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IN THE RESEARCH SERIES OF THE GRADUATE COLLEGE

BULLETINS FROM THE LABORATORIES OF NATURAL HISTORY

Professor CHARLES C. NUTTING, Editor

VOLUME VII NUMBER 3

CONTENTS

PUBLISHED BY THE UNIVERSITY

THE PLANT GEOGRAPHY OF THE LAKE OKOBOJI REGION: ADDITIONAL NOTES

BY BOHUMIL SHIMEK

Since the publication of the Bulletin on the flora of the Lake Okoboji region[1] two years ago, field studies have been continued by several members of the staff of the Macbride Lakeside Laboratory, and papers by Drs. Stephens and Wylie, and Mr. Stoner which are a result of these studies, are included in this Bulletin.

The writer continued his observations on plant distribution in the lake region with some interesting results.

The summers of 1915 and 1916 were unusual in their meteorological conditions. The season of 1915 was exceptionally cool and moist, while that of 1916 was cool and moist in the spring, but hot and rather dry during the summer. The greater abundance of water rehabilitated many of the smaller kettleholes, some of which had entirely lost their earlier character, and their number is greater than is indicated in the forest map of the lake region published in the Bulletin cited, which represents the greater part of the kettleholes noticeable during the dry summers preceding that of 1914. The greater amount of moisture during these two years produced striking changes in the flora. Swamp and low ground species became much more abundant, and several species which are ordinarily found in low grounds were observed on the higher prairie west of West Okoboji lake. The most striking of the latter are the following, which may be added in the former Bulletin to the column numbered in the *Prairie list*, pp. 29-37:

Iris versicolor L. III

Habenaria leucophæa (Nutt.) Gray III

[1] Shimek, B. Bulletins from the Labs. of Nat. History, State Univ. of Iowa, vol. VII, no. 2, May, 1915.

Potentilla Nicolletii (Wats.) Sheld. III
Lycopus americanus Muhl. VII
Gerardia tenuifolia Vahl. IV
Boltonia asteroides (L.) L'Her. III, IV

Several aquatic and swamp species were added to the list. They should be inserted in the hydrophytic list, pp. 43-49:

Carex lanuginosa Michx. n, VI, 1; VII, 1.
Eriophorum angustifolium Roth n, VI, 2; VII, 3.
Lemna minor L. m, III, 1.
Cypripedium candidum Muhl. n, VI, 4.
Hippuris vulgaris L. n, IV, 4.
Gentiana crinita Froel. n, VI, 2.
Gentiana Andrewsii Gris. n, VI, 4.
Bidens laevis (L.) BSP, n, IV, 4.

Aquatic plants flourished, and some of the species, notably *Utricularia vulgaris var, americana,* occurred in unusual numbers. On the other hand *Vallisneria, Elodea,* some of the species of *Potamogeton,* etc., were not much in evidence, the high level of the water in the lake keeping them submerged. *Bidens Beckii,* usually abundant and with many of its heads raised above the water, was less abundant and remained entirely submersed, though flowering abundantly, excepting in the canal between Miller's Bay and Emerson's Bay, where occasional heads appeared above water. *Wolffia columbinana* Karst., added to the aquatic list, was very abundant in ponds connecting with the west side of West Okoboji lake. Numerous flowering specimens were collected in August. On the whole, the deeper water species of flowering plants suffered because of the higher level of water, while the marsh and low ground species were favored.

The two successive favorable seasons also produced their effect upon the flora of the prairies. The usual yellowish or brown color which marks the prairie slopes during the latter part of August was missing, for the vegetation remained fresh even through the hot days of July and August. *Stipa spartea* was so abundant on the knolls and upland prairies that it prevented fieldwork on the prairies for a week on account of the extremely abundant fruit. Several species which belong in the *Prairie list* were added during 1916, and they should be inserted in the earlier list in the columns indicated by number. Those marked "i" in that list are introduced species:

Humulus lupulus L. d, VIII, 3.
Medicago Lupulina L. i, VII, 4.

Helianthemum majus BSP. d, VII, 4.
Euphorbia glyptosperma Eng. e, V, 4.
Ceanothus ovatus Desf. a, III, 4.
Œnothera muricata L. e, V, 3.
Gerardia auriculata Michx. c, III, 2.

Several forest species of flowering plants were also added to the list. The following should be inserted in the *Forest list* in the columns indicated by numbers:

Dactylis glomerata L. i, VII, 4.
Habenaria bracteata (Willd.) R. Br. a, I, 5.
Populus balsamifera L. a, VI, 5. Evidently native.
Geum strictun Ait. a, V, 4.
Apios tuberosa Noench. c, VIII, 3.
Sanicula gregaria Bick. a, I, 2.
Galium palustre L. c, I, 3.
Viburnum pubescens (Ait.) Pursh. b, III, 3.

Many of the cryptogams were also favored by these seasons. Mosses, especially those of the woods, were more abundant than they had been in twenty years, and a very creditable list of additional species was secured. Parasitic fungi were also unusually abundant, and a goodly number of species has been added to the lists. Further collections of diatoms, lichens, etc., were also made. A report upon these groups is in preparation.

Observations on the sand-flora of the beaches were also continued, and the result is included in the accompanying report on the sand-flora of the state. These beach-floras also felt the effect of the greater supply of moisture, and the season of 1916 showed an increased number of low-ground species upon the beaches.

B. SHIMEK,
Director of the Macbride Lakeside Laboratory, 1916.

The materials of these beaches are usually sand and gravel, sometimes bowlders. In the latter case, the bowldery beach usually ends rather abruptly near the base of wooded banks.[2]

2 — *Fluviatile sands.* — These are the ordinary sand and gravel bars along our streams, and they also grade into higher, older bars or flats, now seldom reached by the waters of the stream excepting for a short period during high water. The materials on these shores also vary from fine sand to gravel and bowlders. Illustrations may be found along most of our streams, excepting the prairie streams of the western part of the state, the Cedar river furnishing the finest examples. See also Plate I, figs. 2 and 3.

3 — *Sand-dunes.* — The sand-dune areas of Iowa are quite limited and are practically restricted to two sections of the state: those along the Missouri river, chiefly in Harrison county; and those which lie chiefly in Muscatine county. The latter are in two distinct groups, one occupying a part of Muscatine Island and extending into Louisa county, and the other extending along the Cedar river valley, chiefly in the vicinity of Adams and Bayfield.

The Harrison county dunes[3] are typical low dunes, seldom reaching a height of 20 feet. They are formed from sands blown up from the bars of the Missouri river, and heaped up usually around clumps of willows or cottonwoods. They present various phases of development, some being almost bare (see Pl. II, fig. 1), and frequently shifting, others are densely covered with vegetation (see Pl. II, fig. 3), while still others present intermediate phases (as in Pl. II, fig. 2). The dunes frequently break down (see Pl. III, fig. 2), especially during dry, windy periods, and even the roots of trees may be exposed by the shifting of the sand, as shown in Plate III, fig. 3. The sand of these dunes is derived from nearby bars of the Missouri river.

The dunes of Muscatine county are less pronounced, somewhat scattered, and with the exception of portions of the north end of the Big Mound, mostly covered with well-established vegetation, though this is somewhat variable during different seasons. Three principal groups may be noted: — those on Musca-

[2] See ibid., plate V, fig. 3, and plate VI, fig. 1.

[3] See writer's brief description, with illustrations, in Iowa Geological Survey, vol. XX, pp. 411-412; 1910.

tine Island, forming a part of the Big Mound, derived principally from Mississippi river sands (see Pl. IV, figs. 1-3); — those which are found near Adams, in the bed of the glacial Lake Calvin, which are derived chiefly from the sands of the old lake bed; — and those which have encroached more or less upon the Illinoian drift-plain north and northwest of Bayfield (see Pl. V, fig. 1), which are probably derived in part from the bars of the Cedar river, and in part from the sandy margin of the Illinoian drift.

The dunes of the Muscatine region are largely fixed by a well-developed vegetation, but portions of all these areas become denuded at times, particularly during dry summers.

These dunes, like those of Harrison county, are made up of fine sand.

4 — *The ridge sands and gravels.* — These are more limited in extent, and are found in interrupted groups and patches, chiefly along the border of the Iowan drift from Hardin county eastward to the Mississippi and along the border of the Illinoian, where they blend in places with the dunes; and in limited portions of the Kansan drift area. Similar ridges are found along the border of the Wisconsin drift, especially northward in the state, and they are covered with a typical prairie flora.

These ridges owe their sand and gravel to the several drifts, and they are now mostly quite stable, and their flora blends with that of the adjoining prairie or forest.

5 — *The talus sands.* — These sands are very limited in area, and are restricted to the vicinity of the bases of scattered ledges of St. Peter Sandstone in the northeastern part of the stae. A small portion of such an area is shown in front of the ledge in Plates I-III, Vol. V of this series, following p. 224 (bis); 1904.

The several sand-areas are not sharply defined. The beach and bar areas blend with the prairie, swamp, or forest; the dune areas connect with the alluvial sands on the one hand, and with prairie and forest soils on the other; the ridge sands and gravels grade into prairie and forest; and the limited talus sands likewise soon pass into forest or prairie soils.

The Flora

This intergradation is also reflected in the flora, which sometimes shows an admixture of swamp species, and at others of forest species, but usually blends most completely with the prairie flora.

The beaches of the Okoboji lakes and Spirit lake frequently show the intergradation of swamp and beach. On the newer parts which are subject to wave-wash, there is often a blending of low-ground or swamp species with those which habitually grow in moist, sandy places.

These species are marked "w" in the list, and those which were found on lake beaches are indicated in column I. Of the species so marked in this locality list, *Verbena hastata, Stachys palustris, Erigeron philadelphicum* and *Ambrosia trifida* are not uncommon on higher prairie.

A similar mingling of hydrophytic forms is noticeable in the Harrison county dune region, where pools and low, wet places are not unusual. The hydrophytic species which here appear on wet sand, and which mingle more or less with the ordinary sand-xerophytes, are also marked "w" and appear in column V of the plant-list.

