Blairstown, September 28, 1929, 2 p.m. Clear. Bees one second in a flower.

Aster modestus Lindl. Great Northern Aster

Pubescent or sometimes smooth; stem slender, simple, with few large heads at the ends of slender branches; leaves lanceolate, sharp-pointed, narrowed toward base, sessile, serrulate; bractlets linear, slender-tipped, of equal length, mostly herbaceous; rays dark violet.

Rich soil, from western Ontario and northern Minnesota to Oregon.

Observed (L. H. Pammel) at McGregor and Clermont.

HONEY BEE VISITS

McGregor, October 4, 1918. Blooming.

Clermont, October 4, 1918. Windy, sunshiny. Bee visits 50 flowers per minute; five honey bees visiting one cluster of blossoms at the same time.

Aster paniculatus Lam. Tall White Aster

Stem smoothish, $1\frac{1}{2}$ to 7 feet high, branching. The branches are scattered, medium-sized heads in loose panicles. Leaves narrow, lanceolate, acute, slightly serrate or entire. Involucre one-third of an inch long; bracts linear with attenuate green tips. Rays white or purplish, one-fourth to one-third of an inch long. Wet meadows, thickets, etc.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Cherokee, Clarinda, Clear Lake, Des Moines, Marion county, McGregor, Oelwein, Rock Rapids, Wapsipinicon river, Washington, Wheelerwood (L. H. Pammel); Armstrong (R. I. Cratty), Boone county (G. M. Lummis), Decatur county (J. P. Anderson), Fayette (B. Fink).

It has been observed (L. H. Pammel) at Ames, Chariton, Clinton, Davenport, Hamburg, Hampton, Indianola, Keosauqua, Missouri Valley, Muscatine, Nevada, New Hampton, Winterset.

FIG. 387.—Panicled aster (*Aster paniculatus*). *Photograph by Colburn.*

FIG. 388.—Panicled aster (*Aster paniculatus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

General distribution in the United States:

Illinois—Peoria (F. E. McDonald); Kansas—Argentine (Kenneth K. Mackenzie); Massachusetts—Wyoming (J. W. Blankinship); Minnesota—Cass Lake, Star Island (L. H. and H. E. Pammel and P. S. McNutt), Granite Falls (two specimens, L. H. Pammel); Missouri—Kansas City (Kenneth K. Mackenzie), St. Louis (H. Eggert); Nebraska—Callaway (J. M. Bates); New York—Ithaca (Muenscher and Bechtel, H. E. Summers); Wisconsin—La Crosse (two specimens, L. H. Pammel), Marinette (J. H. Schuette).

HONEY BEE VISITS

Blooms from August to October. "Visited by honey bees first week in October, Macoupin Co., Ill." Robertson. A useful addition to bee pasture in the late season in some localities and in some seasons. Robertson observed many bees getting nectar October 8 to 17.

Lyons, Clinton, September 10 and 20, 1927. Bees abundant. Visit two to six flowers in a head.

Rock Island, Illinois, September 12, 1927, 3 p.m. (Clay soil.) Clear, warm. Bees common. One second in a flower.

Blairstown, September 28, 1929. Bees fairly common, next to apiary. One second in a flower.

Ames, October 2, 1929, 1:30 p.m. Some honey bees. One second.

September 20, 1930, 2 p.m. Some bees. *Bombus* sp. more frequent.

Aster salicifolius Ait. Willow Aster

Resembles *A. paniculatus*, the leaves somewhat shorter, firm, rough, mostly entire. Bracts of the involucre with short obtuse green tips. Heads in raceme-like cluster. Rays purplish to white. Abundant. Blooms from August to October.

Marshy grounds, borders of streams, sandy moist or clay soil. Associated with *Platanus occidentalis, Quercus rubra, Ulmus americana, Salix nigra, S. amygdaloides, Lobelia siphilitica, Rudbeckia laciniata, Silphium perfoliatum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park, Delaware county, Des Moines, Emmetsburg, Fertile, Gillett Grove, Hamburg, Mason City, Ogden, Pilot Mound, Saratoga, Sheldahl, Slater, Stratford (L. H. Pammel); Atlantic (F. Pellett), Cedar Rapids (R. E. Buchanan), Johnson county (T. J. Fitzpatrick), Kelley (L. H. Pammel and C. E. Maxwell), Newton (G. Drew), Osage (Mrs. F. M. Tuttle), Slater (Botanical Party).

It has been observed (L. H. Pammel) at Algona, Carroll, Chariton, Clinton, Denison, Dubuque, Emmetsburg, Estherville, Fairfield, Fort Dodge, Guthrie Center, Indianola, Keokuk, Keosauqua, Marshalltown, Shenandoah, Sioux City.

HONEY BEE VISITS

The corolla of this aster is comparatively wide, making nectar accessible. A large number of species of insects visit this plant.

Each head contains numerous purplish ray florets and 30 to 40 yellow disc florets 9 mm. in length; of this the contracted part of the corolla tube is 4 mm., the nectar-containing portion 2 mm. The nectar is readily accessible to

FIG. 389.—Willow-leaved aster (*Aster salicifolius*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

insects even with a stout proboscis and thick tongue. The honey bee is not mentioned as a visitor by Knuth.

La Crosse, Wisconsin, September 23, 1918. Warm. Some honey bees observed.

Postville, October 4, 1918. Bees at work.

September 2, 1919. Day cloudy. Bees at work. A contributor to fall nectar supply.

Prairie du Chien, Wisconsin, October 23, 1920. Southeast wind, cloudy. Alluvial soil; swamp flood plain. Bees visit 41 flowers per minute. (A.H.)

Ames, September 24, 1927, 2:30 p.m. Warm, cloudy. Bees abundant. One second in a flower.

Cherokee, September 21, 1928, 3 p.m. Bees one second in a flower.

Oskaloosa, September 30, 1928. One second in a flower.
Des Moines, September 21, 1929, 10 a.m. Clear, fairly warm, windy; near apiary. Bees one second in a flower.

On some soils and in favorable weather conditions with plenty of moisture honey bees are frequent and the plant furnishes considerable nectar. Pellett states that this plant is one of the most valuable of the honey plants in low ground in Iowa.

Aster novi-belgii L. New York Aster

Slender, 1 foot to 4 feet high; leaves mostly lanceolate, entire or slightly serrate, the upper leaves partly clasping. Heads about one-third of an inch high; rays from bright blue-violet to white.

FIG. 390.—New York aster (*Aster novi-belgii*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

McGregor (Goodspeed), Mount Pleasant (H. E. Jaques).

Observed (L. H. Pammel) at Ames, Cedar Rapids, Hampton, Humboldt, Lamont, Lansing, Manchester, Mason City, McGregor, New Hampton, Wheelerwood.

General distribution in the United States:

District of Columbia—Brightwood (C. R. Ball); Illinois—Englewood (two specimens, J. R. Churchill); Massachusetts—Cambridge, Malden (J. W.

FIG. 391.—Aster (*Aster umbellatus*). *Photograph by R. S. Kirby.*

Blankinship), Milton (J. R. Churchill); Washington—Rainier State Park (J. M. Grant).

HONEY BEE VISITS

McGregor, October 4, 1918. Some bees at work. It is of some value as a honey plant.

Ames, September 21, 1923, 12 m. Bright, warm. Bees freely visiting this aster in the Horticultural Garden. (C.M.K.)

Aster prenanthoides Muhl. Crooked-stem Aster

Height about three feet, flowers in corymb-like panicles. Leaves abruptly narrowed toward base, and again abruptly widened into a conspicuous auricle at attachment to stem. Rays violet. Borders of streams. New England west to Minnesota and Iowa.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Allamakee county (Yellow river), Ames, Edgewood, Mason City, Spirit Lake (L. H. Pammel); Ames (L. H. Pammel, Mina B. Lynch, and R. I. Cratty), Ogden (L. H. and H. E. Pammel), Archer (Clair Dexter), Chickasaw county (W. D. Spiker), Fayette (B. Fink).

HONEY BEE VISITS

Ames, October 13, 1929, 12:30 p.m. Clear. A slight north breeze. Only a few bees. One second in a flower.

Aster umbellatus Mill. Corymbed Aster

A smooth perennial, leafy to the top. Leaves lanceolate, deeply pointed. Heads with white ray flowers, in flat corymbs. Pappus double, the inner of long capillary bristles, the outer of very short and rigid bristles. Common in moist thickets.

General distribution in the United States:

Arkansas—Texarkana (A. A. and E. Gertrude Heller); District of Columbia—Piney Branch road (C. R. Ball and A. E. Paddock); Kansas—Arkansas City (M. A. Carlton) (U. S. Nat. Herb.); Maine—Bryant's Pond (J. W. Blankinship); Minnesota—Itasca Lake Park, Leech lake, Walker (L. H. Pammel), International Falls (H. S. Kellogg); Nebraska—Halsey (J. C. Blumer), Sheridan county (R. E. Buchanan); Newfoundland—Topsail (C. D. Howe and W. F. Lang); New Jersey—Asbury Park (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel); North Carolina—Dunn's Mountain (John K. Small); South Dakota—Spring creek (L. H. Pammel); Wisconsin—Fond du Lac (F. F. Wood), Holmen (L. H. Pammel), La Crosse (L. H. Pammel and R. Gmelin), Madison (J. R. Churchill), Portland (C. M. King and Dora Pammel).

FIG. 392.—Aster (*Aster umbellatus*). *Photograph by Ada Hayden.*

HONEY BEE VISITS

Bees have been observed upon this plant. F. W. Sladen as quoted in Pellett's "American Honey Plants" reports it as a useful honey plant in the eastern provinces of Canada. Bees have been observed on it in Iowa.

Aster ptarmicoides T. and G. Late White Aster

A low perennial with smooth or rough simple stems. Leaves narrow, linear-lanceolate, acute, rigid. Rough margins. Bracts short, without herbaceous tips. Heads small in flat corymbs. Flower white.

Not common in Iowa. Found in dry calcareous soil from New England to Missouri westward to Colorado and northward.

HONEY BEE VISITS

Ames, September 29, 1922, 11 a.m. Bees one second in a flower.

Aster patens Ait. Showy Blue Aaster

Leaves entire, stem leaves with clasping base; lower leaves not heart-shaped. Plant branching; flowers 1 to 2 cm. broad; rays deep blue-purple. Maine to Minnesota and southward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, L. H. Pammel.

General distribution in the United States:

District of Columbia, Rock creek (L. F. Evard); Illinois—Iuka (H. L. Featherly); Kentucky—Wasioto (T. H. Kearney); Massachusetts—Deerfield (M. A. Day), Malden (J. W. Blankinship), Wayland (K. Mano, M. C. Wiegand); Minnesota—St. Cloud (R. Gmelin); Missouri—Pertle Springs (E. T. and S. A. Harper), St. Louis (H. Eggert); New York—Ithaca (H. E. Summers); Oklahoma—Logan county (M. A. Carleton), Norman (W. E. Bruner); Texas—Tarrant county (Albert Ruth); Wisconsin—Fountain City (R. Gmelin).

HONEY BEE VISITS

Ames, September 1, 1929, 11 a.m. Bees one second in a flower.

September 17, 1929, 1:30 p.m. Some honey bees. One second in a flower.

September 18, 1929. No bees. Temperature 60°. Near an apiary. Many bees on *Aster novae-angliae*.

September 20, 1929. Bees one second in a flower. One *Bombus*. Some beetles.

Some blooming dates recorded for Aster in Iowa

Aster oblongifolius	Armstrong	Sept. 6, 1907	
	Cedar Rapids	Aug. 3, 1908	
	McGregor	Oct. 4, 1918	
	East Dubuque	Oct. 4, 1918	
Aster novae-angliae	Ames	Aug. 20, 1904	(in fruit)
	Cedar Rapids	Aug. 15, 1908	
	Lansing	Aug. 17, 1908	
	Boone	Aug. 24, 1908	
	Lansing	Aug. 20, 1910	
	Ames	Aug. 28, 1912	
	Emmet county	Aug. 8, 1912	
	Ames	Sept. 9-10, 1912-14	
	Ames	Aug. 15, 1916	
	Lansing	Aug. 5, 1916	
	Boone	Aug. 15, 1916	
	Ames	Sept. 5, 1918	
	McGregor	Oct. 4, 1918	
	La Crosse	Sept. 23, 1918	
	Ames	Aug. 15, 1919	
	Ames	Aug. 20, 1920	

	Ames	Sept. 1, 1920	
	Lansing	Sept. 14, 1920	
	Ames	Sept. 14, 1920	
Aster azureus	Armstrong	Sept. 1, 1907	
	Cedar Rapids	Aug. 25, 1908	
	McGregor	Oct. 4, 1918	
	Postville	Oct. 4, 1918	
	Clermont	Oct. 4, 1918	
	Ames	Sept. 5, 1920	
Aster cordifolius	Emmet county	Aug. 20, 1921	
	Ames	Sept. 1-10, 1920	
Aster sagittifolius	Armstrong	Sept. 1, 1907	
	Keosauqua	Aug. 29, 1917	
	McGregor	Oct. 4, 1918	
	La Crosse	Sept. 23, 1918	
	Postville	Oct. 4, 1918	
	Clermont	Sept. 4, 1918	
Aster Drummondii	Mount Pleasant	Aug. 29, 1917	
	Keosauqua	Aug. 29, 1917	
	McGregor	Sept. 4, 1918	
	Cassville, Wis.	Sept. 4, 1918	
Aster Lindleyanus	McGregor	Sept. 4, 1918	
Aster laevis	Ames	Aug. 20, 1902	
	Armstrong	Aug. 25, 1907	
	Ames	Sept. 1907	
	Cedar Rapids	Aug. 29, 1908	
	McGregor	Sept. 4, 1918	
Aster ericoides	Armstrong	Aug. 27, 1907	
	Cedar Rapids	Oct. 1, 1908	
Aster multiflorus	Cedar Rapids	Aug. 16, 1908	
	Ames	Sept. 1-10, 1910-15	Still blooming, no frost.
	Ames	Sept. 2, 1916	
	Boone	Sept. 4, 1917	
	Ames	Sept. 1, 1918	
	McGregor	Oct. 4, 1918	
	Postville	Oct. 4, 1918	
	Clermont	Oct. 4, 1918	

	La Crosse	Oct.	4, 1918	
	Ames	Sept.	1, 1919	
	Ames	Sept.	1, 1920	
	Ames	Sept.	28, 1921	
Aster lateriflorus	Mount Pleasant	Aug.	29, 1917	
	Keosauqua	Oct.	9, 1917	
	McGregor	Oct.	4, 1918	
Aster Tradescanti	McGregor	Oct.	4, 1918	
Aster salicifolius	Ames	Oct.	1908	Still blooming
Aster novi-belgii	McGregor	Oct.	4, 1918	
	Ames	Sept.	5, 1921	
Aster puniceus	Armstrong	Sept.	5, 1907	
	Cedar Rapids	Aug.	27, 1908	
Aster vimineus	Cedar Rapids	Aug.	28, 1908	
	Armstrong	Sept.	2, 1907	
"Wood Asters"	Ames	Sept.	30, 1911	Blooming freely after frost.
	Ames	Sept.	1916	Several kinds blooming after light frosts.
	Ames		1917	Two weeks after light frosts, still blooming.
	Davenport	Nov.	22, 1918	
	Ames	Oct.	10, 1921	No frost, several asters blooming.

Erigeron L. Fleabane

Annual or perennial herbs either caulescent or acaulescent. Leaves entire, toothed or rarely divided. Stem leaves alternate. Flowers with rays or without. Involucre bell-shaped. Ray flowers rose, violet or purple. Pappus soft bristled.

On the species occurring in Europe which have been studied by Mueller (*E. uniflorus, E. canadensis, E. acris*), the honey bee is not recorded.

In spite of the inconspicuous flowers of *E. canadensis*, according to Kerner in Natural History of Plants, they are not self-fertilized.

Charles Robertson discusses this genus under the species *E.*

philadelphicus. He says, "The nectar is easily obtained by small long-tongued insects, which find a convenient resting place upon the disc. Pollen is forced out of the tube in the usual way." The flower blooms from April 26 to June 13 (southern Illinois). He observed the honey bee at work on this flower.

Erigeron annuus (L.) Pers. Daisy Fleabane

Annual, pubescent, leafy-stemmed, branching plant. Leaves coarsely toothed. Heads corymbed, rays white tinged with purple. Fields and waste places, common. Naturalized in Europe.

Cultivated fields, meadows, pastures, alluvial soils, prairie soils, clay, sandy and Missouri loess soils. Associated with *Trifolium pratense, Phleum pratense, Rumex crispus, R. altissimus, R. mexicanus, Lepidium apetalum, Lepidium virginicum, Sisymbrium officinale*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Algona (R. I. Cratty), Ames (C. E. Bessey, Harriet Pammel, C. R. Ball, R.

FIG. 393.—Daisy fleabane (*Erigeron annuus*). *Photograph by A. Hayden.*

E. Jeffs, G. W. Carver), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Dubuque (L. H. Pammel), Fayette (B. Fink), Kelley (Pearl Clayton), Lamont (I. T. Bode), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan, C. M. King), Marathon (H. G. Roberts), Muscatine (C. R. Ball), Osage (R. I. Cratty, Mrs. Tuttle), Ottumwa (John Parks), Postville (L. H. Pammel, Ellison Orr and D. O. Wilson), Red Oak (E. M. Cary), Winneshiek county (H. A. Goddard).

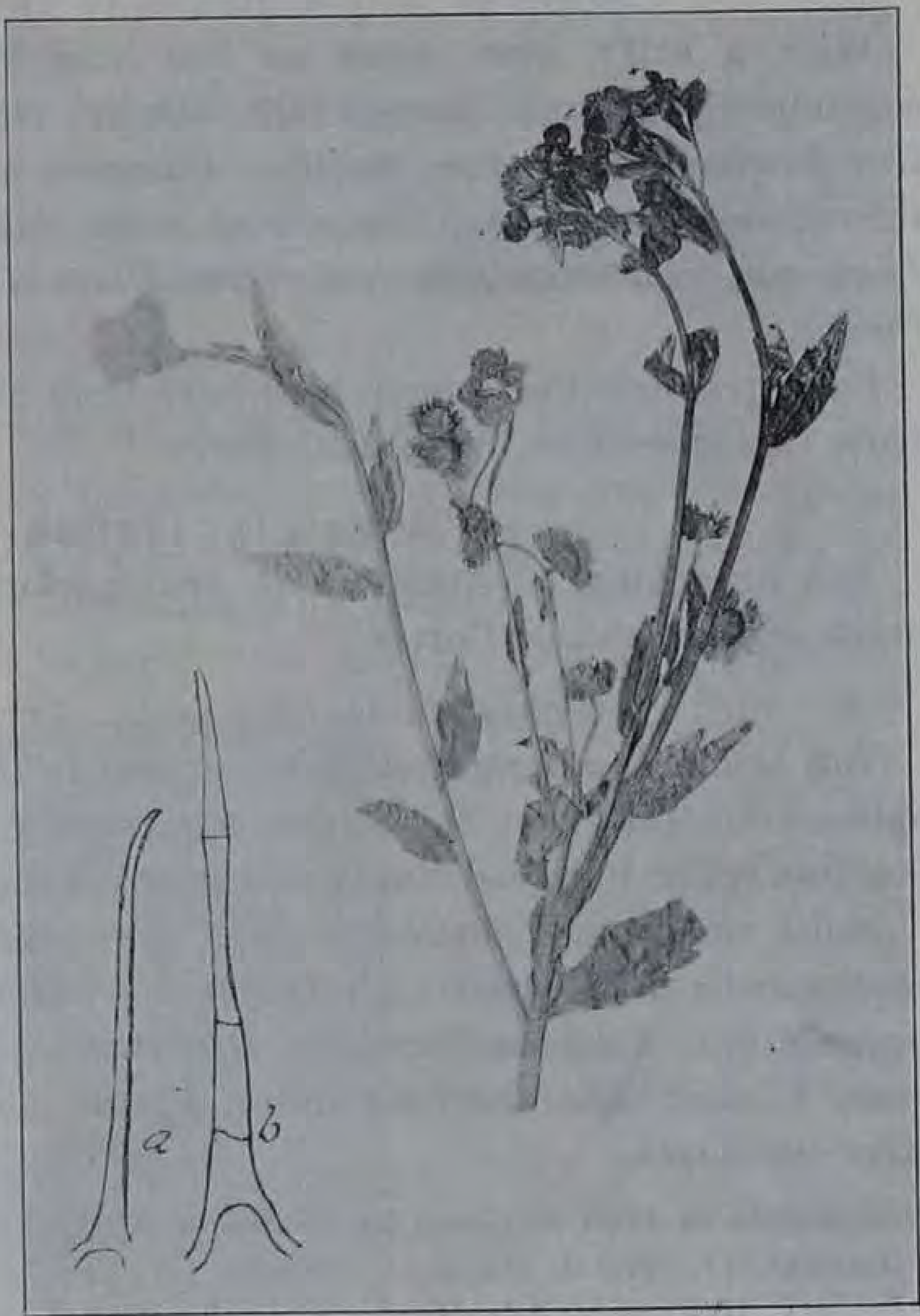

FIG. 394.—Fleabane (*Erigeron annuus*). *Photograph by Colburn.*

It has been observed (L. H. Pammel) at Alton, Anamosa, Bedford, Burlington, Chariton, Charles City, Cherokee, Clinton, Council Bluffs, Columbus Junction, Cresco, Creston, Davenport, Delhi, Eldora, Emmetsburg, Estherville, Fort Dodge, Guthrie Center, Hamburg, Hampton, Humboldt, Indianola, Iowa Falls, Jefferson, Keokuk, Keosauqua, Lansing, Madrid, Manchester, Mason City, McCallsburg, Missouri Valley, Morning Sun, Mount Pleasant, Nevada, New Hampton, Onawa, Oneida, Perry, Peterson, Polk City, Postville, Rock Rapids, Shenandoah, Sioux City, Sioux Rapids, Wapello, Waukon, Winterset, Woodbine.

General distribution in the United States:

Alabama—Montgomery (L. H. Pammel); Arkansas—Hot Springs (L. H. Pammel); California—Yosemite Valley (L. H. Pammel); District of Columbia—.............................. (G. McCarthy); Illinois—Bald Mound (Bruce Fink); Michigan—Jackson (two specimens), Muskegon (L. H. Pammel); New York—Ithaca (Muenscher and Bechtel, Carrie Harrison), Palisade Park (L. H. Pammel); Ohio—Baltimore (Asa Horr).

Honey bees have been observed on this plant, although they are not numerous and probably do not furnish much nectar.

Erigeron philadelphicus L. Fleabane

With a leafy stem, more or less hairy; flowers in heads in corymbose clusters. Leaves thin, oblong, clasping, mostly entire. Ray flowers narrow, rose, purple. Common in alluvial upland soils throughout the state. Associated with *Sanguinaria canadensis, Isopyrum biternatum, Quercus rubra, Ulmus fulva* and *Carya cordiformis.*

Lovell reports that honey bees have been observed taking nectar from this species in the central states.

Polymnia L. Leafcup

Tall branching perennials with heavy odor. Large thin leaves; heads of light yellow florets.

Polymnia canadensis L. Leafcup

Tall branching perennial plants, viscid to the touch, with noticeable odor. The large thin leaves are usually opposite. Light yellow flowers in panicled heads which are broad and many-flowered.

Moist woods and shaded ravines, New England westward and southward. Associated with *Impatiens biflora, Eupatorium purpureum* var., *Lactuca floridana, Dicentra Cucullaria, Viola pubescens, V. cucullata, Quercus rubra, Ulmus fulva, Tilia americana, Acer saccharum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decorah (E. W. D. Holway), Fayette (B. Fink), Madison county (L. H. Pammel), McGregor (Ada Hayden), northeastern Iowa (H. Goddard), Vinton (A. S. Hitchcock).

It has been observed at Dubuque, Harper's Ferry, Lansing, Pammel Park, Waukon Junction. Abundant on shady slopes of Mississippi river.

General distribution in the United States:

Arkansas—Southwestern Arkansas (F. L. Harvey); Kentucky—Bell county (T. H. Kearney, Jr.); Michigan—Clinton county (E. L. Smith); New York—Niagara Falls (G. H. Frazier), Ithaca (Muenscher and Bechtel); Ohio—Fairfield (Asa Horr), Put-in-Bay (L. H. Pammel); Tennessee—Chilhowee Mountain (A. H. Curtis); Virginia—Great Falls of the Potomac (C. R. Ball).

HONEY BEE VISITS

Decorah, August 18, 1929, 11:30 a.m. Some honey bees observed.

The plant is commonly visited by honey bees and furnishes a considerable amount of honey.

Silphium L. Rosin-weed

Tall, coarse, stiff plants with resinous juice. Flowers large, yellow, in clusters. Heads many-flowered; disc flowers apparently perfect, rays numerous, pistillate.

Robertson describes the insect visitors of this genus under the species *integrifolium* Michx.

The bee is recorded as a frequent visitor on rosin-weed (*Silphium Astericus*) by Knuth, as observed by Loew.

Loew does not record the honey bee on *Silphium perfoliatum*. He does, however, record the honey bee as getting both pollen and nectar from *S. trifoliatum*.

Silphium laciniatum L. Compass Plant, Rosin-weed

A coarse, tall, slender perennial, with copious resinous juice. Flowers yellow, heads few, 5 to 10 inches broad, nearly sessile.

Rough, bristly, leaves alternate, with slender pinnate divisions. Seeds (achenes) broad, winged and deeply notched. Blooming throughout July and September. Lower leaves vertical, ovate, on open prairie usually presenting their edges north and south. Common on prairies, especially in drift and sandy soils and on gravel knolls throughout the state. Associated with *Stipa spartea, Panicum Scribnerianum, Helianthus occidentalis, Aster laevis, A. multiflorus, Andropogon scoparius, Bouteloua curtipendula, Viola pedata, V. pedatifida, Ceanothus americana, Salix humilis.*

FIG. 395.—Compass plant (*Silphium laciniatum*). *Photograph by A. Hayden.*

Observed (L. H. Pammel) at Algona, Chariton, Clinton, Cresco, Des Moines, Dubuque, Eldora, Emmetsburg, Estherville, Guthrie Center, Hamburg, Hampton, Indianola, Iowa Falls, Mason City, Missouri Valley, Nevada, New Hampton, Oakland Mills, Perry, Postville, Sioux City, Waukon, Winterset.

General distribution in the United States:

Illinois—Blackberry (Bruce Fink), Fox (L. H. Pammel and Mark Heavenhill), Utica (Mrs. Joseph Clemens); Nebraska—Lincoln (R. Gmelin); Wisconsin—La Crosse (Dora Pammel and C. M. King).

HONEY BEE VISITS

This plant blooms throughout July and honey bees are said to collect nectar from it. No bees were seen upon the plants which were observed, although they were abundant upon the cup plants growing in the same locality.

Robertson has an account of the pollination as follows: "The ray-flowers are female; those of the disc, male. The disc-flowers have a long undivided hairy style, which serves to expose the pollen to the visitors. Nectar is secreted by the disc flowers, which have tubes 6 or 7 millimeters long. This places the nectar beyond the reach of short-tongued insects."

The flowers bloom from July 9 to September 7 (southern Illinois). The honey bee was observed collecting nectar.

Iowa City, August 4, 1927, 3 p.m. (Clay soil.) Clear, warm. No bees. Bees preferring white sweet clover.

La Crosse, Wisconsin, August 7, 1927, 12:30 p.m. (Season moist.) Bees abundant. One second in a flower.

McGregor, August 8, 1928. Bees two seconds in a flower.

Blooming, Ames, July 8, 1924. Blooms through August.

Silphium integrifolium Michx. Rosin-weed

Tall perennial herb, with clustered yellow flowers. Stem smooth or rough, stout, 4-angled. Leaves all opposite, rigid, lanceolate, ovate, entire, pointed, clasping at base. Found on prairies from Michigan to Nebraska and southward. Blooms in August. Fairly common on prairies and along roadsides over much of the state. Less frequent in northeastern Iowa.

Prairies, borders of woods, somewhat sandy and clay soils. Associated with *Brauneria purpurea, Aster multiflorus, A. laevis, Helianthus occidentalis, Andropogon provincialis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dubuque, Eddyville, Indianola, Liscomb, Madison county, Marshalltown, Postville, Shenandoah (L. H. Pammel); Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson), Fayette (B. Fink), Mount Pleasant (H. E. Jaques).

It has been observed (L. H. Pammel) at Agency, Chariton, Davenport, Des Moines, Fairfield, Iowa City, Keokuk, Keosauqua, Muscatine, Ottumwa, Wapello.

It is a common plant of the prairies. The yellow ray flowers are pistillate, the disc flowers which secrete the nectar are staminate in function. The honey bees are infrequent upon this plant.

General distribution in the United States:

Illinois—Berwyn (H. S. Fawcett), Blackberry (Bruce Fink), Chicago, Pullman (L. H. Pammel), Fox (L. H. Pammel and Mark Heavenhill); Indiana—Kosciusko county (Charles C. Deam), South Bend (Mrs. Joseph Clemens); Missouri—St. Louis (H. Eggert), Waldo Park (Kenneth K. Mackenzie); Nebraska—Lincoln (R. Gmelin); Texas—Kerrville (A. A. Heller), Sequin (B. H. A. Groth); Wisconsin—La Crosse (L. H. Pammel).

HONEY BEE VISITS

Iowa City, August 4, 1927, 3 p.m. Clear, warm. No bees. Bees preferring white sweet clover.

August 2, 1928, 3 p.m. One second in a flower. There were also some wasps.

Silphium perfoliatum L. Cup Plant

A coarse tall perennial herb, with square stem and opposite con-

FIG. 396.—Cup plant (*Silphium perfoliatum*). *Photograph by A. Hayden.*

nate leaves. Leaves ovate, coarsely toothed, the upper united by their bases. Heads many-flowered, in loose clusters. Flowers with numerous yellow rays. Seed (achenes) winged.

In rich soil across the northern part of the middle United States. It blooms throughout July and September. Common in all parts of the state, in alluvial bottoms, along streams and in cleared alluvial pastures, not infrequent in uplands along fences.

Associated with *Rudbeckia laciniata, R. triloba, Cryptotaenia canadensis, Salix longifolia, S. discolor, Cirsium discolor, Ambrosia trifida.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Boone (three specimens), Charles City, Cherokee, Emmet county, Granite, Greene, High lake, Indianola, Lost Island lake, Pocahontas county (L. H. Pammel), Osage, West Bend (R. I. Cratty), Adel (C. F. Clark), Ames (S. W. Beyer), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Fraser (Botany Seminar), Ledges (L. H. Pammel, C. M. King, R. E. Buchanan), Monmouth (F. J. DeGreesh), Olin (H. A. Pike), St. Ansgar (Mrs. F. M. Tuttle), Winneshiek county (H. Goddard).

It has been observed (L. H. Pammel) at Algona, Carroll, Chariton, Colo, Eldon, Eldora, Emmetsburg, Forest City, Fort Dodge, Guthrie Center, Hamburg, Iowa Falls, Madrid, Marshalltown, Nevada, Pammel Park, Perry, Sioux City, Winterset.

General distribution in the United States:

Illinois—Hamilton (L. H. Pammel); Ohio—Pickerington (Asa Horr).

HONEY BEE VISITS

Atlantic, July 3, 1914. Very warm and dry. Honey bees working.

Ames, July 22, 1914. Partly cloudy, hot, dry. Wasps, butterflies, flies. Five to two. *Bombus* five to one. Large solitary bees. (L.A.K.)

August 10, 1915. Cloudy, warm. Seven honey bees.

August 19, 1915. Cloudy, cool. Five honey bees. Nearly all have pollen, but many are sucking nectar from disc flowers only. (L.A.K.)

August 20, 1915. Cloudy, cool. Ten honey bees, one wasp. (L.A.K.)

August 21, 1915. Sucking; without pollen in baskets. Six honey bees. (L.A.K.)

August 27, 1915. Partly cloudy, warm. Two honey bees. (L.A.K.)

On August 21 an experiment was performed to show to what extent bees are guided by color. This is one of the most conspicuous of flowering plants, a clump being easily visible one-fourth mile away. From 20 stalks the rays were removed; 20 others were left in normal condition. At intervals bees were counted on each group, and numbers were found to be the same. Bees seem guided by odor or memory rather than by sight. (L.A.K.)

Ames, August 31, 1927, 2:30 p.m. Bee spends one to two seconds in a flower. Visits six to ten flowers in a head.

Jefferson, September 2, 1927, 3 p.m. A few bees. One second on a flower.

Colo, September 6, 1927, 3 p.m. Rain previous night. Bees abundant. One second in a flower.

The flowers in the large yellow heads produce considerable nectar. It is one of the valuable honey plants. Bees have also been observed in other places in the state of Iowa. It is abundant in low ground in Allamakee, Clayton and Winneshiek counties in 1929, also in Cerro Gordo county. Furnishes considerable nectar in some years, but this year bees were not observed.

Ambrosia (Tourn.) L. Ragweed

Coarse weeds of field and roadside, blooming in late summer. Leaves large, rough, lobed or dissected; flowers greenish. Fertile heads few-flowered, in leaf axils. Sterile heads with more numerous flowers.

IG. 397.—Greater ragweed (*Ambrosia trifida*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Ambrosia trifida L. Greater, Giant Ragweed or Bloodweed

Tall, coarse annual herbs 4 to 10 feet high, rough; leaves deeply 3-lobed, the lobes lance-ovate, serrate. Staminate heads in racemes. The fruit obovate with 5 to 6 ribs ending in a spiny point. Flowers

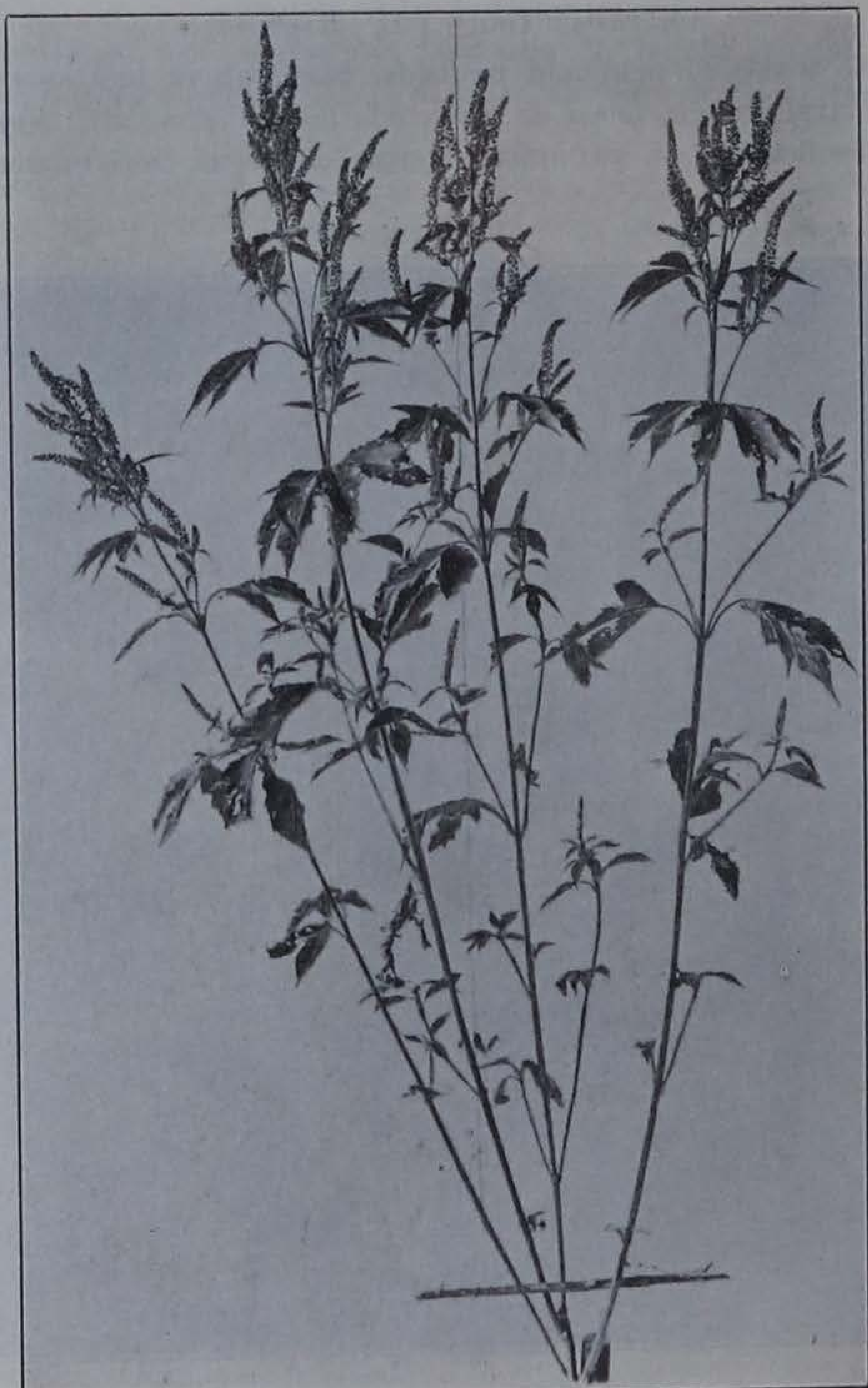

FIG. 398.—Greater ragweed (*Ambrosia trifida*). *Photograph by G. H. Munger.*

greenish. In bloom all the latter half of the summer, along streams and roadsides.

Black prairie soils, alluvial bottoms, swales. Associated with *Rudbeckia laciniata, Silphium perfoliatum, Helianthus tuberosus, Bidens vulgata, B. frondosa.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eddyville, Marshalltown, Nevada, Polk City, Steamboat Rock (L. H. Pammel); Fayette, Wadena (B. Fink), Armstrong, Emmet county (R. I. Cratty), Ames (H. S. Fawcett, H. Ness, C. R. Ball, Violet Pammel, S. W. Beyer, H. E. Pammel, F. R. Rolfs), Cedar Rapids (R. E. Buchanan), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), High Bridge (Boone county) (Botany party), Kelley (Pearl Clayton), Keokuk (P. H. Rolfs), Mount Pleasant (H. E. Jaques), northeast Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

It has been observed (L. H. Pammel) at Algona, Burlington, Chariton, Clinton, Dubuque, Des Moines, Emmetsburg, Estherville, Fort Dodge, Hamburg, Indianola, Mason City, McGregor, Missouri Valley, Rock Rapids, Rockwell City, Shenandoah, Sioux City, Tabor, Winterset. Present in every county in the state.

General distribution in the United States:

Colorado—Fort Collins (L. H. Pammel, Fred Rolfs, C. P. Johnson, C. S. Crandall), New Windsor (George E. Osterhout); Kansas—Wichita (T. L. Andrews); Massachusetts—Deerfield (M. A. Day); Minnesota—International Falls (H. S. Kellogg); Missouri—St. Louis (two specimens, P. T. Barnes and F. R. B.); Nebraska—Lincoln (R. Gmelin); New York—Ithaca (H. E. Summers); Ohio—Pickerington (Asa Horr); Oklahoma—Norman (W. E. Bruner); Wisconsin—La Crosse (Dora S. Pammel), Milwaukee (L. H. Pammel); Wyoming—Sheridan (Ferdinand Reppert, A. Estella Paddock, Sarah Ellis).

HONEY BEE VISITS

Ames, August 19, 1915. *Apis* frequent, gathering pollen. (L.A.K.)

Ambrosia artemisiifolia L. Roman Wormwood, Small Ragweed

A much branched plant one and one-half to two feet high, hairy or pubescent. Leaves finely cut, twice pinnatifid, thin, smoothish above, paler beneath. Flowers greenish, fertile heads, one to three together. Fruit armed with about 6 short, acute teeth. Common along roadsides. Variable.

Various soils, clay, sandy, black prairie, gravel knolls. Associated with *Poa pratensis, Verbena stricta, V. hastata, Trifolium pratensis.*

FIG. 399.—Small ragweed (*Ambrosia artemisiifolia*). *After Clark and Fletcher.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Alton, Armstrong, Centerville, Charles City, Des Moines, Gillett Grove, Harlan, Marshalltown, Nevada, Steamboat Rock, Turin (L. H. Pammel); Algona (E. B. Watson), Ames (L. H. Pammel and G. W. Carver, F. C. Stewart, Violet Pammel, W. S. Dudgeon, Alberta Wolf), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Decorah (E. W. D. Holway), Fayette (B. Fink), High Bridge (Boone county) (G. M. Lummis), Kelley (Pearl Clayton), Maxwell (L. H. Pammel and Elliott), Mount Pleasant (H. E. Jaques), northeast Iowa (H. Goddard), Ontario (E. R. Hodson), Osage (Mrs. F. M. Tuttle), Slater (H. S. Fawcett, W. I. Tener and C. Reinbott).

In all parts of the state. It has been observed (L. H. Pammel) at Adair, Albia, Anamosa, Atlantic, Audubon, Carroll, Cedar Rapids, Chariton, Clarinda, Clinton, Columbus Junction, Council Bluffs, Cresco, Dallas Center, Davenport, Dubuque, Estherville, Fairfield, Fort Dodge, Fort Madison, Glidden, Grinnell, Guthrie Center, Hamburg, Hampton, Ida Grove, Indianola, Keokuk, Keosauqua, Lansing, Lebanon, Lineville, Little Sioux, Madrid, Manchester, Mason City, McGregor, Missouri Valley, Moravia, Muscatine, Newton, Onawa, Plymouth county, Polk City, Rock Rapids, Sac City, Shenandoah, Sioux City, Taylor county, Tipton, Turin, Wapello, West Liberty, Winterset.

General distribution in the United States:

Alabama—Tuskegee (G. W. Carver); Colorado—Denver (L. H. Pammel, C. P. Johnson, G. W. Lummis), Fort Collins (L. H. Pammel, Fred Rolfs, C. P. Johnson, J. H. Crandall), Golden (L. H. Pammel); Georgia—Camp Gordon (D. C. Poshusta); Kansas—Wichita (T. L. Andrews); Minnesota—Leech lake, Walker (L. H. Pammel); Missouri—Allenton (George W. Letterman); Nebraska—Holdrege (J. G. McMillan), Lincoln (R. Gmelin), Sioux county (F. G. Miller); New Jersey—Perth Amboy (L. H. Pammel); New York—Geneva, Odessa (L. H. Pammel), Ithaca (Muenscher and Bechtel); Ohio—Pickerington (Asa Horr); South Dakota—Stover (Bruce Fink); South Carolina—Oconee county (A. P. Anderson); Washington—Fallbridge (Kirk Whited); Wisconsin —La Crosse (Dora Pammel).

HONEY BEE VISITS

Dr. J. N. Martin says bees were abundant upon this plant at Ames this summer (1922) collecting pollen.

Ambrosia psilostachya D.C. Western Ragwort

A branching perennial form with slender running rootstocks. Plant rough and hoary with short, rather stiff hairs. Leaves once pinnatifid, somewhat thick. Fruit obovoid, pubescent, with tubercles small or absent. Found on prairies and plains, Saskatchewan to Wisconsin and southward.

Gravel knolls, sandy prairie, Missouri loess. Associated with *Euphorbia marginata, Helianthus Maximiliani, Sporobolus cuspidatus, Bouteloua curtipendula, B. oligostachya, Andropogon scoparius, Viola pedata, Cassia Chamaecrista.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (S. W. Beyer), Decatur county (J. P. Anderson), Des Moines (L. H. Pammel), Fayette (two specimens, B. Fink).

It has been observed (L. H. Pammel) at Algona, Cherokee, Clinton, Council Bluffs, Emmetsburg, Fort Dodge, Jefferson, Keokuk, Lake Okoboji, Lansing, Le Mars, Mason City, Missouri Valley, Muscatine, Ocheyedan, Rock Rapids, Shenandoah, Sioux City, Spirit Lake, Winterset.

General distribution in the United States:

California—Chico (A. A. Heller), Sacramento, San Bernardino (L. H. Pammel); Colorado—Cache La Poudre river, Lookout Mountain (L. H. Pammel), Garden of the Gods (F. E. and E. S. Clements), Golden (two specimens, L. H. Pammel), New Windsor (George E. Osterhout); Kansas—Greeley (J. P. Anderson); Montana—Glendive (L. H. Pammel); Minnesota—Cass Lake (L. H. Pammel), N. P. Junction (J. H. Sandberg); Nebraska—Scotts Bluff county, Sioux county (F. G. Miller), Halsey (J. C. Blumer); New Mexico—Albuquerque (E. R. Hodson); Oklahoma—Norman (W. E. Bruner); South Dakota—Brookings (L. H. Pammel and N. E. Hansen), Stover (Bruce Fink); Texas—Seguin (B. H. A. Groth); Utah—Peterson (L. H. Pammel and R. E. Blackwood), Salt Lake City (L. H. Pammel).

Zinnia L. Zinnia

Annual or perennial herbs or sometimes shrubby with opposite, mostly sessile entire leaves. Heads solitary. Achenes flat, wingless

Zinnia elegans Jacq. Zinnia

An erect annual 2 to 3 feet high. Short hairy stem. Sessile leaves. Heads solitary. Many different colors.

HONEY BEE VISITS

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary.) Bees one second in a flower.

Heliopsis Pers. Ox-eye

Sunflower-like perennial herbs. Heads showy; flowers with about 10 short rays. Opposite leaves, triple-ribbed. Disc flowers perfect.

Heliopsis scabra Dunal. Ox-eye

Rough perennial herb 2 to 5 feet high; leaves opposite, petioled, 3-ribbed, serrate; flowers yellow, showy, with 10 or more rays. Pappus of achene chaffy. Maine westward.

Prairie sandy soils. Associated with *Aster multiflorus, Viola pedata, Rudbeckia hirta, Silphium laciniatum, Verbena stricta, V. bracteosa, Asclepias verticillata, A. tuberosa, Silene stellata.*

FIG. 400.—Rough ox-eye (*Heliopsis scabra*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Emmetsburg, Garner, Granite, Jefferson, Keystone, Lake Mills, Lamont, Lansing, Little Rock, Marathon, New Albin, Pilot Mound, Postville, Rockwell City, Shenandoah (L. H. Pammel); Kossuth county, Osage, West Bend (R. I. Cratty), Adel (Chas. F. Clark), Alden (C. F. Stevens), Ames (L. H. Pammel and C. R. Ball, S. W. Beyer, L. H. Pammel and C. E. Maxwell), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Eagle Grove (R. E.

Buchanan), Fraser (Botany Seminar), Kelley (two specimens, Pearl Clayton), Lamont (I. T. Bode), Ledges (Boone county) (L. H. Pammel, R. E. Buchanan and C. M. King), Moulton (C. R. Ball), Muscatine (L. H. Pammel, E. R. Harlan, Kelso), northeast Iowa (H. Goddard), Osage (two specimens, Mrs. F. M. Tuttle), Pocahontas (J. Meehan), Postville (Ellison Orr, L. H. Pammel and D. O. Wilson), Slater (C. Reinbott, H. S. Fawcett, W. I. Tener).

It has been observed (L. H. Pammel) at Algona, Charles City, Chariton, Clarinda, Davenport, Eldora, Emmetsburg, Fairfield, Forest City, Garner, Grinnell, Hamburg, Hampton, Humboldt, Iowa Falls, Keokuk, Keosauqua, Lansing, Larchwood, Little Rock, Mason City, McCallsburg, Nevada, New Hampton, Polk City, Rock Rapids, Shenandoah, Sioux City, Winterset. Found in every county in the state.

General distribution in the United States:

Colorado—La Veta (C. S. Crandall); Kansas—Wichita (T. L. Andrews); Michigan—Belle Isle Park, Detroit (L. H. Pammel); Missouri—St. Louis (H. Eggert); North Dakota—Fargo (L. H. Pammel); New York—Geneva (L. H. Pammel); South Dakota—Brookings (L. H. and Edna Pammel), Watertown (L. H. Pammel); Wisconsin—Dresser Junction, La Crosse (L. H. Pammel), Cedar Swamp (J. H. Schuette), Platteville (L. H. Pammel and B. B. Zimmerman).

HONEY BEE VISITS

Ames, July 15, 1914. Railroad. Partly cloudy, south wind. Wild bees, wasps, 15 per head per hour. (G.H.M.)

July 20, 1914. Roadside. Clear, southeast wind. Very many honey bees for nectar and pollen. Few other Hymenoptera and flies. (G.H.M.)

Daily observations were made for some time during the first part of July, 1929, but without observing any honey bees.

July 24, 1929, 1:30 p.m. No honey bees. Many Diptera and small Hymenoptera.

Sept. 15, 17, 20, 24, 1930. No bees. Commmon on New England aster. Cabbage butterfly and *Coleus* common. *Bombus* less so.

Ox-eye furnishes some nectar and pollen during some years. The visits from bees seem to vary with locality and season.

The European observations, Knuth says, do not record the honey bee on *Heliopsis scabra*.

Rudbeckia L. Cone-flower

Perennial herbs, with alternate leaves, and showy terminal heads. Heads of many flowers, rays long, flowers neutral; disc florets hermaphrodite. Receptacle conical.

Charles Robertson gives characteristics of the genus in his study of the species *R. hirta* and *R. triloba*.

Loew observed the honey bee upon *R. laciniata* and *R. speciosa* in Berlin, according to Knuth.

Rudbeckia triloba L. Cone-flower, Black-eyed Susan

A biennial much branched hairy plant, 2 to 4 feet high. Upper leaves ovate-lanceolate, lower 3-lobed, coarsely serrate. Rays yellow, 8 to 10, oval or oblong; yellow chaff of the black-purple, depressed,

FIG. 401.—Black-eyed Susan (*Rudbeckia triloba*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

globular disc smooth, awned. In rich soil, New Jersey to Minnesota and southward. Heads small, numerous, showy.

In a study of variation of flowers of *R. triloba* Dr. W. S. Dudgeon found 8 to be the characteristic number of rays.

Sandy or clay woods, second sandy alluvial bottoms. Associated with *Silphium perfoliatum, Heracleum lanatum, Cryptotaenia canadensis, Osmorrhiza longistylis, O. brevistylis, Ulmus fulva,* *Fraxinus americana, Quercus rubra, Ptelea trifoliata, Evonymus atropurpurea, Vitis vulpina, Leersia virginica, Elymus virginicus, E. striatus.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park, Delaware county, Eddyville, Marion county near Red Rock, McGregor, Waterville (L. H. Pammel); Ames (R. E. Jeffs), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (G. W. Carver), Fayette (B. Fink), Kelley (Pearl Clayton), Muscatine (L. H. Pammel, E. R. Harlan, J. Kelso), northeast Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle), Peru (D. E. Hollingsworth).

It has been observed (L. H. Pammel) at Albia, Boone, Charles City, Dubuque, Eldora, Fairfield, Grinnell, Hampton, Harvey, Iowa Falls, Keokuk, Keosauqua, Mason City, Nevada, New Hampton, Perry, Polk City, Webster City.

General distribution in the United States:

Illinois—near Starved Rock (L. H. Pammel and Mark Heavenhill), Hamilton (L. H. Pammel); Louisiana—(T. L. Andrews); Nebraska—Lincoln (R. Gmelin); North Carolina—Buncomb county (John K. Small) (Biltmore Herb.); Ohio—Cincinnati (C. G. Lloyd and Walter Deane); Oklahoma—Muskogee (L. H. Pammel).

HONEY BEE VISITS

Charles Robertson describes the insect relations. He says, "The tubes of the disc florets are very narrow and measure about 3 millimeters in length. This species blooms from July 23 to October 16 (southern Illinois)." A large number of species of insects were recorded on the species. The honey bee, however, is not among them.

Ames, August 20, 1914, p.m. College Park. Partly cloudy, south wind. Many wild bees, wasps, flies, no *Apis*. Twenty per head per hour. Some small bees for pollen. Most bees for nectar. (G.H.M.)

August 21, 1914, a.m. Skunk river. Cloudy, north wind. Distribution same as above. (G.H.M.)

Sept. 15, 16, 17, 24, 1930. No bees. Common on New England aster adjacent.

Allamakee county, mouth of Yellow river, August 18, 1929, 8 a.m. No honey bees observed.

Blooming, Ames, June 29, 1924.

Rudbeckia subtomentosa Pursh. Yellow Daisy

A perennial branching herb about 1½ to 2 feet in height, downy; leaves petiolate; heads with yellow ray flowers, disc globular, dull brown, receptacle sweet-scented. Found in prairies and low grounds. Wisconsin to Kansas and southward.

Clay or somewhat sandy soils in open woods and prairies and borders of woods. Associated with *Ulmus fulva, Carya cordiformis, Osmorrhiza brevistylis, O. longistylis, Hepatica acutiloba.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel), Decatur county (J. P. Anderson), Marion county (L. H. Pammel).

It has been observed (L. H. Pammel) at Eldora, Iowa Falls, Marshalltown, Nevada.

General distribution in the United States:

Illinois—Fountaindale (M. S. Bebb), Monmouth (I. E. Forbes); Missouri—Springfield (J. W. Blankinship); Wisconsin—Black Earth (J. R. Heddle).

HONEY BEE VISITS

Bees visit the flowers for pollen and nectar.

Rudbeckia laciniata L. Cone-flower

Perennial herbs with showy many-flowered heads and alternate leaves. Stem smooth, branching, about half a meter in height; the lowest leaves pinnate, the upper irregularly 3- to 5-parted. Heads long peduncled, disc columnar, greenish yellow. Rays oblanceolate, drooping. Low thickets from Maine westward and southward, widely distributed. Blooms from July to September.

Associated with *Silphium perfoliatum, Aster Tradescanti, A. salicifolius, Solidago serotina, Bidens vulgata, B. frondosa, Salix longifolia, S. amygdaloides, Populus deltoides.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Dillon, Gillett Grove, Lamont, Madison county, Marion county, Marshalltown, Mud lake, Oelwein, Onawa, Rock Rapids, Sioux City, Wallingford (L. H. Pammel); Clear Lake, Emmet county (R. I. Cratty), Ames (L. H. Pammel and C. R. Ball), Cedar river (R. E. Buchanan), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), northeastern Iowa (H. Goddard), Osage (Mrs. F. M. Tuttle).

It has been observed (L. H. Pammel) at Albia, Anamosa, Audubon, Burlington, Carroll, Cedar Rapids, Charles City, Chariton, Clayton, Clinton, Cresco, Dallas Center, Davenport, Delhi, Denison, Dubuque, Estherville, Grinnell, Guthrie Center, Hamburg, Hampton, Harper's Ferry, Harvey, Indianola, Iowa City, Keokuk, Keosauqua, Lebanon, Logan, Lyon county, Manchester, Mason City, McGregor, Missouri Valley, Mount Sterling, Muscatine, Nevada, New Hampton, Newton, Perry, Polk City, Shenandoah, Sioux City, Slater, Strawberry Point, Tama, Tipton, Toledo, Turin, Waterville, Waukon, West Liberty, Winterset, Woodbine.

General distribution in the United States:

Colorado—Tabeguache basin (Edwin Payson), Fort Collins (C. S. Crandall), Laramie county (two specimens, L. H. Pammel), Windsor (George E. Osterhout); Georgia—Tocco Falls (John K. Small); Kentucky—Poor Fork Post Office (T. H. Kearney, Jr.); Massachusetts—Adams (M. A. Day); Minnesota—

Morrison county (J. H. Sandberg), Ortonville (L. H. Pammel); New Mexico—Pleasant Valley, Santa Fe (A. Isabel Mulford); New York—Ithaca (H. E. Summers); Overland mountain (L. M. Parker); Ohio—Pickerington (Asa Horr); South Dakota—Sioux Falls (L. H. Pammel), Spearfish canyon (C. M. King).

HONEY BEE VISITS

Frank Pellett states that cone-flowers or golden glow are the source of some nectar. The golden glow is a cultivated type of *R. laciniata*. Bees do not often visit the double-flowered type.

This is one of the most valuable honey plants of the Compositae. Here again we must note the variability of honey flow. The blooming period is fairly long. It blooms at a time when the early summer plants are out of flower. Bees also visit the flower for pollen.

Ames, September 2, 1919. Partly cloudy. Honey bees at work.

Clinton to Marshalltown and Yellow river, August 14, 1927. Bees abundant.

Glenville, Minnesota, August 28, 1927, 2:30 p.m. Warm, clear. Bees one in a flower.

Ames, August 30, 1927, 8 a.m. Bees abundant. Two seconds in a flower.

Marshalltown, August 30, 1927, 10 a.m. Warm, clear. Bees one second in a flower.

Ames, August 31, 1927, 2:30 p.m. Bees spend one second in a flower. Visits about two flowers in a head.

September 5, 1927, 9:30 a.m. Clear. Bees abundant. One second in a flower.

Norwalk, September 7, 1927, 3 p.m. Clear, warm. Some bees. One second on a flower. *Bombylius* sp. and butterflies present.

September 10, 1927, 8 a.m. Clear, warm. Bees abundant. One second in a flower.

Tama, August 6, 1928. Bees one second in a flower.

Wauzeka, Wisconsin, August 25, 1928. Bees one second in a flower.

Ames, Sept. 15, 1928, 12:30 p.m. Clear, warm. Some bees. One second in a flower.

Allamakee county, mouth of Yellow river, August 18, 1929. No bees, nor were any bees observed on this plant at Waukon and Decorah several hours later.

This species is abundant in low grounds and in some years furnishes a large amount of nectar. The species was particularly abundant in 1929 in Allamakee, Clayton and Winneshiek counties.

Rudbeckia hirta L. Black-eyed Susan

A biennial herb, very rough and bristly, stem simple or branching at base, 1½ to 2½ feet high, bearing large single heads; leaves nearly entire, the upper oblong, sessile, the lower spatulate,

FIG. 402.—Black-eyed Susan (*Rudbeckia hirta*). *Photograph by Colburn.*

petioled; yellow rays about 14, exceeding the involucre, chaff of the dull brown disc hairy at tip. Found in dry soil. New York westward and southward. Blooms from June to September. In sandy soils, gravel knolls and prairie meadows, common throughout the state, variable as to its characters and habitat.

Dr. W. S. Dudgeon found in a study of variation in this species that 13 is the characteristic number of rays.*

Associated with *Phlox pilosa, Silphium laciniatum, Viola cucullata, V. pedata, Panicum Scribnerianum, P. virgatum, Zygadenus elegans, Polygala verticillata, Scutellaria parvula.*

Charles Robertson writes of the insect relations of this species, "The ray-flowers are neutral. The flowers of the disc are hermaphrodite. The pollen is carried out on the hairy tips of the approximated style divisions. The tubes are slender, about 4 millimeters in length. The nectar is accessible, therefore, only to the longer and more slender tongues, but the pollen is easily accessible. It blooms from June 1 to September 16" (southern Illinois). Honey bees are recorded, getting nectar.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone, Dubuque (two specimens), Eagle Grove, Eddyville, Forest City, Mason City, Pilot Mound, Postville (L. H. Pammel); Armstrong, Osage, West Bend (R. I. Cratty), Ames (R. E. Jeffs, G. W. Carver, W. Newell, Miss Sirrine, F. Rolfs, E. B. Watson), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (two specimens, B. Fink), Kelley (Pearl Clayton), Ledges (Boone county) (L. H. Pammel, C. M. King, R. E. Buchanan), Muscatine (C. R. Ball), northeastern Iowa (H. Goddard), Peru (D. E. Hollings-

* Proc. Ia. Acad. of Sci., 14: 89-106.

worth), Postville (Ellison Orr and D. O. Wilson), St. Ansgar (Mrs. F. M. Tuttle).

It has been observed (L. H. Pammel) at Albia, Algona, Atlantic, Audubon, Carroll, Clarinda, Clinton, Cresco, Creston, Davenport, Denison, Emmetsburg, Estherville, Fairfield, Guthrie Center, Hamburg, Hampton, Harvey, Ida Grove, Keokuk, Keosauqua, Lansing, Little Rock, McGregor, Missouri Valley, Mount Pleasant, Muscatine, Oakland Mills, Perry, Polk City, Rock Rapids, Sac City, Shenandoah, Sioux City, Sioux Rapids, Tabor, Wapello, Waukon, Winterset, Woodbine.

General distribution in the United States:

Alabama—Birmingham, Montgomery (L. H. Pammel); Arkansas—Ashley county (R. E. Fennell), Fayetteville (P. H. Rolfs), Hot Springs (L. H. Pammel); Colorado—Fort Collins (C. H. Cowan), LaPorte (L. H. Pammel), Palmer Lake (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank Raney); Georgia—De Kalb county (Davis, Herb., Univ. of Texas); Illinois—Cheltenham (L. H. Pammel), Fox (L. H. Pammel and Mark Heavenhill); Kansas—Wichita (T. L. Andrews); Louisiana—Alexandria (C. R. Ball); Massachusetts—North Amherst (H. L. Kellogg); Michigan—Green (L. H. Pammel and V. C. Fisk); Minnesota—Black Duck (Mrs. Roy Westley), Brainerd (E. B. Watson), Cass Lake, Richdale (L. H. Pammel), Duluth (L. H. and H. E. Pammel), St. Paul (R. Gmelin); Missouri—Levasey (Kenneth K. Mackenzie); Nebraska—Grand Island (L. H. Pammel), Halsey (two specimens, J. C. Blumer), Sheridan county (R. E. Buchanan); New Mexico—Cuba (A. D. Read); New York—Ithaca (Muenscher and Bechtel); Ohio—Huron (L. H. Pammel); Oklahoma—Norman (W. E. B.); Pennsylvania—Warren (H. E. Pammel); South Dakota—Brookings (two specimens, Edna C. Pammel), Hot Springs (J. C. Witham), Sisseton (L. H. Pammel), Spearfish canyon (C. M. King); Texas—Tarrant county (Albert Ruth).

This species is occasionally visited by bees though not frequently.

Lepachys Raf. Cone-flower

Perennial herbs with alternate pinnately divided leaves. The showy heads have drooping yellow rays. Heads many-flowered. The disc prominent, grayish.

Lepachys pinnata (Vent.) T. and G. Prairie or Green Cone-flower

A perennial herb, with alternate pinnately-divided leaves; the branches bearing single showy heads. Rays yellow, drooping; receptacle columnar. Hoary with minute appressed hairs. Dry soil. New York to Minnesota and southward.

Sandy, gravelly knolls, Missouri loess, sandy or somewhat sandy prairies. Associated with *Brauneria purpurea, Stipa spartea, Euphorbia corollata, E. marginata, Phlox pilosa, Astragalus caryocarpus, A. canadensis, Helianthus occidentalis.*

The plant blooms from the middle of July to the last of August. Honey bees have not been previously mentioned as visitors. We have not seen honey bees on the flowers.

FIG. 403.—Prairie cone-flower (*Lepachys pinnata*). *Photograph by A. Hayden.*

Charles Robertson says, "The ray-florets are neutral. The tubes of the disc florets are 2 millimeters in length." Several bees visit the flowers freely, but the honey bee was not observed. *Lepachys pinnata* blooms from July 4 to August 29 (southern Illinois).

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cherokee, Clarinda, Garner, Gillett Grove, Madison county, Marathon, McGregor, Missouri Valley, New Albin, Palo Alto county, Winterset (L. H. Pammel); Arcadia, Armstrong, Emmet county, Osage (R. I. Cratty), Ames (Mina Belle Lynch, Fred Rolfs, Ada Hayden, L. H. Pammel and C. R. Ball, S. W. Beyer, Violet Pammel), Cedar Falls (G. W. Carver), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Kelley (Pearl Clayton), Lawler (P. H. Rolfs), northeastern Iowa (H. Goddard), Osage (Mrs. Tuttle).

This species is widely distributed. It has been observed (L. H. Pammel) at Albia, Algona, Alton, Atlantic, Audubon, Carroll, Chariton, Clarion, Clinton, Creston, Davenport, Denison, Des Moines, Dubuque, Eagle Grove, Emmetsburg, Estherville, Fort Dodge, Hamburg, Humboldt, Ida Grove, Jewell, Keokuk, Keosauqua, Little Sioux, Mason City, Missouri Valley, Onawa, Perry, Plymouth

FIG. 404.—Green cone-flower (*Lepachys pinnata*). *Photograph by G. H. Munger.*

county, Rock Rapids, Rockwell City, Sac City, Sioux City, Webster City, Woodbine.

General distribution in the United States:

Illinois—Berwyn (H. S. Fawcett); Blackberry (Bruce Fink), Fox (L. H. Pammel and Mark Heavenhill); Minnesota—Cannon Falls (L. H. Pammel), Minneapolis (R. I. Cratty); Ohio—Lancaster (Dr. Bigelow); South Dakota—Brookings (L. H. Pammel and N. E. Hansen); Wisconsin—La Crosse (two specimens, L. H. Pammel).

HONEY BEE VISITS

The prairie cone-flower furnishes some nectar.

Ames, July 10, 1914. Interurban railway. Clear, southeast wind. Very few

Apis (apiary near by); small bees gathering pollen. Thirty per head per hour. (G.H.M.)
Iowa City, August 4, 1927, 3 p.m. (Clay soil.) Clear, warm. No bees. Bees preferring white sweet clover.
Honey bees have been reported on it, though we have not seen any.

Helianthus L. Sunflower

Coarse, stout herbs. Heads with yellow rays, single or clustered, many-flowered. Disc florets hermaphrodite. Fall flowering.

Robertson has written of the insect relations of several species, *H. mollis*, *H. grosse-serratus* and *H. tuberosus*. Knuth records the honey bees on *H. atrorubens*, also *H. decapetalus*, *H. divaricatus*, *H. Maximiliani*, as observed by Loew, who observed them getting pollen and honey from each species.

Pellett does not record the species, but makes the statement that insects may be found on sunflower blooms in search of pollen and nectar. Wherever they are sufficiently abundant they are a source of much nectar. He quotes Mendlesson of California, who obtained some surplus honey from sunflowers.

Helianthus annuus L. Common Sunflower

A tall, erect, rough annual herbaceous plant, with large leaves and circular flat heads of flowers, disc flowers tubular, marginal flowers strap-shaped. A plant long cultivated.

FIG. 405.—Leaf and head of common sunflower. Achene to the right. *After Britton.*

Missouri loess, various soils. Usually associated with *Iva xanthifolia*, *Panicum virgatum*, *Andropogon provincialis*, *Crotalaria sagittalis*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Gillett Grove, Granite, Homer, Marshalltown, Missouri Valley, Ogden, Onawa, Sheldahl, Slater, Turin (L. H. Pammel); Decorah, Fraser (Botany Seminar), Ames (J. R. Campbell), Charles City (L. H. Pammel and E. M. Sherman), Des Moines (A. L. Bakke), Emmet county (R. I. Cratty), Fayette (B. Fink), Kelley (H. S. Fawcett, W. I. Tener, C. Reinbott), Keokuk (L. H. Pammel and Miss Mitchell), Osage (Mrs. F. M. Tuttle).

FIG. 406.—A patch of sunflowers.

It has been observed (L. H. Pammel) at Algona, Armstrong, Blencoe, Boone, Council Bluffs, Fort Dodge, Hamburg, Little Rock, Little Sioux, Marquette, Mason City, Missouri Valley, Onawa, Plymouth county, Rocks Rapids, Rockwell City, Shenandoah, Sioux City, Tabor, Turin.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall), Manitoba (L. H. Pammel); Kansas—Wichita (T. L. Andrews); Nebraska—Lincoln (F. G. Miller), McCook (L. H. Pammel), Willow Island (Jos. Wahl); New Jersey—Kaign's Point, Camden county (Alexander MacElwee); New Mexico—Apache (A. Isabel Mulford); South Dakota—Stover (Bruce Fink); Utah—Bear River (L. H. Pammel and R. E. Blackwood), Logan (A. Isabel Mulford), Salt Lake City (R. E. Buchanan, C. P. Johnson, G. M. Lummis, L. H. Pammel).

HONEY BEE VISITS

The flowers of sunflower are proterandrous, they are pollinated by bees and other insects. Bees visit the sunflower for nectar; sometimes the plants are the source of large quantities of honey.

Hamburg, August 25, 1928. Some bees. One second in a flower.

Mitchellville, August 31, 1929, 1 p.m. Cool and cloudy. Bees one second in a flower.

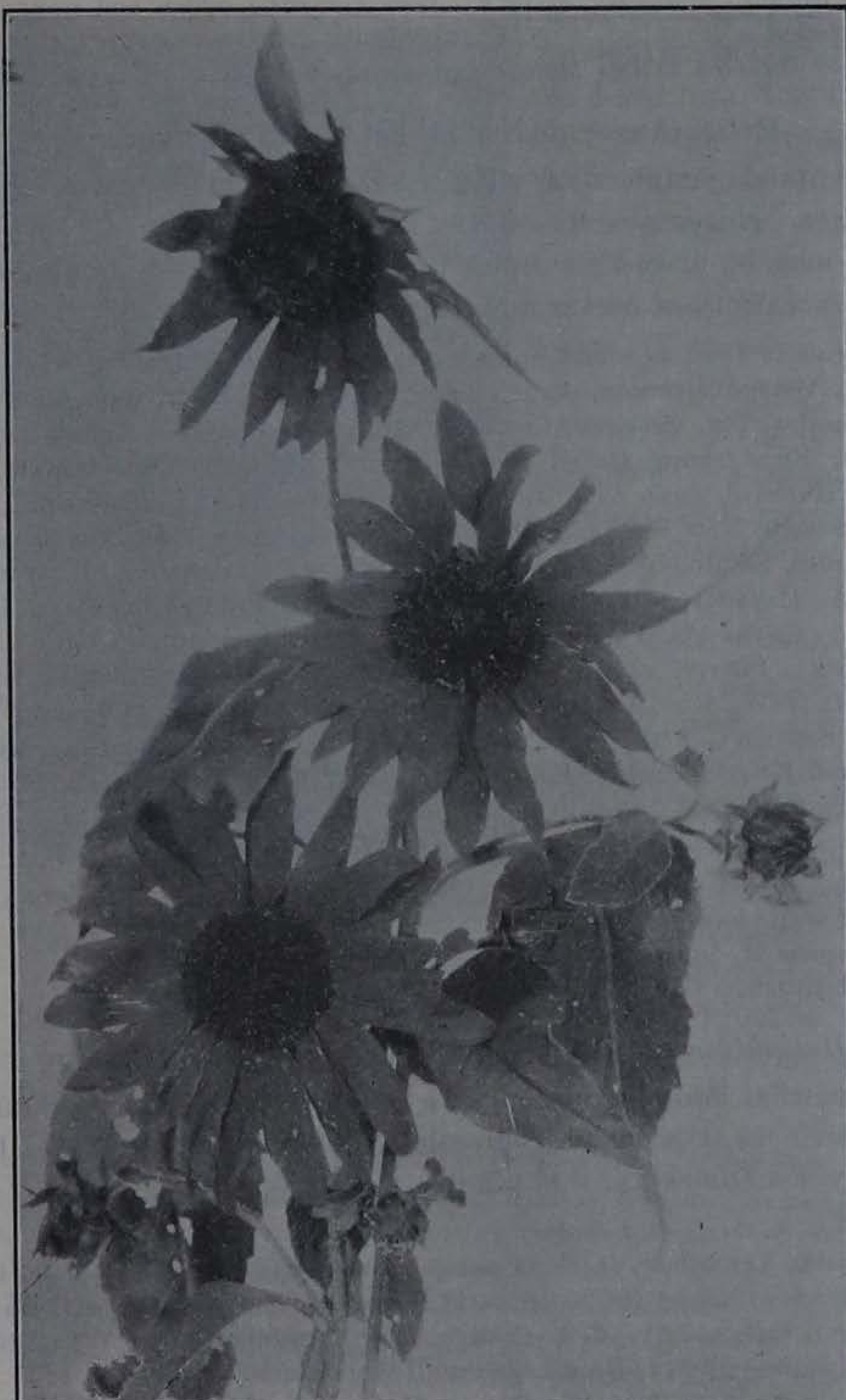

FIG. 407.—Common sunflower (*Helianthus annuus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Bloomfield, Keosauqua, September 1, 1929. A few bees. One second in a flower.
Montrose, September 2, 1929, 9 a.m. Clear and warm. No bees. (Near an apiary.)

Mount Pleasant, September 8, 1929. Bees gathering pollen and nectar. (S. M. Helmick.)

No bees observed at Des Moines and Ames, 1930.

Helianthus scaberrimus Ell. Stiff Sunflower

More or less simple stem with thick, rigid, rough leaves, oblong-lanceolate. Heads nearly solitary and rather large.

Bees may be looked for upon this species, where it is abundant, during a scarcity of nectar secretion.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Alden, Allamakee county, Ames, Bevington, Boone county, Camanche, Clear Lake, Charles City, Chariton, Cherokee, Clinton, Cresco, Des Moines, Delmar, De Witt, Emmetsburg, Grand Island, (Nebr.), Gillett Grove, Granite, Hawarden, Hubbard, Iowa City, Iowa Falls, Jewell Junction, Keosauqua, Lake Mills, Liscomb, New Hampton, Newton, Oelwein, Ogden, Radcliffe, Rochester, Rock Rapids, Saratoga, Wall Lake (L. H. Pammel), Algona (E. B. Watson), Ames (A. Hayden), Armstrong (Mrs. R. I. Cratty), Charles City (E. M. Sherman), Colfax (S. P. Sipe), Commerce (Mrs. Frankel), Decatur (T. J. Fitzpatrick), Decatur county (J. P. Anderson), Decorah (Holway), Emmet county (B. O. Wolden), Farmington (Mrs. Luechel), Fayette (B. Fink), Fraser (Botany Seminar), McGregor (T. F. Weeks, L. H. and Lois Pammel), Manson (L. H. and H. E. Pammel), Rockford (C. L. Webster), Zearing (L. H. Pammel and R. Torrey).

HONEY BEE VISITS

Iowa City, August 4, 1927, 3 p.m. (Clay soil.) Clear, warm. No bees. Preferring white sweet clover.

Ames, August 27, 1929, 10:30 a.m. Many beetles. No bees.

Occasional honey bees were observed at Centerville in 1929.

Helianthus occidentalis Riddell. Western Sunflower

A somewhat hairy perennial with simple stem producing runners from base. Leaves oval to lanceolate. Disc flowers yellow. Bees probably sometimes use this plant.

Dsitribution in the United States:

Minnesota—Leech lake (L. H. Pammel); Wisconsin—Muscoda (L. H. Pammel); Illinois—Chicago (N. S. Moffatt), French Village (H. Eggert), Havana (H. A. G.), Ogle county (R. I. Cratty); North Dakota—Minot (J. C. Blumer); Wisconsin—Allonez, Brown county (J. H. Schuette).

HONEY BEE VISITS

Iowa City, August 4, 1927, 3 p.m. (Clay soil.) Clear, warm. No bees. Bees preferring white sweet clover.

Helianthus grosseserratus Martens. Prairie Sunflower

Coarse, stout perennial 6 to 10 feet in height. Leaves narrow, taper-pointed, scabrous, sharply serrate, petioled, white beneath.

FIG. 408.—Meadow sunflower (*Helianthus grosseserratus*).

Bracts awl-shaped. Dry plains, Maine westward and southward to Texas.

Common throughout the state. Low swales and marshy prairies, cultivated fields. Associated with *Bidens vulgata*, *B. frondosa*, *Aster novae-angliae*, *A. salicifolius*, *A. prenanthoides*, *Solidago serotina*, *S. Riddellii*, *Veronica virginica*, *Thalictrum dasycarpum*, *Galium concinnum*, *Salix discolor*.

Charles Robertson observed insects upon this plant, which was in bloom from September 1 to October 4 (southern Illinois). The honey bee was abundant upon them, collecting nectar.

The flowers of *Helianthus grosseserratus* are collected in heads and are made attractive because of the large yellow proterandrous ray flowers. They are visited by a variety of insects.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Burlington, Cherokee, Crocker, Des Moines, Granite, Greene, Hamburg, Lime Springs, Mount Zion, Oelwein, Rock Rapids, Spirit Lake, Turin, Waterloo, West Burlington (L. H. Pammel); Decatur county, Lawler (P. H. Rolfs), Algona (E. B. Watson), Ames (S. W. Beyer, C. R. Ball, two specimens, H. S. Fawcett and W. S. Dudgeon), Armstrong (R. I. Cratty), Fraser (Botanical Seminar), Kelley (Pearl Clayton), northeastern Iowa (H. Goddard), Slater (Botanical Party, two specimens, H. S. Fawcett, W. I. Tener, C. Reinbott).

This plant has also been observed (L. H. Pammel) at Agency, Albia, Anamosa, Atlantic, Blencoe, Boone, Brooklyn, Burlington, Carroll, Cedar Rapids, Centerville, Chariton, Clarinda, Clinton, Council Bluffs, Creston, Dallas Center, Davenport, Denison, Dubuque, Eldora, Emmetsburg, Estherville, Fairfield, Fort Dodge, Glenwood, Grinnell, Guthrie Center, Hampton, Harvey, Humboldt, Ida Grove, Iowa Falls, Jewell Junction, Keokuk, Keosauqua, Lansing, Lineville, Logan, Madrid, Mason City, McCallsburg, McGregor, Missouri Valley, Nevada, Newton, Onawa, Ottumwa, Perry, Plymouth county, Polk City, Postville, Rock Rapids, Rockwell City, Sac City, Shenandoah, Sioux City, Spencer, Spirit Lake, Tama, Toledo, Wapello, Webster City, West Liberty.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall); Illinois—Argyle, Walnut, Zearing (L. H. Pammel); Minnesota—Brainerd (E. B. Watson), Norway Beach, Cass Lake (L. H. and H. E. Pammel); Nebraska—Sheridan county (R. E. Buchanan); Wyoming—Mud creek, Piedmont (R. E. Buchanan, C. P. Johnson, G. M. Lummis, L. H. Pammel).

HONEY BEE VISITS

Bees are rather frequent. The species is a fairly good honey plant.

Dillon, September 4, 1914, 9 a.m. Clear, southeast wind, dry. One honey bee, one *Bombus*, two Hymenoptera, twenty-five flies. Bees gathering nectar and pollen; flies, nectar. Sometimes two or three flies seen on a flower. Three to five seconds to each flower.

Ames, September 2, 1915. Campus. Clear, cool. Two honey bees.
August 25, 1927, 4:30 p.m. No bees. Many bees on white sweet clover.
August 30, 1927, 8 a.m. Some bees. One second in a flower.
September 4, 1928, 5 p.m. Bees one second in a flower.

Huxley, September 4, 1928. Bees ten to eighteen seconds in a flower.

Helianthus Maximiliani Schrad. Maximilian's Sunflower

A stout, coarse perennial 2 to 6 feet in height. Stem usually simple; leaves stiff and scabrous, entire or slightly dentate. Heads large, with long pedućles. Found growing on prairies.

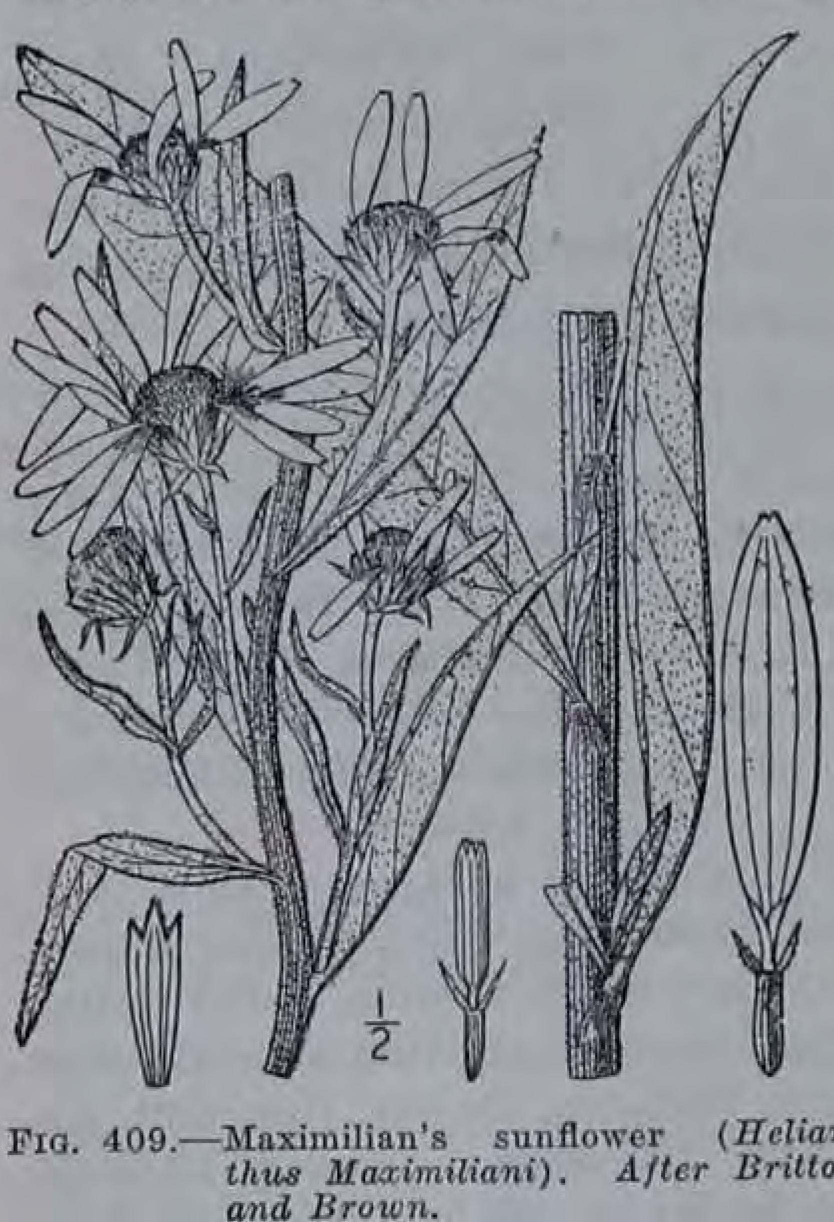

FIG. 409.—Maximilian's sunflower (*Helianthus Maximiliani*). *After Britton and Brown.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bradgate, Carroll, Charles City (two specimens), Cherokee, Emmetsburg, Gillett Grove, Granite, Hawarden, Sioux City, Sioux Rapids, Spirit Lake, Storm Lake (L. H. Pammel); Clear Lake (Mrs. J. S. Naylor and L. H. Pammel), Greene county (R. I. Cratty).

General distribution in the United States:

Kansas—Wichita (three specimens, T. L. Andrews); Minnesota—Benson, Granite Falls, Marshall, Ortonville, St. Paul (L. H. Pammel), Crookston (Mrs. Roy Westley), Duluth (H. E. and L. H. Pammel), Minneapolis (Geo. B. Aiton), N. P. Junction (J.

Sandberg); Missouri—Sheffield (Kenneth K. Mackenzie); Montana—Deer Lodge (L. H. Pammel); North Dakota—Fargo (L. H. Pammel), Minot (J. C. Blumer); South Dakota—Brookings, Milbank, Sioux Falls, Sisseton, Watertown (L. H. Pammel), Brookings (N. E. Hanson and L. H. Pammel), Highmore (Mr. Quick); Texas—Tarrant county (Albert Ruth).

HONEY BEE VISITS

The occurrence of bees on this species in Europe has been noted. In 1920 we made the following note: "No doubt bees will be found on it in this state."

Boone, August 25, 1927, 4:30 p.m. No bees. Many on white sweet clover.

Ames, October 16, 1929, 8:30 a.m. Clear and cool. Bees one second in a flower. Honey bees abundant, getting nectar.

October 18, 1929, 1:30 p.m. Bees frequent; one second in a flower. (C.M.K.)

Helianthus strumosus L. Pale-leaved Wood Sunflower

Smooth, 3 to 6 feet in height. Petioles margined, leaves whitish beneath. River banks and low places.

Honey bees have been found on this species in Europe. This should be an important source of honey, especially in northeastern Iowa, where the species is common.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Boone county, De Witt, Lake Mills, Mason City, McGregor, Oakland Mills, Strawberry Point, Waukon (L. H. Pammel); Chickasaw county, New Hampton (W. D. Spiker), Fayette (B. Fink), High lake, Emmet county (B. O. Wolden), Iowa (northeast part, H. Goddard), Iowa lake, Emmet county, Okoboji lake (R. I. Cratty), McGregor (L. H. and Lois Pammel), Osage (Mrs. F. M. Tuttle).

General distribution in the United States:

Illinois—Berwyn (H. S. Fawcett), Havana (H. A. Gleason), Starved Rock (Mark Heavenhill and L. H. Pammel); Kansas—Wichita (T. L. Andrews); Minnesota—Cass Lake (H. E. and L. H. Pammel, P. S. McNutt), Granite Falls (L. H. Pammel), Minneapolis (R. I. Cratty), Rochester (Mrs. Geo. Amlie), St. Paul (R. Gmelin); Nebraska—Callaway (J. M. Bates); New Jersey—Clinton (George V. Nash); New York—Ithaca (Bechtel and Muenscher), Niagara Falls (G. H. Frazier); South Dakota—Sioux Falls (L. H. Pammel); Wisconsin—Fond du Lac, Holmen, Muscoda (L. H. Pammel).

Helianthus tuberosus L. Jerusalem Artichoke

A pubescent perennial 2 to 10 feet high, with tuberous rootstocks. Leaves somewhat ovate to lanceolate, acuminate, scabrous above, cinereous beneath. Rays 12 to 20, yellow.

New York westward and southward. Borders of woods, alluvial second bottoms. Associated with *Bidens vulgata, B. frondosa, Aster* *salicifolius, Salix longifolia, S. nigra, S. amygdaloides, Ulmus americana, Quercus bicolor.*

Charles Robertson made a study of the insect relations of this plant. He says, "The disc florets have corollas with tubes 6 millimeters long." During the blooming time, from August 13 to 26, he observed a great many different Hymenoptera and other insects. Honey bees were not observed.

FIG. 410.—Jerusalem Artichoke (*Helianthus tuberosus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Charles City, Cherokee, Des Moines, Eddyville, Glenwood, Granite, Hamburg, Hawarden, Lake Mills, Lansing, Rochester, Sioux City, Steamboat Rock (L. H. Pammel); Adel (C. F. Clark), Ames (Mina Belle Lynch and L. H. Pammel, A. F. Miller and L. H. Pammel, F. C. Stewart); Armstrong (R. I. Cratty), Boone county (J. V. Ellis), Ledges (C. R. Ball and L. H. Pammel, R. E. Buchanan), Des Moines (G. W. Carver), Fayette (B. Fink), Mount

Pleasant (H. E. Jaques), northeastern Iowa (H. Goddard), Ontario (E. R. Hodson).

It has been observed (L. H. Pammel) at Adair, Agency, Albia, Algona, Anamosa, Boone, Burlington, Carlisle, Carroll, Cedar Rapids, Centerville, Chariton, Charles City, Clinton, Columbus Junction, Council Bluffs, Dallas Center, Davenport, Denison, Des Moines, Dubuque, Eddyville, Emmetsburg, Fairfield, Fort Dodge, Fort Madison, Glenwood, Grinnell, Guthrie Center, Hamburg, Harvey, Humboldt, Indianola, Jefferson, Keokuk, Keosauqua, Lansing, Lebanon, Lineville, Little Sioux, Logan, Madrid, Manchester, Marshalltown, Mason City, McGregor, Missouri Valley, Moravia, Mount Sterling, Mount Zion, Muscatine, Newton, Onawa, Osceola, Ottumwa, Perry, Polk City, Postville, Rockwell City, Sioux City, Tabor, Tama, Toledo, Wapello, West Liberty, Winterset, Woodbine.

General distribution in the United States:

Minnesota—Ortonville (L. H. Pammel); Missouri—St. Louis (P. T. Barnes); Nebraska—Callaway (J. M. Bates), Sheridan county (R. E. Blackwood), Thedford (J. C. Blumer and W. H. Mast); New York—Ithaca (H. E. Summers); South Dakota—Big Bonanza Springs (L. H. Pammel); Wisconsin—Green Bay (J. H. Schuette), Muscoda (L. H. Pammel).

HONEY BEE VISITS

Ames, September 8, 1918. Plant blooming. No bees.

Tama, September 8, 1918. Plant in bloom. No bees. There is some doubt about the value of this plant for honey.

Des Moines, September 17, 1928, 4:30 p.m. Warm and clear. Bees one second in a flower.

Keokuk, September 2, 1929. Just a few bees. One second in a flower.

Des Moines, September 21, 1929, 10 a.m. Clear, fairly warm, windy. Only a few bees. One second in a flower.

Dahlia Cav. Dahlia

Erect branching plants with tubular roots; large showy flowers. Leaves compound, pinnate. Disc flowers yellow, pink or whitish. The ray flowers are neutral. The branches of the style are covered with sweeping hairs, extending from the tip half way down the style. Stigmatic papillae in two marginal rows.

In garden Dahlias almost all the flowers are changed into rays.

Dahlia variabilis Desn. Common Dahlia

Leaves pinnate, with serrate ovate leaflets. Rays in the natural flowers neutral. Heads large and under cultivation with pistillate ray flowers. Roots tuberous, fascicled.

Commonly grown in all parts of the state in gardens.

HONEY BEE VISITS

Bees are frequently observed on this plant. Knuth records similar observations.

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary). Bees two or one seconds in a flower.

Ames. Bees observed in 1928, in September, 1929, and on August 20 and 24, 1930.

Actinomeris Nutt. Ironweed

Tall branching perennials with serrate leaves tapering to the base. Flowers yellow, heads corymbed, many-flowered, rays neutral, few or none.

Actinomeris alternifolia (L.) D. C. Yellow Ironweed, Wingstem

Perennial, 3 to 6 feet in height. Stem usually winged above. Leaves pointed at both ends. Rays 2 to 8.

FIG. 411.—Wingstem (*Actinomeris alternifolia*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Lacey-Keosauqua Park, Madison county (L. H. Pammel); Ames (C. R. Ball and L. H. Pammel, A. Hayden, Fred Rolfs (College Park), Emma Sirrine), Colfax (S. P. Sipe), Creston (T. L. Andrews), Decatur county (J. P. Anderson), Des Moines (G. W. Carver), Johnson county (T. J. and M. F. L. Fitzpatrick), Keosauqua (L. H. Pammel and H. E. Rees), Page county (T. J. and M. F. L. Fitzpatrick), Keokuk (P. H. Rolfs), Ontario (E. R. Hodson).

This plant has been observed (L. H. Pammel) at Atlantic, Boone, Cedar Rapids, Clinton, Des Moines, Fort Dodge, Keokuk, Keosauqua, Marshalltown, Pammel Park, Tama, Toledo.

General distribution in the United States:

Illinois—Hamilton (L. H. Pammel and Frank Pellett); Kentucky—Wasioto (T. H. Kearney, Jr.); Maryland—High Island (Lyster H. Dewey); Nebraska—Lincoln (R. Gmelin); Ohio—Pickerington (Asa Horr).

HONEY BEE VISITS

Honey bees visit the yellow flowers freely and when the plants are common, they yield considerable honey.

Dubuque, July 13, 1914. Clear, west wind. Twenty per head per hour. Many honey bees; few *Bombus* and small bees; no flies. Honey bees for nectar; small bees for pollen. (G.H.M.)

Ames, July 19, 1914. College Park. Clear, northeast wind. Two per head per minute. Many honey bees; *Bombus* and other Hymenoptera; few flies. Honey bees and *Bombus* gathering nectar, small bees principally pollen.

August 24, 1914. Cloudy, southeast wind. Ten heads per minute. Two to five (av. three) flowers visited per head. (G.H.M.)

August 28, 1914. Cloudy, northwest wind. Two per head per minute. Few honey bees, *Bombus*, flies, beetles; seeking nectar. (G.H.M.)

September 3, 1914. Three per head per minute. Honey bees, *Bombus*, Hymenoptera, flies. (G.H.M.)

Hamilton, Illinois, September 8, 1918. Bright, sunshiny. One bee was observed to spend 35 seconds in one head.

Walnut, Illinois, September 14, 1918. Common in the woods.

Bees were observed on this plant in the College Park in 1925 and 1926, but no records of dates were kept.

Marshalltown (near apiary), August 30, 1927, 8 a.m. Bees one second in a flower.

Ames, September 1, 1927, 2:30 p.m. Bees abundant. One to two seconds in a flower. Visits five to seventeen flowers in a head.

Keosauqua, August 31, 1929. Some honey bees.

Hamilton, Illinois, September 3, 1929. A few bees. One second in a flower.

Ames, October 14, 1929, 1:30 p.m. Bees one second in a flower.

Mr. Pellett considers this one of the best honey plants and finds it extensively visited at Atlantic.

Bidens L. Bur Marigold

Annual or perennial herbs, with opposite leaves and very numerous yellow flowers. The heads are many-flowered; rays, when present, 3 to 8, neutral; usually with barbed achenes, which are disseminated by carriers. These plants furnish no honey on dry soils but abundant honey on moist soils.

Many of the species are excellent honey plants. Some are among the very best of the honey plants of the Composite family. The flow is continuous and the flowers have a fairly long blooming period.

Frank Pellett reports a number of species which are valuable honey plants. *Bidens involucrata,* which is mentioned a little later in this volume, is valuable on the lowlands, especially those of Mississippi river, and reaches into central Iowa. Several species are reported by Richter as valuable in California—*B. frondosa* and *B. pilosa.* These are not valuable in Iowa.

B. involucrata is said to furnish much honey in Texas and Louisiana, but *B. trichosperma* is the most valuable species.

Bidens discoidea (T. and G.) Britton. Boot-jack

Diffusely branched. Leaves ternately-divided. Heads small. Achenes linear-wedge-shaped with stout upwardly-barbed awns. Swampy places.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Montrose (L. H. Pammel and D. H. Edwards), Decorah (E. W. D. Holway).

HONEY BEE VISITS

Montrose, September 2, 1929, 10 to 11 a.m. Some bees. One second in a flower.

Bidens involucrata (Nutt.) Britton

Heads rather large, outer bracts exceeding the inner, achenes with 2 short, acute teeth.

HONEY BEE VISITS

Alexandria, Missouri, September 3, 1929. One second in a flower.

Bidens discoidea is associated with *Bidens involucrata* but is less common. The bees seemed to work this as much as or more than *Bidens aristosa.*

HONEY BEE VISITS

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary.) Bees one second in a flower. Visit two to three flowers in a head.
Mount Pleasant, September 4, 1929. Bees one second in a flower.

Bidens frondosa (T. and G.) Britton. Sticktight

A tall branching annual, smooth, with long stalk. Terminal leaflets sharply serrate.

FIG. 412.—Sticktight (*Bidens frondosa*). *Photograph by A. Hayden.*

Widely distributed in the state and in northern United States. This is often confused with *B. discoidea*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (three specimens), Beulah, Buffalo creek, Anamosa, Colfax, Clinton, Davenport, Eddyville (three specimens), Emmetsburg, Fairfield, Gillett Grove, Iowa City, Melrose, Oelwein, Oskaloosa, Rock Rapids, Saratoga, Turin, Wall Lake, Washington (L. H. Pammel); Ames (S. W. Beyer, L. H. and Violet Pammel, A. Hayden, R. I. Cratty), Armstrong (R. I. Cratty), Chickasaw county (W. D. Spiker), Creston (T. L. Andrews), Emmet county (B. O. Wolden), Fayette (B. Fink), Kelley (L. H. Pammel and C. E. Maxwell, Botanical Seminar), Iowa, northeastern part (H. Goddard), Wapello (R. I. Cratty, J. M. Aikman).

HONEY BEE VISITS

Ames, September 10, 1927, 8 a.m. Clear, warm. Some bees. One second in a flower.

Bidens vulgata Greene. Beggar Ticks

Tall branching form. Leaves 3- to 5-pinnately-divided, slender-petioled, coarsely serrate. Heads large; rays yellow; awns of the achenes backwardly barbed, exceeding in length the yellow corolla. Moist waste places.

FIG. 413.—Sticktight (*Bidens vulgata*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Ames, Chariton, Cherokee, Clinton, Des Moines, Estherville, Fairfield, Granite, Hanlontown, Marshalltown, Newton, Oelwein, Osceola, Wall Lake, Washington, Yellow river (L. H. Pammel); Ames (two specimens, L. H. and V. Pammel), Boone county (Botanical party), Chickasaw county (W. D. Spiker), Estherville (B. O. Wolden), Fayette (B. Fink), Creston (T. L. Andrews), Kelley (P. Clayton), Mount Pleasant (H. E. Jaques); Osage (Mrs. F. M. Tuttle); Polk county (R. I. Cratty and J. M. Aikman).

Bidens comosa (Gray) Wiegand. Sticktight

A stout, glabrous form. Leaves pale, elliptical, with winged petioles, serrate, upper entire. Outer bracts of involucre linear, erect.

Found in sandy soil.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Harlan, Webster county (L. H. Pammel); Ames, (R. I. Cratty, P. H. Rolfs), Armstrong (F. W. Paige), Decatur county (J. P. Anderson).

Bidens trichosperma (Michx.) Britton. Sticktight

A smooth, branching plant, short-petioled leaves, usually 3- to 7-parted. Heads in corymbose clusters, rays conspicuous, bright yellow. Achenes narrow, wedge-oblong, sparsely hairy with two erect awl-shaped stout teeth. Swamps in eastern United States, also New York westward to Minnesota.

This occurs in peat bogs of Cerro Gordo and Worth counties. There are few specimens in the Herbarium. It is, however, common. One of us saw some of this species in sphagnum moss in Charles City at Mrs. Charles Patten's home. Many years ago the sphagnum was used for wrapping nursery stock.

Associated with *Cirsium muticum, Pedicularis lanceolata, Dulichium arundinaceum, Epilobium adenocaulum, E. coloratum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
New Hampton (L. H. Pammel), Chickasaw county (two specimens, W. D. Spiker), Emmet county (R. I. Cratty).

General distribution in the United States:
Indiana—Blackford county (Charles C. Deam), Bluffton (C. C. Deam and H. A. Gleason); Massachusetts—Dedham (M. A. Day and M. L. Fernald); Minnesota—(F. L. Couillard), Minneapolis (two specimens, J. H. Sandberg); Nebraska—Callaway (J. M. Bates); Ohio—Baltimore (Asa Horr), Buckeye Lake (H. L. Jones), Lancaster (Dr. Bigelow).

HONEY BEE VISITS

Undoubtedly a bee plant.

Bidens connata Muhl. Swamp Beggarticks

Tall, branching. Two to five feet high. Leaves bright green, undivided, slender petiolate. Heads about one-third inch high. Rays golden yellow. Swamps and ditches.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville, Commerce, Eddyville, Hamburg, Keosauqua, Waterloo (L. H. Pammel); Ames (two specimens, R. I. Cratty), Charles City (Mrs. F. M. Tuttle), Fayette (B. Fink), Slater (H. S. Fawcett and C. Reinbott).

HONEY BEE VISITS

Polk county (low places) September 7, 1927, 5:30 p.m. Bees one second in a flower.

FIG. 414.—Swamp marigold (*Bidens connata*). *Photograph by A. Hayden.*

Bidens cernua L. Nodding Sticktight

Smooth or somewhat hispid plants one foot to two and one-half feet in height, with short branches. Leaves narrow, lanceolate, pointed, saw-toothed, connate at base. Outer involucral bracts longer than the head; rays yellow; achenes wedge-shaped. Very variable. Wet places; common. Blooms from July to October.