The bars and sandy shores of streams also frequently show a number of these hydrophytic forms. Columns II and III of the plant-list contain such species, marked "w." The species of *Eragrostis* and *Hemicarpha* are very commonly the pioneers on river-bars.

A few species which usually occur in forested regions are also found on the lake beaches and river bars. They are marked "f" in the list.

The most common species which occur on the beaches and bars, especially where the vegetation has become quite well established, are prairie species. *Sporobolus cryptandrus, Cyperus Schweinitzii, Corydalis micrantha*, both species of *Polanisia, Strophostyles helvola*, and *Euphorbia glyptosperma* are the only species restricted to the sands of the lake beaches. Even *Cenchrus*, and *Strophostyles pauciflorus* are not restricted to sand, but often occur on the upland prairies of the western part of the state. All other species are essentially prairie species.

The true sand-species of the river bars are the same as those of the lake beaches, excepting that the *Euphorbia* has not yet been found on the former, which, however, contain the following additional species:

The several species of *Eragrostis*, commonly in wet places;

Cyperus filiculmis, Froelichia floridana, Mollugo verticillata (native?), *Corydalis aurea var., Corydalis curvisiliqua, Draba caroliniana, Cristatella Jamesii, Tephrosia virginiana,* both species of *Croton, Rhus canadensis var., Viola pedata,* the *Opuntia, Oenothera rhombipetala,* the *Androsace, Asclepias amplexicaulis, Phlox bifida, Lithospermum Gmelini, Monarda punctata,* and *Houstonia minima.*

Quite frequently forest species and introduced weeds find their way to the bars. The former are marked "f" and the latter "w" in the list.

The upland sands are often denuded by winds, less frequently by water. Various species of plants become established upon these fresh surfaces.

In the dune region of Harrison county, the *Leguminosae* such as *Cassia, Desmodium, Crotalaria, Dalea enneandra,* and *Strophostyles* are the first to appear, always with an abundance of root-tubercles containing nitrifying bacteria.

On the dunes of Muscatine county, the pioneers are *Mollugo,* the species of *Croton* and *Corydalis, Cyperus Schweinitzii* and *C. filiculmis, Cristatella Jamesii, Euphorbia polygonifolia,* and other prostrate species of *Euphorbia,* and these are soon followed by other sand and prairie species.

The Harrison county dunes present a limited number of sand-species not found in the other areas, — in fact but two: *Euphorbia dentata* and *Lygodesmia rostrata,* a rare western species. All other species not especially marked, are of the prairie type.

The Muscatine dune list of sand-plants is much larger. The following species, not found on the Harrison county dunes, are more or less characteristic of the dune and upland sands of Muscatine county:

Commelina virginica	Euphorbia polygonifolia
Polygonum tenue	Rhus canadensis var.
Cycloloma atriplicifolia	Opuntia Rafinesquii
Froelichia floridana	Oenothera rhombipetala
Mollugo verticillata	Synthyris Bullii
Draba caroliniana	Houstonia minima
Cristatella Jamesii	Aster linariifolius
Croton capitatus	

Other sand plants, already mentioned in connection with the other sand-areas, are also found in these dune areas, as may be observed in the list. The greater part of this flora, however, as in all the sandy areas, consists of prairie plants, and where the dunes and upland sands become well established, the prairie flora takes complete possession, as is illustrated in most of the area represented in Plate V, fig. 3.

Sometimes the plant covering also passes into forest. The transition from bare dune, as shown in Plate II, fig. 1, through the series illustrated in figs. 2 and 3 of the same plate, to Plate III, fig. 1, may be observed in many places in the Harrison county area. The transition usually occurs from *Salix longifolia* and *Amorpha fruticosa*, of low grounds (see Plate I, fig. 3), and *Salix missouriensis, Cornus paniculata*, and *Zanthoxylum americanum* of the dunes, to *Populus deltoides, Salix amygdaloides, Acer negundo, Crataegus mollis* and *Ulmus americana, Populus* being the dominant species.

In the Muscatine dune region, a similar transition to oak forest may be observed. Plate V, fig. 1, illustrates this. The light spot on the fixed dune in the background shows a "blow-hole" with shifting sand. The only plants on portions of this are mats of *Mollugo verticillata* (see fig. 2 on the same plate); then follows a scattering of *Croton capitatus, Cenchrus*, and *Polanisia*; the vegetation then becomes denser and consists in part of sand-species such as *Oenothera rhombipetala, Cyperus Schweinitzii*, and *Carex cephalophora*, but chiefly of prairie species, such as *Panicum Scribnerianum, Amorpha canescens, Rosa pratincola*, and other typical prairie forms; then clumps of *Rhus canadensis var., Vitis vulpina*, etc., form a transition to the forest in the background, which consists of *Quercus velutina* at the margin, with other hard-wood upland species in the deeper forest.

The flora of the sandy ridges, listed in column VI does not differ in important particulars from that of the dune regions, excepting that there is a smaller number of typical sand-plants, and a more complete blending with surrounding prairie and forest floras.

The sand-talus flora is limited, and contains no species which does not occur in the other areas. The sand is quite sterile and the plants are mostly decidedly dwarfed.

The preponderance of prairie plants on these sandy and gravelly areas is of special interest because it demonstrates the fallacy of the conclusion reached by Whitney [4] and others, that the flora of the prairies is determined by the fineness of the soil.

The tabulated list of plants which follows presents a comparative view of the flora as observed on the several sandy areas. It is not presumed that the lists are complete, but they well show the character of the flora. Perhaps column VI is the least complete, as it is very difficult to determine the limits of such areas. It should be stated that the collections on which this report is based are deposited in the Herbarium of the State University of Iowa.

It will be observed that the several areas, even when of the same type, do not show a uniformity of species. Thus the species common to II and III, the river sands areas, number 74; those found only in II number 70; and those found only in III number 85. The dune areas IV and V, from opposite sides of the state, have 45 species in common, while 167 are found only in IV and 42 only in V.

The total number of species listed is 397. Of this number 186 were found in the areas represented in column I; 148 in column II; 163 in column III; 217 in column IV; 88 in column V; 54 in column VI; and 19 in column VII.

According to habitat and habit, the species listed may be grouped as follows:

	I	II	III	IV	V	VI	VII
Prairie species	99	88	86	138	39	37	12
Species of open places, mostly prairie	7	9	8	13	5	6	2
Usually in sand, sometimes on prairie	7	5	16	13	9		
Dry sand species	9	15	22	28	6	3	2
Wet sand or marsh species	49	15	9	4	12		1
Forest species	5	1	5	5	6	4	
Introduced weeds	10	15	17	16	11	4	2

This tabulation emphasizes the fact that the sand floras connect with those of the prairie, forest, and swamp, and that the character of the three latter largely determines the character of the first.

In the plant list, the following symbols are used:

The Roman numerals at the head of the columns designate localities as follows:

[4] J. D. Whitney. American Naturalist, vol. X, pp. 577-588 and 656-667; 1876. Memoirs of the Museum of Comparative Zoology, vol. VIII, part II, pp. 166-183; 1882.

I — The beaches of the Okoboji lakes and Spirit lake.
II — Sandy shores and bars of the Iowa river below Iowa City.
III — Sandy shores and bars of the Cedar and Mississippi rivers in Muscatine county.
IV — The dunes of Muscatine county near the Cedar and Mississippi rivers.
V — The dunes of Harrison county west of Missouri Valley.
VI — The sandy and gravelly ridges along the border of the Iowan and Illinoian drifts, and elsewhere.
VII — The talus sands at the bases of St. Peter sandstone ledges in northeastern Iowa.

The species which are present are indicated in each column by the plus signs. The letters following some of the names have the following significance:

a — Species restricted to sands and gravels.
u — Species usually found in sand, sometimes on prairies.
w — Species of moist grounds or sand, or marsh species.
f — Species belonging in the forest, or at least forest borders.
i — Introduced weeds.
o — Plants of open places and often occurring on prairies.

The unmarked species belong to the prairies.

In all cases only pure sand or gravel areas without appreciable humus were considered in these studies.

		I	II	III	IV	V	VI	VII
Subkingdom III PTERIDOPHYTA								
Family								
Equisetum arvense L.	o		+	+	+		+	
Equisetum hyemale L.	o		+		+	+		
Equisetum hyemale intermedium Eat.	o				+			
Equisetum hyemale robustum (ABr.) Eat.	w	+	+					
Equisetum lævigatum A. Br.				+	+	+		
Subkingdom IV SPERMATOPHYTA								
Subclass MONOCOTYLEDONEÆ								
Family *Typhaceæ*								
Typha latifolia L.	w					+		
Family *Alismaceæ*								
Echinodorus cordifolius (L.) Gr.	w					+		
Family *Gramineæ*								
Andropogon furcatus Muhl.		+	+		+	+	+	
Andropogon scoparius Michx.		+	+		+	+	+	
Sorghastrum nutans (L.) Nash				+	+			
Digitaria humifusa Pers.	i					+		