Shores of lakes, drained lake beds. Associated with *Leersia oryzoides, Bromus ciliatus, Cinna arundinacea, Phragmites communis.*

FIG. 415.—Nodding sticktight (*Bidens cernua*). *Photograph by Photo section, Ia. Agr. Exp. Sta.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (two specimens), Anamosa, Clear Lake, Boone, Clinton, Des Moines, Dolliver Park, Eddyville, Estherville, Fairfield, Forest City, Hamburg, Lacey-Keosauqua Park, Marshalltown, Mason City, Missouri Valley, Montrose, Norwalk, Rock Rapids, Rockwell City, Saratoga, Steamboat Rock, Strawberry Point, Wallingford, Wall Lake (L. H. Pammel); Ames (P. H. Rolfs, R. I. Cratty), College Park (two specimens), Armstrong, Boone High Bridge (G. M. Lummis, Theodore Macklin and L. H. Pammel), Boone county, Ledges (C. R. Ball and L. H. Pammel), Cedar Rapids (R. E. Buchanan), Charles City (Mrs. F. M. Tuttle), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Decorah E. W. D. Holway), Des Moines (G. W. Carver), Fayette (B. Fink, C. C. Parker), Keokuk (P. H. Rolfs), Mason City (L. H. Pammel and C. H. McNider), New Hampton (L. H. Pammel and W. D. Spiker), northeastern Iowa (H. Goddard), Pine creek (L. H. Pammel and R. Torrey). Observed (L. H. Pammel) at Clarion, Clear Lake, Eldora, Forest City, Milford, Ocheyedan, Spirit Lake, Webster City. Observed also at Ames, nine miles south, Mitchellville (L. H. Pammel), Montrose (L. H. Pammel and V. A. Edwards).

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall); Illinois—Oquawka (Harry N. Patterson); Indiana—Upton (John S. Wright); Minnesota—Cass Lake, Clear Lake, Star Island (L. H. Pammel), Minneapolis (J. H. Sandberg), St. Cloud (R. Gmelin); Nebraska—Callaway (J. M. Bates), Lincoln (R. Gmelin); New York—Ithaca (Bechtel and Muenscher); Oregon—Crook county (two specimens, K. Whited); Utah—Echo (R. E. Buchanan, C. P. Johnson, G. M. Lummis and L. H. Pammel).

HONEY BEE VISITS

Hermann Mueller reports the honey bee on this plant in Germany.

Ames, September 6, 1918. Over a space three feet by three feet, ten honey bees were working in one minute; they visited thirty-two heads.

September 17, 1918. Warm, strong south wind. Over an area five feet by two feet, four bees were working. They visited six heads, thirty-two flowers. The heads averaged 205 flowers or 6560 flowers per plant. The space five feet by two feet contained 18 plants, giving this area 52,480 flowers.

Polk county, September 5, 1927, 4 p.m. Clear. Bees common. One second in a flower. Visiting three to five flowers in a head.

Cherokee, September 21, 1928, 3 p.m. Bees one second in a flower.

This is a splendid honey plant.

FIG. 416.—Nodding sticktight (*Bidens cernua*). *Photograph by A. Hayden.*

Ames, September, 1929, 2 p.m. Warm. Bees one second in a flower.
September 17, 1929, 1:30 p.m. Cool west wind, clear. Bees one second. Pollen and nectar.

Dates in bloom: Mechanicsville, September 20, 1918; Lake Mills, September 20, 1918; Clinton, September 20, 1918.

Bidens laevis (L.) B. S. P. Smooth Sticktight

A smooth plant about 3 feet high with sessile lanceolate leaves. The showy bright yellow rays of the flower heads longer than the involucral bracts. Fond of wet locations. Massachusetts and southward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:
Marshalltown (L. H. Pammel), Armstrong (R. I. Cratty), Cedar Rapids (R. E. Buchanan), College Park, Ames (F. Rolfs), Des Moines (G. W. Carver), Fayette (B. Fink), High Bridge (G. M. Lummis).

General distribution in the United States:
California—Los Angeles (George B. Grant); Colorado—Fort Collins (C. S. Crandall); Kentucky—Bell county (T. H. Kearney, Jr.); Montana—Hamilton (L. H. Pammel and H. S. Fawcett); New York—Ithaca (H. E. Summers); South Carolina—(G. McCarthy, Herbarium U. S. D. A.); Utah—Peterson (R. E. Blackwood and L. H. Pammel); Wisconsin—La Crosse (Dora S. Pammel).

HONEY BEE VISITS

Bees are reported upon this plant by Charles Robertson. It is considered a reliable source in sections where it is abundant.

Ames, September 17, 1918. Strong, warm south wind. Six heads (32 flowers) visited by the bees in a minute. Four bees over an area five feet by two feet.

Ottumwa, September 9, 1918. Honey bees visiting this plant freely; over a space four feet square six bees were noted, gathering both pollen and nectar. Bees visited 45 flowers in one minute, on seven heads. On a patch three feet by four feet, five bees were working.

Skunk river bottom, Ames, September 9, 1918. This plant abundant. Fields yellow with its bloom.

West Burlington, September 9, 1918, 9 a.m. Heavy dew, clear. Seven honey bees on a space five feet by five feet. One plant has 50 to 60 heads; 130 plants in area three feet by four feet. A bee visited 45 flowers in one minute on seven heads. Bees visiting the plant freely.

Nearly all beekeepers of Iowa and Illinois who reported emphasize Spanish needle as an important honey plant.

Bidens aristosa (Michx.) Britton. Western Tickseed, Spanish Needle

Pubescent plant, with pinnately divided petioled leaves. Leaflets lanceolate, cut-toothed. Heads corymbosely panicled. Outer bracts 8 to 10, rays showy. Achenes with three long slender teeth.

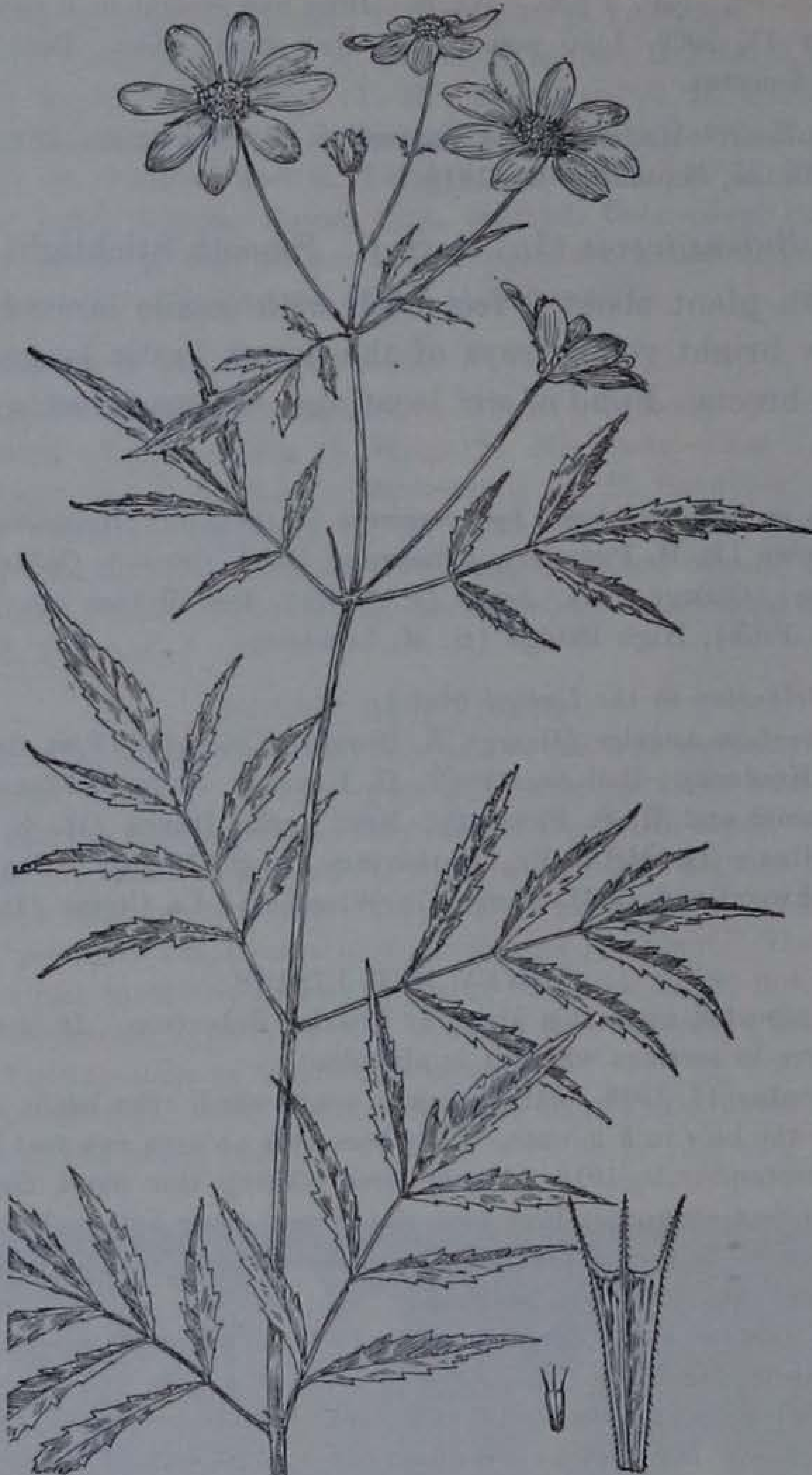

FIG. 417.—Tickseed (*Bidens aristosa*). *Mich. Agr. Exp. Sta.*

Waste places. Associated with *Rudbeckia laciniata, Sporobolus vaginiflorus, Helenium autumnale, Vernonia fasciculata.*

Distribution in Iowă as shown by specimens in the I.S.C. Herbarium:

Chariton, West Burlington, Oskaloosa (L. H. Pammel); Montrose (L. H. Pammel and V. A. Edwards).

It has been observed (L. H. Pammel) at Albia, Burlington, Centerville, Des Moines, Fairfield, Fort Madison, Indianola, Keokuk, Keosauqua, Lineville, Mount Zion, Muscatine, Newton, Osceola, Slater, Wapello, Winterset.

General distribution in the United States:

Illinois—Crawfordsville (W. H. Evans), Graceland (L. H. Pammel), Peoria (F. E. McDonald), Urbana (R. T. DeMotte); Nebraska—Sheridan county (R. E. Buchanan); Ohio—Richland county (E. Wilkinson); Missouri—Alexandria (L. H. Pammel).

HONEY BEE VISITS

Pellett says this plant is particularly valuable on the lowlands along Mississippi and Missouri rivers. Bees are reported upon it by Charles Robertson.

In speaking of *B. aristosa* Lovell says:

"A typical Spanish needles swamp is located at the foot of the bluffs of the Illinois river where there is a broad expanse of low marshy land from 3 to 5 miles wide. The land is subject to an overflow from the river once a year, which usually occurs in early spring. This renders a large portion of the soil unfit for tilling purposes, and in consequence Spanish needle has secured a permanent foothold to the exclusion of all other plants. Early in September the bright yellow rays begin to appear and in a short time the whole district is aglow, and its dazzling brilliancy reminds one of a burnished sheet of gold. The bees revel in this great field of flowers, so rich in nectar, and rapidly store a surplus. A single colony stored 63 pounds of honey in six days, and 43 colonies produced 2,021 pounds in 10 days, an average of 47 pounds per colony."

Pollen is pushed out by brush-hairs of the style. The flower is proterandrous.

West Burlington, September 9, 1918, 9 a.m. Clear, heavy dew. Honey bee visited 45 flowers (7 heads) in one minute. Seven bees at one time working over area five by five feet. Flies, bumble bees, and other Hymenoptera also present.

In a second area, fifty-sixty heads on a medium sized plant, one hundred thirty such plants in an area three by four feet.

Hamburg, August 25, 1928, 3 p.m. No honey bees. Numerous beetles.

Distribution of *Bidens aristosa* in bloom, September 20, 1927. None in Linn county. Common in Polk county south of Des Moines. Common in bottoms and uplands Madison and Warren counties.

Bees were observed on this species at Mitchellville, Keosauqua and Mount Pleasant, September, 1929, and at Oskaloosa, September, 1930.

Bidens involucrata (Nutt.) Britton. Long-bracted Tickseed, Bracted Bur-marigold

Heads large, the outer bracts (12 to 20) mostly longer than the inner, slender and hispid, achenes with a pair of short pointed teeth.

Swamps, western Illinois to Kansas. Shores of lakes and streams. Associated with *Leersia oryzoides, Eragrostis hypnoides, Boltonia asteroides, Lobelia siphilitica, Salix longifolia.*

This is considered a good honey plant. Mr. Holekamp states that these plants yield no honey on dry soil but an abundance on moist soils. L. A. Kenoyer reports that in southeastern Kansas bees worked freely on *Bidens* before a rain, but stopped suddenly when the rain fell.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames 1917, Burlington, Centerville (two specimens), Cooper creek, Clarinda, Eddyville, Knoxville, Lime creek, Madison county, Mount Zion, Ottumwa, Shenandoah, West Burlington, Winterset (L. H. Pammel); Cromwell (Mrs. Ann Dalton), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Des Moines county (P. Bartsch), Essex (L. Hogglund), Newton (G. Drew), Slater 1902 (H. S. Fawcett, W. I. Tener, C. Reinbott).

This plant has been observed (L. H. Pammel) at Burlington, Camanche (low grounds), Cedar Rapids, Clinton (low grounds), Des Moines along Interurban car track, Eldora, Iowa Falls, Keokuk, Lansing, Marshalltown, McGregor, Mechanicsville, Newton, Ottumwa, Quarry, Tama and Toledo.

HONEY BEE VISITS

Centerville, September 2, 1914. Clear, north wind. Ground moist. Honey bees common; one to two per head. Spend one-half to two seconds per flower, visiting all in head in one minute. Gathering pollen and nectar. Other insects. No bumble bees. Five flies, *Pontia rapae*.

September 2, 1914. Two bees dusted with pollen. Bumble bees eight, five to one seconds in one flower. Diptera three.

September 3, 1915, 6 to 8 a.m. Clear, after rain. No insects. Heads expanding at 6 a.m., fully expanded at 8.

August 29, 1917, 3 p.m. Clear. Honey bees and *Bombylius* observed.

Creston, (12 miles east of town), September, 1928. Not many bees, mostly beetles.

Shenandoah, 1928. Bees one second in a flower.

Monroe, August 31, 1929. No bees nor at Colfax. This species is abundant in low ground and up swales. Commonly associated with *Verbena hastata*.

Centerville, September 1, 1929. Low grounds. Only a few honey bees. One second in a flower. Many beetles. An abundance of *Bidens involucrata* between Centerville and Bloomfield and Keosauqua. More than in Mahaska and Jasper counties. In Davis and Appanoose counties up old oat stubble fields, also in draws.

Keosauqua, September 1, 1929. Only a few bees. One second in a flower.

Montrose, September 2, 1929, 9:30 a.m. Bees fairly common. One second in a flower. Butterflies and *Bombus*.

Donnellson, September 2, 1929, 3 p.m. No honey bees. Some *Bombus*.

Alexandria, Missouri, September 2, 1929. Bees fairly common. One second in a flower. Flower beetles common.

Keokuk, September 3, 1929. Bees one second in a flower. (Des Moines river bottom.)

Hamilton, Illinois, September 3, 1929, 2 p.m. Only a few bees. One second in a flower.

Montrose, September 3, 1929. Only a few bees. One second in a flower. *Bombylius, Bombus, Pieris,* yellow butterfly and small bees present. Many flower beetles. *Bidens aristosa* abundant in fields and in low grounds at Donnellson, New Boston and between Donnellson and Keosauqua; oat fields yellow with it. It was also abundant from Montrose to Fort Madison. In some places on sandy soil, but most abundant in low ground. It was less common north of Fort Madison and in high lands. Occurs in draws. Condition at Centerville like that at Keosauqua. To the north, however, occurs in draws.

September 4, 1929. Plants in draws at Mount Pleasant and Fairfield.

Batavia, September 4, 1929, 2 p.m. Some bees. One second in a flower.

Oskaloosa, September 7, 1930. Bees abundant.

This plant is a reliable source for honey. The honey is light yellow in color, and has the faint spicy odor characteristic of the flowers.

Blooming Central City, September 20, 1919; Kelley, September 20, 1919. Fields yellow. Madison county, September 7, 1919, Warren county, September 7, 1919.

Cosmos Cav.

Tall plants with fine foliage and beautiful, rather large heads; ray flowers white to red in color; disc flowers yellow. Blooming late in summer and in fall.

Cosmos bipinnatus Cav. Cosmos

Leaves pinnately divided. Rays of the flower rose color to white. This plant originated in Mexico. Several varieties are common in our gardens. Occurs wild with *Malva rotundifolia, Polygonum pennsylvanicum*.

This Mexican ornamental plant is widely cultivated in the state. We have observed it coming up spontaneously in a few places as at Ames, Boone, Council Bluffs, Des Moines. It has not, however, become established. Bees follow the cosmos in gardens for honey.

HONEY BEE VISITS

Dubuque, September 11, 1914. Clear, northwest wind. Few honey bees, few *Bombus*, few beetles, many small bees. One insect per head per minute. Sucking. (G.H.M.)

October 1, 1914. Clear, southeast wind. One honey bee, one *Bombus*, one other Hymenoptera, two Lepidoptera, 60 flowers per minute. Spent 15 seconds per head. Often carrying pollen. Lepidoptera 30 to 60 seconds per head.

Waukon, September 21, 1918, p.m. Bright, warm. Bees abundant. Visit fifty flowers in a minute. Ten bees at work on area ten feet square.

Ames, August 27, 1923, a.m. Clear, bright. Many bees getting pollen.

September to October 10, 1923. Freely and constantly visited by numerous honey bees, actively getting honey. One bee visits several flowers of each head. One second in the floret. Plants visited on all days except during rain, from early morning to dark. Many other insects also present, working on the flowers.

Bees were observed on this species at Ames in 1927 and 1928.

Mount Pleasant, September 8, 1929. Bees gathering nectar and pollen. (S. M. Helmick.)

Blairstown, September 28, 1929, 2 p.m. Clear. Bees one second. Abundant.

Tama, September 28, 1929, 5 p.m. Cloudy. Bees one second in a flower.

Ames, October 2 to 20, 1929. Clear. Some bees. One second in a flower.

September 16, 20, 28, 1930. Bees fairly common.

Lake View, September 27, 1930, 3 p.m. No honey bees. *Bombus pennsylvanicus.*

Helenium L. Sneezeweed

Erect, branching herbaceous plants. Leaves alternate with resinous dots. Heads in flat-topped clusters, usually yellow. Many-flowered, rays several, wedge-shaped, 3- to 5-cleft, usually fertile.

The sneezeweeds are frequently visited by bees for nectar. The flowers are in heads with yellow ray flowers. The small disc flowers have five syngenesious anthers, as in other composites, the flowers are proterandrous; the pollen is pushed out. Bees readily secure the nectar, which is contained in the corolla tube and is secreted by a small swelling surrounding the base of the style.

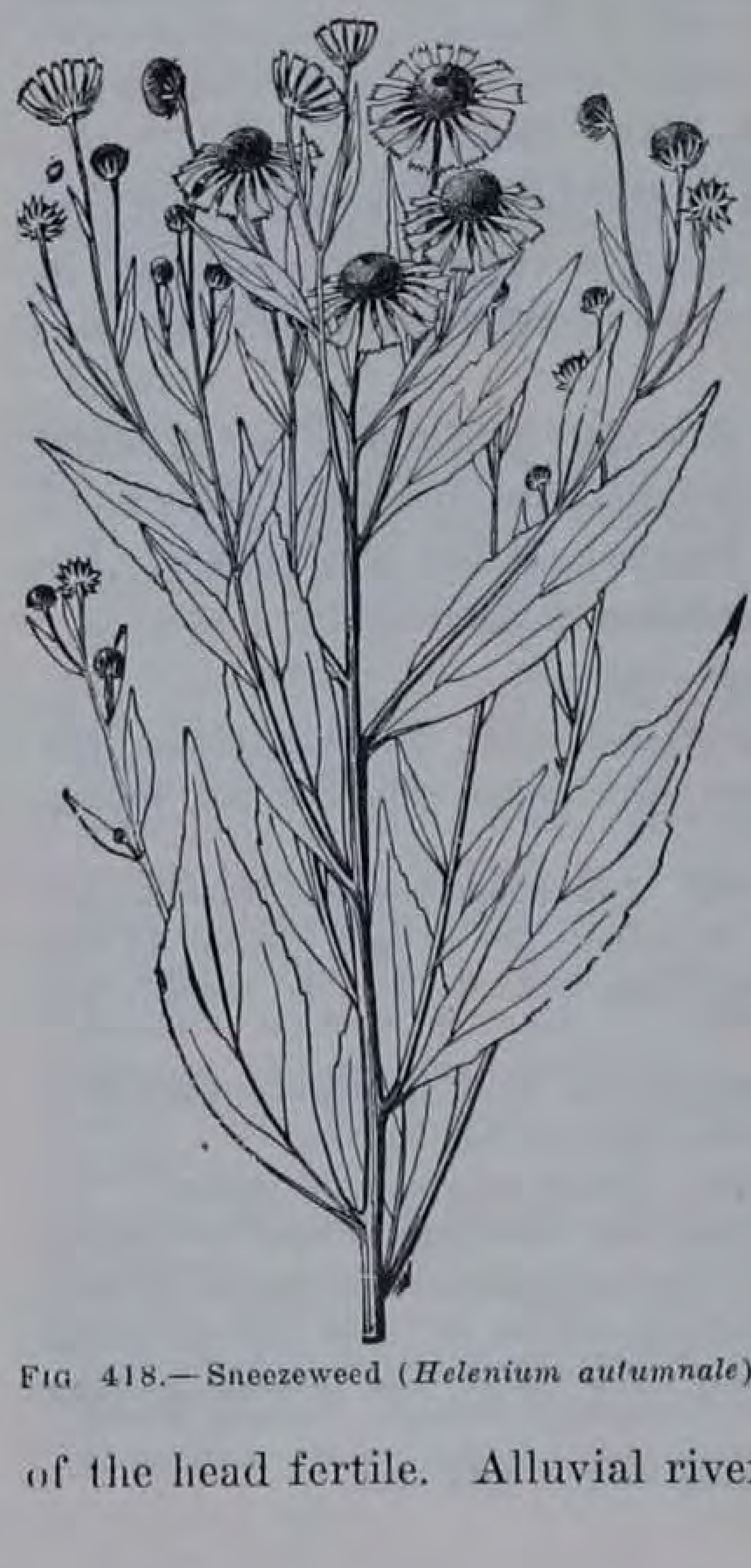

FIG. 418.—Sneezeweed (*Helenium autumnale*).

The nectar in some species is described as bitter. The plants have poisonous properties, but it is not known that the honey from the flowers is ever harmful.

Helenium autumnale L. Sneezeweed

Erect, branching perennial herbs 1 foot to 5 feet tall, nearly smooth, with alternate lanceolate, toothed leaves and yellow heads. Achenes with pappus of five to eight chaffy scales; rays of the head fertile. Alluvial river banks and wet ground, western

Quebec to Manitoba, southwest and westward. It blooms through August, September and October. Associated with *Aster Tradescanti, Lobelia siphilitica, Scirpus atrovirens, Veronica virginica, Thalictrum dasycarpum, Carex vulpinoides, Eupatorium purpureum, E. perfoliatum, Leersia oryzoides, Glyceria nervata.*

FIG. 419.—Sneezeweed (*Helenium autumnale*). *Photograph by Colburn.*

Sneezeweed is common in low alluvial grounds and borders of lakes and streams in every part of the state. It is most abundant in the Mississippi and Missouri bottoms and along the Des Moines, Cedar and other larger streams of the state.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (four specimens), Bixby Park, Cedar Falls (two specimens), Dallas, Eddyville, Edgewood, Fairfield, Hamburg, Liscomb, Manchester, Mason City, Rock Rapids, Rochester, Waterville, Wheelerwood (L. H. Pammel); Ames, Keokuk, Lawler (P. H. Rolfs), Cedar creek (H. E. Jaques and L. H. Pammel), Decatur county (J. P. Anderson), Farmington (F. D. Carn), Fraser (Botany Seminar), Fayette (B. Fink), Iowa City (A. S. Hitchcock), Kelley (two specimens, Pearl Clayton), McGregor (Ada Hayden), Mount Pleasant (H. E. Jaques), northeastern Iowa (H. Goddard), Salem (H. E. Jaques and L. H. Pammel), Slater (two specimens, H. S. Fawcett, C. Reinbott, W. I. Tener).

Observed (L. H. Pammel) at Anamosa, Algona, Atlantic, Audubon, Bellevue, Burlington, Cedar Rapids, Centerville, Charles City, Chariton, Clinton, Cresco, Creston, Delhi, Des Moines, Dubuque, Eldora, Emmetsburg, Fort Atkinson, Fort Madison, Glenwood, Hamburg, Hampton, Indianola, Iowa Falls, Jefferson, Keokuk, Keosauqua, Lansing, Logan, Manchester, Marshalltown, Mason City, McGregor, Missouri Valley, Muscatine, Nevada, New Hampton, Newton, Onawa, Osceola, Rock Rapids, Rockwell City, Sac City, Sioux City, Shenandoah, Steamboat Rock, Strawberry Point, Tama, Tipton, Toledo, Winterset.

General distribution in the United States:

Colorado—Fort Collins (C. P. Johnson, L. H. Pammel, Fred Rolfs); District of Columbia—.................................. (G. McCarthy); Idaho—Idaho Falls (L. H. Pammel); Illinois—Peoria (F. E. McDonald), Silvis (H. Eggert), Walnut (L. H. Pammel); Kentucky—Wasiota (T. H. Kearney, Jr.); Minnesota—Benson, Clear Lake, Lake City, Monticello (L. H. Pammel), International Falls (H. S. Kellogg), St. Cloud (two specimens, R. Gmelin); Missouri—Eagle Rock (Kenneth K. Mackenzie); Nebraska—Callaway (J. M. Bates), Halsey (J. C. Blumer); Nevada—Elko county (A. A. Heller); New Mexico—Whitman's Camp (A. Isabel Mulford); New York—Ithaca (Muenscher and Bechtel), Ithaca (H. E. Summers); Ohio—Baltimore (Asa Horr); South Carolina—Troy (two specimens, F. O. Cook); South Dakota—Watertown (L. H. Pammel); Texas—Austin (two specimens, B. C. Thorpe), Hemphill county (M. A. Carleton, U. S. Nat. Herb.), Lake Worth (Albert Ruth); Utah—Evanston (L. H. Pammel); Virginia—Great Falls of the Potomac (C. R. Ball); Washington—Fall Bridge (Kirk Whited); Wisconsin—La Crosse (two specimens, L. H. Pammel), La Crosse, Portland (C. M. King and Dora Pammel).

POLLINATION AND HONEY BEE VISITS

The pollination of *Helenium* has been studied by Loew, as recorded by Knuth. He observed the honey bee gathering nectar and pollen. Charles Robertson records the honey bee visiting this plant September 15 to September 22 in southern Illinois. It is one of the valuable honey plants of Iowa.

Dillon, September 4, 1914, 11:30 a.m. Clear, southeast wind. Five bees in two minutes; also *Bombylius*.

Clinton, September 6, 1915. South wind, bright sunshine. Honey bees visited 37 flowers in one minute, on 10 separate heads. Bees very active. (L.A.K.)

Dubuque, October 4, 1918. Bees abundant on the plant. One plant had 110 heads with open flowers, bearing nectar and 175 to 200 flowers per head.

Ames, September 21, 1923, 12 m. Bright, warm. Garden varieties being freely visited by honey bees. (C.M.K.)

September 5, 1927, 9 a.m. Bees abundant. One second in a flower. Honey bee visits three to ten flowers in a head.

September 1, 1928. Bees abundant. None on *Solidago canadensis* near by, somewhat past bloom. None on *Helianthus strumosus* or *Helianthus scaberrimus*.

Oskaloosa, September 30, 1928. Bees one second in a flower.

Ames, August 27, 1929, 10:30 a.m. No bees. Many beetles.

Ottumwa, September 4, 1929. Bees numerous. One second in a flower. Also flower beetles.

Ames, September 11, 1929. Some bees. First time this year in formal garden.

September 17, 1929. Some bees. One second in a flower. Flower past its prime. Bees gathering pollen and nectar.

September 18, 1929. No bees. Bees on *Aster novae-angliae*. Temperature 60°. (Near an apiary.)

Dimorphotheca Moench. Cape Marigold

Annual or perennial plants, introduced from Africa. Head 1½ to 3 inches across, solitary; ray flowers white, purple or yellow.

Dimorphotheca aurantiaca D.C. Cape Marigold

Erect perennial. Leaves narrow, oblong, tapering to the base. Heads with long bright yellow rays varying to red or orange.

HONEY BEE VISITS

Centerville, September 8, 1929, 9 a.m. One second in a flower.

Mitchellville, September 8, 1929, 10:30 a.m. Bees one second in a flower.

Gaillardia Foug.

Herbs with alternate leaves. Flowers in long-peduncled showy yellow or purplish heads, many flowered. Rays 3-cleft or toothed, neutral or fertile. Bracts of the involucre in several rows. Achenes top-shaped.

Gaillardia aristata Pursh. Gaillardia

Perennial hirsute herbs with lanceolate or oblanceolate leaves. Disc flowers brownish purple; chaff bristly or subulate. Commonly cultivated for ornamental purposes.

General distribution in the United States as shown by specimens in the I.S.C. Herbarium:

Canada, Calgary (L. H. Pammel); Colorado—Fairview (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank Raney), Fort Collins (L. H. Pammel, F. Rolfs, C. P. Johnson), Golden, Larimer county (L. H. Pammel, Reppert and Witter); Kansas—Wichita (T. L. Andrews); Missouri— Morley (H. Eggert); South Dakota—Hot Springs (J. C. Witham); Wisconsin—La Crosse (L. H. and H. E. Pammel); Wyoming—Table Mountain (Aven Nelson), Dale creek (R. E. Buchanan).

HONEY BEE VISITS

The plant has a long blooming period and while honey bees are not as abundant as on many other Composites it must be considered a good honey plant, because of its long flowering season.

Ames, June 29, 1927, 1 to 3 p.m. Hot, dry and windy. Bees getting honey and pollen.

July 22, 1927, 11 to 12 a.m. After rain. Cloudy, warm. Bees collecting pollen, one second in a flower.

September 5, 1927, 9:30 a.m. Bees one to two seconds in a flower. Visiting four to nine flowers in a head.

October 25, 1927, 12:15 p.m. Bees abundant. One to two seconds in a flower.

June 26, 1928, 2 p.m. Clear, moderate. Bees one or two seconds in a flower.

September 11, 1929. Bees one second in a flower. *Pieris, Coleus, Bombus.*

September 17, 1929, 1:30 p.m. Cool, west wind. Clear. Bees numerous.

September 26, 1929, 10:30 a.m. Clear and warm. No bees, some beetles.

Dr. H. H. Knight reports the following pollinators.

Coleoptera: Yellow beetle. (*Chauliognathus pennsylvanicus* De G.).

Hymenoptera: *Bombus* sp. No honey bees.

Lepidoptera: Yellow butterfly (*Eurymus philodice* Godt.).

Dr. H. H. Knight reports the following insect visitors (October 2, 1929):

Diptera: Tachina fly (*Archytas aterrima* Desv.).

Hymenoptera: *Bombus* sp.

Lepidoptera: Yellow butterfly (*Eurymus philodice* Godt.), Cabbage butterfly (*Pieris rapae* L.), Dingy cut worm moth (*Feltis ducens* Walk.).

October 2, 1929, 1:30 p.m. Some bees. One second in each flower.

October 27, 1929. Clear, cold. Bees one second in a flower.

September 16, 1930, 1 p.m. Bees common. None on *Solidago canadensis, Aster multiflorus, Heliopsis scabra, Helianthus annuus* and *H. grosseserratus.*

Gaillardia amblyodon Gay

A leafy annual. Leaves oblong, auriculate. Rays brown-red. Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

Ames, October 13, 1929, 12:30 p.m. Clear, a slight north breeze. One second in a flower.

October 14, 1929, 1:30 p.m. Bees one second in a flower. Many *Bombus* sp., moths, *Pieris rapae* and other Lepidoptera.

Tagetes

Strongly scented plant. Mostly annual. Branches erect or diffused. Leaves usually opposite, finely dissected or serrulate. Heads solitary or clustered.

Tagetes erecta L. African Marigold

Stout, erect, branching annuals about 2 feet high. Leaves pinnately divided. Heads yellow to orange, rather large. Peduncle swollen just below the head. Pappus 1 or 2; 0 or 2 awned scales and 2 or 3 shorter awns.

This plant is frequently cultivated for ornamental purposes.

HONEY BEE VISITS

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary.) Bees one second in a flower.

Mitchellville, August 31, 1929, 1 p.m. Cool and cloudy. Bees one second in a flower.

Montrose, September 2, 1929. Bees one second in a flower.

Ames, September 26, 1929, 10 a.m. Clear and warm. Bees four seconds in a flower.

Blairstown, September 28, 1929, 2 p.m. Clear. Bees abundant. One second in a flower.

Ames, October 16, 1929, 8:30 a.m. Clear and cool. Bees one second in a flower.

Calendula L. Calendula

Annual or perennial herbs having large heads with yellow or orange rays.

Calendula officinalis L. Pot Marigold

Annual, 1 foot to 3 feet high. Leaves somewhat fleshy, oblong, remotely notched. Heads solitary, $1\frac{1}{2}$ to 2 inches across, closing at night.

HONEY BEE VISITS

Ames, October 14, 1929, 9:30 a.m. Bees one second in a flower.

Achillea (Vaill.) L. Yarrow

Perennial herbs. Leaves 1 to 3, pinnately parted or toothed. Heads small, in many-flowered clusters. Flat drooping branches. The ray flowers pistillate, fertile. Pappus none. Disc flowers perfect.

In yarrow or milfoil the white heads are attractive to insects. A single flower is small and inconspicuous, but many of these small flowers are crowded together in one head, and in addition the white ray flowers certainly render them conspicuous. The nectar is easily reached by many insects. It is secreted by a small body at the base of the style. The flowers are visited by many small insects like flies and bees. They are strongly proterandrous and each flower has five stamens. The anthers are united, and when the flower opens the two divisions of the style are closely appressed in a cylinder made by the five anthers. The anthers when mature shed their pollen into the hollow cylinder. The tips of the lobes of the style are furnished with hairs and as the style elongates it brushes out the pollen, which remains attached to the hairs. When older, these branches turn back and an insect going to a flower cannot help but get some pollen on its body, and as it goes to another flower it is almost certain to leave some pollen on the stigma. While cross-pollination is almost certain to occur, self-pollination also may take place.

FIG. 420.—Yarrow (*Achillea lanulosa*). *Photograph by A. Hayden.*

Achillea Millefolium L. Yarrow

Perennial herb with small corymbose convex heads. Stem leaves numerous, leaves finely bipinnately divided, slightly silky lanate. Rays of the white flower 5 to 10. Plant has a pungent odor. Fields and river banks, common, also in pastures.

Common in prairie soils, especially gravel knolls, sandy soils, limestone rocks. Associated with *Verbena stricta, Solidago mis-*

souriensis, S. nemoralis, Aster laevis, Cirsium Hillii, Viola pedata, Panicum Scribnerianum.

The conspicuous white crowded heads are attractive to insects. Nectar is secreted by a small body at the base of the style and is easily reached.

According to our observation these plants are visited by many insects, Hymenoptera included. Knuth does not record the honey bee nor does Loew nor Willis.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (large heads and ray flowers absent), Beaman, Boone county Ledges, Cedar Falls, Dubuque, Delhi, Indianola, Lamont, Marshalltown (two specimens), Rowley, Sac City, Saratoga, Traer, Waukon Junction (L.H.P.); Boone county Ledges (J. V. Ellis), Battle Creek (E. S. Preston), Decorah (E. W. D. Holway), Des Moines (A. L. Bakke), Decatur county (two specimens, J. P. Anderson), Estherville (R. I. Cratty), Fayette (two specimens, B. Fink), Kelley (Pearl Clayton), Lawler (P. H. Rolfs), Mount Pleasant (H. E. Jaques), northeastern Iowa (H. Goddard), Ottumwa (John Parks), Shell Rock (J. W. Allen).

Observed (L. H. Pammel) at Alton, Albia, Burlington, Centerville, Chariton, Council Bluffs, Des Moines, Hamburg, Indianola, Keokuk, Keosauqua, Lansing, Mason City, McGregor, Newton, Osceola, Rock Rapids, Tabor.

General distribution in the United States:

Alabama—Birmingham (L. H. Pammel); Alaska—.................... (Mr. Weinmann), Nine-mile (Kirk Whited); Arizona—Flagstaff (D. T. MacDougal); Canada—Sault Ste Marie (Wiggins and Roupe); Colorado—Denver, Golden, LaPorte (L. H. Pammel, Herb. J. T. Collins), Providence (R. I. Melvin, E. L. Hughes), Tageguache Basin (Edwin Payson); District of Columbia—Washington (E. A. Hyde); Kansas—Wichita (T. L. Andrews); Louisiana—.................... (T. L. Andrews); Mexico—Hidalgo (C. G. Pringle); Massachusetts—Newton Center (Grace Gilbert), Brimfield (H. E. Pammel), Stockbridge (H. S. Kellogg); Minnesota—Farwell (Ida Grillette), Jackson, Minneapolis, Owatonna (L. H. Pammel), Cass Lake, Star Island (P. S. McNutt, H. E. and L. H. Pammel), Crookston (Mrs. Roy Westley), Duluth (H. E. and L. H. Pammel), International Falls (Harriette Kellogg), Para (Lyle Clapper); Missouri—Nevada (L. H. Pammel); Montana—Bitter Root valley (L. H. Pammel and H. S. Fawcett), Clinton (J. C. Witham); Nebraska—Crete, Harlan county (L. H. Pammel), Holdrege (J. G. McMillan); New Mexico—Cuba (A. D. Reed); New York—Cooperstown (Mrs. L. M. Parker), Niagara Falls (G. H. Frazier), Watkins Glen (L. H. Pammel); Ohio—Cedar Point, Put-in-Bay (L. H. Pammel), Worthington, (Asa Horr); Oregon—Crook county (two specimens, Kirk Whited); Corvallis (H.S.H., Oregon Agrl. College); Pennsylvania—Pittsburg (L. H. Pammel); South Dakota—Brookings (Edna C. Pammel), Camerons Bluff (Rob Combs), Mount Vernon (B. Fink); Texas—Austin (B. C. Thorpe and

C. Werkenthin), Huntsville (B. C. Thorpe), Tarrant county (Albert Ruth); Utah—Black Fork (R. E. Buchanan, C. P. Johnson, G. M. Lummis, L. H. Pammel), Fish creek (R. E. Buchanan, C. P. Johnson, L. H. Pammel), Logan canon (L. L. Barrett, L. V. Lee, L. H. Pammel, Frank Raney), Salt Lake City (R. E. Blackwood, L. H. Pammel); Washington—Everett (two specimens, J. M. Grant), Gearhart Park (L. H. Pammel and W. S. Dudgeon); Mount Paddo (W. N. Suksdorf); Wisconsin—Beloit, Wausau (L. H. Pammel and V. C. Fisk), Bloomingdale (L. H. Pammel), Prescott (Mary Edgar); Wyoming—Bear River (L. H. Pammel), Dome Lake (Sarah Ellis, A. E. Paddock and Ferdinand Reppert); Smoot (George M. Armstrong, Edwin B. Payson).

Some of the specimens recorded as *Millefolium* undoubtedly may be referred to the native form *lanulosa.*

HONEY BEE VISITS

Ames, June 2, 1927. Warm, partly cloudy. Some bees. One second in a flower.
Bees have been found during the past season (1929).

Chrysanthemum (Tourn.) L. Ox-eye Daisy

Heads many-flowered, rays numerous. Receptacle flat. Leaves divided. Heads in corymbs.

Chrysanthemum frutescens L. Marguerite

Much-branched, bushy plant. Heads solitary, 1½ to 2 inches across, with long, narrow white or yellowish rays.

HONEY BEE VISITS

Mount Pleasant, September 2, 1929. Bees gathering pollen. (S. M. Helmick.)

Chrysanthemum uliginosum Pers. Chrysanthemum

Tall perennial, branching, aster-like in appearance. Leaves long-lanceolate. Heads many, 1½ to 3 inches across. Rays white. Commonly cultivated.

HONEY BEE VISITS

Ames, September 5, 1929, 11 a.m. Bees one second in a flower.
September 11, 1929, 11 a.m. Some bees. One second in a flower. Many beetles.

Chrysanthemum Leucanthemum var. *pinnatifidum*. Ox-eye Daisy, Field Daisy

Basal leaves spatulate, on long slender petioles. Upper leaves oblong, coarsely dentate or crenate. Head 1 inch to 1¾ inches broad. Involucral bracts narrow. Rays white. Fields of New England, westward. Not extensively distributed in Iowa.

FIG. 421.—Ox-eye daisy (*Chrysanthemum Leucanthemum* var. *pinnatifidum*). *Photograph by A. Hayden.*

HONEY BEE VISITS

Visited by a variety of insects, occasionally by the honey bees.

Anthemis (Michx.) L. Chamomile

Strong scented branching herbs with pinnately dissected leaves. Solitary terminal heads. Large, white or yellow; disc flowers yellow. Heads many-flowered. Rays pistillate or neutral.

Anthemis Cotula L. Mayweed

A strongly scented annual herb. Leaves pinnately divided. Rays mostly neutral. Receptacle with chaff; pappus none, achenes rough. Common weed throughout the state, especially barnyards and old hog lots and sometimes in oat fields. More common in eastern than in western Iowa.

Knuth does not report honey bees on it in Germany, although many other Hymenoptera visit the flowers. John Lovell reports

FIG. 422.—Dog-fennel (*Anthemis Cotula*). *Photograph by Geo. H. Munger.*

its value as a honey plant in Sacramento Valley, California, and it is also reported as a honey plant by Richter in California.

HONEY BEE VISITS

Bloomfield, July 25, 1927, 10:30 a.m. Some bees. Mr. Egland says bees not infrequent.

Des Moines, September 21, 1929, 10 a.m. Clear, fairly warm, windy. One second in a flower.

Cacalia L. Indian Plantain

Smooth, tall perennial herbs, with discoid heads of whitish flowers. Heads 5- to many-flowered. Flowers tubular, perfect; achenes slender, smooth; pappus of soft-hair-like bristles.

Knuth records the honey bee on *Cacalia hastata* getting nectar.

Cacalia suaveolens L. Indian Plantain

A tall perennial with grooved stems and triangular halberd-shaped leaves; stem leaves with winged petioles. Heads 25- to 30-flowered.

In damp woods in the northeastern part of the state. Associated with *Ulmus americana, Populus deltoides, Celtis occidentalis, Gymnocladus dioica, Carya cordiformis.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Backbone Park (L. H. Pammel), Osage (F. M. Tuttle), Winneshiek county (H. Goddard).

Observed (L. H. Pammel) at Cresco, Decorah, Fort Atkinson, Lansing, New Albin, Waukon.

General distribution in the United States:

North Carolina—Biltmore (Biltmore Herbarium); Ohio—Lancaster (Dr. Bigelow); Wisconsin—Mouth of Kickapoo river (L. H. Pammel).

HONEY BEE VISITS

Each head contains 5 perfect tubular florets. Insects insert the proboscides only into the wide part of the tube. Honey bees and numerous other insects visit this flower. It is a splendid honey plant.

Cacalia atriplicifolium L. Pale Indian Plantain

A smooth plant with round stems, leaves palmately-veined, the lower somewhat heart-shaped, the upper wedge-shaped, toothed. Heads few-flowered.

In rich woods. Associated with *Ulmus fulva, Tilia americana, Celtis occidentalis, Acer nigrum, Solidago ulmifolia, S. latifolia, Phlox divaricata, Podophyllum peltatum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decatur county (J. P. Anderson), Indianola (H. S. Doty, H. E. and L. H. Pammel), Keokuk (W. S. Bell), Keosauqua (A. F. Sample).

It has been observed (L. H. Pammel) at Carlisle, Delaware county, Indianola, Osceola, St. Olaf, Winterset.

General distribution in the United States:

Illinois—Starved Rock (Mark Heavenhill and L. H. Pammel); Ohio—Mansfield (E. Wilkinson); South Carolina—Oconee county (A. P. Anderson); Virginia—Blacksburg (W. A. Murrill, N. Y. Bot. Garden).

Cacalia reniformis Muhl. Great Indian Plantain

A form with leaves green on both sides, fan-shaped or kidney-shaped, and large corymbs. In damp rich woodlands.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Decorah (E. W. D. Holway), Elkader (R. Gmelin), Fayette (B. Fink), Winneshiek county.

It has been observed (L. H. Pammel) at Cresco, Buffalo Center and West Union.

General distribution in the United States:

Missouri—Eagle Rock (B. T. Bush); North Carolina—Caldwell county (J. K. Small and A. A. Heller); Ohio—Baltimore (Asa Horr); Wisconsin—La Crosse (Dora Pammel and C. M. King).

Cacalia tuberosa Nutt. Tuberous Indian Plantain

Stem angled, root tuberous. The thick leaves are green on both sides, 5- to 7-nerved. Lower leaves with long petioles, upper leaves with short petioles. Heads few-flowered.

Black and somewhat gravelly prairie soil. Gravel knolls and prairies. Associated with *Phlox pilosa, Astragalus caryocarpus, Viola pedata, V. cucullata, Panicum virgatum, Andropogon furcatus, Bouteloua curtipendula.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Carroll, Des Moines, Jefferson, Rowley, Webster City (L. H. Pammel); Armstrong, West Bend (R. I. Cratty), Ames (G. W. Carver), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Fayette (B. Fink), Kelley (Pearl Clayton), Spencer (Mr. Eddington), Story City (F. C. Stewart).

It has also been observed (L. H. Pammel) at Adel, Albia, Algona, Audubon, Battle Creek, Carroll, Cedar Rapids, Chariton, Cherokee, Clarinda, Clinton, Dallas Center, Denison, Des Moines, Emmetsburg, Estherville, Fairfield, Forest City, Garner, Guthrie Center, Hamburg, Humboldt, Indianola, Jefferson, Jewell, Keosauqua, Logan, Le Mars, Marshalltown, Mason City, Missouri Valley, Nevada, Newton, Postville, Rock Rapids, Rockwell City, Shenandoah, Sioux City, Thompson, Wall Lake.

General distribution in the United States:

Kansas—Wichita (T. L. Andrews); Missouri—St. Louis (H. Eggert); Ohio—(Dr. Bigelow); Texas—Tarrant county (Albert Ruth), ... (B. C. Thorpe).

HONEY BEE VISITS

It is not an important honey plant though visited by bees.

Arctium L. Burdock

Familiar coarse biennial weeds. Leaves large, cordate; flower heads purple or white. Knuth says of *A. Lappa*, "Florets tubular, hermaphrodite. Stylar branches short, beset along the inner side with stigmatic papillae, outwardly with short sweeping-hairs."

Arctium Lappa L. Great Burdock

A coarse biennial plant, with large leaves and small solitary or clustered heads. Flowers purple, rarely white. Involucre globular. Bracts hooked. Roadsides and waste places. New Brunswick westward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Hanlontown, Mason City, Nevada, Steamboat Rock, Worth county (L. H. Pammel); Ames (Byron Knapp and H. E. Pammel), Appanoose county (T. J. and M. F. L. Fitzpatrick), Armstrong (R. I. Cratty), Boone county Ledges (J. V. Ellis), Kelley (Pearl Clayton), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

General distribution in the United States:

Idaho—American Falls (L. H. Pammel and W. S. Dudgeon); Massachusetts—Adams, Deerfield (M. A. Day, Gray Herb.); New York—Ithaca (H. E. Summers); Ohio—Pickerington (Asa Horr).

HONEY BEE VISITS

Bees have been reported on it.

Arctium minus Bernh. Common Burdock

Leaves tapering at the base. Heads racemose, about one-half to one inch across. Bracts slender, shorter than in great burdock. Found in similar situations, common.

Cosmopolitan weed in various soils. Widely distributed in gardens, roadsides. Associated with *Pastinaca sativa, Zizia aurea, Muhlenbergia mexicana, Geum canadense.*

Knuth records honey bees on this on the North Frisian Islands.

Bees work on this flower to some extent. It is not, however, an important honey plant. In several seasons bees were active on the plant.

The small heads are conspicuous on account of the reddish color of the involucral bracts. The throat of the tubular corolla is about three mm. long; honey collects in the tube sometimes to half its depth.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Eddyville, Washington (L. H. Pammel); Ames (Fred Rolfs, C. R. Ball, Albert Wolf (white flowered form, C. M. King), S. W. Beyer), Charles City (C. L. Webster), Decorah (E. W. D. Holway), Fayette (B. Fink), Lawler (P. H. Rolfs), Mount Pleasant (H. E. Jaques), Osage (Mrs. F. M. Tuttle).

General distribution in the United States:

Illinois—Champaign (B. Fink), Chicago (L. H. Pammel), East St. Louis (H.

FIG. 423.—Burdock (*Arctium minus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

FIG. 424.—Common Burdock (*Arctium minus*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

Eggert); Louisiana........................ (T. L. Andrews); Minnesota—Crookston (Mrs. Roy Westley), St. Cloud (R. Gmelin); New York—Geneva (L. H. Pammel); South Dakota—Sisseton (L. H. Pammel); Washington—Seattle (Kirk Whited).

HONEY BEE VISITS

Tama, August 5, 1915. Warm. Three or four bees.

Ames, August 20, 1915 (and other days). Honey bees predominate. *Megachile* present. (L.A.K.)

La Crosse, Wisconsin, July 29, 1918. Clear, cool. Bees at work on the flowers.

Clayton, August 4, 1923. Clear, dry. East slope at base of hill. Four bees at work on one plant; time in flower two seconds.

McGregor, August 13, 1924. Bees abundant. Two seconds in a flower.

August 8, 1929, 2 and 5 p.m. Bees abundant. One or two seconds in a flower. Somewhat sandy soil.

La Crosse, Wisconsin, August 10, 1929, 5 p.m. Bees one to two seconds in a flower. Black sandy soil. Insects go to this flower in preference to catnip and motherwort.

McGregor, August 16, 1929. Bees abundant. One second in a flower.

Lansing, August 17, 1929, 3 p.m. Bees abundant. One and two seconds in a flower.

Ames, September 8, 1929. Bees one second in a flower. (A. L. Hershey.)

Echinops L. Globe Thistle

Perennial herbs. Leaves usually pinnately toothed, divided lobes, prickly. Flowers in globose heads. Achene 4-angled. Pappus of many short scales.

Echinops Ritro L. Globe Thistle

Perennials 2 to 6 feet high. Leaves spinose, toothed. Flowers blue or white. Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

Ames, July 22, 1927, 11 to 12 a.m. After rain, cloudy, warm. A few bees collecting honey. Bees two and one seconds in a flower.

5 to 6 p.m. Dry, warm, windy. Bees one to three seconds in each flower. (C.C.L.)

July 18, 19, 1929, p.m. Bees numerous. Two seconds in a flower. One of the finest honey plants.

July 24, 1929, 1:30 and 2:30 p.m. Clear. Heavy rain this morning. Bees two seconds in a flower. Bees visiting ten to eighteen flowers in a head.

July 25 and 26, 1929. Warm, windy. Two seconds in a flower. Sometimes two bees on a head. Bees visit four to twelve flowers in a head.

Cirsium (Tourn.) Hill. Thistle

Tall branching herbs, mostly biennial, leaves sessile, usually prickly. Heads large, many-flowered; flowers purple, tubular, perfect. Bracts of the involucre tipped with a prickle.

Knuth says, "Stylar branches remain almost closed; covered with small sweeping hairs externally." He notes the honey bee on *Cirsium arvense*. Hermann Mueller also records the honey bee in the Alps on *Cirsium*.

Cirsium lanceolatum L. (Hill.) Bull Thistle

Branching biennial 3 to 4 feet high. The leaves extend down upon the stem, slender, sharply lobed, rough above, prickly woolly beneath. The flowers are purple, in large heads. The involucre bracts tipped with spines. Roadsides and in pastures.

FIG. 425.—Bull thistle (*Cirsium lanceolatum*). Photograph by *H. I. Featherly.*

In Missouri loess soils, prairies of northwestern Iowa, gravel knolls. Associated with *Lepacys columnaris, L. pinnata, Gaura coccinea, Aplopappus spinulosus, Grindelia squarrosa, Bouteloua curtipendula, Euphorbia marginata, Helianthus Maximiliani.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (J. R. Campbell, P. H. Rolfs, J. H. Frazier, Armstrong (F. W. Paige), Badger (H. Myrhe), Casey, Grand Junction (H. Johnson), College Park, Ames (F. Rolfs, J. N. McBirney), Decatur county (J. P. Anderson, T. J. and M. F. L. Fitzpatrick), Emerson (A. J. Binan), Fayette (B. Fink), Glendon (O. P. Miller), Keokuk (P. H. Rolfs), Missouri Valley (John Zahner), North English (B. Grimm), Pisgah (L. H. Pammel), Steamboat Rock (C. M. King), Tama county (Scott Borse).

This species has been observed (L. H. Pammel) at Burlington, Floyd county, Fort Dodge (introduced), Glenwood, Hamburg, Keosauqua, Missouri Valley, Newton, Rock Rapids, Sioux City, Tabor.

General distribution in the United States:

Illinois—Blackberry (two specimens, Bruce Fink); Louisiana—.................... (T. L. Andrews); Michigan—Port Austin (C. R. Ball); Minnesota—Cass Lake (Star Island) (L. H. and H. E. Pammel and P. S. McNutt), Elmore (W. H. Frank), International Falls (H. S. Kellogg); Montana—Hamilton (L. H. Pammel and H. S. Fawcett); New York—Ithaca (H. E. Summers); Ohio—Wooster (A. D. Selby, Ohio Agrl. Exp. Sta. Herb.); Utah—Farmington canyon (L. H. Pammel and R. E. Blackwood); Wisconsin—Portland (C. M. King and Dora Pammel).

HONEY BEE VISITS

Charles Robertson observed insects upon this plant from July 23 to October 7; he does not record the honey bee.

Florets bright purple in color. Mechanism like that of *C. arvense* except that the corolla tube is somewhat deeper and adapted to visits of long-tongued bees.

According to Knuth this species is visited frequently for nectar. In Iowa, however, the bee is an infrequent visitor. The nectar is secreted as in other thistles.

The five syngenesious anthers shed their pollen on the inside of the anther tube, and when the insect touches the flower, owing to the sensitive character, it is pushed out. The Iowa thistle (*Cirsium iowense*) is pollinated in the same way. Honey bees occasionally visit the thistle for pollen, which is abundant.

Cirsium canescens Nutt. Woolly Thistle

A deep-rooted perennial, with leaves woolly-white beneath and white above. Leaves pinnately parted. Bracts of the involucre tipped with slender spines. Found in Minnesota and western Iowa, westward. Becoming more common in central part.

Associated with *Aploppapus spinulosus, Gaura coccinea, Lygodesmia juncea, Petalostemum multiflorum, P. purpureum, Grindelia squarrosa, Yucca glauca.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Arcadia, Armstrong, Cherokee, Gillett Grove, Granite, Harlan, Little Rock, Sioux City (two specimens) (L. H. Pammel); Afton (A. M. Olmstead), Ames (Ada Hayden), Anderson (P. H. Rolfs), Carroll (J. F. Cooper), Charles City (C. L. Webster), Charter Oak (C. N. Weed), Emmet county (two specimens, R. I. Cratty), Iowa Falls (M. E. Peck), Lake Okoboji (H. S. Coe), Le Mars (W. J. Lang), LuVerne (W. J. Blumer), Milford (H. S. Coe and L. H. Pammel), Neola (Wm. Spears), Pisgah (L. H. Raymond), Rolfe (J. E. Joliffe), Sac City (L. R. Johnson), Sibley (H. L. Emmert), Storm Lake (Henry Meierhard), Webster City (W. E. Barr).

General distribution in the United States:

Colorado—Fort Collins (two specimens, L. H. Pammel and C. P. Johnson); Minnesota—Ortonville (L. H. Pammel), Utica (two specimens, J. M. Holzinger); Nebraska—Sioux county (F. G. Miller); North Dakota—Fargo (L. H. Pammel); "Rocky Mountains" (John Craig); South Dakota—LaBolt, Sioux Falls, Sisseton, Spring creek, Watertown (L. H. Pammel), Brookings (Edna C. Pammel), Trent (two specimens, C. R. Ball).

HONEY BEE VISITS

Bees have been reported on it gathering pollen.

FIG. 426.—Woolly thistle (*Cirsium canescens*). *Photograph by Quade.*

Cirsium discolor (Muhl.) Spreng. Wood Thistle

A branching biennial, 3 to 6 feet high, stem strongly furrowed, basal leaves long, pinnatifid, upper leaves with falcate lobes, white-woolly beneath; heads solitary, at tips of branches, bracts of involucre appressed, the outer tipped by a weak recurved prickle. The inner linear, alternate, with long colorless appendage. Found in rich soil, New England westward.

Various types of soils, borders of woods and fields in clay or somewhat sandy soils. Associated with *Corylus americana*, *Rhus glabra*, *Prunus virginiana*, *P. americana*, *Heliopsis scabra*, *Silphium perfoliatum*, *Silene stellata*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cherokee, Gillett Grove (two specimens), Greene, Lake Mills, Steamboat Rock (L. H. Pammel), Ames (R. Combs, four specimens, F. Rolfs, Verne Whitney), Center Point (D. C. Snyder), Decatur county (J. P. Anderson), Fayette

(B. Fink), Fraser (Botany Seminar), Keokuk (P. H. Rolfs), Ledges (Boone county) (R. E. Buchanan, two specimens, G. M. Lummis), Miller's Bay (Lake Okoboji) (J. R. Campbell), Mount Pleasant (H. E. Jaques), northeastern Iowa (H. Goddard), Postville (C. M. King), Rockford (C. L. Webster), Slater (H. S. Fawcett, W. I. Tener, C. Reinbott).

This has also been observed at Adel, Albia, Boone, Clinton, Creston, Fairfield, Fort Dodge, Hamburg, Humboldt, Keokuk, Keosauqua, Lansing, Muscatine, New Albin, Newton, Rock Rapids, Rockwell City, Sioux City, Winterset.

General distribution in the United States:

Arizona—Southern Arizona (J. C. Blumer); Illinois—Berwyn (H. S. Fawcett), Walnut (L. H. Pammel) .... (F. B. Mead, Engelmann Herb.); Kansas—Wichita (T. L. Andrews); Maryland—Great Falls of the Potomac (C. R. Ball); Minnesota—Howard, Marshall, Minneapolis (L. H. Pammel); Missouri—St. Louis (Geo. Englemann); Ohio—Worcester (J. W. T. Duvel); Oklahoma—Norman (W. E. Bruner) (western type); South Dakota—Brookings (L. H. Pammel and N. E. Hansen), Clear Lake (L. H. Pammel); Texas—Tarrant county (Albert Ruth); Wisconsin—Bloomingdale (four specimens, Dora Pammel and C. M. King), La Crosse (R. Gmelin), St. Croix Falls (L. H. Pammel).

HONEY BEE VISITS

Dubuque, July 13, 1914. Clear, west wind. *Bombus* sucking nectar. *Apis* gathering pollen, one per head per minute. (G.H.M.)

Ames, July 17, 1914. College Park. Clear. Southwest wind. Few honey bees, many *Bombus* and butterflies. Two per head per minute. (G.H.M.)

This species furnishes considerable pollen in some years. On August 18, 1929, bees were abundant on white sweet clover, but there were no bees upon adjacent plants of *Cirsium discolor*.

Centerville, September 9, 1914. Clear, north wind. Five honey bees gathering pollen. Three *Bombus* gathering nectar.

Marshalltown, August 30, 1927, 10 a.m. Warm, clear. Bees fairly common, getting pollen. One to two seconds in a flower.

Ames, September 1, 1927, 2:30 p.m. Bees two seconds in a flower. Getting pollen.

Boone, September 29, 1929, 4:30 p.m. Cool, cloudy. Some honey bees. (Dorothy Johnson.)

The blossoms of the thistle secrete nectar at base of corolla tubes. This tube is so long that honey bees cannot reach the nectar. The bees, however, collect pollen.

Cirsium altissimum (L.) Spreng. Tall Thistle

A biennial from 3 to 10 feet in height, branching. Stem downy, leaves green, roughish above; whitened with close wool beneath, oblong to narrowly lanceolate, undivided sinuate-toothed. Involucre nearly 1 inch high; outer bracts with a short dark glandular line on the back abruptly tipped with a spreading setiform bristle; inner bracts with a deltoid serrulate tip. Flowers purple. Found in fields and copses, Massachusetts westward.

In woods and borders of woods and thickets, eastern Iowa. Associated with *Aster sagittifolius, Solidago ulmifolia, S. latifolia, Hepatica acutiloba, Anemone nemorosa, Viola cucullata, V. pubescens, Uvularia grandiflora, Trillium nivale, Hydrophyllum virginianum, Ulmus fulva, Quercus alba, Podophyllum peltatum, Trillium erectum, Prunus virginiana.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Clinton, Dubuque, Lime Springs, Waukon, Yellow river (L. H. Pammel); Decorah (E. W. D. Holway), Fayette (B. Fink), northeastern Iowa (H. Goddard).

It has been observed (L. H. Pammel) at Anamosa, Cedar Rapids, Manchester, Marshalltown, McGregor, Tama, Tipton, Toledo.

HONEY BEE VISITS

Bees have been observed on this plant.

McGregor, August 8, 1928. Bees gathering pollen. Two to three seconds in a flower.

Cirsium iowense (Pammel) Fernald. Iowa Thistle

Biennial; stem downy, branching, 3 to 10 feet in height. Leaves sparingly sinuate-lobed, whitened with close wool beneath, heads large, about one inch high; bracts with broad, long, dark glandular back; the inner with a prolonged attenuate colorless tip. Generally found along prairie roadsides in Iowa, South Dakota and Kansas.

Black prairie soil, abundant in Wisconsin drift sheet. Associated with *Solidago missouriensis, Aster azureus, A. laevis, Cirsium Hillii, Zygadenus chloranthus, Astragalus canadensis, Asclepias speciosa, A. tuberosa, Vicia americana, Phlox pilosa, Spiranthes cernua, Panicum Scribnerianum, Elymus robustus, Andropogon furcatus, Lilium canadense, L. philadelphicum* var. *andinum.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Centerville (two specimens), Eagle Grove, Estherville, Gillett Grove, Liscomb (three specimens), Rock Rapids, South Dakota opposite Hawarden, Spirit Lake (two specimens, L. H. Pammel); Decatur county, Union (J. P. Anderson), Ames (W. S. Dudgeon), Clarinda (Walter P. Grove), Fernald (two specimens, L. H. Pammel and Mina Belle Lynch), Ledges (Boone county) (L. H. Pammel and C. R. Ball), Little Rock (C. R. Ball), Ontario (E. R. Hodson), var. *Crattyi,* Armstrong, Emmet county (R. I. Cratty), Madison county, Sioux City, Winterset (L. H. Pammel), Kelley (Pearl Clayton).

It has been observed (L. H. Pammel) at Algona, Audubon, Forest City, Fort Dodge, Garner, Hampton, Humboldt, Keosauqua, Jewell, Mason City, Milford, New Hampton, Postville, Rockwell City, Spirit Lake, Waterloo, Webster City.

General distribution in the United States:

Kansas—Manhattan (Herb. Kans. State Agrl. College); Minnesota—Benson, Graceville, Howard Lake, Ortonville (two specimens), Richdale, Sanborn (two specimens) (L. H. Pammel); Nebraska—Halsey (J. C. Blumer).

HONEY BEE VISITS

Ames, September 1, 1927, 2:30 p.m. Bees fairly common. Two seconds in a flower.

Bees were observed on this plant near Marshalltown in 1928.

Ames, September 14, 1928, 10:30 a.m. Clear. A few honey bees getting pollen.

September 8, 1929. Honey bees were observed on it, collecting pollen. (Dorothy Johnson.)

Blooming at Ames, August 20, 1924.

FIG. 427.—Canada thistle (*Cirsium arvense*). *After Clark and Fletcher.*

Cirsium arvense (L.) Scop. Canadian Thistle

Smooth perennial, spreading by underground rootstocks; one to three feet high, branching at top. Leaves sessile, lanceolate, deeply pinnatifid margins with spiny teeth. Heads small, three-fourths to one inch high, bracts appressed. The arachnoid flowers dioecious, purple. The pappus bristles plumose, trichomes long, slender. Locally established in pastures, cultivated fields and roadsides.

FIG. 428.—Canada thistle (*Cirsium arvense*). *Photograph by A. Hayden.*

A common escape in fields and waste places in various soils. Associated with *Poa pratensis, Trifolium pratense.*

It is more or less abundant in Hardin, Pocahontas and Clinton counties and it is especially common in Clayton, Allamakee, Winneshiek, Jackson, Jones, Kossuth, Boone, Story, Marshall and Worth counties, frequently in clover meadows and in pastures.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel), Audubon (M. C. Griffith), Badger (H. E. Myhre), Bedford (A. G. Lucas), Blairsburg (John M. Hall), Brooklyn (E. B. Watson), Cedar Falls (C. E. Daily), Clarion (I. E. Melhus), Clinton (C. H. Arthur), Ewart (Ewart Bros.), Garrison (J. Grayson), Graettinger (E. L. George), Hartley (H. R. Fahlenkamp), Jefferson (Wm. Hopper), Kossuth county (S. A. Merrill), Lawler (P. H. Rolfs), Lorimer (G. R. Lochrie), Linden, (Marion E. Beel), Miles (Lloyd Frohen), Monona (Jas. Ulrich), Monroe (Geo. Larckey), Nevada (G. C. White), Ontario (E. R. Hodson), Rockwell (J. H. Brown), Roland (E. N. Waugh), Tama (Scott Bros.), Woolstock (A. R. Reynolds).

General distribution in the United States:

District of Columbia—Clay Avenue (Lyster Dewey); Illinois—Chicago (L. H. Pammel), Kanesville (Bruce Fink); Michigan—St. Ignace (L. H. Pammel); Minnesota—Cass Lake, Itasca State Park, Pike's Bay (L. H. Pammel), Black

Duck, Crookston (Mrs. Roy Westley), Cass Lake (Star Island) (two specimens, L. H. and H. E. Pammel and P. S. McNutt), Coleraine (R. I. Cratty), International Falls (H. S. Kellogg); New York—Buffalo (M. Nichol), Ithaca (two specimens, H. E. Summers, Herb. Asa Horr); Ohio—Mansfield (E. Wilkinson), Salem (H. S. Fawcett), Sandusky (L. H. Pammel), Wooster (J. W. T. Duvel, Ohio Herb. Agl. Exp. Sta.); Oregon—Redmond (K. Whited); South Dakota—Sisseton (L. H. Pammel); Washington—Everett (J. M. Grant); Wisconsin—Coon Valley (L. H. Pammel), Fond du Lac (L. H. Pammel and Elizabeth Waters), La Crosse (three specimens, L. H. Pammel).

HONEY BEE VISITS

A single head may contain more than 100 florets. In these flowers the nectar rises so high in the throat of the corolla as to be accessible even to insects with a very short proboscis. Bees visit it very freely. The honey is said

FIG. 429.—Canada thistle variety. *Cirsium arvense* var. *mite*. *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

to be of good quality. Pellett states that it is a source of honey and is reported as a surplus in Ontario and the eastern states. Knuth also notes the honey bee on this species. Lovell states that the nectar is abundant and that it rises in the corolla tube where it can be reached by all insects. Moreover, it yields nectar well in dry, warm weather.

A. I. and E. R. Root in "Gleanings in Bee Culture" report the honey as of good quality and on page 594 they state that "tons and tons of most pure white honey are obtained from the Canadian thistle."

Colo, July 17, 1927, p.m. Warm, dry, clear, windy. Bees freely working upon these heads; averaging two seconds. Flowers fragrant. (C.C.L.)

Escanaba, Michigan, to Milwaukee, Wisconsin. Blooming freely, August 12, 1927. No honey bees.

Centaurea L. Star Thistle

Herbs with alternate leaves and single heads. Heads many-flowered. Flowers usually purplish, tubular, marginal flowers longer than neutral. Disc florets hermaphrodite. Filaments irritable to touch.

Knuth says, "Kerner states that the pollen is concealed in the anther-cylinder until insects visit the florets, being thus protected from rain and dew. When the proboscis of a nectar-seeking insect stimulates the filaments, they contract so that the crumbling pollen is carried off by the visitor as soon as it is swept out. After removal of the pollen only cross-fertilization is possible for a short time; the stylar branches then roll back in such way that the stigmatic papillae touch the pollen still clinging to the sweeping hairs, thus effecting self-pollination."

Centaurea Cyanus L. Corn-flower

Long ascending branches, tipped with single heads of many flowers. An ovoid involucre of several rows of bracts. The individual flowers raylike, conspicuous, blue, violet, pink or white. Cultivated and escaped from gardens. Blooms from July to nearly frost. Introduced from Europe. In various soils.

Quite generally cultivated in gardens in Iowa and sometimes persists for several years afterward. Self-sown.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (two specimens, L. H. Pammel, R. I. Cratty), Ogden (L. H. and H. E. Pammel).

This has been observed (L. H. Pammel) as an escape at Albia, Ames, Cedar Rapids, Centerville, Clinton, Davenport, Des Moines, Keosauqua, Nevada, Tama.

General distribution in the United States:

Ohio—Cedar Point (L. H. Pammel), Pickerington (Floyd, M. D. 1838); Oregon—Douglas county (K. Whited). Common in California.

HONEY BEE VISITS

The large blue outer florets are the ones which attract insects. It is a splendid honey plant and yields both pollen and nectar to the honey bee, which is a constant visitor.

Honey bees are recorded for this plant by Hermann Mueller; Loew also records the honey bee collecting pollen. It is visited also by moths.

Ames, July 8, 1914. Near cemetery. Clear, north wind. One insect per head per minute. *Apis.* (G.H.M.)

July 21, 1914. Plot. Clear, south wind. Ten insects per head per minute. Few honey bees, few *Bombus,* very many small bees. (G.H.M.)

July 14, 1917. Dry and clear. Honey bees abundant getting pollen.

June 25, 26 and 28, 1922, a.m. Clear, windy. Two to three seconds in a flower.

Manhattan, Kansas, May 17, 1927, 12 m. Bees abundant. Two and one seconds in a flower.

Ames, July 13, 1927, 7 p.m. Many bees active in the flowers. (C.M.K.)

7:30 p.m. Some honey bees. One and two seconds in a flower. No bees two weeks ago.

July 31, 1927, 10:30 a.m. Dry. Bees gathering pollen. One to three seconds in a flower.

September 5, 1927, 9:30 a.m. Bees abundant. One and two seconds in a flower.

Norwalk, September 7, 1927, 4:20 p.m. (Near apiary.) Bees abundant. One second in a flower.

Des Moines, June 28, 1929. Bees one and two seconds in a flower.

Centaurea nigra L. Knapweed

Pubescent branching perennial, one to two feet high. Involucral bracts with blackish appendages.

Knuth mentions having observed honey bees getting nectar from this species.

Centaurea moschata L. Sweet Sultan

Glabrous branching annual, leaves toothed or pinnatifid. Cultivated as an ornamental plant. Flowers white, yellow or purple, fragrant, long, peduncled.

HONEY BEE VISITS

This is visited by honey bees.

Des Moines, June 20, 1928, 4 p.m. Bees one to two seconds in a flower.

Centaurea montana L. Centaurea

Perennial 12 to 20 inches tall. Somewhat branching. Leaves broadly lanceolate, decurrent. Involucre bracts with four or five rows of flowers. Commonly cultivated as an ornamental plant.

HONEY BEE VISITS

One of the plants most consistently visited by honey bees.

Ames, June 14, 1928, 2 p.m. Bees abundant. One second in a flower.

May 23 to 30, 1929. Warm. Bees abundant, gathering pollen and nectar. One to four seconds in a flower.

June 17 and 27, 1929. Bees abundant. One second in a flower.

Cichorium (Tourn.) L. Chicory

Branching perennials. Heads sessile. Flowers blue.

Cichorium Intybus L. Chicory. Blue Sailors

Stem leaves clasping, lanceolate; the lowest deeply toothed. Roadsides and fields.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cherokee, Clarinda, St. Olaf (L. H. Pammel); Boone (G. W. Carver), Chickasaw county (W. D. Spiker), Jordan (H. S. Kellogg), Ledyard (J. H. Palmer), Pomeroy (W. R. Hartley), Spencer (M. Busenbach), Stanhope (C. E. Currie), St. Charles (H. A. Mueller), Thor (G. E. Friesthe), Webster county (M. Lundblad).

Observed (L. H. Pammel) at Carroll, Des Moines, Hancock county, Jordan, McGregor.

FIG. 430.—Chicory (*Cichorium Intybus*). *Photograph by A. Hayden.*

General distribution in the United States:

California—Chico (A. A. Heller), Yuba City (L. H. Pammel), Colorado—Fort Collins (J. H. Cowan); District of Columbia—Washington (J. N. Rose); Indiana—Bluffton (Charles C. Deam); Michigan—Muskegon (L. H. Pammel), State Park Indian river (Wiggins and Roupe); Ohio—Kelley's Island (L. H. Pammel), Pickerington (M. D. Floyd); Oregon—Tomale (Kirk Whited).

HONEY BEE VISITS

Honey bees are recorded for this species by Hermann Mueller.

Blairstown, September 28, 1929, 2 p.m. Clear. Bees numerous. One second in a flower.

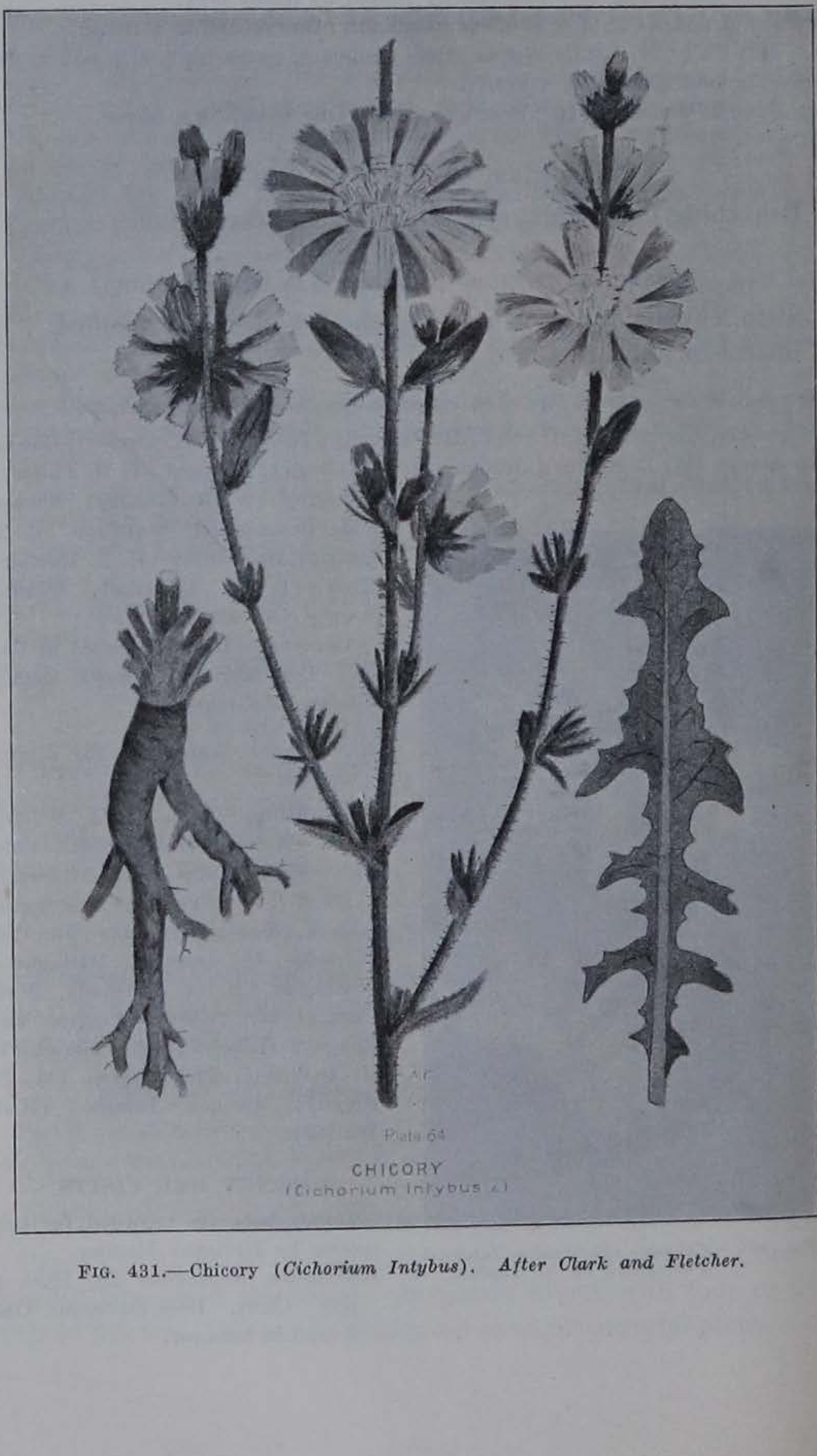

FIG. 431.—Chicory (*Cichorium Intybus*). *After Clark and Fletcher.*

Taraxacum (Haller) Ludwig

Taraxacum officinale L. Dandelion

The common well-known dandelion of fields and pastures. Perennial. Leaves coarsely pinnatifid, sinuate, dentate. Heads large, orange-yellow, fruit with globe of expanded pappus at end of lengthened scapes. Beak of olive-green achene two times its length, pappus white. Naturalized from Europe.

FIG. 432.—Common dandelion (*Taraxacum officinale*).

Cosmopolitan weeds in various soils, sandy, clay, black prairie. Associated with *Poa pratensis*, *Trifolium repens*, *Phleum pratense*, *Medicago lupulina*, *Verbena stricta*, *V. bracteosa*.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Cherokee, Crocker, Des Moines, Granite, Greene, Hamburg, Harlan, Lime Springs, Moingona, Mount Zion, Oelwein, Rock Rapids, Spirit Lake, Turin, Waterloo, West Burlington (L. H. Pammel); Ackley (B. E. Canavan) Algona (E. B. Watson), Ames (C. E. Bessey, C. R. Ball, R. Burgess, J. C. Blumer, S. W. Beyer, H. S. Fawcett, H. E. Pammel, W. S. Dudgeon, M. H. Reynolds, F. Rolfs, A. S. Hitchcock), Armstrong (R. I. Cratty), Dakota City (F. C. Stewart), Decatur county (J. P. Anderson), Decorah (E. W. D. Holway), Des Moines (Emma and L. H. Pammel), Fayette (two specimens, B. Fink, C. C. Parker), Fraser (Botany Seminar), Iowa City (A. S. Hitchcock), northern Iowa (H. Goddard), Kelley (Pearl Clayton), Lawler (P. H. Rolfs), Osage (Mrs. F. M. Tuttle, Ruth Walker), Slater (Botanical Party, two specimens, H. S. Fawcett, W. I. Tener, C. Reinbott).

It has also been observed (L. H. Pammel) at Agency, Albia, Anamosa, Atlantic, Blencoe, Boone, Brooklyn, Burlington, Carroll, Cedar Rapids, Centerville, Chariton, Clarinda, Clinton, Council Bluffs, Creston, Dallas Center, Davenport, Denison, Dubuque, Eldora, Emmetsburg, Estherville, Fairfield, Fort Dodge, Glenwood, Grinnell, Guthrie Center, Hampton, Harvey, Humboldt, Jewell Junction, Keokuk, Keosauqua, Lansing, Lineville, Logan, Madrid, Mason City, McCallsburg, McGregor, Milford, Missouri Valley, Nevada, Newton, Onawa, Ottumwa, Perry, Plymouth county, Polk City, Postville, Rockwell City, Rock Rapids, Sac City, Sioux City, Spencer, Spirit Lake, Strawberry Point, Tabor, Tama, Toledo, Wapello, Webster City, West Liberty, Woodbine.

It occurs in every county in Iowa.

General distribution in the United States:

Alaska—Hyder (Kirk Whited); Illinois—Champaign (Bruce Fink); Kansas—Wichita (T. L. Andrews); Minnesota—Brainerd (E. B. Watson), International Falls (H. S. Kellogg); Oklahoma—Norman (W. E. Bruner); Wisconsin—Madison (L. H. Pammel); Wyoming—Sheridan.

From central Texas to New Mexico and Florida but less common southward to the Gulf. Common in Colorado toward the Rockies.

FIG. 433.—Common dandelion (*Taraxacum officinale*). *Photograph by C. M. King.*

HONEY BEE VISITS AND HONEY PRODUCTION

The numerous bright yellow flowers of this familiar plant are collected in heads. They are open to the bright sunlight of morning and partly closed and covered by the involucre about noontime. They are abundantly visited by honey bees from early spring to midsummer for both pollen and nectar.

Burkill in "Fertilization of Spring Flowers" reports the honey bee. *Andrena* and *Halictus* are the common visitors in Europe, as recorded by Knuth. He cites it for the North Frisian Islands.

When fertilized the "flower stem" contracts, ripens its "seed" and elongates when ripe, so that the "seed" may be distributed. The plant produces an abundance of nectar, which rises a considerable distance in the tube, making it accessible to many insect visitors. The style is covered externally with brush hairs that extend below the cleft. Kerner remarks that in the outer florets these brushes diverge back to such an extent that they come in contact with the pollen of the inner ones.

Mr. Pellett states that the honey is dark and strong. Most of this honey is consumed in brood rearing. Lovell states that the honey is deep yellow and sometimes grainy in quality, and probably would not be liked by those accustomed to a milder honey. He further states that on many farms in Ontario and Quebec it produces more honey in the spring than any other plant, and he also records that at Middlebury, Vermont, the brood chambers sometimes become packed with dandelion honey. He also reports that it is valuable as a honey plant in Colorado.

The writers on honey plants usually refer to the species *Taraxacum officinale,* but as a matter of fact both species should be considered—*Taraxacum officinale* and *Taraxacum erythrospermum.*

The dandelion has a long blooming period; in central Iowa it appears soon after the frost leaves the ground and continues copiously until about the middle of June, when the blooming period ceases until the fall. Occasionally there are quite a number of blooms during the summer when the moisture conditions are favorable, as in 1929, when there were many plants still in bloom toward the latter part of July. Abundant bloom again by the middle of September and occasionally through the middle of November to December (1930).

The dandelion is one of the great sources of both nectar and pollen in early spring. Its abundance, its long blooming period, and its blooming at times in both spring and fall when other nectar plants are not much in evidence make it very valuable to the apiarist. The accumulation of sugar in the flowers is far greater in cool weather than in warm weather, so as a rule the yield is greatest following cool nights.

Besides honey bees, small pollen-gathering bees, *Syrphus* flies and sometimes butterflies have been noted.

Ames, May 8, 1914, 3 p.m. Roadside. Clear, warm. Honey bees, small flies. (Frazier.)

Toledo, May 17, 1915. Plentiful at noon; none in evening when flowers are partly closed. (Kenoyer.)

Ames, April-June 1, 1915. Honey bees abundant in good weather. (L.A.K.)

April 18, 1917. Blooming on south side Central Building.

June 12, 1917. Honey flow large.

June 26, 1917. Cloudy, rainy. Still visited by bees.

September 27, 1917, 12 m. to 2 p.m. Some bees.

April 22, 23, 1918. Honey bees common on dandelion.

May 6 to 13, 1918. Warm. Bees abundant, some on partly closed flower. Steady and good flow of honey.

November 13, 1918. Bright and sunny. Some bees at work.

May 12, 1919. Day wholly favorable, bright, moderately warm, slight wind. Area 3 by 3 feet, favorably situated. Number of flowers about 600. 7:30 a.m., 4 to 6 bees; 8:30, 6 to 8 bees; 9:30, 6 to 8 bees; 10:30, 6 to 8 bees. The bees one-fourth to one-half minute on a head; probe 12 to 20 florets for nectar. Some bees getting pollen. On other areas, with more wind, fewer bees. (C.M.K.)

May 18, 1919, 10 a.m. Sunshine, somewhat cloudy, high humidity, feeling of rain, warm, south wind. Numerous bees at work, collecting both pollen and nectar. Some small Hymenoptera. More bees on dandelion than in apple.

Newton, May 18, 1920, 7 a.m. Heavy dew. No bees on dandelion.

Ames, April 29, 30, 1920. Cool, raw north wind. Bright. Dandelion in abundant bloom. No bees at work.

May 10, 1920, 9 a.m. Sun after shower. Light southeast breeze. No bees.

A few ants in freshly opened flowers.

May 13, 1920, 11 a.m. Sunshiny, warm. Dandelions opening freely. Bees numerous; five seconds in one flower. One bee visited 20 flowers in two minutes, getting nectar and pollen. The newly opened part of the head most visited. At hive bees coming and going actively, in all directions. (C.M.K.)

May 14, 1920. Morning cool. Few bees. Afternoon warm. Many bees. (C.M.K.)

May 19, 1920, 8:30 a.m. Partly cloudy, warm. Westerly winds. Bees visit six to fourteen flowers in a head. Dandelion at height. Bees actively getting pollen and nectar.

May 24, 1920, 8:30 p.m. On area three by three feet: 65 heads. Bee visits three to five flowers in a head. Time on head two to five seconds.

Kelley, May, 1920, a.m. Clear. Bees abundant, getting nectar and pollen; one-half to three-fourths seconds per flower. Number of flowers visited in a head—10, 15, 25, 49, 67, 87. Number of flowers in a head—197, 250, 193.

Ames, May 4, 1921, 12 m. and 2 p.m. Cool, clear, north wind. A few bees collecting pollen. One second spent in one flower.

May 16, 1921, 8:15 a.m. After heavy rain. A few flowers opening. One bee one to two seconds in a flower.

May 3, 1922, 1 p.m. South wind. Bees fairly common. One second in a flower. Visit flowers in a single head as follows: eleven to fifty-five.

May 10, 1922, 1 p.m. Area 1—One to two seconds in a flower. Fifteen to twenty-five flowers in single head. Area 2—About eighteen flowers visited by one bee in a single head.

May 13, 1923, 4 p.m. Southwest wind. Clear. Flowers open. Bees getting nectar and pollen. Two to four seconds in a flower.

September 28, 1923, 10 a.m., also 2 and 4 p.m. Numerous flowers of dandelion open. A number of bees. Length of visit one to two seconds.

Hamburg, April 27, 1924. Clear. Bees one to two seconds in a flower. A bee visits twelve flowers in a head. Ten bees in one-half minute on a space three feet square.

Ames, April 28, 1924, 9 a.m. Heavy dew on ground. Clear. A few bees. One second in a flower. 2 p.m. Warm, slightly windy, partly cloudy. Some bees.

Ledges, Boone, May 1, 1924, 2 p.m. Bright, clear, fairly warm. Bees one second in a flower.

Ames, May 4, 1924, 10 a.m. Clear, warm, slight breeze. Bees one and two seconds in a flower. A bee fourteen to twenty-six seconds in a head.

May 8, 1924, 10 a.m. Slight north wind. Bees one and two seconds in a flower. A bee visits ten to four flowers. Few bees except in sunny places, where they were abundant.

Jewell Junction, May 16, 1924. Fields yellow with the flowers. The bee one second in a flower.

Ames, May 18, 1924, 12 m. Sunshiny, moderate. Bees one second in a flower.

Kelley, May 23, 1924, 10:45 a.m. Clear, north wind. Within a period of three minutes a single bee visited five heads; number of flowers of head visited by bee four to forty-one.

Le Mars, June 12 and 13, 1924. Bees on the plant getting nectar.

Waterloo, June 12 and 19, 1924. Bees on the flower getting nectar.

Ames, May 30, 1925. Bees few. One second in the flower. Some bumble bees.

October 15, 1925. Bright day. Northwest wind. Several bees at work on the heads.

April 22, 1926, 9 a.m. Cloudy, breezy. Bees fairly numerous. Visit is brief. Two to ten seconds in a head, often less than a second. Bees gathering honey and pollen. One bee visits from two to six flowers in a head. Dry weather. Evidently little nectar in the flowers.

May 8, 1926, 1:30 p.m. No bees. Dry weather influences honey flow.

May 13, 1926, 1 p.m. Cool, humid. Bees one to two seconds in a flower.

May 16, 1926, 11 a.m. Campus. Warm, sultry. Bees abundant. One to two seconds in a flower.

November 6, 1926. Two bees in five heads. One second in a flower.

May 1 to 8, 1927. Warm, west and northwest winds. No bees.

May 9, 1927, 8 a.m. Cool, southeast wind. No bees. 2 p.m. Sunshiny, very windy. A few bees. They visit three to four flowers in a head. Bees one second in a flower.

Lincoln, Nebraska, May 13, 1927, 11 a.m. and 12 m. Three bees on twenty-five heads in five minutes. Bees abundant. One second in a flower. Visited three to thirty flowers in a head.

Ames, May 15, 1927. Many bees. Four to sixteen seconds in a flower.

May 23, 1927, 8 a.m. and 12 m. Sunshiny. Bees fairly common. One second in a flower.

May 30, 1927, 11:30 a.m. Clear, warm. Number of flowers visited in a head 35, 50, 10, 65, 120, 85, 15, 5. Bees abundant. One second in a flower.

June 1, 1927, 1 p.m. Damp, cloudy, cool. A bee visited twenty to twenty-five flowers in a head. Time in flower one second.

June 4, 1927, 10 a.m. Cool. Bees visits 35 flowers in one head. Two bees in ten minutes, or about 40 bees per eight hours. Bees one second in a flower.

June 6, 1927. Sunshiny, cool, north wind. One bee visits ten to twelve flowers. One second to the flower.

June 29, 1927, 11 a.m. Bees fairly common. One second in a flower. Flowers visited in the head—twenty to ten. Bees passed over partly closed heads, going to heads fully open.

July 1, 1927, Campus I.S.C., 9 to 10 a.m. Cool and rainy. Bees working dandelions freely, clover slightly. (C.C.L.)

August 25, 1927, 11 a.m. Bees spend one second in a flower, visiting six to three flowers in a head. Getting nectar and pollen.

October 17, 1927. Bees slow in movements. Spend one to two seconds in a flower.

October 26 to 29, 1927. Clear and warm. Bees abundant. One to two seconds in a flower. Visit three to twelve flowers in a head. None on sweet clover.

Keosauqua, May 6, 1928, 9 a.m. Clear, slight breeze. Bees common. One second in a flower, getting pollen.

Bloomfield, May 7, 1928, 1 p.m. Clear, warm. Bees one second in a flower.

Ames, May 10, 1928, 5:30 p.m. Warm, cloudy. Bees one second in a flower.

Waco, Texas, March 17, 1929. Bees one second in a flower.

Oklahoma City, Oklahoma, March 20, 1929, 3 p.m. One second in a flower.
Ames, May 5, 1929, 2 p.m. Fairly warm. Bees fairly common. One second in a flower.
Mason City, May 11, 1929, 1:30 p.m. Cool, rain the night before. One second in a flower.
Elkhart, May 15, 1929, 12:30 p.m. Partly cloudy. One second in a flower.
May 17, 1929, 11 a.m. Bees abundant. One second in a flower.
Meservey, May 23, 1929, 6:30 p.m. Bees one second in a flower.
May 24, 1929, 6:30 a.m. Cold heavy dew. The heads just spreading. No bees. 8 a.m. No bees. 3:15 p.m. Some bees. One second in a flower.
Sheffield, May 24, 1929, 3 p.m. Only a few bees. One second in a flower.
Ames, June 3, 1929. Warm, sunny. Bees frequent. One second in a flower.
September 26, 1929, 10:30 a.m. Clear and warm. Bees abundant.
Des Moines, October 14, 1929. Clear and warm. Bees one second in a flower.
October 17 to 25, 1926. Bees visiting the flowers.
September 20 and 22, 1930. Some bees gathering nectar.
Cedar Rapids, November 19, 1930. One second.

Taraxacum erythrospermum Andrz. Red-seeded Dandelion

Similar to *T. officinale*. Heads somewhat smaller. Leaves deeply cut. Achene reddish brown in color.

Cosmopolitan weed, less common than *T. officinale*, in various soils. Associated with same plants as preceding.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames (L. H. Pammel, R. I. Cratty), Fort Dodge (O. M. Oleson).

Observed also (L. H. Pammel) at Algona, Cedar Rapids, Clinton, Council Bluffs, Emmetsburg, Estherville, Glenwood, Hamburg, Marshalltown, Muscatine, Storm Lake.

Sonchus (Tourn.) L. Sow Thistle

Annual or perennial; leafy stemmed coarse plants. Mostly smooth. Flowers in corymbs or umbels. Heads many-flowered, yellow. Style covered by brush hairs.

Honey bees have been recorded on several species.

Sonchus oleraceus L. Common Sow Thistle

An annual succulent herb with leafy, smooth stems and pale yellow flowers in corymbose or umbellate clusters; leaves of stem dentate, runcinate-pinnatifid, terminal with a large segment; heads numerous. Blossoms in late summer and fall.

A widely distributed weed in Iowa and the eastern United States.

HONEY BEE VISITS

Honey bees have been reported on this species. However, Knuth does not report honey bees in Germany. Frank Pellett states that the sow thistle is reported as a valuable honey plant in eastern Texas. Richter reports it as yielding nectar in California.

The senior writer has found this species visited by honey bees in Texas and in Florida. A. I. and E. R. Root state that in waste places it yields some nectar.

Sonchus asper L. Sow Thistle

This sow thistle resembles the preceding species except that the stem leaves are less divided and more spiny-toothed and have the auricles of the clasping base rounded; achenes 3-nerved on each side and margined, smooth.

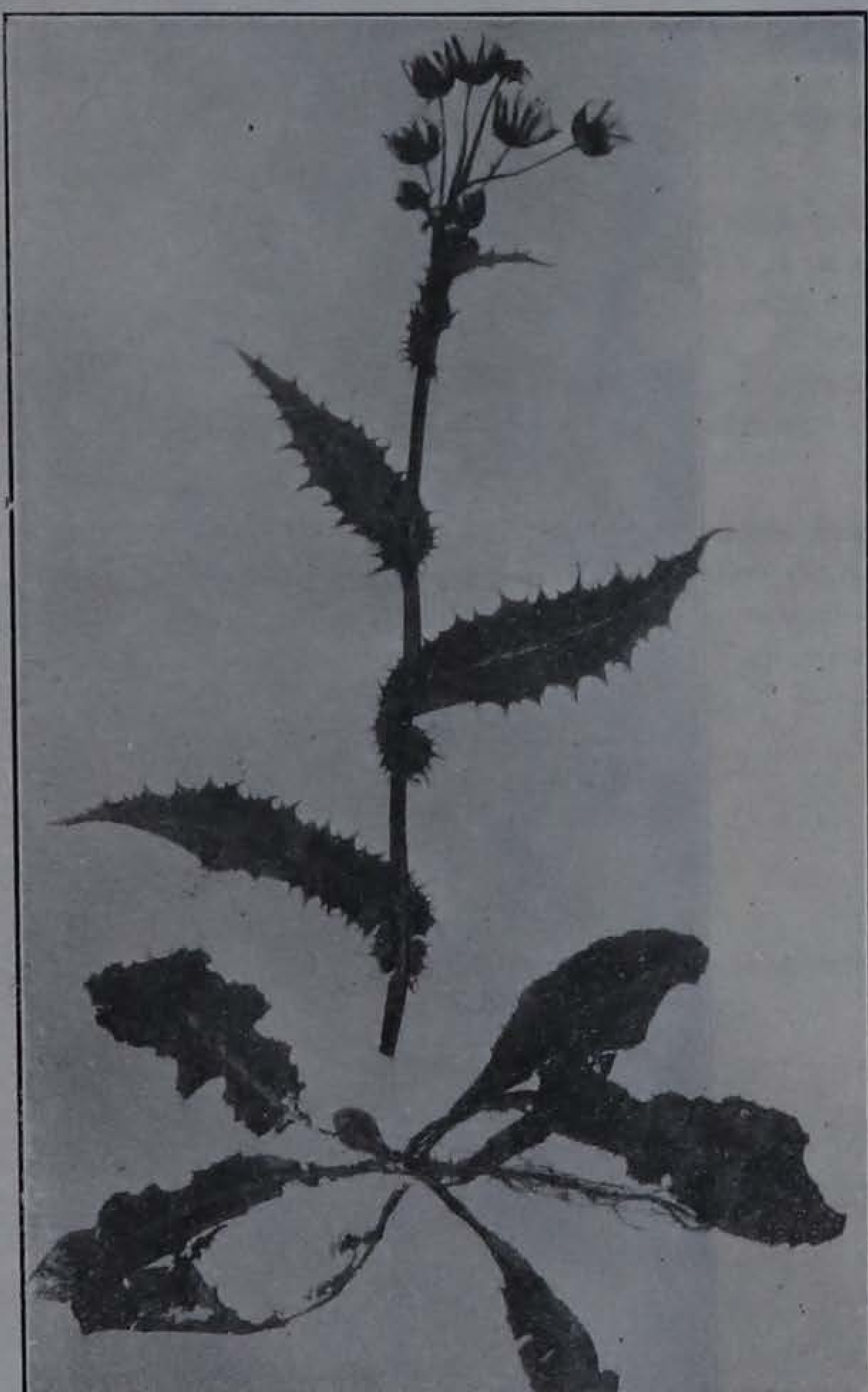

FIG. 434.—Spiny sow thistle (*Sonchus asper*). *Photograph by E. H. Richardson.*

FIG. 435.—Perennial sow thistle (*Sonchus arvensis*). Evening primrose at right. *Photograph by Frykland.*

This weed is widely distributed in the state and may be of some value as a honey plant in some seasons.

Hermann Mueller does not report it nor does Knuth report the honey bee in Germany.

Sonchus arvensis L. Field or Perennial Sow Thistle

A perennial with creeping rootstock and milky juice; leaves runcinate, pinnatifid and spiny-toothed, heart-shaped base; flowers yellow; peduncle and involucre bristly; achenes obcompressed, wrinkled on the ribs.

This weed is becoming spontaneous in many places in the state. We may mention the following places: Algona, Ames, Boone, Mason City, Mitchell county, Postville, Winneshiek county.

It is a widely distributed and very dangerous pest. It is common from Minnesota to the Dakotas, northward and eastward.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Des Moines, Manly, Postville, Waukon (L. H. Pammel); Iowa City (L. H. Pammel, R. F. Adams), Nevada (L. H. Pammel and C. Lounsberry), Ames (E. J. Johnson), Chickasaw county (W. S. Dudgeon), Clarinda, Estherville (B. O. Wolden), Fayette, Marshall county (A. Hayden), Grand Junction (G. H. Tomson) Northwood (W. F. Watkins), Walcott (R. P. Adams).

General distribution in the United States and Canada:

Massachusetts—Plymouth (J. W. Blankinship); Minnesota—Cass Lake (L. H. Pammel), Coleraine (R. I. Cratty), International Falls (H. S. Kellogg); New Brunswick, Canada—Bass river, Kent county; Newfoundland—Conception Bay (G. Fowler, C. D. Howe and W. F. Lang); New York—Geneva (S. A. Beach), Nova Scotia—Purcell's Bay (C. D. Howe and W. F. Lang); Wisconsin—Fond du Lac, Morse Lake (L. H. Pammel).

HONEY BEE VISITS

Gladbrook, July 20, 1929. Bees one second in a flower.

Lactuca (Tourn.) L. Lettuce

Leafy stemmed herbs. Heads few- to several-flowered; variable as to color. Achenes beaked, with capillary pappus.

Flowers variable in color, yellow or blue.

Mulgedium alpinum Less (*Lactuca alpina* Benth. and Hook.)

Knuth records that Hermann Mueller observed honey bees upon *Mulgedium alpinum*.

Lactuca scariola L. Prickly Lettuce

Erect, smooth, green biennial three to five feet tall, stem bristly below. Leaves pinnatifid, tending to turn into a vertical position, with edge up. Midrib bristly beneath. Branches of panicle wide spreading. Flowers small, pale yellow. Roadsides and waste places. New England westward and southward.

Cosmopolitan weed in various soils. Associated with *Chenopodium album, Amaranthus retroflexus.*

This weed is much more common than the variety; formerly the variety was the common type. The senior author has seen prickly lettuce for many years; the plant so common at Madison in 1883, La Crosse, Wisconsin, in 1886, and in Ames and elsewhere in Iowa in 1889 was the variety *integrata.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Harlan (L.H.P.); Ames (Cratty), Colfax (Sipe), Curlew (H. D. Bennett), Fraser (Ivan Henderson, Hayden, Pammel), Jewel (H. M. Hanson), Lee county (W. S. Bell), Sioux City (Mrs. Taylor).

General distribution in the United States:

California—Yuba City (L. H. Pammel); Colorado—Golden (L. H. Pammel); District of Columbia—Washington (Lyster H. Dewey); Illinois—Chicago (L. H. Pammel), Kankakee (R. I. Cratty), Urbana (three specimens, Wm. Trelease and L. H. Pammel); Iowa—Lacey-Keosauqua Park; Michigan—Whitehall (L. H. Pammel); Nebraska—Hastings (L. H. Pammel); Ohio—Gambier (L. H. Pammel); Oklahoma—Muskogee (L. H. Pammel).

HONEY BEE VISITS

Ames, July 14, 1914, all day. Interurban railway. Partly cloudy. Warm. Northeast wind. Butterflies only one per head per minute. But one green bee collecting pollen, one *Syrphus* seen. Flowers close at 11 a.m. (L.A.K.)

July 18, 1914, a.m. Campus. Partly cloudy, still. Many honey bees, several Diptera collecting pollen. Thirty per head per hour. (G.H.M.)

Jordan, August 4, 1914. Clear, south wind. One *Megachile*, one moth, flies; thirty insects per spike per hour. (G.H.M.)

Dillon, September 4, 1914. Clear, southeast wind. Recent rain. In five minutes, one bee, one other Hymenoptera.

Pella, October 11, 1924. Bees abundant.

Webster City, October 17, 1924, 11 a.m. Bees at work. Time in flower one second.

Ames, October 21, 1924, 10 a.m. Bees at work. Time in flowers one second.

Lactuca scariola var. *integrata* Gren. and Godr. Entire-leaved Prickly Lettuce

Similar to the prickly lettuce except that the leaves are oblong, denticulate but not pinnatifid. Midrib either prickly or smoothish. Waste grounds and roadsides across the continent. Westward a bad weed.

Associated with same plants as the preceding but less common now than formerly.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Council Bluffs, Des Moines (two specimens), Eddyville, Gillett Grove, Hancock county, Marshalltown (L. H. Pammel); Ames (two specimens, F. C. Stewart, J. R. Campbell), Eagle Grove (J. H. Buchanan), Lake Okoboji (R. I. Cratty), northeastern Iowa (G. Goddard).

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall), Grand Junction (L. H. Pammel), Greeley (L. H. Pammel, C. P. Johnson, G. M. Lummis, R. E. Buchanan), La Porte (L. H. Pammel and C. P. Johnson); Illinois—Champaign (Bruce Fink), La Salle (L. H. Pammel), Madison (Wm. Trelease); Minnesota—Graceville, St. Paul (L. H. Pammel), Minneapolis (R. I. Cratty); Montana—Billings (two specimens, L. H. Pammel); New York—Geneva, Watkins Glen (L. H. Pammel); Ohio—Gambier (L. H. Pammel), Mansfield (E. Wilkinson); Oregon—Redmore (K. Whited); Pennsylvania—Towanda (L. H. Pammel); Utah—Logan (A. Isabel Mulford); Washington—Seattle (L. H. Pammel); Wisconsin—(four specimens, C. E. Allen), Madison (J. R. Churchill).

This plant at one time was common everywhere in Iowa in waste places and along roadsides.

Lactuca canadensis L. Wild Lettuce

A tall leafy smooth plant with pale leaves having wavy margins, upper leaves entire. Flowers pale yellow.

Prairie and borders of woods, in clay, sandy and gravelly soils. Associated with *Corylus americana, Cirsium discolor, Silene stellata, Zizia aurea, Podophyllum peltatum, Prenanthes alba.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Burlington (two specimens), Farmington, Fraser, Greene, Madison county, Mason City, Ogden (two specimens), Postville (L. H. Pammel); Clear Lake, Emmet county, Forest City (R. I. Cratty), Adel (C. F. Clark), Centerville (C. Deming), Decatur county (J. P. Anderson), Decorah (two specimens, H. Goddard), Des Moines (two specimens, A. L. Bakke, McClure, McKeene, G. W. Carver), Fayette (two specimens, B. Fink), Keokuk (P. H. Rolfs), Ledges (J. V. Ellis).

This plant has also been observed (L. H. Pammel) at Bellevue, Boone, Carroll, Cedar Rapids, Clinton, Cresco, Davenport, Delmar, De Witt, Eldora, Emmetsburg, Estherville, Fairfield, Indianola.

General distribution in the United States:

Colorado—Fort Collins (C. S. Crandall); Louisiana—(T. L. Andrews); Michigan—Whitehall (L. H. Pammel); Minnesota—Black Duck (Mrs. Roy Westley) Cass Lake (L. H. Pammel), Cedar Island (L. H. and H. E. Pammel); Missouri—St. Louis (J. M. Greenman and L. H. Pammel); Nebraska—Halsey

FIG. 436.—Wild lettuce (*Lactuca canadensis*). *Photograph by Photo Section, Ia. Agr. Exp. Sta.*

(J. C. Blumer), Lincoln (R. Gmelin); Oklahoma—Muskogee (L. H. Pammel); Utah—Logan canyon (L. H. Pammel, R. L. Barrett, L. V. Lee, Frank Raney); Wisconsin—Fond du Lac (L. H. Pammel and Elizabeth Waters), Madison (seven specimens, C. E. Allen), Onalaska (L. H. Pammel), Prescott (Mary Edgar).

Honey bees have been observed on this plant in some seasons.

Lactuca ludoviciana (Nutt.) Riddell.

A tall, stout, leafy plant. The lobes of the leaves broad and toothed. Flowers yellow, in panicles, heads larger than in other species.

On prairie, black soils, gravel knolls. Associated with *Solidago missouriensis, Aster laevis, A. azureus, Phlox pilosa, Cirsium Hillii, Panicum virgatum, Andropogon furcatus.*

Honey bees have been observed on this plant and it is probably of some value.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Kelley, Marshalltown, Ogden, Waterville (L. H. Pammel); Armstrong, Dickinson county, Goldfield, West Bend (R. I. Cratty), Ames (Marie Rees, two specimens, W. S. Dudgeon, P. H. Rolfs, S. W. Beyer, F. Rolfs, F. C. Stewart), Des Moines (E. D. McKeene), Fraser (Botanical Seminar), High lake (Wolden), Salem (H. E. Jaques), Slater (C. Reinbott).

This plant has also been observed (L. H. Pammel) at Algona, Boone, Carroll, Cresco, Emmetsburg, Estherville, Forest City, Fort Dodge, Jefferson, Lake Okoboji, Lake View, Lehigh, Mason City, Spirit Lake, Storm Lake.

General distribution in the United States:

Illinois—Pullman (L. H. Pammel); Kansas—Wichita (two specimens, T. L. Andrews); Minnesota—Arnolds Park (L. H. and H. E. Pammel), Graceville (L. H. Pammel), Jackson county (R. I. Cratty); South Dakota—Watertown (L. H. Pammel); Texas—Lake Worth (Albert Ruth); Wisconsin—La Crosse (L. H. Pammel), Madison (C. E. Allen).

Lactuca villosa Jacq. Blue Lettuce

A tall, blue-flowered biennial wild lettuce. Heads many, in a loose panicle, leaves mostly lyrate or runcinate. Achenes thickish, oblong, contracted into a short thick beak. Borders of woods, rich soils, New York westward.

In woods, sandy, black or clay soils in Iowa. Associated with *Eupatorium urticaefolium, Verbesina helianthoides, Helianthus strumosus, Solidago ulmifolia, S. latifolia.*

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Bellevue, Madison county, McGregor (L. H. Pammel); Ames (C. E. Bessey, L. H. Pammel and C. R. Ball), Decatur county (J. P. Anderson), Des Moines (G. W. Carver), Keokuk (L. H. Pammel and Iza Mitchell), Keosauqua (L. H. Pammel and G. B. MacDonald).

This plant has also been observed (L. H. Pammel) at Agency, Albia, Algona, Boone, Clinton, Colfax, Cresco, Davenport, Dubuque, Eldora, Fairfield, Fort Dodge, Harvey, Humboldt, Iowa Falls, Jefferson, Keokuk, Lansing, Marshalltown, McGregor, Moingona, Muscatine, Newton, Osceola, Postville.

General distribution in the United States:

Illinois—Urbana (Wm. Trelease and L. H. Pammel, Wm. Trelease); Louisiana—(two specimens, T. L. Andrews); Missouri—Allenton (two specimens, George W. Letterman), St. Louis (two specimens, J. M. Greenman); Wisconsin—Bridgeport (L. H. Pammel), Prescott (Mary Edgar).

HONEY BEE VISITS

Honey bees have been observed upon this plant.

Lactuca floridana L. Gaertn. Blue Lettuce

A smooth biennial. Leaves lyrate or runcinate, rarely entire, often with clasping base. Flowers blue. Achenes beaked.

Distribution in United States as shown by specimens in the I.S.C. Herbarium:

Florida—Jacksonville (A. H. Curtiss); Texas—Tarrant county (Albert Ruth); Virginia—Alexandria county (Lyster H. Dewey).

HONEY BEE VISITS

"Bees work on it industriously." Bees were observed upon the same plant, same locality, two years previously. Bees also were numerous on this species at McGregor and Ames in 1918. *Lactuca floridana* was a common plant in the woods near Hamilton, Illinois, on September 8, 1918.

This is the best of the honey plants of this genus. It furnishes a constant flow of nectar.

Prenanthes (Vaill) L. Rattlesnake Root

Perennial herbs with upright leafy stems and panicled nodding heads. Involucre calyx-like. Pappus of achenes tawny.

Prenanthes alba L. White Lettuce, Rattlesnake Root

Smooth, glaucous. Stem stout, purplish. Leaves angulate or halberd-form, uppermost undivided. Flowers whitish. Rich woods. Generally distributed.

Distribution in Iowa as shown by specimens in the I.S.C. Herbarium:

Ames, Boone, Edgewood, Hamburg, Lake Mills, Manchester, Mason City, McGregor, Oakland Mills, Strawberry Point, Webster county, Zearing (L. H. Pammel); Ames (J. C. Arthur, F. DeCon, A. Hayden, A. S. Hitchcock), Ames College Park (F. Rolfs), Charles City (C. L. Webster), Chickasaw county (W. D. Spiker), Colfax (S. P. Sipe), Decorah (E. W. D. Holway), Delaware county (I. T. Bode), Des Moines (A. L. Bakke), "East of Kerr's House" (F. C. Stewart), Estherville (B. O. Wolden), Fayette county (B. Fink), Fort Dodge (F. W. Paige), Iowa, northeastern part (H. Goddard), Iowa City (A. S. Hitchcock), Lawler (P. H. Rolfs), Ledges (L. H. Pammel and A. F. Miller, R. E. Buchanan, J. F. Ellis), Marshalltown (F. C. Stewart), Mount Pleasant (H. E. Jaques), Muscatine (F. Reppert), Ogden (W. N. Rosen), Toledo (L. H. Pammel and R. J. Beecraft), Traer (J. W. Provan).

General distribution in the United States:

Illinois—Fountaindale (M. S. Bebb), Ogle county (R. I. Cratty), Peoria (F. E. MacDonald); Michigan—Fayette (J. H. Schuette), Les Cheveaux (E. T. and S. A. Harper); Minnesota—St. Paul, Leech Lake and Walker, Cass Lake, Star Island (L. H. Pammel), Brainerd (E. B. Watson), International Falls (H. S. Kellogg), Rochester (Mrs. George Ainslee), St. Cloud (R. Gmelin); New Jersey—Asbury Park (L. H. Pammel); Ohio—Columbus (H. A. Gleason); Wisconsin—Hudson (L. H. Pammel), Prescott (Mary Edgar).

HONEY BEE VISITS

Jefferson, September 2, 1927. Clear, warm. Flower in bloom three weeks. Bees one to three seconds in a flower. Nine seconds in a head.

TROPAEOLACEAE, Tropaeolum Family

Tropaeolum peregrinum L. Canary-Bird-Flower

A smooth climbing annual; leaves with long petioles, peltate, one to two inches across, roundish in outline, deeply five-lobed. Flowers canary yellow, nearly an inch long, two upper petals large and erect, three lower petals small, and a greenish curved spur, one-fourth inch long. Frequently cultivated in gardens.

HONEY BEE VISITS

Ames, September 15 and 16, 1930, 1 p.m. Honey bees frequent. Three to four seconds in flower.

RANUNCULACEAE

Anemone L. Wind Flower

Anemone japonica Zieb and Zucc. Japanese Anemone

Branching plant, large basal leaves, long stalked, ternately compound. Stems with two-leaved involucres, flowers large, white, rose, reddish or purplish. Blooming in autumn. Cultivated.

BRIEF HISTORY OF STUDIES OF HONEY AND HONEY PLANTS

BY L. H. PAMMEL

There is much literature on honey and honey plants but a complete history of this subject has not been written. A very good historical account is given by F. H. Butler in Encyclopaedia Brittanica. The following is necessarily only a brief account.

Pliny referred to honey in his Natural History of Plants,[1] especially to poisonous honey. In this connection the work of G. Bidie[2] and Moffat[3] may be mentioned. The toxic properties of nectar from a species of the *Euphorbia* are given in several places. Much has been written on poisonous honey. The more important references are given in my Manual of Poisonous Plants.[4] J. D. Hooker[5] has referred to the poisonous honey from Rhododendron.

Honey was much used by the ancients for medicinal purposes, especially new honey, which is a laxative, according to Hindu medical authorities.[6] Aristotle[7] too had great admiration for the honey bee, as had Virgil.[8] Kirby and Spencer[9] in "An Introduction to Entomology" give a very good historical survey. There is, however, little on honey plants. This interesting statement is found in the seventh edition:[10]

"Long before Linné had discovered the nectary of flowers, our industrious creatures had made themselves intimate with every form and variety of them and no botanist, even in this enlightened era of botanical science, can compare with a bee in this respect. The station of these reservoirs, even where the armed sight of science cannot discover it, is in a moment detected by the microscopic eye of this animal."

They cite *Lonicera sempervirens* as an illustration where the bee

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1 21:45.

2 Madras Quart. Jour. Medicine, Sc. Oct., 1861.

3 Miss. Lab. 32, 1849.

4 p. 64.

5 Himalayan Journal, 1:190, 1855.

6 U. C. Dutt, Mat. Med. of the Hindus: 277, 1877.

7 Hist. Animal, LVC. 22.

8 Georgics, LIV.

9 Third edition, 121-170, 1823. 7th edition, 1856, reprint in 1873. The first edition was published in 1815.

10 Introduction to Entomology. p. 383.

cannot get the nectar. The bee avoids the honey of oleander because it is poisonous.

The Koran[11] in a chapter on the bee mentions honey and its sources. There are many references to honey in the Bible,[12] as the references in the book of Exodus,[13] speaking of Palestine, "A land flowing with milk and honey." A. S. Wilson[14] in a study on the nectar of flowers made an estimate of the nectar in clover: 125 heads yield one gram sugar; 7,500,000 flowers produce 2.204 pounds of honey. Christian Conrad Sprengel[15] in a very noteworthy paper published in 1811 makes a plea for the honey bee for the production of seed. A. W. Bennett[16] in his works "How Flowers are Fertilized" states that the perfume of flowers is developed from nectar. This true only in part.

Mr. Henry A. Wallace, in an interesting article on "Where Mendel Lived and Worked, A Visit to the Augustinian Monastery at Brünn,"[16a] notes that the famous geneticist was very much interested in bees.

"Just beyond the orchard and through a gateway was the bee garden, where Mendel kept five or six different species of bees. Bees, in fact, interested him so much that he once traveled four or five hundred miles to attend a German bee convention."

In recent years many books pertaining to honey plants have been published, also many papers have appeared in journals. Thomas G. Newman was formerly the editor and publisher of the American Bee Journal, now edited by the Dadants, Frank C. Pellett and G. H. Cale. These authors have published many papers. This fine Journal contains items on honey plants not only by Dadant and the editors, but also many notes from correspondents. Many years ago the Roots established the Gleanings in Bee Culture now edited by A. I. and E. R. Root. This magazine contains many interesting items on honey plants. The Gleanings in Bee Culture had an interesting history. Prior to 1873 the Roots distributed gratuitously circulars on beekeeping but in this year a quarterly at 25 cents a

11 Sales Koran, Chapter 16.

12 Samuel, 19:25-27. Deuteronomy, 32:13. Matthew, 3:4. Genesis, 43:11. Ezekiel, 27:17. Numbers, 13:27.

13 Exodus, 3:27.

14 Brit. Assn. Rep. 1878, p. 567.

15 Die Nutzlickeit der Bienen und die Notwendigkeit der Bienzucht von einer neuen Seite dargestellt, Berlin 1811.

16 13, 1873.

16a Wallace's Farmer, August 2, 1930—Page 1298 (8).

year was issued called "Gleanings in Bee Culture." This was soon changed to a monthly at 75 cents and in 1876 to 10 copies per year. The Journal has been an important factor in beekeeping.

Another journal, "The Beekeeper's Review," was at one time (1904) edited and published by W. Z. Hutchison of Flint, Michigan. The "Western Honey Bee," edited by Helen Weightman (1928) and S. S. Knabenshue (1929) was published at Los Angeles, California. "The Beekeeper's Item," published by the Texas Beekeepers Association, San Antonio, Texas, with E. G. Stourgeon as editor at one time, is still another journal.

Professor Paddock is issuing the "Iowa Bee Keeper's Bulletin," of which nine volumes have appeared. Many notes will be found on the subject of honey and honey plants. For instance, "Outside Industries Depend on Bees",[17] in which he calls attention to the importance of bees in pollination of flowers, of sweet clover and fruit. This interesting statement occurs in a recent note:[18] "Honey is a natural resource; nature produces it, and unless gathered by the bees, it is wasted."

HONEY BEE TREES

An interesting phase of the subject of honey bees is the bee tree. Bradbury, in his "Travels in the Interior of North America between 1809 and 1811," reports the finding of a bee tree[19] in Missouri, probably western Carroll or eastern Ray county. It was beyond the Osage country in Missouri. This bee tree was found some 275 miles above the mouth of Missouri river and beyond La Grand (Grande) river. This article was reprinted in the American Bee Journal, Volume 70, page 338. In that same connection Bradbury relates an interesting incident in St. Louis. A lady in St. Louis received a present of honey from Kaskaskias and was so delighted with it that having been told that it was produced by a certain kind of flies, she sent a negro to get a pair of flies from Kaskaskias that she might breed them.

The article speaking of the bee trees is as follows: "April 6, 1809. Walked all day, and in the afternoon met the hunters, who had found a bee tree and were returning to the boat for a bucket and a hatchet to cut it down. I accompanied them to the tree. It contained a great number of combs and about three gallons of

17 Iowa Bee Keepers Bulletin, 9, Jan., 1930.

18 Ibid, 9, April, 1930.

19 Reuben Gold Thwaites, Early Western Travels, 1748 to 1846, Vol. 5, p. 57.

honey. The honey-bees have been introduced into this continent from Europe but at what time I have not been able to ascertain. Even if it be admitted that they were brought over soon after the first settlement took place, their increase since appears astonishing, as bees are found in all parts of the United States; and since they had entered upon the fine countries of the Illinois and Upper Louisiana, their progress westward has been surprisingly rapid. It is generally known in Upper Louisiana, that bees had not been found westward of the Mississippi prior to the year 1797. They are now found as high up the Missouri as the Maha nation, having moved westward to the distance of six hundred miles in fourteen years. Their extraordinary progress in these parts is probably owing to a portion of the country being prairie, and yielding therefore a succession of flowers during the whole summer, which is not the case in forests. Bees have spread over this continent in a degree, and with a celerity so nearly corresponding with that of the Anglo-American, that it has given rise to a belief, both amongst the Indian and the Whites, that bees are their precursors, and that to whatever part they go the white people will follow.

"I am of the opinion that they are right, as I think it is impossible to stop the progress of the one as of the other."

The following item is of interest in connection with the honey bee as given by Benjamin F. Gue[20] in his "History of Iowa." Colonel J. W. Johnson established a trading post at Flint Hills near Burlington. He purchased from the Indians on March 28, 1809, bees wax and tallow to the extent of $141.00. This bees wax must have come from bees in bee trees. No doubt honey bees must have become naturalized some time previous.

During the days in which I was interested in bees on the home farm in Wisconsin, A. I. Root of Medina, Ohio, was publishing an interesting volume, The A B C of Bee Culture. The subject matter was arranged alphabetically. This splendid work has passed through many editions. In the 1917 edition E. R. Root says: "Nearly forty years have elapsed since the original edition of this work. Two hundred twelve pages were placed before the public. . . . Beekeeping was hardly known then as a business but now it has grown to enormous proportions." The authors of this work up to this time were A. I. Root, E. R. Root and H. H. Root, with many collaborators like John W. Love, A. Hugh Bryan, John H. Lovell on pollination, Professor Edwin G. Baldwin, Leslie Burr, Dr. C. C. Miller, D. E. F. Phillips, W. K. Morrison, R. E. Snodgrass, Mrs. J. H. Comstock, James A. Nelson. I was also one of the contributors

20 Vol. 1, p. 151.

to the later editions. The 1917 edition as well as subsequent ones were issued under the title "ABC and XYZ of Bee Culture." The work contains many separate articles on different honey plants like white clover, buckwheat, cat's claw, and huajilla, and eight closely printed pages on a list of honey plants.

There are also such foreign publications as the "Victorian Bee Journal" of Melbourne, Australia; the "South African Bee Journal" of Johannesburg, South Africa, started in 1921; "Die Bienen wirtschaftliches Centralblatt," published in Hanover, Germany, since 1864 and at one time edited by G. Lehzen. Many important books and articles in earlier American literature discuss honey plants. I may mention the work of Rev. Mr. Langstroth, whose book was the standard fifty years ago. He mentions many honey plants. Dr. Wilmon Newell[21] in a paper "Practical Information for Beginners in Bee-keeping" discusses briefly the importance of bees in the fertilization of the blossoms of fruit trees and other plants, and notes that bees are never injurious to fruits.

A. J. Cook[22] in the nineteenth edition of "the Beekeeper's Guide, or the Manual of Apiary," refers to honey plants[23] in Chapter 17, where there are many good illustrations. He gives the date of blooming of a large number of plants. There is a most interesting comment on pollination and bees; namely that they are not injurious. The first edition of Cook's work was published in 1876 and was called Manual of the Apiary. It was little more than the notes he gave to his classes in entomology. Two years later another edition was issued and the third and fourth editions followed in rapid succession. In all editions honey plants were mentioned.

In 1853 M. Quinby[24] issued a work on beekeeping which passed through several editions. The first edition was published when he lived at Coxsackie, New York, and later editions were published when he lived in St. Johnsville, New York. The eighth edition, "Mysteries of Beekeeping Explained," was published in 1864. This work contains an account of honey plants. He mentions that the alder is the first plant to furnish pollen, followed by the aspen. There are many interesting botanical items about honey plants, such as the one that "Fruit flowers are important in good weather." He also mentions the singular fatality when the bees visit *Asclepias*

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21 Bull. Texas Agr. Exp. Sta. 142.

22 1-543, f 1-295, George W. York & Co., Chicago, Ill., 1910.

23 389-453.

24 Published in New York by C. M. Saxton, Chapter 4:89-113.

syriaca. He describes in an interesting way the honey which bees found in the galls produced by Aphis on witch hazel. He discusses one of the old superstitions that the honey bee takes away the substance of a crop. "Bees are an advantage to vegetation," he declares.

Thomas G. Newman, editor and publisher of the American Bee Journal, in 1882 published a book, "Bees and Honey." This passed through seven editions, one in 1892. A special chapter is devoted to bee pastures as a necessity. He notes the honey plants of the roadside, trees like the honey locust, tulip, clovers, buckwheat, etc.

A. Gilman in 1929 published a book on Practical Beekeeping in which he refers to honey and has an occasional note on honey plants. An interesting translation by C. P. Dadant of Francis Huber's "New Observations upon Bees," was published in 1926.

The book by Frank C. Pellett, "American Honey Plants, Together With Those Which Are of Special Interest To the Beekeeper As Sources of Pollen," was published by the American Bee Journal in 1928, and is one of the most comprehensive treatises on honey plants published in this country. The book is splendidly illustrated by photographs largely made by the author. Mr. Pellett gives full descriptions of a large number of North American honey plants with notes on honey plants of Hawaii, and brief accounts of honey plants in different states. The common and Latin names of honey plants are given. The book contains a short discussion of honey plant regions. There is a most interesting account also of nectar and a short account of Sprengel's and of Darwin's work on pollination.

Frank C. Pellett, while state bee inspector, issued a series of bulletins on bee keeping. In some of these reference is made to honey plants. Bulletin number 4 is of special value because it lists books on bee-keeping and honey plants. The splendid volume of "Beekeeping," a discussion of the life of the honey bee and of the production of honey, by E. F. Phillips, has a chapter of 38 pages devoted to the sources of nectar and pollen, in which he discusses nectar sources, function of nectar, variation in nectar, variation in secretion, advantages of swamp sources, cultivation of plants for nectar, gathering of pollen, value of bees in cross-pollination. He asks "Do bees puncture ripe fruit? Would this give poisonous honey?" He doubts that the honey from such plants as *Kalmia latifolia, Gelsemium sempervirens, Clethra alnifolia* is poisonous. Plant honey dew and insect honey dew are discussed and an annotated list of honey plants is given chiefly of the United States and a few of tropical regions, namely Hawaii and Porto Rico. In most cases the distribution of the species is given.

Mention should also be made of the following works: J. W. Freiherrn Ehrenfels: "Die Bienenzucht nach Grundsätzen der Theorie und Erfahrung," in which there is an occasional account of honey plants; also the book, "Beekeeping Up-to-date," by W. Herrod Hemsel, in which there are a few notes on nectar; and the French work on "The Natural History of the Bee," by Bazin, translated into English. Then there are some notes on nectar.

On the matter of nectar secretion the following papers are important: One of the earliest notes on nectar will be found in the paper by Malpighi,[25] the Italian anatomist, in 1687. Linnaeus[26] also published a note in 1762. Other papers are by Conrad Sprengel,[27] Bishoff,[28] R. Caspary,[29] A. Brongniart,[30] W. J. Behrens,[31] William Trelease,[32] on "Nectar and Its Use," G. Bonnier[33] on nectaries. One of the latest papers is by William S. Cook[34] on "The Structure of Some Nectar Glands of Iowa Honey Plants."

E. F. Phillips[35] wrote on Beekeeping in the Buckwheat region, F. C. Leighty[36] wrote on the same plant, and E. F. Phillips,[37] in "Beekeeping in the Clover Region," discussed the subject of fertility.

The following authors have made notable contributions: M. B. Waite[38] did some of the early experimental work in this country in connection with the pear; E. S. Goff,[39] worked on the plum; S. A. Beach,[40] worked on the grape; Professor F. A. Waugh,[41] W. A. Luce, O. M. Morris and C. T. Lewis,[42] Roye E. Marshall, Stanley Johnston and H. D. Hootman,[43] on pollination of orchard fruits; Freeman S. Howlett,[44] on "Apple Varieties and Fruit Setting Factors;" Roy Hutson,[45] on pear pollination; Frank Pellett,[46] on cross-pollination of

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25 Anatome Plantarum.

26 Linne Nectaria florum.

27 Das Endeckte der Geheimniss der Natur, 1793.

28 Lehrbuch der Botanik.

29 Die Nectaries. Bonn, 1854.

30 Ann. of Sci. Nat. Bot. Ser. 4. 2:5-23, 1854.

31 Die Nectarien der Blüthen. Flora Neu Ser., 37, 1879.

32 Henry Comstock. Report on Cotton Insects, U. S. Dept. Agr., 1879.

33 Les Nectaries—Ann. der Sci. Nat. Bot. 1879:1.

34 This volume, page 1020.

35 Farmers Bull., U. S. Dep't of Agr., 1216.

36 Farmers Bull., U. S. Dep't of Agr., 1062.

37 Farmers Bull., U. S. Dep't of Agr., 1215.

38 Rep. U. S. Dep't Agr., 1898:167.

39 Rep. Wis. Agrl. Exp. Sta., 1894:3; 1895:300.

40 Bull. Geneva, N. Y., Agrl. Exp. Sta., 157.

41 Vt. Agrl. Exp. Sta. 13:359.

42 Wash. Agrl. Exp. Sta., 223.

43 Oregon Agrl. Exp. Sta., 111. Special Bull., Mich. Agrl. Exp. Sta., 188.

44 Am. Fruit Growers Mag., 1927:7.

45 Journ. Economic Ent., 18:387.

46 Am. Bee Jour., 1929:544.

fruit; Kilty,[47] on renting bees for the orchards; F. B. Paddock,[48] U. P. Hedrick,[49] W. P. Tufts,[50] on the pear; and John H. Lovell,[51] on pollination of the pear. H. D. Hootman and G. H. Cale,[52] in ''Busy Bees Bring Bending Branches'', discuss the subject in a general way and give the literature. Lastly are the two fine contributions by Professor Hedrick[53] on the grape and by N. O. Booth[54] on the potency of pollen grains of different varieties of cultivated grapes. The Booth experiments were among the early ones on the grape in this country.

Joseph Oskamp,[55] of Cornell University, discusses the importance of bees in the orchard, and M. C. Richter[56] in a treatise on the honey plants of California has made a splendid contribution. Many interesting notes are found in this treatise. For instance, speaking of *Eucalyptus phaccafolia* he notes that as many as three bees have been observed to sip nectar from a single blosson at one time. The honey plants are arranged systematically and include some of the cultivated plants. He also gives the distribution of honey plants in different California areas.

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47 Extension Bull., Mich. Agrl. Coll., 56.

48 Iowa Bee Keepers Bulletin, several issues.

49 Plums of New York.

50 Bull. Calif. Agrl. Exp. Sta.

51 Am. Fruit Growers Mag., March, 1929.

52 Am. Bee Jour. Publications.

53 Grapes of New York.

54 Geneva, New York, Agrl. Exp. Sta., 169:224.

55 Cornell Extension Bull., N. Y. State Coll. of Agr., Cornell University, 89.

56 Bull. Agr. Exp. Sta., 217, pages 973-1037.

BRIEF HISTORY OF INVESTIGATIONS OF FLOWER POLLINATION[1]

L. H. PAMMEL

The history of the subject of pollination of flowers is one of great interest. Many authors have taken up the subject. The succinct account by Paul Knuth[2] is a valuable one and we may quote from the English translation of this work by J. R. Davis:

"'Dr. Joseph Gottlieb Kölreuter[3] was the first to make observations on flower pollination and to expressly point out the fact that the visits of insects are necessary for the pollination of flowers. In his work 'Vorläufige Nachricht von einigen das Geschlecht der Pflanzen betreffenden Versuchen und Beobachtungen,'[4] with continuation (1763), second continuation (1764), and third continuation (1766), he communicates the results of numerous hybridization experiments, and in connection with these gives his observations on the pollination of flowers by the agency of insects. The first sentences on this subject occur on page 21, followed by subsequent text of the 'Preliminary Notes.' "

Knuth quotes this historical and significant statement from Kölreuter: "Experience has taught me that this, which has long been asserted concerning the fig-tree, is true of many other plants, some of them very common. In all cucumber plants (Cucurbitaceae), in all sword-lilies (Iridaceae), and in not a few plants of the mallow order (Malvaceae), pollination of the female flowers and stigmas is effected only by insects. I was amazed when I made this discovery in one of those plants for the first time, and saw that Nature had left so important a matter as reproduction to a mere chance, to a fortunate accident. My amazement was gradually converted, however, after prolonged observation, to admiration of the means, at first sight casual, but in fact most sure, which the wise Creator employs to secure reproduction. It is true that every movement of these small insect servants of Nature makes it quite evident that when they visit flowers, they have not the intention of discharging an office so important. But what does that matter? It is enough that they, without themselves knowing it, undertake most important work for themselves

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1 A full account of the historical development of flower pollination is given by E. Loew in his excellent work "Einführung in die Blütenbiologie auf historischer Grundlage." (Berlin, 1895, 8vo, 432 and xii pp.)

2 Handbook of Flower Pollination based upon Hermann Mueller's work. The Fertilization of Flowers by Insects, Vol. 1, p. 1.

3 According to Sach's 'History of Botany', Engl. Ed., p. 406, note: Kölreuter was born at Sulz on the Neckar and died in 1806 as Professor of Natural History in Karlsruhe, where he had been also superintendent of the Botanic and Royal Gardens from 1768 to 1786. There he began his investigations, which were subsequently continued in his own small garden, after he had given up his post on account of the opposition of the gardeners.

4 This work has been republished by W. Pfeffer. It appeared in Ostwald's "Klassiker der exakten Naturwissenschaften", XLI (Leipzig, 1893).

and for the plants. Their needed sustenance, little drops of sweet nectar, is hidden away down in these flowers. It costs them some trouble and labour to collect it; and during their manifold movements it comes about that they gather pollen in great quantity among the hairs of their body, to which it readily adheres, and rub it off again on the stigmas. As the surface of these is covered with innumerable warts, tubes, or spines, and smeared with an oily moisture, the pollen adheres more readily than to other parts of the flower. The insects, moreover, put pollen on the stigmas in a quantity far exceeding what is sufficient for complete fertilization; and this they do in so many flowers that Nature perfectly achieves her purpose. It will now be understood how it happens that cucumbers and melons will not prosper in hot-beds that are too well covered in. Until now, pollination of the female flowers has been ascribed to the wind, but other views would necessarily have prevailed if only close attention had been paid to the relative positions of the male and female flowers, to their forms, and to the character of the pollen. And how can one do this without at once recognizing in these busy insects the true agents of pollination? Certainly any one who had made these observations before me would have discovered this, and would have cleared up for himself and for all other naturalists this secret of Nature. Whoever will convince himself of the truth of what I have here maintained with all caution, should give close attention throughout a whole day in still, clear, and warm weather (for then pollination is most commonly effected) to all that happens to one of the plants in question. He will then see that all manner of insects gradually assemble among the flowers, after these begin to open, that they will wander about in them, and pass over from one to another. He will see that one after the other in the course of its manifold movements and turnings, gathers, on the hairy parts of its body, sometimes more, sometimes less of the pollen hanging on the stamens of a male flower, and soon thereafter either passes into another flower of the same kind, or goes into a female flower. In this latter case let him not disturb the insect, but await its voluntary departure, watching meanwhile at some distance all its movements. When it has gone, he should examine with a lens of low power the inner surface of the flower on all sides; and then pollen belonging to the same plant, and of which previously there was not a trace, will be found here and there adhering to the hairs of the flower, and especially to the stigma, which previously was quite free from it. This drama may often be seen re-enacted in the same blossom, so that the stigma, about the time when the flower begins to close, will be almost completely covered with pollen. Occasionally, one may notice with satisfaction how a few of the insects roll about in the pollen, how they cover their whole body with it, and how, in this new golden costume they carry the fertilizing material in bulk to the female flowers!"

We are indebted to Christian C. Sprengel for having clearly laid down the principles of pollination and the theories connected with flowers. His book "Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen" contains in detail the floral adaptations of nearly five hundred species of plants. Knuth comments as follows: "Many of these are described in great detail, and with such accuracy that hardly anything can now be added, except information as to the visitors, with their scientific names; for Sprengel was an excellent botanist, but knew little about insects."

Sprengel laid down the following propositions in regard to flowers pollinated by insects. Flowers are pollinated by some one species of insect or by several species. Insects in approaching the honey brush pollen from the anthers with various parts of their bodies and convey it to the stigma. He noted in his studies (1) a nectar gland, (2) a nectar receptacle, (3) a shelter to protect the nectar, (4) a contrivance to enable the insect to find the nectar, the pathfinders, (5) the impossibility of self-fertilization.

In the introduction to this work of Sprengel's is this remarkable statement, using the translation in Knuth's Handbook of Flower Pollination: "In the summer of 1787, while I carefully watched the flower of the wild geranium (*Geranium sylvaticum*), I found that the bases of its petals were provided on the inner side and on both edges with fine soft hairs. Convinced that the wise Creator of Nature has brought forth not even a single hair without some particular design, I considered what purpose these hairs might serve. And here it occurred to me that if one starts with the supposition that the five drops of nectar, which are secreted from as many glands, are destined for the nourishment of certain insects, one must at the same time find it not improbable that there should be some provision for preventing this nectar from being spoiled by rain, and that these hairs may have been placed here for the attainment of this purpose. . . . . . . In the following summer I investigated the forget-me-not (*Myosotis palustris*). I found not only that this flower has nectar, but also that the nectar is completely protected against rain. At the same time, however, I was struck by the yellow ring which surrounds the opening of the corolla tube, and which is so beautifully conspicuous against the sky-blue colour of the limb. Might not, I thought, this circumstance also have some reference to insects? Might not Nature have specially coloured this ring, to the end that it might show insects the way to the nectar reservoir? With this hypothesis in view, I examined other flowers, and found that most of them confirmed it. For I saw that flowers, in which part of the corolla is differently coloured from the rest, always have spots, figures, lines, or dots of peculiar hue just where the entrance to the nectar reservoir is situated. I now inferred from the part to the whole. If, thought I, the corolla is coloured at one particular part specially for insects, then the whole colouring is for the benefit of insects; and if the particular colour or one part of a flower serves to enable an insect which has settled on the flower easily to find the right way to the nectar, then the general colour of the corolla is serviceable in rendering the flowers provided with it conspicuous even from afar to the eyes of insects that hover around in the air, in search of food."

Some of the other discoveries made by Sprengel are as follows:

In 1791 he noted the difference in time of maturing of stamens and pistils in our common fireweed (*Epilobium angustifolium*), that is to say that the stamens and pistils do not mature at the same time, hence self-fertilization is excluded. In 1789 the discovery with reference to orchids and iris was made. He concluded they were pollinated only by long tongued insects and he described accurately how the insect takes the nectar out of the flower of certain species of orchids. It so happened that in some plants there was no nectar but the odor attracted insects and the pollinia were withdrawn when the insect left the flower. We are indebted to Sprengel for the discovery of the presence of the nectary, and why it occurs in flowers. Quoting from the English translation we take the following:

"Parts that enable insects readily to find the nectar: Corolla, Odour, Nectar Guides. Nature has taken care that insects may recognize flowers even from afar, either by sight or by smell, or by both senses together. All nectar flowers are adorned with a corolla, and very many give forth an odour, which, as a rule, is pleasant to mankind, although frequently it is unpleasant, and occasionally intolerable; but it is always agreeable to the insects for which the nectar is destined. The corolla is, except in a very few species, coloured, i.e. other than green, so that it is conspicuous against the green colour of the plants. Sometimes the calyx also is coloured, and when the corolla is developed, the calyx may be different from it, or if it makes one whole with this, it is similarly coloured on the inner side. But if the corolla is absent, then the calyx takes its place. . . . If now an insect, attracted by the beauty of the corolla, or by an agreeable odour, has gone to a flower, it will either forthwith perceive the nectar, or, if this is in a concealed place, will not perceive it. In the latter case Nature comes to the rescue with the nectar guide. This consists of one or several spots, lines, dots, or markings of another colour than that of the corolla as a whole, and consequently conspicuous against its lighter or darker tint. It is always placed just where the insects must creep in if they are to reach the nectar.

"In connection with the nectar guide I must refer to the difference in nectar flowers with regard to the time of day at which they open. As there are insects that move about only in the daytime, so there are day flowers and night flowers. The day flowers burst forth into bloom in the morning. Many of them close in the evening, or incline downwards, while they stand erect by day. The day flowers are adorned with nectar marks, though not in all cases. The night flowers blossom in the evening. In the daytime most of them are closed or limp and inconspicuous, from which it is clear that they are not destined for day insects. The night flowers have a large and bright-coloured corolla, so that they are conspicuous to the eyes of insects in the darkness of the night. If their corolla is inconspicuous, the defect is made good by a powerful odour. No nectar guides occur in them; for if the white corolla of a night flower had a nectar guide of another, but still light tint, this would not be conspicuous against the colour of the corolla in the darkness of the night, and so would be useless; while if it had a dark-coloured nectar guide, this would be inconspicuous, and therefore would be as useless as the other.

DICHOGAMY

"All these arrangements are in the first place and immediately for the benefit of insects, but through these also for the flowers themselves; and their final purpose is that the flowers may be pollinated by insects. . . . There is undeniable evidence of the pollination of flowers by insects in the arrangement discovered by me in very many hermaphrodite flowers, which secures that no individual may be fertilized by its own pollen, but only by pollen from another individual. . . This arrangement I call the development of sexual parts (anther and stigma) at different times, or shortly, dichogamy. It consists in this: After the flower has opened, the filaments have or assume, either all together or one after the other, a definite position, in which their anthers open, and their pollen is available for pollination. . . . . .

"As there are two kinds of dichogamy, they must be distinguished from one another by different names. The first discovered I call the male-female (we now say proterandrous), and the later discovered the female-male (proterogynous) dichogamy (*dichogamia androgyna, dichogamia gynandra*). The opposite of dichogamy is called homogamy.

"In contrast to nectar flowers, which are pollinated by the agency of insects, are flowers pollinated 'in a mechanical way by the wind.' These, the wind flowers, as we now call them, produce a much greater quantity of pollen than the insect flowers."

Sprengel did not carry the subject far enough to get the full significance of cross-pollination of plants but he makes this very pertinent statement: "As very many flowers are of separate sexes, and probably quite as many of the hermaphrodite ones are dichogamous, *it seems that Nature is unwilling that any flower should be fertilized by its own pollen.*"

Sprengel was born in 1750 and died in 1816 in poor circumstances. It is said that his publisher did not even furnish him with a complimentary copy of his published book. Owing to the poor reception of the book his second part was not published, and in the later years of his life he devoted his attention to languages. Sprengel was born at Brandenburg, and was the son of a clergyman.

Earlier than this Kölreuter saw the necessity of insect visitors to some flowers. This German was the oldest son of a pharmacist in Sulz, was born on the 27th of April, 1733, and died November 11, 1806, in Karlsruhe. His earliest hybrid experiments were made in 1759 while he was an adjunct to the Academy of Sciences in St. Petersburg. Later he became professor and director of the public gardens in Karlsruhe.

In 1799 Andrew Knight after some experiments in cross-fertilization and self-fertilization of the pea, arrived at the important conclusion that in no plant does self-fertilization occur in an unlimited number of generations. It is not enough to merely mention the name of Andrew Knight, who was born in England in 1759 and died in 1838. Mr. Knight's greatest achievements were accomplished along ecological lines. Knight was a real experimenter. He was convinced that all varieties are less productive during later periods of their existence. Knight was the first experimenter to undertake the improvements of plants by means of cross-fertilization.

Van Mons was another early apostle of improving fruits and plants. He was born in Brussels in 1765 and died in 1842. Van Mons, though educated as a pharmacist, became professor of physics and chemistry, receiving the degree of Doctor of Medicine in 1800 from a French university. He was one of the first to propound a theory of the philosophy of the origin of varieties of cultivated plants. The principal facts of his theory are briefly told by Professor Bailey in his book, "The Survival of the Unlike."

W. Herbert in 1837 stated that he had observed beneficial results in cross-fertilization. Herbert was born January 12, 1778, and died May 28, 1847. Gaertner in 1844 published two extensive treatises on the subject of pollination and hybridization. He was led to the same conclusions as Herbert in his experiments with the Lobelia, Passiflora and Fuchsia.

The brilliant observations of Sprengel were probably not generally known until Charles Darwin saw the full import of his work on the pollination of flowers. Hermann Mueller, one of the most celebrated of German ecologists says:

"The charm that kept Sprengel's theories inoperative was broken only when, in the next year (1859), Darwin produced his 'Origin of Species,' and in it emphasized Knight's law as a general law of nature, placing it on broader and surer foundation and uniting it ultimately with his theory of natural selection."

Darwin, the greatest naturalist of the last century, added much to our knowledge of the relations of flowers to their insect visitors, and in 1862 published his first work "On the Fertilization of Orchids," which has become classical. It gave an impetus to the study that has continued to the present time. Many of Darwin's most important investigations were first published as papers and later republished in books in which the subject is treated exhaustively. His books are models of scientific treatment of the subject. The student should consult "Different Forms of Flowers of the Same Species," "Cross- and Self-Fertilization in the Vegetable Kingdom," "Variations of Animals and Plants under Domestication." The first observations made by Darwin on certain Papilionaceae (1858) proved that insects were essential in pollination. He used a net to cover up the flowers and thus prevented the formation of seeds or at least they were not as vigorous as when cross-fertilization was brought about. The most classical of his works is on "Various Contrivances by which English and Foreign Orchids are Fertilized by Insects." 1877.

In addition to his work dealing with plants Darwin published important memoirs on zoology and geology. He was born on February 12, 1802, at Shrewsbury and died April 19, 1882. "The Life and Letters of Charles Darwin," including an autobiographical chapter, edited by his son, Francis Darwin, should be read in this connection.

The brilliant researches on heterostyled plants led many other investigators to take up the subject. Among these we may mention Hermann Mueller, Delpino, Hildebrand, Fritz Mueller and many other European investigators.

The most important contributions were made by the German biologist, Hermann Mueller, who was born September 22, 1829, and died August 25, 1884, in Lippstadt. His earliest paper was on orchids, in 1868, but his great work, "Die Befruchtung der Blumen durch Insekten," was published in 1873 and was translated into English, "The Fertilization of Flowers," by D'Arcy W. Thompson in 1883. This was followed by many other papers, and a second classic published by him was on "Die Alpenblumen, ihre Befruchtung durch Insekten an dieselben," issued in 1881. Both works record a large number of facts on the relations existing between flowers and insects.

Hildebrand, another German naturalist, published many original observations, especially on trimorphic and dimorphic flowers. In 1867 he published a work of much merit on "Geschlechter Vertheilung bei den Pflanzen" in which a classification was proposed to show how self-fertilization is excluded in many plants.

There was much opposition among scientists to the theory of Charles Darwin on pollination of flowers. Men like L. C. Treviranus and H. V. Mohl criticized the work of Darwin especially in regard to heterostyly, but numerous defenders came to support the theories of Darwin, Sprengel and Knight. Among these was the botanist, Fritz Mueller, who was a correspondent of the great Englishman and who in 1866 published some valuable papers on the subject of pollination, especially some concerning humming birds.

Fritz Mueller lived in Blumenau in the province of Santa Cathrina, Brazil, and in spite of many troubles did splendid work. A brother of Fritz Mueller, Hermann, was perhaps the most brilliant student in the subject of pollination of flowers in Germany.

Knuth in his handbook takes this statement from Mueller: ''Whenever progeny resulting from crossing comes into serious conflict with the offspring resulting from self-fertilization, the former is victorious. Only where there is no such struggle for existence can self-fertilization often prove satisfactory for many generations.''

That direct and indirect proofs attest the correctness of this great law of life has already been stated. They are given as follows by Hermann Mueller (in 'Alpenblumen,' pp. 474-475): ''In the flowers investigated in this connection, it appeared, as first shown at any length in 'Die Befruchtung der Blumen durch Insekten,' to be a general rule, offering only a few easily explained exceptions, that flowers to which insect visits are constant and sufficient, are adapted exclusively for crossing by the insects, and that, on the contrary, in porportion as insect visits are uncertain, the floral arrangements permit or favour spontaneous self-fertilization. It appears from the direct experiments of Darwin, as well as from the pollination arrangements of flowers considered in relation to actual insect visits, that crossing is absolutely the more advantageous mode of fertilization.''

The work that had the greatest influence on Mueller was Darwin's ''Origin of Species'' and ''Handbook of Fertilization of Orchids.'' Knuth in his Handbook makes this statement: ''Hermann Mueller made an amazingly large amount of observations from many hundreds of plants and large numbers of insects. After these many studies he made this very significant statement: 'If, on the one hand, the experimental method has the advantage of being directly demonstrative, there is, on the other hand, a much larger amount of indirect evidence adducible from the arrangement for pollination. It is, perhaps, hardly more difficult to obtain indirect evidence from a few hundred flowers than to make direct experiments on a few. If by itself, such evidence would scarcely satisfy us, yet it brings complete conviction when considered along with the results of the Darwinian experiments, and takes us even a step farther than those experiments. From Darwin's experiments, which lasted eleven years, it is not proved, and perhaps it would not be proved if the experiments lasted a hundred years, whether the capacity of certain flowers to reproduce by spontaneous self-pollination is limited or unlimited. From the floral arrangements, on the other hand, we can conclude that this capacity must have its limit. For, were it unlimited cleistogamous flowers would be the most advantageous, and many plants would necessarily have come to possess such flowers only. As a matter of fact, however, not a single plant is known which reproduces itself exclusively by spontaneous self-fertilization. The investigation of pollination arrangements in connection with actual insect-visits therefore furnishes evidence that is very convincing, even though of secondary nature. It continues a no less essential support of the floral theory than the experimental proof that, as a matter of fact, more vigorous offspring result from crossing than from self-fertilization.'

"Hermann Mueller's works stimulated many botanists in the most marked way, and a vigour never before manifest became apparent in the field of flower pollination. In addition to the older specialists, Darwin, Delpino, Hildebrand, Hermann Mueller, and his brother, who was no less enthusiastic for his science, a number of younger investigators began to apply themselves to this branch, so that a division of labor resulted, and the investigations undertaken in various districts were directed partly to the extension of the various sections of flower pollination, partly to an investigation of floral arrangements and the discovering of the visitors of flowers. Our knowledge of nectaries was extended in Germany by the works of W. J. Behrens; in France by Gaston Bonnier; in North America by Trelease (all 1879). Investigations on stamens were published by Chatin (France), Askenasy, H. Fischer, Oetker (Germany), Bennett (England); on stigmas by J. Reinke, Behrens (Germany), Capus (France); in the processes of fertilization by Dalmer, Strasburger, Elfving, Treub, Goroschankin, Guignard; on the distribution of sexes by Asa Gray, E. Warming, Hackel, Breitenbach, Magnus, Potonie, Errera and Gevaert, F. Ludwig, Solms-Laubach; on heterostyly by Breitenbach, Kny, Kohne, W. Burck, Urban, Bailey, Clarke, Meehan, Ernst, Bessey, Battandier, Todd, Knoblauch, Pirotta, Wilson; on cleistogamy by Ascherson, Potonie, Batalin, Ludwig, Trelease, Heckel, Pringle, Asa Gray, Godron, Hackel, Meehan, Coulter, Graebner, Schroter, Battandier, G. M. Thompson, Grisebach, Drude, Kearney, Kohne, Solms-Laubach, Burck; on pseudo- and hemi-cleistogamy by Fitzgerald, Moore, Reichenbach fil., Freyhold, Eggers, Henslow, Meehan, Coulter, Bush, Battandier, Errera and Gevaert; on self-sterility by Gentry, Warming, Meehan, Delpino, Ludwig, Schneck, Rimpaus, Liebenberg, Hoffmann, Neubert, Focke, Eggers, Hunger, Battandier; on self-fertility by Pedicino, Comes, Meehan, Caruel, Wilson, Henslow, Asa Gray, Delpino, Ludwig, Hoffmann; on the relations between crossing and self-fertiliaztion by Henslow, Meehan, Pedicino, Caruel, Comes. Cultivation and pollination researches were carried out by Hoffmann, Wilson, Rimpau, Liebenberg, Beal, Vilmorin, Ottavi, and Horvath."

Delpino, an Italian naturalist, was the great exponent of the Darwinian theory in Italy and the author of several books and many papers on the subject. The "Ulteriori Osservazioni sulla Dicogamia nel Regno Vegetale" is the Italian classic on this subject.

Severin Axell, a Swedish botanist, published his "Om Anordningarna for Fanerogama Vaexternas Befrukting" in 1860. The work contains an excellent summary of the subject up to that time, but adds many original investigations. As Hermann Mueller says:

"Now Axell justly showed that this conception entertained by Hildebrand and Delpino was unfounded, for he brought forward in opposition to it the facts that in many flowers self-fertilization results in the production of good seed. By this explanation Axell rectified the conception that was so distinctly uttered by Hildebrand and Delpino in their earlier writings, viz., that cross-fertilization is advantageous and is better than self-fertilization and consequent sterility; and he also removed by his elucidation of cleistogamic flowers one great objection to the Knight Darwin law—the argument which was used by H. von Mohl."

Axell was born on October 22, 1843, but did not continue his researches for any length of time. He died January 1, 1872.

One of the more recent European writers, Kerner von Marilaun made some valuable contributions in his "Pflanzenleben." He deals not only with the ecology of flowers but with a large number of other ecological subjects. The English translation, "The Natural History of Plants," by Oliver is the best modern popular botany on the subject of plants. Anton Kerner must be regarded as one of the great modern biologists. On the subject of pollination he published in German "Flowers and Their Unbidden Guests," which though a popular treatise is correct from a scientific standpoint.

Dr. F. Ludwig of Greiz, Germany, also has published many important contributions, as has Sir John Lubbock. Lubbock's work on "British Wild Flowers in Relation to Insects" is well known to ecological students. Jules MacLeod, a Belgian scientist, has made several important contributions.

Subsequently Knuth[5] published that masterly work, "Handbook of Flower Pollination" based upon Hermann Mueller's work "Fertilization of Flowers by Insects" and upon the work of many other writers like Ludwig, Delpino, Trelease, Gray, Fritz Mueller, and others. The English translation is by J. R. A. Davis. This is a three volume work in which there is a splendid summary of the subject of flower pollination.

The book by E. Loew on the "Flower Biology of Northern Europe and Greenland" is a most interesting work and summarizes in the briefest possible way all the researches in flower pollination published between 1884 and 1894, in both English and German, and

5 Handbuch der Bluethenbiologie unter zurgrundlegung von Hermann Mueller's Werk Die Befruchtung der Blumen durch Insekten, 1; 382 pp.; 2, 705 pp.; 3, 644 pp. Leipzig, 1898-1899.

as Knuth says, forms a supplement to the pioneer work of Hermann Mueller and other works published in Europe.

In this country there have been quite a number of workers. Standing foremost as pioneer investigators along these lines, Drs. Asa Gray, Charles Robertson and Wm. Trelease should be mentioned. Reference to the life of Doctor Gray will not be out of place in this connection, especially so since a younger generation of botanists does not give him the place in American botany he so richly deserves.

Dr. Asa Gray was of Scotch-Irish descent and was born on November 10, 1819, in Sanquoit Valley in the township of Paris, Oneida county, New York.

Professor C. S. Sargent in commenting on Doctor Gray, says: "Since Linnaeus, a few men have appeared at different times and in different countries, masters of science, who have shaped its development and impressed their genius upon the intellectual movement of their age." The list is not a long one: Bernard and Laurent de Jussieu in France, August Pyrame DeCandolle and Alphonse DeCandolle in Switzerland, Robert Brown and George Bentham in England. "In intellectual grasp, in astuteness and judgment, in philosophical breadth of view, in the amount and quality of the work he has accomplished and the influence he has exercised, the American botanist is not surpassed by any of the men whose names are here associated together."

To get an idea of the scope and breadth of Dr. Gray's work "The Scientific Papers of Asa Gray" selected by Charles Sprague Sargent should be consulted. Doctor Gray's terse accounts and his popularization of botany have done much to diffuse knowledge on this subject. Most of his earlier articles were published in the American Journal of Science. In his little book, "How Plants Behave," published in 1872, much was done to bring this matter before the younger people.

Dr. William Trelease, formerly the Director of the Missouri Botanical Garden and later Professor of Botany Emeritus, University of Illinois, is the author of several important papers. Mention may be made of his papers on the pollination of Yucca, "Nectar, What It is and Some of Its Uses," "The Heterogamy of *Oxalis violacea*." Another pioneer investigator is J. E. Todd, whose papers were published chiefly in the American Naturalist from 1879 to 1882. Dr. C. E. Bessey published an excellent paper "On the Supposed Dimorphism of *Lithospermum longiflorum*." Thomas Meehan, the well known horticulturist, also published many notes on the pollination of flowers. The name of Dr. C. V. Riley, the well known economic entomologist, should always be connected with the adaptations to secure cross-pollination in Yucca. August F. Foerste of Ohio, a close student of flowers, published a number of papers about a decade ago. Dr. W. J. Beal of Michigan contributed many notes on the pollination of flowers, as "The Agency of Insects in Fertilization," and "Fertilization of Flowers by Humming-Birds." Dr. Clarence M. Weed is the author of a small and attractive volume, "Ten New England Blossoms." Hamilton Gibson, the author of "Sharp Eyes," carried this fascinating subject to the homes of thousands of Americans, not only because of the artistic drawings that embellish the work but by his excellent account. The greatest worker in America, who has done a great deal of scientific labor in this field, is Charles Robertson of Carlinsville, Illinois. His work is comparable to that done by Hermann Mueller in Europe and he has done it in such a thorough way that the field in which he worked has practically been covered. Many of his papers were published by the St. Louis Academy of Science and the Botanical Gazette. In a recent book on the subject of Flowers and Insects he gives us an interesting survey of the subject.

Knuth[6] refers the literature in a general way as follows:

1. Alps of Mid-Europe: v. Dalla Torre, Hoffer, and Kerner (Tyrol); A. Schulz (neighborhood of Bozen); MacLeod (Maritime Alps); Calloni, Chodat, Christ, Frey, Frey-Gessner, Kirchner, Loew, Schroeter (Switzerland); Hoffer (Steiermark).
2. Austria-Hungary (excluding 1): Borbas, Burgerstein, Freyn, Gelmi, Hackel, Hansgirg, Kerner, Kronfeld, Rathay, Schilberszky, Velenovsky, v. Wettstein, Wiesner, Willkomm.
3. South and Mid-Germany: Correns, Haussknecht, Kraus, Loew, Ludwig, Schenck, A. Schulz, Thomas.
4. North Germany: Alfken, Ascherson, Buchenau, Engler, Focke, Koehne, Loew, Magnus, Potonie, Ule, Urban, Warnstorf.
5. Denmark: Kjaerskou, Lund, Raunkjaer, Warming.
6. Scandinavia: Almquist, Forsberg, Lagerheim, Lindman, Ljungstroem, Wittrock.
7. Russia: Batalin, Beketow, Borodin, Maximowicz.
8. Holland and Belgium: Giltay, Heinsius, de Vries, Vuyck.
9. British Isles: Archer-Briggs, Belt, A. W. Bennett, G. Bentham, Boulger, J. Britten, Burton, Christy, Cockerell, Comber, Dickie, Douglas, Duncan, Dyer, Evans, Farrer, Forbes, Fulton, Green, Hart, Henslow, J. D. Hooker, Keeble, Kitchener, John Lubbock, Marshall, Moggridge, S. Moore, Myers, Ogle, Powell, Ridley, W. S. Smith, Wetterhan, C. F. White, Whitelegge, Williams, Wilson, and others.

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6 Handbook, 1:26.

10. France: Baillon, G. Bonnier, Clavaud, Crie, Duval-Jouve, Giard, Godron, Guignard, Magnin, Maury, Roze.

11. Switzerland: Dodel-Port.

12. Italy: Arcangeli, Baroni, Beccari, Bonis, Buscalioni, Cobelli, Comes, Gibelli, Macchiati, Martelli, Mattei, Mori, Nicotra, Ottavi, Pasquale, Pedicino, Pirotta, Ricasoli, Ricca, Savastano.

13. North America: Bailey, Barnes, Beach, W. J. Beal, Bessey, Bush, Courtis, Ellacombe, G. Engelmann, Foerste, Gentry, Greene, Halsted, Leggett, Martindale, Meehan, Pammel, Patton, Potts, Pringle, Redfield, C. V. Riley, Rusby, J. C. Russell, Schneck, C. J. Sprague, Todd, Trelease, F. Ward, Webber, C. Wright, and others.

14. Tropical Regions: Balfour, Barber, Bossier, Evans, Faivre, Fitzgerald, Forbes, Gibbons, Greenleaf, Hartog, Haviland, Heckel, Hieronymous, Hunt, Irwin, Kellermann, Lynch, Moore, Murray, Nicholson, Parish, Rusby, W. G. Smith, Syme, Troop, E. Ule, F. Ward, Mansel Weale, Wright and others.

Methods of pollination in cucurbits are fully described by Pammel and Beach[7] in the case of *Cucurbita maxima, C. pepo, Citrullus vulgaris, Cucumis melo, C. sativus, Lagenaria vulgaris.* Since the flowers are monoecious it is absolutely necessary that the pollen be conveyed by insects and probably in most cases cross-fertilization results as the pollen comes from another plant.

Knuth in his Handbook[8] quotes from Arcangeli the following list: *Cucurbita maxima, C. pepo, Lagenaria vulgaris, Cucumis melo, Benincasa, Ecballion, Momordica,* and *Trichosanthes*; in which bees are active pollinators. Nothing, however, is said concerning cross-pollination. Among later investigations on the subject of pollination of Cucurbitaceae is the paper by E. F. Castetter on the crossing of Cucurbits.[9]

In spite of a very prevalent belief that melons and pumpkins mix there is conclusive evidence to the contrary.

One of the latest and most valuable contributions on the extrafloral nectaries is the paper by Fr. Knoll[10] who states that much nectar is secreted by the nectar glands of the leaves of *Catalpa bignonioides.* These have an attractive odor and are visited by many different insects of the general type that visit the Umbellifereae, including honey bees. The glands were studied microscopically as well as macroscopically.

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7 Proc. Ia. Acad. Sci., 1894.

8 Handbook of Flower Pollination, 2:454.

9 Proc. Ia. Acad. Sci., 31:130.

10 Uber die Laubblattnektarien von *Catalpa bignonioides* und ihren Insektenbesuch. Separate Biologi Generalis 4:541-570, f. 1-5.

POLLINATION

L. H. PAMMEL

To make this subject matter of pollination clear some fundamental knowledge is necessary. The following facts pertain to the subject of pollination and fertilization and are taken from Ecology.[1]

Pollination is the conveying of pollen from stamen to stigma; the term fertilization was formerly used in this way, but fertilization takes place only after the pollen reaches the stigma; it is the impregnation of a special cell in the embryo sac of the ovule, a complicated process.

In most higher plants the essential organs, e.g., stamens and pistils, occur in the same flower. It is therefore possible to have close pollination. The term *autogamy* is used to designate the transfer of pollen from the stamens to the stigmas of the same flower. Autogamy can therefore occur only in hermaphrodite flowers. Many such plants are not, however, autogamous since there are adaptations to secure cross-pollination. By this is meant the transfer of pollen from the stamens of one flower to the stigma of another flower. The production of seed in this way is called cross-fertilization. The term *geitonogamy* is used when the pollen comes from the same plant but from another flower, the term *xenogamy* when the pollen comes from the same species but another plant. In many plants where cross-fertilization has occurred, there are contrivances which permit of autogamy. In some cases the stamens actually move toward the stigma. Many cases of this kind are cited by Kerner in his "Natural History of Plants." Autogamy must occur in those plants which produce closed or *cleistogamous* flowers. In these flowers the floral envelopes are more or less aborted. In some there is no trace of a corolla while the sepals form a protective covering. In these cleistogamous flowers, as in our blue violet (*Viola papilionacea*) the anthers come in immediate contact with the stigmas. In most cases, as in our blue violet, a crop of irregular flowers is produced earlier in the season and these are pollinated by insects, but in the autumn the violets produce the cleistogamous flowers

1 L. H. Pammel, pp. 1-364, Figs. 1-181, 1903.

close to the ground. The anthers of the cleistogamous flowers produce but little pollen.

In *monoecious* flowers the stamens and pistils are separated, but on the same plant, as in maize, melon, oak, hazel, hemp, ragweed and walnut. Self-pollination cannot occur, but the degree of inbreeding is greater than in some hermaphrodite flowers. These flowers are therefore geitonogamous. The term *trioecious* is used to designate plants like the ash where staminate, pistillate and hermaphrodite flowers occur on different branches of the same plant. The term *gynodioecious* is used for plants like the thyme in which some plants produce hermaphrodite flowers, others only pistils without stamens. There is a possibility here for autogamy and geitonogamy. A number of plants, like the buckeye and horse chestnut, produce hermaphrodite flowers, while some flowers have a rudimentary pistil but perfect stamens. These are called *andromonoecious*. As in the thyme autogamy and geitonogamy may occur.

Autogamy is prevented in many plants by the maturation of the sexual organs at different times. This is known as *dichogamy*. This difference in time is efficient in securing cross-fertilization. Dichogamy is of two kinds. When the stamen matures first it is called *proterandrous*, as in the sunflower, willow herb and many others; when the pistil is mature before the stamens of the same flower or same plant are ready to receive the pollen it is *proterogynous*, like Simpson honey plant (*Scrophularia*). Many monoecious plants are proterogynous, such as maize, birches, walnuts and oaks. *Heter-*

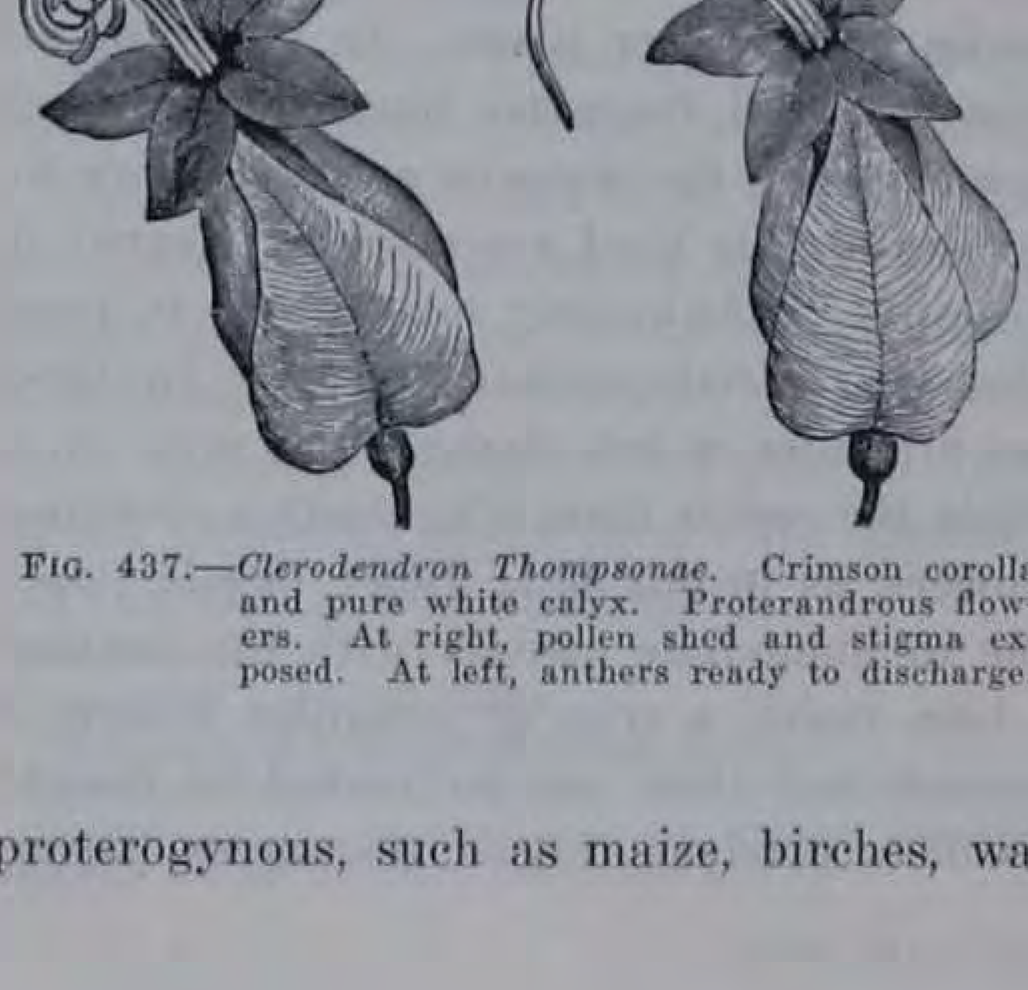

FIG. 437.—*Clerodendron Thompsonae.* Crimson corolla and pure white calyx. Proterandrous flowers. At right, pollen shed and stigma exposed. At left, anthers ready to discharge.

odichogamy is the maturing of pollen first in some plants of the same species, while in others the pistil matures first.

Darwin, Hildebrand and others have called attention to the differences in length of stamens and pistils in the same flower with corresponding heights of stamens and pistils of other plants of the same

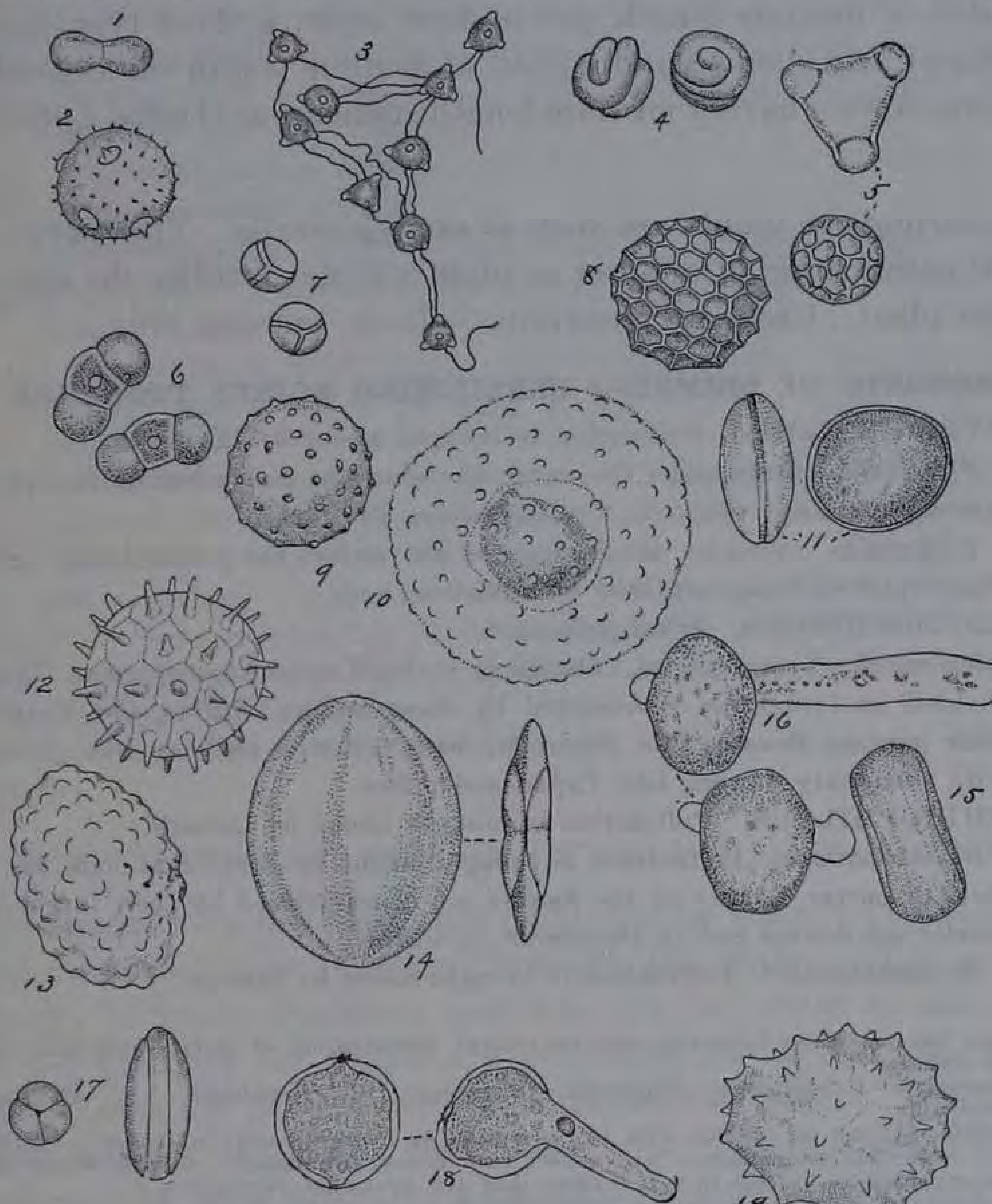

FIG. 438.—Various types of pollen grains.

A. Insect pollinated.
1. *Mertensia virginica* (Bluebell); 2. *Cucurbita pepo* (Squash); 3. *Epilobium angustifolium* (Fire-weed); 4. *Mimulus moschatus* (Monkey flower); 6. *Oenothera biennis* (Evening primrose).

B. Wind pollinated.
5. *Pinus pumilio* (Dwarf pine); 7. *Cannabis sativa* (Hemp).

C. Bird pollinated.
8. *Cobaea scandens* (Cobaea).

D. Bird and insect pollinated.
9. *Canna indica*, dry, (Canna); 10. *Canna indica*, in water (Canna); 11 and 14. *Monarda mollis* (Horse mint); 12. *Helianthus annuus* (Sunflower); 13. *Polygonum pennsylvanicum* (Heart's-ease); 15. *Lathyrus odoratus* (Sweet pea); 16. *Lathyrus odoratus*, germinating (Sweet pea); 17. *Rosa pratincola* (Wild rose); 18. *Rosa pratincola* germinating (Wild Rose); 19. *Cirsium lanceolatum* (Bull thistle). *Pammel, King and Kerner.*

species, which is termed *heterogamy.* Heterogamy is of two kinds: *dimorphic,* where the same species produces two kinds of plants, some having long stamens and short style and others having a long style and short stamens, as in primrose (*Primula*); *trimorphic,* some plants having a long style and short stamens, others having stamens of medium length and a short style; a third type having short and long stamens and a pistil of medium length corresponding to those flowers having medium length stamens, as *Oxalis, Lythrum,* etc.

Autarigynous plants are such as are self-sterile. The sperm cell of the pollen grain of a flower or plant will not fertilize the egg cell of that plant. Cases are numerous,—clover, calamus, etc.

METHODS OF BRINGING FERTILIZING BODIES TOGETHER

1. HYDROPHILOUS. Pollination is brought about by the water.
   a. Pollination occurs under the water, the spores or pollen having the specific gravity of water. *Zostera, Ceratophyllum,* Florideae.
   b. Pollination occurs on the surface of the water, the pollen being lighter than water or being attached to a floating body.
2. ANEMOPHILOUS. Wind pollinated.
   Ovules naked; Gymnosperms. Ovules in a closed sac; Angiosperms. This is divided up into types represented by those having catkins, like *Corylus*; with pendent flowers, like *Negundo;* with versatile anthers, like grasses; with stationary flowers, like *Typha* and palms.
3. ZOIDIOPHILOUS. Pollination is brought about by animals.
   a. *Ornithophilous.* Pollination is brought about by birds that look for insects or nectar. Many of the flowers are characterized by their large size, scarlet red flowers and an abundance of nectar.
   b. *Entomophilous.*[2] Pollination is brought about by insects.

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[2] Loew has made the following very convenient classification of insects and their relations to flowers:

Hymnoptera—1. Eutropic, Polytropic, Oligotropic. 2. Hemitropic. 3. Allotropic. 4. Dysotropic.

Eutropic includes all *Apidae* with the exception of *Prosopis* and *Sphecodes.* In these we have reciprocal adaptations; they collect both honey and pollen. On the whole they must be regarded as useful; in a few cases they are somewhat destructive.

Hemitropic includes *Prosopis* and *Sphecodes*; they are highly developed and have considerable freedom of movement, but these collect only nectar, like Sphegidae.

Allotropic includes the social Vespidae, the Ichneumonidae and Tenthredinidae. The members of this group feed not only on nectar and pollen, but are also carnivorous.

Dysotropic includes Formicidae; they are entirely destructive. The mandibles are strong and well developed; the development of small teeth upon the mandibles enables them especially to bite and gnaw.

Diptera { *Hemitropic* (Conopidae, Bombyliidae, Syrphidae).
Allotropic (Muscidae, Empididae, Tabanidae, Stratiomydae).

Coleoptera { *Dysotropic* (Curculionidae, Melolonthidae, Chrysomelidae).
Allotropic (Lepturidae, Melyridae, Cetoniaridae, Phalacridae, some Cleridae and Dermestidae).
Hemitropic (Nemognatha and perhaps also some Euchridae, some Hoplidae, and Telephoridae).

Most of the Lepidoptera are *Hemitropic.* Loew uses the word "Heterotropic" to designate the unequal selections that insects display in going to flowers.

Anthophora pilipes and *Anthidium manicatum* visit few species and confine themselves

1. *Mellitophilous*, pollinated by large bees (Hymenoptera), diurnal flowers, colors and odors agreeable to human beings. Sage, etc.
2. *Micromellitophilous*, pollinated by small bees and other insects.
3. *Myiophilous*, pollinated by flies (Diptera); the flowers are usually small, colored yellowish, wine red, or spotted with these colors. The odors are somewhat disagreeable. The nectar is not deep seated, or when absent an abundance of pollen occurs. *Euonymus.*
4. *Micromyiophilous*, pollinated by small Diptera; the flowers or inflorescences produce a closed chamber with an opening for insects. Small amount of nectar or only pollen. *Arum.*
5. *Sapromyiophilous*, pollinated by carrion flies or beetles; characterized by carrion odors. *Stapelia.*
6. *Cantharophilous*, pollinated by beetles (Coleoptera). Large diurnal flowers with conspicuous blossoms which afford shelter or lodging for the insect.
7. *Psychophilous*, pollinated by diurnal Lepidoptera. Day flowers with bright colors, in which the pollen is concealed in a deep narrow tube. *Dianthus.*
8. *Sphingophilous*, pollinated by nocturnal Lepidoptera, like the Sphingidae and Noctuidae. Flowers light in color and with strong but agreeable odors. Nectar deep seated. *Nicotiana affinis.*

c. *Malacophilous.* Plants adapted to be pollinated by snails. The flowers are so closely crowded that snails in passing over pollinate them.

d. *Cheiropterophilous.* Flowers pollinated by bats as first indicated by Burck and later by Hart.

4. CLEISTOGAMOUS HERMAPHRODITE. Flowers which are self-fertilized.

WATER POLLINATED OR HYDROPHILOUS PLANTS

Comparatively few plants are pollinated by water. The pollen of many hydrophilous plants is without the extine. The specific gravity of pollen grains is less than that of water or the same. In the first case the plants are pollinated on the surface, in the second case the pollination occurs under the water. The pollen of *Callitriche* is lighter than water, the pollen coming to the surface. In freshwater eel grass (*Vallisneria spiralis*) the male flowers come to the surface and pollinate the pistillate flowers. In *Ceratophyllum* the anthers are provided with an outgrowth filled with air rendering it lighter than the water, which enables the anthers to float on the water, strewing their path with pollen, which attaches itself to the viscid stigmas.

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to bee and bumble-bee flowers of Labiatae, Scrophulariaceae, etc., and are called *Oligotropic*, as opposed to the many-sided visits of the species of *Bombus*, which are called *Polytropic*.

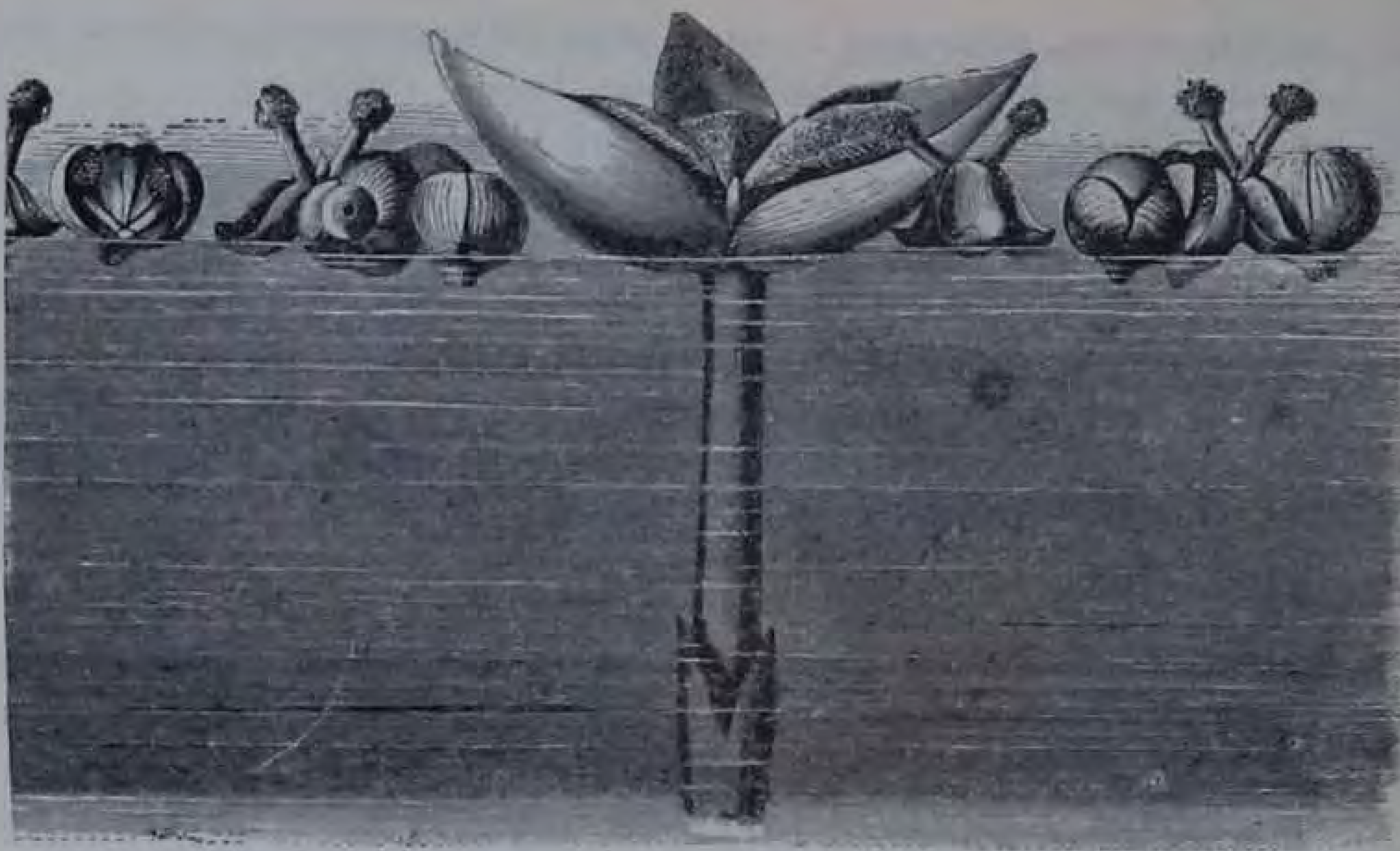

FIG. 439.—Freshwater eel grass (*Vallisneria spiralis*). Staminate flowers on surface of water. Currents of water bring the staminate flowers in contact with the stigmas. *Kerner-Oliver.*

Eel Grass (*Vallisneria spiralis*) is an excellent illustration. It is a common plant found in ponds and slow running streams in many parts of the eastern United States. It is stemless, bearing linear, thin, ribbon-like leaves. The flowers are dioecious. The pistillate flowers are solitary and borne on long, slender threads, which bring them to the surface of the water. The flower consists of a perianth composed of three petals and three small sepals. The three large stigmas are two-lobed and are so situated in the mature flowers that they turn back beyond the three petals; hence it is important that the sepals should be small. The staminate flowers are numerous and crowded in a head at the bottom. When nearly mature the staminate flowers break away from the plant and come to the surface of the water, on which they float. In this condition they form a ball, but when fully mature the petals turn back, forming a boatlike arrangement, the stamens lengthen out and the anther cells open. Each anther contains thirty-eight large, more or less viscid, pollen grains. The three boatlike sepals are admirably adapted to float the flowers on the water. Short waves or currents of wind drive the flowers along until they come against a solid object, where they remain, and if it be a pistillate flower the stamens come in contact with it, leaving the pollen attached to the stigmas. After fertilization the threads that bear the fertile flowers coil up spirally, drawing the fruit under water to ripen.

Lemna.—Species of duckweeds are admirably adapted to pollination by water and also by snails. The following account of *Lemna minor* is based on the observations made by Dr. Trelease. Duckweeds are among the smallest of flowering plants and form scums on the surface of ponds and slow running streams in summer. They are very simple in their structure. Each fertile frond produces a single flower from a cleft in the margin. The flower consists of a single pistil and two stamens and a subtending bract. When the flower expands, the pistil elongates sufficiently to expose about half its length beyond the tips of the marginal fissure of the frond. The stigma becomes moist by the exudation of a fluid and is now receptive. In this condition it remains some days, when the stamen furthest from the base of the frond becomes exserted, attaining the length of the pistil, when it dehisces, the pollen remaining heaped in the open cells of the anther. The second stamen dehisces several days later. The flowers are therefore strongly proterogynous. "Surface currents due to the wind or other causes crowd the plantlets together in masses in which the relations of the several individuals are incessantly changing." The receptive stigmas must be pushed against the older anthers, through which they are pollinated. While there is in this case an admirable adaptation for cross-pollination, self-fertilization may result when the pollen of the older stamen drops on the stigma.

Water-weed.—Another interesting plant pollinated by water is *Elodea canadensis*, commonly found in slow running streams and ponds of the northern United States. It has also attracted considerable attention in Europe from the fact that it has become a veritable nuisance in choking canals and streams. The plant bears three kinds of flowers: staminate, hermaphrodite and pistillate. But all of these forms apparently never appear together, although staminate and pistillate flowers do occur together. The fertile flowers are borne on a long tube which in most cases comes to the surface of the water, where it expands. The staminate flowers are attached at the bottom; they break off as in *Vallisneria*, come to the surface and float on the water. When fully mature they expand and shed their pollen around the stigmas. Several other plants, especially the Asiatic *Vallisneria alternifolia* and the tropical African *Lagarosiphon*, are pollinated in a similar way.

WIND POLLINATED OR ANEMOPHILOUS FLOWERS

Colors.—Sprengel in a general way noted the characters of anemophilous plants. The flowers are usually dull in color but there are some apparent exceptions, as in *Plantago*. This plant is, however, intermediate between anemophilous and entomophilous flowers.

The stigmas are small and generally inconspicuous. They are colored red in the hazel and other trees but these colors are due to certain chemical changes and the constitution of nutritive fluids and the action of light and heat. They may serve various purposes, but there is no reason to believe that they were developed for insect pollination. Some plants, like the soft maple (*Acer saccharinum*), come from anemophilous ancestors. The soil, climate and altitude affect the production of color. John H Lovell[3] has contributed a

[3] Am. Nat., 33:493. 35:197. 36:203.

number of interesting papers on the colors of northern flowers, and these papers should be consulted in this connection.

Doctor MacDougal[4] has likewise given a good popular account of colors. He says: "The functions subserved by many of the coloring substances besides chlorophyll are by no means secondary in distribution or importance to the individual plant to the exterior adaptation described above," that is, the physiological uses of color in plants. F. Grace Smith[5] has also given an interesting discussion of red color in plants. In this connection the discussion on the subject Pigment or Color by Overton[5a] under the heading, The Physiology of Color in Plants gives the various theories, and reviews the work of Von Mohl and others.

Doctor MacDougal in speaking of color substances says: "That it cannot be presumed apriori that the colors exhibited by the flowers or any other organ of the plant are devices to attract and guide insect visitors is becoming more and more apparent—that great care is necessary in the interpretation of areas of color in plants is emphasized by the fact that accumulating observations tend to show that a color sense is wholly lacking except among the higher insects, and that if the colors of flowers were fashioned to attract insect visitors these colors must have been received at a very recent date, that is, since the acquisition of the color sense by insects."

Dr. J. M. Coulter[6] makes the statement that experiments indicate that the presence of the red color slightly increases the temperature by absorbing more heat and that the red color may be a slight protection to living substance and thus lessen the danger from exposure to cold. If this explanation is correct it shows why the pistils of anemophilous plants and the cones of conifers in the spring should be red, but it is more likely that there are other reasons that must be taken into consideration in accounting for these colors.

Marion I. Newbiggin[7] is probably correct in saying that it is impossible as yet to give a definite physiological explanation as to the origin of pigment.

Stamens and Pistils.—The sexes of anemophilous flowers are often separated, e.g., either monoecious or dioecious. The anthers are

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[4] Pop. Sci. Mo., 49:71.

[5] Bot. Gazette, 32:332.

[5a] Pringsheim Jahrb., 33:171.

[6] Plant Relations 242.

[7] Biological Lectures. Wood's Hole.

FIG. 440.—Pollination of maize or corn. Wind pollinated, male and female flowers separated, central figure above. A, young ear, with stigmas; B, (above) staminate flower; B, (below) pistillate flower; J, pistil; J, G, ovule.

easily accessible to the wind. The pollen is easily blown out as in the versatile anthers of grasses and the loosely arranged stamens of conifers. There is always an abundance of pollen. The pollen grains are light, spiny, but not viscid. The long "silk threads" of maize are familiar to every one as are the plumose stigmas of timothy. Since the pollen is easily destroyed by rain it is protected in various ways. The anthers of grasses discharge during dry weather. The pollen of such plants as the hazel and poplar is protected by scales over the anthers.

FIG. 441.—Filbert (*Corylus Avellana*) showing fruits to the left and large staminate catkins and the short axillary branches with pistillate flowers to the right. The stigmas are red. *Kerner.*

Locality determines largely the number of anemophilous plants. They occur in large numbers where the wind has a long sweep. Knuth states that in Germany 21.5 per cent of the flora is pollinated by the wind and in Schleswig Holstein 27 per cent. Islands like Romoe in the North Sea, which receive the sweep of the west winds, have 47 per cent pollinated by the wind.

Kerner calls attention to the interesting fact that certain plants which are adapted to insect pollination, e.g., some Ericaceae, are towards the end of their period of pollination anemophilous plants. In such cases the filaments of the anthers are elongated and stamens protrude beyond the corolla. The pollen can then be carried by the wind to the stigmas of younger flowers. Hildebrand cites an excellent illustration of this kind in the pollination of Cyclamen. During the entomophilous stage the pollen of this plant is somewhat oily, but later it is dry and powdery.

A large number of our woody plants are pollinated by the wind—the hazel, birch, pine, cottonwood, oak and elm. Nearly all grasses and many herbaceous plants, like hemp, Russian thistle and others are anemophilous.

Hazel.—In our own hazel (*Corylus Americana* Walt.) the staminate catkins are pendent and the pistils occur in short erect inconspicuous cones. The stigmas are red. A great abundance of pollen is produced in the eight half stamens with one-celled anthers under the large bracts. Our hazel flowers open early in April. In the European hazel nut (*Corylus Avellana*) the staminate flowers are borne in drooping cylindrical catkins, each flower containing eight stamens with short filaments. The anthers contain an abundance of pollen. The pistillate flowers are not conspicuous, several occurring in the scaly bud. The stigmas are of reddish color and are inconspicuous compared with the staminate catkin. The flowers may be proterandrous or proterogynous.

As a general rule, wind pollinated shrubs and trees bloom before the leaves are out, because the leaves interfere with the distribution of pollen. As Robertson says: "In the case of the wind pollinated trees it is obvious that if the leaves were developed before the flowers, the process of pollination would be greatly impeded by the leaves interfering with the free circulation of the wind and catching the pollen which is intended for the stigmas."

Conifers.—The staminate flowers occur at the base of the shoot of the same sprig. The fertile catkins occur below the terminal bud or on the lateral young shoots. The stamens have two anther cells which open lengthwise. The slightest jar on a tree will cause a shower of pollen to issue. The structure of the pollen grains is such that it is easily carried by the wind. It consists of three cells, one of which is fertile. The others serve to buoy the pollen and

FIG. 442.—Branch of dwarf mountain pine (*Pinus montana*). 1, staminate flowers; 2, same in section; 3, staminate catkins; 5, pistillate flowers. *Kerner.*

therefore make it of easy transport. The pistillate ones are colored red, and have a large receptive surface. When the pistil is ready to receive the pollen small drops of mucilage are excreted by the micropyles of the ovules.

Pollen of some conifers has been carried for more than a hundred miles. The so-called "showers of sulphur" on ponds consist of pollen grains which were suspended in the air and brought down during a shower of rain.

Zamia.—Doctor Webber in a valuable monograph on *Zamia* states concerning the pollination of this plant, "Pollination is accomplished by the wind. The scales of the cone gradually reflex from the base upward in regular sequence, leaving an opening about one-fourth of an inch wide between the scales when fully open, into which the pollen must be blown to cause fecundation. When blown into the cone in this way it naturally rattles down to the axis of the cone near the micropyle of the ovary. In the further process of pollination a mucilaginous fluid is evidently extruded, which catches the pollen grains and is later drawn into the pollen chamber at the apex of the nucellus, either by absorption or by suction created by the breaking down of the tissue in the formation of the pollen chamber. In this way the pollen grains come to lie in the pollen chamber at the apex of the nucellus where they germinate and form the spermatozoids."

Pollination of Some Forest Trees

A large number of our North American forest trees are anemophilous. We need only cite as illustrations the pine and other conifers. The latter have been considered in a previous paragraph.

Betulaceae.—Our common paper birch (*Betula papyrifera*) is native from New England to Pennsylvania, Wisconsin, Minnesota and Hardin county in central Iowa. In central Iowa it is associated with *Betula lutea*. In northern woods both species are common. The birches belong to the family Betulaceae. The flowers are monoecious and are produced in scaly catkins with two or three flowers at each bract. The sterile catkins are pendulous and contain the staminate flowers. The flowers of the birches mature in early April. The stigmas of the fertile flowers are small, greenish red and inconspicuous. When the staminate flowers mature the pollen comes out in clouds of dust. The oak (*Quercus*) belongs to the family Fagaceae. Nineteen species are given within the range of the family in Gray's Manual, but Sargent in his Silva of North America recognizes more species in the same range. One of the most common oaks in the northern United States is the bur oak (*Quercus macrocarpa*). The range of this species is from Nova Scotia southwest to Kansas and Nebraska and west to the Dakotas. The flowers are monoecious and are borne in catkins. The sterile flowers occur in slender catkins with distant flowers, three to twelve stamens in a single flower, with two-celled anthers. The fertile flowers are scattered or somewhat clustered, inconspicuous, borne in the axils of the leaves. Flowers of the oak, like the birch, appear before the leaves so that the pollen is not wasted as it would be if anthesis occurred when the plant is in full leaf.

Juglandaceae.—The black walnut (*Juglans nigra*) is native to the Mississippi valley, east to western New England. It produces monoecious flowers and the sterile or staminate catkins are larger and greenish, each flower having from twelve to forty stamens with very short filaments. The fertile flowers are solitary or several together, inconspicuous, having four small petals, two very short styles and two somewhat club-shaped and fringed stigmas. The walnut, like the butternut and hickories, is anemophilous. The butternut blooms somewhat later than the oak and birch but still before the leaves are well developed.

Elms.—The elm (*Ulmus*) belongs to the elm family. Two species are quite common in the northern United States, namely, the slippery elm (*Ulmus fulva*) and American elm (*Ulmus americana*). The elms bloom very early in this latitude, about the latter part of March or early April.

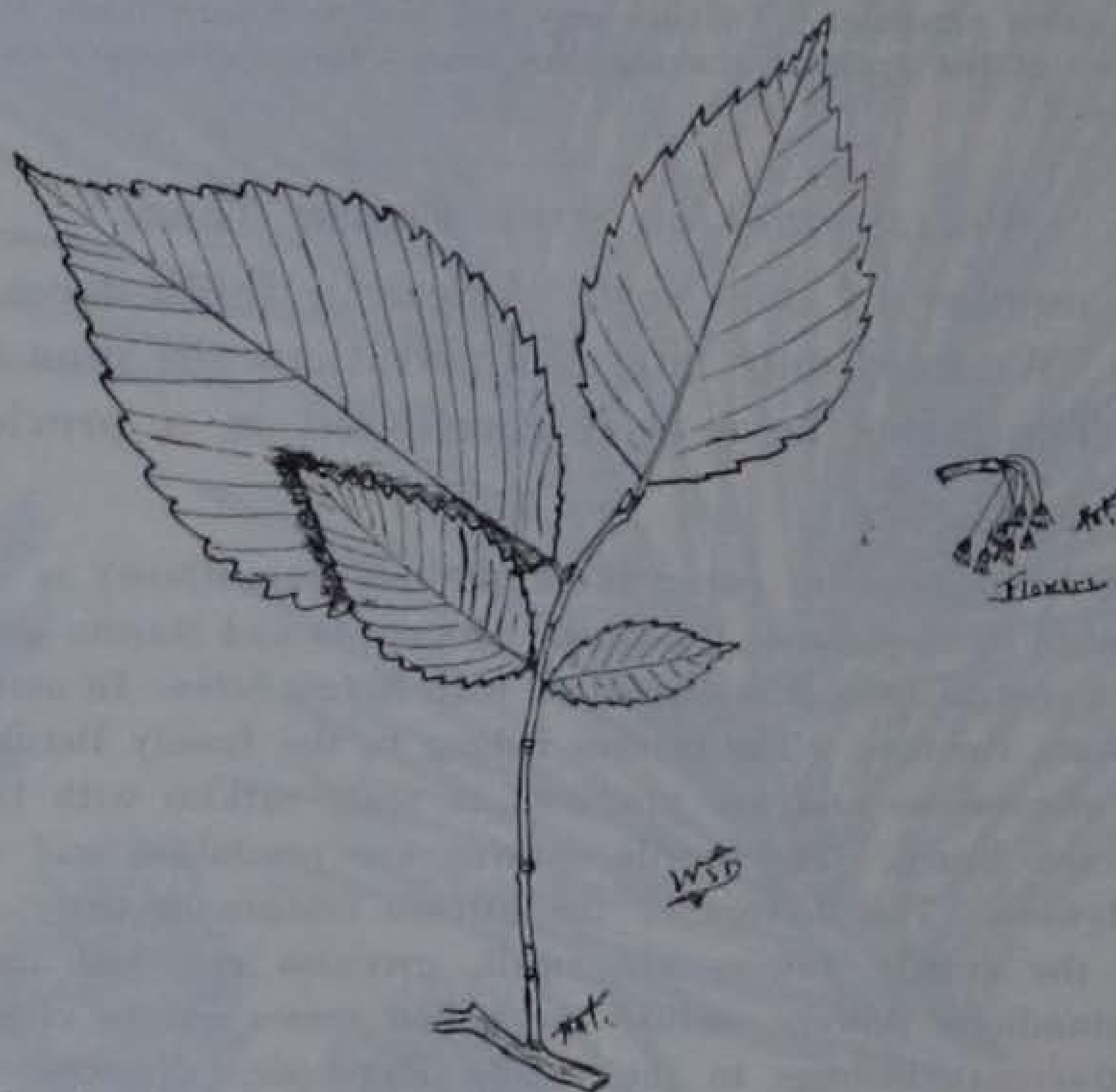

FIG. 443.—American elm, wind pollinated flower. *Drawn by W. S. Dudgeon.*

In the slippery elm the flowers are borne in sessile clusters, the stamens are purplish in color, the stigma is greenish and somewhat plumose. Both mature at about the same time. The American elm produces less conspicuous stamens. The flowers are borne in slender drooping pedicels, thus permitting the pollen to be easily dislodged by the wind. The pollination is easily brought about because both of these plants are in bloom before the leaves appear.