		I	II	III	IV	V	VI	VII
Digitaria sanguinalis (L.) Scop.	i		+		+	+		
Paspalum ciliatifolium Michx.	u			+	+	+		
Panicum capillare L.	o	+	+			+		
Panicum huachuchæ silvicola H. & C.						+	+	
Panicum Scribnerianum Nash		+	+		+	+	+	
Panicum virgatum L.		+	+		+	+	+	
Echinochloa crus-galli (L.) Beauv.	i			+				
Setaria viridis (L.) Beauv.	i			+	+	+		
Cenchrus carolinianus Walt.	u	+	+	+	+	+		
Stipa spartea Trin.		+		+	+			
Aristida basiramea Engelm.				+		+		+
Aristida gracilis Ell.	u			+		+		
Muhlenbergia mexicana (L.) Trin.	o	+						
Muhlenbergia racemosa (Michx.) BSP.	o	+				+		+
Alopecurus geniculatus L.	w			+				
Sporobolus brevifolius (Nutt.) Scrib.	o						+	+
Sporobolus cryptandrus (Torr.) A.Gr.	a	+	+	+	+			
Sporobolus heterolepis Gray						+		
Sporobolus neglectus Nash	u			+	+			
Agrostis alba vulgaris (With.) Thurb.					+			
Sphenopholis obtusata (Michx.) Scrib.					+			
Koeleria cristata (L.) Pers.		+	+	+	+			
Spartina Michauxiana Hitch.	w	+	+					
Bouteloua curtipendula (Michx.) Torr.				+	+			
Bouteloua hirsuta Lag.				+	+			+
Bouteloua oligostachya (Nutt.) Torr.		+						
Tridens flavus (L.) Hitch.	u			+				
Triplasis purpurea (Walt.) Chap.	a				+			
Eragrostis Frankii (T.M.&L.) Steud.	w		+					
Eragrostis hypnoides (Lam.) B.S.P.	w		+					
Eragrostis megastachya (Koel.) Link	i		+			+		
Eragrostis pectinacea spectabilis Gray	u		+	+	+			
Eragrostis pilosa (L.) Beauv.	o		+					
Eragrostis trichodes (Nutt.) Nash	u			+				
Poa compressa L.	i	+			+		+	
Poa pratensis L.	i	+	+	+	+			+
Poa triflora Gilib.	w	+						
Festuca octoflora Walt.		+	+	+	+			
Agropyron Smithii Ryd.		+	+		+			
Agropyron tenerum Vasey		+						
Hordeum jubatum L.		+	+	+	+			
Hordeum pusillum Nutt.				+				
Elymus canadensis L.		+	+	+	+	+	+	
Elymus virginicus L.	o	+						
Family *Cyperaceæ*								
Cyperus acuminatus T. & H.	w					+		

		I	II	III	IV	V	VI	VII
Cyperus aristatus Rottb.	w	+		+				
Cyperus diandrus Torr.	w	+						
Cyperus erythrorhizos Muhl.	w	+						
Cyperus ferax Rich.	w	+	+					
Cyperus filiculmis Vahl.	a		+	+	+			
Cyperus rivularis Kunth	w	+						
Cyperus Schweinitzii Torr.	a	+	+	+	+	+		
Cyperus strigosus L.	w	+						
Cyperus strigosus compositus Britt.	w	+						
Eleocharis acicularis (L.) R. & S.	w	+						
Eleocharis palustris (L.) R. & S.	w	+						
Stenophyllus capillaris (L.) Britt.	i	+		+				
Scirpus americanus Pers.	w					+		
Scirpus validus Vahl.	w					+		
Hemicarpha micrantha (Vahl.) Britt.	w		+					
Carex cephalophora Muhl.	a		+	+	+			
Carex comosa Boott	w	+						
Carex cristata Schw.	w			+				
Carex festucacea Schk.		+	+	+	+			
Carex gravida laxifolia Bail.	w			+				
Carex hystericina Muhl.	w	+						
Carex pennsylvanica Lam.			+		+		+	
Carex scoparia Schk.	w			+				
Carex stenophylla Wahl.		+						
Carex sychnocephala Carey	w	+						
Carex tetanica Meadii (Dew.) Bail.		+						
Carex vulpinoidea Michx.	w	+						
Family *Commelinaceæ*								
Tradescantia bracteata Small				+				
Tradescantia reflexa Raf.	o		+	+	+		+	
Commelina virginica L.	a				+			
Family *Juncaceæ*								
Juncus nodosus L.	w	+						
Juncus tenuis Willd.	o		+	+	+			
Juncus Torreyi Cov.	w	+						
Family *Liliaceæ*								
Allium stellatum Ker.		+						
Smilacina stellata (L.) Desf.				+			+	
Family *Amaryllidaceæ*								
Hypoxis hirsuta (L.) Cov.							+	
Family *Iridaceæ*								
Iris versicolor L.	w	+						
Sisyrinchium campestre Bick.					+		+	
Family *Orchidaceæ*								
Spiranthes cernua (L.) Rich.	w					+		

		I	II	III	IV	V	VI	VII
Subclass DICOTYLEDONEÆ								
Salix cordata Muhl.	w					+		
Family *Salicaceæ*								
Salix amygdaloides Anders.	w					+		
Salix humilis Marsh.			+	+	+	+	+	
Salix longifolia Muhl.	w	+	+		+	+		
Salix missouriensis Bebb	w					+		
Family *Urticaceæ*								
Cannabis sativa L.	i					+		
Urtica gracilis Ait.	w	+	+					
Family *Santalaceæ*								
Comandra umbellata (L.) Nutt.		+			+		+	
Comandra umbellata Richardsoniana (Fern.)		+						
Family *Polygonaceæ*								
Rumex acetosella L.	i		+	+	+		+	
Rumex altissimus Wood				+				
Rumex brittanica L.	w	+						
Rumex crispus L.	i		+		+			
Rumex persicaroides L.	w	+						
Polygonum acre H. B. K.	w	+						
Polygonum convolvulus L.	i	+	+		+			+
Polygonum lapathifolium L.	w	+						
Polygonum pennsylvanicum L.	w		+			+		+
Polygonum ramosissimum Michx.		+	+	+	+			
Polygonum tenue Michx.	a				+			+
Family *Chenopodiaceæ*								
Cycloloma atriplicifolia (Spr.) Coult.	u			+	+			
Chenopodium album L.	i		+	+	+	+		
Chenopodium Boscianum Moq.	f	+						
Chenopodium botrys L.	i				+			
Chenopodium leptophyllum Nutt.		+	+	+	+			
Salsola kali tenuifolia G.F.W. Mey.	i	+	+	+	+	+		
Family *Amaranthaceæ*								
Amaranthus blitoides Wats.						+		
Amaranthus retroflexus L.	i	+	+					
Frœlichia floridana (Nutt.) Moq.	a			+	+			
Family *Nyctaginaceæ*								
Oxybaphus nyctagineus (Michx.) Sweet		+	+		+			
Family *Aizoaceæ*								
Mollugo verticillata L.	a		+	+	+			
Family *Caryophyllaceæ*								
Cerastium viscosum L.	i				+			
Silene antirrhina L.		+	+	+	+			
Silene noctiflora L.	i	+						
Silene stellata (L.) Ait. f.		+	+	+	+			

		I	II	III	IV	V	VI	VII
Saponaria officinalis L.	i			+				
Family *Ranunculaceæ*								
Ranunculus abortivus L.	f					+	+	
Ranunculus cymbalaria Pursh.	w	+						
Ranunculus fascicularis Muhl.					+		+	
Ranunculus pennsylvanicus L. f.	w	+						
Ranunculus sceleratus L.	w	+						
Thalictrum dasycarpum F. & L.			+	+				
Anemonella thalictroides (L.) Spach.	f						+	
Anemone canadensis L.					+			
Anemone caroliniana Walt.				+	+			
Anemone cyclindrica Gray		+	+		+		+	
Anemone patens Wolfgangiana (Bess.) Koch		+						
Clematis Pitcheri T. & G.			+	+	+			
Aquilegia canadensis L.	f	+						
Delphinium Penardii Huth.				+	+			
Family *Fumariaceæ*								
Corydalis aurea occidentalis Eng.	u			+				
Corydalis curvisiliqua Eng.	a			+				
Corydalis micrantha (Eng.) Gray	a	+		+				
Family *Cruciferæ*								
Draba caroliniana Walt.	u		+	+	+			
Lepidium apetalum Willd.		+	+	+	+		+	
Brassica arvensis (L.) Ktze.	i			+				
Brassica nigra (L.) Koch.	i			+				
Sisymbrium canescens Nutt.					+	+		
Sisymbrium canescens brachycarpon (Rich.) Wats.					+	+		
Erysimum cheiranthoides L.	o	+						
Arabis hirsuta (L.) Scop.	f	+						
Family *Capparidaceæ*								
Polanisia graveolens Raf.	a	+	+	+	+			
Polanisia trachysperma T. & G.	a	+		+				
Cristatella Jamesii T. & G.	a				+			
Family *Saxifragaceæ*								
Heuchera hispida Pursh			+	+	+		+	
Ribes gracile Michx.	f				+			
Family *Rosaceæ*								
Spiræa salicifolia L.	w		+					
Fragaria virginiana Duches.		+	+	+	+	+	+	
Potentilla arguta Pursh		+	+		+			
Potentilla canadenais L.			+	+			+	
Potentilla monspeliensis L.		+	+	+	+			
Potentilla Nicollettii (Wats.) Sheld.	w u	+						
Potentilla paradoxa Nutt.	u	+				+		

		I	II	III	IV	V	VI	VII
Potentilla rivularis pentandra (Eng.) Wats.	u			+				
Rubus occidentalis L.	f					+	+	
Rosa humilis Marsh.				+	+	+		
Rosa pratincola Greene		+	+	+	+	+		
Rosa Woodsii Lindl.				+				
Prunus americana Marsh.	f				+			
Prunus virginiana L.	f			+				
Family *Leguminosæ*								
Desmanthus illinoensis (Michx.) MacM.	u	+		+		+		
Cassia chamæcrista L.	o		+	+	+	+		
Baptisia bracteata (Muhl.) Ell.					+			
Baptisia leucantha T. & G.				+				
Crotalaria sagittalis L.	u				+	+		
Trifolium repens L.	i	+	+			+		
Trifolium stoloniferum Muhl.				+	+			
Melilotus alba Desv.	i	+	+		+	+		
Melilotus officinalis (L.) Lam.	i	+		+				
Psoralea esculenta Pursh		+						
Amorpha canescens Pursh			+		+	+	+	+
Amorpha fruticosa L.	w	+						
Dalea enneandra Nutt.	u					+		
Petalostemum candidum Michx.		+	+		+			
Petalostemum purpureum (Vent.) Ryd.		+	+		+	+		
Tephrosia virginiana (L.) Pers.	a			+	+		+	
Astragalus canadensis L.		+	+			+		
Astragalus caryocarpus Ker.		+						
Astragalus distortus T. & G.	a				+			
Desmodium canadense (L.) DC.		+	+	+	+	+		
Desmodium canescens (L.) DC.	u					+		
Desmodium Dillenii Darl.	f					+		
Desmodium illinoense Gray		+	+		+			
Desmodium paniculatum pubens T.&G.	f					+		
Lespedeza capitata Michx.		+	+	+	+	+	+	+
Lespedeza leptostachya Engelm.		+						
Vicia americana Muhl.		+						
Vicia villosa Roth	i			+				
Lathyrus palustris L.	w	+		+				
Lathyrus venosus Muhl.		+						
Strophostyles helvolus (L.) Britt.	a	+	+	+	+	+		
Strophostyles pauciflorus (Benth.) Wats.	u	+	+		+	+		
Family *Linaceæ*								
Linum sulcatum Rid.		+			+	+		+
Family *Oxalidaceæ*								
Oxalis filipes Small		+						
Oxalis stricta L.		+			+			+

		I	II	III	IV	V	VI	VII
Oxalis violacea L.			+		+		+	
Family *Geraniaceæ*								
Geranium carolinianum L.	a		+		+			
Family *Zygophyllaceæ*								
Tribulus terrestris L.	i				+			
Family *Rutaceæ*								
Zanthoxylum americanum Mill.	f			+		+		
Ptelea trifoliata L.	f			+	+			
Family *Polygalaceæ*								
Polygala incarnata L.					+			
Polygala sanguinea L.	u				+			
Polygala verticillata L.					+		+	
Family *Euphorbiaceæ*								
Croton capitatus Michx.	a			+	+			
Croton glandulosus septentrionalis (Muel.) Arg.	a			+				
Euphorbia corollata L.			+	+	+		+	
Euphorbia dentata Michx.	a					+		
Euphorbia glyptosperma Eng.	a	+						
Euphorbia maculata L.				+	+			
Euphorbia polygonifolia L.	a				+			
Euphorbia Preslii Guss.		+	+	+	+	+		
Euphorbia serpens H. B. K.						+		
Euphorbia serpyllifolia Pers.		+	+	+	+			
Family *Anacardiaceæ*								
Rhus canadensis trilobata (Nutt.)Gray	a			+	+			
Rhus glabra L.		+		+	+			
Rhus toxicodendron L.		+	+	+	+	+		
Family *Balsaminaceæ*								
Impatiens biflora Walt.	w	+						
Family *Rhamnaceæ*								
Ceanothus americanus L.			+	+	+			
Family *Vitaceæ*								
Vitis vulpina L.	f	+	+	+	+	+		
Family *Malvaceæ*								
Callirhoe triangulata (Leav.) Gray	o			+	+			
Family *Hypericaceæ*								
Hypericum cistifolium Lam.			+	+	+			
Family *Cistaceæ*								
Helianthemum canadense (L.) Michx.					+			
Helianthemum majus BSP.			+	+	+		+	
Lechea stricta Legg.	f				+			
Lechea tenuifolia Michx.	o				+		+	
Family *Violaceæ*								
Viola cucullata Ait.		+	+			+		
Viola fimbriatula Sm.				+	+			

		I	II	III	IV	V	VI	VII
Viola papilionacea Pursh						+	+	
Viola pedata L.	a		+		+		+	
Viola pedatifida G. Don.		+	+					
Family *Cactaceæ*								
Opuntia Rafinesquii Eng.	a			+	+			
Family *Lythraceæ*								
Ammania coccinea Rottb.	w					+		
Family *Onagraceæ*								
Œnothera biennis L.		+	+		+	+		
Œnothera fruticosa L.				+				
Œnothera muricata L.	u	+		+	+			
Œnothera rhombipetala Nutt.	a		+		+			
Œnothera serrulata Nutt.		+						
Family *Umbelliferæ*								
Eryngium yuccifolium Michx.			+	+	+		+	
Sium cicutæfolium Schranck.	w	+						
Zizia aurea (L.) Koch		+		+				
Pastinaca sativa L.	i			+				
Family *Cornaceæ*								
Cornus amomum Mill.	w	+						
Cornus stolonifera Michx.	w	+						
Family *Primulaceæ*								
Androsace occidentalis Pursh	a		+	+	+			
Family *Apocynaceæ*								
Apocynum cannabinum L.			+		+			
Apocynum cannabinum pubescens (R. Br.) DC.					+			
Family *Asclepiadaceæ*								
Asclepias amplexicaulis Sm.	a		+	+				+
Asclepias incarnata L.	w	+		+				
Asclepias syriaca L.		+	+		+			
Asclepias tuberosa L.		+	+		+			
Asclepias verticillata L.		+	+		+			
Acerates viridiflora Ell.					+			
Acerates viridiflora lanceolata (Ives) Gray			+		+			
Family *Convolvulaceæ*								
Ipomœa hederacea Jacq.	i			+				
Convolvulus sepium L.		+	+	+	+			
Cuscuta arvensis Beyr.	o			+	+			
Cuscuta cuspidata Eng.	o			+				
Family *Polemoniaceæ*								
Phlox bifida Beck	a			+				
Phlox pilosa L.					+			
Family *Hydrophyllaceæ*								
Ellisia nyctelea L.	o		+		+			

		I	II	III	IV	V	VI	VII
Family *Boraginaceæ*								
Lappula Redowskii occidentalis (Wats.) Ryd.		+	+					
Lithospermum angustifolium Michx.		+			+			
Lithospermum canescens (Michx.) Lam.		+	+		+	+	+	
Lithospermum Gmelini (Michx.) Hitch.	u		+	+	+			
Onosmodium occidentale Mack.		+		+	+			
Family *Verbenaceæ*								
Verbena angustifolia Michx.				+	+			
Verbena bracteosa Michx.			+	+	+			
Verbena hastata L.	w	+	+	+	+			
Verbena stricta Vent.		+	+	+	+	+		
Verbena stricta x angustifolia	u			+	+			
Family *Labiatæ*								
Teucrium canadense L.		+	+	+	+			
Isanthus brachiatus (L.) BSP.			+					
Scutellaria parvula Michx.		+						+
Prunella vulgaris L.	f						+	
Stachys palustris L.	w	+	+	+	+	+		
Monarda mollis L.		+	+		+			
Monarda punctata L.	a			+	+			
Hedeoma hispida Pursh		+	+		+	+		
Hedeoma pulegeoides (L.) Pers.			+				+	
Pycnanthemum flexuosum (Walt.) BSP.				+	+			
Lycopus americanus Muhl.	w	+						
Lycopus lucidus americanus Gray	w	+						
Lycopus rubellus Moench.	w	+						
Mentha arvensis canadensis (L.) Briq.	w	+						
Family *Solanaceæ*								
Solanum nigrum L.	i		+	+		+		
Physalis heterophylla Nees						+		
Physalis pruinosa L.		+	+		+			
Physalis pubescens L.		+			+			
Family *Scrophulariaceæ*								
Verbascum thapsus L.	i		+	+	+		+	
Scrophularia leporella Bick.		+	+	+	+			
Pentstemon gracilis Nutt.					+			
Pentstemon grandiflorus Nutt.	u	+			+			
Veronica virginica L.			+					
Gerardia tenuifolia Vahl.	w		+					
Synthyris Bullii (Eat.) Hell.	a				+			
Family *Acanthaceæ*								
Ruellia ciliosa Pursh.			+	+	+		+	
Family *Plantaginaceæ*								
Plantago aristata Michx.				+	+			
Plantago Rugelii Dcne.		+			+			

		I	II	III	IV	V	VI	VII
Family *Rubiaceæ*								
Houstonia minima Beck	a		+		+			
Family *Caprifoliaceæ*								
Symphoricarpos occidentalis Hook.		+						
Family *Cucurbitaceæ*								
Sicyos angulatus L.	f	+						
Family *Campanulaceæ*								
Specularia perfoliata (L.) A. DC.	o			+	+			
Family *Lobeliaceæ*								
Lobelia inflata L.	o				+		+	
Lobelia siphilitica L.	w	+						
Lobelia spicata Lam.					+			
Lobelia spicata hirtella Gray	w	+						
Family *Compositæ*								
Kuhnia eupatoroides corymbulosa T.&G.		+		+	+			
Liatris cylindracea Michx.		+			+			
Liatris punctata Hook.		+						
Liatris pycnostachya Michx.					+			
Liatris scariosa Willd.			+		+			
Solidago canadensis L.		+		+		+		
Solidago graminifolia (L.) Salis.		+		+	+			
Solidago missouriensis Nutt.			+	+	+			
Solidago nemoralis Ait.					+		+	+
Solidago rigida L.		+	+	+	+		+	
Solidago serotina Ait.					+	+		
Solidago speciosa angustata T. & G.			+		+			+
Aster linariifolius L.	a			+	+			
Aster multiflorus exiguus Fern.		+	+	+	+			
Aster novæangliæ L.		+			+			
Aster oblongifolius Nutt.				+	+			
Aster oblongifolius rigidulus Gray				+	+			
Aster ptarmicoides T. & G.					+			
Aster sericeus Vent.		+	+		+		+	+
Erigeron canadensis L.		+	+	+	+	+	+	+
Erigeron divaricatus Michx.					+			
Erigeron philadelphicus L.	w	+						
Erigeron ramosus (Walt.) BSP.		+	+	+	+	+		
Antennaria neodioica Greene					+		+	
Antennaria plantaginifolia (L.) Rich.	o				+		+	
Gnaphalium polycephalum Michx.				+	+			
Silphium integrifolium Michx.			+	+	+			
Silphium laciniatum L.				+	+			
Silphium perfoliatum L.	w	+						
Parthenium integrifolium L.				+				
Iva xanthiifolia Nutt.		+						
Ambrosia artemisiifolia L.		+	+		+		+	+