Box Elder.—The box elder (*Acer Negundo*), native of Iowa and growing from New England to the Dakotas south and westward, is commonly cultivated. The flowers are dioecious with a minute five-cleft calyx, sterile flowers are borne in capillary pedicels. Each flower has four to five stamens.

Alder.—The alder, which is a common plant in the eastern states, northeastern Iowa and the Rocky mountains, bears its staminate flowers in long slender catkins. The pistillate catkins are more or less erect. Usually self-pollination is not prevented in the cultivated European species, nor in some of our wild species. John H. Lovell states that *Alnus incana* is partly dioecious. Honey bees occasionally visit the staminate flowers for pollen.

Hemp and Hop.—There are two widely distributed species of the Urticaceae in the state. The European hemp (*Cannabis sativa*) is naturalized in many sections of the state and hop (*Humulus Lupulus*) is a native. Both species are anemophilous. The hemp is a coarse annual from four to eight feet high. Flowers dioecious, the staminate in axillary racemes or panicles, with five greenish sepals and five drooping stamens from which the pollen falls very easily. The fertile flowers with a single sepal enlarge at the base. The flowers of the hop are dioecious, the staminate occurring in loose axillary panicles with five greenish sepals and four erect stamens. Fertile flower in short axillary and solitary spikes, calyx of a single sepal. It is native to many parts of Iowa but more common northward. It also occurs in the Rocky mountains.

Aquatic Plants.—Aquatic plants are also pollinated by the wind, as *Potamogeton crispus*, a plant growing in ponds and slow run-

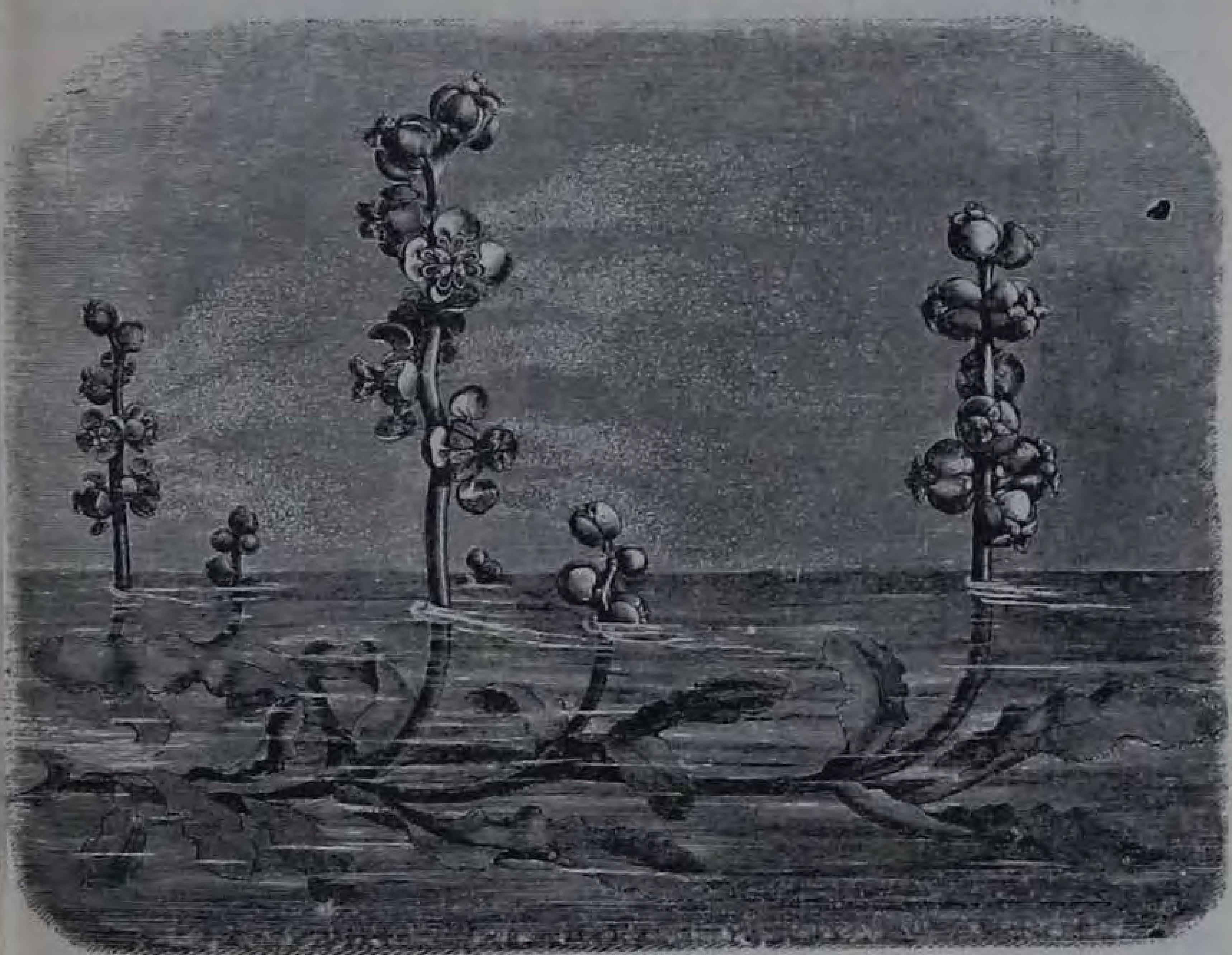

FIG. 444.—*Potamogeton crispus*, one of the pondweeds. Staminate flowers, discharging pollen, at left; pistillate flowers with large stigmas at right. *Kerner.*

ning streams. While its leaves are immersed in water the flowers are produced above. The reddish brown stigmas mature before the anthers of the same flower are open, but when the stigmas are wilting then the perianth of the flower opens. The matured anthers shed their pollen, which is carried by the wind. When it blows over the water some of it is wasted, but a part of it is almost certain to come in contact with the stigmas of younger flowers.

FIG. 445.—Pond-weed (*Potamogeton natans*). Wind pollinated. 1, Apex of flowering shoot; 2, Flower viewed from above; 3, Flower viewed from side; 4, Diagram of flower. *After Wossidlo.*

Herbaceous Plants.—Anemophilous herbaceous plants occur in widely separated families, as meadow rue (Ranunculaceae), ragweed (Compositae), hemp (Urticaceae), and Russian thistle (Chenopodiaceae). Common plantain (*Plantago major*) occurs in all of our door yards, and who has not observed the long slender spike? The flowers are proterogynous, the slender style showing before the stamens and when the stamens appear the style is withered. The pollen must therefore move upward.

Our common meadow rue (*Thalictrum dasycarpum*) is a tall plant, from two to four feet high, belonging to the family Ranunculaceae. The flowers are dioecious, greenish and consist of four or five greenish petal-like sepals that fall off early. The anthers are long, linear and drooping so that the wind has easy access. The Rocky Mountain *Thalictrum Fendleri* is much like it. The plant is dioecious and blooms in the foothills during the months of June and July. At higher altitudes the *T. sparsiflorum*, with large and perfect flowers, is abundant. This species is more frequently visited by insects than the other species; the sepals are whitish or brownish. The species is in a transition stage between the anemophilous and entomophilous. *Thalictrum dasycarpum, T. dioicum* and *T. Fendleri* are anemophilous though sometimes visited for pollen. *Thalictrum dioicum* blooms in early May in our northern woods. The ragweeds have monoecious flowers and are wind pollinated.

Grasses.—This family contains a large number of species, many of which are of great economic importance. They are almost ex-

FIG. 446.—Wind pollinated flower. *Ambrosia artemisiifolia*, showing flowering stalk, pistils, stamens, and longitudinal sections of stamens in perianth and ovary. *After Faguet.*

clusively pollinated by the wind. The flowers are usually hermaphrodite, like wheat and oats; some are monoecious, like maize; some are dioecious, as is true sometimes of Texas blue grass. In quite a number there is a difference in the time of maturing of the stamens

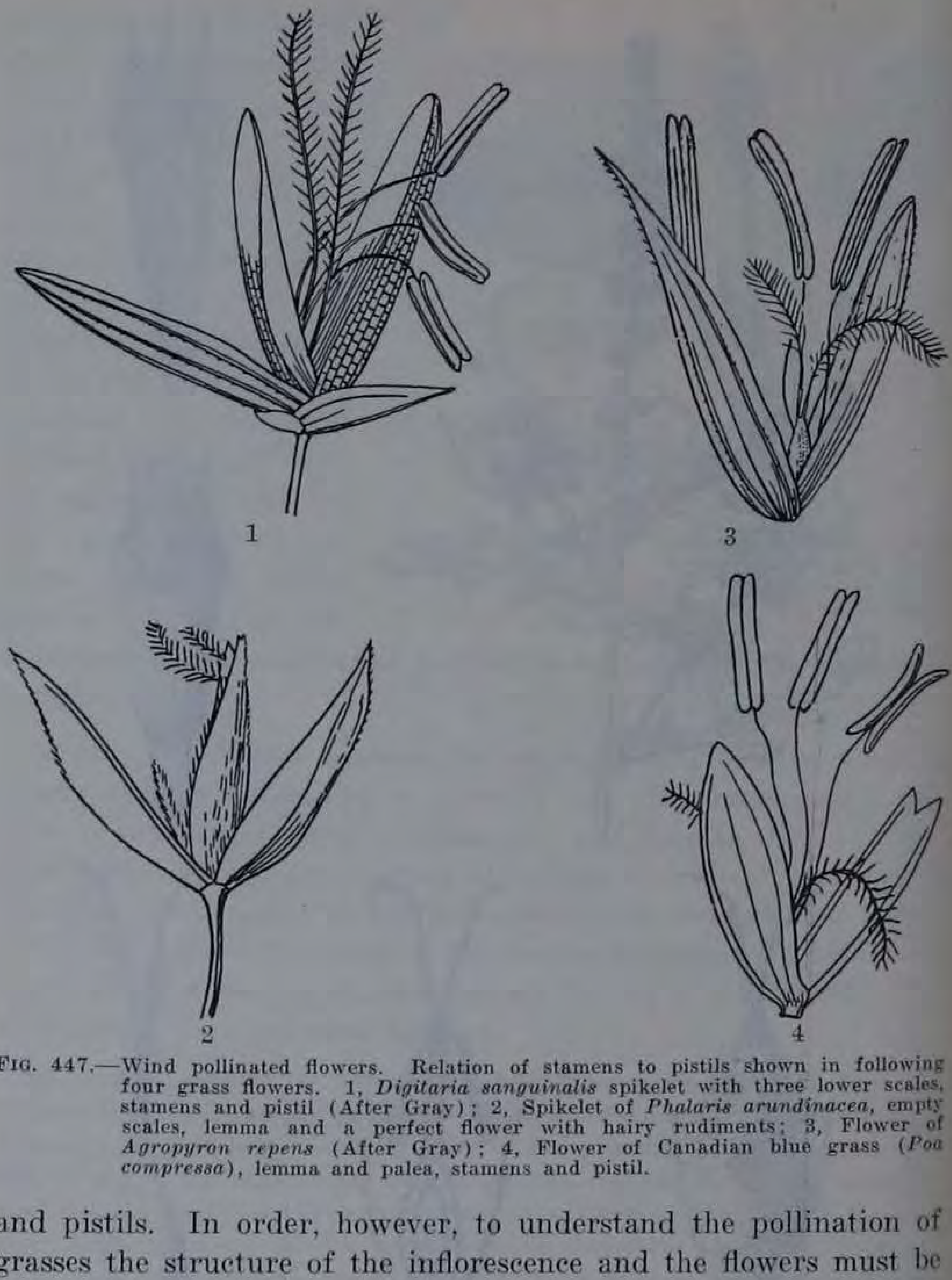

FIG. 447.—Wind pollinated flowers. Relation of stamens to pistils shown in following four grass flowers. 1, *Digitaria sanguinalis* spikelet with three lower scales, stamens and pistil (After Gray); 2, Spikelet of *Phalaris arundinacea*, empty scales, lemma and a perfect flower with hairy rudiments; 3, Flower of *Agropyron repens* (After Gray); 4, Flower of Canadian blue grass (*Poa compressa*), lemma and palea, stamens and pistil.

and pistils. In order, however, to understand the pollination of grasses the structure of the inflorescence and the flowers must be considered. The flowers of grasses are enclosed by bracts. The lower bracts at the base are known as empty scales. Each flower is subtended by two other bracts, the outer one called the lemma, the inner the palea. These bracts are followed in many grasses by the little scales, the lodicules, which are of great importance in pollination. The bases of these lodicules are grown together. The rapid swelling of the bases causes the separation of the lemma and palea, hence the opening of the flower. These turgid scales may be seen at the time of flowering in many grasses. They are very evident in *Poa arachnifera, Panicum miliaceum, Avena sativa, Bromus mollis* and *Festuca elatior*. In grasses where these scales swell but little, the flowers do not open very far. Where they are absent the spikelets are closed at the sides and the stamens and pistil protrude only at the apex.

The changes are so dependent on environment that grasses are frequently close-fertilized. Rain may thus retard the opening of the flowers, dry weather may also retard or altogether prevent the opening of the flowers and the discharge of the pollen.

The flowers of grasses open, as a rule, early in the morning, usually when there is some dew. *Festuca pratensis* opens before 7 a. m. Mr. F. A. Sirrine found that about Ames the flowers of grasses usually open between 5 and 9 a.m. Some, however, open between 5 and 7 p.m. Kerner von Marilaun[8] gives 4 to 5 a.m. for *Poa* and *Koeleria*; 5 to 6 a.m. for *Briza media, Aira caespitosa*, wheat and barley; rye, 9 a.m. This is, however, not always the case in cereals, as they may open at any hour of the day. Hayes and Boss[9] state that the flower of wheat opens at 40 minutes past 4 and closes at 18 minutes past 5 a.m. in Minnesota. Flowers of oats and timothy open between 7 and 8 a.m. *Agrostis* at 11 a.m.; *Elymus* between 12 m. and 1 p.m.; *Agropyron* at 4 p.m. *Holcus* opens its flowers twice during the day, at 8 a.m. and 7 p.m., provided atmospheric conditions are favorable—when the temperature is not below 57° Fahrenheit.

Beal says in regard to the length of time a grass remains in flower: "As a rule, a certain specified flower of grass remains open only for a short time, but different flowers of a plant may appear at successive periods extending over eight days, more or less, in timothy, several days in oats and wheat, and for a much longer period in branching grasses like *Eragrostis* and *Muhlenbergia*." Several grasses produce what are known as cleistogamous flowers. *Amphicarpon Purshii*, indigenous to New Jersey and southward, produces two kinds of flowers. Those with open flowers are sterile, while those borne on the small runners at the base of the culms are abundantly fertile. *Leersia oryzoides* produces cleistogamous flowers.

Maize.—In monoecious grasses like *Zea* the staminate flowers form the so-called tassel. Each staminate flower contains three stamens; when mature they hang losely from the flower. The pollen consists of small round grains easily

8 Pflanzenleben, 2:139.

9 Wheat varieties, breeding, cultivation: Bull. Univ. of Minn. Agrl. Exp. Sta., 62:415.

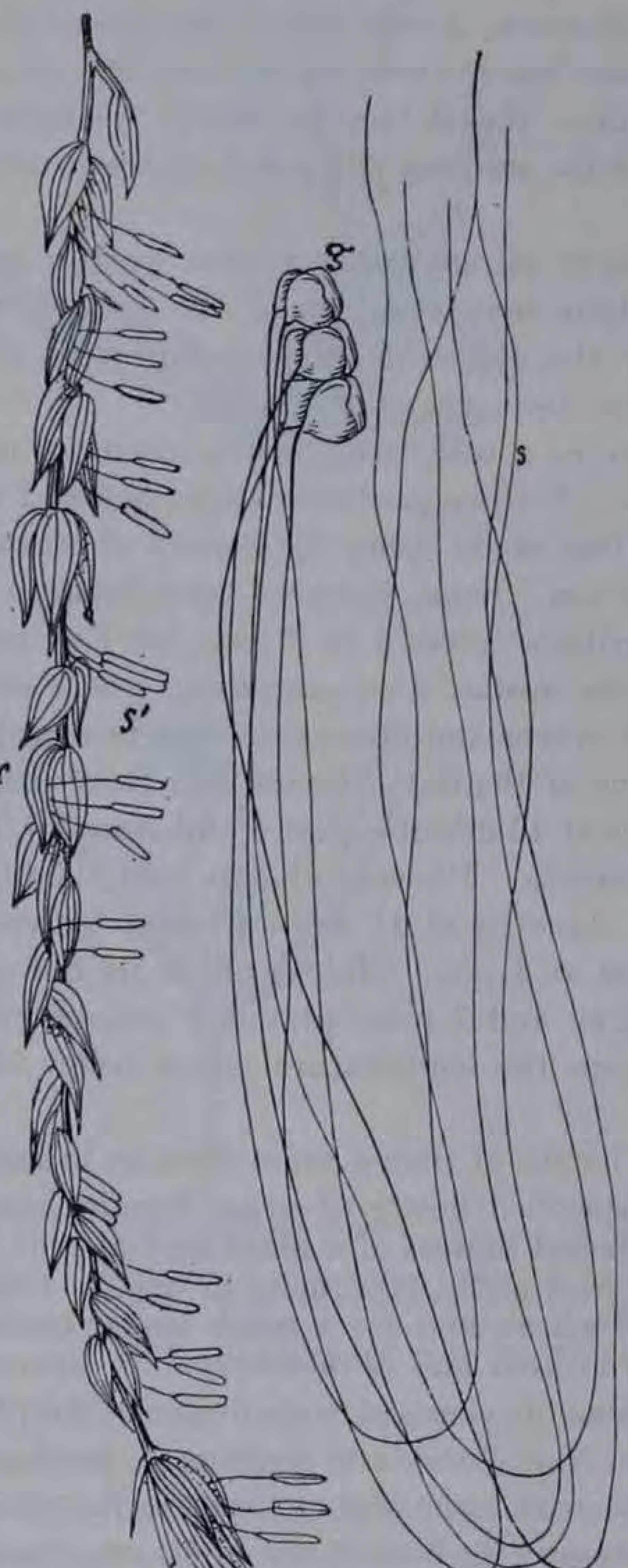

FIG. 448.—Maize flowers. Long plumose stigmas s., the ovary shown at g. Staminate flowers to right. The anthers at s'.

shaken out of the versatile anthers. The slightest breeze suffices to set the anthers in motion, causing them to shed "loads of pollen." Since the pollen is light it may be easily carried by the wind. The pistillate flowers occur in the axils of the leaves and constitute the so-called cob. Each ovule has coming from it a long slender filiform thread, the stigma, provided with plumose hairs. These plumose hairs are readily made out with the naked eye and are for the purpose of holding the pollen grains. The moist surface of the stigma causes the pollen grain to germinate. It sends a slender tube down the style to the ovule where the generative nucleus unites with the egg cell of the ovule, and as a result of this fertilization the kernel develops into a seed. Corn produces an enormous amount of pollen. Much of this is, of course, wasted. The staminate flowers are visited by honey bees and other insects chiefly for the pollen. Corn when in flower has a decided odor.

Tall meadow oat grass.—This grass is now commonly cultivated as a forage plant. When mature the glumes are suddenly distended because of the rapid swelling of the lodicules. The versatile anthers are exposed to the air on slender filaments, the filaments previously having made a rapid longitudinal growth. The least jar or the slightest breeze will cause a shower of pollen to issue from the anthers; the very plumose stigmas are exposed and readily receive the pollen. The wind causes the pollen

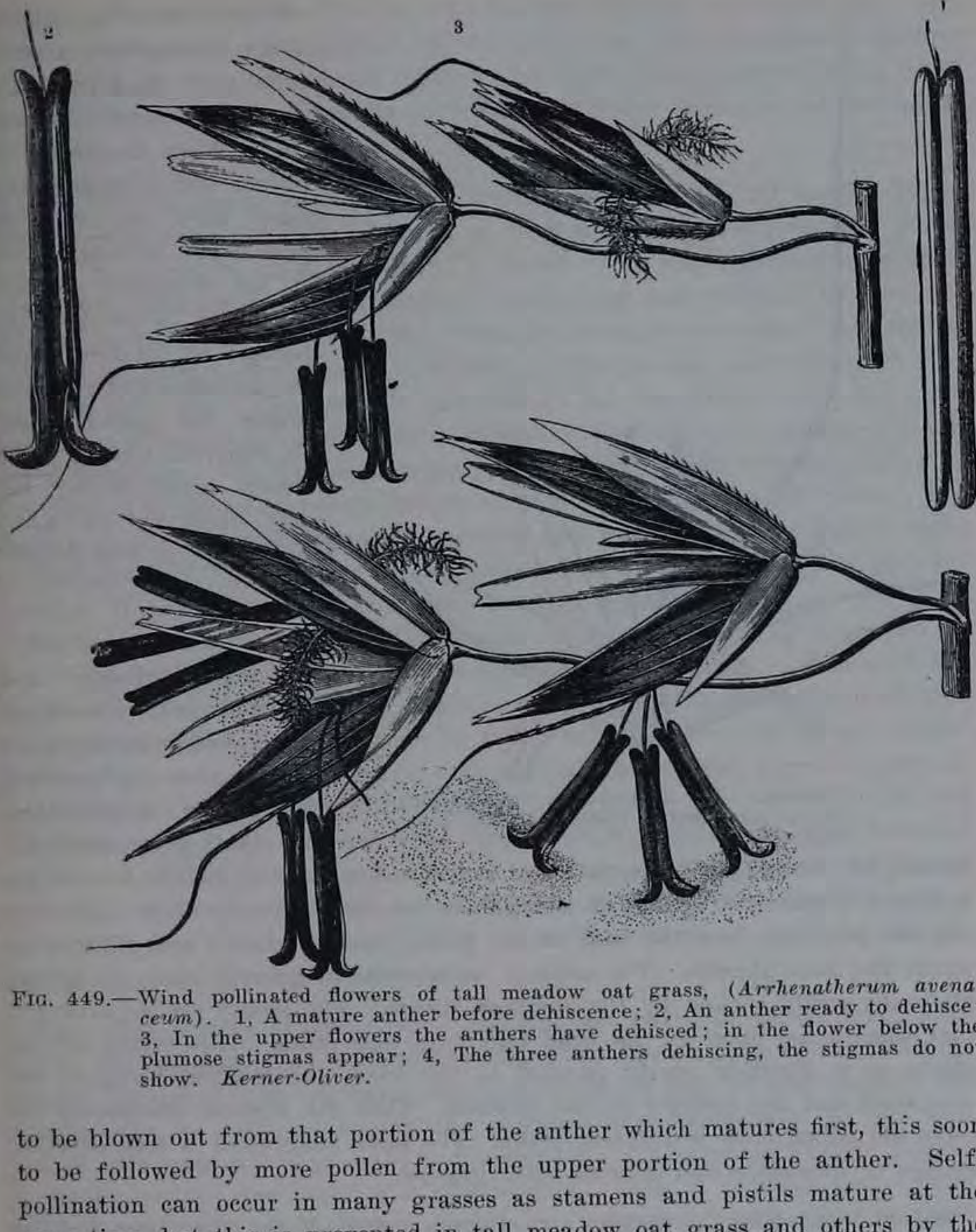

FIG. 449.—Wind pollinated flowers of tall meadow oat grass, (*Arrhenatherum avenaceum*). 1, A mature anther before dehiscence; 2, An anther ready to dehisce; 3, In the upper flowers the anthers have dehisced; in the flower below the plumose stigmas appear; 4, The three anthers dehiscing, the stigmas do not show. *Kerner-Oliver.*

to be blown out from that portion of the anther which matures first, this soon to be followed by more pollen from the upper portion of the anther. Self-pollination can occur in many grasses as stamens and pistils mature at the same time, but this is prevented in tall meadow oat grass and others by the difference in time in which the stamens and pistils mature. In this grass the pistil matures first and is therefore proterogynous. When the pollen is mature and is shed, the stigmas have wilted and are no longer in a receptive condition.

from flowers that originated from the same seed, in other words, that this plant needs to be cross-fertilized.

ANIMAL POLLINATED OR ZOIDIOPHILOUS FLOWERS

The agents so far known that pollinate flowers of this class are birds, insects, snails, and bats. Of course bats and snails and birds are not nearly so important as insects.

Bats.—The first recorded observation of cheiropterophilous pollination of flowers was by Burck, who noticed that *Pteropus edulis* ate the colored bracts surrounding the perianth of the male and female flowers of one of the Pandanaceae,[13] or screw pine family.

In the process of eating these bracts of the staminate flowers the anthers are brushed with the hairy head of the bat and in going to the female flower for the same purpose the pollen is deposited on the stigmas. Mr. J. H. Hart of Trinidad states that a species of *Bauhinia* is pollinated by bats. The long white flowers open between 4 and 6 p.m. Bats in large numbers frequent these flowers, but these visits are immediately followed by the white corolla falling to the ground. The following morning not a single flower will be found entire. The bats in going to the flowers hold themselves to the anthers. The stigmas seem to be uninjured. Nectar seems not to be produced. This same writer has observed that another tree, *Eperua falcata,* is one of the legumes visited by the bats. The brushlike tongue of the bat (*Glossonycteris*) is similar to that of the humming-bird. Its behavior in the flower is so similar to *Lepidoptera* that it was first regarded as a butterfly.

ORNITHOPHILOUS OR BIRD POLLINATED FLOWERS

Catesby, in his natural history of Carolina and the Bahama Islands in 1731, mentioned humming-birds visiting flowers. In 1874 Thomas Belt in "The Naturalist in Nicaragua" gave a description of humming-birds visiting *Marcgravia nepenthoides.*

Bird pollinated flowers are brightly colored and usually regular. Ornithophilous flowers are more abundant in the tropics than in temperate regions. In our region, Iowa and eastern North America, but one species of humming-bird (*Trochilus colubris*) occurs. In the southern Rocky Mountain region and in southwestern Texas, there are several species and they increase in abundance in Cuba, Mexico and Central America. In the tropical regions of Africa,

13 *Freycinetia* belongs to this family and is pollinated by bats.

Australia and Asia the honey-birds and honey-eaters are active pollinators. They suck the honey with their long, tubular tongues, which are brushlike at the top.

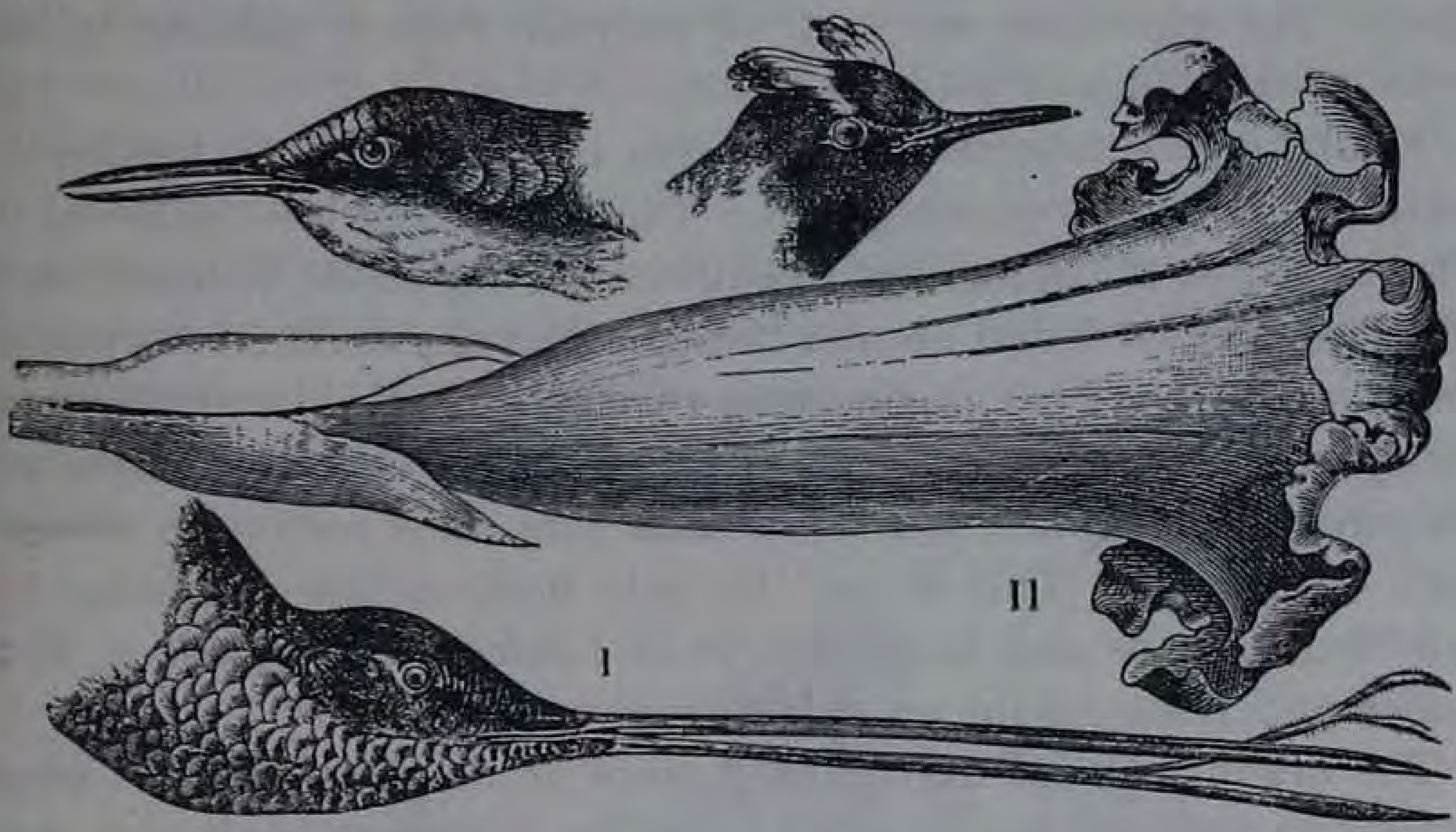

FIG. 451.—Birds and flowers. In the center the Trumpet vine (*Tecoma radicans*). In figure 1, note the length of the beak and tongue of the bird. *Behrens.* (This figure is labeled Datura in the original, but the picture is more like Tecoma.)

Humming-birds are usually small. Some are said to attain the size of a swallow, while the smallest are not much larger than a bumble bee. Their flight is maintained by the rapid vibrations of the wings, which enable the birds to remain in a position apparently motionless for some time. Behrens says, "To all outward appearance the humming-birds are birds when at rest, insects when in motion." Bates[13a] states that he shot several times by mistake a humming-bird moth (*Macroglossa Titan*) because its actions on the flower were similar to those of the humming-bird. It was only after many days' experience that he could tell the difference.

The migrations of our ruby-throated humming-bird, according to Hancock,[14] represent some 2,000 miles, so that it may transport pollen for considerable distances. The bird is certainly an important pollinator. The tongue is admirably constructed for collecting the nectar. It is long and tubular, often bifid and hairy at the tip. The tongue is used to catch the insects in the flower. The beak is long, thin and pointed. The upper jaw closes over the lower. The length of the beak differs with the length of the flower the bird visits. The bird has a special contrivance for collecting pollen.

[13a] The Naturalist on the River Amazon: Reprint Appleton & Co., 94, 1892.
[14] American Naturalist, 28:679.

This was first described by Hancock quoted above. The barbules of the feathers are armed with thistle-like projections, some of which are somewhat curved, and the pollen grain is held by these projections. The glutinous secretion of stigmas when it adheres to the feathers also helps to hold the pollen.

The trumpet honeysuckle (*Lonicera sempervirens*) is frequently pollinated by the humming-bird. The red flowers are collected in whorls, red on the outside and yellowish on the inside, without odor. The bird may be found around these flowers any time from June to September. The bird on the wing thrusts its beak into the flowers, going in as far as it can. Thus the pollen is dislodged, some remaining in its feathers, but at the same time some coming in contact with the stigma. This is not the only honeysuckle pollinated by this bird. I have seen many flowers of *Lonicera Sullivantii* in Wisconsin and Iowa pollinated by this active bird.

The orange-colored, irregular flowers of the spotted jewel-weed (*Impatiens fulva*) are much visited by humming-birds. A few years ago in one of the moist little ravines in a springy place near Steamboat Rock, Iowa, in the month of August, a large mass of these flowers attracted an unusual number of these birds. I could hear the peculiar buzzing noise of the dozens of these birds as they passed from the spurred sac of one flower to another. The flowers are orange yellow spotted with reddish brown, one petal forming a large inflated spurred sac. Our trumpet creeper (*Tecoma radicans*) is pollinated by the same birds while the South African *T. capensis* is pollinated by honey-birds. The tropical American sages *Salvia splendens* and *S. gesneraefolia*, according to Doctor Trelease, are pollinated by birds.

The common ruby-throated humming-bird is the active pollinator of the tropical American *Salvia splendens* and *S. coccinea* at Ames. The bracts and calyx lobes are colored and attractive. The flowers are purple in *S. coccinea*, scarlet and villous in *S. splendens*. The nectar rises in the tube and is secreted by the nectar glands below the ovary.

The plants of many families and genera like Rubiaceae, *Abutilon, Datura, Petunia, Passiflora, Tecoma* and some Cucurbitaceae of the dipper gourd types are pollinated by birds. In Brazil, according to Bates, humming-birds are found by the scores on the orange trees. They do not take the flowers serially but skip from one part of the flower to another. Our cultivated *Daturas,* like *Datura Wrightii,* are much visited by humming-birds.

The climbing *Marcgravia nepenthoides* produces its flowers in pendulous whorls. The flowers contain either stamens or pistils as they are dioecious. The bright colored bracts are cuplike and form a cluster beneath the flowers. These during the months of February and March contain a sweetish fluid when the plants are in bloom in Nicaragua. This sweet fluid attracts many insects and therefore birds come to get the insects. When birds go to these flowers for the insects and nectar they brush the stamens and in the pistillate flower they come in contact with the stigmas, on which the pollen is deposited.

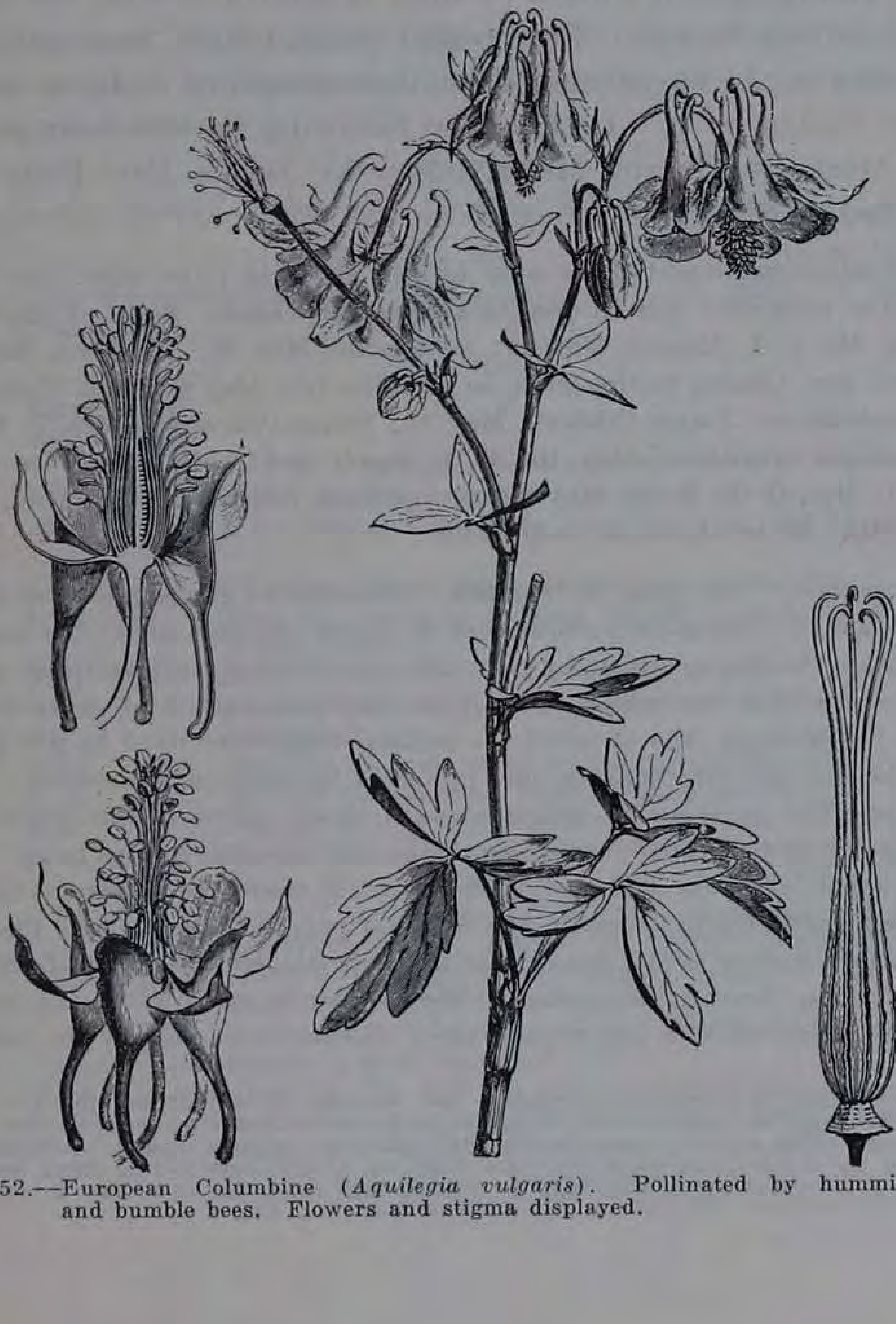

FIG. 452.—European Columbine (*Aquilegia vulgaris*). Pollinated by humming-birds and bumble bees. Flowers and stigma displayed.

The American columbine, frequently called honeysuckle (*Aquilegia canadensis*), is a typical humming-bird flower. The regular flowers have five sepals colored like the petals and produced backward into large hollow spurs. These contain the nectar, which is secreted in the fleshy tip of the spur.

Another early blooming humming-bird flower is the bluebell (*Mertensia virginica*). This has a regular corolla which is trumpet shaped, bluish in color, hanging in graceful racemes from the plant. The humming-bird is an active visitor and the blooming season, Miss King states, coincides nearly with the flight of the humming-bird in Iowa. It comes into bloom about eight to ten days earlier than the actual arrival of the humming-bird.

The humming-bird's flight in Iowa is correlated with the blooming of certain flowers. For several years I have been gathering some data on the appearance of the humming-bird in Iowa and the flowers visited by it. In 1930 the following reports were sent to me: Ames, Dr. Charles Murray, May 13; Boone, Carl Fritz Henning, Ledges State Park, May 20.

Many additional reports have come to me. Of these I can select only a few here. The remainder will be used in a later publication. Some of these are: Corning, Mr. C. L. Rogers, May 18; Centerville, Mrs. W. A. Brown, May 20; Fairfield, Mrs. Charles E. Goodman, on Siberian Iris, May 6; Louis Vieth, May 16; Marshalltown, Emma Caldwell, May 13; Velma Pearce and Mrs. T. LaRice on *Aquilegia canadensis*, May 19; R. E. Spadt and A. B. Hoover on tulips, May 19; Mrs. O. E. Hoag, May 20 on *Aquilegia vulgaris;* Mason City, H. J. Kassel, May 23, on *Aquilegia canadensis.*

Pelargonium.—This plant is frequently cultivated in greenhouses and during the summer for decorative purposes out of doors. It goes under the name of Geranium. The true geranium or cranesbill (*Geranium maculatum*) and related cousins are wild in our woods. One of the European species of geranium was studied by Sprengel, who observed the nectar, which is secreted by five glands at the base of the outer stamens and protected by hairs on the corolla.

The so-called geranium or pelargonium is closely allied to the cranesbill.[15] There are many cultivated forms, one of the very common species being *Pelargonium zonale* of South Africa. The colors in our cultivated forms are various. The flowers are slightly irregular. In the light purple flowered forms there are darker zones leading to the base of the upper petals, which overlap, forming a groove leading down to the nectary. The nectary is made up of the base of one sepal, which forms a long narrow tube. Nectar is secreted by the hairs on

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15 The flowers of *Geranium maculatum* are strongly proterandrous; the five outer stamens discharge their pollen over the center of the flower and afterwards the five inner do the same. The anthers commonly drop off before the stigmas expand. According to Robertson the flowers may be in the male stage for several days during rainy weather, but during warm and bright days they go through both stages the same day.

the lower side near the base of this tube. The flowers, as in the geranium, are proterandrous. The stamens maturing before the stigmas are in a receptive condition. Five stamens mature before the two shorter, which occur in front of the opening to the nectar tube. After the anthers dehisce the pistil lengthens, the stigmas spread out and are ready to receive the pollen. The pelargoniums out of doors in Iowa are frequently pollinated by humming-birds, in the Cape region of South Africa by honey-birds.

The Bee-balm (*Monarda didyma*), occurring from New England to Michigan and south to the Appalachian mountains, is adapted to the ruby-throated humming-bird. The stamens and styles are exserted beyond the straight upper lip of the corolla. The smooth corolla is nearly two inches in length, bright red, very showy. Although pollinated by long-tongued bumble bees and butterflies, the corolla seems to point to the adaptation of birds.

Miss Althea Sherman has furnished us with the following notes on flowers visited by humming-birds:

SUMMARY OF HUMMING-BIRD NOTES (From 1903 to 1930)

Taken by Althea R. Sherman at National, Iowa, a spot six miles from Mississippi river, latitude 43°.

Migration Dates

	Arrivals: Spring—First;	Average Date.	Departure: Latest;	Av. Date
	May 7	May 15	Oct. 3	Sept. 18
In Dane Co., Wisconsin,	May 10	May 17	Sept. 23	Sept. 18

By A. W. Schorger.

(Remarks)

Year	First seen	Last seen	
1903			July 28 a humming-bird searched tassel of cornstalk.
1904		9/19	Sept. 15. One searched a bunch of catnip.
1905	5/10		I was absent from home in spring and part of summer.
1906			
1907	5/14	9/17	This was year I began feeding humming-birds.
1908	5/12	9/7	May 14, one was feeding among gooseberry blossoms, smooth, wild.
1909	5/21	9/17	June 24 one was noted searching a clover blossom. This year in Monona six humming-birds frequented Howard's trumpet vine.
1910	5/22	9/22	Sept. 13, 14, one noted searching nasturtium blossom.
1911	5/22	9/20	May 22 one searched buds of black raspberry.
1912	5/7	9/13	May 13 and 14 humming-birds were seen searching apple blossoms; May 19, raspberry blossoms; May 21, wild currants; May 22, five female humming-birds hunt in blossoms of tame crab apples; May 28, among rose bushes; August 6, clover; August 22, catnip; August 27, phlox.
1913	5/12	9/28	May 14 one hunts in wild currant bush.
1914			Was absent entire humming-bird season.
1915		9/26	No humming-bird was seen until midsummer; August 3, catnip, August 28, jewel weed.
1916	5/17	9/30	June 15, 16, and 17, one searched "wax berry" blossoms; beginning August 24 for nine days 4 to 6 humming-birds haunted a half acre of red clover there being 4, 4, 5, 6, 4, 4, 3, 3 of tnem in sight at one time; Sept. 9 and 11, jewel-weed; Sept. 17 and 21, nasturtium.

1917	5/25	9/27	May 28 found many humming-birds in woods among blooming crab apple trees and Indian turnips; August 16 searches clover.
1918	5/14	9/2	May 27 a female humming-bird spent several hours searching buds of black raspberries and wild grapes; June 24 bloom of "wax berry."
1919	5/18	9/23	May 18 one was seen in an apple orchard.
1920	5/10	9/6	May 10 humming-bird here all day, visiting wild gooseberry blossoms (smooth variety of berry); July 21 one searched corn tassel.
1921	5/18	9/9	May 31 one searched clover, June 9 (tame) columbine, white.
1922	5/13	9/26	July 12 one searched seed onion in blossom; August 16, jewel-weed.
1923	5/14	9/15	June 4 one hunts among roses; August 29, 30, Sept. 6, 10 one found in neighborhood of blooming jewel-weed.
1924	5/13	9/18	August 10, 11, 12, two humming-birds and August 13, three in neighborhood of jewel-weed. Near by clover field four are busy.
1925	5/21	9/10	May 24 it was snowing, a humming-bird came to snowball blossom. June 26 one hunted in blackberry bushes.
1926	5/14	9/18	June 2 one searches black raspberry blossoms; August 25 to Sept. 18 visits tiger lilies and phlox.
1927	5/16	10/3	Aug. 28 last tiger lily fell yesterday, today a humming-bird came to the stalks expectantly. Sept. 10, 16 nasturtiums. Oct. 3 one appeared to search every pansy in bed.
1928	5/10	9/16	June 17 and 18 humming-bird was seen several times searching (tame) white columbine blossoms; July 27 searches "wax berry" bloom, August 1 to 28 one or two came daily to tiger lilies.
1930	5/24		May 24 a male humming-bird was searching black raspberry blossoms.

General Remarks

Above are given observations that chanced to be noticed at the time; such as a humming-bird hunting in the tassel of a cornstalk or blossom of a seed onion. The usual has not been noted, such as the humming-birds haunting blossoms of fruit trees, the wild gooseberries and wild grapes that are blooming when they arrive in May. To be accurate I went over records for twelve years and find more humming-birds have been present in August and September than in May, June and July, hence far more have been seen searching tiger lilies and phlox followed by nasturtiums, clover and jewel-weed.

Snail Pollinated or Malacophilous Flowers

Malacophilous flowers are not numerous. Snails can pollinate flowers only when they are easily accessible to them and the plants adapted to snail pollination are but few. The flowers of malacophilous plants usually have a longer blooming period than most of the entomophilous class. Some of the common characteristics of these plants are that they are closely crowded, the stigmas and anthers do not protrude very far out of the flower, so that snails may creep over them to take the pollen from the anthers, which adheres to the slimy, flattened part of the foot, and later leaves the pollen on the stigma. Delpino[16] made the earliest contribution on snail pollination. He states that *Rhodea japonica* is pollinated by *Helix*. The plant has a kind of spadix in which the flowers are arranged in a close uninterrupted spiral. The limb of the perianth is spread on a level with the tips of the anthers and stigmas. Delpino observed snails feeding on the spadix. After they had eaten about ten flowers they crawled to another spadix. He found that only those flowers on which snails had crawled were fertilized. Ludwig[17] states that *Philodendron pinnatifidum* is pollinated by snails and that the structure of the spadix and pollination agrees in many respects with that of *Rhodea japonica*. Self-fertilization does not occur. The pollen, he says, is transferred by snails.

Ludwig regards some of the duckweeds (Lemnaceae) as pollinated by snails. The floating fronds of *Lemna* are found in large numbers in close proximity to each other. *Lemna* is certainly hydrophilous, as was shown in a previous paragraph. As there stated, the plant is usually proterogynous. Ludwig states that *Lemna minor* in his locality, Greiz, Germany, is proterandrous. The structural details have been set forth in another connection. *Lemna minor* differs from other zoidiophilous plants in that the perianth is greenish and not colored. Ludwig says that the pollen grains are spiny with numerous protuberances, which undoubtedly points to a zoidiophilous character. The insects and snails that occur upon masses of *Lemna* remove the pollen grains and place them upon the concave side of the stigma.

Another aroid, *Colocasia odora*, is pollinated by snails. In the words of Hermann Mueller, "The spadix is covered in its whole length with normal and abortive stamens and pistils; only female flowers occur in the lower, wider part of the spathe, and they are mature only in the first period. From this chamber an attractive odor issues, and the snails are admitted by a narrow entrance. In the second stage this entrance closes, and the anthers dehisce. Snails which creep under the flowers at this stage vainly seek for the entrance, and dust themselves with pollen, which they afterwards carry to the stigmas of younger plants. Delpino supposes that the snails after effecting cross-fertilization are poisoned by an

16 Atti. della. Soc. ital. delle. sc. nat. Milano, 12:238-240. See also Kosmos. 6:34. 11; 347-351. Warming, Jahrb. f. Syt. 4:328, does not regard this plant as pollinated by snails, because of the rarity of snails in Lagoa Santa, the rarity of the plant in that vicinity and the time of blooming. The production of carbon dioxide gas in the flower is detrimental to snails.

17 Lehrbuch der Biologie d. Pflanz., 543.

irritant secretion within the chambers of the spathe, and are so prevented from devouring the flowers."

Warming[18] states that the water arum (*Calla palustris*) is pollinated not only by flies but also by snails.

Hermann Mueller observed snails pollinating *Chrysoplenium alternifolium*, a plant related to *Adoxa* and *Saxifraga*. The calyx has four or five lobes without petals; eight to ten very short stamens inserted on a disc. The two styles come from the middle of the flower, bending outward and capped by a smooth stigma. The styles are surrounded at the base by a broad, fleshy disc, which secretes the nectar. The four outer stamens mature first, then the others.

Hermann Mueller says, "Also, I find small snails, (young *Succineae*) upon many flowers, either creeping about or devouring the stigmas or anthers. In the slimy matter left upon the flowers, pollen grains could as a rule be recognized; in several cases I could distinctly see that pollen was placed upon a stigma by help of the snails."

Insect Pollinated or Entomophilous Flowers

Anton Kerner, in that delightfully written work on the Natural History of Plants, says, "If, however, mere casual observation of the relation between flowers and their insect visitors is sufficient to cause aesthetic pleasure, and has stimulated people of every age and nationality to the production of works of art, it may be imagined how great must be the incentive to scientific study supplied by a deeper insight into these phenomena, and what extreme pleasure is derived from the successful discovery of the reasons for these wonderful relations, and from tracing their connection with other facts of science."

Zoologists believe that the bodies of insects are developed for the special purpose of visiting certain flowers. It is equally true that flowers are correlated with the shape and habits of insects that visit these flowers. These insects vary from the small thrips, scarcely more than 1 mm. long, to our largest butterflies and the still larger ones of the tropics, whose expanded wings measure 15 cm. across. Such differences among insects must have some bearing on the pollination of flowers. We also find great diversity among the flowers as to size, odor and color. Beginning with the early spring

18 Botan. Tidisskrift, 1877. Knuth, Handbuch der Bluetenbiologie, 96, observes that *Calla maculata* is pollinated by snails.

flowers to those of late autumn there is a constant relation with the varied forms of insect life.

Neltje Blanchan says in the preface to the book "Nature's Garden," "Do you doubt it? Then study the mechanism of one of our common orchids or milkweeds that are adjusted with such marvelous delicacy to the length of a bee's tongue or of a butterfly's leg; learn why so many flowers have sticky calices or protective hairs; why the skunk cabbage, purple trillium and carrion flower emit a fetid odor while other flowers, especially the white or pale yellow night bloomers, charm with their delicious breath; see if you cannot discover why the immigrant daisy already whitens our fields with descendants as numerous as the sands of the seashore, whereas you may tramp a whole day without finding a single native ladies' slipper. What of the sundew that not only catches insects, but secretes gastric juice to digest them? What of the bladderwort, in whose inflated traps tiny crustaceans are imprisoned, or the pitcher plant, that makes soup of its guests? Why are gnats and flies seen about certain flowers, bees, butterflies, moths, or humming-birds about others, each visitor choosing the restaurant most to its liking? With what infinite pains the wants of each guest are catered to! How relentlessly are pilferers punished!"

How important insects are in the work of pollinating may be learned from the experience of those who have been unsuccessful in growing the seeds of certain plants. It is said that the bean crop failed in Nicaragua because the right kind of a bee to pollinate the flowers was absent. The early flowers of the scarlet runner (*Phaseolus multiflorus*) in our climate usually fail to set seed because of the scarcity of the right insect to pollinate them. Agriculturists do not generally obtain a profitable agricultural harvest of red clover seed from the first crop of clover because there are not enough bumble bees to pollinate the flowers. Seline Gaye states that in England the holly berries were scarce one year; now the holly flowers are chiefly pollinated by bees. That season the bees were remarkably scarce.

Reasons for attraction.—Why do insects go to flowers and of what advantage is it to the plant? Insects go to the flower because it offers food, nectar, pollen, or other nourishing substance. The insect must care and provide for its young. Plants would not long provide this food without some advantage accruing to them, hence we have reciprocal adaptations. Note as an illustration the adaptation in sage, clover, etc., or in certain nocturnal Lepidoptera that lay their eggs in the flowers of some pinks, as Soapwort. The larvae after hatching, feed on the young ovules and seeds. When mature they bite a hole through the side of the ovary and escape. These insects do not require all of the ovules. Shelter is another reason why insects go to flowers, as in Indian turnip, skunk cabbage, etc.

Attractive features.—The attractive features of flowers are most important for the insect. I think that no one can doubt that bright colors assist greatly in attracting insects. Not all insect pollinated flowers are of bright color. Many flowers that are pollinated at night are white, as in *Datura* and *Nicotiana*. Some night pollinated flowers are pink and other colors, as in *Phlox paniculata*.

Grant Allen says: "we can hardly resist the inference that the colored whorls represent an intensification of the natural tint in growing shoots and floral organs, slowly modified by the selective action of the insect eye." Mueller, who has carefully noted flowers and their insect visitors, observed 31 distinct visitors upon purple colored flowers of *Malva sylvestris* and only four on the small white flowered *Malva rotundifolia*. *Heracleum Sphondylium* had 118, *Aegopodium podagraria* 104, *Anthriscus sylvestris* 73, *Daucus Carota* 61, *Cirsium arvense* 88, *Centaurea Jacea* 48, *Tanacetum vulgare* 28. He says although it is impossible in statistical tables to take into account the various conditions which may modify the visits of insects, the general law holds good that the more conspicuous flowers are visited more frequently than others.

Mr. John H. Lovell in American Naturalist[19] says: "In the apetalous families of eastern North America there are 175 green, 89 white, 51 yellow, 45 red and 24 purple flowers. The 1217 polypetalous plants have 140 green, 410 white, 333 yellow, 84 red, 193 purple and 57 blue flowers. The northern Choripetalae, then, contains 315 green, 499 white, 384 yellow, 129 red, 217 purple and 57 blue flowers. Of the 92 families belonging to the Choripetalae, 47 contain green, 52 white, 45 yellow, 28 red, 49 purple and blue flowers. The much greater abundance of species and families with green, white and yellow colorations, as well as the less specialized structure of the flowers, points to these colors as more primitive or more easily developed than red, bright purple or blue. In certain genera, however, small dull red and purplish flowers are evidently derived directly from the primitive green."

Mr. Robertson well shows that: "Concealment of nectar, however, accomplishes one important result that cannot be accomplished by a change in time of blooming, and that is the simultaneous exclusion of flies and short-tongued Hymenoptera. The effect of concealment of nectar can only be ascertained by comparison with

19 American Naturalist, 35:140-145.

forms having free honey, and blooming at the same time with *Eryngium* and *Cicuta.*

"The first condition which seems to be a departure from the original is an aggregation of flowers in a more or less close cluster. In this case the lower lip loses its distinctive function both as a vexillary organ and as a landing place. Both offices are immediately assumed by the inflorescence itself. As long as the flowers remain separate they attract the insects, which are pleased by the special floral form and are adapted to it. But when the flowers become clustered they attract less specialized insects to what appears an undifferentiated color mass. In a similar way, separated flowers are only readily visited by insects to which the lower lip forms a convenient resting place. But when the flowers form a compact inflorescence, a landing place is formed by the flower cluster. Even when the floral structure remains the same, I always expect to find less specialized insects on the crowded flower."

The relation between conspicuousness and pollination of flowers is noticeable in some flowers, as in *Lysimachia vulgaris,* of which two forms occur, one in which the parts of the flower are larger and colored more intensely; in this case self-pollination rarely occurs; but a form which grows in shaded places has smaller and less conspicuous flowers and these are seldom visited by insects. An equally instructive case is afforded by the small heart's-ease (*Viola tricolor*). The species has two varieties. The large flowered variety with conspicuous flowers, variety *vulgaris,* which has given rise to our pansy, is frequently visited by bumble bees and other insects. In fact there is no occasion for self-pollination since insects carry pollen from one flower to another. The variety *arvensis,* on the other hand, is smaller and is a weed in gardens and fields. It is seldom visited by insects. Yet in both cases the spur of the lower petal contains the honey. *Rhinanthus crista-galli* variety *major* is abundantly visited by insects while the variety *minor* has few visitors. It follows from this that colors are important in pollination.

The dimorphic *Primula Parryi,* the most beautiful and attractive of all the Rocky Mountain flowers, also shows a color variation. The petals though persistent become more purplish when old. This change in color, it is thought, is developed to indicate to the insect that its services are no longer required. Be this as it may, it is interesting to know that color changes do occur. An insect attracted by colors or odors would lose no time after it reaches the flower to get the nectar. Many flowers are therefore characterized by producing certain marks which point toward the nectar, and as someone has said, "These marks are to the insect what the finger-post is to the wayfarer, guiding and directing him to his desired destination." These marks occur in the form of deeper colored portions of the petals, sepals, etc., lines or hairs on the surface of the corolla, stamens, etc. In the pansy these guides consist of lines that are colored blue or purple. On the rose colored petals of some flowers there are a number of black rings, lines, etc.

Fritz Mueller goes on to say: "According to Delpino the changing colors of certain flowers would serve to show the visiting insects the proper moment for effecting the fertilization of these flowers. We have here a *Lantana*, the flowers of which last three days, being yellow on the first, orange on the second and purple on the third day. The plant is visited by various butterflies. As far as I have seen the purple flowers are never touched. Some species inserted their proboscis both into the yellow and orange flowers (*Danais archippus, Pieris rapae*). Others, as far as I have hitherto observed, exclusively into the yellow flowers of the first day (*Heliconius apseudes, Colaenis juli, Eurema leuce*). This is, I think, rather an interesting case. If the flowers fell off at the end of the first day inflorescence would be less conspicuous; if they did not change their color much time would be lost by the butterflies by inserting their proboscis in the already fertilized flowers.

In another *Lantana* the flowers have the color of lilac, the entrance of the tube is yellow surrounded by a white circle; these yellow and white markings disappear on the second day."

Color variations.—Changes in colors of different species must be of advantage. Take a meadow in which here and there occur groups of yellow flowered meadow parsnip (*Zizia*), a little distance away is the scarlet painted cup (*Castilleia coccinea*). In late summer the white flowers of spotted cowbane (*Cicuta maculata*), *Sium lineare*, and a group of yellow flowered goldenrod (*Solidago Missouriensis*) are contrasted and the wild yellow lily (*Lilium Canadense*) is wholly unlike the purple fringed orchis (*Habenaria psychodes*). The change in colors is often conspicuous in closely related species, especially in similarly modified flowers like *Phlomis, Lamium, Salvia, Delphinium, Aquilegia* and *Aconitum*; these species usually bear violet, blue, pink or purple flowers. But when these are visited by the same class of insects and grow in close proximity variation in color in flowers of the same species insures with more certainty visits of insects. Our species of *Monarda* show this color change beautifully. *Monarda didyma* is bright red, *M. mollis* is rose color varying to white, *M. Bradburiana* is pale purplish white, *M. punc-*

tata is pale yellowish. Some of our violets are blue, some are white, others yellow. The cardinal flower (*Lobelia cardinalis*) is bright cardinal, great lobelia (*Lobelia siphilitica*) is blue. It is true that these flowers do not always occur in the same place, yet in some cases they are adapted to the same general class of visitors and it must be of some advantage to have a contrast in colors. The matter of color variation is important where these species grow together. There are wide stretches in this country where only one *Monarda* grows, as in Iowa and northward and in the Rocky mountains, as in the case of *M. mollis*. In Missouri and southern Illinois this species grows with *M. Bradburiana*. The time of blooming of the two species is different, and therefore they do not compete for the same class of visitors.

It is noteworthy also that some species under different conditions show changes in color of flowers. Kerner von Marilaun cites a species of *Campanula* (*C. Trachelium*) which has white flowers in the neighborhood of Brenners, Austria, but in the valleys of the limestone Alps the flowers are blue. The alpine flora of the Rocky mountains is remarkable in showing changes in the colors of flowers from one altitude to another. In the higher Rocky Mountain region, especially between ten and twelve thousand feet, there are great masses of *Castilleia pallida* var. *septentrionalis*, running into several distinct forms that show a great range in color from scarlet to lavender and red. In northern Wyoming in the Big Horn mountains one cannot help noticing the deeper purple color of *Monarda fistulosa* at 6,000 feet than it has at an altitude of 3,500 feet in the Sheridan basin along Goose creek. *Prunella vulgaris* at 4,500 to 5,000 feet is much darker in color than in the lowlands.

FIG. 452.—Labiate flower. Horse mint (*Monarda mollis*). Flowers in clusters. Pollinated by bees. In Iowa the flowers are pale in color. The Rocky Mountain *Monarda fistulosa* varies in color.

The genus *Delphinium* is remarkable in showing color variations. A large larkspur, common everywhere in Iowa, is described as having blue flowers, but the form commonly found at Ames, Iowa, and LaCrosse, Wisconsin, is whitish with occasionally a slight tinge of blue. Another species, *D. tricorne*, which occurs in southern Iowa usually has blue flowers, but on the limestone cliffs at Glencoe, Missouri, only white flowers occur. I was therefore agreeably surprised to find that in the great American bottom opposite St. Louis near Falling Springs, in deep rich woods, a beautiful pink form occurred.

The mandrake (*Podophyllum peltatum*) usually has white flowers. The writer has observed near Ames, over an area of a rod square, flowers striped with red.

Our painted cup (*Castilleia coccinea*) usually has red flowers, but at Madison, Wisconsin, where I noticed the plant for several years in a swamp, the yellow flowered form occurred. Mr. Warren Upham, however, states that in some years in Minnesota upon districts ten to twenty miles in extent the flowers are yellow, elsewhere scarlet with occasional yellow flowers intermixed.

Often, even in Iowa, closely related species with different colored flowers are found. A notable illustration is the clover, white, red and alsike.

On June 11, 1930, at Ames, the writer had occasion to observe many honey bees for half an hour on two species of the legume family growing in close proximity to each other. One was the common white clover and the other the yellow sweet clover. With rare exceptions a particular bee confined its visits to one species of plant. One bee from the dozens seen went from the white clover (*Trifolium repens*) to the yellow sweet clover (*Melilotus officinalis*) but thereafter confined its visits to the yellow sweet clover.

In June, 1929, similar observations were made in three species of clover (*Trifolium repens, Trifolium pratense*, and *Trifolium hybridum*) and white sweet clover (*Melilotus alba*). There can be no question that difference in color is an important factor for bees.

Color changes.—In our common bell-flower (*Mertensia virginica*) and the Rocky Mountain *M. sibirica* the flowers at different stages are variously colored. The buds are reddish, when the flowers open they are violet, when fertilization has taken place they change to blue. This peculiarity of changing color after fertilization occurs in many flowers, like Missouri currant (*Ribes aureum*), cotton (*Gossypium herbaceum*), horse-chestnut (*Aesculus Hippocastanum*), buckeye (*Aesculus glabra*), etc.

Nectar and nectaries.—Let us briefly consider nectar. This is a sweetish fluid secreted by certain parts of the plant. It has been defined by Doctor Trelease in a splendid paper as follows: "Fluid always, usually sweet, often odorous, which is elaborated in any part of a plant, remaining where formed or making its way to some other part; its *raison d'aitre* being the necessity for the removal of some useless or injurious substance, or for some provision to attract nectar-loving animals to the plants for some definite purpose.''

Nectar glands have been divided into floral and extra-nuptial:

Floral nectaries	Receptacle
	Pistil
	Stamen
	Corolla
	Calyx

FIG. 453.—Cotton (*Gossypium herbaceum*). Flowers change color, at first creamy white then reddish. 1, a plant with flowers and leaves; 2, a cotton boll; 3, seed. *Strasburger, Noll, Schenck and Schimper.*

Extra-floral nectaries	Calyx
	Ordinary bracts
	Specialized bracts
	Involucre
	Peduncle
	Leaf

The family Ranunculaceae is interesting as regard the secretion of nectar. The meadow rues (*Thalictrum*) are anemophilous and do not secrete nectar. Hepatica apparently does not secrete nectar. Mr. Robertson thinks some nectar is secreted here though he could not detect any. Hepatica certainly emits some odor and insects act as though they were obtaining some nectar. In buttercups (*Ranunculus septentrionalis, R. Flammula* and others) the nectar is secreted by little scales at the base of the petals. In the pasque flowers (*Anemone patens* var. *Nuttalliana*) the nectar is secreted by the rudimentary stamens. In some species of clematis the honey is secreted by the basal half of the filament. In marsh marigold (*Caltha palustris*) the nectar is secreted by the pistils. In the columbine (*Aquilegia canadensis* and *A. caerulea*) the nectar is secreted by a fleshy thickening at the end of the petal. In larkspur (*Delphinium azureum, D. scopulorum* and others) the honey is secreted by the two upper petals, which are spurred and enclosed by the spur of the calyx. In monk's hood (*Aconitum columbianum*) the posterior petals are developed into nectaries. In the mint family (*Labiatae*) the nectar is secreted by a disc-shaped gland under the

FIG. 454.—To the left, I, Hellebore (*Helleborus viridis*): II, Columbine (*Aquilegia vulgaris*); III, Violet (*Viola odorata*); a, anther, n, nectary, h, enlarged connective. To the right, I, Parnassia (*Parnassia palustris*); II, Nectary enlarged, k, glandular process, s, nectary, n, where the nectar is secreted, f, stamens. *Behrens.*

deeply four-lobed ovary; the nectar secreting tissue is easily made out in *Salvia lanceaefolia*, a common plant in western Iowa. It is also easily made out in horse mint (*Monarda fistulosa*) a common plant everywhere in Iowa. In many of the Boraginaceae the nectar is secreted by the fleshy base of the pistil, as in *Borago officinalis*, the nectar being retained by a short tube formed by the fleshy base of the ovary. In toadflax (*Linaria vulgaris*) the nectar is secreted by a prominent enlargement at the base of the ovary. After the secretion of the nectar it passes down a smooth, narrow groove which is lined by short, stiff hairs, and thence to the tip of the spur. In the sunflower family (Compositae), like *Helianthus, Achillea*, dandelion (*Taraxacum officinale*) and others, it is secreted by a ridge which surrounds the base of the style. After its secretion it rises up into the tube of the corolla and is made accessible to short-tongued insects like the honey bee.

In the simple entomophilous willows the nectar is secreted by a gland at the base of the bract. The willows are abundantly visited by Hymenoptera and Diptera.

In the pulse family there is some variation. Partridge pea (*Cassia Chamaecrista*) secretes no nectar. In red clover the nectar is secreted by the bases of the stamens and is contained in the tube formed by the united filaments of the diadelphous stamens.

In the Rosaceae, like *Pyrus ioensis*, the nectar is secreted by the calyx tube, to which the stamens are attached, being found between the ends of the filaments. In *Rubus villosus* nectar is secreted by the flattened disc between the pistil and the filaments.

Extra-floral nectaries.—The extra-floral nectaries occur outside the flower and are produced usually to keep unbidden guests out of the flowers.

Doctor Trelease observed certain sand wasps belonging to the genus *Elis* within the flower of the cotton plant. They did not feed on the pollen but instead of collecting this substance "they were exploring with their tongues the cavities between petals," the extra-floral nectaries. As the flower does not contain nectar and as the insects were constant in their visits he inferred that the viscidity of hairs was caused by the exudation of true nectar. In the common maypop (*Passiflora incarnata*) there occur at the base of every flower several bracts, each bearing two large nectar glands. Very little nectar is secreted and yet ants are common. The writer has often observed that ants, wasps and other insects are frequent visitors to the extra-floral nectaries of the common cow pea. These are described thus by Doctor Trelease:[20] "At the summit of each peduncle are several small crater-shaped circumvallate glands which secrete until the fruit is well advanced toward maturity as well as during the flowering period. Occupying as they do, the very end of the peduncle, they are beyond the clustered flowers of the seed vessels."

The writer has observed extra-floral nectaries on the leaves of certain species of paeonies which are visited by certain ants. In many cases these extra-floral nectaries are produced to protect the flowers from ants, which are universally destructive to flowers.

Nowhere are the contrivances to protect flowers from ants so numerous as in the tropics. Many naturalists, beginning with John Ray, 1686, had observed the extra-floral nectaries. Sprengel observed that ants were attracted by the extra-floral nectaries on *Vicia sepium*. Belt and Delpino, about the same time, in 1874, suggested the use of these extra-floral nectaries. In a classical work on the subject Delpino gave many illustrations of these protective nectaries. There are many illustrations in plants to provide for their protection and likewise many illustrations of how ants protect aphids.[21]

Some of the families in which these extra-floral nectaries have been found are as follows:

Buttercup (Ranunculaceae)	Mallow (Malvaceae)
Passion flower (Passifloraceae)	Marcgravia (Marcgraviaceae)
Pulse (Leguminosae)	Rose (Rosaceae)
Madder (Rubiaceae)	Sunflower (Compositae)
Smartweed (Polygonaceae)	Orchids (Orchidaceae)
Palms (Palmae)	Spurges (Euphorbiaceae)

20 c. 325.

21 See Delpino. Funzione mirmecfila nel regno vegetal, 1886-1889. While ants are destructive to flowers they are serviceable in destroying the larvae of many insects. The Chinese carefully protect ants in their orange orchards. Forel estimates that a single nest of ants destrcys 100,000 insects in a single day and Ratzburg regards them as the police of the forests. The abundance of ants in the west, especially in wood, forest and plain, is enormous. Were it not for these ants other insects would be much more abundant.

In the Rocky Mountain region many trees contain myriads of ants that protect aphids. Some years ago the writer observed on the leaves of trees like *Populus angustifolia* and *Negundo aceroides* myriads of aphids and ants. The sidewalks in the streets of Evanston, Wyoming, and Salt Lake City, Utah, were covered in many places with the sweet exudate from these aphids. On touching the ants they fiercely resented intrusion. The writer has observed similar conditions as to honey dew with the box elder, oak, elm and maple at Ames.

A total of 3030 species in 292 genera are recorded by Delpino. Of these 563 are in America; 310 in the Indo-African region; Missouri region, 42; Siberian European region, 35; Australia, 61; the remainder scattered in other parts of the world. The greatest number occurs in the pulse family (*Leguminosae*), closely followed by the Spurge family (*Euphorbiaceae*).

Belt[22] in his "Naturalist in Nicaragua" describes the extra-floral nectaries of *Marcgravia nepenthoides* as follows: "The flowers are disposed in a circle hanging downward like an inverted candelabrum, from the center of the circle of flowers is suspended a number of pitcher-like vessels, which when the flowers expand in February and March are filled with a sweetish liquid, the nectar being secreted inside a kind of pouch, passing to the surface by the way of two pores." Anyone familiar with the common castor oil bean (*Ricinus communis*) has observed the pair of glands underneath the peltate leaves of this plant, and also other glands farther down on the petioles. These glands secrete a liquid that attracts insects and on any pleasant day the ants may be observed on the castor oil plant. The extra-floral nectaries of choke cherry are well known.

Odors of plants.—Odors in flowers are due largely to the presence of nectar, but some flowers have odors without nectar. A bunch of hepaticas often produces a decided odor, but there is no visible nectar.

The odors of flowers have been divided into five groups: (1) Indoloid, (2) aminoid, (3) benzoloid, (4) terpenoid, and (5) paraffinoid.

(1) The indoloid odors are frequent in aroids, stapelias, aristolochias and some orchids. These carrion-like odors are attractive to insects that feed on carrion, like some flies and beetles. The flowers have livid spots and reddish brown veins.

(2) The aminoid odors are closely related to the above, and are derived from the amido derivatives in which one, two or three parts of the water in the ammonia is replaced by the alcohol radical. These occur in hawthorn (*Crataegus*); the odor here is due to trimethylamine. It is similar in the flowers of the pear (*Pyrus communis*). Somewhat different is the odor in manna ash (*Fraxinus Ornus*), horse chestnut (*Aesculus Hippocastanum*), tree of heaven (*Ailanthus*).

(3) The benzoloid odors are derived from the aromatic bodies and occur in various species of *Dianthus*, in *Asperula odorata*, lily of the valley (*Convallaria majalis*), *Heliotropium*, *Reseda odorata*, etc. From this class one might distinguish special odors as in heliotrope, violet, vanilla, etc. It is also noteworthy that the same odors occur in plants distantly related. Carnation

22 The Naturalist in Nicaragua, 128.

odors occur in some orchids as *Platanthera*, also in *Orobanche*, Missouri currant (*Ribes aureum*), narcissus (*Narcissus poeticus*).

(4) The terpenoid group comprises the etherial oils but more properly terpene; these occur at times in certain glandular hairs or other parts of the plant, seldom in parts of the flower, but the odor of citrus flowers belongs here, also that of certain species of magnolia (*M. Yulan*), artillery plant (*Dictamnus fraxinella*).

(5) The paraffinoid odors occur in *Valeriana officinalis, Ruta graveolens*, grape (*Vitis vulpina*) and honey locust (*Gleditschia triacanthos*). The odor from newly filled honey combs is allied to some of the odors that belong to this group, as buckwheat, white and other clovers.

In the hawthorn (*Crataegus mollis*) the odor is distasteful to many and is readily perceived when the flower is past its prime. Many other species, as the black cherry (*Prunus serotina*), produce a similar odor.

The idiopathic odors of the common elder (*Sambucus canadensis*) are quite pronounced and are easily recognized for some distance. They are rather distasteful to honey bees though they do sometimes visit the flowers in spite of this.

Another classification of odors has been prepared by Delpino[23] who in 1873 distinguished two great groups, the Sympathic and Idiopathic, which he arranged in five classes: Sweet, Aromatic, Fruity, Unpleasant, and Nauseous.

This classification, with illustrations, is given in Knuth's Handbook (English Translation), with many subdivisions as follows:

A. Sympathic Odours

Class I: Sweet Odours

1. Jessamine—*Jasminum grandiflorum.*
2. Narcissus—*Narcissus Jonquilla.*
3. Mignonette—*Reseda odorata.*
4. Hyacinth—*Hyacinthus orientalis.*
5. Lily—*Lilium candidum.*
6. Nuphar—*Nuphar luteum.*
7. Spartium—*Spartium junceum.*
8. Violet—*Viola odorata.*
9. Honey-and-wax—*Symphytum officinale.*
10. Hawthorn—*Crataegus oxyacantha.*
11. Ambrosial or rose—*Rosa moschata.*
12. Balsam—*Gladiolus viperatus.*
13. Hay—*Dracaena fragrans.*
14. Orange or Lemon—*Citrus medica.*
15. Musk—*Hoya viridiflora.*
16. Acacia-odour—*Acacia Farnesiana.*
17. Coryanthes—*Coryanthes macrantha.*

Class II: Aromatic Odours

18. Carnation—*Dianthus Caryophyllus.*
19. Vanilla—*Heliotropium peruvianum.*
20. Cinnamon—*Maxillaria aromatica.*
21. Nutmeg—Anonaceae.
22. Laurel—*Ilicium religiosum.*

23 'Ult. Ass., 'Alli. Soc. ital. sc. nat., Milano, XVI, 1874.

Class III: Fruity Odours

23. Banana—*Magnolia fuscata.*	25. Pineapple—*Victoria regia.*
24. Apricot—*Plumeria alba.*	26. Turnip—*Cereus Napoleonis.*

B. Idiopathic Odours

Class IV. Unpleasant Odours

27. Elder—*Sambucus nigra.*	34. Poppy—*Papaver Rhoeas.*
28. Goat—Species of *Elaeagnus.*	35. Tobacco—*Aristolochia gigas.*
29. Bug—*Rosa Eglanteria* and *laxa.*	36. Rhodea—*Rhodea japonica.*
30. Beetle—*Cornus paniculata.*	37. Pea—*Gonolobus hispidus.*
31. Bitumen—*Iris viscaria.*	38. Fig—*Ferraria undulata.*
32. Onion—*Pothos foetida.*	39. Fermentation—*Asimina triloba.*
33. Rue—*Aristolochia Bonplandi.*	

It is especially important from our point of view to recognize that some flowers produce several kinds of odors. Some plants, though closely related, have entirely different odors, e.g., *Daphne alpina,* vanillin; *D. Philippi,* violet, and *D. Balgayana,* carnation. Kerner von Marilaun says anyone who is familiar with the genus *Rosa* will recognize with closed eyes, such species as *alpina, pimpinellifolia, arvensis, indica, moschata, canina, gallica,* and *cinnamomea* by their odors.

Professor Charles Robertson of Carlinville, Illinois, has published a highly instructive paper on the philosophy of flower seasons. The insect orders which contain what may properly be called flower loving groups, viz., the Hymenoptera, Diptera and Lepidoptera, are the most highly specialized. The particularly anthophilous groups we have observed to have their maxima in the late summer, with the exception of the bees, which are true flower insects, depending upon flowers and showing true mutual correlations. The flight of these insects may be more properly regarded as determined by conditions favorable for their young. Flowers and flower groups blooming at times favorable for utilizing them should be regarded as correlated with the time of flight of the insects, and not vice versa. Of the bees he has observed that the most highly specialized (Apidae) show late maxima while the less specialized (Andrenidae) show an early maximum, which is explained largely as a result of competition of the former. In view of the fact, therefore, that the most highly specialized flower insects are most abundant in late summer, it is but natural that there should also be a preponderance at the same time of the most highly specialized flowers, whose development has been simultaneous with them. In so far as it applies to insect-pollinated flowers I think we have here the answer to Mr. Clark's question, "Why should there be a correspondence between the course of the flower seasons and the system of floral evolution?"

INSECT POLLINATORS

In order to understand the wonderful adaptations between insects and flowers it will be necessary to consider the structure of certain parts of insects. Insects have been divided into several orders. In point of importance they may be arranged as follows:

Hymenoptera, the bees.
Lepidoptera, the butterflies and moths.
Diptera, the flies.
Coleoptera, the beetles.
Hemiptera (Rhynchota), the bugs, aphids and cicada.
Orthoptera, the grasshoppers, crickets and locusts.
Neuroptera, the dragon flies, Aphis lions (now divided into many orders).

The insects may be briefly discussed, beginning with those of little importance, the Orthoptera and Neuroptera.

ORTHOPTERA AND NEUROPTERA

Hermann Mueller[24] says in speaking of these insects: "These groups contain, at least among our native species, no form which is habitually anthophilous or which shows any trace of adaptation for a floral diet." The earwigs often creep into such flowers as poppy, nasturtium (*Tropaeolum*), roses, etc., and feed on the softer parts of the flowers at night. Grasshoppers are frequently found upon various plants and occasionally feed upon the flowers. They do not usually pollinate flowers, except accidentally. Darwin[25] states that in New Zealand several species of grasshoppers pollinate some papilionaceous plants. A few other orthoptera have been known to visit flowers in some cases where the nectar is more deeply seated. It is quite exceptional for Neuroptera to visit flowers and Hermann Mueller says "certainly no native flower has been modified by the agency of either group."

HEMIPTERA

The group Hemiptera has been variously subdivided by modern authors. The Hemiptera in the broader sense includes several orders. They are somewhat more highly developed than the Orthoptera and Neuroptera. Several forms are anthophilous. Her-

24 The Fertilization of Flowers, 30.
25 Ann. and Mag. of Nat. Hist, III, 2:451.

mann Mueller[26] says: "The species of *Anthocoris* (so-called from their fondness for flowers), are fitted by their small size to creep into and suck honey from various flowers. I have seen no structural adaptations for floral visits in any of these insects unless the small size of *Anthocoris* be of this nature; the long proboscis is found in many allied forms which never visit flowers. No flower has been shown to be especially adapted for the visits of field bugs, and I know no species for whose pollination these insects are especially important. The structure of their proboscis need not be considered."

COLEOPTERA

Some of the Coleoptera are certainly much more highly specialized than the Hemiptera, Orthoptera, and Neuroptera, and in some cases there are certainly adaptations to a floral diet. They are much more important than the preceding division since many species of different families get their food exclusively from the flower. In flowers where the nectar is fully exposed, as in the order Umbelliferae, "beetles may be seen licking the honey" and even where the nectar is concealed beetles may be seen feeding upon the nectar and consuming or eating the pollen.

Beetles in some cases show adaptations to utilize nectar and pollen, but there is a very marked difference in species and suborders. "None of our native plants," says Hermann Mueller, "are fertilized exclusively or mainly by Coleoptera." The beetles of the large genus *Meligethes*, which are small insects and can creep into most flowers, are of much importance in pollinating flowers. In flowers where the honey is exposed (*Cornus*, etc.) many species of beetles lick the honey. In flowers like plantain (*Plantago*) where the honey is concealed, beetles feed upon pollen. Tropical and subtropical beetles have in some cases excellent adaptations for obtaining nectar. Fritz Mueller observed a species of Nemognatha[27] sucking the flowers of *Convolvulus* in Brazil. The maxillae when opposed form a tube like the proboscis of a butterfly, which is, however, not capable of being rolled up.

The order of Coleoptera is thus of special interest, as affording us the first tendency of insects towards floral diet, and the first corresponding modifications. We see how, in the most diverse families, accustomed to widely varying nourishment, single species have become habituated, first partly, then exclusively, to a floral diet, and that then, by natural selection, structural changes have developed

26 L. c., 31.

27 l. c., 32.

to insure greater success in the search after food, and we can learn how a dependence on flowers has sprung up at different epochs of time, for in some beetles there has been time for the attainment of adaptations, and then for their divergence to form genera and families, while others, which have acquired the habit later, remain isolated anthophilous species among near allies which never resort to flowers.

FIG. 455.—The positions of insects in flowers. To the left, bumble bee (*Bombus hortorum*) in the flower of white dead nettle; upper middle figure, bumble bee on the flower of horse chestnut; lower middle figure, honey bee in the flower of violet; right hand figure, beetle on the flower of tway blade (*Listera*). *Behrens.*

Our large and beautiful evergreen *Magnolia foetida* of the southern states is adapted to pollination by rose beetles. In magnolia there are three sepals and six to nine white petals. The flowers are very fragrant. The beetles find shelter beneath the three inner petals that come over to the stigma. In addition to the warmth these insects receive they obtain the nectar that is found between the stigmas. The insects remain here until the petals or sepals fall off and then they fly to another flower. The anthers mature somewhat later than the stigmas. Self-fertilization is prevented because the flowers are proterogynous. The beetles go from a younger to an older flower, causing cross-fertilization.

Magnolia acuminata, the cucumber tree, native from western New York to Illinois and southward, is occasionally cultivated in southern Iowa. It produces oblong bell-shaped yellowish green flowers. This species is likewise adapted to beetles.

The parsnip (*Pastinaca sativa*), which is closely allied to *Heracleum*, has 375 visitors, of which Mr. Robertson[28] records 40. He says: "In the same year I discussed the question in connection with Umbelliferae, enumerating the visits of 40 species of beetles to the flowers of *Pastinaca*, which is only twice as many as Mueller ever found on any Umbelliferae."

"Two effects upon the insect visitors have been attributed to the dull yellow colors of *Rhus*. Mueller says that *R. Cotinus*, like all other flowers of a dull yellow color, is almost completely avoided by Coleoptera. The general proposi-

28. American Nat., 36:499. Bot. Gaz., 22:160. Trans. Acad. Sci. St. Louis, 5:454.

tion is denied by Bonnier and Schultz says that it is not true for *R. Cotinus* in the Tyrol, where he found many beetles among the visitors. *Pastinaca*, on which I have taken forty species of beetles, is mentioned by Mueller as an example of the same kind.''

In *Rhus glabra* the flowers are greenish yellow, as they are also in *R. canadensis*. In both cases the petals are short, the nectar, which is quite freely exposed, being secreted by five orange-colored glands between the bases of the filaments. The Canadian *Rhus*, *R. canadensis*, is polygamous. The stamens in the pistillate flowers are apparently normal, somewhat reduced in size, but produce no pollen.

FIG. 456.—Diptera, pollinating insects; to the left the bumble-bee fly (*Bombylius major*), frequently found on red clover; middle figure (*Empis livida*); to the right syrphus fly (*Syrphus*) found on the parsnip. *Behrens.*

DIPTERA, FLIES

FIG. 457.—An aroid (*Arum concephaloides*), front part removed. Pistillate flowers between, staminate flowers in a ring above. Flies are the pollinators. *Kerner-Oliver.*

So far as diet and visitation are concerned the flies are very important in the pollination of flowers. Many of these species depend on nectar and pollen. Their adaptations are such as to allow them to collect these foods. *Rhingia* and *Eristalis* have a complicated mouth structure. The bee-flies are also provided with a complicated sucking apparatus. In flying they carry their proboscides forward and ready for action. They have the power of detecting concealed nectar in flowers in a most marked degree. Thrips enter all sorts of flowers, which they are enabled to do on account of their small size. They feed on both pollen and honey.

Aristolochiaceae.—We have but a single species of this family native to Iowa, the wild ginger (*Asarum canadense*). The stem of this plant is more or less prostrate, bearing the soft pubescent kidney-shaped leaves. The plant flowers early in May in the latitude of Ames. The solitary perfect apetalous flowers are frequently hidden under the leaves. The calyx is three-parted and brown. When the flower first opens the six radiating stigmas are mature (proterogynous); when the stigmas have withered the twelve stamens are ready to discharge their pollen. As only one flower is developed from a single rootstock, cross-fertilization must be brought about. I have seen only Diptera go to the flowers; they are repaid by the ample supply of food and shelter that the flower affords.

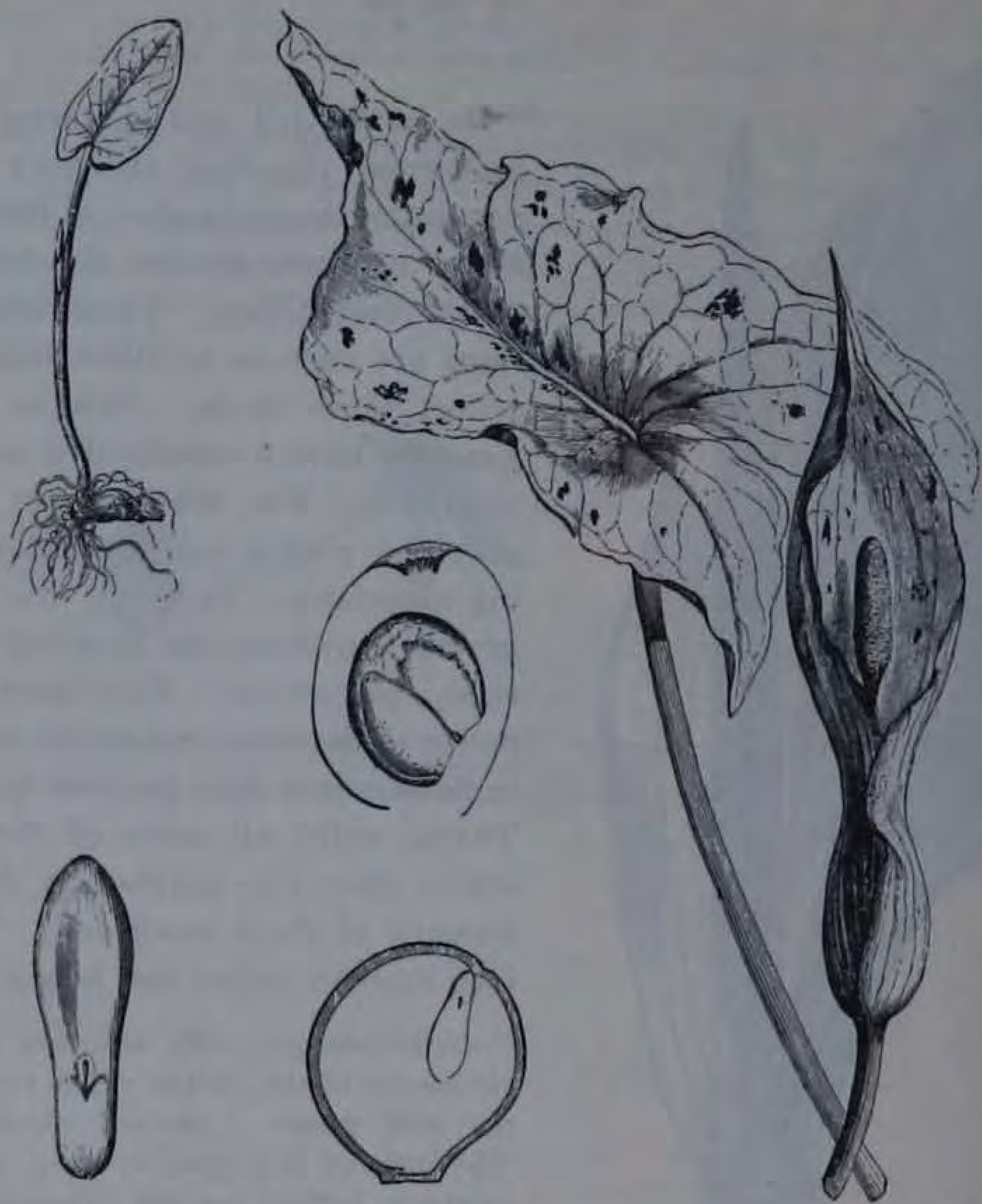

FIG. 458.—Common European Arum, Cuckoo-pint or Wake-robin (*Arum maculatum*). Pollinated by flies. Leaf; spadix; longitudinal section of ovary; upper left, young plant; longitudinal section of seed; embryo. *After Faguet.*

None of the American species of *Aristolochia* is native to the state although *A. Sipho* is hardy and not infrequent under cultivation. The species blooms in May. The yellowish green calyx is tubular, spreading out into purplish lobes curved like a dutch pipe, hence the common name Dutchman's pipe. The flower has six stamens adnate to the calyx, in pairs under the three lobes of the short, thick stigma. The flowers are proterogynous. Insects easily enter through the small opening but cannot escape because the hairs point downward. On going into the flower they leave some of the pollen on the fleshy stigma and later the stigma withers. Many of the imprisoned flies perish, some of them, however, remain in the flower feeding on the nectar. When the stigmas with the anthers mature they shed their pollen on the imprisoned guests, the hairs relax and the insects find egress easy. They enter a younger flower and leave some of the pollen on the stigmas. The European birthwort

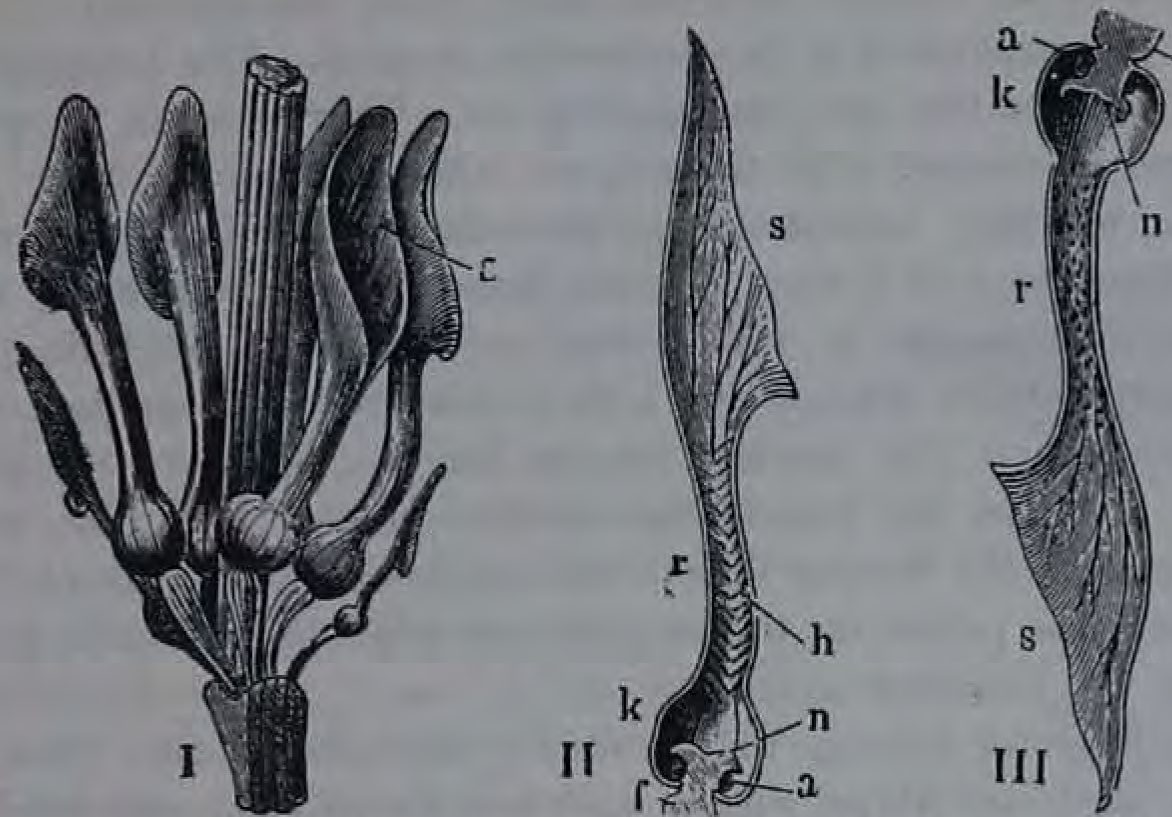

FIG. 459.—Fly pollinated. Birthwort (*Aristolochia Clematitis*). 1, inflorescence; 2, transverse section of flower before pollination; 3, after fertilization; s. throat; r. tube; h. hairs; k. expanded part of calyx; n. stigmas; a. anthers. *Behrens.*

(*Aristolochia Clematitis*) is pollinated by small flies. The yellow flowers are arranged in whorls. The long tubular flowers consist of a wide funnel-shaped throat and a long and narrow tube which is lined with stiff hairs. The lower part is enlarged and contains the stamens and part of the pistil. In *Aristolochia ringens* the calyx has developed a lower and upper lip. In the birthwort there is a flattened expansion which serves as a resting place for insects. The colors as well as the disagreeable odor make these flowers attractive to certain kinds of insects. Flies find no difficulty in going into the flower, since the

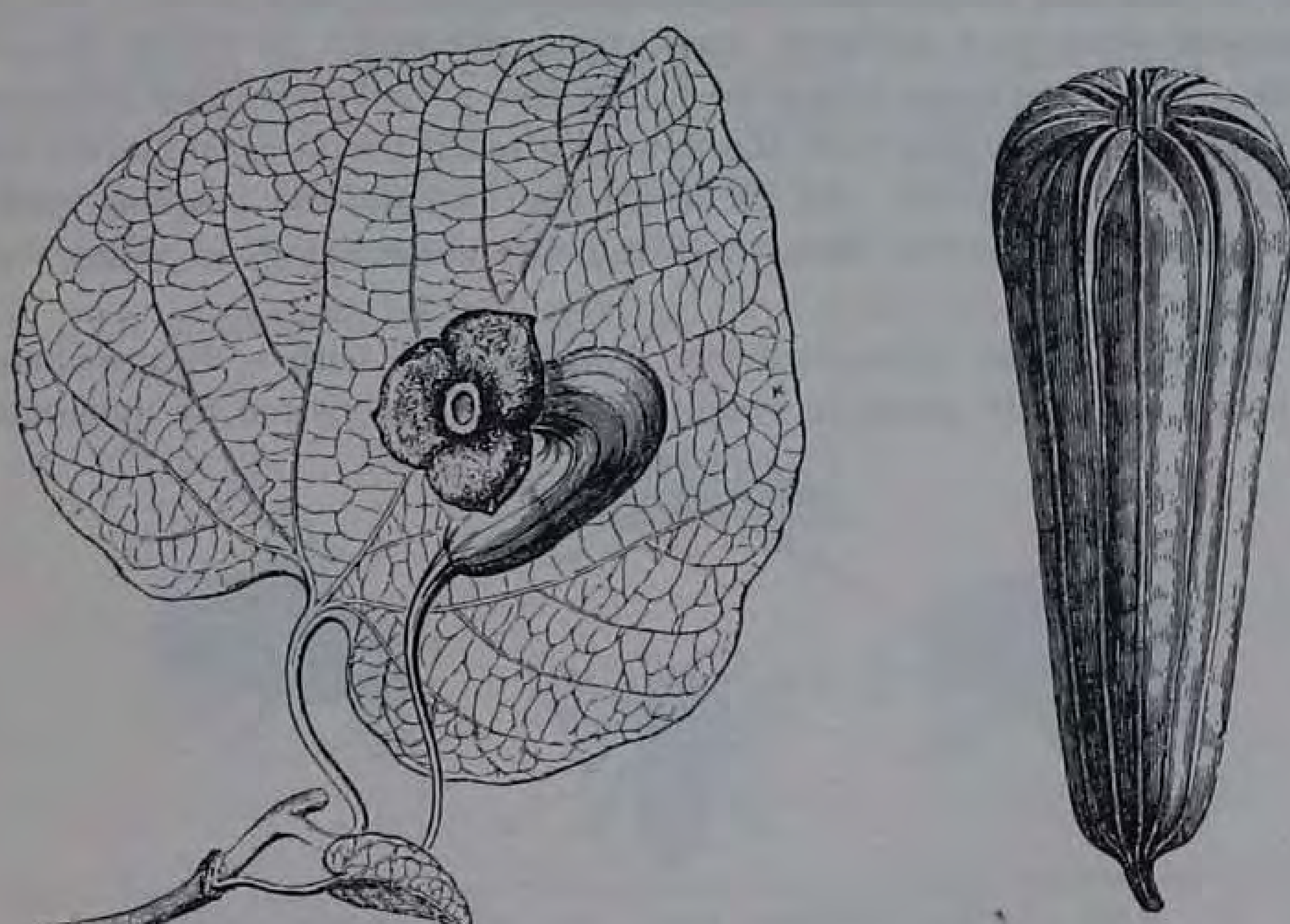

FIG. 460.—Flower and fruit of *Aristolochia*. Pollinated by flies.

hairs all point in an oblique direction away from the opening. When the insect reaches tne expansion it is confortably housed. The temperature is several degrees warmer than the surrounding air. They now try to escape and in doing so come in contact with the stigma, where they leave some pollen from other flowers, but they cannot escape since the hairs all point in a downward direction. The flower is a trap and the insects are prisoners for one or more days. Some nourishment is found, but in the course of time the stamens mature and the anthers dehisce and a large amount of the pollen drops on the floor of the cavity. The restless insects become covered with pollen. The hairs wither and now the insects can escape; at the same time the peduncle bends over so that the flowers drop. The prisoners escape, go to the younger flowers, leave some pollen on the stigma and when the stamens dehisce, after imprisonment are liberated again.