		I	II	III	IV	V	VI	VII
Ambrosia psilostachya DC.		+	+		+	+		
Ambrosia trifida L.	w	+	+					
Ambrosia trifida integrifolia (Muhl.) T. & G.		+	+		+			
Xanthium commune Britt.	o	+	+			+		
Xanthium speciosum Karn.	o	+						
Heliopsis scabra Dunal.		+	+	+				
Rudbeckia hirta L.			+	+	+		+	
Rudbeckia subtomentosa Pursh					+			
Bidens vulgata puberula (Wieg.) Grn.	w	+						
Brauneria pallida Nutt.			+	+	+			
Lepachys pinnata (Vent.) T. & G.		+	+	+	+			
Helianthus annuus L.				+		+		
Helianthus grosseserratus Mart.		+	+	+	+			
Helianthus occidentalis Rid.			+		+			
Helianthus petiolaris Nutt.	u			+				
Helianthus scaberrimus Ell.		+	+	+	+			
Helianthus tuberosus L.				+				
Coreopsis palmata Nutt.			+	+	+			
Helenium autumnale L.	w	+						
Dyssodia papposa (Vent.) Hitch.			+		+			
Achillea millefolium L.			+		+		+	
Chrysanthemum leucanthemum L.	i			+				
Artemisia caudata Michx.	a	+	+		+	+	+	
Artemisia dracunculoides Pursh.		+			+			
Artemisia ludoviciana Nutt.		+	+		+			
Artemisia serrata Nutt.		+						
Erechtites hieraciifolia (L.) Raf.	f			+				
Cacalia tuberosa Nutt.					+			
Senecio balsamitæ Muhl.	w	+	+					
Senecio integerrimus Nutt.		+						
Senecio plattensis Nutt.					+			
Cirsium altissimum (L.) Spr.				+	+			
Circium canescens Nutt.		+						
Cirsium Hillii (Canb.) Fern.				+	+			
Cirsium iowensis (Pam.) Fern.		+				+		
Krigia amplexicaulis Nutt.					+		+	
Taraxacum officinale Web.	i		+		+	+	+	
Lactuca canadensis L.		+		+	+	+		
Lactuca ludoviciana (Nutt.) Ridd.		+	+	+	+			
Lactuca pulchella (Pursh.) DC.		+		+				
Lactuca sagittifolia Ell.		+						
Lactuca scariola L.	i		+		+			
Lygodesmia rostrata Gray	a					+		
Agoseris cuspidata (Pursh) Steud.		+						

EXPLANATION OF PLATES

Plate I—Beach and bars.

Fig. 1—Sand beach on the south side of Gull Point on West Okoboji lake. The ridge to the left was formed by ice during the preceding winter. August, 1916.

Fig. 2—Sand and mud bar of the Missouri river soon after its formation by a flood. Harrison county, Iowa.

Fig. 3—The same bar a year later. Covered largely with young *Salix longifolia.*

Plate II—Sand dunes.

Fig. 1—A new dune near the Missouri river. West of Missouri Valley, Iowa.

Fig. 2—A somewhat older dune among the cottonwoods, in the same locality.

Fig. 3—An old dune, now covered with *Salix missouriensis* and various prairie and sand species, in the same locality. The dunes and sand flats in the background are covered with a still older cottonwood forest. The U. S. survey of 1853 shows that this part was occupied by the Missouri river at that time.

Plate III—Harrison county sand areas.

Fig. 1—A part of the forest shown in the preceding figure.

Fig. 2—A dune which had been held by *Salix amygdaloides*, but is now breaking down.

Fig. 3—A cottonwood with roots exposed by the blowing away of the sand.

Plate IV—Muscatine county dunes.

Fig. 1—A bare surface at the north end of the Big Mound, with *Gleditsia triacanthos* (dwarfed) in the background.

Fig. 2—North end of Big Mound, with bare surfaces, shifting.

Fig. 3—Dune on Big Mound which has nearly covered a fence; buried posts show at right. At left is part of a newer fence.

Plate V—Muscatine county dunes.

Fig. 1—Old dune in background, with a small ''blow out.'' The soil in the cornfield is also very sandy. *Quercus velutina* is abundant in the sandy soil in background.

Fig. 2—*Mollugo verticillata* on blown out part of dune in fig. 1.

Fig. 3—Old sandy slope on Big Mound, now covered with prairie plants.

A STUDY OF A RED-EYED VIREO'S NEST WHICH CONTAINED A COWBIRD'S EGG

By T. C. Stephens

The nest of the Red-eyed Vireo (*Vireo olivacea*) upon which this study was made was found on June 21, 1916, and contained on this date two Vireo eggs and one Cowbird's egg. The nest was of the usual type, and was suspended in a very low-hanging branch of a red elm tree (*Ulmus fulva*, fig. 1). The general location was the rather heavily wooded lake shore back of Gull Point, on West Lake Okoboji, Iowa.

The position of the nest was so low as to be ideal for study, but the distance from the Laboratory militated against attempting a continuous study. It was planned, however, to make a few short studies, especially to watch the behavior of the young Cowbird. Accordingly two full days from daylight till dark, and one-half day from daylight to noon, were devoted to this work. On July 8 the study began at 4:45 a. m., and continued without intermission until 8:22 p. m. On July 9 the observations began at 5:00 a. m. and continued till 12:00 m. On July 10 in the afternoon a brief visit was made to the nest and a single feeding visit was recorded, No. 176. On July 11 observation again started at 5:05 a. m. and continued until 8:00 p. m. Observations for shorter periods were made on the 13th, 14th and 17th.

The work at the nest-side during these periods was shared by the writer and Mr. Arthur F. Smith about equally; the latter, however, taking the early morning hours. The writer here expresses his obligation to Mr. Smith for this cordial coöperation.

To distinguish the young birds they were marked with aniline dyes in alcoholic solution. On July 8 the nest contained the Cowbird and two young Vireos. One of the latter was marked with methelyn blue, and designated "Blue;" the other was left unmarked, and designated "White."

The two parents were distinguished as follows: The male was much more shy and approached the nest more cautiously, and usually with feathers more or less erected, especially on the crown. The female, on the other hand, was very sleek and well groomed, and displayed very little fear, or scarcely even concern. We soon discovered also that the hind toe was lacking on the right foot of the female. There was also a recognizable difference in the shape of the head in the two individuals; the crown of the male being noticeably higher, i. e., above the level of the eyes, while the crown of the female was low and flat.

No blind was erected for the study of the nest. By depressing the limb slightly, and anchoring it, the nest was low enough to be observed by the person seated. A camp chair was placed beside the nest, first at a distance of four or five feet; but within an hour or so the chair was moved so close that the observer could touch the nest, and further observations were made from this position, with no attempt whatever at concealment.

While the work of the parents went along in a fairly regular manner, there may be some question as to whether their behavior was perfectly normal, or as nearly so as it might have been with the observer concealed in a blind. The parental instincts are so strong at this period that the fear instinct is, to a greater or less extent, modified. However, if there was any modification of normal behavior on this account, it probably did not in any way alter the character of the food brought to the young birds. On one occasion prior to the commencement of the study, the writer approached the nest with care and stroked the back of the female Vireo several times before she flew from the nest. It is impossible, of course, to know to what extent the bird in such a case was possessed of fear of the intruder, and to what extent the fear instinct was subdued by the ascendency of other instincts. For further work along this line there must be devised a method of gauging or standardizing a given instinct or emotion in a wild animal.

So, while birds as fearless as these Vireos seemed to be, can be studied without concealment, it is probably doubtful whether the conclusions as to some forms of action are to be regarded as more than tentative; and general conclusions can be reached only after numerous repetitions of the studies on the same species.[1]

[1] Nevertheless I may quote the following extract from my field note-book: "Feeding today (July 11) has been very slow, but still I am inclined to think it has been normal. When the birds do come there is practically no evidence of timidity, so that it does not seem likely that they are being restrained at all by fear."

Feeding

Both parents shared in this duty, though not quite equally. The number of feeding visits during the time of observation, by hour and sex is shown in Table I.

TABLE I

SHOWING THE FEEDINGS BY THE HOUR ON THREE DAYS

Hour	July 8 Female	Male	Total	July 9 Female	Male	Total	July 11 Female	Male	Total
5:00 a.m.	5	2	7	9	3	12	5	2	7
6:00 a.m.	3	1	4	5	0	5	5	3	8
7:00 a.m.	11	4	15	9	3	12	5	0	5
8:00 a.m.	8	1	9	4	1	5	5	5	10
9:00 a.m.	8	0	8	10	3	13	3	3	6
10:00 a.m.	7	3	10	9	5	14	2	4	6
11:00 a.m.	7	0	7	6	1	7	3	1	4
	49	11	60	52	16	68	28	18	46
12:00 a.m.	14	2	16				2	1	3
1:00 p.m.	9	1	10				1	1	2
2:00 p.m.	6	1	7				3	1	4
3:00 p.m.	4	0	4				5	2	7
4:00 p.m.	4	1	5				3	2	5
5:00 p.m.	3	0	3				2	1	3
6:00 p.m.	1	0	1				2	1	3
7:00 p.m.	1	0	1				2	1	3
	91	16	107	52	16	68	48	28	76
	85%	15%		76%	24%		63%	37%	

These figures show that altogether 75% of the work of feeding was done by the female, while the male did about 25%.

There is considerable work to be done in the study of the variation of the reflexes of the nestling under varying conditions. For instance, at visit No. 75 the record shows that the Cowbird was fed a Mayfly by the female parent. But the notes say also that the morsel was first offered to White who did not respond. And at visit No. 79 the female parent fed a fat green worm to the Cowbird; again the notes say that White was tried several times without a response. Now shall we conclude that the reflex failed in the case of White because the reflex mechanism was in a state of fatigue, or because the particular food did not provide the necessary stimulus?

To answer this question let us observe that at feeding visits Nos. 17, 29, 39, 45, 50, 73, 86, 111, 133, and 198 a Mayfly did evoke the swallowing reflex in White. And that on visits Nos. 100, 155, 228, 240, and 251, it was produced in White with a green worm. Probably, then, the fault was not with the stimulus.

At visit No. 73, just four minutes before visit No. 75, White had been fed a Mayfly, and had received another feeding nine minutes previous to this. It seems fair enough to conclude that the difficulty was internal; either the reflex mechanism was fatigued, or the presence of food in the stomach set up a reflex which inhibited the swallowing reflex. At visit No. 133 a Mayfly was offered to the Cowbird, but the swallowing reflex not being promptly shown, the food was given to White, as recorded.

Sometimes this insistence by the adult on a quick response of the reflexes may work to the detriment of the young, as illustrated in the following incident. At visit No. 107 the female bird brought a large green worm, a quarter of an inch in diameter and an inch and a half long — of sufficient thickness to greatly distend the gullet of the nestling. White was tried and responded but the worm entered the gullet slowly, and the mother became impatient and jerked the worm to give it a new start, or to test another young one. White, however, held on, or could not let go, and was pulled out onto the rim of the nest, from which he toppled over and fell to the ground. As this was happening the mother bird hopped over and caught hold of the green worm in White's mouth, thus saving the worm which was now promptly fed to the Cowbird. While the Cowbird had nothing to do directly with the accident to White, yet it would not have happened, probably, if the big Cowbird (at least twice the size of either Vireo) had not been present to fill up the cavity of the nest. After feeding the Cowbird the mother bird looked carefully into the nest, as if to see what had happened, but immediately flew away, apparently without further concern. White was then replaced in the nest by the observer.

Regurgitation

Although the young were a few days old at the time of observation, a very careful watch was kept for evidence of regurgitative feeding. No evidence was found.[2] In all but one or two visits the food was visible in the bird's beak, though not always identified, of course. In the feeding process of this species there is not time enough for any regurgitation. There was no instance of feeding in which the bill of the old bird was not inserted and withdrawn practically instantaneously.

Some observers have noticed a thread of saliva connecting the beaks of the parent and nestling after withdrawal of the former's bill. This saliva thread was repeatedly observed at this nest, and did not in the slightest degree suggest regurgitative feeding.

At visit No. 28 the female carried two unrecognized objects (probably snails) in her beak. One was fed to Cowbird and one to Blue. After each withdrawal a thread of saliva one and a half to two inches long was drawn out. The same saliva thread was also noted at visits Nos. 33, 53, 81, etc.

TABLE II

SHOWING THE VARIETY OF FOOD, AND THE NUMBER OF FEEDINGS TO EACH NESTLING DURING THE PERIOD OF OBSERVATION

	To Blue	To White	To Cowbird	To ?	Total
"Green worms"	19	10	20	1	50
Spiders	20	14	8		42
Lepidoptera	15	12	14		41
Mayflies	11	11	18		40
Snails	7	10	8	1	26
Miscellaneous larvae	9	7	5		22
Diptera	5	4	9		18
Probably Snails	5	1	7	1	14
Miscellaneous insects	3	1	6		10
Unknown	4	1	4		9
Grasshoppers	2		3		5
Odonata	1	1	1		3
Harvestman	1				1

Food

Table II classifies and summarizes the food. No seeds or fruit appear in the list, of course. The great bulk of the insect food is such as the birds would be able to pick from the foliage of the trees and shrubs. The food table shows the relative abundance

[2] The writer has elsewhere discussed the nature of evidence for and against this kind of feeding. See Journ. Animal Behavior, VII, 4, 1917.

of different kinds of food materials; but it is a numerical table, and does not show the quantities of food in terms of bulk or weight. Results upon the latter basis must be left for a laboratory examination.

During the short time which these Vireos were under observation we did not see any regurgitation of pellets of undigested food, as has been described by Nuttal [3] and also by Herrick.[4]

One of the most interesting facts obtained in the study of these Vireos was that land snails formed a considerable portion of the nestling diet. In the food table (Table II) it is shown that the snails stand fifth in numerical abundance. If we add to this the items which were thought to be snails (without certain identification), our total would then place the snail in the third place.

Some of the snails were specifically identified. Thus twelve snails were recognized as *Succinea avara*, and all of them were delivered by the female. At visit No. 210 the male carried one specimen of *Bifidaria armifera*. At other visits the depressed shells were brought, but these were not so easily recognized. For instance, at visit No. 200 the female brought a depressed, polished shell which must have been either *Vitrea hammonis* or *Zonitoides arboreus*, since the only similarly depressed species in the region is *Pyramidula striatella* (*P. cronkhitei anthomy*), which is not polished, but ribbed.

At visit No. 9 a snail was removed by the mother from the Cowbird's mouth, and crunched in her beak so that the observers heard the sound.

Although I have not been able to make an exhaustive search of the literature, I have been unable to find any reference to the use of snails as food by the Vireos. So we cannot say whether the present instance is an idiosyncrasy or a more general habit which has hitherto been overlooked. Perhaps it indicates a greater tendency for ground feeding than has been recognized heretofore. Although Herrick [5] makes this significant remark: "The adult Vireos glean most of their animal food from the foliage and, as might be expected, are great caterpillar destroyers, but while feeding their young I frequently saw them explor-

[3] Nuttall: Popular Handbook of Birds of the Eastern United States and Canada. Revised edition, 1911. Part I, page 185.

[4] Herrick: The Home Life of Wild Birds. Revised edition, 1905. Page 106.

[5] Op. cit., page 109.

ing the grass as any Robin or Song Sparrow might do, snapping up everything which came in their path."

The most common kind of food for the nestlings was "green worms," making up about 17% of the whole. The term is, of course, very indefinite, and refers to any soft-bodied, worm-like larva which is green in color. But since probably all of these larvae were feeding on the green foliage of one kind of another, their destruction must on the whole be beneficial, economically.

Spiders constituted next to the most abundant kind of food for the nestlings. At visit No. 264 the female bird brought a spider to the nest which was of a species that I had noticed frequently in the beaks of the parent birds, as well as often in the woods. I was able to take this specimen from the beak of the parent bird and preserve it for later identification. In due time this specimen was identified by Mr. J. H. Emerton as *Epeira trivittata* Keyserling. This is a very common round web spider, whose web is stretched between the branches of the trees at all heights up to fifteen or twenty feet, and would thus be readily found by the foliage gleaning Vireos.

Shortly after visit No. 90 the male came to the nest with a small snail, and had it in the mouth of White, when I made an effort to secure the specimen for identification; my manipulation of the forceps at his beak frightened him away, carrying the specimen with him, thus thwarting my purpose. Again at visit No. 102 the female came with two shells in her beak; in order to delay the feeding so that I might have an opportunity to identify the specimens, I made a movement to attract her attention, which, however, drove her away; but not until I had positively identified both shells as *Succinea avara.*

At visit No. 267 the female brought another *Succinea avara*, and I made a determined effort to secure it with my forceps, but failed, and it was fed to White.

Cowbird Behavior

It was hoped to make the behavior of the nestling Cowbird the special feature of this study; but its early disappearance frustrated this purpose to some extent. The young Cowbird was in the nest at eight o'clock p. m. on July 9th but was missed in the afternoon of the next day.

We never knew whether an accident befell the Cowbird, or whether it departed from the nest in the natural way. Our attention was not drawn to the old birds giving any care to it away from the nest. The following notes were recorded on the forenoon of the 8th:

"40. 9:39 a. m. Cowbird gets his feet against one rim of the nest, and with this brace pushes backward against the young Vireos."

"49. 10:24 a. m. Cowbird attempts to preen feathers, and repeatedly raises up in nest to stretch, and at same time crowds Vireo young to the wall."

These notes suggest that the Cowbird was preparing for departure, and also the manner in which the rightful owners of the nest may be evicted.

TABLE III

SHOWING THE RELATIVE NUMBER OF FEEDINGS GIVEN EACH OF THE NESTLINGS DURING CERTAIN PERIODS WHILE THE COWBIRD WAS STILL IN THE NEST. THE RECORDS FOR JULY 8 ARE FOR THE ENTIRE DAY; THOSE OF JULY 9 ARE FROM DAY-LIGHT TO NOON

	July 8	July 9	Total	Percentage
White	18	8	26	15
Blue	30	16	46	27
Cowbird	57	44	101	58
	105	68	173	

The tabulation of the feeding visits (see Table III) shows that during the day and a half of study, before the Cowbird disappeared, it received 58 per cent of all the food. While this may seem to be an excessive proportion of food, two factors may be borne in mind, viz., that the Cowbird was both older and larger, besides being a Cowbird. The data of this study show that, during the same period, Blue, the older Vireo, got 27 per cent of the food, while White, the younger, got 15 per cent. While this may be a general and simple fact, our inquiry here is simply as to whether the Cowbird got more food by virtue of being a Cowbird, or also because of other factors. Our answer is that we cannot overlook the facts of age and size; and further discussion would relate to the instincts of the adult Cowbird in selecting the nest and time for deposition of the egg, which is beyond the present purpose.

Nuttall [6] says: "The Red-eyed Vireo is one of the most favorite of all the adopted nurses of the Cowbird; and the remarkable gentleness of its disposition and watchful affection for the safety of its young, or the foundling confided to its care, amply justifies this selection of a foster parent."

The same author also says: [7] "The most usual nurse of this bird seems to be the Red-eyed Vireo, who commences sitting as soon as the Cowbird's egg is deposited." He also suggests, in effect, that the incubation period of the Cowbird is shorter than that of the Vireo (page 107). This question should be easy of determination under favorable circumstances, and is important. If the Cowbird deposits her egg in a nest before the other eggs are laid, the rightful owner is more likely to desert. If the nest already contains a clutch of eggs, then the shorter incubation period for the parasite would be a very decided advantage.

Instinct or Intelligence [8]

Coues [9] has attempted an analysis of the behavior of the rightful owners of a nest after the intrusion of a Cowbird's egg, and his evident conclusion is that they are usually conscious of the imposition, and intelligently decide to make the best of it. Or that when the parasitic egg is buried under a superstructure, it is indicative of a mental faculty analogous to human reason. Coues states that "instinct is a lower order of reason," which view may be in harmony with the present views of behaviorists, insofar that the development of instincts precedes that of the reasoning faculty; and that intelligent behavior may in some organisms control instinctive behavior, and in the higher organ-

[6] Op. cit., page 182.