The genus *Stapelia* belongs to the family Asclepiadaceae. They are native to the Cape of Good Hope region and are frequently cultivated in greenhouses. The plants are fleshy leaved and produce large flowers of lurid brownish color and marked with transverse stripes. The petals are hairy. The five-parted corolla is wheel-shaped. The pollen is collected in masses, forming the pollinia, of which there are ten. During anthesis the flower exhales a strong, unpleasant and disagreeable odor, which attracts flies like *Sarcophaga* and *Musca*. The appearance of the flower combined with the odor causes blow flies to deposit their eggs, believing that they are depositing them in putrid flesh.

It is not uncommon in the greenhouse in Iowa to find the flowers visited by blow flies, and numerous larvae may be observed about the plant.

Another plant adapted to be pollinated by flies is the pawpaw (*Asimina triloba*). It has been studied by Robertson and Delpino. The plant is proterogynous with short-lived stigmas. The dull purple petals, of which there are six, attract flies. The three inner secrete nectar on their roughened inner faces and are so disposed that insects must come in contact with them. The numerous stamens occur in a globular mass, from the midst of which the stigmas protrude. The three inner petals lie in the first period close upon the stamens; they compel the flies which visit the flower to touch the already mature stigmas on their way to the honey and to strike the anthers and stigmas with their beaks. Cross-pollination is effected if the flies come bringing pollen from an older flower.

The Skunk Cabbage (*Symplocarpus foetidus*) has both a disagreebale odor and a brown color. It grows in swampy places and is visited by numerous flies that breed in these marshy places. Skunk cabbage occurs in a few places in Iowa. The pollination of this plant is, therefore, of interest.

Carrot and Parsnip.—The carrot belongs to the family Umbelliferae. The flowers are collected in whitish umbels, rendered conspicuous by the massing of the flowers. The individual flowers are small, consisting of the small green sepals and very small white petals. The honey is secreted by a cushion-shaped disc and is easily accessible to short-tongued insects. The five stamens spread apart so as not to interfere with the insect. The flowers are strongly proterandrous. They are visited chiefly by the Diptera, Coleoptera and Hymenoptera.

The flowers of the parsnip are collected in yellow umbels and are also dichogamous. Each flower has five small yellow petals and five stamens inserted on the disc. The plants are visited chiefly by Diptera and Hymenoptera.

FIG. 461.—Flowers of wild carrot. Pollinated by flies (*Diptera*) and some bees.

BEES AS POLLINATORS

The most important pollinators in the order Hymenoptera are honey bees, wasps, *Halictus*, *Andrena* and *Anthophora*. The mouth parts of bees are especially constructed for the purpose of collecting nectar. The mouth parts of an insect consist of upper lip and underlip, a pair of anterior jaws or mandibles, and a pair of maxillae. The lower lip and maxillae are each provided with a pair of feelers or palpi. The mandibles are usually hard and horny, while the maxillae are delicate and membranous. Different insects show a great range in the structure of their mouth parts, even in the same order. In members of the genus *Prosopis*, which construct their

FIG. 462.—Bees. Left, hairy bee (*Anthophora retusa*); right, bumble bee (*Bombus terrestris*); upper, honey bee (*Apis mellifica*); lower, earth bee (*Andrena Schrankella*).

cells of sand and dry sticks, the lower lip is constructed in the form of a trowel. This insect has in fact no special adaptation for collecting nectar. Although these bees feed their young on honey and pollen they can obtain nectar only in flowers with shallow nectaries. In different bees there are different gradations, as in *Andrena*, *Halictus* and *Chelostoma*. The lower lip differs in length, and in some it is elongated until it reaches the length and form found in hive bees and bumble bees, which enables them to extract honey from irregular flowers with deep-seated nectar, like clover, catnip and motherwort.

In *Bombus* the mouth parts consist of the paraglossa, the ligula, labial palpi, maxillary palpi, lamina, mentum, stipes and mandibles. When the mouth parts are fully extended and separated it seems hardly possible that this large and complex apparatus for sucking, exceeding in length that of the head, can be received in the cavity below the head, but such is the case. When a bee is sucking honey just within its reach, the caudines, the chitinous retractors just at the base of the mentum, the laminae, labial palpi and tongue are fully extended. As soon as the whorls of hairs at the point of the tongue are wet with honey, the bee by rotating the retractors (below the submentum) draws back the mentum and with it the tongue, so far that the laminae now reach as far forward as the labial palpi. The laminae and labial palpi now lie close upon the tongue, overlapping their edge, and form a tube, of which only a small portion protrudes. At the same time the bee draws back the basal part of its tongue into the hollow end of the mentum and so draws the tip of the tongue moist with honey into the tube where the honey is sucked in by the sucking stomach. In flowers with shallow nectaries the bee need not rotate the retractors. The tongue is therefore constantly encased by the laminae and labial palpi.

When a bee flies from one flower to another it carries the proboscis extended so as to introduce it, in the act of alighting, into the tube of the flower. The tongue is, however, concealed within its sheath, to protect the delicate whorls of hairs. Bees also have certain parts specialized for the collection of pollen. In some bees this is collected on the lower posterior surface of the body; in others it is collected on the legs. In *Megachile*, where it is collected on the ventral surface, "the abdomen is furnished with long, stiff, retroverted hairs, by means of which the pollen is brushed from the anthers as the insect passes in or out of the flower." This is done by the hairs on the tarsus and later the pollen is transferred to the tibia. In *Bombus terrestris* the tibia is smooth on the outer surface; the inner is covered with long, stiff hairs, which with the tibia form a little depression; into this the pollen is brushed by the short hairs of the tarsus. In the honey bee, the arrangements are similar, except more perfect for collecting pollen from the anthers. There are eight or nine rows of hairs. The pollen of the anthers is transferred to the surface of the tibia or hairs, to which it readily adheres. Behrens says, "after the process of collecting has been carried on for some time, the pollen forms in thick yellow masses, which completely envelop the legs. Laden with the fruits of its toil, the insect wings its way homeward and deposits them in the bee-hive."

Willows.—Some of the willows are among the earliest of our spring flowers. The early flowering species like *S. discolor* and *S. rostrata* bloom before the leaves appear, at a time when the nights are cold and frosts are frequent. The willows are simple entomophilous plants. Members of the genus *Populus*,[29] closely allied to the willows, are anemophilous.

The flower of the willow is simple in its structure and is usually dioecious. The anthers of the staminate flowers usually have some decided color. The flowers are massed in catkins and open out before the leaves appear, as is usual with anemophilous plants. They have an abundance of nectar, which, in the early flowering periods, leads many insects to go to it. They also have a decided odor. The staminate flowers are more conspicuous than the pistillate, especially in *Salix nigra*.

Each flower consists of a small bract, with the stamens, one or more, on the inside. These are accompanied by one or two small nectar glands. In the pistillate flower the stamens are replaced by the pistil and a nectar gland. The willow is one of the lowest of the entomophilous plants. It is visited by a variety of insects. The honey bee, the bumble bee, the earth bee and other Hymenoptera visit it, as also do flies (*Bombylius*), butterflies like *Vanessa*, and beetles. The *Andrenas* are common visitors; the head and thorax of these insects are provided with hairs and as the insects take the nectar from the staminate flowers the pollen grains adhere to the bristles and then as they go to the pistillate flowers for nectar some of the pollen is left on the stigma. The petioles of some of our willows are provided with glands. The shining willow (*S. lucida*), occurring on the banks of streams in northern Iowa from Allamakee through Chickasaw, Cerro Gordo, Worth and Audubon counties, has glandular petioles. The European *S. laurifolia* has so many of these

29 The quaking aspen (*P. tremuloides*), so abundant in northern woods and higher altitudes of the Rocky mountains, flowers early. The loose and long catkins shed their pollen in central Iowa about the middle of April, when small bees and honey bees are collecting pollen and nectar from the beaked willow (*Salix rostrata*). The cottonwood (*Populus deltoides*) also is anemophilous, but this species blooms a few weeks later than the quaking aspen, about the 24th to the 28th of April in Ames. The red catkins contain an abundance of pollen, which is easily shaken out by the wind. There are no fully developed leaves on the plant when it is in flower, so that the stigmas of the pistillate catkins of neighboring trees may receive the pollen. Insects frequently collect pollen from these anemophilous plants, but they do not go to the pistillate flowers.

glands that the tree exhales a very pleasant odor. These glands attract ants, which obtain the nectar from these extra-floral nectaries.

FIG. 463.—Pasque flower or wind flower. Pollinated by bees. Sepals followed by nectar glands, outer row of stamens, three stamens and pistils. *Ada Hayden.*

Wind Flower.—The common wind flower or wood anemone (*Anemone quinquefolis*) is an early bloomer, coming a few weeks later than the hepatica. The stem bears a single flower with five petal-like sepals, numerous stamens and numerous pistils. During the early stages of flowering some of the anthers mature first, but for the most of the time stamens and pistils are mature at the same time. Although the flowers have a slight odor there is no nectar, although Bonnier states that the small papillae on the receptacle secrete nectar.

Larkspur.—The common larkspur (*Delphinium Penardii*) blooms about the first of July or a little earlier in the latitude of Ames. The flowers are borne in a large ample raceme. They have five greenish white irregular petal-like sepals, the upper one prolonged into a spur. Petals four, irregular, the upper pair continued backward into long spurs, which are enclosed in the spur of the calyx. The flowers are not as conspicuous as the *Delphinium Consolida* or the *D. tricorne*. Mueller in describing the *D. elatum* says, "The hollow spur of the uppermost sepal neither secretes nor contains honey. Its peculiar rough and crumbled wall serves rather as a cover for the organs which secrete and conceal the honey, which without it would be exposed to the rain; and also it forces the bumble bee to suck the honey by the way that alone leads to fertilization.

Fig. 464.—Larkspur (*Delphinium Penardii*). a, spur of the calyx, nectary shown in lower figure; c, upper petals prolonged in the calyx spur. *Charlotte M. King.*

The two upper petals serve a very different purpose. In each the hollow pointed end of the spur, which is directed backwards and is inclosed in the hollow sepaline spur, secretes honey and becomes so full of it that part rises into the wide, half conical part of the spur which is open on the inner side. When both petals lie close to one another, they form together a hollow cone which splits at the end into two points filled with honey and guides the insect's proboscis, if long enough, safely to the honey, while by its length it prohibits the access of insects wtih shorter tongues."

Violets.—Of *Viola pubescens* Robertson says: "This is yellow with dark nectar lines. The petaline spur is little more than a gibbosity. The nectar-secreting processes of the lower stamens are very short, being much wider than long. The summit of the peduncle and the flower axis are strongly curved so as to throw the spur well backwards, giving the flower a characteristic appearance, and this serves to limit the insects' visits much more than the mere length of the spur."

In regard to visitors Robertson says: "Really, the proper visitors are bees which are small enough to use the beard as a support, so that the bumble bees and butterflies may properly be classed as intruders even when they are the reverse. For the proper visitors of the bearded violet we must look to small bees, among which the *Osmias* are most important."

Our violets are all early flowering and the only species to be had during the summer is the Pansy (*Viola tricolor*). In the cultivated forms the colors have been greatly changed. Three of the petals have conspicuous pathfinders. The corolla is irregular, the lower petal spurred at the base; stamens closely surround the ovary, the two lower spurred. The anther spur acts as nectar gland while the lobed, hollow spur of the petal acts as a receptacle. The insect thrusts its proboscis close under the stigma into a hair-lined groove on the lower petal. The anthers shed their pollen in this groove and thus the proboscis becomes dusted with pollen. A small projection below the stigma prevents the pollen on the insect from coming in contact with the stigma.

Our common blue violet (*V. papilionacea*) produces cleistogamous flowers. This is also true for some other species.

Buttercups and Allies.—The hepatica (*Hepatica acutiloba*) is one of the earliest of our vernal plants. It pushes its flowers out of the ground among the leaf mold soon after the frost disappears. It has apetalous flowers but underneath the sepals are three calyx-like bracts. The sepals range from six to twelve in number and are blue purplish or nearly white in color. Stamens and pistils are numerous and slightly odorous. So far as I have been able to tell the hepatica produces no nectar. It is visited by small bees and syrphus flies. Mr. Robertson says in regard to the nectar, "I could not satisfy myself of its presence in this species either by sight, taste or test for sugar in water in which the flowers have been immersed. In spite of the failure I am inclined to suspect that it occurs in a thin layer, for all of the insects mentioned in the list thrust their proboscides about the bases of the filaments, except *Syrphus Americanus*."

Apple and Pears.—The flowers of the apple (*Pyrus Malus*) are perfect and produce an urn-shaped calyx tube with five rose-colored petals. There are numerous stamens, one pistil, five styles and five stigmas. The stigmas ripen before the stamens. The somewhat shorter stamens curve to the center and an abundance of nectar is secreted and is easily accessible to insects. Self-pollination may be brought about but there is reason to believe that some varieties of apples are self-impotent. This is said to be true of the Ben Davis apples in some places though not in all since there are cases in the south where solid blocks of the variety are very fruitful.

The wild crab (*Pyrus ioensis*) is one of the most interesting of our native plants. The large, showy and attractive purple-colored corollas are attractive to insects because of their color and fragrance. The filaments of the numerous stamens form in a circle about the summit of the receptacle tube. These are also directed upwards and inwards, thus concealing the nectar effectually and barring short-tongued insects. Robertson says "The nectar is reached by a bee thrusting its proboscis between the separating ends of the filaments." The pollination is similar in the more eastern species *P. coronaria*.[29a] The flowers are proterogynous; self-pollination is prevented because the stigmas are much longer than the stamens.

The pear (*Pyrus communis*) has flowers somewhat similar to those of the apple and the petals are whitish or pinkish. The stamens are usually longer than the styles and when the flower opens they are curved inward, but later bend outward. In the center of the flower is a disc that secretes the nectar, which is largely sought by insects like bees. They are guided to the nectar by the showy petals. The pollen from the anthers is brushed on the insect and when it comes in contact with the rough stigmas it leaves some of the pollen on them. The stigmas, according to Mr. Waite, mature two or three days before the stamens.

Common Thorn.—The white flowers are borne in corymbs and are very conspicuous. They are proterogynous. The nectar is secreted in the receptacular tube and is not concealed. It is visited by many Diptera and small Hymen-

[29a] On pollination of Rosaceae see Robertson, Trans. Acad. Sci. St. Louis, 6:435-450.

optera, among them the honey bee, also some Coleoptera and Lepidoptera. Of the four species *Crataegus punctata, C. coccinea, C. mollis,* and *C. tomentosa,* no two flower at the same time about Ames. The *Crataegi* are frequently cultivated for ornamental purposes. There are many species in the United States, but they are difficult for any but a trained botanist to recognize. The most common species are those enumerated above. They are easy to obtain in any of our northern woods.

Plums.—The plums, like the apple, belong to the rose family (Rosaceae). Our native plum (*Prunus americana*) frequently forms thickets in woods. It has given rise to many varieties, like the De Soto, Rollingstone, Wolf, etc. The white flowers are conspicuous, with a decided odor. It flowers from the latter part of April to early May, depending on the season. The flowers are slightly proterogynous, but when they open they are ready to receive the pollen. Some varieties of the European plum (*P. domestica*) are more strongly proterogynous as the stamens mature somewhat later. They are as long as or a little longer than the style. Self-pollination may occur, though this is prevented by self-impotency in some varieties. *Prunus hortulana,* as I have had occasion to observe for some years, has imperfect flowers. Many flowers of our native plum have been examined and I have never failed, in some individuals at least, to find this character well pronounced. In every case examined the suppression was all in the direction of the pistil. The stamens in all cases were well developed. In the imperfect flowers the pistil is short, scarcely as long as the calyx tube. In the Rollingstone the pistil is entirely absent in many cases.

Professor Bailey has likewise given this subject some attention. In the paper of Professor Goff[30] reference is made to some observations of Mr. Lord. He says: "I have found some groups entirely without pistils for a series of years, and last year I was surprised to find no pistils on my Gaylord trees that had never refused to bear before. They are loaded again this year."

According to Professor F. A. Waugh[31] the insects found pollinating the plum at Denton, Maryland; Ithaca, New York; Madison, Wisconsin; Burlington, Vermont; were 18 Hymenoptera and 10 Diptera. The greatest number of Hymenoptera were found at Denton, Maryland. They included the common honey bee, the bumble bee (*Bombus virginicus*), eight species of *Andrena,* four species of *Halictus,* one species each of *Vespa, Polistes, Xylocopa,* and *Augochlora.* That the insects are important in pollination is made evident by the fact that on 153 blossoms of the Arkansas lombard that were covered no fruit set; on 457 blossoms of the wild plum (*Prunus americana*) that were covered no fruit set; and on 90 blossoms of the Japanese plum (*Maru*) that were covered no fruit set.

Raspberry and Blackberry.—The raspberries and blackberries belong to the rose family. The red raspberry (*Rubus strigosus*) has white petals and is not nearly so attractive as the blackberry (*R. villosus*). Nectar is abundantly secreted by the flattened disc between the pistils and filaments, and bees obtain it by inserting their proboscides between the stamens and pistil. The

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30 Bull. Cornell Univ. Exp. Sta., 38.

31 Rept. Vt. Agrl. Exp. Sta., 1897-98:237.

stamens are inflected inwardly toward the pistil. The stigma is receptive before the stamens mature. In the absence of insect pollination, self-pollination may take place. The flowers are visited by Hymenoptera; honey bees are frequent. *Rubus villosus* is much more attractive. The petals are large and white. Nectar is secreted as in the red raspberry but is more difficult for the insects to obtain. It is visited by honey bees and Robertson records several species of *Bombus* for Carlinville, Illinois.

Strawberry.—The strawberry belongs to the same family as *Rubus*. Both of our wild strawberries, *Fragaria vesca* and *F. virginiana*, have perfect flowers, but the cultivated strawberry, which is derived from *F. chiloensis* and known as the var. *ananassa*, produces perfect and staminate flowers so that fruit will be produced only when a staminate and pistillate variety are grown close together. Varieties with perfect flowers also produce fruit. The white flowers of the strawberry are conspicuous, producing numerous stamens and pistils. The nectar is secreted by the receptacle at the base of the filaments, next to the outer row of pistils, where it is held. The flowers are gynodioecious, the female flowers being smaller and bearing shorter stamens. The staminate flowers in some cultivated varieties, as the Bubach, are very large. The plant may be self-pollinated, though it is nearly always cross-pollinated. It is visited by honey bees frequently at Ames and also by species of *Halictus*.

Gooseberry and Currant.—The various species of the genus *Ribes* differ in regard to the depth at which the nectar can be obtained. *Ribes alpinum* is visited at Ames by various species of Diptera, the common honey bee and *Bombus pennsylvanicus*. *Ribes gracile* and *R. Cynosbati* are both early flowering species and are visited by *Apis mellifica, Bombus pennsylvanicus* and a species of *Vespa*; a western species, *R. speciosum*, is visited by birds, and *R. cereum* of the Rocky mountains by several species of *Bombus*. The calyx tube is coherent with the ovary in all species of *Ribes*. In *R. gracile* the peduncles are long and slender, the flowers whitish with slender closely adhering filaments and soon much longer than the calyx lobes. The petals, as in other members of the genus, turn red.

Grape.—Flowers are very commonly polygamous or dioecious but greenish, inconspicuous and very fragrant. Ovary has an adnate fleshy disc of five nectar glands which secrete the nectar. The disc bears the stamens and petals and the calyx is short. The stamens are held by the petals, which separate only at the base, which forms a kind of head. When mature the stamens are released, thus allowing the pollen to be thrown on the insect. Professor Beach[32] has shown that many of the cultivated grapes are impotent.

Orchidaceae.—Darwin, in the introduction to his classic work, "On the Fertilization of Orchids by Insects," says: "As orchids are universally acknowledged to rank among the most singular and most modified forms in the vegetable kingdom, I have thought that the facts to be given might lead some observers to look more curiously into the habits of our several native species. An examination of their many beautiful contrivances will exalt the whole vegetable kingdom in most persons' estimation."

32 Bull. N. Y. Exp. Sta. Geneva, 169:321, 223; Garden and Forest, 1892:45.

Earlier Sprengel observed that insects were necessary to remove the pollen masses, and Waechter, who seems not to have been acquainted with Sprengel's work, stated that insects are necessary for the pollination of orchids. Orchids have been the objects of a large number of interesting papers. The family is represented by more than three thousand species. Few of our native species compare in beauty with those of the tropics. In habit they are extremely diverse. Hermann Mueller says: "I do not doubt that orchids owe their extraordinarily perfect adaptations to particular insects not only to the tendency of the parts of their flowers to variation, but also to the separation in time of the two stages in the act of impregnation. The extremely complete adaptations to cross-fertilization have in their turn resulted, in many cases, in the flowers becoming absolutely sterile to their own pollen."

It may take days, weeks, or even months for the pollen tube to reach the ovule and cause impregnation. It may be interesting to observe that the period of flowering in many cases extends over a considerable length of time.

Many orchids are pollinated by bumble bees, as *Goodyera repens*. *Spiranthes*, *Cypripedium pubescens*, *C. acaule* and *C. hirsutum* are pollinated by small bees; *Orchis spectabilis* by large bumble bees and the Sesia moths. *Epipactis* is pollinated by wasps, but *Listera ovata* is pollinated by beetles and Ichneumonidae. Some of the *Habenarias* are pollinated by Sphinx moths and butterflies. The Madagascar *Angraecum sesquipedale* is pollinated by moths with very long proboscides.

Orchids are seldom very abundant, although they produce an enormous number of seeds. Fritz Mueller estimated over 1,750,440 in a single capsule of *Maxillaria*. Orchids differ in their capacity for self-fertilization; some have cleistogamous flowers, as in *Cattleya* and *Epidendrum*; some are self-pollinated, or at least occasionally so, frequently in *Neottia nidus-avis*; others are never self-pollinated, although when their own pollen is applied artificially it is fertile, while some are absolutely sterile to their own pollen though fertile to the pollen from a plant of another species. In some cases the pollen of a plant acts as a poison when applied to its own stigmas.

In order to fully understand the mechanism of pollination the technical terms used to describe orchids should be considered. The perianth consists of six parts in two sets, the three outer, known as the sepals, generally being colored. The petals consist of three parts, one of which, the upper, is larger than the others and springs from the lower side. This is the labellum and is often produced into a spurlike nectary. In front of the labellum occurs the stamen, which is united with the pistil. In *Cypripedium* there are two stamens with the rudiment of a third. The anther has two very distinct cells and in most orchids the pollen coheres in masses, each of which has a stalk; these masses with their stalks are known as the pollinia. In the genus *Cypripedium* the pollen is granular. The ovary is produced above the perianth and rises up in the middle of the flower as a column. The stigma is broad and glutinous, the rostellum is a modified stigma; a part of this is removed with the pollen masses and is called the viscid disc.

Cypripedium.—There are three species of the genus in Iowa, but all are becoming rare. *Cypripedium pubescens* occurs in rich woods, most abundantly in eastern and northeastern Iowa. The plants bloom during the latter part of

FIG. 465.—Showy lady slipper (*Cypripedium hirsutum*). Insect pollinated. A plant thought to cause dermatitis.

FIG. 466.—Smaller yellow lady slipper (*Cypripedium parviflorum* var. *pubescens*). Pollinated by bees. A beautiful flower of early summer, seen in the woods of Iowa. *C. M. King.*

May or early June. The showy lady slipper (*C. hirsutum*) blooms late in June. This species occurs in bogs or in cool moist woods and shady places. The small white lady slipper (*C. candidum*) occurs in marshes and bogs. It was once common in central Iowa, now rare and local, but more common in northern Iowa. The stemless lady slipper (*C. acaule*) does not occur in this state but is found in the eastern states and west to northern Indiana to Minnesota.

The yellow lady slipper has three spreading sepals; two of them are usually united into one under the lip. The labellum is arranged into a kind of moccasin, hence the common name, lady slipper or moccasin flower. The edges are recurved or overarched. The stamens and pistils are united, so that we have a peculiar shieldlike body which is notched or hollowed out and two fertile anthers. The pollen is not united in pollinia. The surface of the stigma is beset with numerous sharp pointed papillae which are for the purpose of holding the pollen.

Insects are attracted by the color and strong odor and find it an easy matter to get into the flower, but they experience some trouble in getting out the way they entered, since the margin of the lip is rolled in. Professor Trelease was the first to call attention to the fact that in some of our *Cypripediums* a portion near the upper end of the inflated sac is transparent, serving as a window. An insect would naturally make for the light, and since this window is near the small opening the insect goes out. It gets some of the pollen on its head as it comes in contact with the varnished film of the pollen. Some nectar is found on the hairs in the bottom of the labellum. Now, when the insect flies to another flower and enters by the large opening, it cannot fail to get some of the pollen from its head against the large stigma which partly blocks the passageway. Doctor Gray says: "The stigma of every other orchid is smooth and glutinous; this is merely moist and finely roughened; the roughness comes from the very minute projections all pointing forward so that the surface may be likened to a wool-card or rasp." These windows occur so far as I have observed in all of the species native to Iowa. They are absent in *C. acaule*. The pollination of the eastern *C. acaule* has been studied by Doctor Weed, who has furnished a good description. This species has, as have the others, an inflated sac, the labellum, which also projects forward and downward. Above the labellum—at the upper end—there is a curious organ, the rudimentary stamen metamorphosed into a petal-like projection. "Beneath it is the pistil with the stigmatic surface on the under side." The anthers of the stamens occur on the sides. The stigmatic surface is somewhat viscid and so holds the pollen that comes from the insect as it creeps under the stigma. On the bottom of the labellum on the inside are hairs which project upward and backward. These secrete a glutinous substance which it is thought is eaten by insect visitors. The insect visitors are not numerous but Doctor Weed found what he thought might be a species of *Halictus*.

Mueller describes the process as follows: "These bees, attracted by the color and perfume of the flower, fly into the slipper-shaped lip and lick and bite the hairs lining its floor, which are sometimes covered with small drops of honey. They try for some time to escape by climbing up the vaulted sides of their prison toward the orifice by which they entered; at last, after creeping beneath the stigma, they manage with a great effort to escape by one of two small lateral openings at the base of the lip; in doing so they smear one shoulder with a sticky pollen from the anther immediately above. In the next flower, the bee, as it creeps under the stigma, leaves some pollen on its papillae, which are long and pointed obliquely forwards; then, squeezing itself again through one of the small orifices, it acquires another load of pollen; cross-fertilization is thus effected regularly."

Spiranthes.—Flowers are white and very fragrant. The parts of the perianth are so disposed as to limit insects from obtaining nectar. Charles Robertson describes it for *Spiranthes gracilis* as follows: "The upper sepal is connivent with the two upper petals, forming the upper walls of the tube. At the free end these part from a three-toothed upper lip. This is too small to form a landing place for insects, but makes the flower a little more conspicuous. A proboscis about four millimeters long can drain the nectar with ease. At Orlando, Florida, I saw them visited by a bee which I failed to capture, but which I supposed was *Anthidium notatum* Latr., and also by *Megachile brevis* Say.

"The last mentioned insect had two discs with attached pollinia fastened to the maxillary laminae, and I think this is the particular part of a bee to which the flower is adapted to fasten its pollinia.

"But the most important consideration is that when the bee's proboscis is folded up under the head, the maxillary laminae fall into such a position that the pollinia retain their hold without danger of being disturbed."

Iridaceae.—In the Flower-de-Luce (*Iris versicolor*) the perianth is made up of six parts of violet blue color and purple-veined. The three outer divisions are reflexed; the three inner are smaller and erect. There are three stamens, one on each side of the stigma; back of each stamen and partly overhanging it is a peculiar petal-like body, a branch of the style; the stigma occurs as a thin lip under the apex. Stigma and stamens are protected; the former is larger than the latter; the anther discharges its pollen through a long opening away from the stigma. An insect alights on the expanded petal and, guided by the hairs, obtains the nectar which is secreted by the lower portion of the perianth and is collected between this space and the pistil, and in doing so, brushes against the stigma, where it leaves some of the pollen from another flower. Self-pollination is then possible. It is visited by bumble bees, Syrphus flies, also butterflies, which, however, are not normal pollinators. Our blue iris is common throughout the state, growing in low, marshy places. It blooms about the latter part of May in the latitude of Ames.

FIG. 467.—Iris. The upper portion of perianth tube showing the passage to the nectar, the stamen above the passage, and arching over the stamen the petaloid bilobed stigma. *Kerner-Oliver.*

The European *Iris Germanica* has similar adaptations. Insects seeking the nectar light on the divisions of the perianth, which they use as a landing place, and then brush the upper parts of their body against the anther, becoming covered with pollen.

Sage.—As previously stated, irregularity is one of the causes that leads to cross-pollination by insects. The pollination of the European sage (*Salvia pratensis*) was studied first by Sprengel[33] and later by Hildebrand[34] and Mueller.[35] The irregular blue labiate flowers are arranged in a raceme. The upper lip is arched. The flowers are proterandrous. In their first stage the stigmas are folded together and protrude from the upper lip; later they unfold and point downward. The opening of the tube of the corolla is guarded by two oblique processes which are the sterile, transformed half anthers. Attached to these are extremely long connectives. The other part of the anther cell is under the arched lip of the corolla. When a bumble bee lights on the under lip and thrusts its proboscis downward into the tube of the corolla it comes in contact with the processes which close the throat of the corolla. When these

33 Des Endeckte Geheimniss der Natur, 702.

34 Ueber d. Befruchtung d. Salbei—Arten durch Insekten. Verh. nath. verh. 21. Bonn. 54.

35 The Fertilization of Flowers, 477.

FIG. 468.—Flower of European iris (*Iris Germanica*). Pollinated by bees. The three outer segments of the perianth reflected, with hairs near the base used as a landing place. The stamen and petaloid stigma. The nectar contained in perianth tube. *Kerner-Oliver.*

sterile anther cells are touched, they lift upward and backward; the fertile anthers concealed under the arched upper lip come forward and downward and in this way the pollen is brushed off on the bee's back. The presence of nectar is indicated to the insect by the odor and the purplish spot on the lower lip. Nectar is found in abundance in the lower part of the tube of the corolla and is secreted by the yellow fleshy portion underneath the ovary.

The western *Salvia lanceaefolia*[36] is frequent in western Iowa and has become naturalized in other parts of the state, as near Des Moines and Newton.

[36] Newton, G. W., Iowa Acad. Sci., 4:109.

The blue flowers are conspicuous and the lower lip of the flower forms a landing place for insects. The style extends beyond the arched upper lip and the sterile half anthers block the passage way. When the sterile anther cells are touched they lift upward and backward; the two fertile anther cells are concealed under the arched upper lip, but they come forward and downward and in this way the pollen is brushed off on the bee's back. The presence of nectar is indicated to the insect by the odor and the darker spot on the lower lip. Nectar occurs in abundance in the lower part of the tube of the corolla and is secreted by a yellowish fleshy body underneath the ovary. In the European *Salvia glutinosa* the arrangements are similar to that of *S. pratensis*. In *S. officinalis* the connective is much shorter and the lower anther is not sterile.

Horse Mint.—*Monarda mollis* is a common plant, growing in our woods and along railroads. It is conspicuous in summer and early autumn. The numerous branches bear the light purple flowers in glomerate heads. In the Rocky Mountain country, especially in Wyoming, the flowers are much darker in color. The bilabiate corolla is pubescent; the upper lip is narrow and extends obliquely upwards, containing the stamens and pistil, the former of which are attached to the lower lip of the corolla. Since the anthers and stigmas are so far apart the largest bees are likely to touch them only when landing upon it. The nectar is secreted by the fleshy disc below the ovary and is protected from unbidden guests by small projections.

Mr. Robertson in speaking of the flower, says, "The tubes measure 18 to 19 mm., which indicates an adaptation to long tongues. The form of the tube, the bilabiate corolla, and the position of the stamens and style indicate that the flower is a modification of a nototribe flower originally adapted to bumble bees. The level-topped heads, the erect corollas, the exposed organs and the rose color indicate a tendency to suit butterflies, which in fact are the principal guests."

The Iowa flowers, as well as those of Wyoming and Colorado, are frequently visited by bumble bees, though butterflies are not uncommon on the flowers in Iowa.

Fig.—It has been known for some time in Mediterranean countries that a small chalcid wasp, *Blastophaga grossorum*, is important in pollinating the fig (*Ficus Carica*). Since ancient times caprification was brought about by the *Caprificus*. This was done by hanging ripe fruit of the *Caprificus* to the branches of the fig tree "whose figs are then in their female stage with open ostiola." The wasps issue from the *Caprificus*, enter the fig and bring pollen of the former. In order to fully understand the method of pollination we should study the structure of the flowers. A fig is not a single ripened fruit, but a branch in which there are a number of fruits. In some species, such as *Ficus pumila*, female flowers occur only in the bottom of the urn, while the pollen-bearing flowers occur around the opening.

Solms Laubach states that many species of *Ficus* have in addition to the male flowers two different kinds of female flowers; flowers with a short style in which the wasp can deposit its eggs, the other with a long generally bent style in which the wasp cannot deposit its eggs. The first constitute the "gall flowers," the second the "seed flowers."

The common fig produces two kinds of plants, one known as the *Caprificus* which bears on the inner wall a large number of female flowers, which are later formed into galls. The male flowers which line the opening do not mature till the insects are hatched. The second kind only bears figs, the *Ficus*. The galls in the *Caprificus* are formed in this way. A small chalcid wasp (*Blastophaga grossorum*) enters the urn through the ostiolum and its ovipositor is thrust vertically in the style of the flower. It deposits its eggs in the ovary of the female flowers between the nucleus and the integuments, placing one egg only in each. The small white larvae grow rapidly and cause the wall of the ovary to develop, and in consequence the seed does not form, but the fruit develops into a gall. When the insects are mature they leave the galls, the wingless male first; the females remain somewhat longer and after leaving the ovary they are fertilized by the male. They do not tarry long in the urn, but in going out by way of the ostiolum they come in contact with the pollen, which is dusted over their whole body. They allow their wings to dry, and then run to another urn, either on the same plant or another. In entering a new urn their wings are injured or broken off. They leave some of the pollen on the stigmas and when these are in the "seed"-producing flowers fruit is developed; but when left on the stigmas of those which produce galls, fertilization does not occur. In the common fig, *Ficus Carica*, it has also been observed that although the insect deposits its eggs in the flowers with a long style they will not develop galls or very seldom, since the ovipositor is so short that it can not reach the ovule. The *Caprificus* becomes hard and withers on the tree, its only use being to produce pollen and the gall flowers farther down. The fruit of the fig tree *Ficus* becomes sweet and juicy when the seed ripens. The pollination of all species of *Ficus* has not been studied, although for the 600 species described there are at least fifty species of small wasps belonging to the genera *Blastophaga*, *Crossogaster*, *Sycophaga* and *Tetrapus*, which carry pollen from one urn to another. One species, *Blastophaga brasiliensis*, has been found on seven different species of fig tree. Figs will also develop without caprification, but the figs are not of such good quality.

FIG. 469.—Fig tree (*Ficus Carica*). Pollinated by *Blastophaga*. 1, Flowering branch; 2, pistillate flower cut through longitudinally; 3, staminate flower; 4, fig in longitudinal section. *After Wossidlo.*

Figs have been grown abundantly in the southern states and California for many years. The fig growers in California could not compete with the Smyrna fig; therefore early introductions of the Smyrna fig were made, but it was found that the Smyrna plants introduced did not produce fruit but dropped them before they were the size of a marble. Dr. L. O. Howard[37] gives the further history as follows: A banker in San Francisco sent an agent to obtain cuttings. He succeeded with some difficulty in obtaining the Smyrna cuttings as well as those of some wild plants. The Smyrna fig is exclusively female while the wild fig contains the stamens. Dr. G. Eisen[37a] gave much attention to the subject and was early convinced of the importance of *Blastophaga* in pollination. The *Blastophaga* wasp was introduced first by James Shinn of Niles, California, followed by several importations.

In 1897 the Secretary of Agriculture, Hon. James Wilson, directed Dr. L. O. Howard to import the insect and establish it if possible. Dr. W. T. Swingle, who was then in Europe, was authorized to procure the gall insects. The success of these efforts dates from the importation of wasps obtained in Algeria. Unless something unusual happens the Smyrna fig industry will be a success in the United States, demonstrating anew the value of scientific knowledge applied to the principles of horticulture.

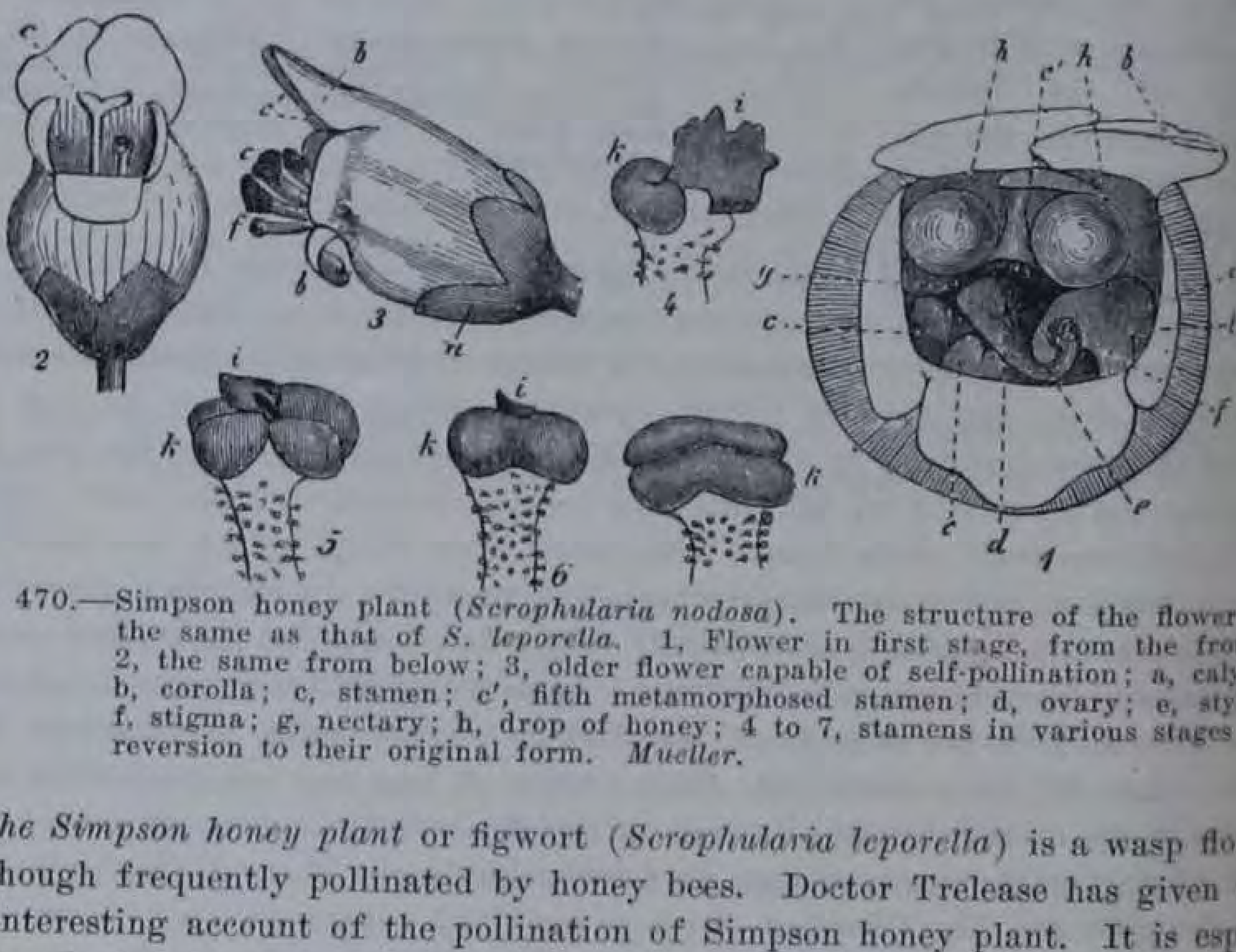

FIG. 470.—Simpson honey plant (*Scrophularia nodosa*). The structure of the flower is the same as that of *S. leporella*. 1, Flower in first stage, from the front; 2, the same from below; 3, older flower capable of self-pollination; a, calyx; b, corolla; c, stamen; c′, fifth metamorphosed stamen; d, ovary; e, style; f, stigma; g, nectary; h, drop of honey; 4 to 7, stamens in various stages of reversion to their original form. *Mueller.*

The Simpson honey plant or figwort (*Scrophularia leporella*) is a wasp flower though frequently pollinated by honey bees. Doctor Trelease has given us an interesting account of the pollination of Simpson honey plant. It is especially adapted to wasps. Mueller records six Vespidae. He says: "The fact that they hold a proportion of over one-third in the list of *Scrophularia* is sufficient evidence that the flower especially favors wasps. I know of no bee-flower on which so many wasps occur as intruders." It is frequently visited by hive bees.

The small, greenish purple irregular flowers are proterogynous. In its earlier stages the stigma only protrudes and is inclined over the lobe. Honey bees

[37] Yearbook U. S. Department of Agriculture, 1900:79.

[37a] Proc. California Acad. Sci., 5:897.

and wasps, which largely pollinate the flowers, approach from the front and come in contact with the stigma, leaving some of the pollen on it. The following day the stamens come in view and the style becomes flabby and rests on the lower lip. An insect in going to the flower for the nectar is dusted with pollen from the later flowers. Self-pollination cannot occur.

The common toadflax (*Linaria vulgaris*) is a common weed in many sections of the country. It belongs to the same family as the Simpson honey plant (*Scrophularia nodosa*). The details of its pollination have been given by Mueller.[38]

"The flowers consist of a five-parted calyx and a yellow personate corolla with a palate that often closes the throat. The corolla is spurred at the base on the lower side. There are four stamens and one pistil, the latter having a single style which is two-lobed. The honey is secreted by the base of the ovary, which is especially prominent anteriorly opposite the lower lip." "As a rule the honey does not, as Sprengel thought, leave the tip of the spur empty, flowing down at intervals in large drops which cannot reach the bottom because of the air contained there, but it glides in a smooth, narrow groove bordered by short, stiff hairs which pass over the nectar between the two anterior stamens and thence to the tip of the spur which it fills to a depth of five or six mm. or even more." The length of the spur and the personate corolla somewhat exclude small insects. The palate of the lower lip is bright orange color and along each side of the groove is a row of hairs. We have here an excellent nectar guide. The bee lights on the lower lip and creeps into the tube. In doing this it comes in contact with the anthers and stigma. The plant is frequently visited by honey bees and by species of *Bombus*, *Osmia* and *Megachile*.

In the related snap dragon (*Antirrhinum majus*) the flowers are borne in a raceme, and the purple, brown and yellow corollas are very conspicuous. It is pollinated by bumble bees that are sufficiently strong to force the upper lip back. The honey is secreted at the base of the ovary.

This plant differs from common toadflax in its larger flowers, into which bumble bees can enter bodily, and also by its firmly closed corolla, which excludes the smaller bees. The nectar is secreted by the smooth, green, fleshy base of the ovary.

Leguminosae.—The Leguminosae in the broad sense include the Papilionaceae, Caesalpinieae and Mimoseae. The flowers are papilionaceous or sometimes regular with ten (rarely five or many) monaldelphous, diadelphous, or distinct stamens and a single free pistil. Many of the Leguminosae have excellent adaptations to secure cross-pollination. In the Papilionaceae the flowers are horizontal or nearly so. The two lower petals are united to form the keel and enclose the reproductive bodies. The insects use the two lateral wings of the flower as a resting place. The wings also act as a lever to depress the keel or keep it in place, because the basal lobes enclose the column, or in some cases there are swollen pouches. The weight of the insect depresses the keel and in nearly all cases the pollen and stigma come in contact with the insect on the ventral surface. After the insect leaves the flower the keel returns to its position, again enclosing the stamens and style.

In some cases, as in *Mucuna*, *Melilotus* and *Spartium*, the stamens and pistil

38 Fertilization of Flowers, 431.

are in a state of tension and act like watch springs. The anthers liberate their pollen, which accumulates in the front part of the keel. The keel and wings with a sudden jerk explode when mature and touched by the insect, the stamens and style lying in the keel spring up, throwing the pollen on the thorax of the insect. In the bean and vetch the pollen is carried out with the brush hairs on the style.

In *Cassia*, belonging to the Caesalpinoideae, and *Schrankia*, belonging to thorax of the insect. In the bean and vetch the pollen is carried out with the exposed.

Most of the Leguminosae are pollinated by insects, especially by bees, although butterflies, beetles and flies are also visitors; some are pollinated by birds and some are close pollinated. A large number of insect visitors are recorded. Robertson records ten visitors, mainly Hymenoptera, on the cow vetch (*Astragalus canadensis*) and five visitors for the Kentucky coffee tree. Hermann Mueller records thirty-nine insect visitors on the red clover (*Trifolium pratense*).

The special contrivances are so numerous that only a few special cases can be considered.

Phaseolus vulgaris.—The common garden bean is cultivated in all parts of the United States. The bloom may be obtained in Iowa from June until frost. The species is abundantly self-fertilized. The flower of the bean consists of the green calyx and the white corolla. The corolla is made up of five parts, the upper part called the standard, the two lateral wings, and a keel made up of two parts. The oblique stigma is on the tip of the style, which is bearded near the end on which the pollen is discharged. An insect in searching for the nectar at the base of the flower lights on the two lateral petals, coming first in contact with the stigma, and deposits pollen from another flower. The weight of the insect causes the style to protrude.

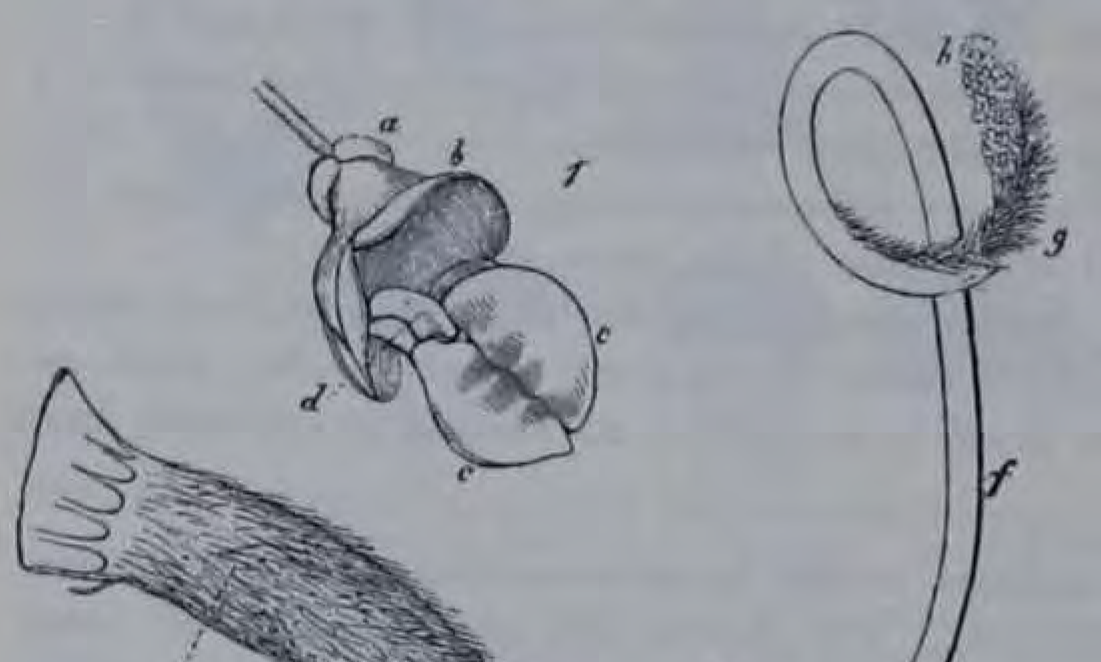

FIG. 471.—Above, flower of common bean (*Phaseolus vulgaris*). Below, enlarged pistil. e, ovary; f, style; g, brush hairs; h, stigma. *Mueller.*

The scarlet runner (*Phaseolus multiflorus*) has similar adaptations except that the keel with its style is so bent that when pressed down the style comes out and points downwards and toward the left. Francis Darwin has shown that the tenth stamen, which is free, bears an appendage which prevents a bee from taking the honey, except from the left side. On the college grounds at

Ames the early flowers of this species are invariably sterile, but those produced in August are fertile. The scarlet runner is evidently not self-fertilized. The Lima bean (*Phaseolus lunatus*) has similar adaptations, but few of the early flowers set seed.

Strophostyles helvola, one of our native beans, flowers in August, and is common in the flood plains of our streams and on gravelly embankments. The flower, as in other Leguminosae, consists of five parts, the standard, wings and keel. The keel is bent strongly to the right and occurs in such a way that its tip stands over the base. Robertson says: "The base is large and sac-like and is produced above into a ridge which opposes the passage to the nectary. The left wing is turned to the right so that the bee is required to alight upon the right side, and she enters the flower between the tip and the basal process of the keel. Seizing the process with her front foot, the bee pulls the keel downward and backward, whereupon the stigma and the pollen-laden brush of the style sweep out over the thorax. In this way the stigmas receive pollen already deposited by another flower, and the style-brush leaves a new load."

Apios tuberosa is another near relative of *Phaseolus.* The flower of this plant has a large standard with a rather firm texture and at the top of the standard is a small boss as seen from the back, or a shallow sack as seen from the front. The sickle-shaped keel is arched and fixed into the notch at the upper end of the sac. When an insect touches the flower in quest of nectar, which is secreted as in other *Leguminosae,* it pushes forward into the space under the arched keel, and by lifting from underneath dislodges its apex; first the stigma and then the anthers are brought against some portion of the insect's body and against the same portion in succeeding blossoms, thus effecting cross-pollination. The structure of the flower was first pointed out by Doctor Gray.

FIG. 472.—*Apios tuberosa* with half the standard cut away to show the blunt apex of the keel resting in the notch. *After Gray.*

FIG. 473.—*Apios tuberosa* before being visited by an insect.

Amorpha fruticosa.—The flowers of the wild indigo are purplish and arranged in a conspicuous spike. In this plant the keel and wings are wanting and the standard surrounds the stamens and pistils, which are exserted. The flowers are proterogynous, at Ames as elsewhere, as observed by Trelease, Robertson, Mueller, and Beal. It is visited at Ames by *Bombus* and the honey bee.

The lead plant (*A. canescens*) flowers nearly a month later at Ames and grows in different situations. It is not a competitor with *A. fruticosa.* The flowers are without keels or wings. The standard encloses stamens and pistils in the bud and when the flower opens only the style and stigma show, the flowers being proterogynous. In an older flower the stamens project beyond the flower and shed their pollen on the thorax of the insect and so cross-pollination occurs. Charles Robertson[38a] at Carlinville, Illinois, reports among other insects *Bombus Americanorum*, *Megachile brevis* and other long tongued bees and the short tongued bees *Agapostemon texanus*, *Prosopis pygmae*, besides Diptera and Coleoptera.

Red clover (*Trifolium pratense*) has an interesting method of pollination because of the explosive arrangement. This is fully described in another part of this volume under clover and need not be repeated. There is a slight variation in the pollination of the different species of clover.

Alfalfa (*Medicago sativa*).—The violet flowers are arranged in compact racemes and each flower consists of the upper large petal-like standard and two lateral wings. The insect lights on the keel and in so doing the pistils and diadelphous stamens come forward, pressing against the thorax of the bee. Burkill[38b] has stated that the basal processes of the wings and keel are two triggers by which the flowers are fired off. The stigma remains unreceptive until the papillae have been subjected to friction. It has been shown by Burkill and Urban that unexploded flowers do not set seed. Knuth[38c] states that Lepidoptera can bring about explosion when they thrust their proboscides into the nectary, but insects like the bee, which suck laterally, cannot do so.

Black Locust (*Robinia Pseudo-Acacia*).—This entomophilous flower is pollinated by honey bees and bumble bees. The flowers are white and arranged in racemes and emit a strong but pleasant odor. The large white standard has a greenish nectar guide with two lateral petals. The keel serves as a landing place for the insects. Knuth states: "The carina, alae and sexual column are mainly held together by the vexillum, the lower part of which grasps all of them by means of two well-developed elastic lobes. The posterior processes of the alar laminae also surround the sexual column so long as the alae are pressing the laminae inwards and downwards. The anthers dehisce before the flower opens; pollen collects among the hairs of the stylar brush, but protective bristles terminate the capitate stigma. The perpendicular style is 6 mm. long, and the terminal capitate stigma is surrounded by a circlet of protective bristles directed obliquely upwards. Below these comes a hairless region about one-fourth mm. long, while the part underneath this carries a brush of collecting-hairs crowded together externally into a tract about one-half mm. long, more loosely arranged internally, and stretching over a distance of 1½ to 2 mm. I was able to satisfy myself that the stigma remains sticky and receptive long after the anthers dehisce and the pollen has been removed."

Vetch (*Vicia sativa*).—This plant is pollinated by bumble bees and honey bees as well as by certain butterflies. The irregular flowers are in racemes. The wings are violet in color and the keel is whitish with a blue tip. The keel and wings are united in such a way that to secure pollination the insect must light upon the keel, which is then pressed down and the stamens come in contact with the thorax of the bee. Knuth puts it in the following way, "The posterior angles of the carina are drawn out into processes which lie upon the sexual column. There are also finger-shaped alar processes, running backwards parallel to each other. The upper filament is united with the other nine, but two nectar-passages are left at its base. The style is about 2 mm. long, and bears a brush on its upper half, the hairs of which are disposed all round it,

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[38a] Flowers and Fruit, 126.

[38b] Proc. Phil. Soc. Cambridge Vol. 8, 1894.

[38c] Handbook of Flower Pollination, 2:276.

and directed obliquely upwards. Externally there is a tuft of longer protective hairs, projecting beyond the stigma.''

Pea (*Pisum sativum*).—The pea has a rather large whitish flower. The sickle-shaped keel is produced into a leaf-like expansion attached to the firmly united wings. The diadelphous stamens are contained within the keel and the style has brush hairs on its lower side. An insect lights on the keel, pressing it down against its thorax and then leaves some pollen on the stigma. This is described by Knuth as follows, ''The style runs up vertically from the end of the horizontal ovary; its end is curved inwards to such an extent that the terminal stigma faces almost directly downwards towards the base of the flower. The inner side of the style is beset with long bristly hairs for almost half its length. The tip of the carina is also directed towards the base of the flower, and dilates into a pair of swellings which inclose the anthers in the bud. The conical space thus bounded possesses an opening through which the style can protrude.''

Sweet peas.—The flowers of sweet peas are conspicuous for their odor and color. The margins of the wings of the corolla adhere to the keel by a process which folds inwardly and the standard also fits into these wings. It thus requires considerable force to press down the keel, which contains the pistil and stamens. The style is flattened and hairy along the inner side and these hairs contain the pollen, which is swept out as the keel is pressed down.

Another weed of this family is the partridge pea (*Cassia Chamaecrista*). This leguminous plant is conspicuous in dry situations and has some interesting features, which were first described by J. E. Todd.[39] These are described by Robertson[40] as follows: ''The sickle-shaped pistil is turned either to the right or the left, holding the stamens in such position that they touch the bee upon the side; the flower is therefore an example of what Delpino calls a pleurotribe flower. Ten long black anthers with terminal pores turn in an opposite direction from the pistil. The petals are bright yellow and the upper ones are provided with a little red base which serves as a pathfinder but not as a nectar guide, since nectar is wanting. All are widely expanded and flexible except the lateral one toward which the anthers turn, which is erect and strongly incurved and so stiff that it commonly breaks on being bent back.''

The conclusions of Harris and Kucks[41] are somewhat at variance with Todd and Meehan; they find that right- and left-handed flowers are produced at the same time on the plant. When several plants are taken, the number of right- and left-handed flowers produced is practically the same.

So far as observed, the flowers were never seen open at the same time on a cluster, nor was a bud ready to open the following morning ever found on a cluster with an open flower. Thus, cross-pollination between flowers on the same cluster would not be possible, as it frequently is in *Solanum rostratum*.

Solanaceae.—The tomato (*Lycopersicum esculentum*), native of tropical America, produces short flower clusters with a wheel-shaped, yellow, five-parted corolla. The five anthers open lengthwise. The flowers of the tomato are visited by various species of beetles, flies and bees. Professor B. Fink observed that bumble bees visited about six of the flowers in a minute and that they

39 Am. Nat., 16:281.

40 Bot. Gaz., 15:199. See Halsted: Bot. Gaz., 15:103, for the amount of pollen produced.

41 Bull. Univ. of Kansas, 2:15.

gathered chiefly the pollen. According to Professor Fink the pollen sacs open sooner in small than in large flowers and sooner in dry weather than wet weather. In dry weather he observed while castrating flowers of the red cherry tomato that the anthers occasionally snapped open and the pollen could be seen flying about like dust as soon as the corolla had begun to open. It was found that twelve hours was long enough for the pollen tube to pass through the style when the stigma was mature at the time of pollination. The length of time that the stigma is in condition to receive the pollen is from four to eight days, but during the first two days close pollination can not occur as the anther cells are not open. Close pollination certainly frequently occurs in the tomato. The results of the work of Professor Fink and others indicate this beyond a doubt, but in one of the experiments reported it was found that the first tomato produced by close fertilization contained 48 seeds, the average number of seeds for the variety being more than 200, and that the fruits were below the average in size. Other observations recorded by this writer indicate that the size of the fruit is slightly increased and that the crossed fruits have a greater tendency to be irregular than those not crossed.

The potato, tobacco, egg plant and tomato belong to the family *Solanaceae*. In the common potato, native of South America, the flowers are borne in corymbs and the corolla is wheel-shaped, of white or purplish color, five-parted, with a very short tube. The five anthers meet around the style, forming a cone. The style extends slightly beyond the stamens and curves more or less downward at the stigmatic end. The anthers begin to dehisce at the apex and when touched allow the pollen to fall out. The flowers of the potato secrete no nectar and are not visited by many insects.

The writers mentioned above report, however, that nectar is produced and they observed that there is considerable odor early in the morning. The flowers harbor a considerable number of insects.

In the buffalo-bur (*Solanum rostratum*) the flowers are yellow and the stamens and style are much declined. The lowest anther is much longer than the others.

"As far as the writers have been able to ascertain, there is no law governing the producing of the right and left-handed flowers on the opposite sides of the main axis.

Various species of insects visit the flowers for pollen.

It seems that pollination is effected in many cases by the transfer of pollen from the leg of the insect, where it is being carried, to the stigma of the pistil upon which the insect is supporting itself. The function suggested by Professor Todd for the incurved petal seems to the writers entirely improbable."

Yarrow.—In yarrow or milfoil (*Achillea lanulosa*) the white heads are attractive to insects. A single flower is small and inconspicuous, but many of these small flowers are crowded together in one head, and in addition the white ray-flowers certainly render them conspicuous. The nectar is secreted by a small body at the base of the style and is easily reached by many insects. The flowers are visited by many small insects like flies and bees and are strongly proterandrous, each with five stamens. The anthers are united and when the flower opens the two divisions of the style are closely appressed in a cylinder made by the five anthers. The anthers when mature shed their pollen into the

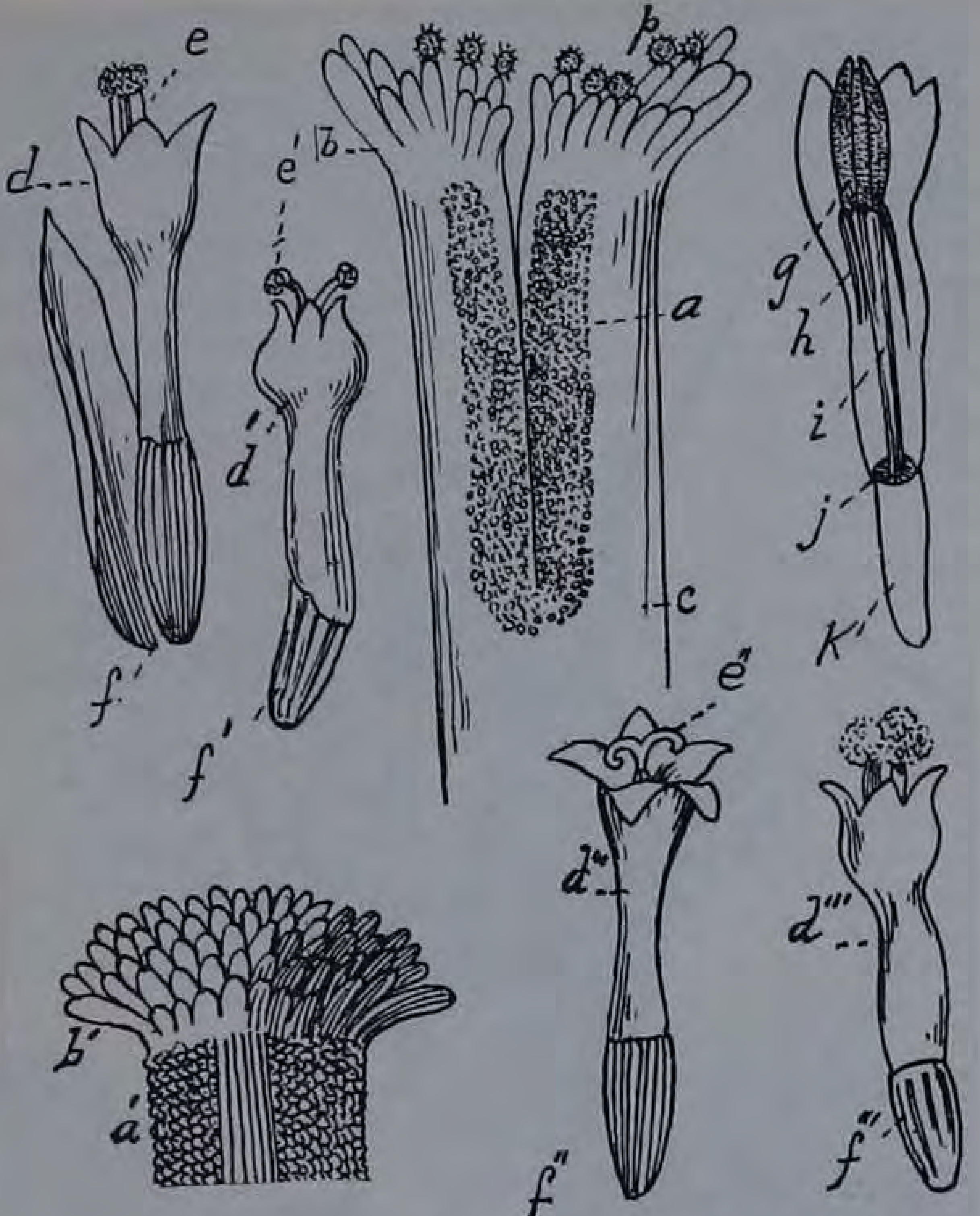

FIG. 474.—Yarrow (*Achillea lanulosa*). a, stigmas and style; b, brush hairs and pollen; p, g, the syngenesious anthers; k, ovary; d, corolla; e, style protruding from anther tube; e′, a later stage; e″, end of pistil reflexed; b′, brush hairs; a′, stigmatic papillae. *Mueller.*

hollow cylinder. The tips of the lobes of the style are furnished with hairs and as the style elongates it brushes out the pollen, which remains attached to the hairs. When older, these branches turn back and an insect going to a flower cannot fail to get some pollen on its body, and as it goes to another flower it is almost certain to leave some pollen on the stigma. While cross-pollination is almost certain to occur, self-pollination also may take place.

Dandelion.—In dandelion (*Taraxacum officinale*) the numerous flowers are collected in a head. All the flowers of the head are alike and bright yellow. The head is open in the bright sunlight of early morning and partly closed about noon. When fertilized the "flower stem" contracts, ripens its "seed" and elongates when ripe, so that the "seed" may be distributed. An abundance of nectar is produced and rises up for a considerable distance in the tube, making it accessible to many insect visitors. The Hymenoptera are common and among these the honey bee is a very frequent visitor, as are also species of *Bombus*. Many Diptera, syrphus flies, visit it. Mueller records sixty-seven Apidae, seven Lepidoptera, twenty-five Diptera and sixteen other insects. In the Alps Lepidoptera are more numerous than the Apidae.

FIG. 475.—Group of composites and other prairie plants (*Liatris* sp. and *Solidago* sp.). The composites are pollinated mainly by bees, the grasses are wind pollinated.

Asclepiadaceae.—The milkweeds are as interesting in their adaptations as are the orchids.

Common Milkweed.—Hildebrand and Mueller long ago called attention to the adaptations in *Asclepias syriaca.* The deeply five-parted corolla is of purple color. Next to the corolla is a crown of five hooded bodies seated on the stamens. The five stamens are attached to the corolla, the filaments are united in a tube which encloses the pistil, and the anthers adhere to the stigma. Unlike the pollen of orchids, milkweed always has a pair of pollinia. They are pear-shaped, of a yellow waxy appearance and hang by a curved stalk from a dark colored disc. These masses of pollinia are taken out by the insects as they suck the nectar from the glands and are attached to the insects' hairs, legs and tongues. Charles Robertson,[42] in an excellent account of plants be-

[42] Bot. Gazette, one of his early contributions.

longing to this family, finds that in *Asclepias verticillata* pollinia are usually attached to hairs of insects. In *Asclepias syriaca* the pollinia are more frequently attached to the claws. It is dangerous for small insects to extract the pollinia and insert them into the stigmatic chamber. In one day Mr. Robertson picked thirty-four dead hive bees from the flowers. The feet had become entangled with the pollen masses. In the case of another species, *A. Sullivantii*, he states that in a small patch bearing fifty-two follicles one hundred and forty-seven dead bees were found. In a single umbel he has often found four, and in one case seven dead hive bees. The insects pollinating these flowers belong to the bees (Hymenoptera), butterflies and moths (Lepidoptera), flies (Diptera), a few Coleoptera and Hemiptera. Some of these visitors are useless since they do not light on the flower. Others cannot extract the pollinia. Humming-birds have been observed, but Mr. Robertson thinks they are useless. Professor Frye[43] has published an account of the development of the flower which has some bearing on pollination.

Cucurbits.—The cucurbits are usually said to be monoecious or dioecious, although G. O. Miller says they are occasionally polygamous. It has been known for some time that some species are proterogynous and dioecious. Crozier says in regard to the watermelon: "In making some crosses today on the Volga

FIG. 476.—2, Perfect Gem Watermelon (*Citrullus vulgaris*); 3, Pollen grains from *Lagenaria vulgaris*; 4, The same, on addition of water. *C. M. King.*

43 Bot. Gazette, 1, 1902, also as a separate.

watermelon, a variety from southern Russia, I discovered that the so-called pistillate flower possessed stamens."

The flowers of the cucumber are also commonly visited by bees, but the striped cucumber beetle also may cause pollination. The flowers are monoecious, and the staminate flowers far outnumber the pistillate and appear before

FIG. 477.—1, Musk melon (*Cucumis Melo*); 5, Pollen grains of *Echinocystis echinata*. *C. M. King*.

them. Cross-fertilization is the rule so far as the experiments of F. C. Stewart and the writer could determine.[44] The pollination has been described.[45]

The pale yellow corollas of the varieties of watermelon (*Citrullus vulgaris*) are widely spreading. The honey is secreted at the base of the flower. It is easy to observe how the honey bee obtains the nectar. It uses the petals as a resting place and obtains nectar through the opening. It first probes one side and then passes over the stamens to the opposite side of the flower, from which

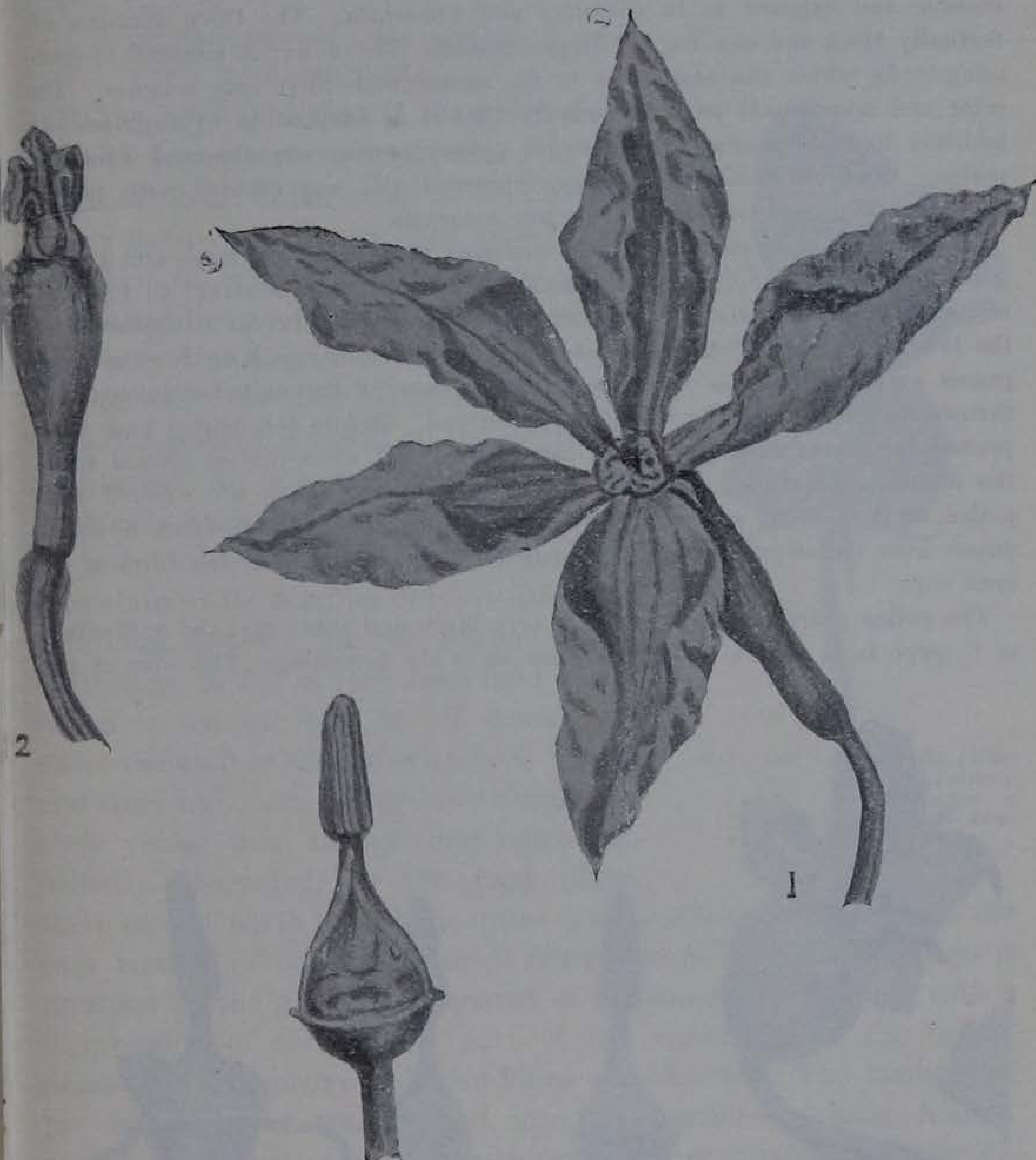

FIG. 478.—1, 2, *Lagenaria vulgaris*. 1, staminate flower; 2, pistillate flower, petals removed; 3, staminate flower of perfect gem squash.

44 Bull. Ia. Agr. Exp. Sta., 23:906, and Beach.

45 For a study of pollination of cucurbits see Pammel, Proc. Ia. Acad. Sci., 2:146. Pieters, Yearbook U. S. Dept. of Agrl., 1896:211.

the nectar is taken. When the work is finished it flies to another flower. Its visits are confined chiefly to one variety, but occasionally other varieties are visited.

Of the insect visitors the Hymenoptera were represented by *Apis mellifica* and the Diptera by several species of syrphus flies.

The musk-scented flowers of the dipper gourds (*Lagenaria vulgaris*) have a funnel- or bell-shaped calyx with a long tube. The white petals are persistent a much longer time than in *Cucurbita pepo* and the nectar is not so easily accessible and exposed as in *Citrullus* and *Cucurbita*. The three stamens effectually block the way for the larger insects. The flower is adapted to humming-birds, which can easily get to the nectar with their long tongues. The color and odor would seem to indicate that it is adapted to Sphingidae. In addition to the humming-bird, *Bombus pennsylvanicus* was observed collecting pollen. *Diabrotica vittata* also was observed and was covered with pollen. These beetles must frequently pollinate cucurbits.

In the common squash (*Cucurbita maxima*) the flowers are large and yellow, with a very pleasant odor. The corolla is five-cleft and adherent to the bell-shaped tube of the calyx. In the staminate flowers the nectar is contained in the lower part of the staminal tube, and an insect in searching for the same passes over the stamens down along the grooves of the united filaments and thrusts its tongue into the slit at the lower end. Before the flowers have been probed for nectar only the furrow can be seen, but when probed several times the filaments separate. The thorax and back of the insect are covered with pollen, as it falls out very easily. When the insect goes to a pistillate flower it passes over the stigmas and down to the nectary, which is in the form of an open cup.

The pollen grains of *Cucurbita* are very large and spiny and the pollination of *C. pepo* is in general much the same as in the preceding. The odor of the

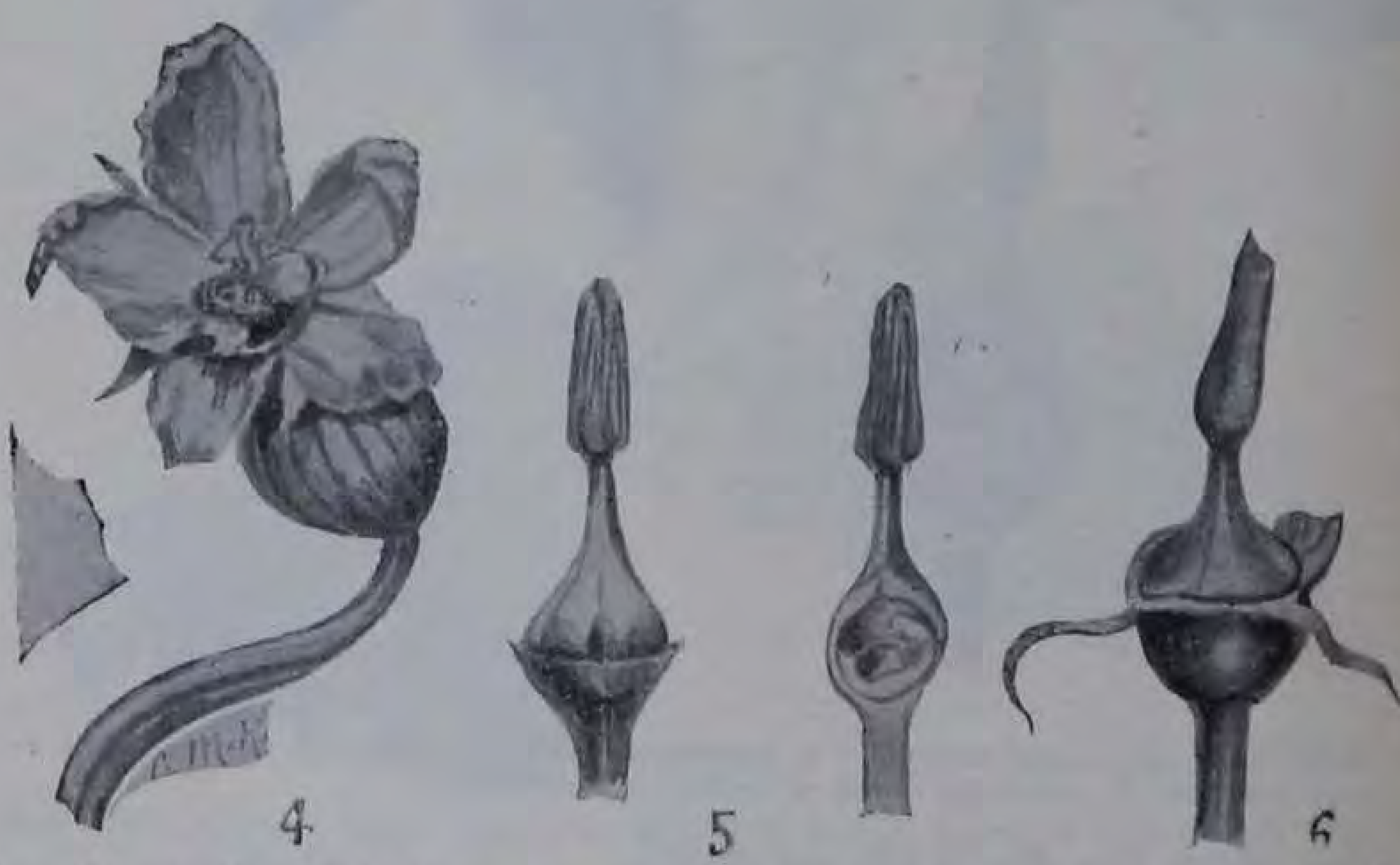

FIG. 479.—4, New White Gem Watermelon, perfect flowers; 5, Nectary below expanded part of filament; 6, Opening in nectary at base.

flower is not so pleasant, the nectar is abundant and the insect reaches it in essentially the same way. The flowers open early in the morning and an enormous amount of pollen is produced. The following insects are found upon the squash: the bumble bee (*Bombus Pennsylvanicus* and *B. fervidus*), also *Xenoglossa pruinosa, Mellissodes* sp., Andrenidae, *Halictus coriaceous, H. tegularis, H. zephyrus, Halictus* sp., *Augochlora similis* and *Andrena*. The following were found upon the pumpkin: *Melissodes, Bombus Pennsylvanicus, B. fervidus, Xenoglossa pruinosa*, and *Augochlora similis*.

BUTTERFLIES AND MOTHS, LEPIDOPTERA

FIG. 480.—A butterfly (*Hipparchea Janira*) at rest upon a cluster of flowers. *Behrens.*

It has been said that if the chief divisions of insects are to be arranged in the order of their importance as pollinators of our native flowers, the first place must be given to bees (Hymenoptera), while the butterflies and moths (Lepidoptera) take only the second or third place, before or after the flies (Diptera). But if the arrangement is based on the degree of adaptation to flowers, Lepidoptera undoubtedly take the first place, and it is the only order which throughout, and not in certain of its families only, is fitted for obtaining honey. In the perfect state, butterflies, so far as they take food at all, which is not the case in all species, restrict themselves almost entirely to honey, and since they take no further thought for their young than to lay their eggs, sufficiently concealed, on the food plant, their mouth parts have been quite free to adapt themselves to the easy method of obtaining honey from flowers. This adaptation is attained by the great development of the maxillary laminae with a suppression of the greater part of the remainder of the mouth organs. The labrum and mandibles are aborted. The laminae of the maxillae are transformed into two immensely long, hollow, rounded filaments provided with semicircular grooves on their inner surfaces, thus forming a tube when placed in close apposition. In a state of rest this tube is spirally coiled and concealed between the labial palpi.[46] The chief pollinators among the Lepidoptera are the butterflies, moths and hawk moths. The butterflies are diurnal

FIG. 481.—Position of the monarch butterfly (*Danaus archippus*) on one of the milkweeds while getting nectar out of the flower. *Courtesy Better Homes and Gardens.*

visitors, and when on the wing they flutter to and fro; when they are on the flower their wings are folded back. The moths and hawk moths are nocturnal visitors and do not take a position like that of

46 The account of insects is mainly taken from Mueller's work, Die Befruchtung d. Blumen.

butterflies when collecting honey, but hover over the flowers with their wings in rapid motion. Some of the Sphingidae or hawk moths have very long tongues. A species found in Brazil has a tongue between ten and eleven inches long. In southwestern United States and Mexico some of the hawk moths have tongues several inches long.

Soapwort.—Saponaria officinalis is a common European perennial weed in many sections of the state. The fragrant flowers are in corymbed clusters; the long calyx tube is terete. The five petals are white with a little tinge of purple, their claws stand a little higher than the calyx tube and they are crowned with an appendage. The flower is strongly proterandrous, the five outer stamens protruding first and dehiscing over the entrance of the flower. These anthers become flaccid and leave the entrance and the five inner stamens

FIG. 482.—Flowers of soapwort or bouncing betty (*Saponaria officinalis*). Pollinated by night flying moths. Calyx, corolla, stamens and pistil. *C. M. King.*

then follow the same course. The styles are still enclosed within the tube. When the inner stamens have withered the two styles grow up out of the flower, spread apart and turn their inner or stigmatic face upwards. The nectar is secreted from an annular ridge of the receptacle and is found in the lower part of the tube of the flower. Self-pollination is prevented because of the marked dichogamy. The plant is adapted to nocturnal Lepidoptera. Mueller[47] observed *Sphinx ligustri* in Germany. In the vicinity of Ames the species is commonly visited by *Sphinx Carolina, Philampelus, Deilephila lineata* and *Hemoris thysbe*. The sphinx moths are rapid in their flight, successively visiting different flowers. They begin their visits about dusk and later in the season may be observed as early as four o'clock in the afternoon.

Phlox and *Sweet William.—Phlox maculata* is native to southeastern Iowa. The fragrant flowers are produced in cymelike clusters with pink-purple corollas. The salver-form corolla has a long, small tube on which the five stamens are inserted. The flowers are proterandrous. The three-lobed style is ready to receive the pollen when the stamens have discharged their

[47] The Fertilization of Flowers, 128.

pollen. The cultivated *Phlox paniculata* produces an ample panicle of pink, purple or white fragrant flowers. The flowers are larger than in *P. maculata*, are proterandrous and especially adapted to diurnal Lepidoptera, but are also visited by nocturnal sphinx moths. The small, long, narrow tube of the corolla makes it especially adapted to such insects, but by no means are these the exclusive visitors. The cultivated *Phlox Drummondii* with flowers varying in color has a somewhat smaller flower with a shorter tube.

Woodland Sweet William (*Phlox divaricata*) is one of the most abundant of our woodland plants and occurs in great masses in practically all of the upland woods and sometimes in upland bottoms. It is one of the early bloomers. The pale lilac or blue, showy flowers form conspicuous cymose clusters crowded in the upper axils of the leaves. The nectar is secreted at the base of the ovary and occurs in the tube of the corolla. The anthers practically block the passage way to the corolla tube and mature before the stigma. The style during the shedding of the pollen is shorter and then gradually elongates until it reaches the same height as the stamen. The stigma then spreads apart and exposes the stigmatic surface.

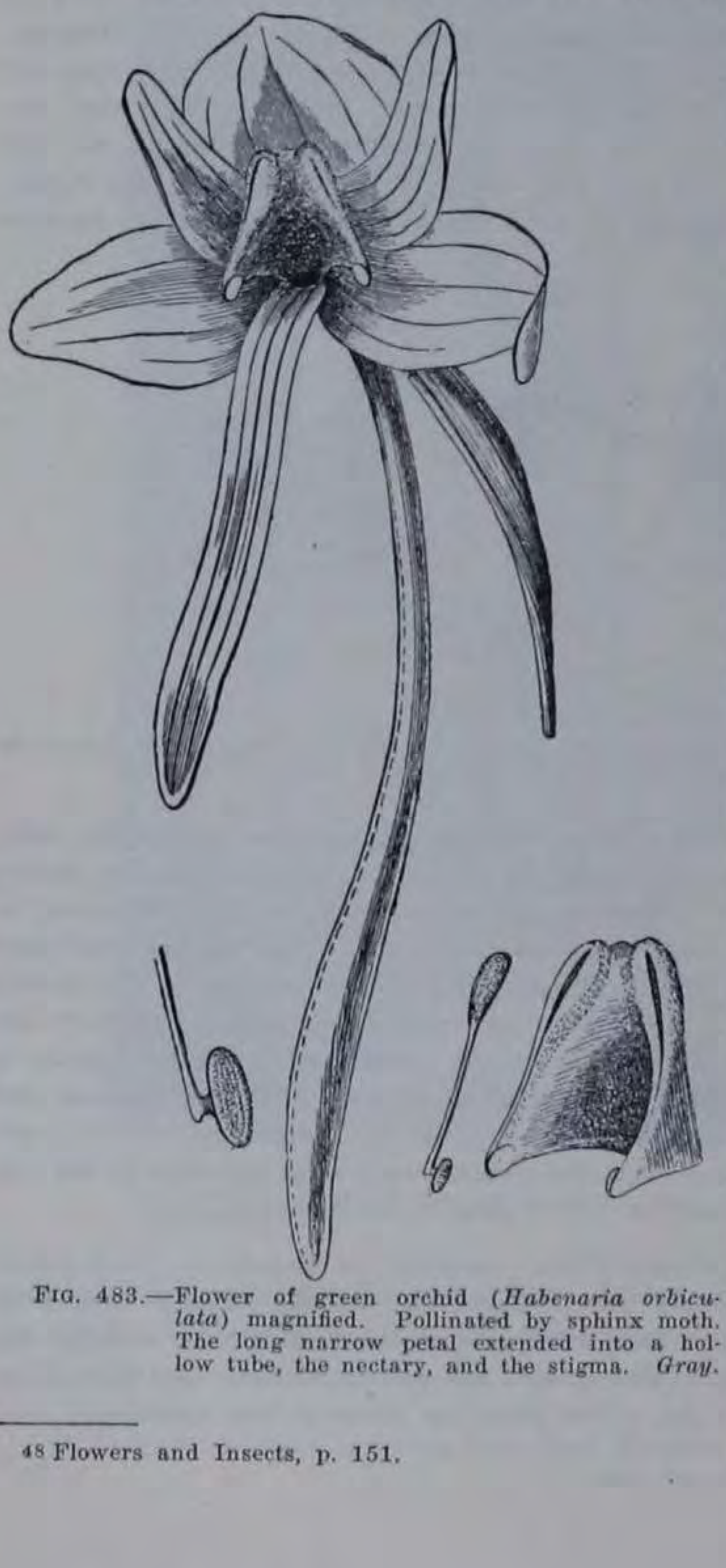

FIG. 483.—Flower of green orchid (*Habenaria orbiculata*) magnified. Pollinated by sphinx moth. The long narrow petal extended into a hollow tube, the nectary, and the stigma. *Gray*.

This flower is visited by the long-tongued bees and several of these are recorded.[48] I was interested therefore to notice on May 5, 1930, at Pammel State Park, that one of the Lepidoptera, the

[48] Flowers and Insects, p. 151.

humming-bird clear-wing (*Hemoris thysbe*)[49] was the active pollinator. Several of these were found within an area of a square rod.

Habenaria.—The greater green orchis (*Habenaria orbiculata*) was studied many years ago by Doctor Gray, who describes the essential features of the process of pollination as follows: "The three external parts of the perianth, the sepals, are much broader than the three internal, the petals. The base of the long and narrow petal is turned downward and hollowed out into a long tube, which is closed at the bottom and open at the top. This is the spur or nectary. The single anther and stigma are united and lie just beyond the opening of the nectary. The anther cells open by a long chink approaching each other at the upper end, while the lower is widely separated and the space between is very glutinous. The pollen grains are united by fine threads, then into larger, finally forming pellets, and having a stalk attached to a central stalk. At the lower end of this stalk is a button-shaped disc attached, the face of which is exposed and is on a line with the surface of the anther, so that these two discs look toward each other across the broad, intervening stigmatic space. When a finger or any small body touches these discs they adhere so firmly that the attached pollinia or pollen masses are dragged out of the cell and carried away entire. When a hawk moth like *Sphinx drupiferarum* visits these flowers and presses its head into the center of the flower to get the nectar out of the nectary a pollen mass will be fixed to each eye, and on withdrawal these will stand as shown in the figure."

The purple fringed orchis (*Habenaria psychodes*), an inhabitant of our northern marshes and bogs, and rare in Iowa, produces its many purple fragrant flowers in dense racemes. The fan-shaped lip is three-parted above the stalklike base, having its divisions fringed. The plant blooms in July and is visited by butterflies and long-tongued bees.

Catasetum.—This is interesting as regards its pollination. It is not uncommon now in greenhouses. Its remarkable adaptation to insect visitors was first pointed out by Darwin. In this orchid the pollinia and stigmas are in different flowers. As in *Habenaria* the pollinium is furnished with a viscid disc, but in this case the insect does not touch the disc. The flower is sensitive and throws the pollinium at the insect. Sir John Lubbock says that Darwin irritated one of the flowers in his presence and the pollinium was

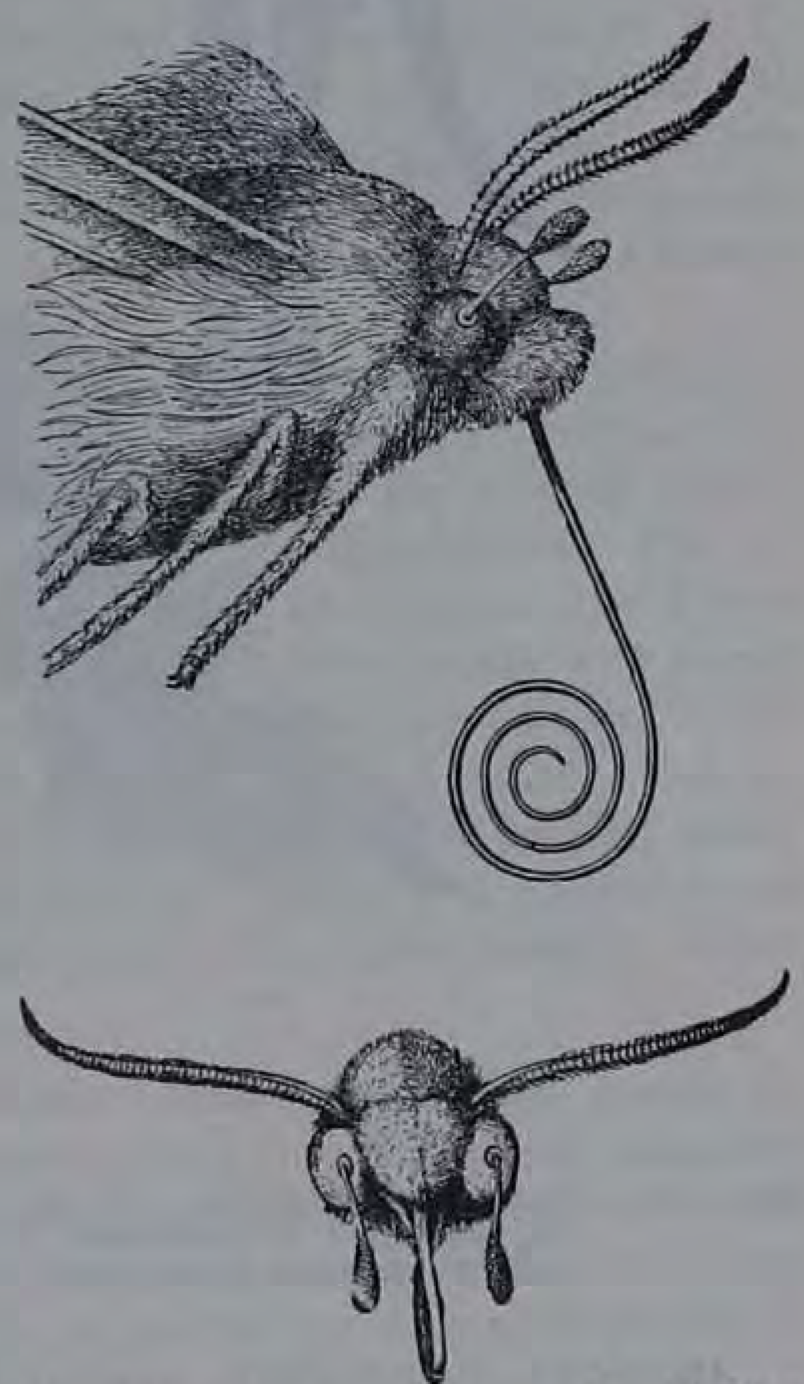

FIG. 484.—Above, sphinx moth (*Sphinx drupiferarum*) bearing pollen grains from *Habenaria orbiculata* attached to each eye. The long tongue partly coiled. Lower, front view of head of sphinx moth, eyes with pollinia attached, tongue coiled. *Gray.*

[49] Identified by H. M. Harris, Department of Zoology and Entomology, Ames.

thrown nearly three feet. I have seen the pollinium of this species thrown two feet.

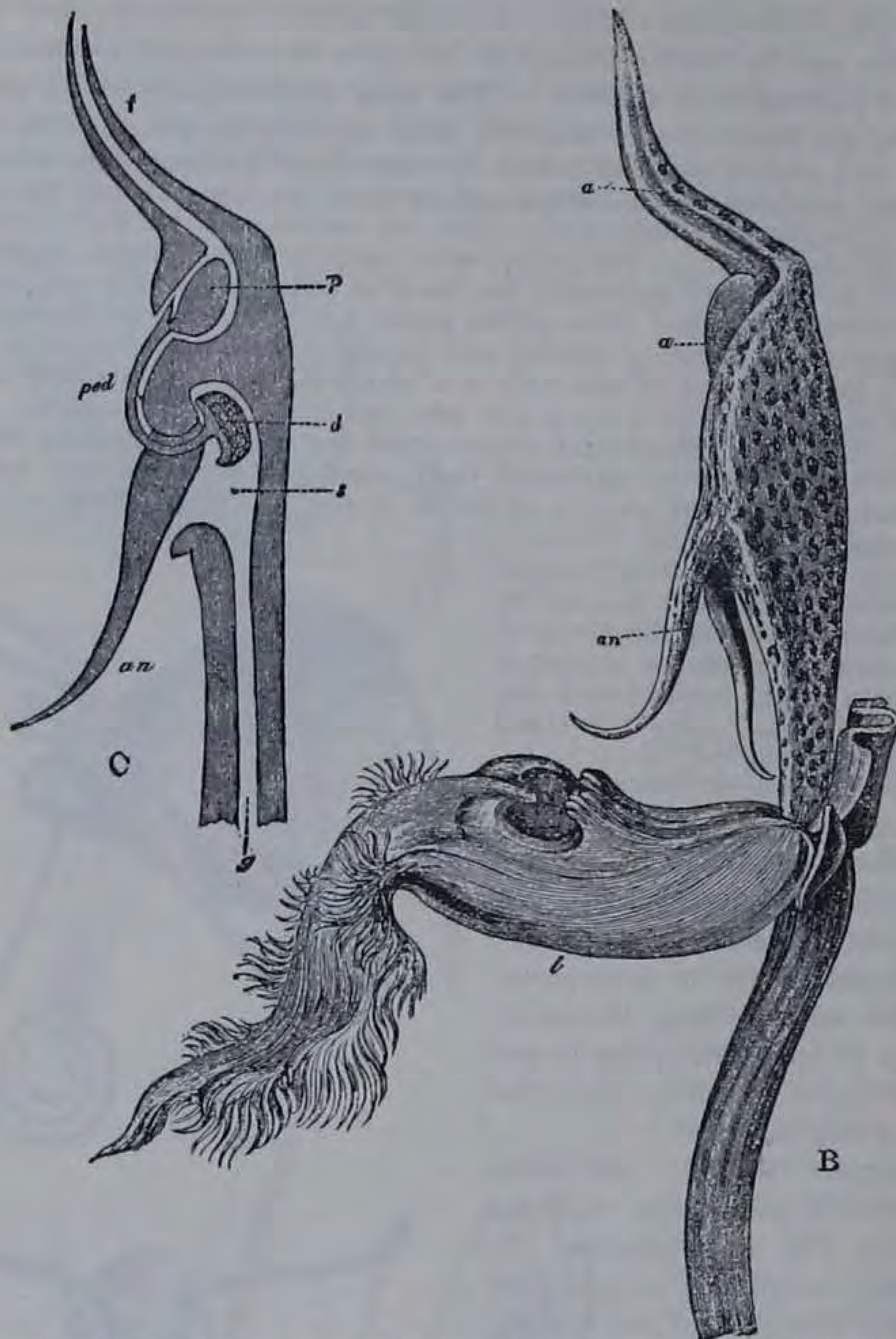

FIG. 485.—*Catasetum saccatum.* B, side view of the flower; C, diagrammatic section; an, antennae of rostellum; a, anther; d, disc of pollinium; f, filament of anther; g, ovary; ped, pedicel of pollinium; l, labellum. *Darwin.*

Angraecum.—Angraecum sesquipedale is a native of Madagascar and is cultivated in greenhouses. The spur in this species is longer than that of any other orchid, ranging from 10 to 14 inches in length. It is said, according to Darwin, that an insect must have a tongue 11 to 12 inches long in order to reach the nectar.

Darwin in describing this plant says: "It is, however, surprising that any insect should be able to reach the nectar. Our English Sphinxes have proboscides as long as their bodies, but in *Madagascar* there must be moths with proboscides capable of extension to a length of between 10 and 11 inches. This belief of mine has been ridiculed by some entomologists, but we now know from Fritz Mueller that there is a sphinx-moth in southern Brazil which has a proboscis of nearly sufficient length, for when dried it was between 10 and 11 inches long. When not protruded it is coiled up into a spiral of at least twenty windings.'' Mr. Forbes has found a moth in Madagascar long enough to reach the nectar. A green whiplike nectary hangs down beneath the labellum. According to Darwin only the lower one and one-half inches, in the species he examined, was filled with nectar. I have seen some nectaries that were between 12 and 14 inches in length.

Lilies and their Allies.—In the order Liliaceae there are some remarkable adaptations for insect pollination, as in the yucca. We have several native species of the lily in the state, like *Lilium philadelphicum*, *L. superbum* and *L. canadense*. These species, however, are adapted chiefly to Hymenoptera while the European *L. Martagon* is adapted to Sphingidae. The anthers and stigma in this species ripen simultaneously and the nectar is contained in the groove found at the base of the segment of the perianth. *Lilium speciosum* is white with the perianth segments speckled and the tips recurved as in *L. superbum*. In addition to these spots there are wartlike projections near the center on each side of the nectar groove. These spots, projections and grooves point the way to the nectar. In addition to sphinx moths observed pollinating the flower at Ames, the writer has also observed the ruby-throated humming-bird.

Although the Canadian lily and *L. superbum* are no doubt chiefly pollinated by *Megachile*, according to Mr. Weed, they are also visited by *Trochilus* and butterflies, as I have observed. Schuyler Mathews[50] notes the monarch butterfly (*Anosia plexippus*). It is also visited by other Lepidoptera. The essential points in the pollination of *L. superbum* are as follows: the flowers are pendulous, the perianth consists of six parts, yellowish orange with brown spots; petals and sepals are completely reflexed. The nectary[51] occurs in the form of a groove in the middle of each division of the perianth. The six stamens have their linear anthers extrorsely attached near the middle, finally becoming versatile. They are completely exposed. The style is elongated and somewhat club-shaped; the stigma is three-lobed. The insect is easily dusted with pollen when in search of the nectar.

Yucca.—The most remarkable interrelation between flowers and insects occurs in the genus *Yucca*, the most interesting and peculiar of the American liliaceous plants. The plants are found along the southern Atlantic sea coast and westward, one species, *Yucca glauca*, extending as far west as the loess bluffs of western Iowa. The early studies on pollination were made by Dr. C.

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50 Field book of American Wild Flowers, 52.

51 The order Liliaceae is separated into several distinct families: in some members of the order the nectar is easily accessible, in others it is quite deep seated. In some, as in the tulip, there is no nectar. Onion (*Allium*) is visited by a miscellaneous class of insects. The Rocky Mountain proterandrous *Lloydia serotina*, with a whitish perianth, has special nectaries which form a ridge at the base. In *Veratrum Californicum*, found at higher altitudes in the swamps of the Rocky mountains, the flowers are greenish yellow, produced in large ample panicles. The lower flowers are mostly staminate; the others hermaphrodite. The species is for practical purposes dioecious. Many of the plants do not produce seed. I have found them chiefly visited by flies. The *V. Woodii* is found in eastern Iowa, while *V. viride* is common in the eastern states.

V. Riley,[52] Dr. Wm. Trelease[53] and Dr. Geo. Engelmann.[54] Doctor Trelease more than anyone else has studied the method of pollination in many species. He says, "The pollination relations of nearly all of the groups are among the most peculiar and exclusively restricted thus far discovered. *Hesperoyucca* secretes much nectar and appears adapted to birds, as are the Cape aloes, to which it bears no inconsiderable resemblance in its flowers. The other genera are sparingly if at all nectariferous, though all have sepal glands, which are rather small in *Clistoyucca*, but very large in the others."

FIG. 486.—Yucca (*Yucca angustifolia*). Pollinated by yucca moth (*Pronuba yuccasella*). An ornamental plant. *L. H. Pammel.*

The other yuccas "depend for their pollination upon small moths belonging to the tineid genus *Pronuba*, of which one species (*P. synthetica*) is known only in connection with the single species of *Clistoyucca*, one (*P. maculata* and its variety *aterrima*), with the single species of *Hesperoyucca*, and the only other known species (*P. yuccasella*) accompanies the various species of Yucca across the continent."

The pendent, more or less bell-shaped flowers are borne in mostly simple racemes and have a perianth of three sepals and three petals, yellowish white in

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52 Rept. Mo., Bot. Garden, 13:124. Trans. Acad. Sci. St. Louis, 3:55; 1873. Proc. Biol. Soc. Wash., 7:96.

53 Rept. Mo. Bot. Garden, 3:99; 4:18.

54 Bull. Torrey Bot. Club, 3:33-37; 1872. Trans. Acad. Sci. St. Louis, 3:17-54; 1873.

color and very fragrant. Both color and odor make them conspicuous for night-flying insects. The viscid pollen is contained in small anthers which arise from the papillose, curved filaments. A flower remains open for a single day and on the second day the ends of the six stamens begin to close up and the flower has the shape of a balloon with six small openings. At twilight and during the night there may be seen flying about the flowers of the yucca a yellowish white moth with a metallic luster, the *Pronuba yuccasella.* The first joint of the maxillae is extraordinarily lengthened, and on the inner side it is provided with stiff bristles. It can be rolled up as a proboscis. This structure is for the purpose of collecting, rolling up and holding the pollen. The females of the moth enter the open flower and obtain the pollen, not, however, to eat, but to carry it to another flower. In a short time the moth has collected a ball of pollen which it holds on the under side of the head by the rolled up palpi. This large load of pollen received from several anthers is sometimes three times as large as the head of the insect. It immediately leaves the flower to deposit its egg in the pistil of another flower, in the side of the ovary close to the ovule. The ovipositor consists of four horny bristles pressed together, which are well adapted for boring the tissues of the ovary. After the eggs are deposited the moth runs to the hollow funnel-shaped stigma and then rolls up her proboscis-like mandibles and places the pollen on the stigmas. The eggs hatch on the fourth or fifth day and each larva requires 15 to 20 ovules for its development. When mature the larva bits a hole through the fleshy wall and reaches the ground by means of a thread, enters the soil and forms an egg-shaped cocoon. It remains in this stage until the following summer. About fourteen days before the flowering time of the yucca it pupates and when the flowers open, tiny moths issue from the pupa. The pollination of yucca is an extraordinary case. Without the yucca moth the viscid pollen could not reach the stigma. If the yucca moth is excluded seed will not develop. *Yucca angustifolia* and *Y. Whipplei,* when grown in Europe, have never developed a single seed.

Seed formerly was not produced in parts of the United States where the yucca moth and yucca were not native. A few years ago I studied this subject and Mr. Wesley Greene of Davenport told me that seed originally was not produced on the cultivated plant prior to the *Civil War.* He thinks that soldiers of the civil war brought some of the yucca moths back to Davenport. At any rate he observed seed after 1865. I saw an abundance in Rock Island, Illinois, on *Yucca glauca* and *Y. filamentosa* in 1928. Prior to 1925 there were no seed capsules observed in Ames. Mr. Verne Wiggins observed some in Story City in 1925 on *Yucca glauca* and the year following capsules were observed on each of two plants of *Yucca filamentosa* at Ames. In 1930 I saw some capsules in Newton and Des Moines.

Dr. Riley says: "Upon a superficial view this little moth shows nothing very peculiar. The general coloration is white, the primaries being purely white on the upper surface, so that when at rest in the half-open flowers of the Yucca, it is not easily detected. The under surfaces, however, are dusky and offset in flight the whiteness of the rest of the body, so as to render the species somewhat difficult of detection while flitting from plant to plant. The male shows no very marked peculiarities to distinguish it from the other members of the family, the most noticeable being, perhaps, the prominence of the exposed portions of the genitalia. The female, however, shows remarkable structural peculiarities which admirably adapt her for the functions she has to perform, for she must fertilize the plant, for her larvae feed upon the seeds.

"Her activity begins soon after dark, and consists at first in assiduously collecting a load of pollen. She may be seen running up to the top of one of the stamens and bending her head down over the anther, stretching the maxillary tentacles, so wonderfully modified for the purpose, to their fullest extent, the tongue uncoiled and reaching to the opposite side of the stamen, while the head is kept close to the anther and moved peculiarly back and forth as in the motion of a caterpillar when feeding. The maxillary palpi are used in this act very much as the ordinary mandibles are used in other insects, removing or scraping the pollen toward the tentacles. After thus gathering the pollen she raises her head and commences to shape it into a little mass or pellet by using her front legs, very much as a cat does when cleaning her mouth, sometimes using only one leg, at another time both, smoothing and pressing the gathered pollen, the tentacles meanwhile stretching and curving. After collecting all the pollen from one flower she proceeds to another and repeats the operation, then to a third and fourth, after which, with her relatively large load—often twice as large as the head—held firmly against the neck and front trocanters, she usually runs about or flies to another plant; for I have often noticed that oviposition as a rule is accomplished in some other flower than that from which the pollen was gathered, and that cross-fertilization is thus secured."

FIG. 487.—Flowering tobacco (*Nicotiana alata*). Position of flower during bright sunshine. *Charlotte M. King.*

Tobacco (*Nicotiana Tabacum*) is a native of tropical America. The flowers are borne in rather open corymbs with a bell-shaped corolla, which has a broad red or somewhat greenish inflated tube. The funnel-form corolla is two inches long. The calyx is viscid granular. The species of *Nicotiana* are visited by night-flying insects.

Datura Stramonium.—The Jamestown weed is a tall weed with a white corolla about three inches long and stamens adherent to the corolla tube for a part of the distance, then leading inwards, thus effectually excluding bees from the honey so that only Sphingidae can obtain it. Mr. Robertson reports that honey bees remove the pollen as soon as the flower is open, before the flight of a moth, *Deilephilia lineata*. A Venezuelan species of *Datura* is visited by *Docimastes ensifer*, the female of which has a beak 8 cm. long and the male one 10 cm. in length, these corresponding in length to the tube of the corolla.

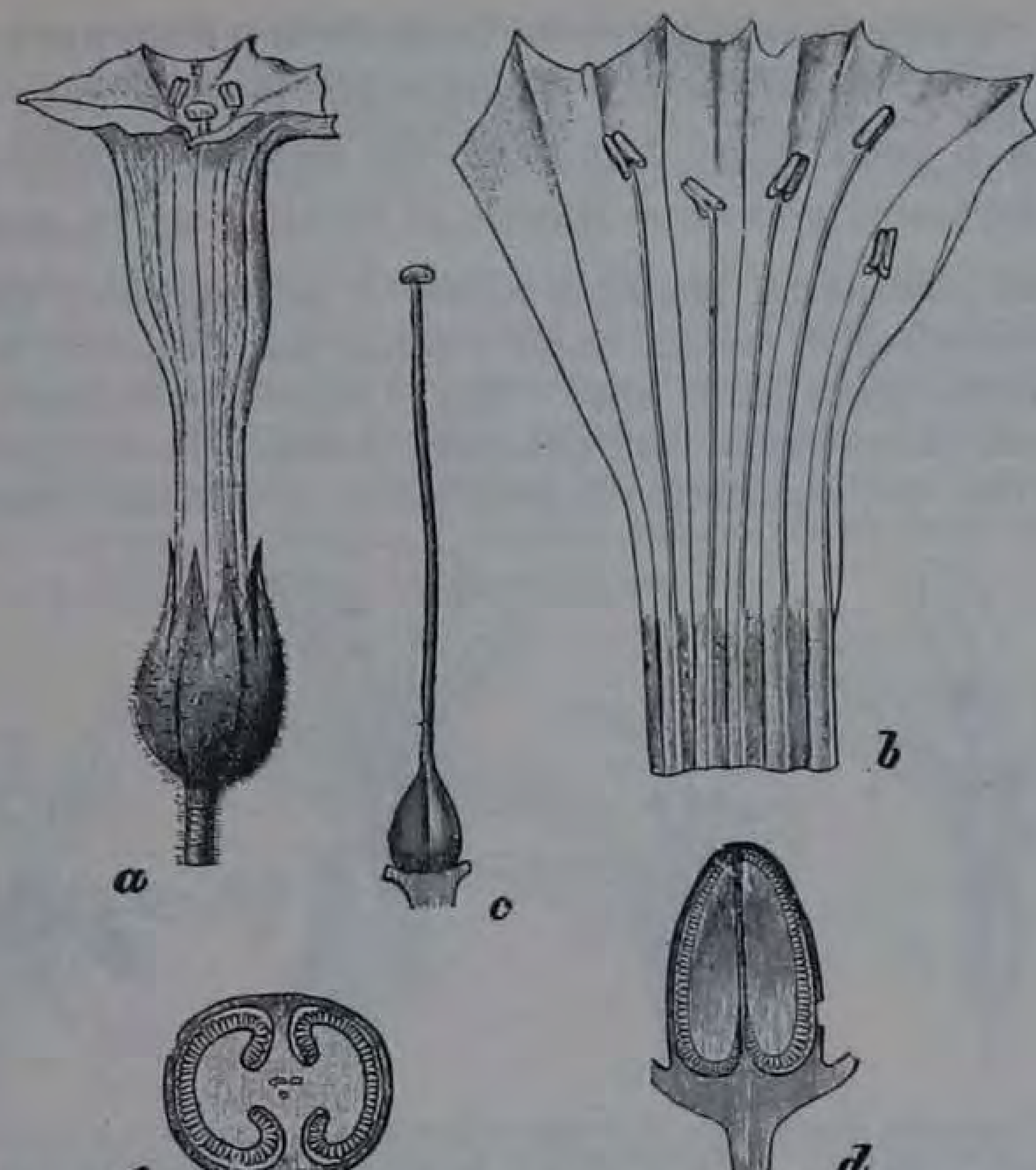

FIG. 488.—Tobacco plant (*Nicotiana Tabacum*). Pollinated by moths. a, flower; b, corolla cut open; c, ovary; d, e, young fruit. (a, b, c, natural size; d, e, x 2). *After Strasburger, Noll, Schenck and Schimper.*

HETEROGAMY

A large number of papers have been published on heterogamy.[55] In heterogamy there is an inequality in the length of stamens and styles of the same species. The flowers are perfect and pollinated by insects. Plants with this inequality of styles bear two or three different forms of flowers, although each individual plant bears only one kind. When a species bears two sets of flowers it is said to be dimorphic. In a second type, the trimorphic, three different sets of flowers are produced on as many different plants. One plant produces flowers with a long style, medium length stamens and short stamens, a second plant produces flowers with a style of medium length, long stamens and short stamens, a third plant produces flowers with a short style, long stamens and those of medium length. Dimorphic flowers have been detected in about fifteen natural families. Of these plants *Primula vulgaris*, *P. Parryi*,

55 Darwin, C., The different Forms of Flowers and Plants of the same Species.
Hildebrand, F., Experiments ueber den Dimorphismus von *Linum perenne* und *Primula sinensis*: Bot. Zeit., 22:1.
Gray, A., Structural Botany, 234.
Mueller, Hermann, Fertilization of Flowers, 255.

Mitchella repens, Linum perenne, buckwheat (*Fagopyrum esculentum*) are good illustrations. Trimorphic flowers have also been detected in a good many families. Of these *Houstonia caerulea, Lythrum Salicaria* and some species of *Oxalis* may be mentioned.

Lythraceae.—Loosestrife (*Lythrum Salicaria*) is a native of Europe but is sparingly naturalized in eastern North America and frequently is cultivated. Flowers purplish, petals six to seven. Spiked loosestrife is classic because of Darwin's work in connection with trimorphic flowers. Darwin proved beyond a question that the reproductive bodies, when of different lengths, behave

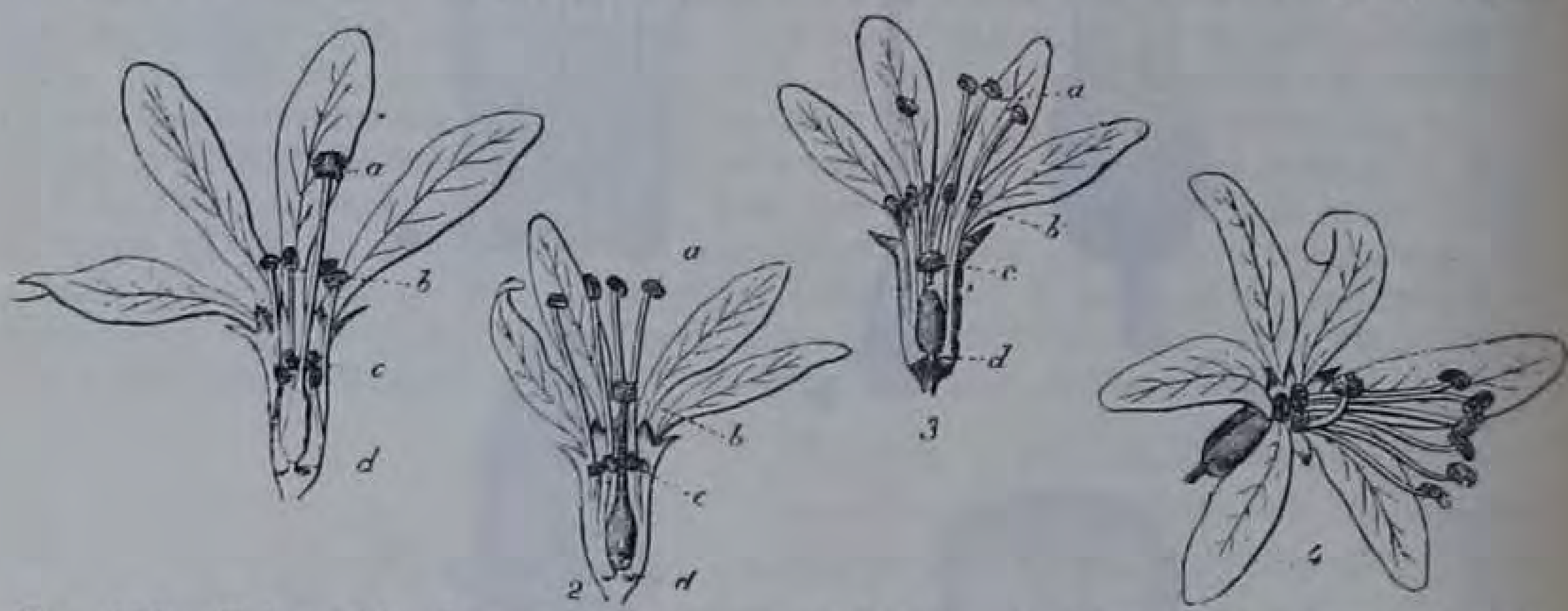

FIG. 489.—Trimorphic flowers of *Lythrum Salicaria.* 1, long-styled flower; a, style; b, mid-stamens; c, short-stamens; d, nectary; 2, mid-styled flower; a, long-stamens; b, mid-style; c, short-stamens; d, nectary; 3, short-styled flower; a, long-stamens; b, mid-stamens; c, short-style; d, nectary; 4, mid-styled flower viewed obliquely. *Mueller.*

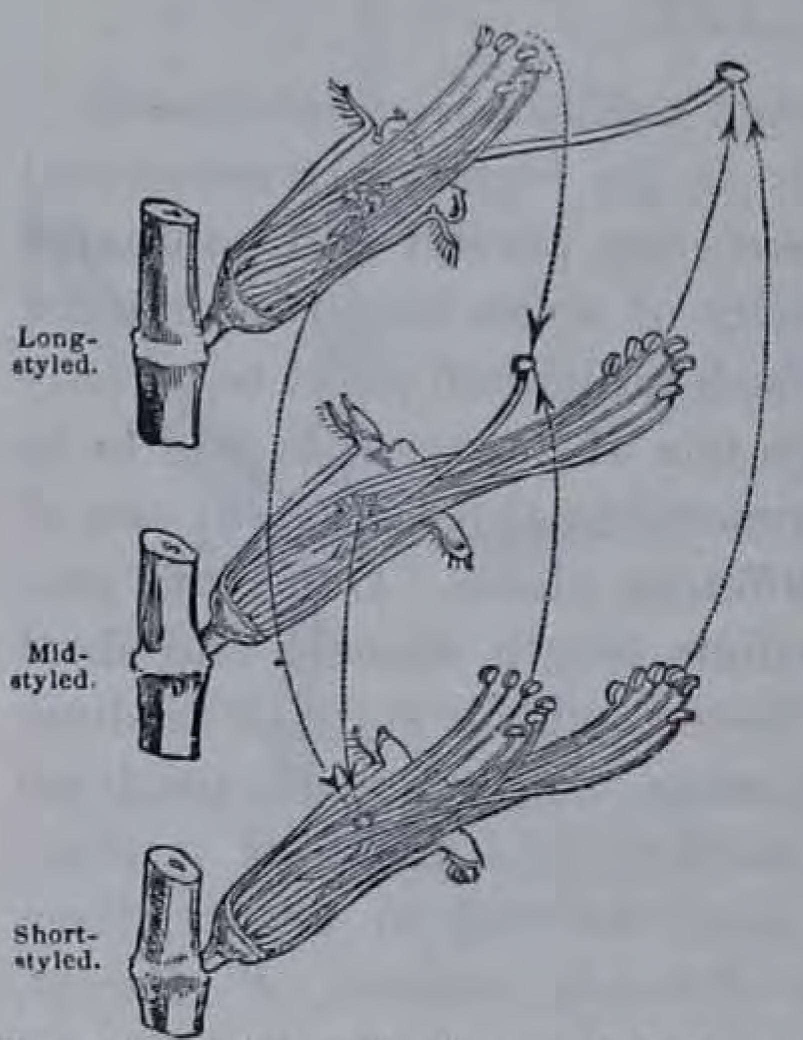

FIG. 490.—Trimorphic flowers of *Lythrum Salicaria* with perianth removed. Arrows show direction in which pollen must be carried. *Darwin-Gray.*

like different species of plants, that is to say, the pollen taken from a short stamen and placed upon the long style in the same flower or plant has no effect. So, too, of all the other stamens taken from the same plant. Darwin also demonstrated that the pollen grains differ as well as the stigmatic papillae. The pollen grains of the longer stamens are greener than those of the mid- and short stamens and they also differ in size. The longest stamens have the largest pollen grains, the mid-stamens are intermediate, while the short stamens have the smallest pollen grains.

In this species three kinds of plants are produced. One plant produces only a short style with long stamens and mid-stamens; a second plant has a long style with short and mid-stamens; a third has a medium style with short and long stamens. In order to have full and complete fertility pollen must be brought from the long stamens over to the long-styled, short stamens over to the short-styled, and mid-stamens over to the mid-styled form. The honey in this plant is accessible to a large class of visitors.

Many species of the genus *Primula* are dimorphic. Of the handsome North American species that I have examined *Primula Parryi* is dimorphic. This plant is common in the alpine and subalpine regions of the Rocky mountains, where it occurs on the edges of snow banks and of cold brooks. It produces succulent, spatulate, oblong or lanceolate leaves, with a five- to twelve-flowered scape. The flowers are fragrant, corolla crimson purple with a yellow eye. The plant is pollinated chiefly by Lepidoptera.

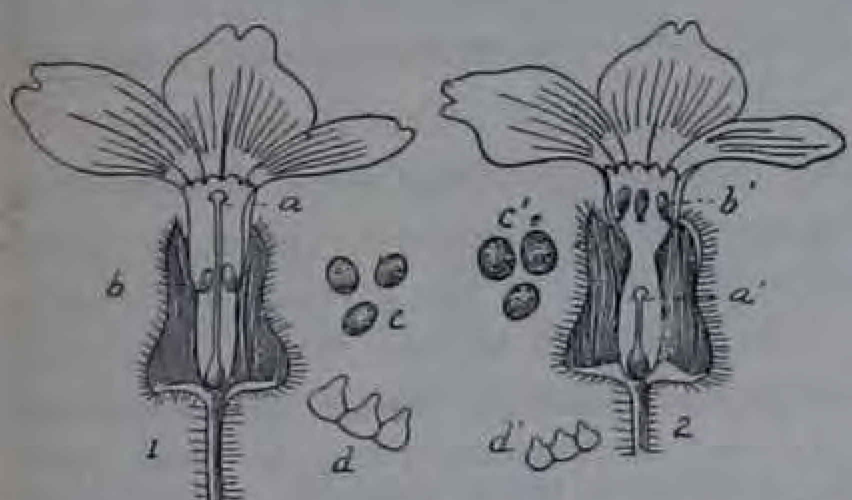

FIG. 491.—Primrose (*Primula sinensis*). Two flowers from different plants. 1, long styled flowers; a, style; b, stamens; c, pollen; d, stigmatic papillae; 2, short styled flower, a′, style; b′, stamens; c′, pollen; d′, stigmatic papillae. *Strasburger, Noll, Schenck and Schimper.*

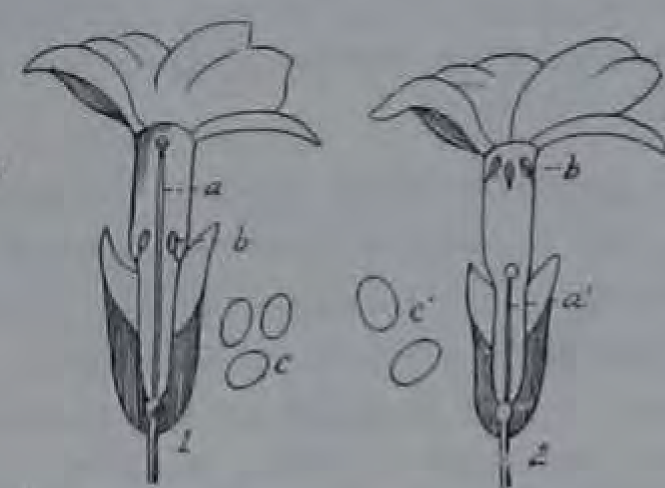

FIG. 492.—Cowslip (*Primula*). 1, long styled flower; a, style; b, stamens; c, pollen from short stamens; 2, short styled flower; b, stamens; a, short style; c′, larger pollen grains. *Lubbock.*

Darwin, who studied nine species of *Primula*, summarizes the fertility of legitimate unions and illegitimate unions. The legitimate unions between the two forms of the nine species of *Primula* were found to be more fertile than the illegitimate unions. In *Primula veris*, of which some very careful studies were made, Darwin found that short styled plants produced more seed than the long styled in nearly the proportion of three to two, but if we take the fairest standard of comparison, namely, the product of seeds from an equal number of umbels, the excess is, as in the former case, nearly as four to three.

The genus *Primula* is much more common in Europe than in this country and there are a larger number of hybrids of the genus. We have only one species of *Primula* in the state of Iowa, namely *P. mistassinica*.

In dioecious flowers it is very evident that cross-fertilization must result. It is evident also that in monoecious flowers the pollen must come from a different flower than the one in which it is produced. A large number of trees that flower in the spring or early in the season are either monoecious or dioecious, such as the elm, the willow and the cottonwood. There are many plants which are imperfectly dioecious or monoecious. These in systematic works are usually called polygamous. In the buckeye (*Aesculus glabra*) there are perfect flowers and others with rudimentary pistils and perfect stamens. In the ash the stamens are rudimentary in some individuals, the pistils in others, and others have hermaphrodite flowers. In the bittersweet (*Celastrus scandens*) the flowers are polygamo-dioecious. It is well known that fruit growers use both staminate and pistillate varieties. The purely staminate flowers produce no fruit; the females, when staminate flowers are close at hand, produce a good crop of berries; the hermaphrodite flowers a fair or scanty crop. The European buckthorn, as well as our native species (*Rhamnus lanceolata*), occurs in several different forms. Professor Trelease[56] says: "In most species of Rhamnaceae the flowers are hermaphrodite. Exceptions are found in *Gouania* and one section of *Rhamnus*, where by suppression of stamens or pistil, they become essentially dioecious, as in *Euonymus*, *Ilex*, *Acer*, etc. Darwin has called attention to the curious difference in length of the pistil in the dioecious *Rhamnus cathartica*, which bears long and short-styled staminate, and long and short-styled pistillate flowers. This unexplained differentiation apparently dates back to a time anterior to the separation of the sexes by abortion of one or the other of them. Long and short-styled flowers of *R. lanceolata*, first carefully observed, I believe, by Professor Porter, are described by Dr. Gray."

In the gyno-dioecious species the plant produces hermaphrodite flowers and females, and occasionally shows some tendency to be dioecious. Most of these types belong to the Labiate family. Such types occur in the thyme, in *Brunella* and in ground ivy (*Nepeta Glechoma*). Darwin says of the thyme (*Thymus Serpyllum*) "The females of the present species produce rather fewer flowers and have somewhat smaller corollas than the hermaphrodites; so that near Torquay, where this plant abounds, I could after a little practice, distinguish the two forms whilst walking quickly past them." The female flowers are generally shorter than the hermaphrodite. The stamens in the female vary in length. In the ground ivy (*Nepeta Glechoma*) Mr. Hart found that all the plants in Ireland were females. In Bath, however, they were hemaphrodite and at Hartford both were present. In Italy, according to Delpino, they are trimorphic. Hermann Mueller[57] concludes that originally some individuals varied so as to produce more conspicuous flowers and that these were habitually visited by insects first, the insects afterwards visiting the less conspicuous flowers. The pollen of the less conspicuous plants would be superfluous; it is therefore advantageous for the species to check the production of pollen, those less conspicuous being converted into female flowers. Darwin[58] suggests that increased fertility seems to have been a probable cause for the formation and separation of the two forms, the production of a larger supply of good seeds being of great importance to the plant.

IRRITABILITY OF THE FLORAL ORGANS

There are a number of plants in which certain parts of the flower are sensitive for the purpose of insuring pollination. The barberry,

56 Trans. Acad. Sci. St. Louis, 6:359.
57 Fertilization of Flowers, 472.
58 Different Forms of Flowers, 304.

Opuntia, Kalmia, the orchid *Catasetum,* and *Schizanthus* are illustrations.

The explosive movemēnts occuring in certain Leguminosae are familiar, as in the genus *Medicago* and *Melilotus.* In *Medicago sativa* when the insect presses down the keel the stamens rise forwards and curl. The tension in the stamens is so great that the pollen is thrown up with some force. In the European *Genista tinctoria* the part of the keel is in a state of tension and the moment it is touched it explodes, the keel and wings spring downwards and the tube containing the stamens with the pistil is jerked upwards, thus throwing the pollen some distance. I have seen the pollen of *Mucuna* thrown several inches like a cloud of dust. In *Lopezia coronata* the flower has one perfect stamen and a second below which is reduced to a leaf-like body. The spatulate leaf-like stamen encloses the perfect anther. This sterile anther has an elastic tension downwards and when the insect alights on it, the anther turns upward and is set free and dusts the insect with pollen.

Barberry.—The common barberry (*Berberis vulgaris*), so frequently cultivated as an ornamental, is much visited by the honey bee. The essential points in the structure of the flower are as follows: The yellow flowers are borne in racemes and contain some nectar, which is secreted by two fleshy, orange-colored glands at the base of each petal. The honey collects between the stamens and the ovary. When the insect visits a flower it thrusts its head into one of the angles and in doing so comes in contact with the stamens, which being sensitive come forward and shed their pollen on the insect. The anthers open by uplifted valves. Then, as Hermann Mueller[59] says: "The insect usually flies away at once after the first drop of honey on being struck by the stamen, and as it thrusts its head or proboscis into the flower in many different ways as the different positions of the flower require, now under, now over the stigma, now to the right, now to the left, its head must soon be dusted all around with pollen, and it must fertilize every succeeding flower that it visits."

Schizanthus.—*Schizanthus pinnatus,* native to Chile and Peru, is a member of the nightshade family and is commonly cultivated as an ornamental in our gardens. The flowers are irregular, two-lipped, the upper lip made up of five parts variously colored and spotted with yellow and purple, with a groove leading to the nectar. The smaller lobes form a landing place for insects. Two stamens are fixed firmly in the furrow of this keel-like body; these are released the moment the insect touches this keel and probes for the nectar, and they throw the pollen out a considerable distance.

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59 Fertilization of Flowers, 91.

FIG. 493.—Sensitive stamens of mountain laurel (*Kalmia latifolia*). Bee pollinated. a, flowering spray, one-third natural size: b, vertical section of flower showing peculiar attachment of stamens, natural size; c, fruiting capsules, natural size. *Chestnut, U. S. Dept. Agr.*

Laurel.—In the American laurel (*Kalmia latifolia*) the discharge of pollen is somewhat different. Doctor Gray many years ago described the mechanism to secure cross-pollination, although the observations were first made by Professor Beal. The five-lobed regular corollas have ten stamens with slender filaments, whose anthers lie in pouches in the sides of the corolla. Doctor Gray says: "If untouched the springs generally remain set until the corolla begins to fade; by that time the filaments lose their elasticity and become flabby also. If we jostle them, however, by a somewhat rude touch when the flower is in fresh condition, so as to liberate the anther, the filaments straighten elastically and suddenly, and generally curve over in the opposite direction. As they fly back they discharge a quantity of pollen." The style is longer than the stamens. Bumble bees are the pollinators. The common wood thistle (*Cirsium discolor*) and other common species like the Iowa thistle (*C. iowense*) and woolly thistle (*C. canescens*) are sensitive. The insect visitors have been noted by Robertson,[60] Mueller[61] and Weed,[62] while Halsted[63] studied the sensitive stamens of *C. iowense*.

A contraction of the filaments takes place, and it is this contraction that causes the pollen to be pushed out. This motion takes place when the insect seeks the nectar, which is secreted by a ring surrounding the base of the tube of the corolla. Dr. Halsted says: "They are, therefore, the laterally extended tips of adjoining epidermal cells and become triggers, which, when touched by the insects' proboscides, set the filament in motion and cause the drawing down of the tube of the anthers. The style, as has been stated, occupies the space within the tube and has its exterior covered with short stiff hairs which point upward. When the conditions are favorable the filaments contract quickly. It frequently occurs that the filaments do not act at the same time, and this causes the noticeable swaying of the flower. With a needle any particular filament may be touched, and the movement to and fro of the flower governed with pleasure, until the stimulus is transmitted to the other filaments, when the swaying ceases. During this time the anther tube has descended two or three millimeters and a quantity of pollen is pushed out of the pore by the pro-

60 Trans. Acad. Sci. St. Louis, 6:475.

61 Mueller, Fertilization of Flowers, 340.

62 Weed. Ten New England Blossoms, 126.

63 Bull. Ia. Agr. Coll. Dept. Botany, November, 1886:29.

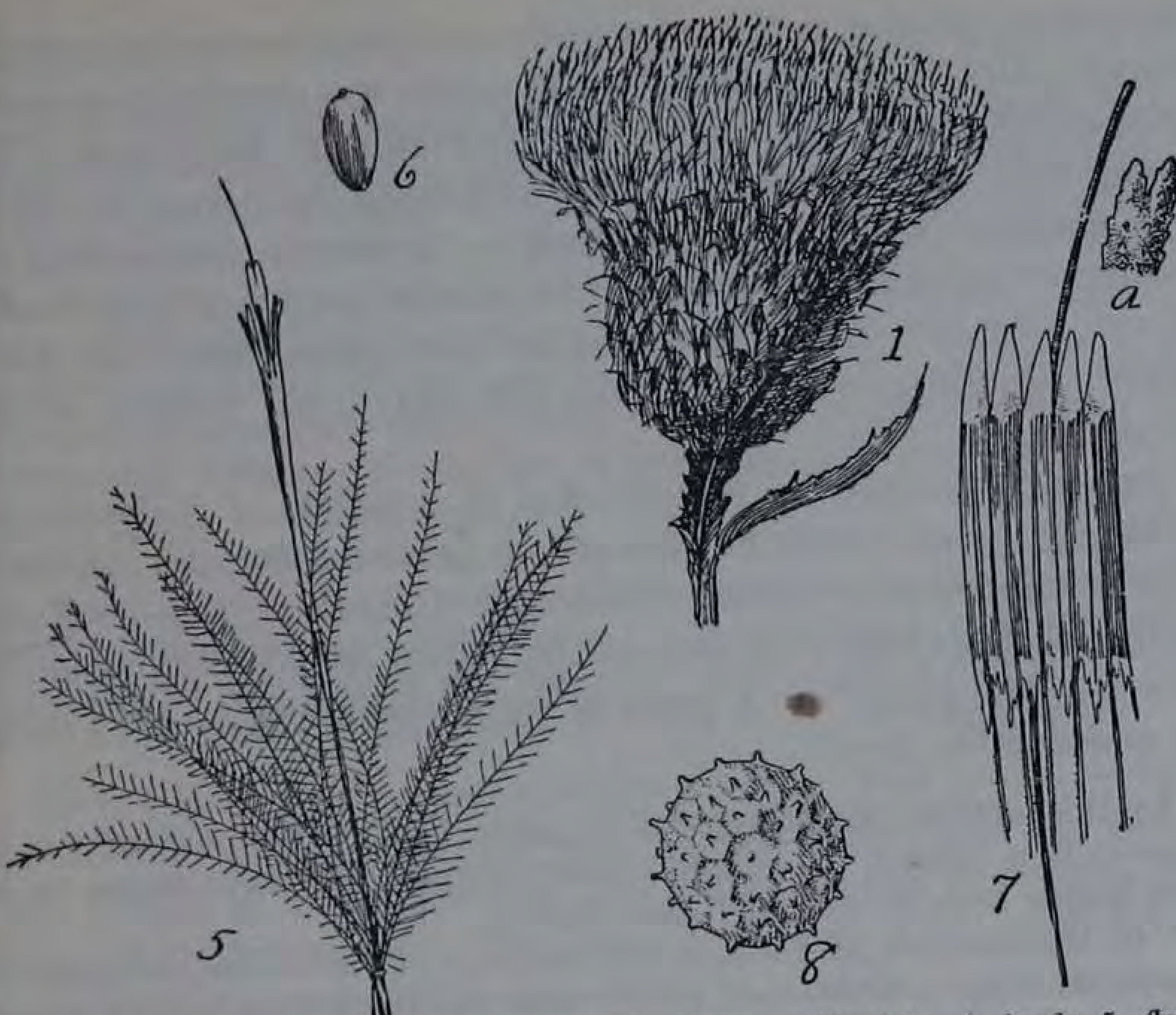

FIG. 494.—Woolly thistle (*Cirsium canescens*). Insect pollinated. 1, head; 5, flower and pappus; 6, achene; 7, anthers and style cut open, sensitive stamens; 8, pollen grain; a, end of style. *Charlotte M. King.*

truding style. The filaments soon readjust themselves and succeeding touches of the flowers by insects or otherwise will bring the anther ring down until the brush of hairs has passed through, when the work of the sensitive structures is accomplished.''

In *Centaurea Cyanus* the marginal flowers serve to attract insects. The flowers are proterandrous and the pollen is liberated from the syngenesious anthers because of the sensitive stamens. Attached to the united anthers are appendages which close the anther tube; these appendages separate, and on touching the filaments a contraction takes place which causes the anther tube to be drawn down and the pollen pushed out. The nectar is secreted at the base of the narrow tubular flower and is accessible to bees and Lepidoptera. Just below the division of the style is a ring of short brush hairs which serve to hold the pollen.

From other excellent illustrations of plants with sensitive stamens mention may be made of the prickly pear (*Opuntia Ficus-Indica*), *Cereus* and moss rose (*Portulaca grandiflora*).

FLOWERS AND THEIR UNBIDDEN GUESTS

Perforation of Flowers.—It is a matter of very common observation that insects frequently perforate the corolla in order to obtain the nectar. And in a few cases birds have been known to perforate flowers. In the spring of 1902 my attention was especially attracted to the fact that a large number of flowers were perforated. The honey bees were frequently found obtaining the nectar of one of our common species of honeysuckle (*Lonicera Sullivantii*) by means of perforations found in the tubular portion of the corolla. Honey bees were commonly found the same season upon the clover flowers obtaining the nectar through the lower portion of the corolla.

In 1888 my attention was directed to a species of *Xylocopa* obtaining its nectar from the flowers of *Phlomis tuberosa*. In addition to this Darwin,[64] Jack,[65] Trelease,[66] Robertson, Mueller,[67] and many other writers have contributed notes on the perforation of flowers. The writer[68] in a paper of some length took up the subject in considerable detail.

In this article the statement is made that "The perforation of flowers is a matter of common observation. The rule seems to be that honey bees do not perforate flowers.

"In the summer of 1883, in the vicinity of La Crosse, Wisconsin, I noticed large numbers of honey bees on the flowers of red clover and wondered whether they made perforations or what they were doing. In some cases they obtained pollen, but in a vast majority of cases nectar was collected through perforations made by some other insect. Among bee-keepers there is a notion that the Italian bee is able to get nectar from red clover. I doubt whether this is true, for in my experience I never found them collecting nectar in the normal way; they seemed to collect only through perforations made by some other insect. One thing will show, in part at least, why honey bees go to red clover at certain times and not on other occasions. It is a well known fact that the amount of nectar secreted by a plant varies according to season and locality. There are periods, as I have had occasion repeatedly to observe, when hive bees cannot collect enough to supply their young, and they then freely use the perforations made by *Bombus* and other insects; but when there is an abundance of nectar they pass over fields of red clover, and when *Monarda punctata* is in flower and has a good supply of nectar they will even pass over fields of white clover and fly some distance to fields of this wild bergamot."

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64 Darwin, The Effects of Cross and Self Fertilization on the Vegetable Kingdom.

65 Jack, Garden and Forest, 5:29.

66 Trelease, Bull. Torrey Bot. Club, 8:68.

67 Mueller, Befruchtung der Blumen, 320; Kosmos 5:422.

68 Trans. St. Louis Acad. of Sci., 5:241-277. Contribution Shaw School of Botany, No. 1.

HONEY BEES FOLLOW WOOD BEES FOR NECTAR[69]

In Science, A. C. Burrill writes, "E. A. Schwarz and the writer made observations May 2, 1925, showing that honey bees get nectar from long-tubed corollas of bush honeysuckle (*Diervilla florida*). They tried continually to go down the tube, only to stick long before reaching the nectar. Then they would buzz around big wood bees (*Xylocopa virginica*), who did not seek to enter the corolla, but crawled down outside near the tip of the sepals and punctured the corolla tube with their strong black mouth parts. Honey bees frequently followed these bees and stuck their proboscis through the large slit made by wood bees. This is another instance of *Apis mellifica* adaptability to secure nectar from flowers with tubes longer than the tongue. A war of words has raged in bee journals for some years as to how honey bees could get nectar from red clover with florets longer than bee tongues. Is it possible that they follow some other insect to punctures in floret tubes already there?"

More than a century ago Sprengel observed how insects perforated flowers. Numerous observations were made also by Kerner, who published a book showing how plants protect themselves from these unbidden guests. The beautiful colors and exquisite contrivances are rendered inoperative because of these perforations.

One of the perforators in the middle, southern and central states is the carpenter bee (*Xylocopa virginica*). This species has the most northern distribution of any of the genus, according to Cresson. It has been found to perforate *Physostegia, Mertensia, Petunia, Phlomis* and *Monarda*. The European *Xylocopa violacea*, according to Delpino, perforates *Antirrhinum majus*. *Bombus mastrucatus* is a well known dysteleologist of the alpine regions of Europe, or as Loew prefers to call it a case of disharmony. By this term he understands the non-adaptation of certain insects to certain flowers. This disharmony develops in many flowers and insects of a given region whenever plants begin to develop tubular flowers which surpass in length the tongues of their former visitors, that is, the perforations are made by bumble bees and *Apis* because the tubes of certain bee flowers are lengthened beyond the mean lengths of the tongues of these insects. In Europe several other species of *Bombus* perforate flowers, among them *Bombus terrestris* and *B. muscorum*.

According to Doctor Trelease the white faced hornet, *Vespa maculata*, perforates several different flowers. Mr. Robertson re-

69 Reprint from Science, August 7, 1925, Vol. LXII, No. 1597, p. 134.

ports that at Orlando, Florida, he found five species of wasps obtaining nectar through perforations of *Gaylussacia dumosa* var. *hirtella*. In Missouri he found that *Odynerus foraminatus* made perforations in the tube of *Monarda Bradburiana*.

Why should insects perforate flowers? Darwin believes that, as a general rule, flowers are perforated only when they grow in large quantities close together; for he found in a garden where *Stachys coccinea* and *Pentstemon argutus* were growing in large numbers every flower was perforated, but at some distance from these was a small stock of *Stachys coccinea*, the flowers of which were much scratched, showing that they had been visited by bees, although not a single flower was perforated. The same thing was noticed on a small stock of *Pentstemon* growing in the same garden. The same fact holds true for *Trifolium pratense* when growing in fields and for *Phaseolus multiflorus* when grown in large and conspicuous clusters in gardens. It is a well-known fact that alpine flowers grow in much larger masses than plants of lower regions. Familiar examples of our flora are afforded by *Silene acaulis, Arenaria Groenlandica, Bryanthus taxifolius, Trifolium* sp., *Ledum*, etc. Mueller has shown of alpine and subalpine plants that more were visited in the Alps than in the lowlands and also that more species were perforated, as is well shown by the list of flowers which *Bombus mastrucatus* visits.

Flowers grown in large masses are conspicuous and therefore attract many insects; and, as the perforated flowers usually contain considerable nectar, the number of insects visiting the flowers at any one time is very large, and, as Darwin has shown, some of the nectaries are sucked dry; now, in order to save time, for the flower would have to be probed for their nectar, the insect makes perforations. To this rule there are exceptions, as has been shown in some of the cases cited, where an insect, unable to get the nectar in a normal way, takes to perforating flowers. Mueller and others have shown that there is a certain correlation between the length of the tongues of Hymenoptera and the flowers they perforate, as can be seen by consulting Mueller's tables on flowers and their vistors.

How flowers are protected.—Were it nor for the contrivances in many flowers, very unwelcome guests would often enter the flowers and utilize for themselves what legitimate visitors should have. Flowers are protected from unbidden guests in various ways.

In a few previous paragraphs we have briefly called attention to

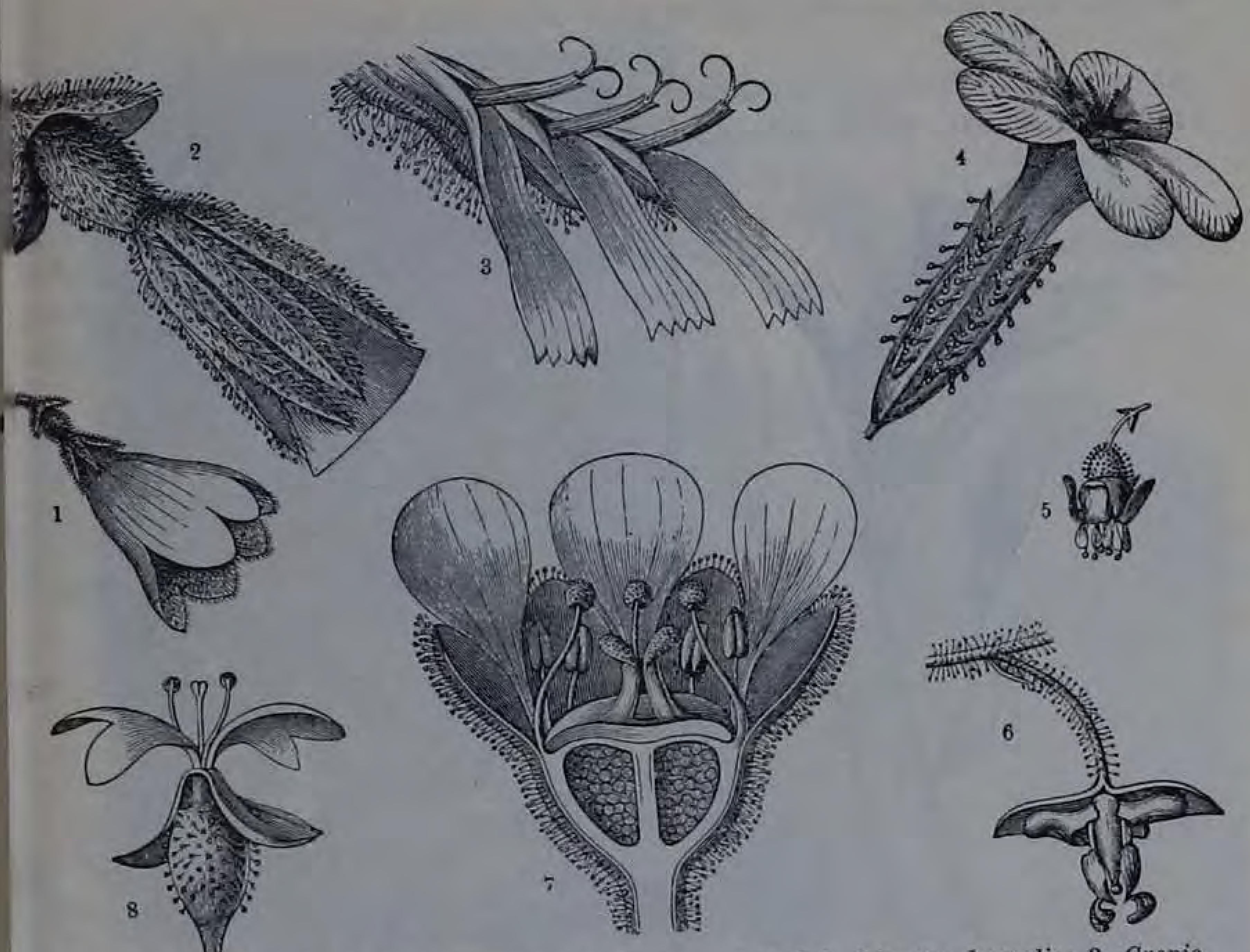

FIG. 495.—Sticky glands as a protection to flowers. 1 and 2, *Linnaea borealis*; 3, *Crepis paludosa*; 4, *Plumbago europaea*; 5, *Ribes grossularia*; 6, *Epimedium*; 7, *Saxifraga*; 8, *Circaea alpina*.

a few of the agents which destroy flowers. It is equally interesting to study the contrivances which protect the flowers from unbidden guests. Darwin has well said in a prefatory letter to Dr. William Ogle's translation of Kerner's admirable book on "Flowers and their Unbidden Guests:" "The beauty and poetry of flowers will not be at all lessened to the general observer by his being led through Kerner's investigation to notice various small and apparently quite unimportant details of structure, such as the presence of differently directed hairs, viscid glands, etc., which prevent the access of certain insects and not of others."

Delpino recognizes three principal modes of protection:

1. The coriaceous, thick, hard tubular calyx sometimes found surrounding the region of the nectar receptacle.

2. Inflated organs, like the calyx of *Rhinanthus* and the involucre of *Convolvulus sepium*.

3. A hooded or spurred calyx enclosing as a second envelope the nectariferous spurs, as in *Delphinium*, and still more effectively in *Aconitum*.

FIG. 496.—Protection of pollen. 3 and 4, *Campanula patula*; 5 and 6, *Scabiosa lucida*. *Kerner-Oliver.*

It will be well to consider these structures somewhat in detail.

In *Rhinanthus alectorolophus* there is at least a partial protection, as the calyx is inflated and the arch of the corolla is firm and smooth. Mueller observed a female of *Bombus mastrucatus* making unsuccessful attempts to bite holes in the tubes of the corolla of this plant. *Pedicularis verticillata* is also somewhat protected, as the calyx is globular, smooth, and compressed laterally, while the corolla has an abrupt rectangular band within the calyx and the upper lip is firm. *Bombus mastrucatus* and *B. terrestris* both made several unsuccessful attempts on this species.

In Labiates the awn-pointed lobes of the calyx are very effective, as in *Lamium, Melissa, Nepeta, Phlomis,* etc.

In *Antirrhinum* and *Linaria* the lips of the corolla come close together, so that only such insects can get the nectar as are able to push the upper lip back; but the flowers are so often perforated that this is only a partial protection.

In *Symphytum officinale* and other members of the Boragineae scales are developed which close over the throat of the corolla.

In *Passiflora* the throat of the calyx is crowned with a double or triple fringe of hairs. Quite as useful as this must be the intermediate and plaited folds in the corolla of some gentians, from which teeth project into the opening of the flower. Viscid stems and parts of the flower in close proximity to the essential organs may also be of service.

The glandular phyllodia of certain Acacias, the involucral bracts of *Gossypium*, the petioles of *Cassia*, etc., secrete nectar, which attracts ants and other insects so that they do not molest the flowers.

Pollen is protected in various ways. A curious case of protection is found in *Ophrys insectifera*, where the labellum simulates the thorax of an insect which visits the flowers of some orchids. As this plant is self-pollinated, the mimicry may be beneficial in repelling insects.

FIG. 497.—*Serratula lycopifolia* protected by ants from the attacks of a beetle. *Kerner-Oliver.*

In *Iris* the stamens are sheltered under the over-arching petal-like stigmas. The syngenesious stamens of Lobeliaceae and Compositae open inwardly around the style, so that there is not much waste of pollen. The arched upper lip of labiate flowers, which is often hairy, as in *Monarda*, *Pedicularis* and *Castilleja*, is very effective, especially against rain and dew. The same is true of the overarching spathe in aroids.

Ants, which from this standpoint must be regarded as entirely injurious to flowers, are prevented from getting at this nectar in various ways.

1. Aquatic plants are protected by their isolation in water. Land plants have occasionally secured for themselves the same advantages in that certain leaves form cups around the stem. In some there is a leaf cup at each joint,

while in others there is a single basin formed of the rosette of leaves at the base. In these rain and dew not only collect, but are retained for a considerable time, as in *Dipsacus sylvestris*, *D. laciniatus* and *Silphium perfoliatum*.

2. Some plants have slippery leaves, which often have curved surfaces, over which it is impossible for ants to climb, e.g., in *Gentiana firma*. In *Cyclamen* the reflexed lobes of the corolla are turned upwards, so that ants cannot crawl over them.

3. Plants, and especially parts near the corolla, are covered with hairs and spines; these often point downwards, as in flowers of *Salvia*, *Verbena*, *Linnaea* and *Stachys*.

4. Some plants are especially distinguished by viscid and glutinous secretions. These occur on the stem in *Silene antirrhina*, on the involucral bracts of *Grindelia squarrosa*, on the calyx and stem of *Silene noctiflora* and on the young branches of *Robinia viscosa*, the secreting glands shriveling up when the flowers are pollinated. The involucral bracts of some of our thistles, like *Cirsium discolor* and *C. iowense*, have a pronounced glutinous ridge which holds insects like flies and ants.

5. Kerner believes that the milky juices of some plants, e.g. *Lactuca*, *Asclepias*, *Euphorbia*, *Apocynum*, *Chelidonium*, etc., serve to keep ants away. In an experiment he found that an ant, placed on a lettuce leaf, cut the epidermal tissue with its sharp claws so that the milky juice exuded and hardening, held the ant to the leaf.

THE MORPHOLOGY OF THE POLLEN GRAINS OF SOME HONEY PLANTS

CHARLES A. HOFFMAN

Excepting nectar, pollen is the most important raw material used by honey bees, although both are essential to their life. Pollen is stored by the bees for use over winter in the form of bee-bread. It is a necessary food of the larvae and without it the swarm must soon die out. Rye flour has been used as a substitute but pollen is the natural and best food for the larvae and the sole source of protein for all the bees. Phillips[1] says the bee larvae increase in weight 1550 times in a little over five days and that the food given the young larvae is a secretion. "The bees evidently digest and assimilate the protein material of the pollen and then secrete it through glands opening near the mouth. Later the larvae are fed a mixture of pollen grains and honey."

With the information which follows, a good microscope, an eyepiece micrometer whose divisions have been evaluated, and some experience, the beekeeper may examine the pollen from the pollen basket of the incoming bee and, if the bee has visited a species studied in this paper, determine from what source the bees are obtaining their pollen. By using this method in conjunction with other sources of information we may be able in the future to find what are our best pollen plants even as we now know our best honey plants. The source of the bees' honey supply can also be found with certainty in this way.

During the last 50 years pollen has been one of the popular subjects for the investigation of the botanist. The method of its formation, its function and the manner of its germination, and intensive investigations as to its sterility in different crosses seem, however, to have occupied the attention of most of the investigators. The only works that were found covering the morphology of more than a few very closely related species were the following.

Smith[2] in his two papers figures the pollen of 94 species magnified 400 times and drawn to scale. F. P. Sipe[3] has photomicro-

1 Gleanings in Bee Culture, 52:215.
2 Smith, W. G. Notes on Pollen. Gard. Chron. n.s. 6:516-517.
3 Sipe, F. P. Studies on the Structure and Content of Pollen. This volume, page 986.

graphs of 27 species of pollen together with their approximate measurements. Neither of the above states in what medium the pollen was mounted when it was studied, although from the figures it seems that Smith studied the pollen dry or mounted in honey while Sipe used water.

Brown and Young[4] figure 30 different species of pollen taken from honey. These had been in honey for differing periods of time and were treated with water before being photographed and therefore they do not agree exactly with the drawings in this paper and the measurements are generally shorter as to length and greater as to diameter than those given in this paper. This is the usual condition of pollen when it has absorbed water.

Kerner and Oliver[5] give a table showing the differences in size of pollen grains, that of *Mirabilis Jalapa* (220 mu to 250 mu in diameter) being 100 times larger tllan that of *Myosotis alpestris* (2.5 mu to 3.4 mu in diameter). They also figure the pollen of 23 species and give a discussion of the different shapes and structures which may be found in pollen grains. Of the pollens studied in this paper the largest was that of *Althaea rosea* (107 mu to 128.7 mu in diameter) and the smallest was that of *Solanum Dulcamara* (length 17.5 mu, diameter 10.3 mu).

Dorsey[6] deals extensively with the different kinds of pollen found in the grape and takes up the cytology and development of these different kinds. There are numerous figures. He also gives an excellent 11 page bibliography on pollen in general.

Pammel[7] figures sixteen species of pollen.

Parker[8] figures 12 species of pollen and gives measurements and short descriptions of 28. He caught and killed the bees working on the plant whose pollen he wished to study, removed the pollen and covered it with honey and studied it later.

Phillips[9] gives figures of twelve species of pollen.

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4 Brown, C. A., and Young, W. J. Chemical Analysis and Composition of Amer. Honeys. U. S. Dept. Agr., Bur. Chem., Bull. 144.

5 Natural History of Plants, 2:98.

6 Dorsey, M. J. Pollen Development in the Grape with Special Reference to Sterility. Minn. Agr. Exp. Sta., Bull. 144.

7 Pammel, L. H. Ecology. 214. J. B. Hungerford, Carroll, Ia.

8 Parker, R. L. Some Pollen Gathered by Bees. Amer. Bee Jour., 63:16-18.

9 Phillips, E. F. Some of the Wonders of Pollen. Gleanings in Bee Culture, 52: 140-145.

DESCRIPTIONS OF POLLEN GRAINS

Smartweed. *Polygonum pennsylvanicum* L.

Mounted in Honey.—The grains are disc-shaped, with rather large reticulations on the surface. The thickness ranges from 6.9 mu to 8.7 mu, and averages 7.8 mu. The diameter ranges from 43 mu to 52 mu and averages 47 mu. The measurements are from 5 grains.

FIG. 498.—*Polygonum pennsylvanicum.*

Lady's Thumb. *Polygonum Persicaria* L.

Mounted in Honey.—The grains are spherical with reticulations as on the above. Seventeen grains were measured in honey. Their diameter ranges from 32.7 mu to 48.3 mu and averages 37.9 mu. Only a few grains were measured in water. Their diameter ranges from 43 mu to 46.6 mu and averages 44.8 mu.

Prairie Rose. *Rosa setigera* Michx.

Mounted in Honey.—The grains are diploidal, nearly rectangular in outline as can be seen by figure 3 of *R. setigera.* This shows the contrast more than the average grain, however, and I would be unable to tell with certainty to which species a single grain belonged. The length differs from 23.7 mu to 28 mu and averages 25.3 mu.

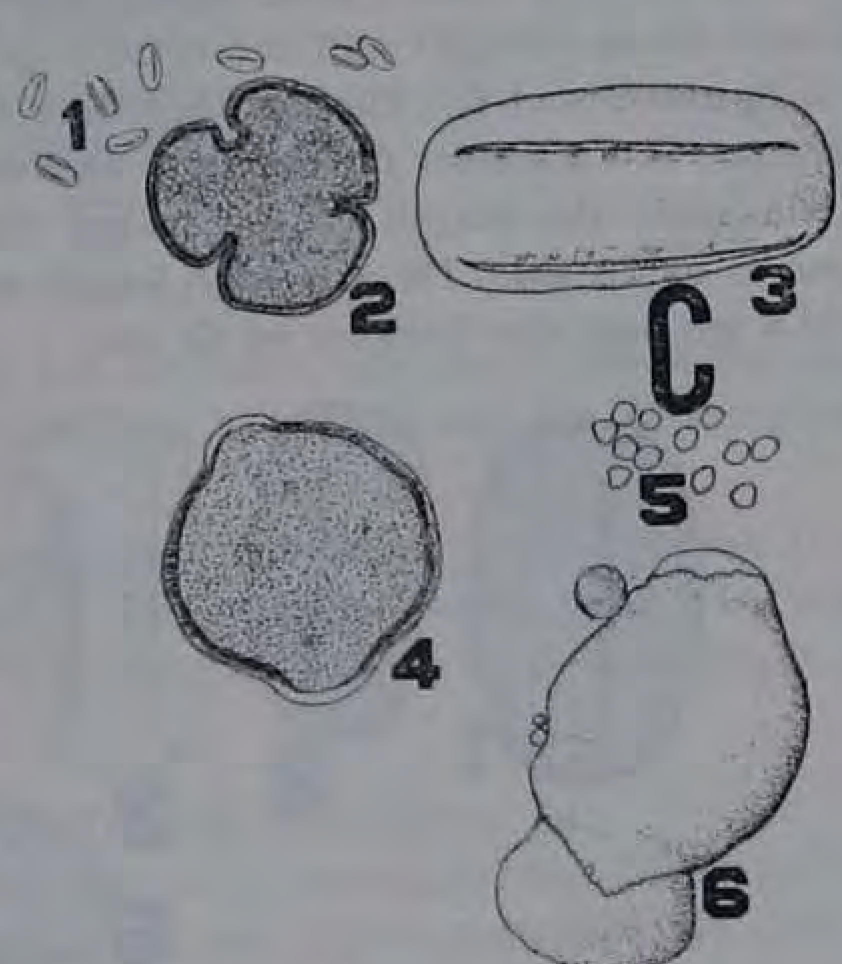

FIG. 499.—*Rosa setigera.*

Mounted in Water.—The grains are spherical. The sutures are not apparent and the grains burst more generally than those of *R. virginiana.* Also more oil is present over the surface of the grain. The diameter averages 29 mu.

False Indigo. *Baptisia leucantha* T. and G.

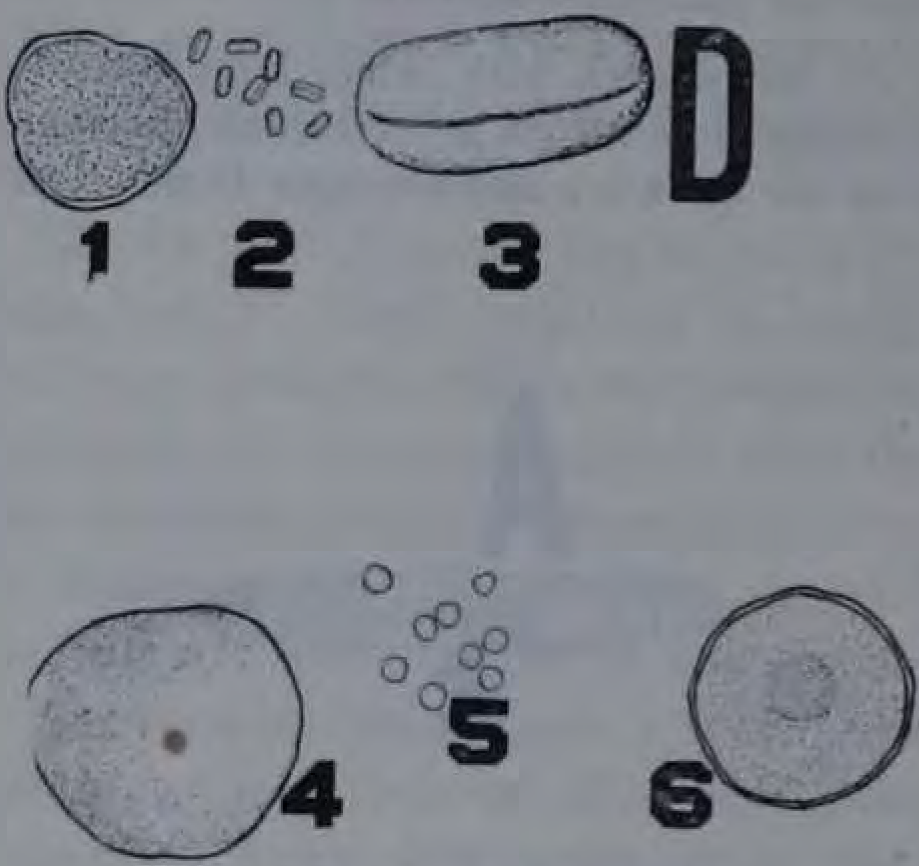

FIG. 500.—*Baptisia leucantha.*

Mounted in Honey.—The grains are capsule-shaped and small. No air bubbles are found in the sutures. The length ranges from 25.3 mu to 28.5 mu and averages 26.8 mu. The diameter ranges from 14.2 mu to 20.6 mu and averages 16 mu.

Mounted in Water.—The grains are subspherical with many oil globules on them. Figure 4 is an end view of a grain and figure 5 is a group to show their general shape.

Red Clover. *Trifolium pratense* L.

Mounted in Honey.—The grains are ellipsoidal, with a rough surface. The outline of the grain varies with the view of it that is taken. If viewed so that a suture or the part of the grain equidistant from two sutures appears in the middle of the grain, as in figure 3, the grains appear ellipsoidal and symmetrical, while if viewed after being given a quarter turn from this position, one side seems straight and the corners at the ends of this side appear sharp, as in figures 5 and 6. The length differs from 52.1 mu to 58 mu and averages 53.6 mu. The diameter differs from 22.1 mu. to 31.3 mu and averages 28.4 mu. Martin gives the length of the pollen when mounted dry as 48 mu and its diameter as 26 mu. He gives the length when the pollen is mounted in water as 44.5 mu and the diameter as 43 mu.

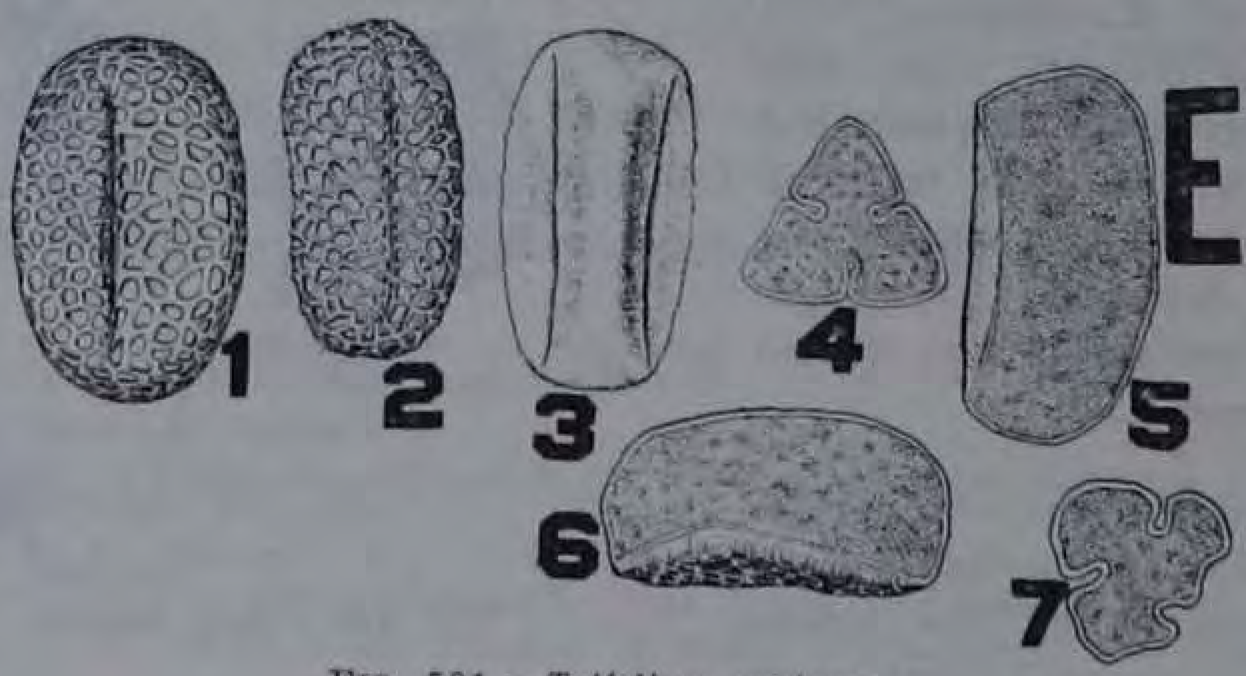

FIG. 501.—*Trifolium pratense.*

Figures 1 and 2 show the pollen as it appears when studied dry. The reticulations give the rough appearance to the pollen when mounted in honey but are themselves not visible in honey. Figure 3 is a grain mounted in honey and shows the depressions that generally appear along the sutures. Figures 5 and 6, longitudinal sections in honey and dry, also show these depressions. Figure 4 is a cross-section of a normal grain and figure 7 is a cross-section through a shriveled grain such as is rather common in honey mounts.

White Clover. *Trifolium repens* L.

Mounted in Honey.—The grains are ellipsoidal but soon shorten and thicken in honey. Some few even burst in honey. Some of the grains have yellow oil globules clinging to them. After being in honey 15 minutes, 10 grains showed an average increase in their diameter of 35 per cent. The length of the grains when first put in honey ranges from 34.4 mu to 43 mu and averages 39.5 mu. Their diameter ranges from 16.3 mu to 22.2 mu and averages 19.7 mu.

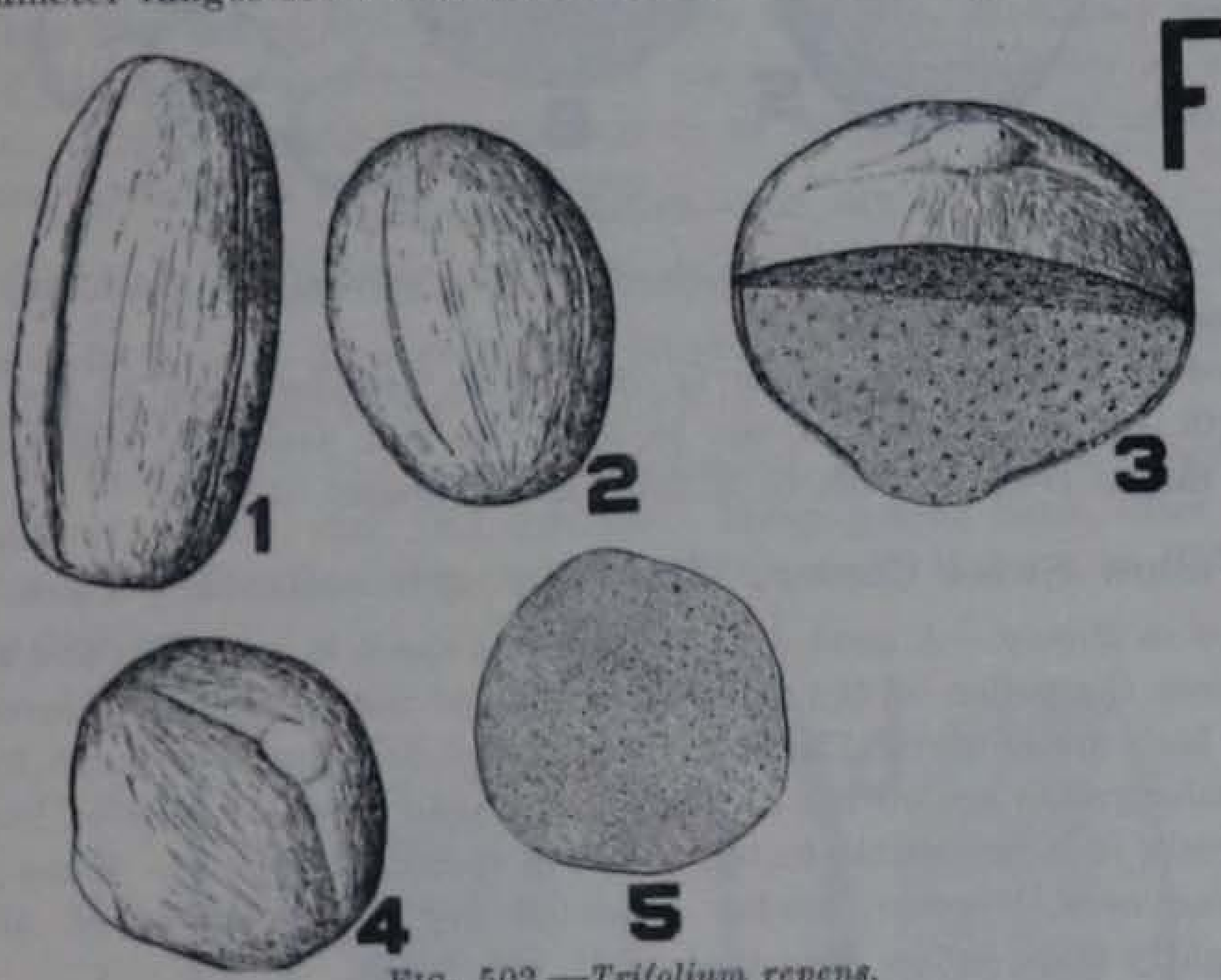

FIG. 502.—*Trifolium repens.*

Figure 1 shows a grain when first put in honey. Figure 2 shows the shape of grain that is usual after the grains have been in honey for 15 minutes or more.

Mounted in Water.—The grains are almost spherical. Their diameter is less than three mu less than their length. Their length ranges from 32.6 mu to 39.2 mu and averages 37.2 mu. Their diameter ranges from 31.9 mu to 37.8 mu and averages 36 mu.

Alsike Clover. *Trifolium hybridum* L.

Mounted in Honey.—The shape of this pollen resembles that of *T. pratense* and for the same reason as in that species can appear somewhat different according to the view of it that is taken. It is perhaps even more sunken at the sutures than is *T. pratense.* The wall, measured from a broken piece, is between 0.3 mu and 0.4 mu thick. The length of the grains differs from 33.9 mu to 40.4 mu and averages 36.8 mu. The diameter differs from 16.9 mu to 22.1 mu and averages 18.9 mu.

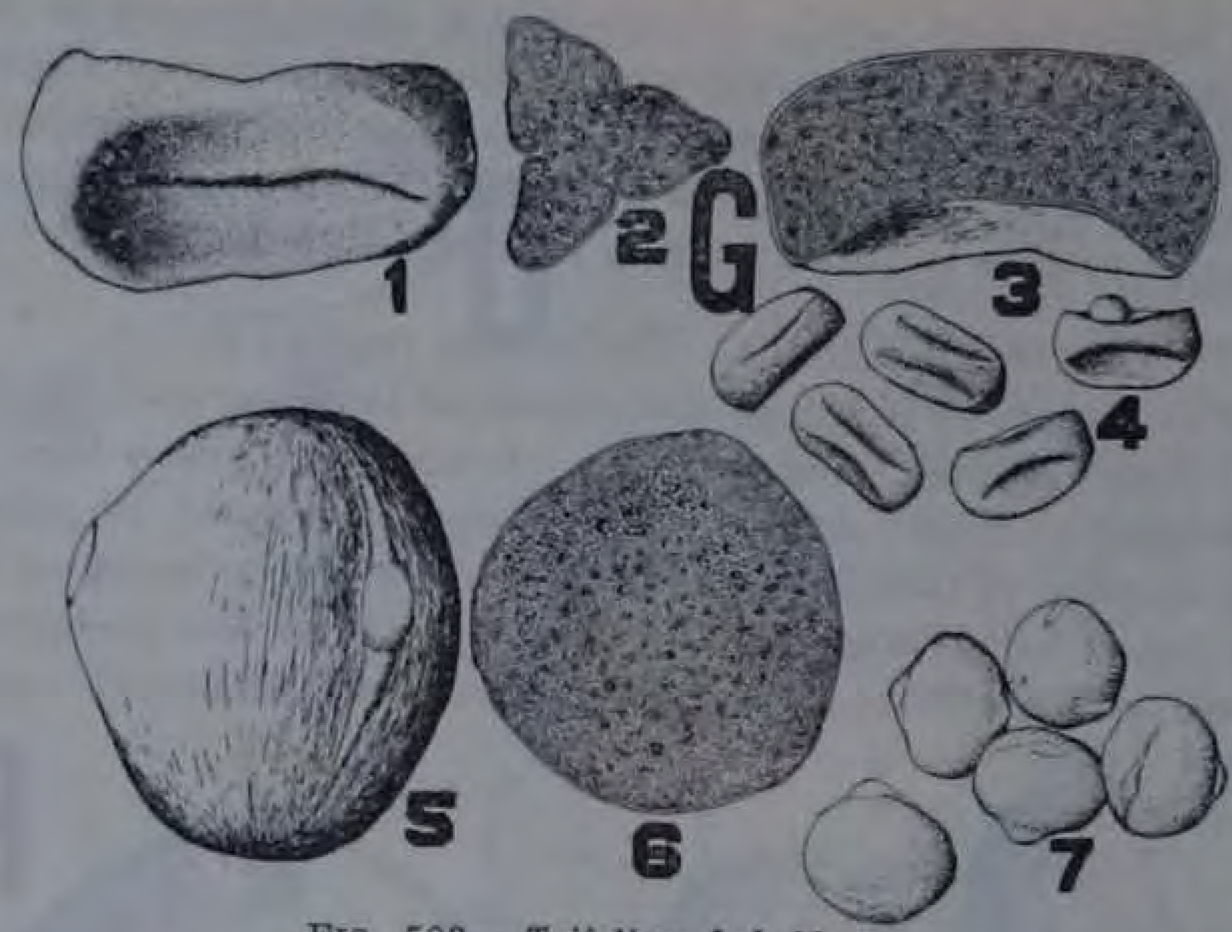

FIG. 503.—*Trifolium hybridum.*

Figure 1 is a side view taken to show how one side of the grain may appear convex and the other concave.

Mounted in Water.—The grain is ovoid with protuberances at the sutures. The length ranges from 32.6 mu to 39.1 mu and averages 31.2 mu. The diameter ranges from 28.7 mu to 33.2 mu and averages 31.2 mu.

Yellow Sweet Clover. *Melilotus officinalis* (L.) Lam.

Mounted in Honey.—A good deal of time was spent in trying to find a difference between the pollen of the yellow and that of the white sweet clover. The grains of both are ellipsoidal and only one set of drawings was made for both. *M. officinalis* grains are on the average larger than those of *M. alba* but given a single grain it is impossible to tell to which species it belongs. Some general observations were, however, made. Mounted dry the pollen of *M. alba* appeared slightly more yellow than that of *M. officinalis.*

The length of the *M. officinalis* grains ranges from 36.4 mu to 41.2 and averages 38 mu. Their diameter ranges from 19 mu to 20.6 mu and averages 19.9 mu. Figure 1 shows a cross-section and figure 2 a group. Figure 3 is a side view showing two sutures.

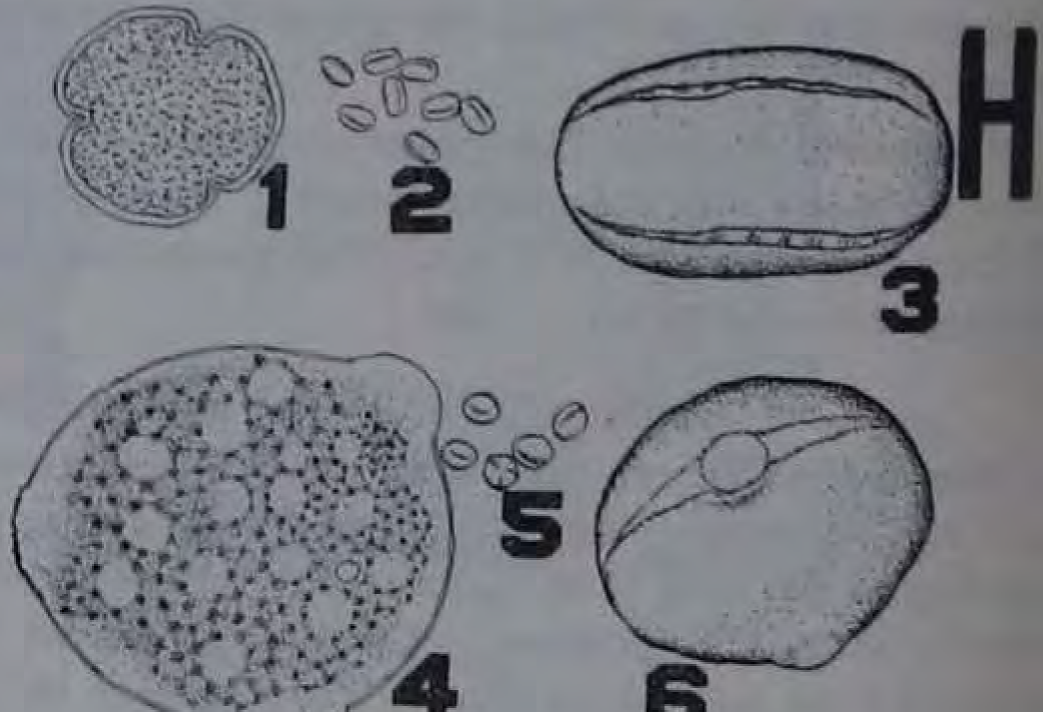

FIG. 504.—*Melilotus officinalis* and *M. alba.*

Mounted in Water.—The protoplasm of *M. alba* seemed denser than did that of *M. officinalis* and usually touched the protoplasmic envelope while that of *M. officinalis* did not.

In a strong IKI solution *M. officinalis* grains stained reddish brown while *M. alba* grains stained a yellowish brown. The length of the *M. officinalis* grains differs from 39.6 mu to 42.8 mu and averages 41.2 mu. Their diameter differs from 33.2 mu to 34.1 mu and averages 33.4 mu.

White Sweet Clover. *Melilotus alba* Desr.

Mounted in Honey.—The shape is the same as that of *M. officinalis* pollen. The length of the grains ranges from 34.8 mu to 38 mu and averages 35.6 mu. Their diameter ranges from 19 mu to 20.6 mu and averages 20.3 mu. The figures are the same as for *M. officinalis.*

Mounted in Water.—The grains are similar to those of *M. officinalis.* The length ranges from 30.1 mu to 38 mu and averages 35.1 mu. The diameter ranges from 23.7 mu to 33.3 mu and averages 28.9 mu. McKinsey reports the length of 134 grains as averaging 29.03 mu and their diameter as averaging 24.32 mu. Rogers reports their dimensions as being 19 by 23 microns. The figures are the same as for *M. officinalis.*

Alfalfa. *Medicago sativa* L.

Mounted in Honey.—The grains are ellipsoidal with a very smooth surface. Their shape may be that of figures 1, 4 or 5 or intermediate.

Mounted in Water.—The grains are spherical, gray or light brown in color and stain very easily with IKI solution. Many grains burst after being in water for a few minutes. The diameter differs from 41.2 mu to 47.5 mu and averages 44.3 mu.

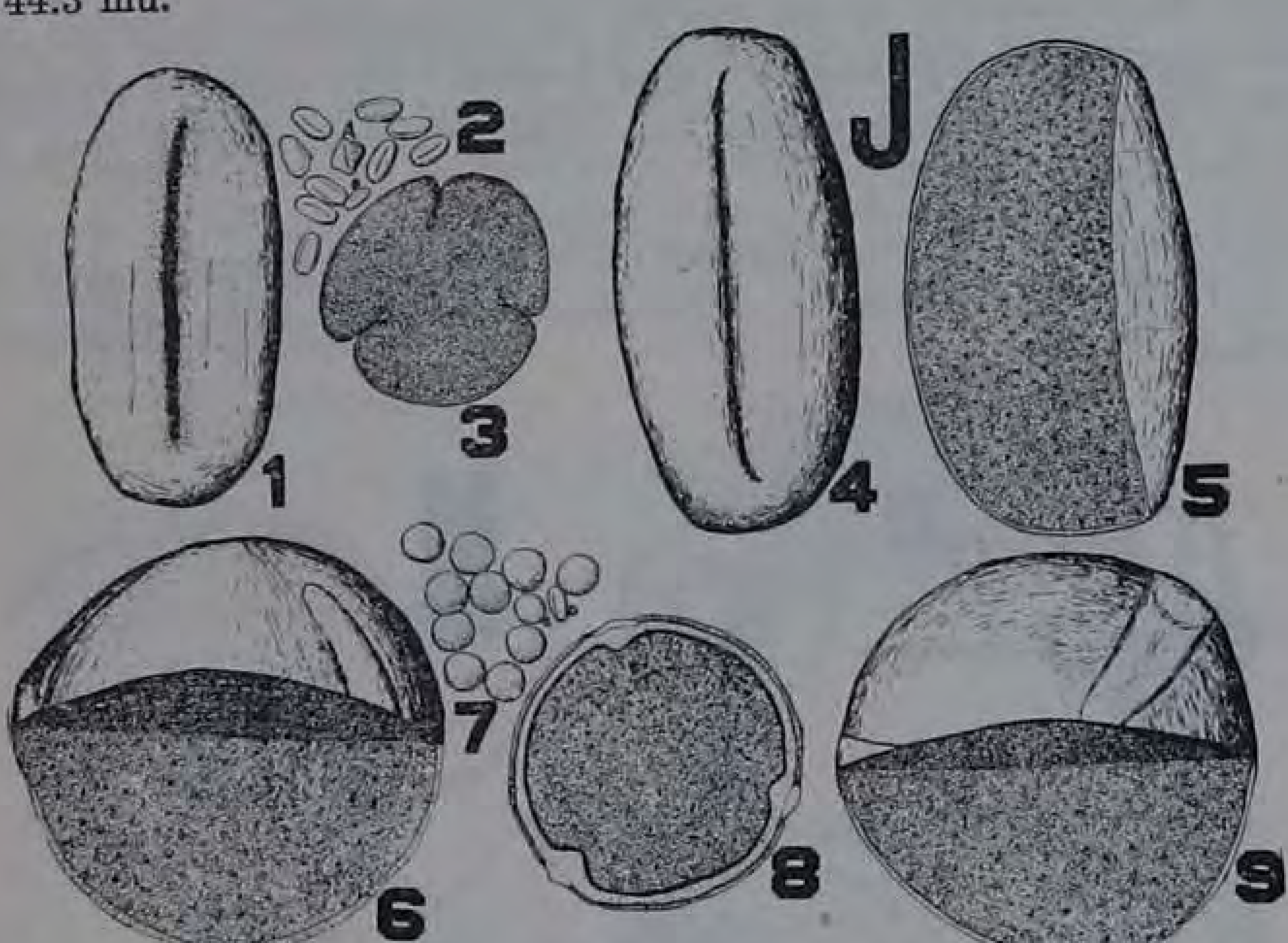

FIG. 505.—*Medicago sativa.*

Black Medick, Nonesuch. *Medicago lupulina* L.

Mounted in Honey.—The grains are long and ellipsoidal and most of them have air bubbles in the middle of the sutures. Many of them appear shriveled somewhat near the middle as shown in figures 2 and 3. Some, when mounted in iodine-honey, sent out germ tubes. The length ranges from 31.6 mu to 38 mu and averages 36.4 mu.

Mounted in Water.—The grains are ellipsoidal with protuberances at the sutures. In some these swellings are not large while in others they lengthen and become germ-tubes. The length averaged 31.7 mu and the diameter 26.9 mu.

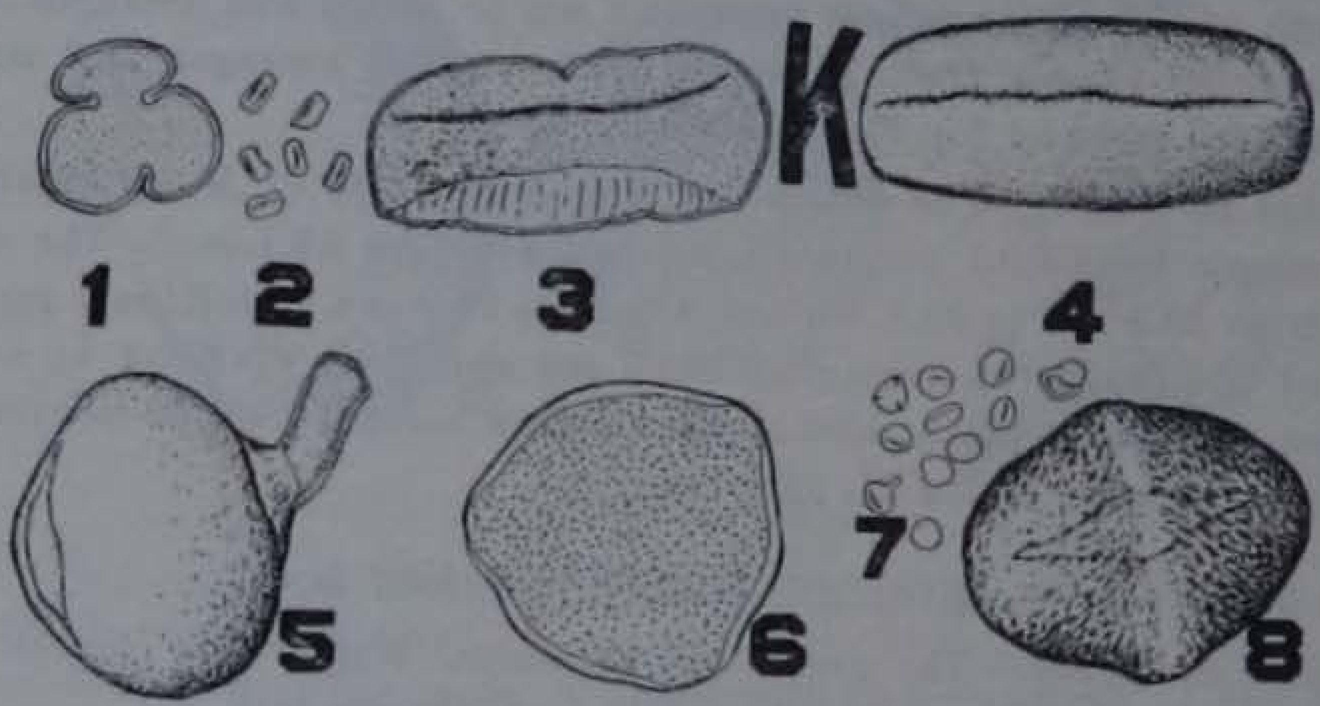

FIG. 506.—*Medicago lupulina.*

Basswood. *Tilia americana* L.

Mounted in Honey.—The grain is biscuit-shaped with a depression, usually containing an air bubble, in the middle. If viewed from the edge one side of the grain appears concave and the other convex. The diameter differs from 38 mu to 50.7 mu and averages 44.3 mu. The thickness differs from 19 mu to 25.4 mu and averages 22.2 mu.

Mounted in Water.—The grains are still somewhat biscuit-shaped but much thicker and with no depressions. The diameter ranges from 34.8 mu to 38 mu and averages 36.4 mu.

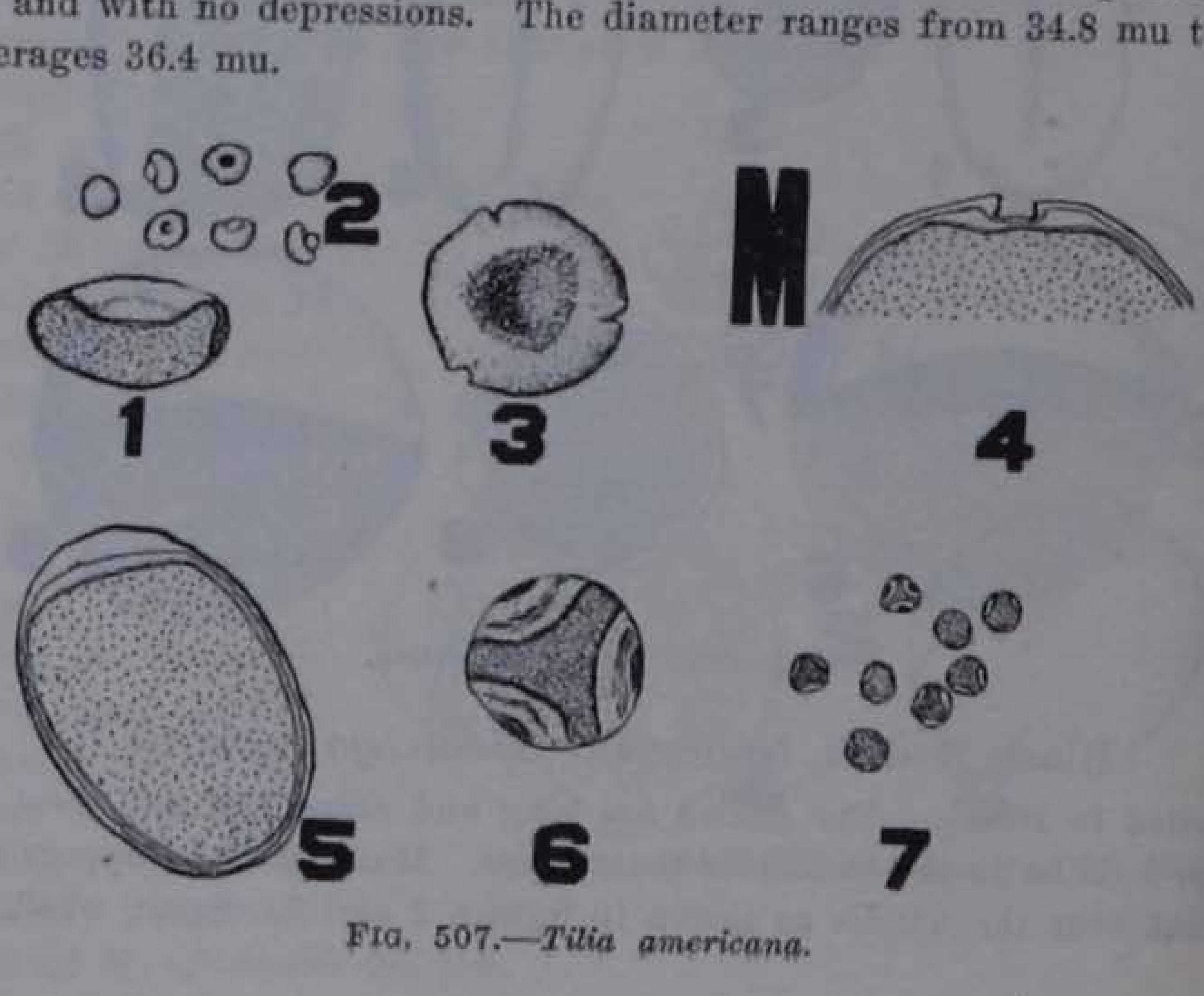

FIG. 507.—*Tilia americana.*

Hollyhock. *Althaea rosea* Cav.

Mounted in Honey.—The grain is spherical and spined with two kinds of spines and with intermediates. Mounted dry, the pollen shows two distinct sizes.

Mounted in Water.—The shape is the same as in honey but the size is somewhat larger. There are two distinct sizes.

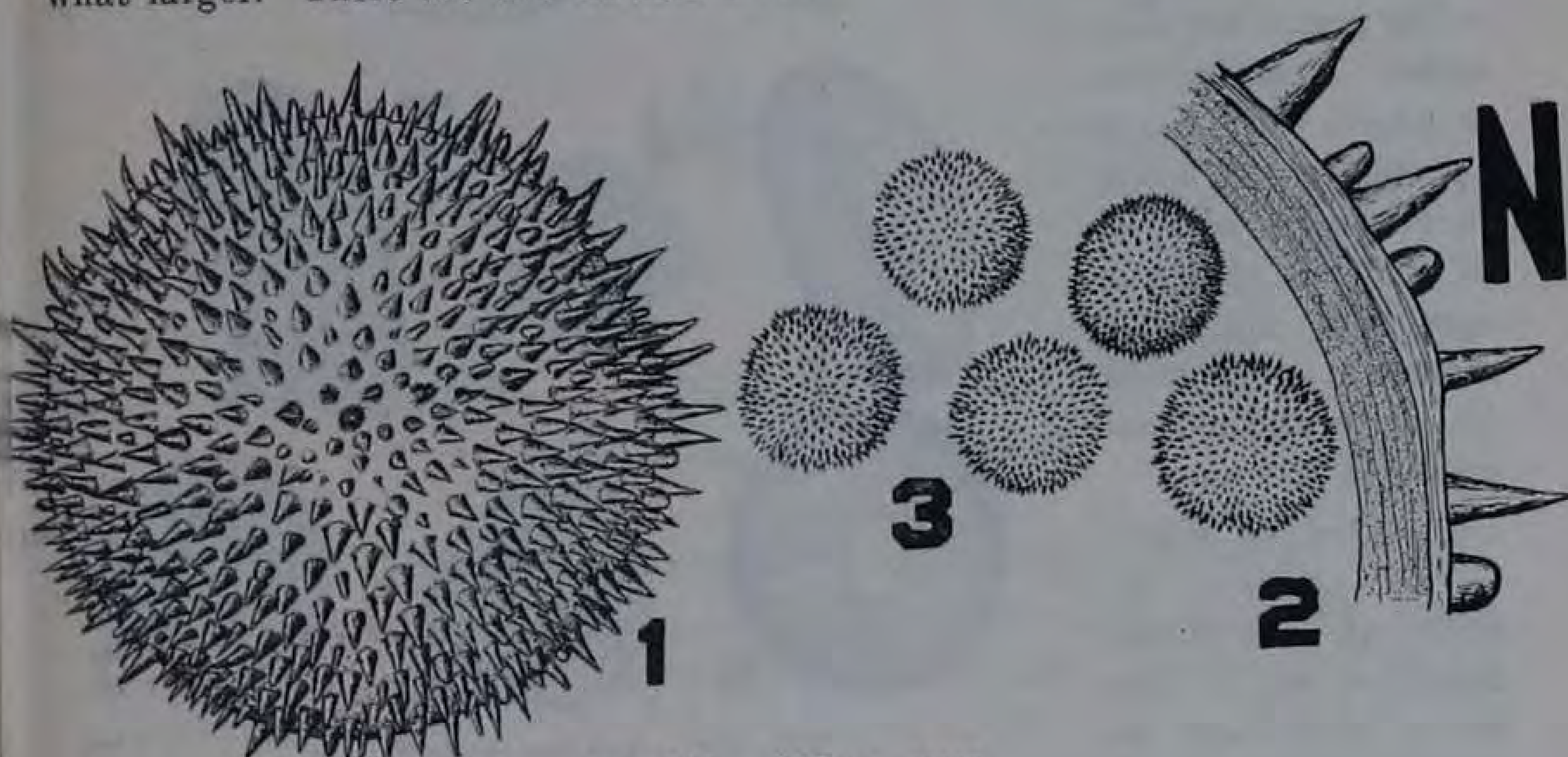

FIG. 508.—*Althaea rosea.*

Horse Mint. *Monarda mollis* L.

Mounted in Honey.—The grains are flat with three sutures on each side. When viewed from the edge the grain is narrowly oblong in outline and when viewed so three sutures can be seen it is broadly oblong. An end view shows all six sutures. The surface is indented with round pits arranged more or less in irregular rows as shown in figure 8. The length differs from 57 mu to 61.8 mu and averages 47.5 mu.