[7] Ibid., page 107.

[8] In the discussion of this topic the writer is guided by the interpretation of animal behavior as recently set forth by Parmalee in "The Science of Human Behavior." According to this interpretation the simplest form of behavior is the tropism — a direct and predictable motor response of an organism to an external stimulus. Next in order is the reflex arc — similar in action to the tropism, but operating only in the specialized tissues of the nervous system. An instinct is defined as "an inherited combination of reflexes which have been integrated by the central nervous system so as to cause an external activity of the organism which usually characterizes a whole species and is usually adaptive." Intelligent action is based upon experience and depends upon associative memory. "Intelligent behavior is therefore made up of tropic, reflex, and instinctive actions which have been combined in new ways as a result of experience so as to constitute new forms of behavior." (Page 258). Intelligent action depends upon the development of the association areas in the central nervous system, by means of which experience, or past images, may be used as stimuli.

[9] Birds of the Northwest. By Elliott Coues. Washington, 1874. Pages 180-186.

isms supercede it. He says, however, that "Instinct . . . could never lead a Summer Yellow-bird up to building a two-story nest to let a Cowbird's egg addle below." And also, on the subject of a two-story nest, "It argues as intelligent a design as was ever indicated in the erection of a building by a human being. No question of inherited tendency enters here; and if it did, the issue would only be set back a step no nearer determination, for there must have been an original double nest, the result of an original idea." A different interpretation of this behavior will be offered presently, but first let us note that Coues' conception of an instinct differs very little from our own, as indicated in the following words: "Such an 'instinct' is merely force of habit, inherited or acquired — a sum of tendencies operating unknowingly and uniformly upon the same recurring circumstances, devoid of conscious design, lacking recognized prevision; totally inadequate to the requirements of the special emergency." (*Ibid.*, page 183).

There need be no denial of the fact that the imposed-upon birds often give signs of distress at the visit of the imposter Cowbird. Similar signs of distress are shown, however, by practically all birds at the approach of an enemy. If their distress could be subjected to analysis no doubt the emotions of fear and anger would be prominent components. These emotions are commonly and readily explained as instinctive.

Suppose, now, that a Cowbird egg is deposited, and is found by the rightful owners of the nest upon their return. The most difficult problem of the case is now presented. Do the imposed-upon birds recognize the egg as an object which will hatch into a young bird larger than their own, and which will be detrimental to their own offspring? Or do they simply recognize the egg as a foreign body which does not belong in their nest? Our answer to this inquiry will, doubtless, point the way to the conclusion as to instinctive or intelligent behavior in the case.

Under one set of circumstances the Cowbird may have been discovered at the nest of another bird; the latter shows signs of excitement and opposition to the presence of the Cowbird. Upon the withdrawal of the Cowbird the exciting stimulus is removed and the reactions cease. Such behavior may take place without greater necessity of assuming intelligence than in the case of the reactions of an amoeba.

To illustrate the absence of a thought process we may recall the incident related on page 28, and note the apparent unconcern which the female Red-eyed Vireo showed when its youngest nestling was jerked out of the nest and fell to the ground. Here so serious an event as the loss of a young one did not seem to set in motion any reactions, because, as I interpret it, the stimulus was unique, and could not excite any stereotyped or instinctive response. The mechanism for instituting any new response was lacking.

Under another set of circumstances the Cowbird's eggs may have been laid in the nest. There are, at least, four possible types of response to the presence of the Cowbird's egg, viz., (1) the acceptance and continuation of incubation; (2) the abandonment of the nest and egg; (3) the removal of foreign egg from the nest by the hosts (and I do not know of any specific instance of such behavior); (4) the building of a superstructure over the intruded egg.

The relative frequency of these responses has probably not been determined. Nor will I attempt to discuss the relative complexity of the several responses. The first one named is probably the most frequent one, and possibly the simplest, since it involves only the supersedure by the highly developed chain-reflexes of the breeding period of any other reflexes which might be affected by the foreign egg. But in any of the possible cases, to put the reaction in the class of intelligent behavior, we must concede a knowledge on the part of the bird of the potential consequences of the foreign egg. It seems doubtful to the writer if the evidence will justify this conclusion, and that we are compelled to seek a simpler explanation if it is possible.

Before offering an explanation of the behavior in question in terms of reflex action, it will be necessary to describe a simple experiment performed at the Vireo's nest.

On Tuesday, July 11th, shortly after noon, the writer was at the nest, and conceived the notion of placing a small piece of green paper on the edge of the nest, for the purpose of ascertaining what effect it might have on the fairly well-established routine of behavior of the parent birds.

The male Vireo came first (visit No. 226), and fed a green worm to Blue. He then picked up the green paper quickly, but dropped it to catch the excreta sac voided by Blue. It had been the habit throughout this day for the parents to carry away the excreta. It is well known that many nest-building birds devour the excreta sacs of the young until they reach a certain age (or until a limit is fixed by some other factor), after which it is carried away and deposited. On the occasion of this experiment the male Vireo dropped the green paper to catch the excreta, which he immediately devoured, contrary to the existing habit, and then again picked up the paper and flew away.

A similar piece of green paper was again placed in the nest, and the female bird came (visit No. 227), and fed a moth to White. Almost exactly the same performance was repeated. One fact of difference being that owing, perhaps, to the earlier stage of development of White, the habit of carrying away the excreta had been more recently established.

Somewhat later a small bit of paper was rolled into a ball and deposited in the nest, where it remained unseen by the parent birds for several visits. When the female Vireo finally discovered it (visit No. 240), she swallowed the excreta sac from White, instead of carrying it away, and flew away with the paper ball.

We cannot suppose that the birds had any knowledge of the nature of the foreign body (the paper), but its presence was a sufficient stimulus, and the removal was the reaction. Some doubt may be expressed as to whether this behavior can be ranked any higher than a reflex act, or an integration of several reflexes. It was here possible for the birds to remove the foreign object. What if it had been too large or too heavy for them to move? Would they not then have been forced to one of the other alternatives, possibly to abandon the nest or build a superstructure? So that, when the host species does resort to one or other of these two responses in the case of a Cowbird's egg, is the behavior not explainable in the same terms that we have suggested in the experiment with the paper?

It would have been interesting could it have been determined in just what manner the paper ball was deposited; since the habit of removing and depositing the excreta sac becomes a more or less stereotyped process in many species. Some birds drop the excreta while in flight, others carefully deposit it on the limb of a tree, or on the ground, etc. The removal of the foreign object (the paper) was probably a reaction controlled by very much the same nervous mechanism as that which controlled the behavior in the excreta removal. Thus, we may explain the apparently unique behavior of the birds in promptly removing the foreign bodies, such as bits of paper, as a modification of a well-developed instinct of removing the excreta from the nest; and which is adaptive, but not purposeful.

May we not also explain the behavior of birds toward a foreign egg in the same way? May we not consider the Cowbird's egg to be a foreign body, merely, to the imposed-upon parents? And it is not only unnecessary, but unwarranted to assume that the foster parents have any knowledge of the potential capacity of this egg to hatch, or to have any conscious knowledge of the past experience by which they may draw judgments? Are the facts of this behavior not sufficiently explained in terms of reflex action, as suggested above?

The capacity for intelligent action, or the actual occurrence of it in birds under other circumstances is not denied or discussed here.

During the season of 1916 Professor B. Shimek, Director of the Iowa Lakeside Laboratory, generously placed at my disposal the facilities of this institution, and I appreciate the many courtesies and kindnesses extended to me.

EXPLANATION OF PLATES

Plate VI

Fig. 1—General view of the nest site. Nest is in depressed limb of the elm tree.

Fig. 2—Nearer view of the Vireo nest.

Fig. 3—The young are removed to show how much larger the Cowbird is than the Vireo nestlings.

Plate VII

Fig. 1—The Female Vireo inspecting the young.

Fig. 2—The Female Vireo at the nest. The pencil is held almost in contact with her bill.

Fig. 3—The Male Vireo at the nest. He was a little more aggressive and would peck at the pencil.

Plate VIII

Fig. 1—The female feeding.

Fig. 2—The female often sat for several seconds beside the nest after feeding.

Fig. 3—Inspecting.

THE PENTATOMOIDEA OF THE LAKE OKOBOJI REGION

By Dayton Stoner

The present paper is based on collecting and observations made, for the most part, in the vicinity of Okoboji lakes, Dickinson county in northwestern Iowa. It is offered as a general preliminary and progress report of a more extensive treatise, now under way by the writer, dealing with the Pentatomoidea of the entire state of Iowa. The discussion which follows includes some new distributional records within the state with notes on abundance, habitats, etc., of some species of pentatomids and presents a list of these insects occurring in northwestern Iowa which may serve as a basis for future studies in this group.

Collecting of material upon which this work is based was done during the latter half of June and at intervals during July and August, 1916. As indicated by the number of nymphs found, especially during June, it seems apparent that the season averages somewhat later in northwestern Iowa than in the central and southern portions of the state. Pentatomids were not found in any numbers on typical prairie plants before the latter part of July when such plants were only beginning to flower. Most of the specimens were taken by sweeping grasses, weeds and foliage with a hand net, while others were taken by digging about the roots of vegetation growing on sandy beaches. A large share of the collecting was done in the vicinity of the Macbride Lakeside Laboratory situated on the west shore of West Okoboji lake. In addition, outlying points as far away as Sioux City were visited. Twenty-nine of the sixty species of pentatomids now recorded from Iowa are mentioned in this paper, along with one species not before recorded and it is probable that further collecting and study will reveal several others from this most interesting region.

Acknowledgment for assistance in the collecting of specimens

is due L. L. Buchanan, Wilbur Briggs, Miss Eva Hastings, my wife, and others who were present at the Lakeside Laboratory during the summer. To Professor B. Shimek the writer is indebted for the determination of the plants hereinafter mentioned.