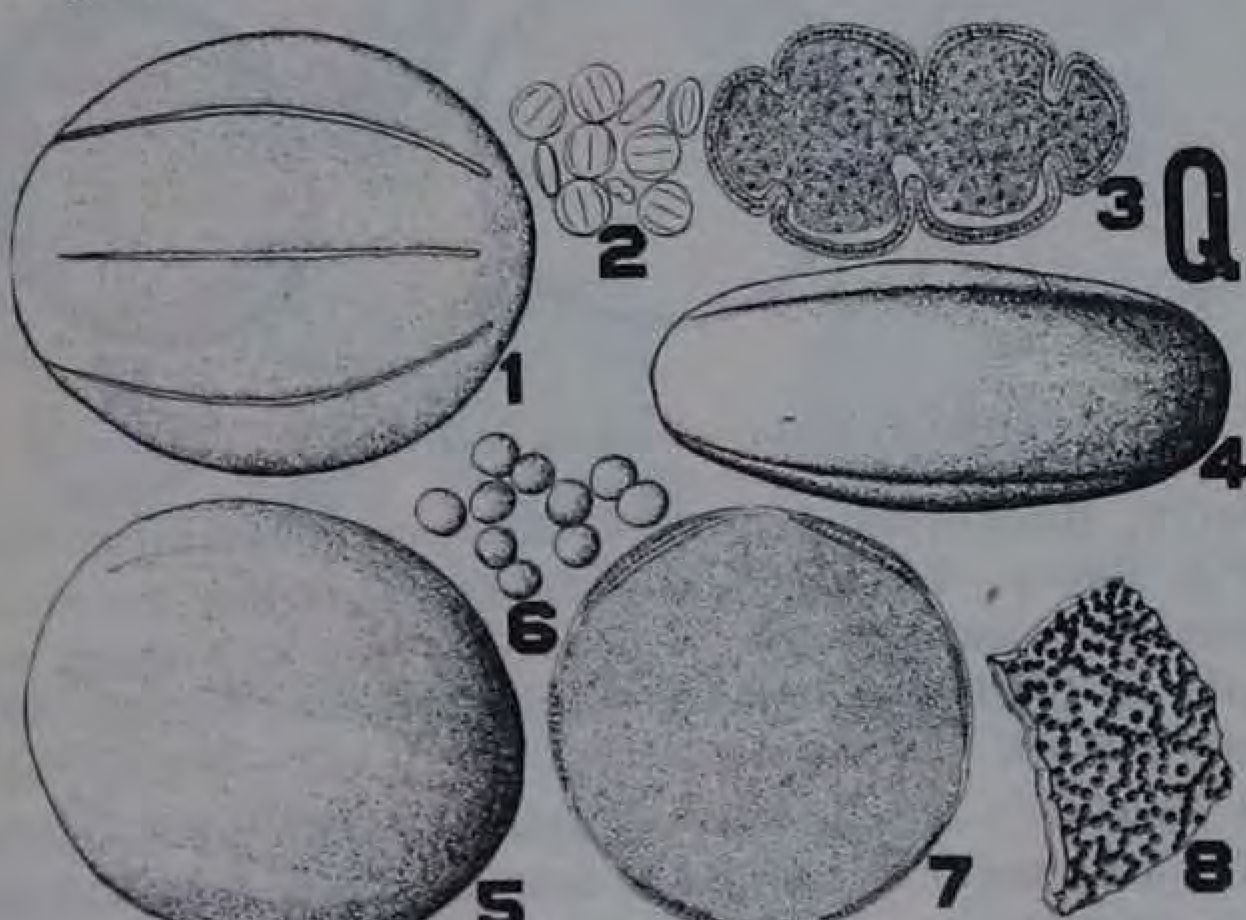

FIG. 509.—*Monarda mollis.*

Mounted in Water.—The grains are almost spherical but never entirely so. The sutures are seen with difficulty. The length ranges from 50.7 mu to 69.7 mu and averages 59.7 mu. The diameter ranges from 39.6 mu to 54.7 mu and averages 48.3 mu.

Matrimony Vine. *Lycium halimifolium* Mill.

Mounted in Honey.—The grains are ellipsoidal. Their surface is ridged with smooth low ridges. The length ranges from 41.2 mu to 47.5 mu and averages 45.1 mu. The diameter ranges from 19 mu to 23.8 mu and averages 22.1 mu.

Mounted in Water.—The grains are spherical. The surface markings can be seen as in honey and the sutures are rounded out.

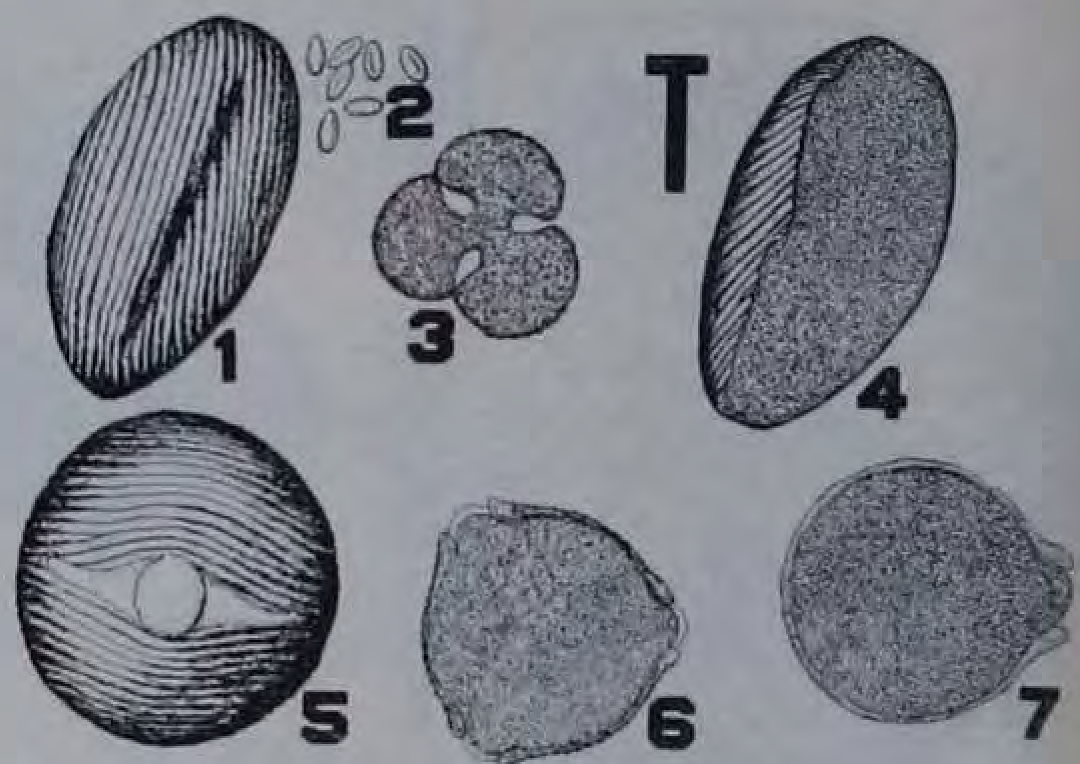

FIG. 510.—*Lycium halimifolium.*

Honeysuckle. *Lonicera Morrowi* Gray

The appearance of the grain in honey and in water is the same except as to size. The grains are larger in water. The surface has scattered over it small spines.

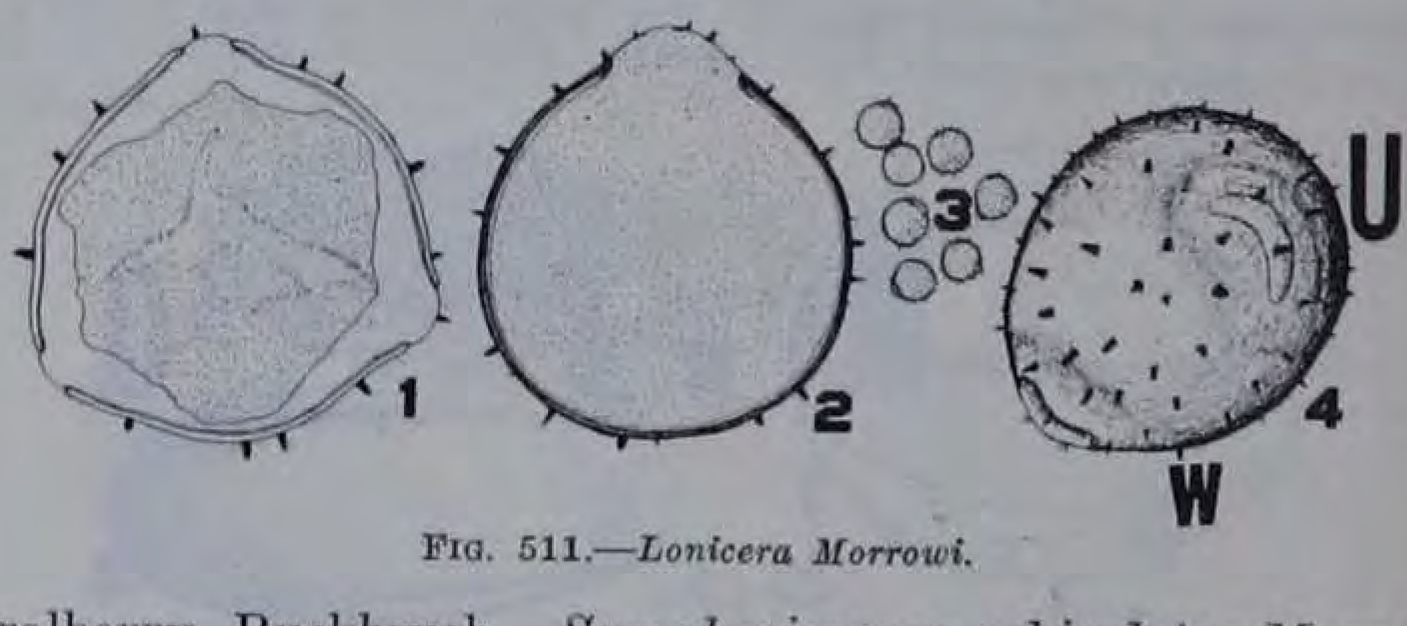

FIG. 511.—*Lonicera Morrowi.*

Coralberry, Buckbrush. *Symphoricarpos orbiculatus* Moench.

Mounted in Honey.—The grains are subspherical if they are not shriveled. Most of them are indented or warped in various ways as is shown in figure 2. The diameter of the less shriveled grains ranges from 33.2 mu to 44.4 mu and averages 38.8 mu.

Mounted in Water.—The grains are spherical with protuberances at the sutures. The diameter of all the grains in water ranges from 33.3 mu to 44.4 mu and averages 40.4 mu.

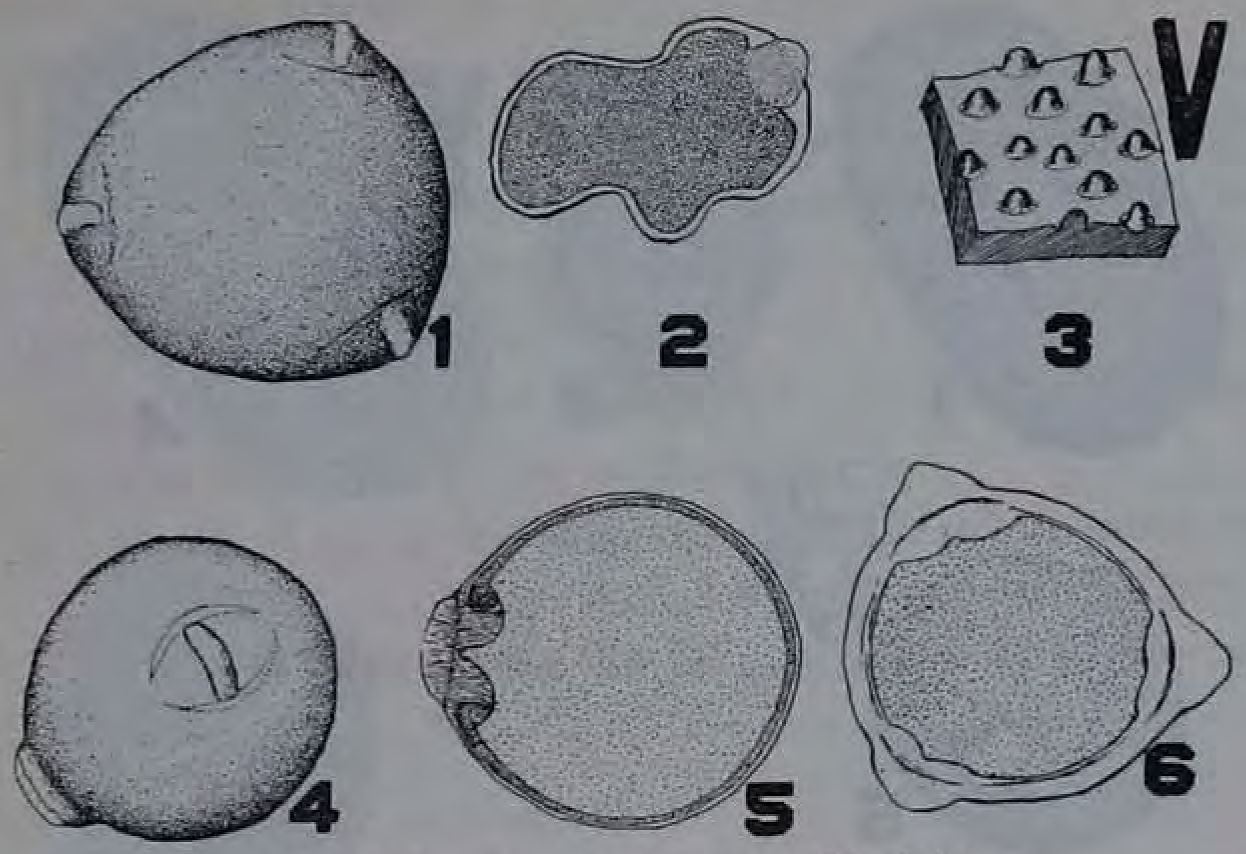

FIG. 512.—*Symphoricarpos orbiculatus.*

Field Thistle. *Cirsium discolor* (Muhl.) Spreng.

Mounted in Honey.—The grains are spherical with large wide-based spines over the surface. There are about 60 of these on a grain and most of them are sharp-pointed.

Mounted in Water.—The grains are a little shorter in length than in diameter.

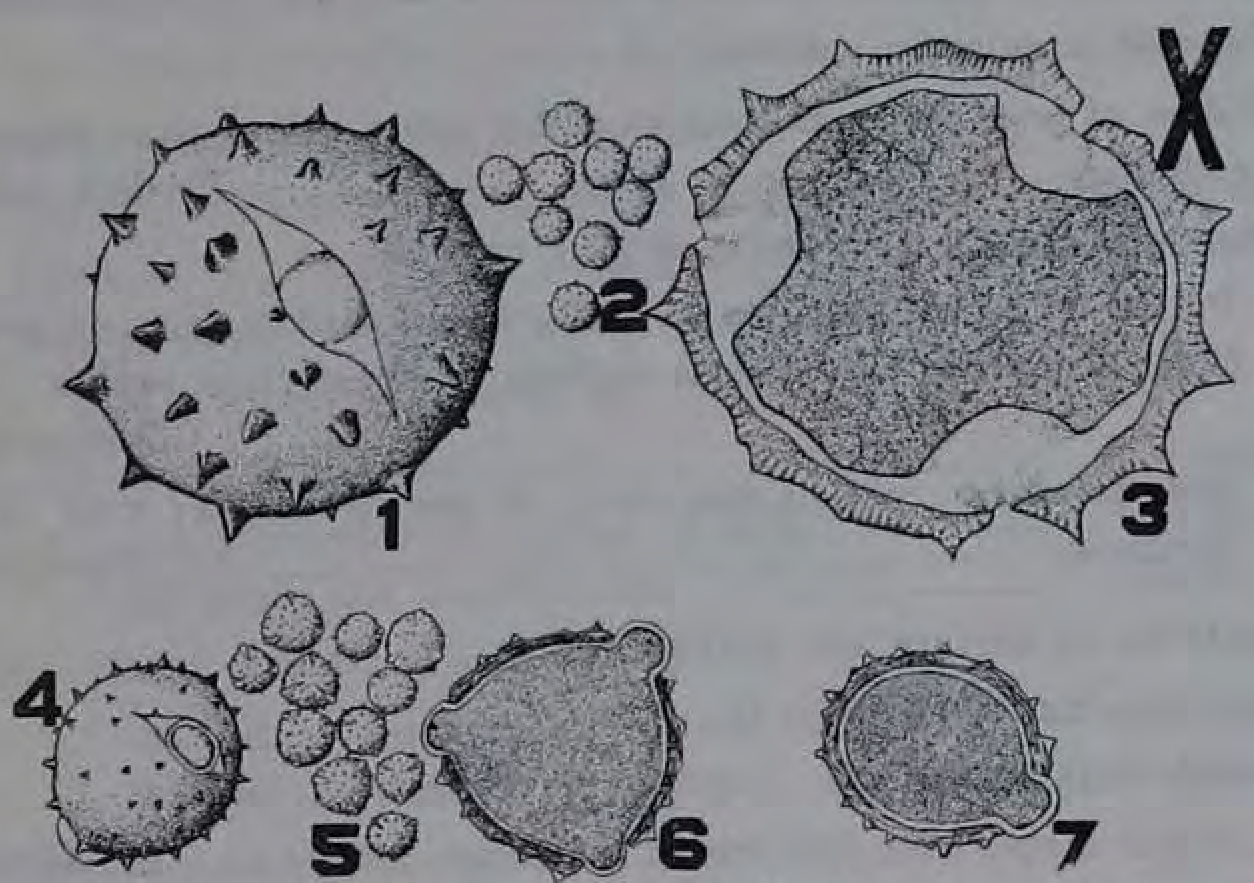

FIG. 513.—*Cirsium discolor.*

Bachelor's Button, Bluebottle. *Centaurea Cyanus* L.

Mounted in Honey.—The grains are capsule-shaped. The surface is pitted with very small reticulations.

Mounted in Water.—The grains are shortly ovoid. There are protuberances at the sutures. The surface detail appears as in honey.

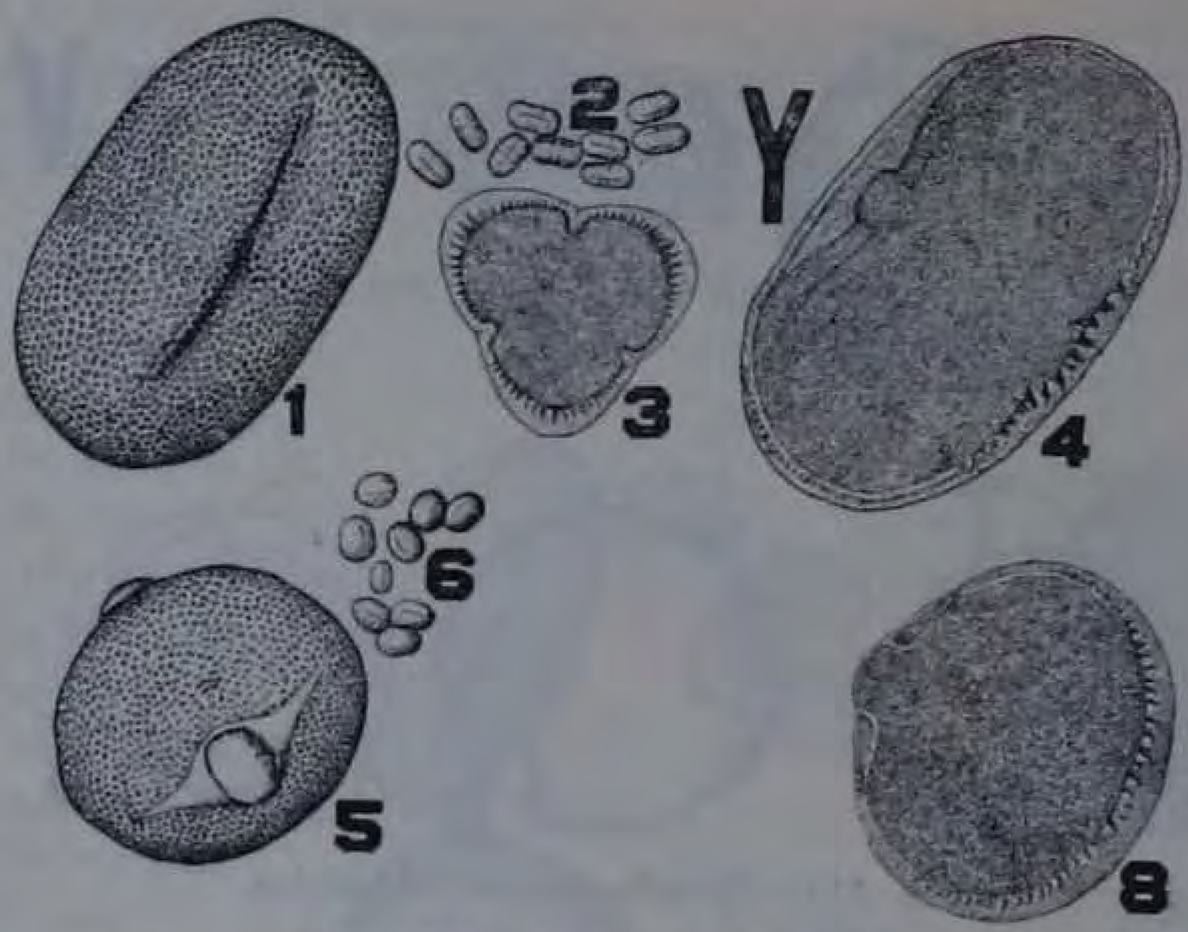

FIG. 514.—*Centaurea Cyanus.*

KEY TO TWENTY-EIGHT SPECIES OF POLLEN.

I. Reticulations on surface visible. 1

  1. Pollen circular in outline........ *Polygonum* A.
    A. Pollen spherical........ *P. Persicaria*
    A. Pollen disc-shaped........ *P. pennsylvanicum*
  1. Pollen not circular in outline. B
    B. Pollen at least twice as long as wide; ovoid rather than capsule-shaped in outline........ *Psedera quinquefolia*
    B. Pollen not more than twice as long as wide. a
      a. Pollen with two lines transversely across middle part of grain; more than 38 mu in length; wall thickest farthest from suture *Centaurea Cyanus*
      a. Not as above; pollen less than 38 mu in length; wall of uniform thickness........ *Ligustrum Ibota*

I. Reticulations on surface not visible. 2

  2. Pollen circular in outline. C
    C. Pollen with spines. b
      b. Pollen large, over 100 mu in diameter........ *Althaea rosea*
      b. Pollen less than 100 mu in diameter. c
        c. Walls thick, the two comprising about one-twelfth of the diameter of the grain. Spines prominent, wide at base and nearly triangular in outline........ *Cirsium discolor*
        c. Walls thin, comprising less than one-twentieth of the diameter of the grain. Spines not flaring out at the base as in the above *Lonicera Morrowi*

C. Pollen without spines. d

d. Grains with six sutures or germ fissures. e

e. Grain longer than wide. Symmetrical........................*Monarda mollis*

e. Grain circular in outline or wider than long. The two ends of the grain not exactly alike..*Salvia splendens*

d. Grains with only three sutures. f

f. Grains less than 25 mu in diameter..........................*Lycopsis arvensis*

f. Grains more than 25 mu in diameter. g

g. Grains more or less than 44 mu in diameter when mounted in WATER........................*Symphoricarpos racemosus* var. *laevigatus*

g. Grains biscuit-shaped, twice as great in diameter as in thickness..*Tilia americana*

2. Pollen not circular in outline. D

D. Grains less than 29 mu in length. i

i. Grains capsule-shaped in outline rather than oval. Almost twice as long as wide..*Baptisia leucantha*

i. Grains not as above. j

j. Grain narrower at one end than at the other. Sutures as seen in cross-section going scarcely deeper than the wall of the grain *Lycopsis arvensis*

j. Grain not as above. k

k. Grains less than 20 mu in length......................*Solanum Dulcamara*

k. Grains more than 20 mu in length..........................*Solanum nigrum*

D. Grains more than 29 mu in length. l

l. Surface of the grain furrowed lengthwise as on the palm of one's hand ....*Lycium halimifolium*

l. Not as above. m

m. Grain with six sutures. n

n. Grain longer than wide..*Monarda mollis*

n. Grain circular in outline or wider than long. The two ends of the grain not exactly alike....................................*Salvia splendens*

m. Grain with three sutures. o

o. Two lines transversely across the middle of each grain; wall thickest farthest from sutures............................*Centaurea Cyanus*

o. Not as above. p

p. Grains less than 34 mu in length. q

q. Some of the grains shriveled. At least 5 per cent of the grains putting out germ tubes in WATER. Surface in WATER appearing pitted with shallow scratched pits *Medicago lupulina*

q. Grains not shriveled in WATER, not as above, surface rather smooth..*Physalis pruinosa*

p. Grains more than 34 mu in length. r

r. Grains averaging more than 43 mu in length. s

s. Reticulations visible on surface when mounted dry *Trifolium pratense*

s. Reticulations not visible on surface when mounted dry, in WATER, or in honey. t

t. Walls at sutures appearing double when mounted in WATER. u

u. Sutures apparent when mounted in WATER *Rosa virginiana*

u. Sutures not apparent when mounted in WATER *Rosa setigera*

t. Walls at sutures not double when mounted in WATER *Medicago sativa*

r. Grains averaging less than 43 mu in length. v

v. At least 5 per cent of the grains putting out tubes from the germ-pores when mounted in WATER. Surface in WATER appearing pitted with shallow scratched pits. Many of the grains appearing shriveled in honey and some in WATER..*Medicago lupulina*

v. Not as above. w

w. Cross section of the grain through the three germ-pores rather triangular in shape. Taking the points of the wall farthest from the sutures as the apices of the triangle, about one-half of wall between the apices and the sutures in the average grain is straight or sometimes even concave..............................*Trifolium hybridum*

w. Cross section of the grain through the three germ-pores more nearly round than triangular in shape. All parts of the wall convex. x

x. Grains spherical when mounted in WATER. y

y. Less than 32 mu in diameter in WATER *Physalis pruinosa*

y. At least 32 mu in diameter in WATER *Trifolium repens*

x. Grains not spherical when mounted in WATER. z

z. Grains when mounted in WATER, less than 39.5 mu in length..............................*Melilotus officinalis*

z. Grains when mounted in WATER, less than 39 mu in length. (a)

(a) Grains when mounted in WATER, less than 3 mu longer than wide..................*Trifolium repens*

(a) Grains when mounted in WATER more than 3 mu longer than wide....................*Melilotus alba*

The size and shape of the pollen of one species is ordinarily thought of as rather constant. The one fact that made itself felt in this study was that the size of these single cells often varied extremely in a single species. It was quite the usual thing for the largest pollen grain to have twice the volume of the smallest normal grain. Because of this extreme variation in size the averages given will rarely agree with those found in subsequent measurements. In order to check up the reliability of the averages two groups of 20 grains each from one flower of *Trifolium pratense* were measured. Also another group of 20 grains from another plant were measured. The following table shows how the second and third lots differed from the first. The first lot was taken as standard.

Table I

	Maximum length	Minimum length	Average length	Maximum diameter	Minimum diameter	Average diameter
ollen om ame ant	34 per cent Greater	1.2 per cent Less	1 per cent Greater	4.3 per cent Greater	2.5 per cent Less	0.2 per cent Greater
ollen om a iffer- it lant	Same	17.1 per cent Less	2.2 per cent Less	4.3 per cent Greater	13.8 per cent Less	1.6 per cent Less

In this species the maximum length was 11.2 per cent greater than the minimum length and the maximum diameter was 41.2 per cent greater than the minimum diameter. If the variation were greater or the number of grains measured were fewer the chances are that the deviation of the average of a second lot of grains from the average of the first would be even greater than that found in *Trifolium pratense*. A 5 per cent or 6 per cent deviation of the average is not uncommon in *Cirsium, Symphoricarpos* and others.

DISCUSSION

The results obtained in this study have revealed more interesting problems to be investigated than they have justified conclusions to be drawn.

The two distinct sizes of pollen found in *Althaea rosea* and in *Cirsium discolor*, the structure of the wall in *Centaurea Cyanus* and in *Rosa*, the cause and effect of the minute pores found in the wall of many of the pollens, the minute structure about the sutures of the Caprifoliaceae, and the action of *Psedera quinquefolia* and of *Medicago lupulina* when placed in water all present interesting problems to the scientific investigator.

Although causes of the two distinct sizes shown by the hollyhock and by the thistle pollen were not investigated, the findings of others may be of interest. Darwin,[1] who was the first to extensively investigate dimorphic pollen in plants, states that about 80 per cent of the flowers possessing dimorphic pollen exhibit two distinct sizes. The flower whose pollen is to be used in fertilizing the long-styled forms always has the larger anthers and pollen. The diameter of the smaller size pollen in some cases is to the diameter of the larger size as 55 is to 100. Their volumes would compare as 1 to 6. This is the greatest difference that was found. Phillips[2] found the same conditions true in the primrose and in the cowslip, which have dimorphic pollen.

Castetter[3] describes some abnormally large grains of *Melilotus alba* (annual variety). He says: "Numerous pollen grains were found, the volume of which was from five to six times that of the normal pollen in the same anther. The abnormal pollen grains have less dense, vacuolate cytoplasm, and pores are absent in the extine."

These pollen grains are formed by the failure of the pollen mother cell to send in walls dividing the cytoplasm and four nuclei into four parts or, if development has reached the tetrad stage, by the failure of the four tetrads to separate. Castetter believes the above abnormality to be due to hybridity between the annual and biennial varieties.

It is interesting to note that in the two cases (hollyhock and thistle) where two distinct sizes of pollen were found there were good reasons for believing that the plants were not pure strains. In the case of the hollyhock the volume of the largest grain was 3.1 times that of the smallest while with the thistle it was 2¼ times.

The measurements and drawings given in this paper for the different species agree fairly well with the results of other workers. Most of these others have worked with pollens taken from honeys rather than with the grains obtained directly from the flowers.

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1 Darwin, Chas. The Different Forms of Flowers on Plants of the Same Species.

2 Phillips, E. F. Some of the Wonders of Pollen. Gleanings in Bee Culture.

3 Castetter, E. F. Studies on the Comparative Cytology of the Annual and Biennial Varieties of *Melilotus alba*. Amer. Jour. Bot., 12:270.

Parker[4] is the only one who attempted to describe the pollen as it comes from the bee. He obtained the pollen from the bee working on the plant he studied, covered the pollen with honey and studied it later. Although it would seem that this method would be free from gross error, the picture and measurements he gives for the pollen of *Althaea rosea* (hollyhock) are without doubt those of some other pollen, for I have taken the hollyhock pollen from the flower and found nothing but spined spherical grains which are big enough to be seen with the eye. Parker describes the pollen as ellipsoidal and 27 to 37 mu in length and 17 mu in diameter.

I have also found that most of the ellipsoidal pollens that I studied change shape somewhat when left in honey for several days and that some of the thinner walled species (e.g. *Trifolium repens*) absorb water from the honey to such an extent that the difference in measurements is very noticeable. I have found no medium in which all pollens will retain the shape they had when put into that medium. Honey with the least possible amount of water in it most nearly approaches this medium but different pollens probably retain their shape best in different media. Since there is this change in the length and diameter of pollen that is stored in honey, Parker's measurements cannot be used with certainty in immediately identifying pollen that is taken from the incoming bee.

The following table shows the difference between Parker's observations and those made in this study.

Table II

Parker's observations

Species	Shape	Length	Diameter
Polygonum pennsylvanicum	Spherical		52 mu to 63 mu
Trifolium repens	Ellipsoidal	28 mu	23 mu
Melilotus officinalis	Ellipsoidal	30 mu—33 mu	23 mu— 25 mu
Melilotus alba	Ellipsoidal	27 mu—30 mu	22 mu— 23 mu
Tilia americana			37 mu— 40 mu
Althaea rosea	Ellipsoidal	27 mu—37 mu	17 mu
Symphoricarpos orbiculatus	Ellipsoidal	37 mu—40 mu	28 mu— 37 mu

4 Parker, R. L. Some Pollen Gathered by Bees. Amer. Bee Jour., 63:16.

Data from present study

Polygonum pennsylvanicum	Disc-shaped	(Thickness) 6.9 mu— 8.6 mu	43 mu— 52 mu
Trifolium repens	Ellipsoidal	39.5 mu	19.7 mu
Melilotus officinalis	Ellipsoidal	36.4 mu—41.2 mu	19 mu— 20.6 mu
Melilotus alba	Ellipsoidal	34.8 mu—28 mu	19 mu— 20.6 mu
Tilia americana	Disc-shaped	(Thickness) 19 mu—25.3 mu	38 mu— 50.7 mu
Althaea rosea	Spherical		107.2 mu—128.7 mu
Symphoricarpos orbiculatus	Subspherical		33.2 mu— 44.4 mu

Since many pollens do change shape when kept in honey, the differences in the above table between Parker's measurements and those taken in this study may be explained. It will be noted that most of the grains he describes are less in length and greater in diameter than the ones studied in this paper. This reveals the fact that the grains have taken up water, for most ellipsoidal grains when mounted in water become almost spherical.

Pollen of one family does not necessarily possess structures characteristic of that family. It seems that environment has often played an important part in the characteristics of a single species.

Bennet[5] states "Altho a common form of pollen grain not infrequently runs thru a whole group of plants, yet more often the form is found to be adapted to the particular requirements of the species in respect to its mode of fertilization and varies even within a small circle of affinity." As an example, he gives the case of *Pringlea antiscorbutica,* which has a spherical grain whereas all the other Cruciferae have the common form of pollen.

SUMMARY

Little work has been done on the morphology of pollen as it is brought in by the bee. All the pollens found in the American honeys have been described by families by Young.[6] The methods used in studying the species of pollen described in this paper are given. Twenty-seven species of pollen from 19 genera and 12 families have been taken in both honey and water. Drawings of the pollen in honey and in water have been made of most of the species figured. A key is given for 28 species of pollen grains. The reliability and the variations of the measurements given in the descriptions are discussed. An erroneous description of *Althaea rosea*

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5 Bennet, A. W. On the Form of Pollen Grains in Reference to the Fertilization of Flowers. Rept. Brit. Assoc. Pt., 2:133.

6 Young, W. J. Chemical Analysis and Composition of American Honeys. U. S. Dept. Agr., Bur. Chem., Bul. 144.

pollen by Parker[7] was discovered. The data on 7 species of pollen studied by both Parker and myself are compared in a table.

CONCLUSIONS

Since most of the work of this paper is descriptive, the conclusions form a more or less incidental part of it.

The general statement has been made that Composite pollen is spined. That of *Centaurea* was found to be without spines. Also it has been said that insect-pollinated flowers are either spined or ellipsoidal. The pollen of *Tilia americana* and of *Polygonum pennsylvanicum* could hardly be called ellipsoidal, while that of *Symphoricarpos orbiculatus* and of *S. racemosus* is spherical and without true spines. All four species are insect-pollinated.

Studies were made of eight species in the Leguminosae, 4 in the Solanaceae and 3 in the Caprifoliaceae. The only characteristics that were noted for all the Leguminosae were their ellipsoidal shape when mounted in honey and their thin wall. *Melilotus officinalis* resembles *Trifolium repens* as much as or more than it does *M. alba*, so a natural key is impossible.

The rather abrupt corners which the grains have near their middle part along each suture were common to all members of the family.

The members of the Caprifoliaceae resembled each other in having at the end of each suture a curved line enclosing a light area.

While it may be possible to identify the different families by their pollen, still all the pollen in any one family does not necessarily possess a character common to that family.

Because of the minute size of pollen grains an amateur will find it exceedingly difficult to recognize pollens from descriptions. Many of the species can not be identified unless the average size of a group of rather fresh grains is taken in both water and honey and their behavior noted in both these media. An acquaintance of pollen gained by studying it as it comes from the flower will greatly facilitate the identification of pollen as it is brought in by the bees.

The author wishes to acknowledge the help of Dr. J. N. Martin in giving suggestions concerning the work done and the writing of the paper. He is also indebted to Dr. L. H. Pammel, Dr. E. F. Castetter, Dr. Ada Hayden and R. G. Reeves for their helpful suggestions.

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7 Parker, R. L. Some Pollen Gathered by Bees. Amer. Bee Jour. 63:16.

THE STRUCTURE AND CONTENT OF POLLEN

FRANK P. SIPE

In many ways the pollen grain develops in much the same way as other plant cells, but some variation has been found in the details of the process in different species of plants. At the close of the tetrad division there is formed about each young spore a gelatinous "special wall." Within this special wall the spore coats develop. The method or process of development from this point differs in different species.

In general the extine is laid down on the inner surface of the special wall through the activity of the protoplast. Within the extine is a second wall, the intine, laid down in a similar manner. The structures of this extine and intine differ. Kraemer states that the intine is cellulose, the extine mostly of cutin or oily materials.

It has often been suggested and believed that the pollen grains of plants might be used in distinguishing species, thus constructing a system of taxonomy on the pollen grains alone. Alwin Köhler made an extensive study of this subject, and I am quoting some of his notations concerning the researches of earlier workers on this subject.

One of the first studies along this line, according to Köhler, and one that furnished incentive for most later researches, was Mohl's "Über den Bau und die Form der Pollenkörner." He grouped plants into families according to the form of the pollen, and was able to group in this way even the genera and species. Schacht in 1860 used, as a basis for grouping pollen grains, their tendency to adhere in groups or not to adhere. Radlkofer in 1883, Köhler says, was the first to point out the significance of the structure of pollen in the systematic grouping of plants. He dealt especially with the Acanthaceae. Lindau, in 1893, made use of Radlkofer's results, in his work on Acanthaceae in Engler and Prantl's "Die natürlichen Pflanzenfamilien." Lindau distinguished the following kinds of pollen: simple round pollen, ribbed pollen, spangled pollen, girdled pollen, staved pollen, honeycomb pollen, and ringed pollen. Hugo Fischer in 1890 found that the pollen grains of the same species of plant were essentially alike, and that the pollen grains of plants in the same family showed a certain typical form. He even asserted that one could tell, from the pollen, the family, genus, and even the species of a plant. He emphasized especially the structure of the extine.

E. Gilg in 1895 constructed a key of the Gentianaceae in which the pollen grain was used as a basis of identification. Below is given a short extract of his key, to show his method.

A. Single grains or tetrads, the single grain spherical or longish, egg-form or somewhat curved, never flattened on the side........................I, Gentianoideae
   a) Single grains, grains spherical or longish, especially with three fissures running lengthwise, in whose midst the three germ pores lie....Gentianeae
      1) Pollen small. Extine not to be distinguished from the intine, entirely smooth. Germ fissures hardly to be seen.............................*Ia*. Exacineae
      2) Pollen fairly large. Extine easily distinguished from the intine, smooth, or rarely finely dotted. Germ fissure finely dotted.................... *Ib*. Erythracineae

Köhler gives a detailed study of the pollen of the Gentianaceae, comparing his results throughout with those of Gilg. His observations have been made on the following things:

1. Form of pollen.
2. Diameter of pollen.
3. Fissures of pollen.
4. Pores of pollen.
5. Structure of the extine.

His general conclusions are best stated in the following translation of his own statements.

"As I have already stated . . . . it was the chief aim of my research to prove, whether and to what extent the pollen structure of the Gentianaceae can be used in their systematic classification."

The analysis of the content of pollen has not been carried out as thoroughly as the study of their form and their physiology. Molisch analyzed 100 kinds of pollen, finding starch in 45, a trace of starch in 9, and no starch in 46. Lidforss examined 150 wind pollinated flowers of Scandinavia, finding all rich in starch. Wind pollinated plants of the tropics, he found, had no starch. Biourge found four substances in the wall of pollen: cutin, cellulose, pectic substances and callose. He examined nineteen species of monocots and 26 species of dicots. The water content of pollen differs, Koessler finding 10.5 per cent of water in ragweed pollen, and Lidforss finding an average of 10 per cent in a number of species.

The pollen grain is not a simple structure; its content is made up of a number of chemical constituents, as shown by the following analysis of ragweed pollen.

Heyl's analysis of ragweed pollen

Moisture	5.28	Dextrin	2.10
Starch	0.00	Fat	10.80
Crude fiber	12.20	Lecithin	9.75
Pentosans	7.26	Ether Sol.	1.75
Protein	24.40	Sucrose	0.40
Nitrogen in alcohol extract	1.08	Glucose	1.60
Ash	5.39	Resin	17.40

Paton, in a study of pollen, found the following enzymes present in eighteen kinds of pollen: amylase, invertase, catalase, reductase, pectinase; some had pepsin, trypsin and amylase. Cytase was doubtfully present in six. Tyrosinase and laccase were not found; zymase was found in Siberian crab.

G. Tischler in his paper on "Pollenbiologische Studien" constructed a table showing the findings of a number of investigators concerning the starch content of a number of species of plants. Most of the species treated here are European, but a few, listed below, may be of interest.

TABLE I

Pollen of	*Starch*	*No starch*	*Some find starch, others none*
Polygonum Convolvulus			*
Cannabis sativa	*		
Polygonum lapathifolium	*		
Pyrus Aucuparia		*	
Fragaria vesca	*		
Trifolium pratense			*
T. repens		*	
T. hybridum		*	

In this study most emphasis has been placed on the content of the pollen grains, but some study has been made of the structure and appearance. These features are shown in Table II. The diameter of the pollen has been taken in microns and these data have been recorded in Table III along with the analyses of content. The following table gives some data concerning the features of several kinds of pollen.

TABLE II

Pollen of	*Germ pores*	*Wall*	*Form of Grain*
Nepeta Cataria		Smooth	Ellipsoidal
Sneezeweed		Spiny, thick	Spherical
Sweet pea	3	Smooth	Ellipsoidal
Tomato	3	Smooth	Spherical
Mignonette		Fissured	Ellipsoidal
Gentiana pallida	3	3 lengthwise fissures	Ellipsoidal
Selinum capitellatum	3	Smooth	Capsule shape
Buckwheat		Smooth	Ellipsoidal
Cosmos	3	Spiny, thick	Spherical
Helenium autumnale	3	Spiny, thick	Spherical
Sweet clover	3	Smooth	Ellipsoidal
Carrot	3	Smooth	Capsule shape
Mignonette		Smooth	Spherical
Evening primrose	3	Smooth	Triangular
Pumpkin	Many	Spiny	Spherical
Maple (A. saccharinum)		Smooth	Spherical
Tulip		Smooth, thick	Spherical
Pansy	5	Smooth	Five sided
Bloodroot		Smooth	Spherical
Box elder	3	Smooth, three long fissures	Spherical

The reserve food material stored away in the pollen grain may be starch, sugar, protein, or fat. The analyses in this work were made by using weak IKI solution as a test for starch, the Flückinger reaction, sometimes followed by the phenylhydrazine test for sugar; Sudan III for fat; and a dilute solution of eosin for protein.

The content of pollen varies considerably with its maturity, the storage substances probably being laid down about the time of ripening. Ripe pollen is in most cases likely to contain one or more of the common food substances. There is also a difference in the amount present, some pollen indicating when tested a scant content of any stored food, while others seem packed with reserve food material.

Pollen is always filled with a dense nonvacuolate protoplasm. This protoplasm is always nitrogenous in character, and may furnish abundant food for insects, even though storage foods are absent.

TABLE III

Content of Pollen

Pollen from	*Starch*	*Sugar*	*Fat*	*Protein*	*Diameter, microns*
Gramineae					
Bromus inermis	*		–	–	40
Liliaceae					
Asparagus officinalis	–	–	–	*	28
Hyacinthus orientalis	some		*	some	
Tulipa	–	–	much	little	
Dioscoreaceae					
Dioscorea divaricata (cinnamon vine)	–	–	–	*	36
Amaryllidaceae					
Hippeastrum			little	*	84x75
Amaryllis	–	*			
Narcissus	–		*	some	48
Salicaceae					
Salix rostrata	–	–	*	little	28
S. lucida	–	–	*	*	
Populus tremuloides	–	–	*	–	32x36
Betulaceae					
Corylus americana (hazel)	–	–	*	–	28
Polygonaceae					
Polygonum orientale	*	–		–	60
Fagopyrum esculentum (buckwheat)	*	–	–	–	56x76
Nymphaeaceae					
Nelumbo lutea	–		–	*	70
Papaveraceae					
Sanguinaria canadensis (bloodroot)	–	*	*	some	40
Papaver somniferum (poppy)	–		*	–	40
Cruciferae					
Lobularia maritima (sweet alyssum)	–	–	*	*	20
Brassica oleracea (cabbage)	–		some	*	28
Resedaceae					
Reseda (mignonette)	–	–	*	–	
Saxifragaceae					
Ribes gracile	–	–	*	little	28
Rosaceae					
Pyrus Malus	–	–	*	–	
Spiraea Van Houtei	–	–	*	some	
Prunus americana (wild plum)	–	*	*	–	48

P. Cerasus	–				36
Leguminosae					
Phaseolus lunatus	*	–			
P. vulgaris	–	–	some	–	50
Melilotus officinalis	*	–	*	*	28x32
Trifolium repens (white clover)	–	–		*	28x32
T. pratense (red clover)	–	–	*	*	30x40
Lathyrus odoratus (sweet pea)	–	–	*	–	44
Medicago sativa (alfalfa)	–	–	some	*	44x52
Geraniaceae					
Tropaeolum majus (nasturtium)	–	–	–	–	36
Aceraceae					
Acer saccharinum	*	–	*	–	
A. Negundo	–	–	–	*	32
Violaceae					
Viola tricolor (pansy)	*	–	*	–	96
Onagraceae					
Oenothera biennis (evening primrose)	*	–	*	–	132
Umbelliferae					
Daucus Carota (carrot)	*	–	*	–	16x32
Eulophus Parishii	–		–	*	
Verbenaceae					
Verbena Aubletia	–	–	*	–	40
Labiatae					
Monarda mollis	–				40
Nepeta Cataria	–	–	–	*	40
Salvia splendens	–		–	–	56x76
Solanaceae					
Lycopersicum esculentum (tomato)	–		*	–	24
Solanum Melongena (egg plant)	–		*	*	36
Datura Stramonium (Jimson weed)	–		*	*	60
Scrophulariaceae					
Verbascum Thapsus	–	–	*	*	32
Martyniaceae					
Martynia	*		–	little	88
Plantaginaceae					
Plantago lanceolata (buckhorn)	*	–	*	–	30
Cucurbitaceae					
Cucurbita sativus (cucumber)	–	–	*	–	84
Echinocystis lobata (balsam apple)	–			*	72
Lagenaria vulgaris (gourd)	–	–	–	–	72
Citrullus vulgaris (watermelon)	–	–	*	–	60
Cucurbita moschata (squash)	*	–	–	*	130
Lobeliaceae					
Lobelia siphilitica	*	–	–	*	31
Compositae					
Liatris scariosa	–	*	–	*	32
L. pycnostachya	–			*	
Aster prenanthoides	–	–		*	27
Aster novae-angliae	–	–	–	–	21
Aster azureus	–	–	–	*	27
Erigeron strigosus	–	–	–	–	
Taraxacum officinale	*	–	*	*	36
Solidago Riddellii	–	–		–	24
S. rigida	–	–	*	*	36
Cosmos bipinnatus	–	–	–	–	40
Helenium autumnale	–	–	–	–	34
Helianthus grosseserratus	–	–	–	*	32

STRUCTURE AND COMPOSITION OF POLLEN GRAINS OF VERNAL PLANTS

ADA HAYDEN AND J. N. MARTIN

Among the first morphological studies of pollen were those of Malpighi (1686) and of Grew (1675). While numerous articles on their structure and composition have been contributed, the amount of data available in application to several problems involved in such study is yet somewhat fragmentary.

Some of the problems upon which pollen study has a bearing are: (1) Structural studies with reference to the taxonomic aspect; (2) the identity of pollen grains and content thereof in relation to hay fever; (3) the identity and composition of pollen grains used by bees for food, and (4) biotic studies relative to pollination. Among the contributions which have a taxonomic bearing are those of Von Mohl (1835), Smith (1876), Biourge (1892), Gilg (1895), Pope (1925) and Wodehouse (1926 and 1928). Dealing with the relation to hay fever are the papers of Sheppegrell (1922), Koessler and Durham (1926) and La Garde (1926). The articles of Sipe (1930) (this volume), Phillips (1924), Parker (1924) and Hoffman (1930) (this volume) pertain to the study of pollen grains as bee food. Very extensive is the literature dealing with biotic relationships. Among these may be mentioned the work of Sprengel (1793), Darwin (1876), Kerner and Oliver (1895), Pammel (1903) and Knuth (1906).

METHODS

In this study pollen grains from fifteen species of spring-flowering trees were included.

Microchemical Tests

For starch IKI was used. For sugars the Flückinger reaction was employed and for proteins tests were made with eosin, Millon's solution and the Biuret reaction. Fats were tested with Sudan III.

Microscopic Studies

The grains secured from the trees were used fresh or preserved in an ice box. The grains were mounted and immediately measured in water with the high dry lens of a Bausch and Lomb microscope. Most of the camera lucida drawings were made with a Zeiss eyepiece of 15x magnification. The relative size of the grains was drawn with low power and for detail of structure the 1.8 oil immersion was used. Acid nigrosin solution was used for staining pores and for differentiating their lids. The drawings are by A. Hayden.

DESCRIPTION OF POLLEN GRAINS

FAMILY SALICACEAE

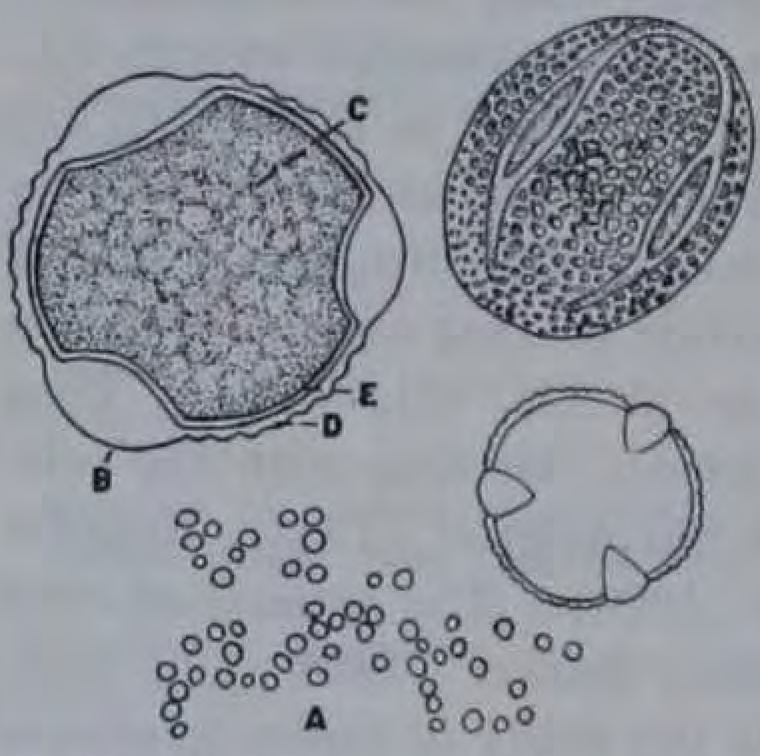

FIG. 515.—*Salix longifolia.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

Salix longifolia Muhl. Sand Bar Willow

Shape subspherical; pores 3, without lids, lying midway in the germ sutures; surface finely reticulate between the germ sutures, which appear smooth. Starch present in about 10 per cent of grains; trace of sugar; no reducing sugars.

Salix rostrata Richards. Beaked Willow

Shape oval to subspherical; size 19 to 27 mu; pores 3, without lids, located in germ sutures; surface finely reticulate except over germ sutures and pores, which appear smooth. Starch present in 10 per cent of grains.

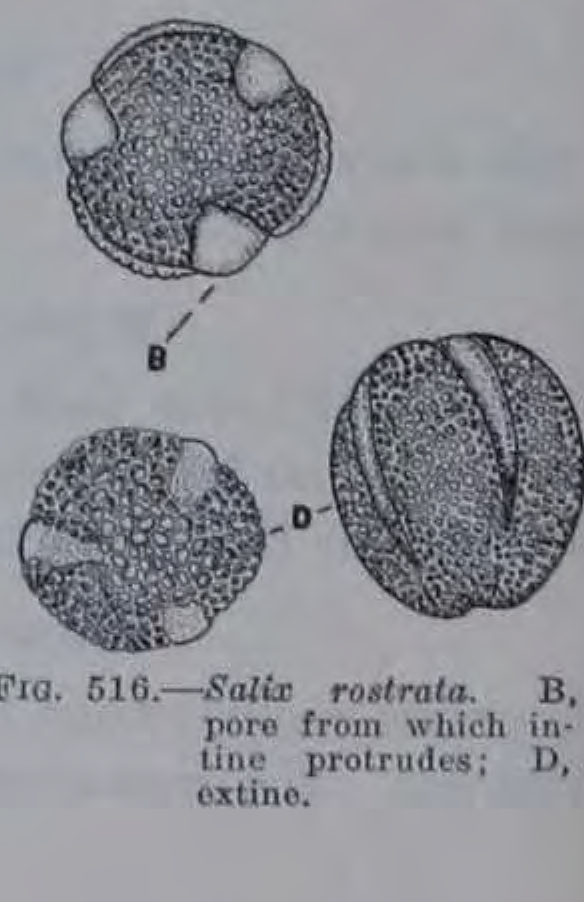

FIG. 516.—*Salix rostrata.* B, pore from which intine protrudes; D, extine.

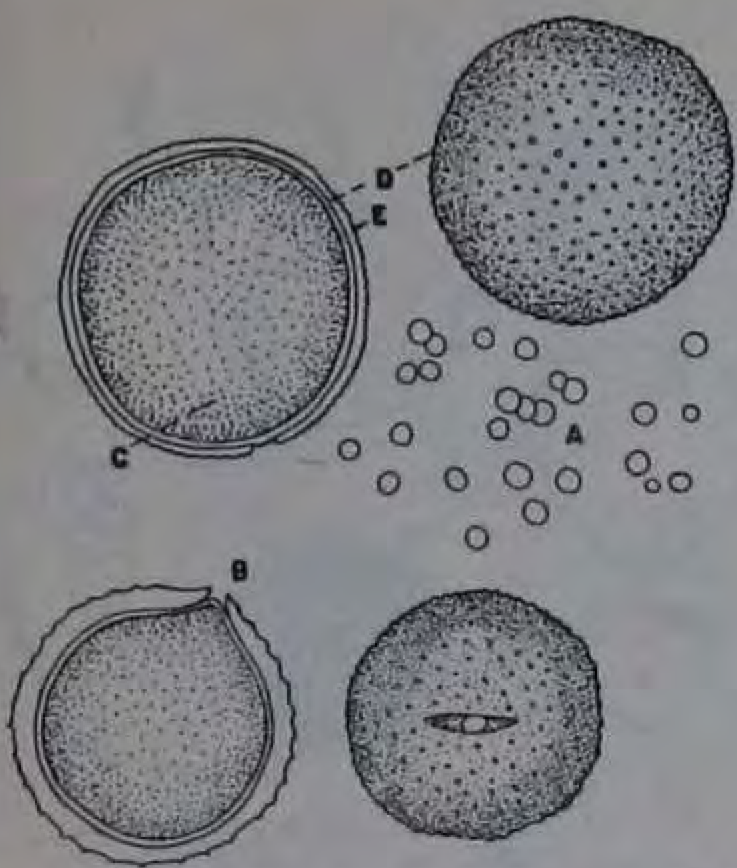

FIG. 517.—*Populus deltoides.* A, cluster of pollen grains; B, pore; C, protoplast; D, extine; E, intine.

FAMILY BETULACEAE

Betula alba L. White Birch

Shape subspherical; size 28 to 34 mu; pores 3 to 4, with plugs; behaving like *B. papyrifera* when treated with acid nigrosin.

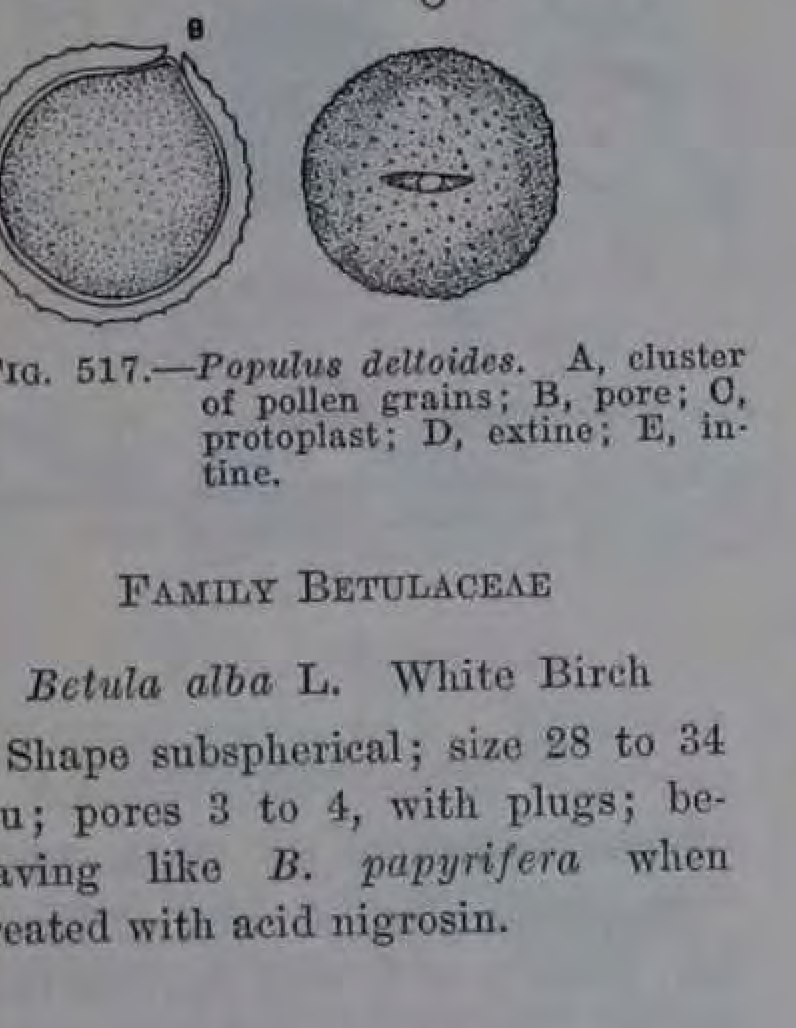

FIG. 519.—*Betula papyrifera.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, intine; E, extine.

Populus deltoides Marsh. Cottonwood

Biscuit-shaped; size 28 to 38 mu; one large germ pore; surface dotted with fine pores which give the extine a somewhat tuberculate appearance; very little starch; decided Biuret reaction for protein.

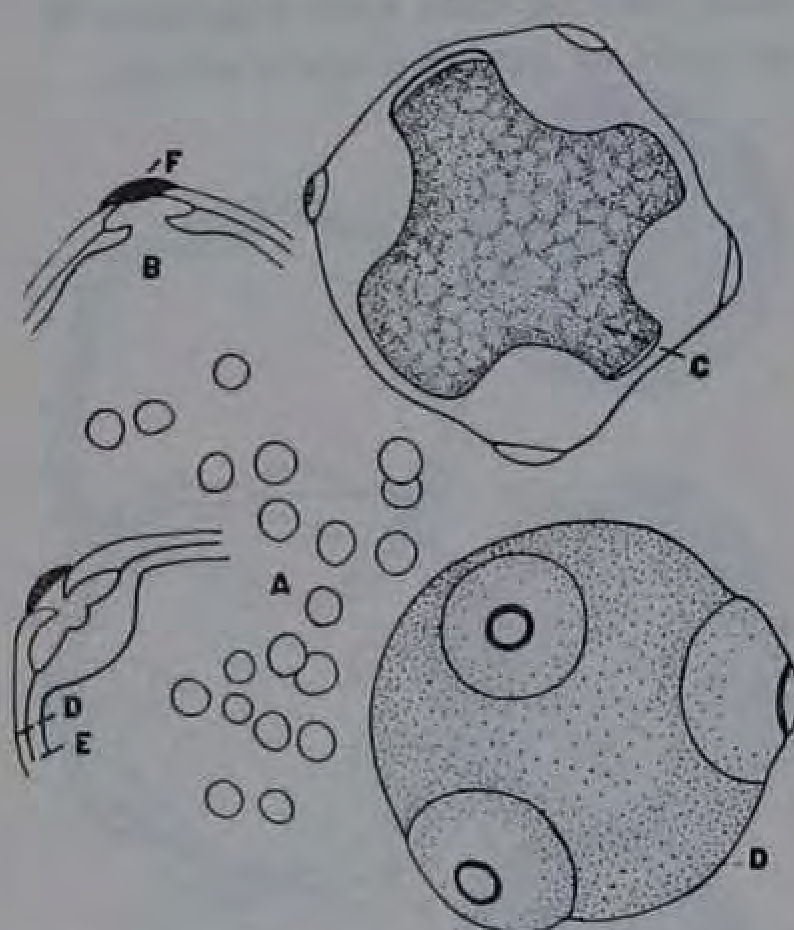

FIG. 518.—*Betula alba.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine; F, lid of pore.

Betula alba var. *papyrifera* (Marsh.) Spoch. Paper Birch

Shape subspherical; size 20 to 40 mu; pores 3 to 4, rarely 5. The walls are distended around the pores; the intine being much thickened gives a bull's-eye-like appearance. When treated with acid nigrosin, the opening of the pore appears to be filled with a deep staining substance which swells and behaves more like a plug than a lid. The surface of the extine is smooth. Starch is abundant in 95 per cent of grains.

Ostrya virginiana (Mill.) K. Koch.
American Hop Hornbean

Shape triangular; size 25 to 33 mu; pores 3, occasionally 4—pores appear like those of *B. papyrifera* when treated with acid nigrosin; 95 per cent of grains contain starch.

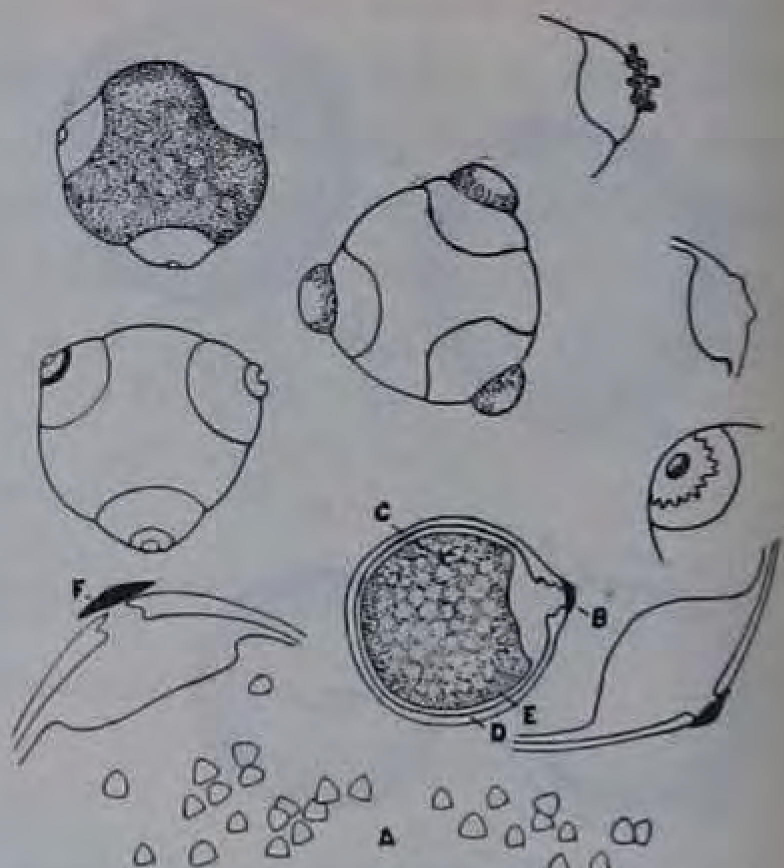

FIG. 520.—*Ostrya virginiana.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine; F, lid of pore.

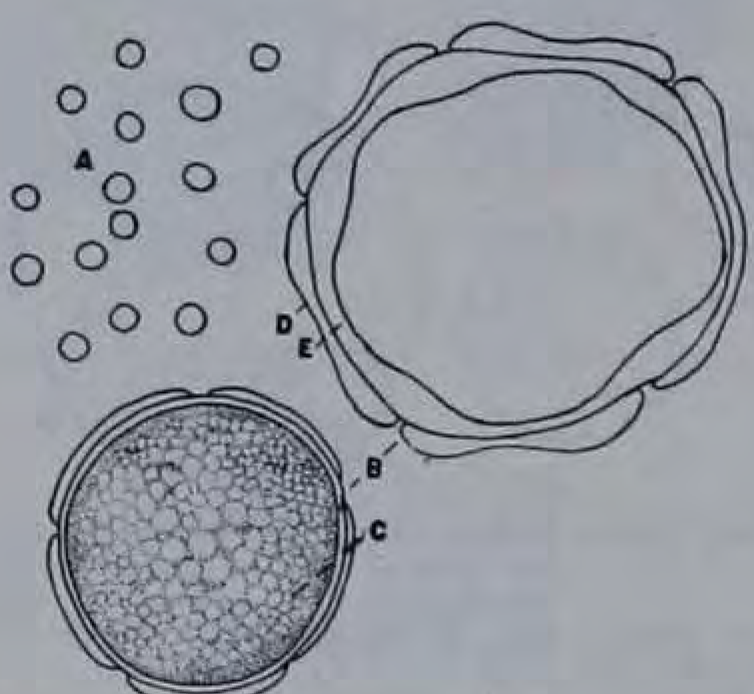

FIG. 521.—*Ulmus americana.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

FAMILY URTICACEAE

Ulmus americana L. White Elm

Shape subspherical; size 27 to 40 mu; pores 4 to 5, with lids; surface smooth; 95 per cent of grains densely filled with starch; protein indicated by Biuret reaction.

Ulmus fulva Michx. Slippery Elm

Shape subspherical; size 27 to 35 mu; pores 4 to 5, with lids; surface smooth; 80 per cent of grains dense with starch; dextrin present, trace of disaccharids; distinct protein reaction manifested by Biuret test.

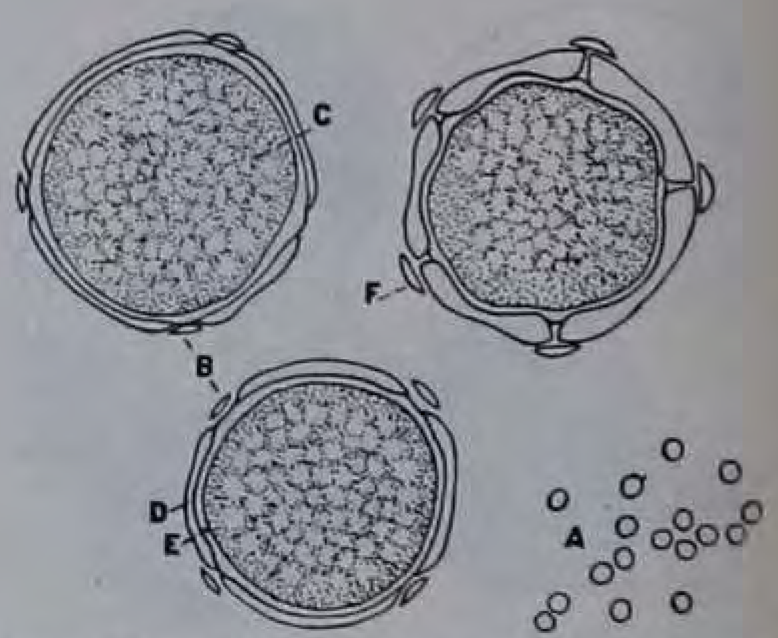

FIG. 522.—*Ulmus fulva.* A, cluster of pollen grains; B, pore; C, protoplast; D, extine; E, intine; F, lid of pore.

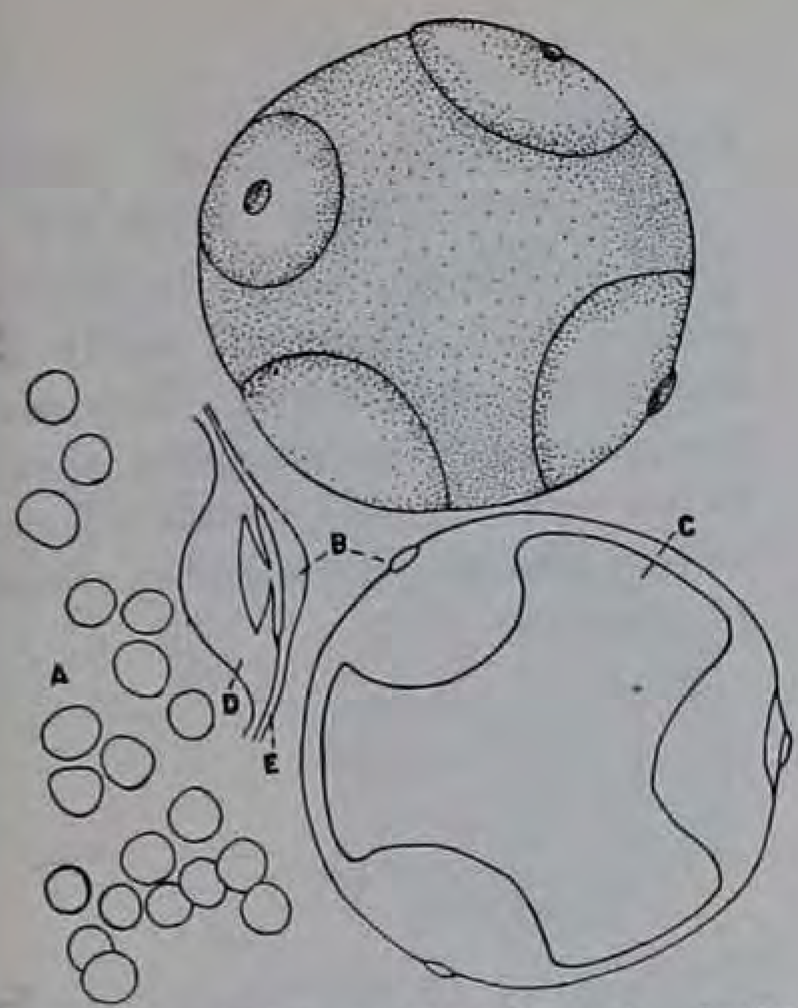

FIG. 523.—*Celtis occidentalis.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

FAMILY OLEACEAE

Fraxinus americana L. White Ash

Biscuit-shaped; size 24 to 32 mu; pores 4 to 5; surface of extine smooth, inner wall perforated with reticulate depressions. Seventy-five per cent of grains containing starch; protein present.

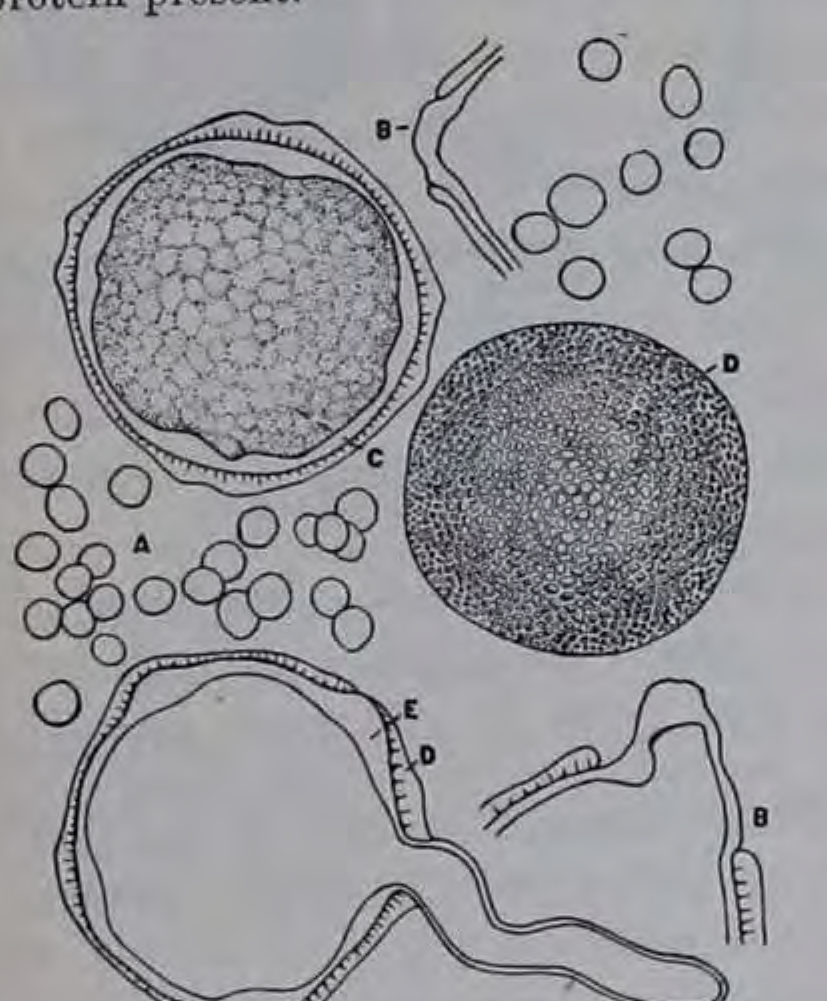

FIG. 525.—*Fraxinus pennsylvanica.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

Celtis occidentalis L. Hackberry

Shape subspherical; size 30 to 33 mu and 37 to 41 mu; pores 3; surface smooth; 95 per cent of grains dense with starch.

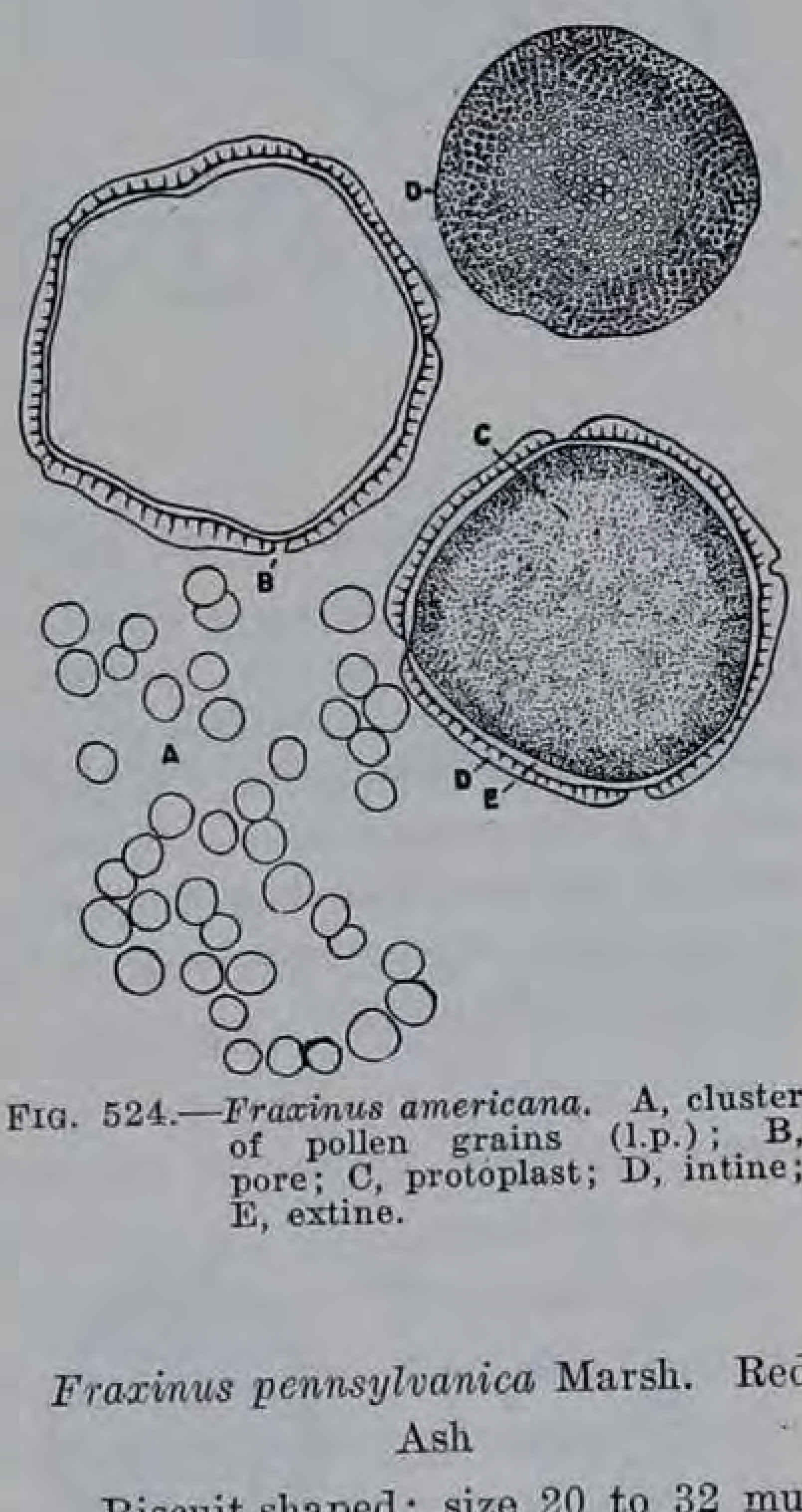

FIG. 524.—*Fraxinus americana.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, intine; E, extine.

Fraxinus pennsylvanica Marsh. Red Ash

Biscuit-shaped; size 20 to 32 mu, apparently two sizes, 20 to 25 mu and 25 to 32 mu; pores 4 to 5, rarely 6; surface of extine smooth but perforated on inner surface by reticulate pores; 95 per cent of grains contain starch; protein present according to Biuret reaction. Some of the pollen grains germinating before leaving the anther.

Fraxinus pennsylvanica var. *lanceolata* (Borkh.) Sarg. Green Ash

Biscuit-shaped; size 20 to 32 mu; pores 3 to 4 (common), rarely 5; surface of extine smooth, inner surface penetrated by reticulate pores; 95 per cent of grains contain starch; protein present. Some pollen grains germinating.

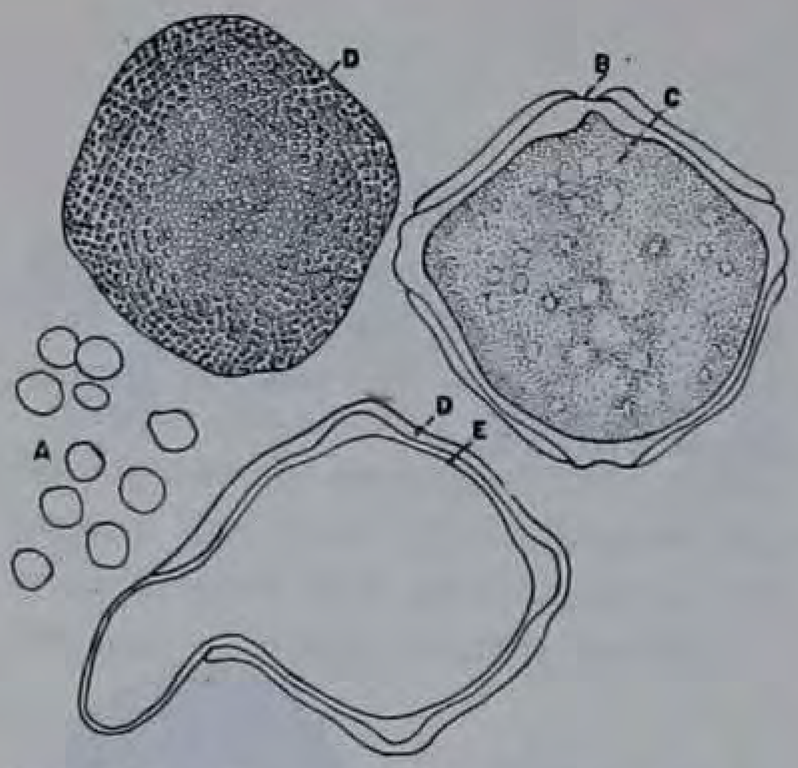

FIG. 526.—*Fraxinus pennsylvanica* var. *lanceolata*. A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

Fraxinus nigra Marsh. Black Ash

Biscuit-shaped; size 24 to 36 mu; pores 3, in some cases 4; surface of extine smooth, inner surface penetrated by reticulate pores; 95 per cent of grains contain starch; Biuret reaction and eosin test show protein. A few grains were germinating before shed by the anther.

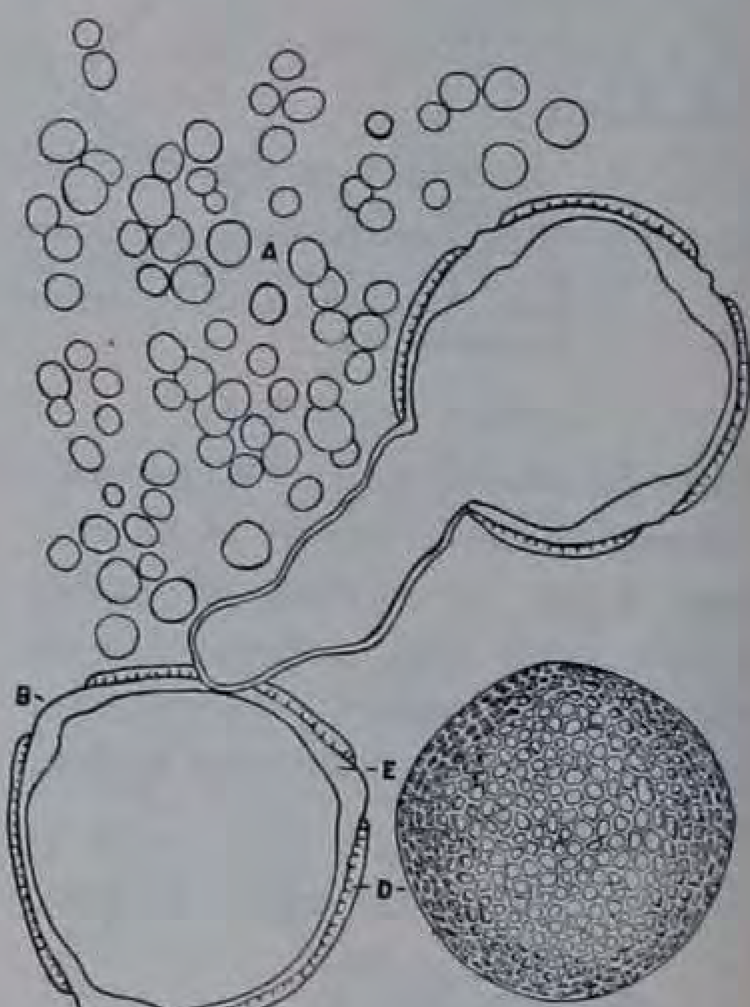

FIG. 527.—*Fraxinus nigra*. A, cluster of pollen grains (l.p.); B, pore; D, extine; E, intine.

FAMILY ACERACEAE

Acer Negundo L. Box Elder

Shape subspherical; size 26 to 37 mu; pores 3, with germ sutures; surface of extine smooth, inner surface reticulate porous; 95 per cent of grains contain starch; protein present.

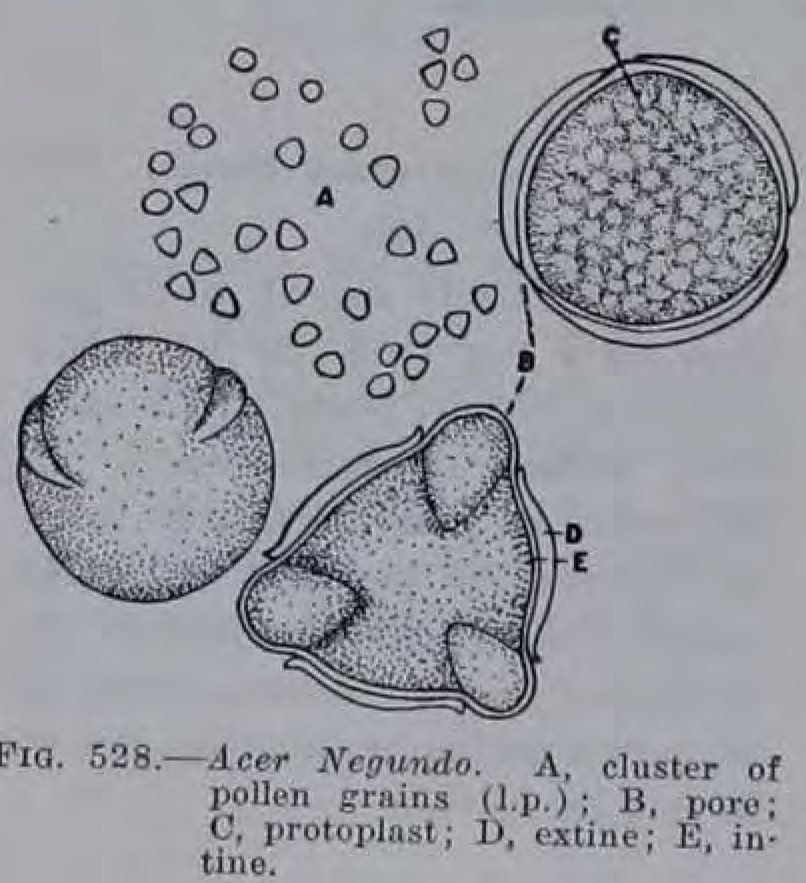

FIG. 528.—*Acer Negundo*. A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

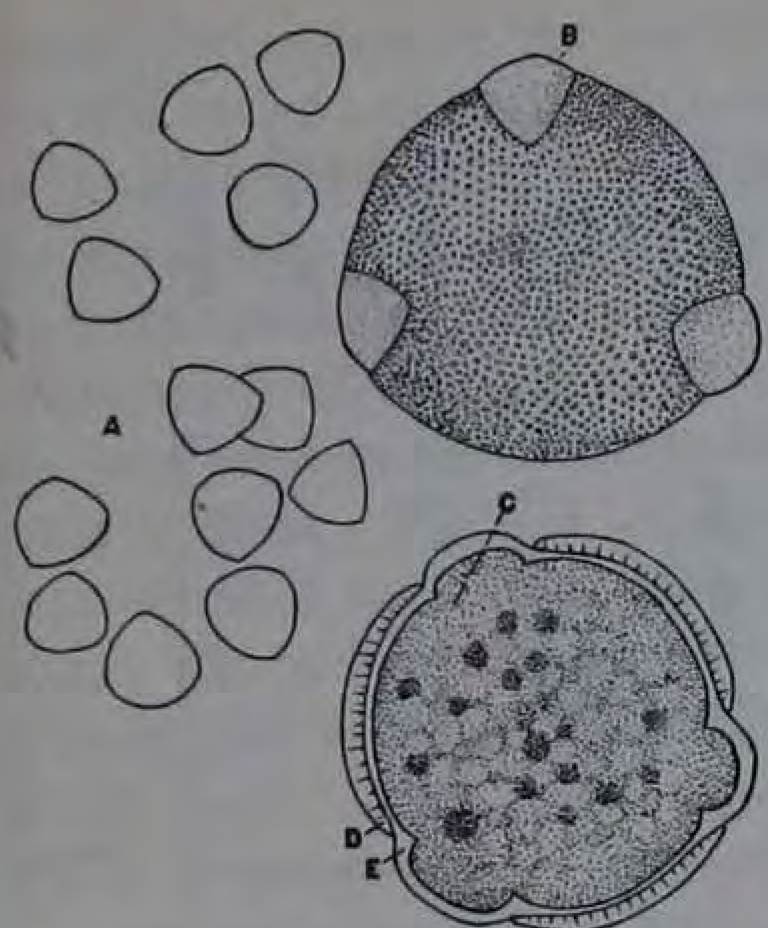

FIG. 529.—*Acer nigrum.* A, cluster of pollen grains (l.p.); B, pore; C, protoplast; D, extine; E, intine.

Acer saccharum var. *nigrum* (Michx. f.) Britton. Black Maple

Shape subspherical; size 37 to 54 mu; pores 3; surface of extine smooth; starch present in 95 per cent of grains; protein present.

DISCUSSION

Of the trees considered, only those of the willows and of the hard maple appear to be visited by bees. Not only the pollen but also the nectar is collected. All of these trees have abundant pollen, which is distributed by the wind.

Scheppegrell points out that the shape, size and nature of the surface of pollen grains have a bearing on their causal relationship to hay fever and asthma. Among the smallest of pollens which have a causal relation to hay fever is that of ragweed, measuring 15 mu in diameter, and that of corn, measuring 80 mu in diameter. By the application of Stoke's law the velocities and rates of fall of pollen of various diameters may be calculated. This knowledge, compared with the amount of pollen produced and the abundance of the plant in question, will give some idea of which plants might be expected to figure as possible stimuli of hay fever, provided that their pollen protoplasts cause a positive reaction.

It will be noted by the data included in our table that there is not great variation in the size of the pollen grains examined. Compared with other lists of pollen measurements they range as average in size. They are practically smooth and approximately spherical in shape, which characters facilitate their distribution by wind. According to tests made by Scheppegrell with the anemophilometer for testing the rate of travel of pollen, it has been shown, for ex-

Name of Plant	Reserve	Food			Structure			
	Starch*	Sugar	Protein	Fat	Size in microns	Shape	Pores	Surface
SALICACEAE								
Salix interior	10 grs.	Trace	Present	....	21-25	Subspherical	3	Reticulate ridged
Salix rostrata	10 grs.	....	Present	....	19-27	Oval subspherical	3	Reticulate ridged
Populus deltoides	95 grs.	....	Present	....	28-38	Biscuit	One large, many fine	Slightly tuberculate
BETULACEAE								
Betula papyrifera	95 grs.	....	....	....	20-40	Subspherical	3 to 4 rarely 5	Smooth
Betula alba	95 grs.	....	....	....	28-34	Subspherical	3 to 4	Smooth
Ostrya virginiana	95 grs.	....	....	....	25-33	Triangular	3	Smooth
URTICACEAE								
Ulmus fulva	80 grs.	Dextrin Disacch. trace	Present	....	27-35	Subspherical	4 to 5 with lids	Smooth
Ulmus americana	95 grs.	....	Present	....	27-40	Subspherical	4 to 5 with lids	Smooth
Celtis occidentalis	95 grs.	....	Present	....	30-33	Subspherical	3	Smooth
OLEACEAE								
Fraxinus americana	95 grs.	....	Present	....	20-36	Biscuit	4 to 5	Smooth
F. pennsylvanica	95 grs.	....	Present	....	20-32	Biscuit	4 to 5 rarely 6	Smooth
F. pennsylvanica var. lanceolata	95 grs.	....	Present	....	20-32	Biscuit	3 to 4 to 5	Smooth
F. nigra	95 grs.	....	Present	....	24-36	Biscuit	Usually	Smooth
ACERACEAE								
Acer Negundo	90 grs.	....	Present	....	26-37	Subspherical	3	Smooth
Acer saccharum var. nigrum	90 grs.	....	Present	....	37-54	Subspherical	3	Smooth

* In per cent of the grains studied.

ample, that pollen of the common ragweed having a diameter of 15 mu will travel one-half mile under the same wind velocity at which corn pollen with a diameter of 80 mu will travel only 43 feet. Since the ragweed pollen is small and the plants are abundant, it becomes a greater problem than pollens which are larger and abundant.

The study of the form and the structural features of pollen grains has been used in the identification of source plants of honeys which contain them. Phillips, however, points out that this is not yet demonstrated as a dependable method, for bees are able to obtain nectar from some flowers without coming in contact with the anthers and, hence, such nectar may not contain the pollen grains of this plant. Also, in extraction of honey, there is danger of pollen grains from species of plants blooming at different seasons of the year entering the honey during extraction. Whether there is any mixing in comb honey has not been determined.

The chemical composition and structure of the pollen protoplasts and of their cell walls makes their behavior, when subject to various media or reagents in nature or in the laboratory, of common interest in its application to hay fever phenomena and to the subject of pollen as food for bees, as well as to the behavior of the pollen grain in germination under various combinations of environmental stimuli, such as temperature, presence of moisture, or chemical reagents which involve similar principles. In other words, the protoplast of the pollen grain is inactive both with reference to its capability of acting as an irritant in producing hay fever and in its availability as food for bees as long as it is confined within its walls. The protoplast may be freed from its detaining wall (1) by normal germination, (2) by bursting of the wall due to swelling and expansion when exposed to moisture secretions (nasal) or reagents, and (3) by mechanical injury. It has been noted by Phillips that in addition to the empty (digested) pollen grains found in the digestive tracts of bees some were undigested, the coats not having been penetrated by digestive agents.

SUMMARY

All of the 15 species of vernal flowering trees studied contained starch in abundance. The willows had the least, only about 10 per cent of the grains containing starch. In the other 13 species starch was prominent in 80 to 95 per cent of the grains. No fats were present. Sugar was noted in *Salix longifolia* and in *Ulmus fulva.*

Protein was observed in all of the species except those of the birch family.

In shape the grains were nearly all subspherical when examined in water. The surfaces of all were smooth except those of the willow family, which had a slightly tuberculate surface.

The four species of ash had a few pollen grains which germinated before the anthers were open.

None of these pollens burst when immersed in water, which might imply either that the osmotic pressure was low or that the walls were with difficulty permeable.

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STRUCTURE AND CONTENT OF SOME POLLEN GRAINS

ADA HAYDEN

Pollens have been studied since the advent of the microscope more or less intensively from several angles: (1) morphology, (2) chemistry, (3) physiology and (4) biotic relationships. These aspects are intimately associated. In application they assist in the verification of genealogical relationships of seed plants, have a bearing on germination of the pollen grain in relation to seed production, and shed light on the role of the pollen grain in hay fever and as a source of bee food.

THE MORPHOLOGY OF THE POLLEN GRAIN

The combination of features by which pollen grains of different plants may be recognized are:

(1) *Size.* This is variable, dependent on the humidity of the atmosphere and in various media, and therefore not dependable. Moreover, polymorphism in certain plants complicates this factor.

(2) *Shape.* The principal types are

- (1) Simple
  - Spherical
  - Ellipsoidal
  - Cylindrical
  - Polyhedral
- (2) Tetrads
- (3) Pollinia—masses of cohering grains.

(3) *Surface markings.* These include sculpturing such as may be described by the terms reticulate, echinate, punctate, papillose, pitted, verrucose, or granulate in contrast with smooth surfaces.

Ridges which assume some geometric design.

Grooves which constitute depressed areas running longitudinally toward poles. These areas frequently differ in composition from the remainder of the wall, allowing for expansion when the grain swells on absorption of moisture. The depressed ridge or furrow when in contact with water stretches, becoming convex instead of concave. This swelling accommodates the absorption of considerable water without the rupture of the wall.

(4) *Pores.* Germ pores differ in number, the Monocotyledons, according to Von Mohl, Biourge and others, containing few pores or only one. Dicotyledons have a larger number of pores, this number being more or less constant in the species, genus or sometimes throughout the family. These pores differ in size and presence or absence of sculpture. Both extine and intine may be sculptured at the pores. In some cases the extine appears to constitute only a thin layer at the pores and this, when the extine swells, bursts, shedding the extine covering the pore, which breaks off as a lid. Sometimes the extine has no covering at the pores and not infrequently bears papillae or some other form of sculpture.

(5) *The wall* is generally recognized as composed of two layers, extine and intine, both of which may show composite lamellae. The sculpturing appears generally on the extine, though it sometimes occurs around the lidless pores of some species. The term perine is sometimes applied to the sculpturing on the extine.

APPLICATIONS OF POLLEN STUDY

Morphological features of pollen grains are valuable in correlating genealogical relationships, though with these, as in the case of other morphological indices, are many missing links. This status has been suggested by the works of Smith, Von Mohl, Kerner and Oliver, Biourge, Pope and others.

In the preceding paper reference has been made to the use of the pollen grain as a source of identification of honey plants. However, this is not a dependable method. The chemical composition and the structure of the pollen grains is important in connection with hay fever phenomena because various types of hay fever antitoxins come from different hay-fever-producing plants. The toxins are produced within the pollen grains and are not injurious unless the wall is broken.

The ability of the protoplast to serve as food or to act as an irritant in another environment depends:

1. On the composition of the protoplast and its manner of distribution (pollination).

2. And, regardless of its composition, on the reaction of its walls or parts thereof to the surrounding media.

Reserve foods of the pollen protoplast in relation to their uses.—The protoplasts of pollen have been shown to contain in addition to the cytoplasmic network of protein reaction, reserve foods such as protein, starch, oil and sometimes sugars which serve in nutritive capacity.

Biotic relationships—The role of pollen in hay fever.—Although some form of protein is the alleged irritant in hay fever, it has not been shown that these which contain reserve protein are more active in this connection than those which store other forms of reserve food. While all pollen grains show a protein reaction of protoplasm when tested microchemically, few appear to have irritant qualities. Relatively few plants are wind pollinated, the majority being pollinated by insects. Since entomophilous plants have viscid or heavy pollen, which seldom is carried far by the wind, insect pollinated plants are not effective in producing hay fever except by direct contact. It has been shown by experiments of Kessler and Durham, Moore and LaGarde that the pollen which is abroad in the air is almost exclusively that of wind pollinated plants.

Pollen as bee food.—Proteins and vitamines are particularly essential for the intensive feeding and growth of bee larvae. This food is supplied by pollen grains, which according to different analyses have been reported as high as 64 per cent in proteins. Fat and starch are, according to Phillips, indigestible by bees. In accounting for the food materials in pollen grains the transforming activity of enzymes must be considered, hence the content of pollen in an unopened anther may be different from that of a dehiscing anther and the germinating pollen grain may also have made transformations of its food materials. Paton in 1921 examined 18 pollens and identified 13 different enzymes.

Normal germination.—Hansgirg and Lidfors germinated pollen of many species in tap water or moist air. Rittenhaus has shown that pollen of many species will germinate in cane sugar solutions. Other workers have stimulated germination by the addition of weak acids or salts to their media. Martin in his studies on *Trifolium pratense, Trifolium hybridum* and *Trifolium repens* shows that the only function of the sugar solution in the case of the pollen of *T. hybridum* is the control of the water supply, and the germination of the pollen of *T. pratense* is delicately adjusted to water absorption. In these three species the nature of the pollen demands no other function of the stigma in its germination than the control of the water supply.

Whether or not a pollen grain bursts when subject to immersion in water appears to be a question of the composition and permeability of its walls and its protoplast.

Composition of the extine and intine.—According to the researches of Von Mohl, the intine is a lamellate structure of pure cellulose or of pectin and of cellulose or a mixture of both. It is cutinized where the cellulose is thin or absent about the pores. The extine is a lamellate structure usually of cellulose composition, generally cutinized on the exterior with sometimes a pectose inner lamella. Callose is also found in the pores and in the grooves. Beer finds similar composition, though he does not mention callose.

It is obvious that the penetrability of these membranes to certain media in some measure determines the great difference in behavior of grains of various structure and composition. Many empty (digested grains) are found in the rectal region of bees. It is noted by Phillips, however, that some of these are undigested, the coats not having been penetrated.

METHODS

With the intention of investigating pollens of plants contributing pollen or nectar to bees, most of these observations were made during July and August, 1922. Fresh materials were secured and branches of the plants were kept in the laboratory at room temperature. The pollen tested was taken from anthers ready to dehisce. The grains were examined, mounted in honey, in water, and in the media used for testing the content. (See tests.) No record was kept of the reaction of the walls.

It was the intention to make records of the pollen grains as they appear in honey, but because the grains were transparent in this medium it was not possible to adequately study their structure in honey medium alone. When placed in honey they contract first and then expand to approximately normal shape. When immersed in water the grains immediately swell. While in honey they do not expand much, yet the concentration of honey is variable and hence one would expect variation in size with the concentration of the honey. Hoffman, in his article in this volume shows that measurements made in fresh honey differ from measurements which Parker made from pollen grains which had been standing in honey. The pollen grains here examined were measured immediately after mounting in water. Pollen grains mounted in honey retain their characteristic appearance after six years, recent observation shows.

The size factor is, however, not accurate, for the pollen grain might be expected to vary in relation to its surrounding medium.

The pollen grain differs considerably in appearance in different media. The ellipsoidal grains show depressed sutures when dry and usually swell in water to a subspherical state, the sutures then becoming expanded. The extine and intine are not readily differentiated unless treated chemically. The concentrated NaOH or the KOH of the Biuret test usually differentiated these layers and showed the sculpture clearly. Pore lids were in some cases seen, though the reagents mentioned were not adequate to determine definitely the presence of lids.

In the summer of 1928 these pollen grains were again studied with the application of acid nigrosin, which is recommended by Moore and LaGarde for the differentiation of lids. The solution used in this case, however, was a water solution of acid nigrosin substituted for the described alcohol solution of nigrosin. This gave apparently the same reaction which Moore and LaGarde describe. The stain penetrates the protoplasm. This dye does not penetrate the lids of the pores, which retain it, becoming bluish black in color.

Microchemical Tests

The following tests were made with the object of determining what food materials the pollen grains contained when ready for pollination. The results are recorded in tabular form for the species tested. Duplicate tests were made in each case.

SUGARS

Flückinger's reaction.—A small piece of copper tartrate (as large as shot) is mixed on a slide with 20 per cent NaOH. The material to be tested (fresh pollen grains) is put into this mixture of copper tartrate and NaOH. Tests were made (1) in cold solution and (2) by heating the amount over a flame. Such monosaccharids as glucose (in cold), fructose (slightly heated) and dextrin (longer heating) will produce a reddish precipitate when they are added to a solution of copper compound such as $CuSO_4$.

Phenylhydrazine ($C_6H_5NH\text{-}NH_2$).—Test for ozozone, crystal formation.—Solutions used: A. One gram of phenylhydrazine hydrochloride dissolved in 10 c.c. of glycerine was filtered and kept in a brown bottle. B. One gram of sodium acetate was mixed with 10 c.c. of glycerine and placed in a brown bottle.

Procedure: A drop of each solution was mixed together on a slide, then pollen grains were placed in this mixture. One set was heated for 40 minutes on a water bath and cooled. The formation of crystals indicates fructose. The other set was left at room temperature over night. The formation of crystals now indicates the presence of sucrose.

STARCH

IKI reaction (0.3 g. I, 1.5 g. KI, 100 c.c. H_2O).— Starch grains turn blue.

PROTEIN

IKI reaction.—Turns protein yellow.

Eosin.—Put material to be tested in a very dilute solution of eosin for 10 minutes, then clear in glycerine. Protein stains red.

Biuret reaction.—Place material to be tested in a 5 per cent solution of $CuSO_4$; after 30 minutes wash thoroughly with water and put on a slide in a drop of concentrated (50 per cent) KOH or NaOH. Protein gives a red to blue or violet color.

FATS

Sudan III.—Place material to be tested on a slide in a solution of Sudan III (1 g. Sudan III; 200 c.c. 70 per cent alcohol). After twenty minutes wash carefully with 50 per cent alcohol. All fatty substances stain red. The fats appear as red globules.

PORE LIDS

Acid nigrosin.—To 100 c.c. of a 2 per cent acetic acid solution was added 5 c.c. of a saturated and filtered solution of water soluble nigrosin. Shake thoroughly.

Note.—The solution prescribed by Moore and LaGarde in their studies is made by adding 100 c.c. of a 2 per cent acetic acid solution to 5 c.c. of a saturated and filtered alcoholic (ethyl) solution of nigrosin (Gruebler).

Procedure: A small drop of the acid nigrosin was added to the water mount of pollen grains.

LEGEND FOR FIGURES USED IN THIS ARTICLE

The enlarged drawings of the surface show sutures and the sculpture of the extine and the intine, and the detail of the pores as they appeared in different mounting media used for making tests of food content. The optical sections show the granular appearance of the protoplast. Drawings were made by A. Hayden.

A—group of pollen grains showing relative size; B—pore; C—protoplast; D—extine; E—intine; F—lid of pore.

DESCRIPTION OF POLLEN GRAINS

FAMILY URTICACEAE

Cannabis sativa L. Hemp

Shape, spherical; size 20 to 32 mu; pores 3, with small lids surrounded by cornea-like protuberances; surface of wall smooth, extine and intine not readily distinguishable; protoplasm finely granular, including large vacuoles, starch grains conspicuous. Wind pollinated.

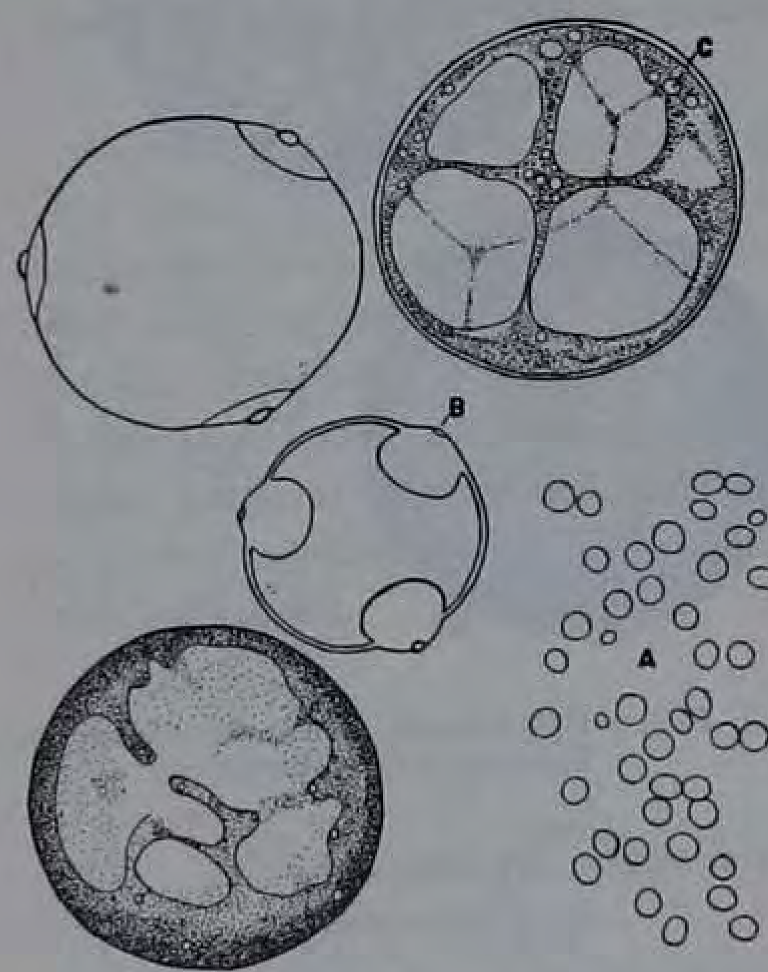

FIG. 530.—*Cannabis sativa* L. Hemp.

FAMILY POLYGONACEAE

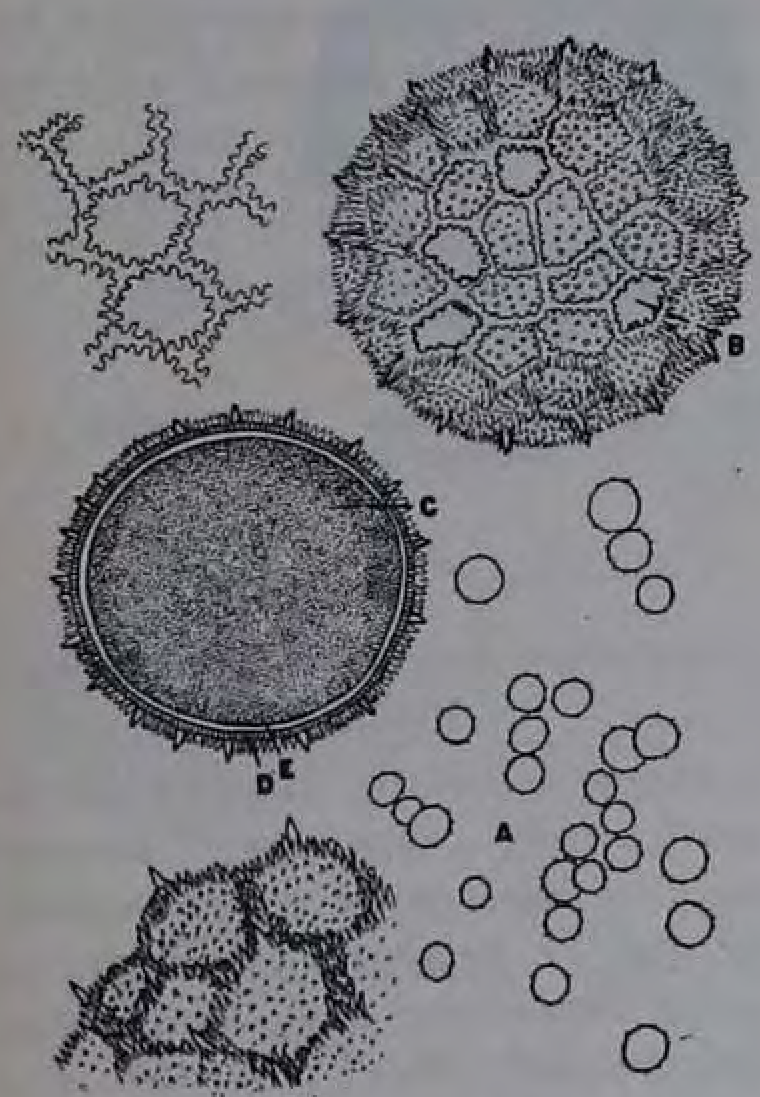

FIG. 531.—*Polygonum Persicaria* L. Lady's thumb.

Polygonum Persicaria L. Lady's Thumb

Shape spherical; size 44 to 56 mu; pores numerous, 15 or more, without lids; surface papillose, extine conspicuously sculptured by reticulate papillose ridges; at the juncture of ridges is a single large spine; fine pits present; protoplasm finely granular. Insect pollinated.

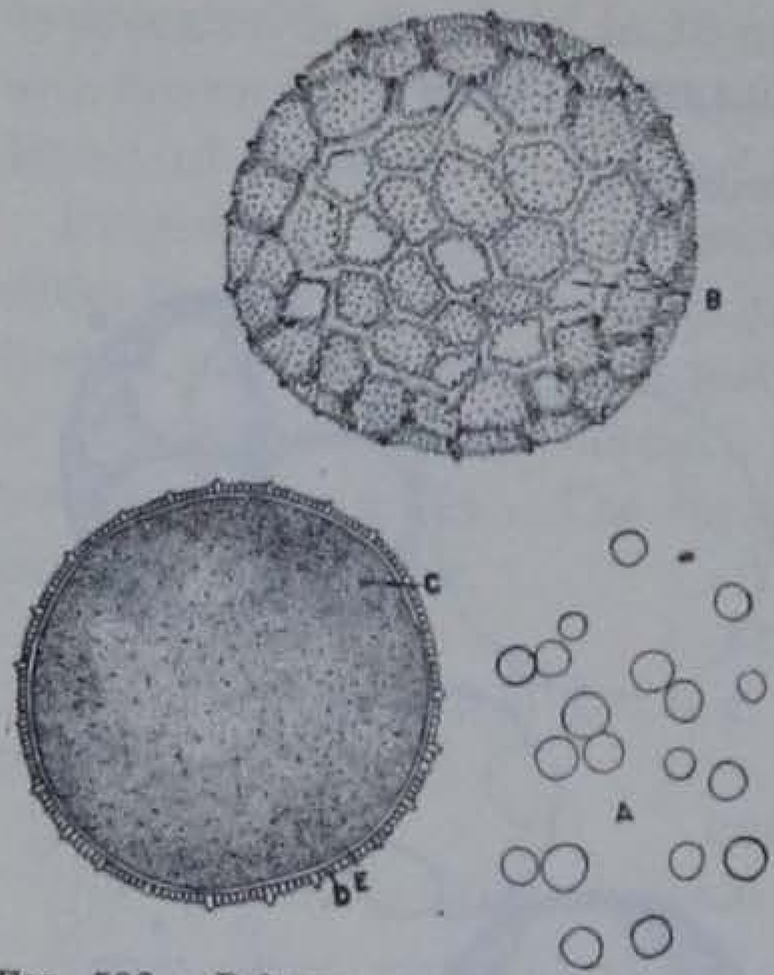

FIG. 532.—*Polygonum pennsylvanicum* L. Pennsylvania smartweed.

Polygonum lapathifolium L. Nodding Smartweed

Shape spherical; size 36 to 44 mu; pores numerous, lidless, 15 or more; surface smooth; surface of extine like previously described species, though the walls are thinner and the papillose character is not so pronounced. Insect pollinated.

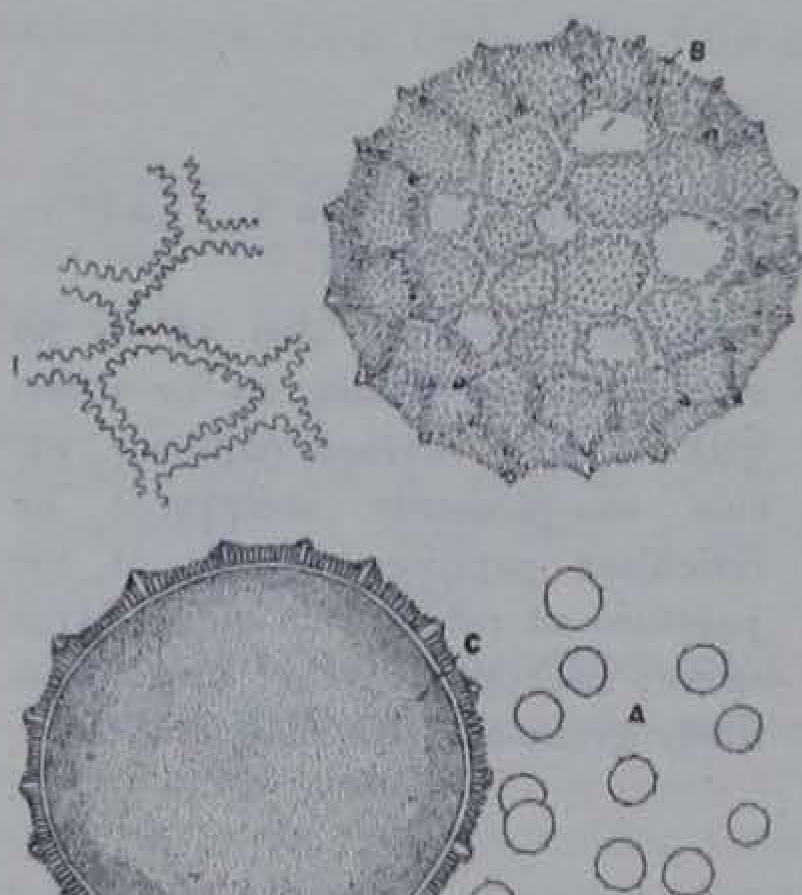

FIG. 534.—*Polygonum orientale* L. Prince's feather.

Polygonum pennsylvanicum L. Pennsylvania Smartweed or Knotweed

Shape spherical; size 56 to 72 mu; pores large, numerous, 15 or more, lidless; appearance of extine much as in *P. Persicaria*; wall pitted and papillate-spinose; protoplasm finely granular. Insect pollinated.

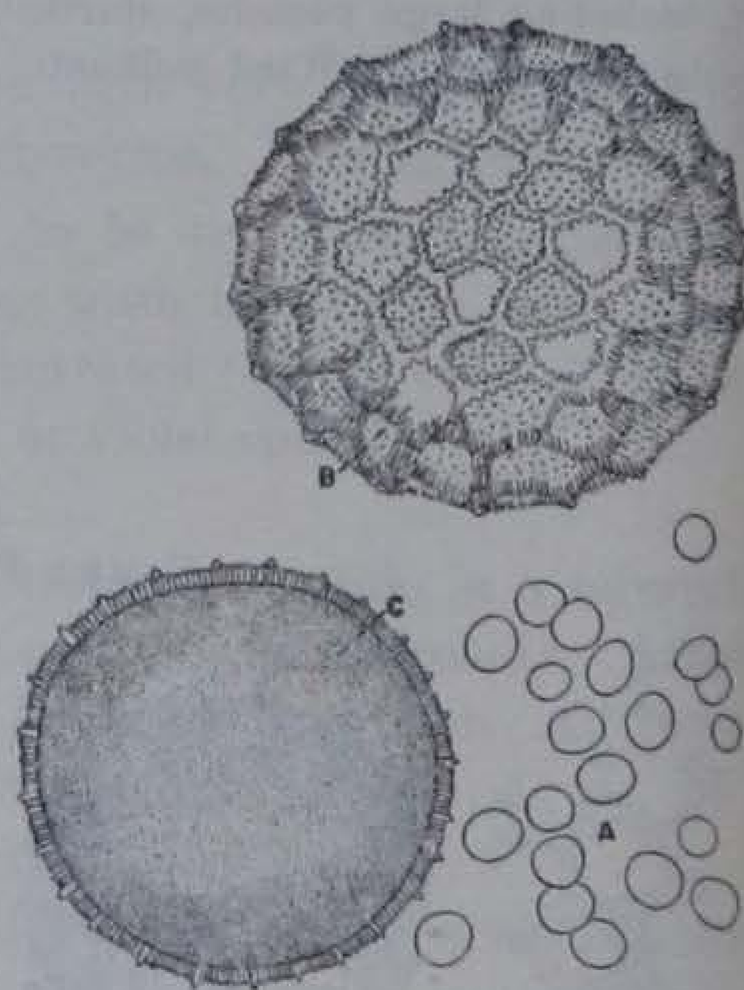

FIG. 533.—*Polygonum lapathifolium* L. Nodding smartweed.

Polygonum orientale L. Prince's Feather

Shape spherical; size 48 to 68 mu; pores numerous; surface smooth; surface of extine similar to that of *Polygonum pennsylvanicum*; intine very thin, hardly distinguishable. Insect pollinated.

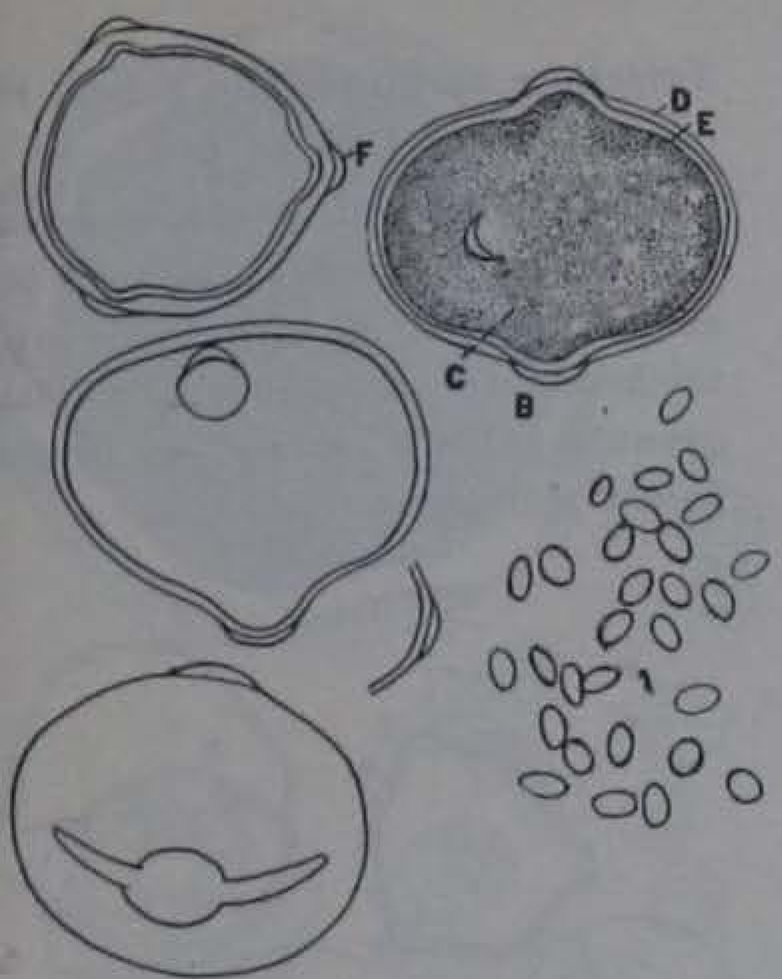

FIG. 535.—*Melilotus alba* Desr. White sweet clover.

FAMILY LEGUMINOSAE

Melilotus alba Desr. White Sweet Clover

Shape ellipsoidal; size 32 to 36 mu; pores 3, with lids. The lid stains purple and swells when treated with acid nigrosin; pore slits stain but the potoplasm beneath does not. Extine and intine are smooth;protoplasm granular with small vacuoles; occasional surface drops of oil. Insect pollinated.

Melilotus officinalis (L.) Lam. Yellow Sweet Clover

Shape subspherical; size 28 to 36 x 24 to 28 mu; pores 3, with lids, pore stains under lid with acid nigrosin; extine and intine smooth; intine hardly differentiated; some oil drops on surface; protoplasm verrucose granular with small vacuoles. Surface oil present. Insect pollinated.

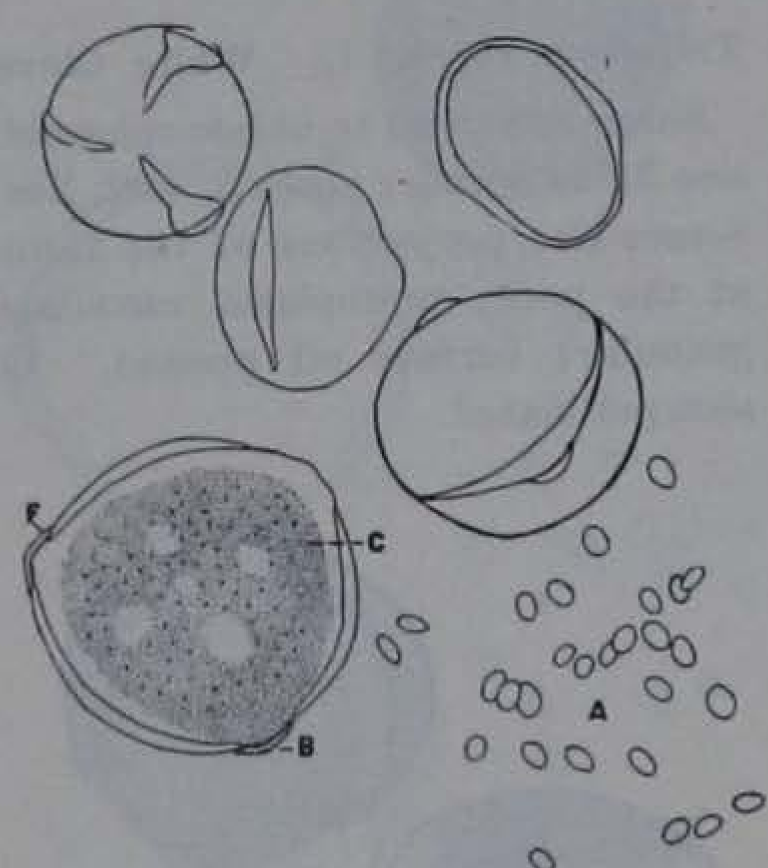

FIG. 536.—*Melilotus officinalis* L. Lam. Yellow sweet clover.

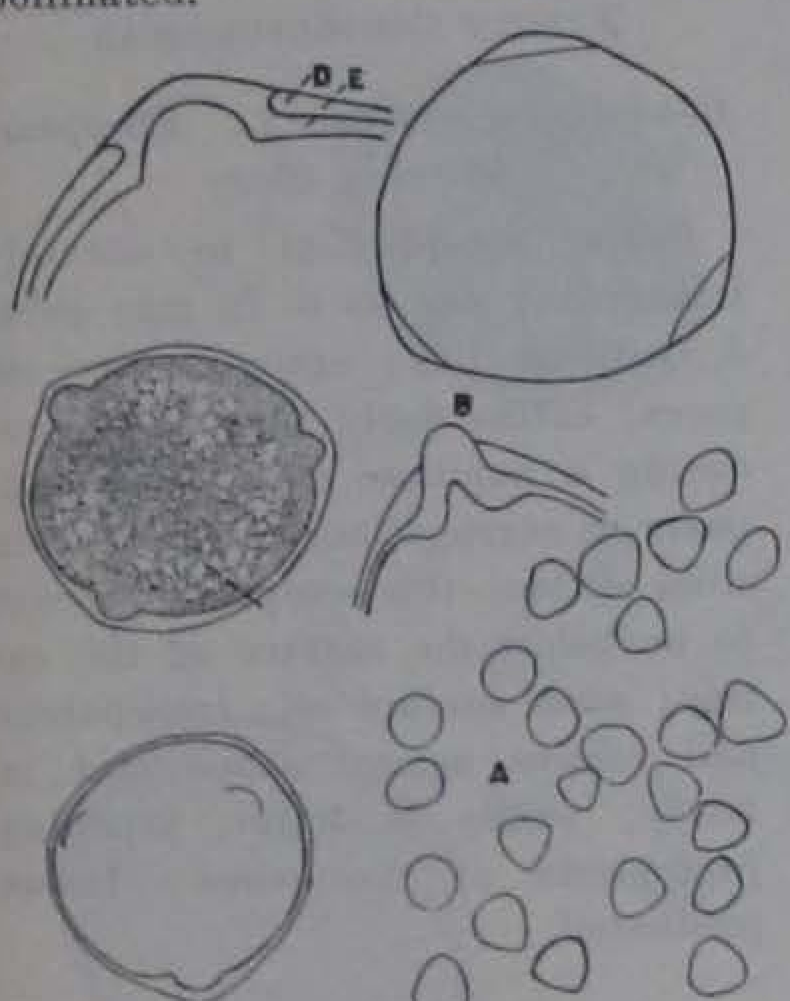

FIG. 537.—*Phaseolus multiflorus* Willd. Scarlet runner bean.

Phaseolus multiflorus Willd. Scarlet Runner Bean

Shape subspherical to triangular; size 64 to 76 mu; pores 3, without lids; wall smooth; extine thickened into a cornea-like structure surrounding the pores; protoplasm verrucose-granular; some surface oil. Insect pollinated.

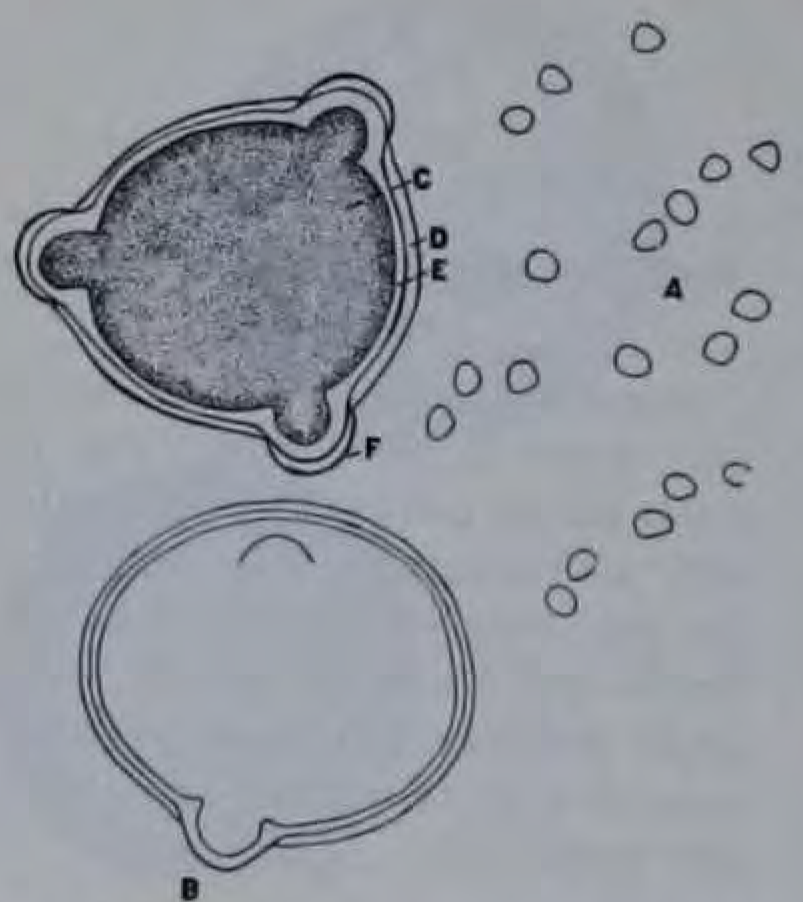

FIG. 538.—*Trifolium agrarium* L. Yellow hop clover.

Trifolium repens L. White Clover

Shape spherical to oblate-spheroid; size 32 to 36 mu; pores 3, with lids; cornea-like projections of the intine at the pore; protoplasm vacuolate-granular; surface oil present. Insect pollinated.

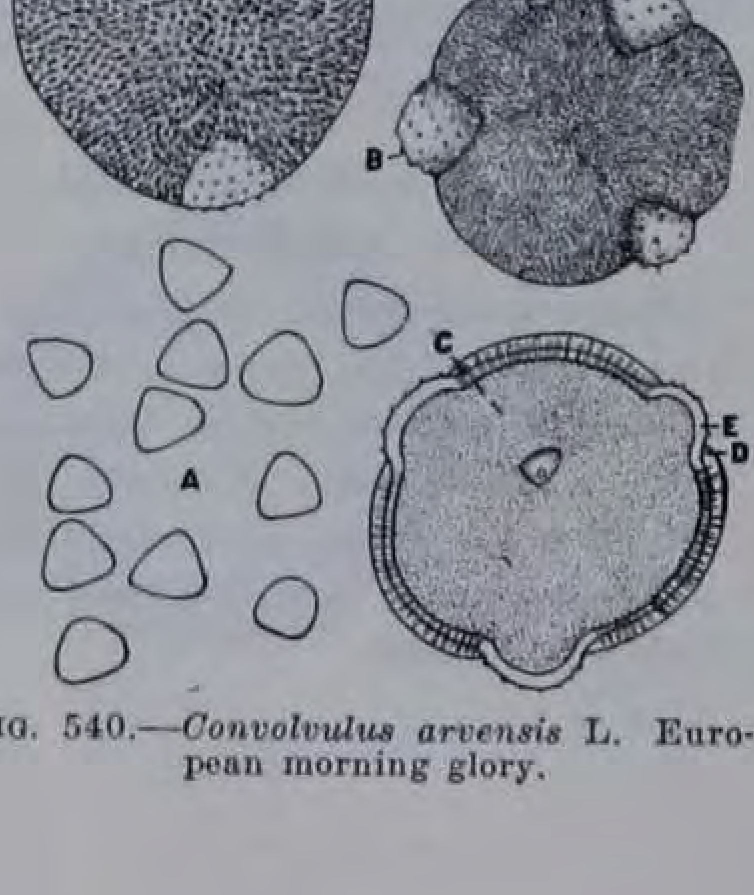

FIG. 540.—*Convolvulus arvensis* L. European morning glory.

Trifolium agrarium L. Yellow Hop Clover

Shape subspherical to triangular; size 40 to 28 x 40 to 24 mu; wall smooth; pores 3, with lids; intine thickened at the pores; protoplasm granular; little surface oil present. Insect pollinated.

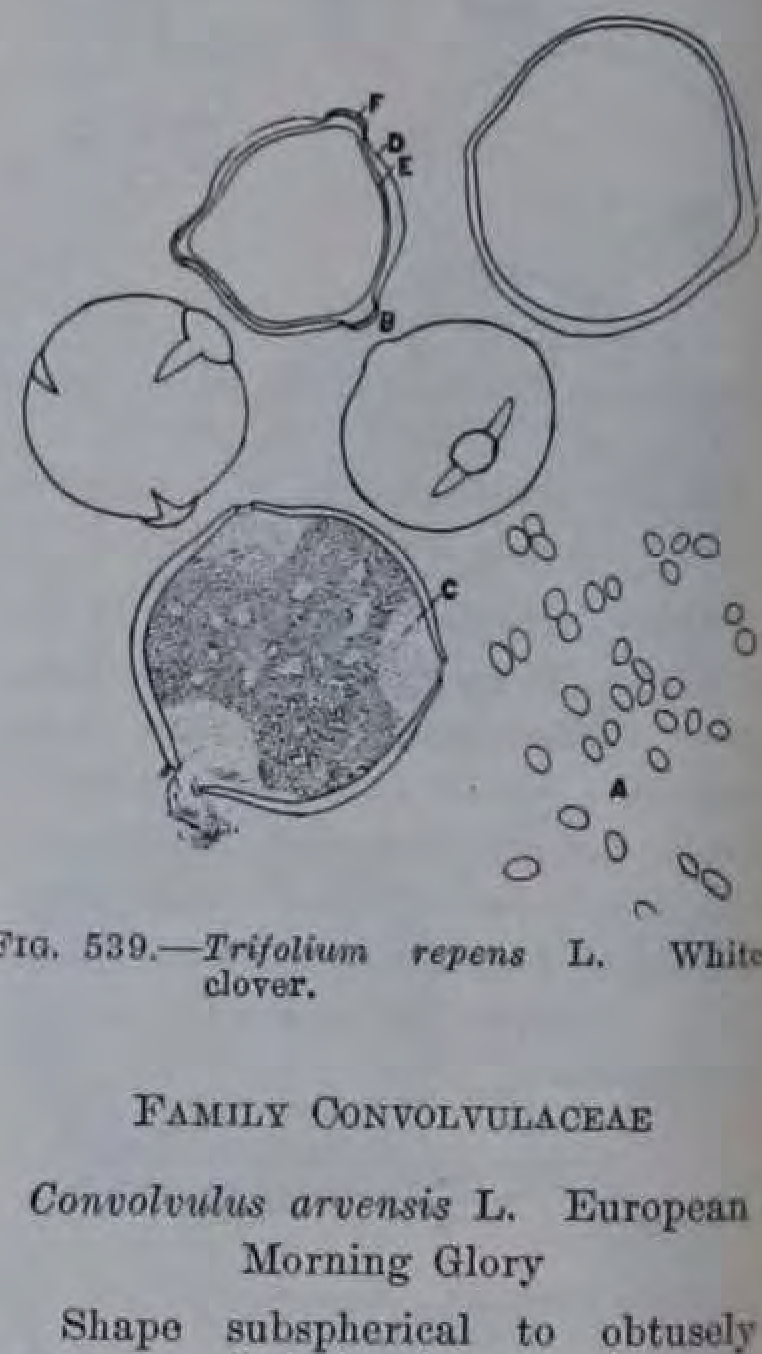

FIG. 539.—*Trifolium repens* L. White clover.

FAMILY CONVOLVULACEAE

Convolvulus arvensis L. European Morning Glory

Shape subspherical to obtusely triangular; size 60 to 73 mu; pores 3, without lids; entine warty—at pores; extine finely tubercular, producing a papillose effect which appears as corrugations in the wall in cross-section—this sculpture appears to be below the surface of the extine; some surface oil; transparent and retains normal shape best in honey; swells in water, expelling protoplasm at the pores. Insect pollinated.

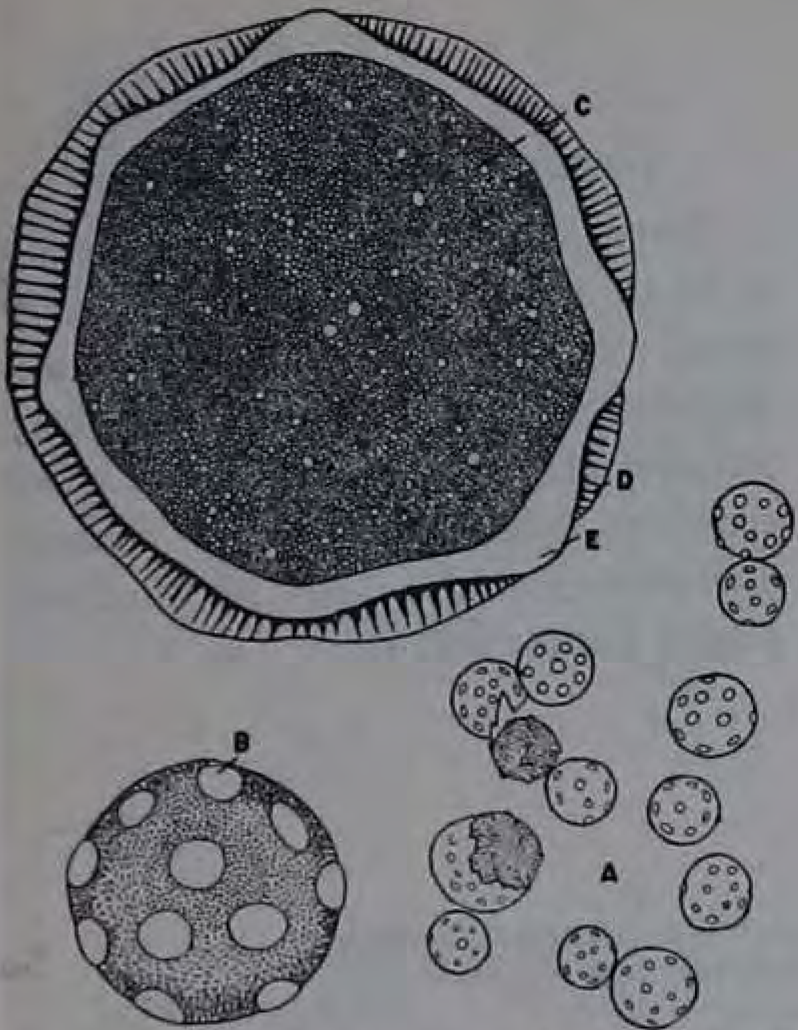

FIG. 541.—*Convolvulus sepium* L. American morning glory.

Mentha arvensis var. *canadensis* (L.) Briquet. Mint

Shape oblate-spheroid, size 44 to 32 x 40 to 24 mu; pores 6, without lids, located in polar sutures; wall of extine slightly papillose, appearing corrugated in cross-section; intine smooth, protoplasm verrucose-granular; some oil on surface. Insect pollinated.

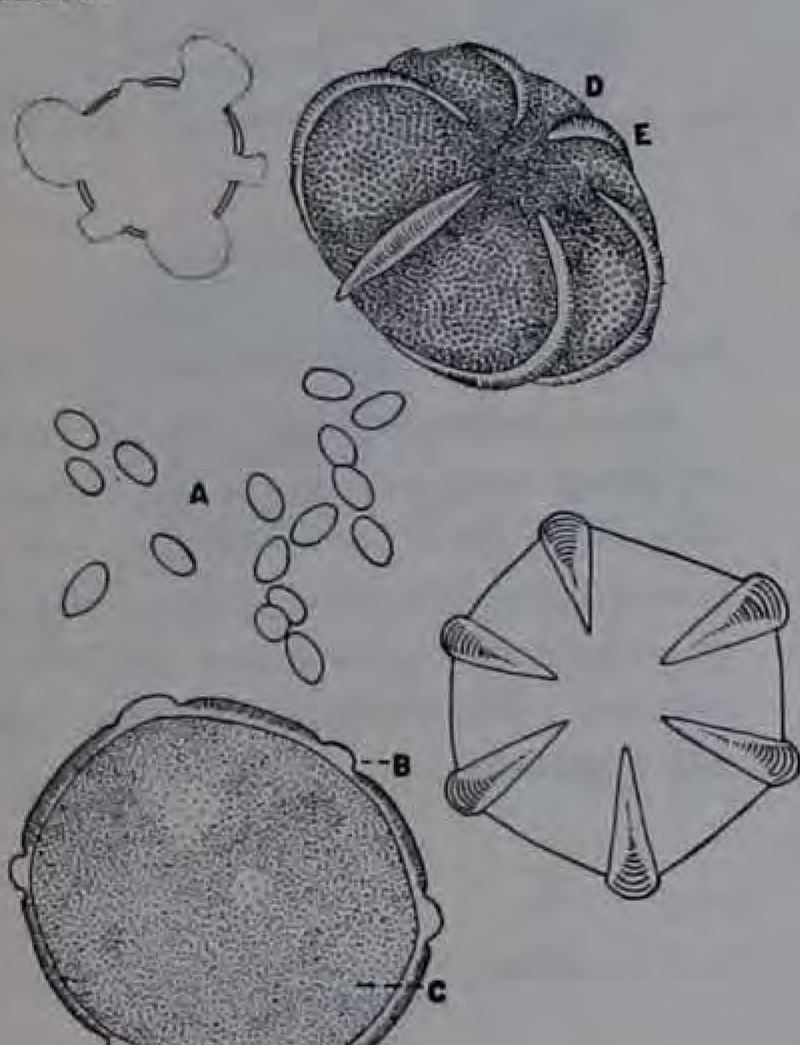

FIG. 543.—*Monarda mollis* L. Horse mint.

Convolvulus sepium L. American Morning Glory

Shape spherical; size 76 to 112 mu; pores 16 to 20, without lids; wall of intine smooth, extine ridged with fine canals which give the smooth surface a tubercular appearance where the canals approach the edge of the extine; surface oil abundant; protoplasm uniformly granular. Insect pollinated.

FAMILY LABIATAE

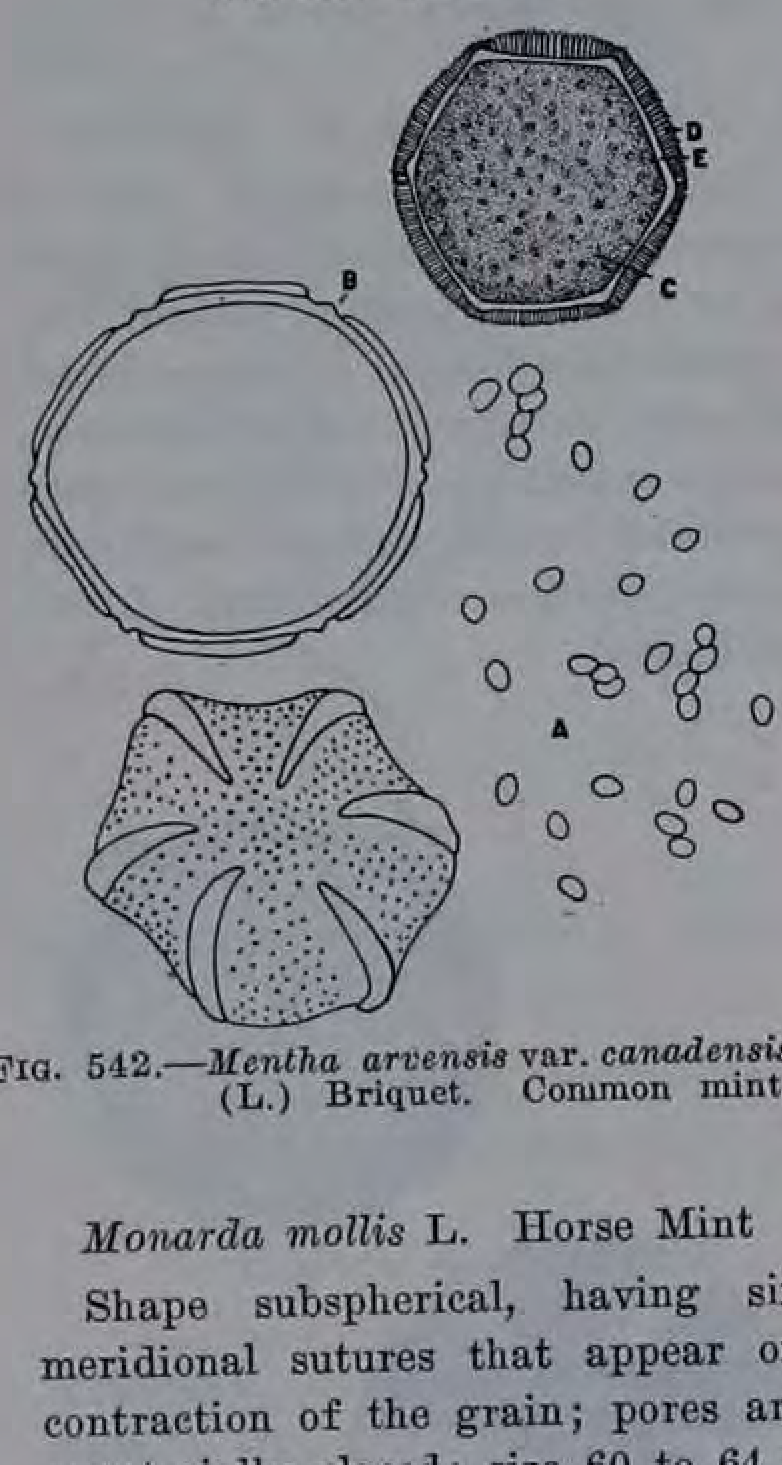

FIG. 542.—*Mentha arvensis* var. *canadensis* (L.) Briquet. Common mint.

Monarda mollis L. Horse Mint

Shape subspherical, having six meridional sutures that appear on contraction of the grain; pores are equatorially placed; size 60 to 64 x 52 to 64 mu; pores 6, lidless; wall of extine slightly roughened, appearing ridged on side view at the pores; extine finely tuberculate; protoplasm granular. Surface oil present. Insect pollinated.

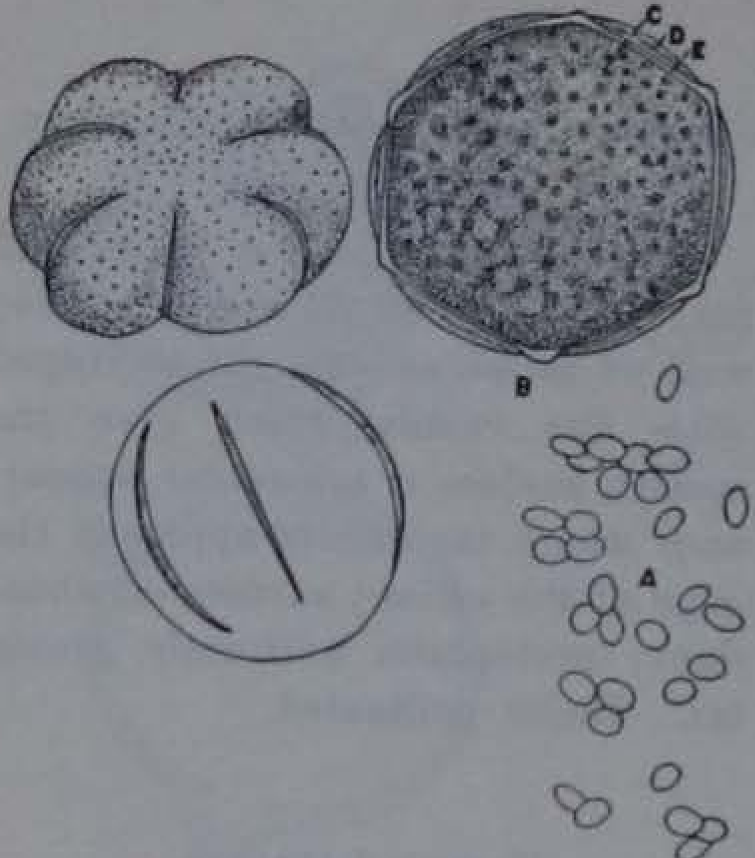

FIG. 544.—*Nepeta Cataria* L. Catnip.

Nepeta Cataria L. Catnip

Shape subspherical; size 40 to 48 x 36 to 40 mu; pores 6, lidless; located equatorially in meridional sutures; intine smooth to slightly roughened; extine finely ridged when seen on edge; protoplasm densely verrucose-granular; oil on surface. Insect pollinated.

Prunella vulgaris L. Self-heal

Shape oblate-spheroid; with 6 polar pointing sutures; size 56 to 48 x 48 to 44 mu; pores 6, without lids, equatorially located in 6 meridional grooves; surface of extine reticulate, intine smooth; protoplasm uniformly granular; pores rupture readily in water; surface oil abundant. Insect pollinated.

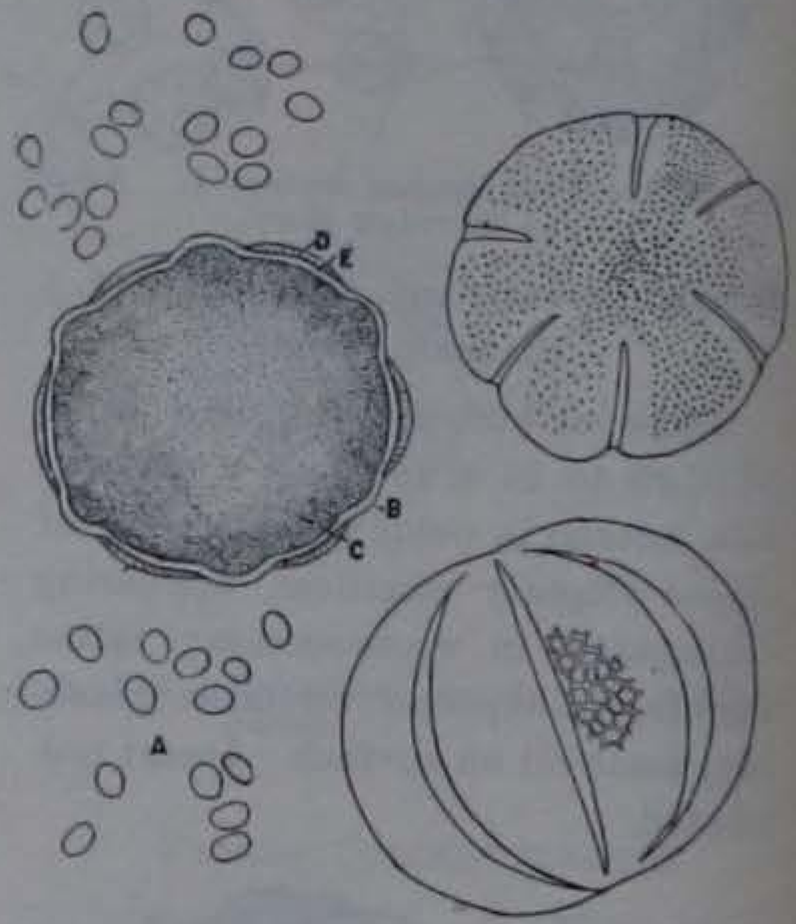

FIG. 545.—*Prunella vulgaris* L. Self-heal.

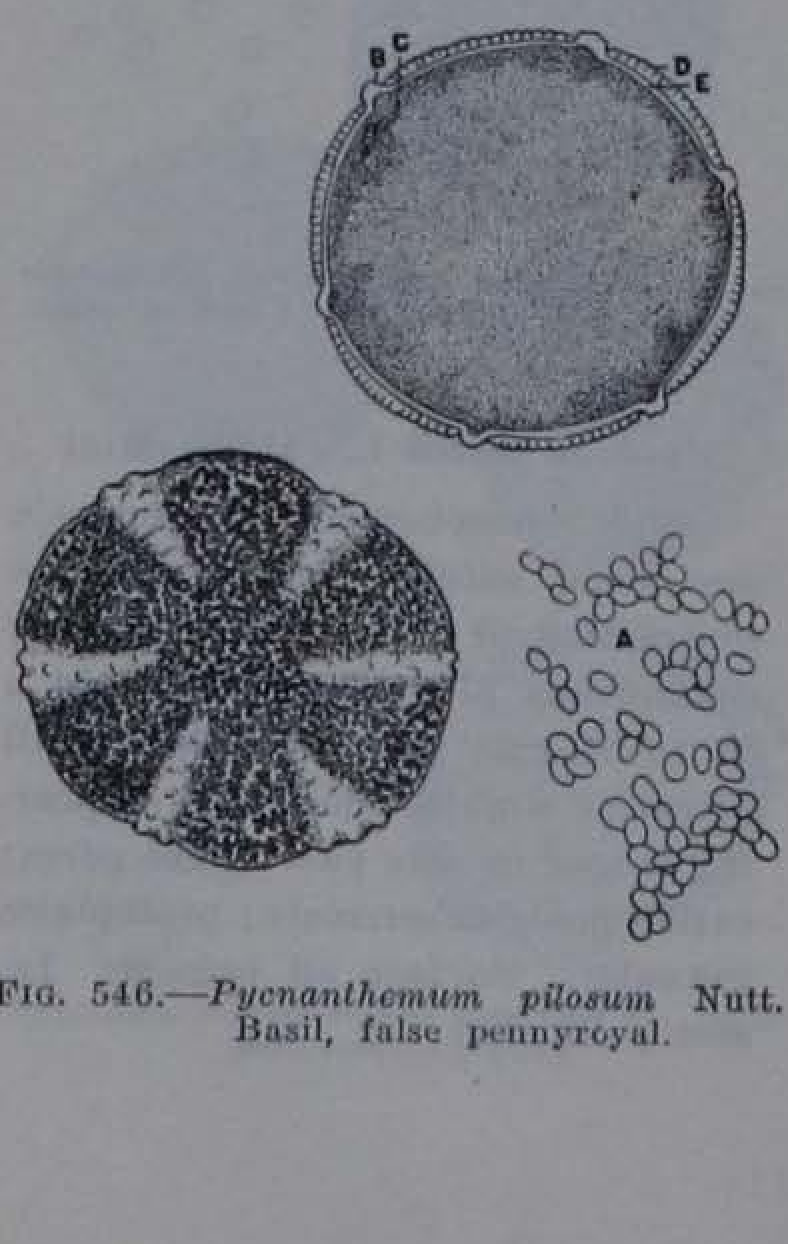

FIG. 546.—*Pycnanthemum pilosum* Nutt. Basil, false pennyroyal.

Pycnanthemum pilosum Nutt. Basil

Shape subspherical with 6 polar pointing sutures; pores 6, lidless; size 40 to 60 x 28 to 44 mu; extine tuberculate, verrucose; intine slightly roughened; protoplasm uniformly granular; oil present on surface. Insect pollinated.

Pycnanthemum virginianum (L.) Durand and Jackson. Basil

Shape subspherical with six pole-ward—extending sutures in which the pores are equatorially located; size 36 to 40 x 28 to 36 mu; pores 6, lidless; extine tuberculate, erose; intine slightly roughened; protoplasm uniformly granular; surface oil present. Insect pollinated.

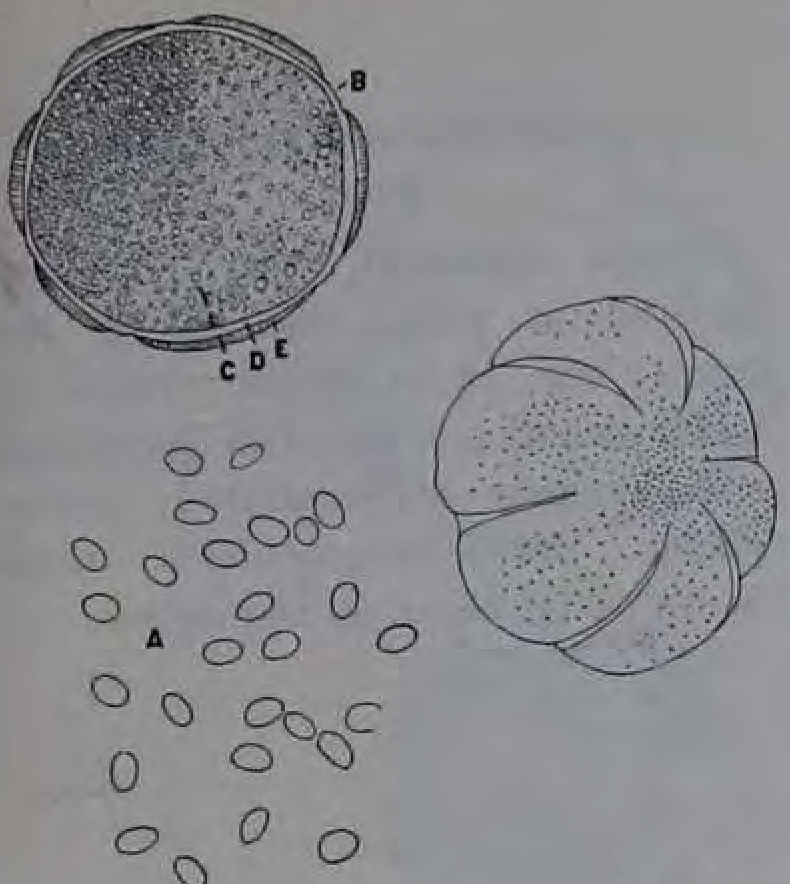

FIG. 547.—*Pycnanthemum virginianum* (L.) Durand and Jackson. Basil.

Teucrium canadense L. American Germander

Shape ellipsoidal, with three furrow-like sutures; when contracted (in honey) pores 3, with lids; size 32 to 36 mu; extine smooth; oil on surface; protoplasm uniformly granular. Insect pollinated.

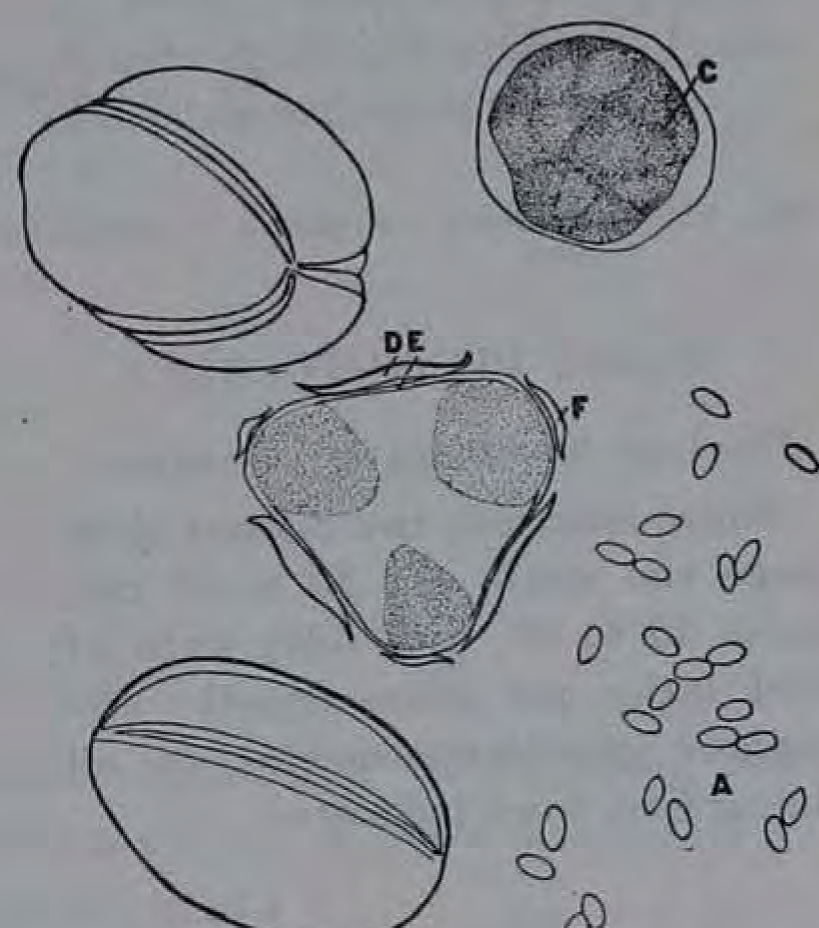

FIG. 548.—*Teucrium canadense* L. American germander.

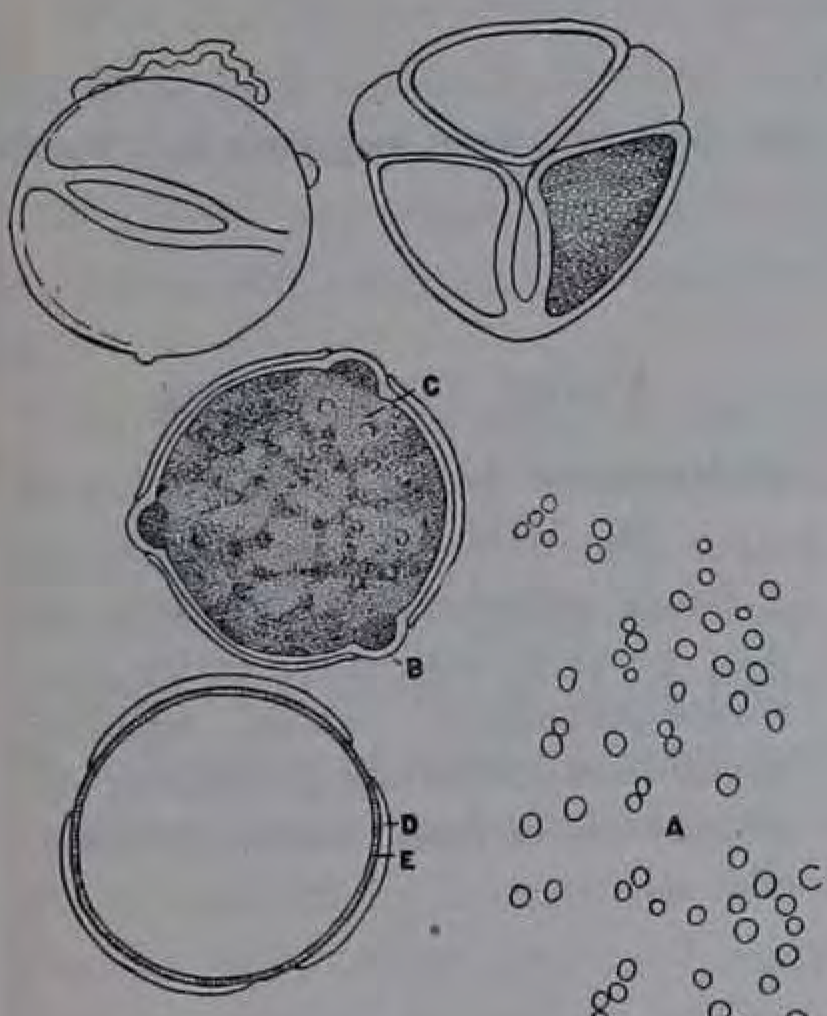

FIG. 549.—*Scrophularia marilandica* L. Figwort.

FAMILY SCROPHULARIACEAE

Scrophularia marilandica L. Figwort

Shape spherical, size 32 to 36 mu; pores 3, lidless, extine smooth, with bandlike ridges extending toward the poles; intine rough tuberculate; protoplasm verrucose-granular; oil globules on surface. Insect pollinated.

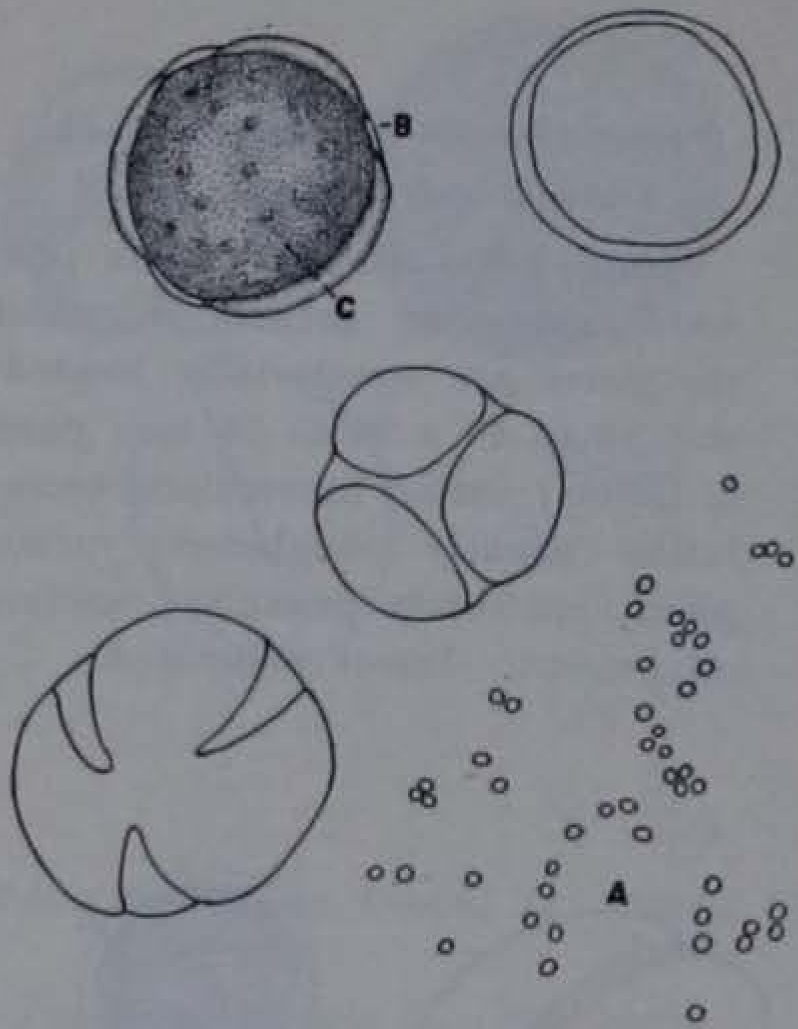

FIG. 550.—*Veronica virginica.* Culver's root.

Veronica virginica L. Culver's Root

Shape spherical, becoming constricted in polar lines along the pores; size 16 to 24 mu; pores 3; walls smooth; extine and intine not conspicuously differentiated; protoplasm verrucose-granular; some drops of oil occur on the extine.

FAMILY PLANTAGINACEAE

Plantago lanceolata L. Buckhorn

Shape spherical, two distinct sizes, large and small, size 20 to 32 mu; pores 15 to 20, with lids; walls of both intine and extine smooth; protoplasm granular-vacuolate; no oil on surface, wind pollinated.

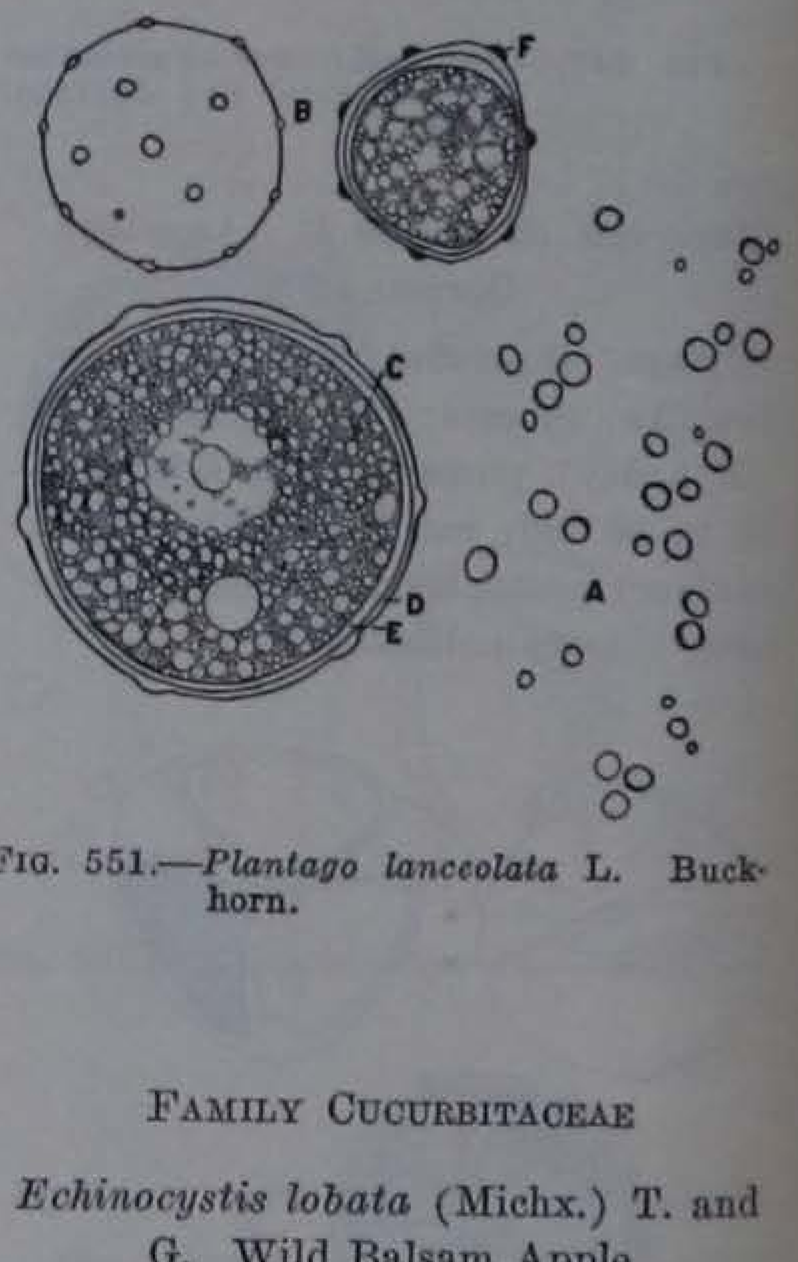

FIG. 551.—*Plantago lanceolata* L. Buckhorn.

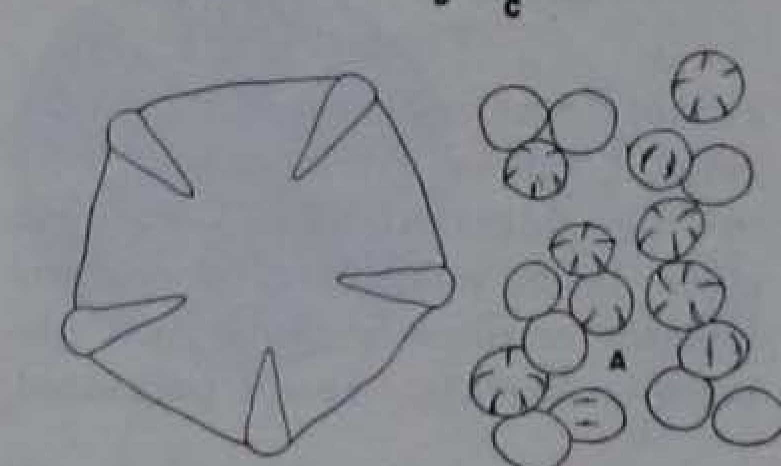

FIG. 551A.—*Echinocystis lobata.* Wild balsam apple.

FAMILY CUCURBITACEAE

Echinocystis lobata (Michx.) T. and G. Wild Balsam Apple

Shape subspherical; size 64 to 88 mu; pores 5, with lids; extine perforate-reticulate; intine smooth; protoplasm uniformly granulate; oil present on surface. Insect pollinated.

FAMILY CAPRIFOLIACEAE

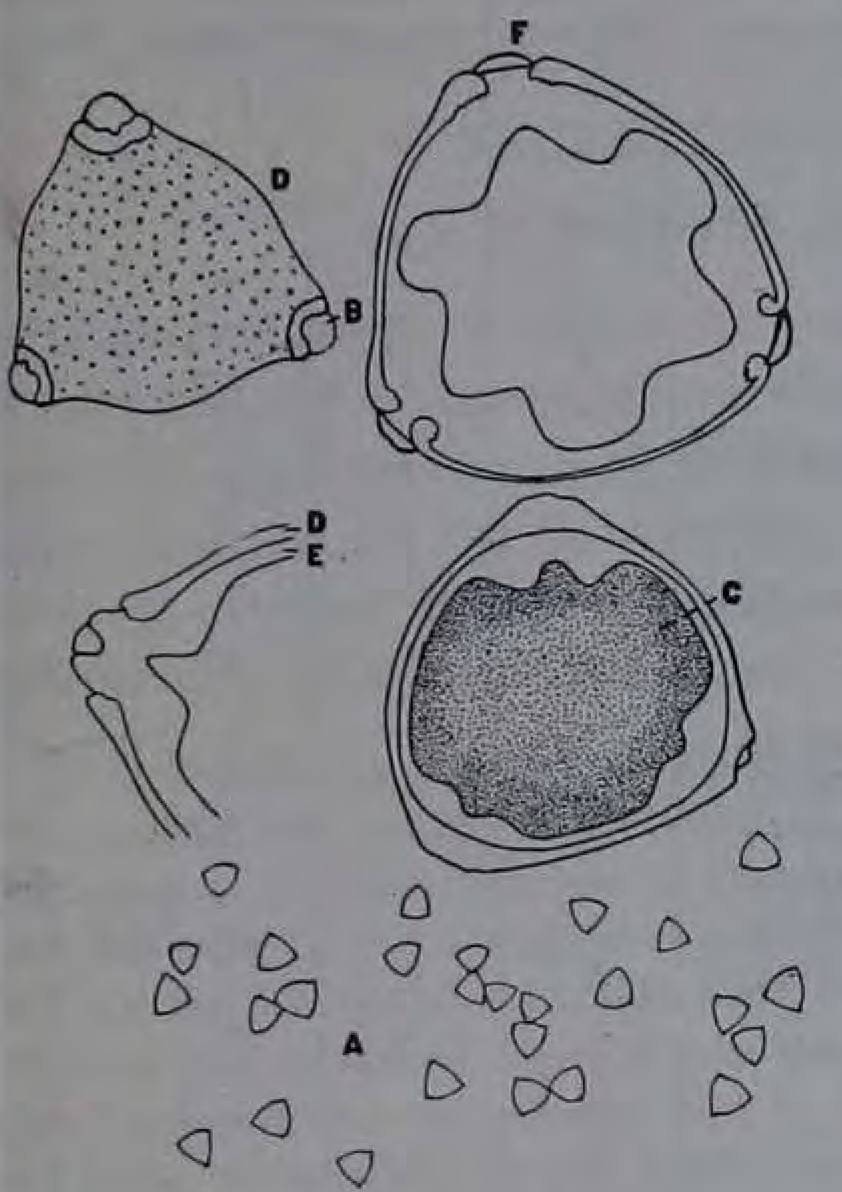

FIG. 552.—*Symphoricarpos racemosus* var. *laevigatus* Fernald. Snowberry.

Symphoricarpus racemosus var. *laevigatus* Fernald. Snowberry

Shape subspherical-triangular, size 48 to 64 mu; in a pitlike depression around the pore the intine is capped with a lid; extine is somewhat granular on surface, terminates in a sort of collar around the pore; protoplasm coarsely granular; oil on surface. Insect pollinated.

SUMMARY

It is hardly profitable to generalize regarding outstanding features of such a small number of pollen grains as were examined in this study. It may be stated, however, that:

None of the wind-pollinated pollens examined bore oil on their surfaces while all of the insect-pollinated plants bore more or less oil.

No reaction was secured for reserve sugar in any of the twenty-four species studied. Reserve fat was noted in 66 2/3 per cent of the species; reserve protein was found in 50 per cent of the species; starch was found in 54 per cent of the species. In all the plants studied at least one of these forms of reserve food was indicated; in 16 2/3 per cent of them three reserve foods were found.

Measurements of pollen grains are subject to variation, for dry pollen cannot be accurately measured and the grains differ in relation to contraction and expansion in different media such as honey, water or reagents. Most pollens swell in water and honey is variable in concentration.

Table of Measurements and Tests of Pollen Grains

Name	Size in microns	Starch	Sugar	Protein	Fat
Family Urticaceae					
Cannabis sativa	20-23	*	x	–	x
Family Polygonaceae					
Polygonum Persicaria	44-56	*	–	–	*
P. pennsylvanicum	56-72	*	–	–	–
P. orientale	48-68	*	–	–	–
P. lapathifolium	36-44	*	x		*
Family Leguminosae					
Melilotus alba	28-36x24-28	–	x	–	x
M. officinale	24-40	–	–	–	x
Phaseolus multiflorus	64-76	*	–	–	*
Trifolium agrarium	40-28x40-24	–	–	–	*
T. repens	32-36	–	x	–	x
Family Labiatae					
Mentha arvensis var. canadensis	44-32x40-24	*	–	–	x
Monarda mollis	66-64x52-64	x	–	–	–
Nepeta Cataria	40-48x36-40	*	–	–	–
Prunella vulgaris	56-48x48-44	–	x	–	*
Pycnanthemum virginianum	36-40x28-36	x	–	–	–
P. pilosum	40-60x28-44	*	x	–	x
Teucrium canadense	32-36	–	x	–	–
Family Convolvulaceae					
Convolvulus arvensis	60-75	x	*	–	*
Convolvulus sepium	76-112	–	*	–	*
Family Scrophulariaceae					
Scrophularia marilandica	32-64	–	x	–	–
Veronica virginica	16-24	–	–	–	x
Family Plantaginaceae					
Plantago lanceolata	20-32	x	x	–	–
Family Caprifoliaceae					
Symphoricarpos racemosus var. laevigatus	48-64	*	–	–	x
Family Cucurbitaceae					
Echinocystis lobata	64-68	–	x	–	x

Legend: * abundant; x present; – absent.

In the genus *Polygonum* the four species here studied showed such close resemblance in sculpture and number of pores that size seemed helpful in differentiating between them. The two species of *Convolvulus* showed outstanding differences in sculpture and number of pores, as well as in size. In the members of the Labiatae studied, the general topography and number of lidless pores were very similar; surface sculpture combined with measurements appear to be the most useful features here.

Structure and chemical composition of pores is a subject which has been neglected in most pollen studies. Since the pores are the gates which guard the potential content of the pollen grain more knowledge of their operation would be useful.

SECRETION OF NECTAR

L. H. PAMMEL AND C. M. KING

There is great variation in the secretion of nectar in plants. Buckwheat (*Fagopyron esculentum*) secretes abundantly in the northern regions before 10:00 a.m. In central Iowa no bees have been observed on the flowers after this time. During a dry spell early in August, 1929, no honey was secreted after 9:00 a.m. The plants were growing in sandy soil.

E. F. Phillips in a paper on Beekeeping in the Buckwheat Regions states: "It appears also not to secrete nectar as freely when grown outside its optimum distribution, probably because of the special requirements of temperature, soil, and moisture in the abundant secretion of nectar in this species. It secretes best on the Volusia and DeKalb soils, which are formed by the disintegration of shale and sandstone, especially in the glaciated plateau region of New York and Pennsylvania. It secretes best in regions where the nights are cool and the mean temperature during the blooming period does not exceed 70° F. So far as known the nectar is always dark in color and the resulting honey is strong in flavor.

RELATION TO OTHER BEEKEEPING REGIONS

"The buckwheat region lies within the boundaries usually given for the clover region, but buckwheat is found most abundantly in parts of the country where white and alsike clovers are less reliable sources of nectar. Beekeeping practices of the region are often materially modified by the presence of alsike clover, which grows in soils more acid than are suitable for the vigorous growth of red clover. The region extends southward into the tulip-tree region, although in the southern part of the buckwheat range the area devoted to the growth of the plant often lies too high for the best development of the tulip tree. . . . .

"The secretion of nectar from buckwheat is quickly influenced by various factors. It is commonly observed that buckwheat secretes best in the early part of the day; but in some localities, especially those where the temperature is lower, secretion may continue throughout the day. Secretion is more abundant following cool nights, especially if the sun comes out bright the following day and if there is little or no wind. Secretion is reduced or stopped when the temperature drops below 70° F. While buckwheat is usually planted so that the blooming period comes in August, earlier plantings are sometimes made, especially for the orchard cover crops. It is often observed that the earlier bloom is almost if not entirely devoid of nectar. The last bloom of the year, after about September 1 until frost, secretes little or not at all. The flowers

[1] Farmers' Bulletin, U. S. Dept. of Agr. 1216; pp. 5-7.

are quickly blasted by unfavorable weather conditions, thus stopping nectar secretion. Leighty calls attention to the fact that 'many buckwheat growers believe that the weight per bushel of the seed is heavier where the crop has been worked largely by bees.' "[2]

It may be of interest to note that honey flow from white clover varies greatly. In central and eastern Iowa in 1929 the plants grew most luxuriantly with an abundant flow of nectar. The flow is generally much more abundant in northeastern Iowa than elsewhere in the state because of more moisture in the soil. In some years white clover furnishes very little nectar in Iowa. It is essentially a plant of the glaciated region.

There was much less flow in northwestern Iowa than in central Iowa because the rainfall was less.

CLOVER

The alsike is far less dependable in Iowa than the white and red clover. Clover furnishes nectar only where there is an abundant rainfall. E. F. Phillips[3] in "Beekeeping in the Clover Region" has thoroughly covered this ground. He states that the secretion of nectar by these plants is influenced by many factors.

"and, as a result there are many places in the area here indicated in which the plants are almost valueless for nectar secretion. In general, the farther north one goes the better the secretion becomes from these species. Most of the best clover territory lies in the area covered by the last glacier, and the best of the clover region lies in western Vermont, northern and central New York, northwestern Ohio, northern Indiana and Illinois, Michigan, Wisconsin, Minnesota, and northeastern Iowa.

There is also, as is well known to beekeepers, an enormous variation in the amount of nectar secreted by these plants according to soils, climatic conditions, and other environmental factors, to be discussed briefly further on."

In regard to white clover the statement is made: "The plants thrive best when there are good rains in July, August and September. Winterkilling is less noticeable for white clover than for red clover. If there are abundant rains in May the plants are put into a condition of great vigor, and this adds greatly to the probability of a heavy secretion for the season. Rains while the plants are in bloom serve to prolong the period of blooming and of nectar secretion. White clover is seemingly most valuable as a honey-source in the northern part of its range, and this is probably due to the fact that the plants are most vigorous and secrete nectar most freely where the temperatures at blooming time are relatively low."

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2 For further information regarding the cultivation and uses of this species, the reader is referred to Farmers' Bulletin 1062, Buckwheat, by Clyde E. Leighty, issued in 1919.

3 Farmers' Bulletin, U. S. Department of Agriculture, 1215.

We have found for central Iowa that the alsike clover does not yield as much as the white clover. Phillips states:

"In general, the conditions favorable for nectar secretion for alsike clover are the same as those for white clover. This species differs from white clover, however, in the fact that it is a regular farm crop in some places, and such locations are unusually favorable for the beekeeper. It is increasing as a farm crop, especially in locations where, because of increasing soil acidity, red clover is no longer so profitable. Alsike clover is grown alone and with timothy for hay, and in some limited localities it is grown for seed, thus giving the maximum time for nectar secretion. It does not yield nectar equally well in all places where it is grown for hay, since the best yields are possible only where the soil and climatic conditions are most favorable. In the northern part of the range of this species the nectar secretion is greatest."

We have found much variation in the production of nectar from red clover. In many parts of Iowa the honey bees are only occasional visitors, but in northeastern Iowa after rains and during rather cool weather the bees were frequent. Apparently the nectar rises up the tube of the corolla by capillarity. Phillips states:

"It is well known that the amount of nectar produced by the red-clover flowers is greater than that in the flowers of the other two clovers, and it is indeed unfortunate that the honeybee cannot take full advantage of this abundant source. The beekeeper usually does not credit red clover with the production of much nectar available to the honey bees, but it is doubtless true that where this species is grown it forms at least an important minor source of nectar, and probably much of the clover honey produced in the United States is partly derived from red clover. Usually the benefit from red clover is more noticeable from the second crop, it being believed that the shorter corolla tubes enable the honey bees to gather a large proportion of the nectar. This is especially valuable to the beekeeper because at this time the secretion from white and alsike clovers has usually ceased."

Alfalfa, which is an important honey plant in the west, is a most variable plant in the secretion of nectar in Iowa. In many places it is not visited by bees, apparently secreting but little nectar. In 1929 this species was abundantly visited in Des Moines on somewhat sandy soil, but apparently there was no honey flow at Ames. The honey flow is much more abundant along Missouri river and on the loess bluffs than in central Iowa.

THE STRUCTURE OF SOME NECTAR GLANDS OF IOWA HONEY PLANTS

WILLIAM S. COOK

INTRODUCTION

The anatomical study of nectar glands was taken up at the suggestion of Doctor Pammel, who for many years has been interested in honey plants and their economic importance in Iowa.

The structure of nectar glands has not received much attention from the present day botanist. He takes for granted that they are present, but that is about as far as he goes. Older botanists of the eighteenth century were much interested in the subject of nectar glands. Glands of many plants were studied as thoroughly as could be done with the equipment they possessed. Not only was the anatomy of the glands studied but also the physiological process taking place in these glands. It is to be regretted that with our present day equipment more work has not been done on such an important subject.

While the subject of nectar glands may not be one of the greatest importance from an economic standpoint, still it is one which should receive more attention. Every person interested in honey production should know something about the organs that secrete the nectar, upon which the bees depend for their honey. A knowledge of the structure and principles of functioning of nectar glands is essential to a thorough understanding of honey production.

The work reported in this paper was undertaken with two objects in view; first, to give those interested in honey production some information concerning the structure of nectar glands; second, to create interest in this fascinating field of study with the hope that other students of botany may pursue the investigation further.

HISTORICAL

An occasional discussion of the secretion of nectar and the structure of nectar glands in flowers is found not only in the works of many older botanists but also in the discussions of antiquated articles; but these are only superficial remarks. Ruellins[1] described the nectaries of *Aconitum Napellus* and *Fritillaria imperialis*. He first designated the secretion of nectar as "honey secretion."

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[1] Ruellii, J., De natura stiripum: Bas. 3, 21:1543.

Malpighi[2] in 1675 made an investigation of nectar secreting organs of plants, but his results are not very reliable. He described those on the inner side of certain flower blades, as *Fritillaria* and *Ranunculus,* and in these he called it "honey sap." Pontedera[3] in 1720 advanced the view that the honey sap of plants is secreted in order to nourish the young embryo. The sap which streams through the plant appears here as resin and there as gum, etc. The flower sap is collected to nourish the fruit buds. If the embryo is deprived of this sap it will not develop in the fruit. The first comprehensive discussion concerning nectaries was by Linné[4] in 1763 under the title "Nectaria florum." He called the organs nectaria, and the sweetish juice they secreted he called nectar. Linné's view was similar to that of Pontedera. He thought that the solution was necessary for the fruit buds and that it furnished a substance for moistening these buds. Linné thought that the bees and other insects sought nectar for their nourishment and in so doing transferred the pollen to the stigma. He thought the corolla to be the honey forming organ. He described several different kinds of nectaries in different locations in the flower. Roth[5] in 1787 transmitted nectar through a tube into the fruit buds and held the view that it was necessary for the nourishment of fruit buds. Krunitz[6] thought the sap was not necessary for the buds. He thought it was injurious to them.

Conrad Sprengel[7] first stated the opinion that nectaries are for the purpose of furnishing a sweet substance intended to attract insects in the fertilization of plants. Goethe[8] in 1790 published an article "Metamorphose der Pflanzen." He tried to explain the morphological nature of the nectaries. There are, according to him, passageways from the calyx to the stamens that secrete the sap that is found on the petals. He came to the conclusion that the nectar secretion was very important in attracting the insects and bringing about pollination. Sprengel had found that flowers pollinated by insects generally have nectar. Goethe suggested the name "sap glands" instead of nectaries. The sap glands are the part of the flower which prepares and secretes the sap. The forms of the sap glands are many and various. In some cases they are different and are separated. They may be fleshy layers of one or more than one cell layer in thickness. If they are thin, they could not secrete much sap. They are smooth. Sometimes they are colored, but seldom are they green, the most common color is yellow; seldom are they white; sometimes they are cherry red. The color depends on the quality and mixture of the secretion. Miribel[9] in 1815 discussed the structure and anatomy of nectar glands. According to him the nectaries are the fleshy bodies which are borne on the receptacle, the ovary, the stamen, or the petals. They secrete a sweet fluid called nectar, which collects at the base of the perianth. The cells of the nectar tissue have very thin walls and are traversed by vascular ramifications. According to their

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2 Malphighi, M., Anatome plantarum, Lugd. Bot., 1687.

3 Pontedera, J., Dissertationes botanicae, Diss. 1, 1719.

4 Linné, Nectaria florum: Amaen. 6, p. 263, Upsalae, 1762.

5 Roth, Roemer, and Ustri, Magazin für die Botanik, 2. Stück, p. 31, 1787.

6 Krunitz, Oekonomische Encyclopaedie, Bd. 4, p. 773.

7 Sprengel, Conrad, Das entdeckte Geheimniss im Bau und in der Befruchtung der Blumen.

8 Goethe, Cottasche, Ausgate Bd. 36, pp. 35-38, 1853.

9 Miribel, Elements de botanique, t. 1, Paris, 1815.

position Miribel distinguished fifteen varieties and made a new classification. Desvaux[10] in 1826 tried to determine whether nectar glands were specialized parts of plants or if they were modifications of organs already recognized. He stated that nearly all the structures which have been designated as nectar glands pertain to some floral structure. He gave the nectaries the name ovarian glands. He set forth the theory that all glands arise from bundles of fibers, which instead of elongating and spreading out are suppressed and agglomerated.

Soyer-Willemet[11] thought that the nectary should have a direct communication with sexual organs. All glands which do not communicate with these organs should not be regarded as nectaries even though they secrete a sweet liquid.

DeCandolle[12] applied the word nectary to all glands situated on the floral organs.

Raspail[13] does not use the name nectary except for the circular swelling which surrounds the base of certain ovaries. In many cases, he says, the nectaries appear as glands, in others there is found a mass of substance secreted without any trace of the organ of secretion.

Bischoff[14] in 1839 established two types of nectaries: 1. The nectaries, properly speaking, which consists of various parts of the flower that have been transformed or aborted, such as the nectariferous scales of the Ranunculaceae. 2. The nectar gland.

Lorenz Oken[15] in 1839 expressed the view that nectaries are stunted organs and in nearly all cases stunted stamens. The honey arises out of sugar and slime and is mixed with ethereal oils and other substances.

L. Bravais[16] in 1842 published a paper on the structure of the nectar glands. He attempts to show that they exist mostly in Phanerogams and that they should be classified according to the floral leaves which bear them. He divides these glands into nine classes. According to him one should distinguish four parts in each of the floral leaves: 1. The support or point of attachment. 2. The nectary. 3. The anther. 4. The stem. Sometimes not all of these four parts are developed. If the nectary develops alone it appears as a glandular disc at the base of the ovary.

The first anatomical work on nectaries was by Caspary[17] in 1848. He studied sixty-four different species and found that the secretion comes out of cells and not out of vascular bundles. In many cases the secreting cells are not different from other cells in appearance; usually they are covered by an epidermis. Many nectaries have stomata of round or elliptical form, but they are present usually only when the epidermis is absent. Commonly the surface is furrowed, sometimes raised to an eminence. The nectar-secreting cells never have vascular bundles. The secreting cells contain a granular material and oil,

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10 Desvaux, Recherches sur les nectaries, Paris, 1826.

11 Soyer-Willemet, Memoirs sur les nectaries, Nancy, 1826.

12 De Candolle, Organogr. veget., Paris, 1827.

13 Raspail, F. V., Nouveaux Systeme de physiologie vegetale, Paris, 1837.

14 Bischoff, Lehrbuch der Botanik, Stuttgart, 1839.

15 Oken, Allgem. Naturgeschichte für alle Stände, Bd. 2, p. 71:1839.

16 Bravais, Examen organographique des nectaries, Ann. des Sci. Nat., p. 18, 1842.

17 Caspary, R., De nectariis. Elverfeldae, 1848.

regardless of whether or not there is a distinct form or shape to the gland, and they are, therefore, distinct from the neighboring cells. The secreting begins with the opening of the anther and ends when the pollen is shed and anthers are dry. Caspary thought nectar was most likely to occur in male flowers where stamens are likely to abort and become nectar glands.

M. Brongniart[18] in 1885 published an important memoir on the nectar glands which are found at the side of the ovary of various families of the monocotyledonous plants. He called them septal glands. He studied the septal glands of the Liliaceae, Amaryllidaceae, Bromeliaceae, Iridaceae, and other families of the monocotyledons.

J. Martinet[19] in 1872 discussed nectar glands in his work on the secreting organs of plants. His anatomical study of them was limited to a few examples of plants.

In 1879 appeared the important work of Behrens[20] "*Die Nectarien der Blüthen.*" Behrens in his work on nectar secretion gives a detailed discussion of the anatomy of the glands and the physiological process of secretion. He also gives a very good review of the literature up to his time. In this work Behrens takes up different kinds of nectar secretion. He divides nectar secretion into several different classes, according to the structure of the different nectar-secreting tissues.

Class No. 1.—Secretion through thin-walled, noncutinized epidermal cells. The epidermal cells have no cutin but join the cutinized epidermis of the stamens and sepals. The nectar cells contain a yellow metaplasm, but the epidermal cells are transparent. The secretion reaches the surface by diffusion through the epidermal cells.

Class No. 2.—Secretion of nectar through thin-walled epidermal papillae by the process of diffusion. In this class we have an epidermal layer, some of its cells being extended into rather large, single celled papillae. They resemble trichomes that have become secretive organs. The papillae have thin, colorless walls and contain a colorless and coarsely granular metaplasm. Dextrose is present and also other carbohydrate bodies. Small amyloid bodies appear in the papillae and the secretion soon begins either at the apex or on the sides. The drop enlarges and covers the entire papilla. Small bodies are noticed on the outer surface of the papilla and these act indifferently to reagents. The amyloid bodies disappear when the nectar appears on the outside and it is evident that the secretion is passed through the walls. most possibly by means of a molecular change of the membrane.

Class No. 3.—Secretion at the point of many-celled nectary papillae by means of building up of collagen. In this class the papillae are many-celled, being terminated by a single cap-cell. Their outer walls are soft and possess no cuticle. When the papillae are young the cap-cell has a wall as thick as the other cells, but gradually the wall at the top spreads, so that one sees an outer and an inner part. The two parts are further separated until there is a half-

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18 Brongniart, Ap., Memoire sur les glandes nectariferes de l'ovaire: Ann. des Sci. Nat., t. 2, 1855.

19 Martinet, J., Organes de secretion des vegetaux: Ann. des Sci. Nat., t. 14; 1872.

20 Behrens, W. J., Die Nectarien der Blüthen: Flora Bd. 62, 1879.

moon-shaped middle layer. This middle half-moon-shaped slime layer increases and the inner membrane or layer is pushed farther into the cell until the cavity of the cell is nearly filled up. Finally the outer layer of the wall breaks and the slime escapes.

Class No. 4.—Secretion of nectar through the opening of stomata on the epidermal layer. In this class we have nectar tissue covered by an epidermis. In this epidermis are found stomata which are sometimes sunken. They look like ordinary stomata and have a stomatal chamber beneath them. The epidermal cells and guard cells of the stomata are cutinized. Secretion passes from the lower nectary tissue into the stomatal chambers and then out through the stomata.

Class No. 5.—Secretion through the sliming of the outer walls of the epidermis by means of the formation of collagen and destruction of the cuticle. In this class the outer walls of the epidermis are heavily cutinized. Three layers or bands in this wall can be seen, two of them firm and dark and a clear one between them. The secretion proceeds as follows: the wall becomes slimy just under the cuticle. It is split into tangential layers. As the formation of slime proceeds, certain high points are produced, raising up the cuticle, which is finally ruptured, thus allowing the slime formed by the nectar part of the wall to escape. Several more cuticles form in succession as previous ones are ruptured in the same way and the nectary becomes covered by the swollen mass of the outer cell walls of the epidermis.

Wm. Trelease[21] in 1879 published an article on "*Nectar and its Use.*" He divides glands into floral and extra-floral. He also gives a very good bibliography relating to the subject.

G. Bonnier[22] in 1879 published a very important memoir on nectar glands. The title of his paper was "*Les Nectaries.*" He described the anatomy of many nectar glands and also gave a detailed account of the physiology of nectar secretion.

Knuth[23] in his "*Hand-book of Flower Pollination*" gives a general discussion of nectar glands. Each genus of the monocotyledons and dicotyledons is described as to the location of the gland and whether it secretes nectar or not.

MATERIALS AND METHODS

All the material for the study of nectar glands was collected at Iowa State College, during the summer and spring of 1922. All material that was collected was in good condition and care was taken to see that the flowers were secreting nectar in abundance when they were collected. All material was killed in chromacetic acid, which was found very satisfactory. The paraffin method was used for imbedding material, as is described in Chamberlain's Histology.[24] Sections were cut about 8 mu in thickness and were

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21 Trelease, W. M., Nectar and its Use, Report on Cotton Insects, Pt. 2, U. S. D. A., 1879.

22 Bonnier, G., Les Nectaries: Ann. des Sci. Nat. Bot., 1, 1879.

23 Knuth, Paul, Handbook of Flower Pollination, Oxford, 1906.

24 Chamberlain, C. J., Methods in Plant Histology, 85-89.

stained with Delafield's Haematoxylin. Later on as the work progressed this reagent was discarded, as it took too much time to carry it through, and it was found also that it did not give as good differentiation of cell-walls as was desired. Nothing else was found, however, that gave as good results for cell contents. Light Green was substituted. It gives good results and works quickly. This method will be described in full later.

Method of making sections for temporary mounts.—Often after material is imbedded in paraffin it is difficult, without cutting many sections, to find out exactly where the nectar tissue is located. The following methods were used for a preliminary examination. Sections were cut from 18 to 25 mu in thickness, usually about 20 mu. If the sections are cut smaller than 18 mu they have a tendency to tear as will be shown in the description of the method. Sections were easily cut at 25 mu and good ribbons were obtained, if the paraffin blocks were placed in warm water for a minute before being cut. After the sections were cut, two or three were placed on a slide and a drop or two of the xylol-eosin-clove-oil mixture was added. This mixture was made up as follows: A little eosin on the end of a knife-blade was placed in 10 to 15 cc. of clove oil and shaken until the eosin was dissolved and the clove oil had a good red color. The solution was then filtered. To this eosin-clove oil was added enough xylol so that a pure paraffin ribbon would dissolve readily. Care was taken not to add enough xylol to form a precipitate as this will ruin the stain. As was stated above two or three of the paraffin sections were placed on a slide and dissolved in a drop of eosin-clove-oil-xylol solution. In about a minute the paraffin was dissolved by the xylol and the sections were stained by the eosin. In addition to being a solvent for the eosin, the clove oil of this solution cleans the section very nicely. The excess liquid was removed with a piece of filter paper and a cover glass was put on. If sections were to be kept for any length of time a drop of balsam was added before the cover glass was put on. The sections soon faded and could not be kept satisfactorily stained for any length of time by this method.

Method of making permanent mounts.—As has been stated before Light Green was used exclusively for staining permament mounts in the later part of this work. The following method was found very satisfactory for this work. Five gms. of Light Green was dissolved in 12.5 c.c. of absolute alcohol, which was shaken until practically all of the stain was dissolved; then 37.5 c.c. of clove oil was added and the solution was filtered. The stain was then ready for use. The slides with the paraffin sections were placed in absolute xylol for five minutes. They were then removed from the jar of xylol and rinsed with a small amount of 95 per cent alcohol to remove the excess xylol. They were then placed in 95 per cent alcohol for five minutes, then in absolute alcohol for five minutes. The slides were now ready to be stained. They were removed from the absolute alcohol and a drop of clove oil was run over them to remove the excess alcohol. They were then stained in Light Green for three to five minutes, when they were removed from the stain and a drop or two of clove oil was run over them, followed by a drop of cedar oil. The slides then were placed in an equal mixture of absolute alcohol and xylol for three to five minutes. After this last step they were ready to be mounted in balsam. Staining with Light Green, if done correctly, gives a very good mount and the time required is not long. By this method ten to fifteen slides may be stained and mounted in a half hour, a great saving of time as compared with other methods.

LIST OF PLANTS USED

The following is a list of plants used in this paper, arranged in the order of their Families, Genera and Species.

Family Saxifragaceae
  Philadelphus coronarius L.
Family Rosaceae
  Pyrus communis L.
  Spiraea sp.
  Prunus virginiana L.
  Physocarpus opulifolius (L.) Maxim.
  Crataegus mollis (T. and G.) Scheele
  Pyrus Malus L.
Family Tiliaceae
  Tilia americana L.
Family Solanaceae
  Petunia violacea Lindl.
Family Bignoniaceae
  Catalpa bignonoides Walt.
Family Caprifoliaceae
  Lonicera tatarica L.
Family Cucurbitaceae
  Cucurbita pepo L.

ANATOMY OF THE GLANDS

It might not be amiss before we go into the study of the glands to discuss just what nectar glands are. In studying the structure of nectar glands we do not always find what agrees with our common idea of a gland. We generally think of a gland as being a stalked body, which has arisen as a projection on the epidermis, and is usually multicellular. But frequently we do not find any gland of this description. There is in many cases a mass of tissue with a