In the arrangement and classification of species the system adopted by E. P. Van Duzee in his Check List of the Hemiptera has been followed.[1]

A brief review of the general physiographic features of some typical collecting grounds may not be out of place here. However, for a more comprehensive account of the physiographic features of the Okoboji region as a whole, the reader is referred to Professor Shimek's paper on "The Plant Geography of the Lake Okoboji Region."[2]

The vicinity of the Macbride Lakeside Laboratory offers excellent collecting grounds all within easy access. Indeed, so many ecological areas are seldom found within so circumscribed a region. Deep woods, swamps, sandy beaches, high rolling prairies with their respective types of flora — all are within one's ability to investigate and they afford excellent opportunities for the entomologist. The Laboratory itself is situated at the head of Miller's Bay on West Okoboji lake which Professor Shimek has designated "the finest body of water in Iowa." Immediately to the south of the Laboratory grounds the topography is rough and all along the margin of the lake are rather abrupt banks on which typical forest vegetation is found. These well-wooded ridges are separated at intervals by swamps and sloughs. In the wooded areas *Cosmopepla bimaculata, Apateticus cynicus* and *Euschistus tristigmus* were found in some numbers. The region to the north of the Laboratory is high, rolling prairie.

Lookout, a considerable elevation a quarter of a mile west of the Laboratory, is about 155 feet above the level of the lake. Here, xerophytic conditions prevail and pentatomids more typical of the prairie were found, the Scutellerid *Homœmus bijugis* being most abundant.

Elm Crest, about a mile southeast of the Laboratory, presents a shore line of high, wooded banks. From here there is a gradual slope away from the margin of the lake to the southeast furnish-

[1] Van Duzee, E. P. Check List of the Hemiptera of America North of Mexico, N. Y. Ent. Soc., 1916.

[2] Bulletin from the Laboratories of Natural History, State University of Iowa, Vol. VII, pp. 4-13, 1915.

ing low, swampy areas and kettleholes. Farther to the south of Elm Crest the Beck canal has been constructed through a part of the above-mentioned swamp along a wooded peninsula. Between the canal and the woods rank growths of weeds, hazel, wild grape and willow yielded such species as *Euschistus tristigmus*, *Thyreocoris lateralis*, *Thyreocoris nitiduloides*, *Brochymena quadripustulata*, etc. To the south of the canal are open fields of native and cultivated grasses where *Homæmus bijugis* was found in some numbers.

Gull Point, about three miles southeast of the Laboratory, presents a fine, sandy beach extending a hundred yards or more out into the lake. The sandy soil here supports such plants as Wormwood, Rush Grass, Beard Tongue and Sedge. In the sand among the roots of these plants were found the only specimens of *Æthus obliquus* taken in the region.

Hayward's Bay offered the best pentatomid collecting ground in the vicinity of the Laboratory. Here, along the east side of West Okoboji lake is another low, sandy beach with small elevations and swales just away from the margin of the lake. A few yards directly east from the head of the bay is a small, swampy area grown up in rushes and water plants which furnished nesting places for many Red-wing Blackbirds. Excellent collecting was enjoyed along the edges of this swamp on the cultivated and native grasses. Such places yielded *Podops parvulus*, *Thyreocoris pulicarius* and *Thyreocoris ater*. On both north and south sides of the swamp are low hills, the larger of which presents a southwest exposure and the sandy soil supports an abundance of blue grass and red clover with a few native plants. Here, *Homæmus bijugis* was very common with *Euschistus variolarius*, *Coenus delius*, *Neottiglossa undata*, *Cosmopepla bimaculata* and others present in some numbers. Nowhere else in the Okoboji region were so many species of pentatomids found in such great abundance as in this small area of perhaps three acres.

Of the outlying points where good collecting was had in northwestern Iowa but three will be mentioned.

At Estherville, about sixteen miles east of the Laboratory in Emmet county, collecting was done on the upland prairie which furnishes a portion of the watershed between the Missouri and Mississippi drainage systems.

Sibley, about twenty-five miles west of Okoboji lakes in Osceola county, is situated on a low, flat, prairie country with characteristic flora. There are few trees except cottonwoods and willows. However, it was not on this wild, unbroken prairie that pentatomids seemed most abundant but along the margins of cultivated fields and roadsides, where semi-cultivated areas are the rule. Few of the pentatomids seemed to be attracted by the wild prairie flowers and plants, at least during July, and most were taken from the cultivated ones such as blue grass, timothy, red clover, etc.

Toward the latter part of July, part of a day was spent in collecting southeast of Sioux City in the vicinity of Sargents Bluff. Here again it was demonstrated that at this season of the year at least, few pentatomids were to be found on the hills and high prairies that had never been under cultivation. Better results were obtained in the semi-cultivated orchards and fields and along roadsides.

Family SCUTELLERIDÆ

Subfamily Tetyrinæ

Homœmus æneifrons Say. During the summer but two specimens which can with certainty be placed in this species were taken. Two other specimens collected by M. P. Somes at Rock Rapids in September, 1914, are also referable to the present species which appears to be much less common than the following. Specimens are at hand from Lake Okoboji, Estherville, and Rock Rapids.

Homœmus bijugis Uhler. One hundred and fifty-five specimens of this form were taken mostly from prairie and blue grass pastures along the edges of woods. Of this lot twenty-two are nymphs most of which were taken in June although a few half-grown ones were taken as late as August 16. Next to *Cosmopepla bimaculata* this was the most abundant species of pentatomid found in the region. The adults became more and more evident as the season advanced until in the latter half of July and during August they reached the maximum of abundance. The species is represented by specimens from Lake Okoboji, Sibley, Estherville, Emmetsburg, Granite, and Silver Lake.

Subfamily Odontotarsinæ

Eurygaster alternatus Say. This species was taken only on low swampy prairie and roadsides grown up in timothy and blue grass at Lake Okoboji, Sibley, and Emmetsburg. It is represented by four specimens two of which are nymphs taken in July.

Family CYDNIDÆ

Subfamily Thyreocorinæ

Thyreocoris ater A. and S. Several specimens of this species were taken on the weeds and grass along the margins of both Spirit and West Okoboji lakes.

Thyreocoris nitiduloides Wolff. The most common Thyreocorid of the region and commonly found along the edges of woods and on prairie hill-side pastures. Several nymphs also were taken, most of them in July. Specimens are at hand from Lake Okoboji and Granite.

Thyreocoris lateralis Fabr. But ten specimens of this species were taken during the summer and at Lake Okoboji only. All the specimens were taken in July. They are usually found on vegetation along the edges of woods in more or less moist situations.

Thyreocoris pulicarius Germ. Two specimens only of this smallest Iowa Thyreocorid were taken in this region.

Subfamily Cydninæ

Æthus obliquus Uhler. This species, first recorded from Iowa by the writer, (Ent. News, XXIII, 182, 1916) was found in considerable numbers on the sandy beaches at Gull Point. Heretofore, no nymphs had been found but in the locality just mentioned on July 4, nymphs far outnumbered living adults. In all, sixty-three specimens were taken; fifty-seven of these were nymphs, some still in the first instar others apparently ready to molt for the last time. A number of dead adults and a single live one were also taken. The specimens were collected from among the roots of the following plants all of which grow in considerable abundance on this sandy peninsula: Beard Tongue (*Penstemon grandiflorus* Nutt.), Sedge (*Cyperus schweinitzii* Torr.), Wormwood (*Artemisia caudata* Michx.) and Rush Grass (*Sporobolus cryptandrus* (Torr.) Gray). Usually not more than three or four nymphs were found under a single plant; however, in one instance, twenty-seven nymphs of different sizes were found in the sand among the roots of one small bunch of Rush Grass. Some of the nymphs collected were found near the bases of the stalks of Rush Grass, not hidden in the sand at all but under the dead fragments of leaves and stems lying on the sand. A few specimens were found down between adjacent stalks and buried to a depth of an inch or more in the sand. At Iowa City, the first locality record for Iowa, this species has been taken only from among the roots of Rush Grass and until September, 1916, no nymphs had been taken. On September 23 a single half-grown nymph was colletced at this place.

Amnestus spinifrons Say. But two specimens of this species were secured and these constitute the only ones taken in the state during the past three summers. The present specimens were taken from blue grass on the sandy knolls immediately to the south and west of the Lakeside Laboratory.

Amnestus pusillus Uhler. One specimen of this small Cydnid was taken in July at the same locality as the preceding. The only other Iowa specimens at hand are from Iowa City.

Sehirus cinctus P. B. At Lake Okoboji to the south west of Elm Crest two specimens of this species were taken in a low cleared space grown up in timothy and blue grass. Six other specimens were taken at Forest City from weeds growing along the margins of a large drainage ditch. The species has usually been found in low places near water.

Family PENTATOMIDÆ

Subfamily Graphosominæ

Podops cinctipes Say. This and the following species were always found in damp situations and were not abundant at any time. The long grass about the swamp at Hayward's Bay proved to be the best collecting ground for members of this subfamily although but a single specimen of the present species was taken.

Podops parvulus Van Duzee. This species has not before been recorded from Iowa. Seven specimens are at hand from Lake Okoboji and Estherville. The small size, short, acute humeral tooth and somewhat explanate juga will serve to differentiate this species from *P. cinctipes*. Another specimen of *P. parvulus* has been taken at Solon, Iowa, by L. L. Buchanan.

Subfamily Pentatominæ

Brochymena quadripustulata Fabr. In the Okoboji material two half grown nymphs, taken July 4, represent this species. The specimens were taken from low willows along the Beck canal.

Peribalus limbolarius Stål. Surprisingly few specimens of this usually common species of pentatomid were taken in northwestern Iowa, the summer's quota amounting to but nine individuals; three of these are nymphs taken during July and August.

Trichopepla semivittata Say. One specimen of this widely distributed species was taken at Hayward's Bay. The species appears to be nowhere common in Iowa and most of the specimens at hand have been collected in the southern portions of the state.

Mormidea lugens Fabr. Four specimens only were taken and all at Lake Okoboji. One of these is a nymph about half grown and taken July 17. The few specimens collected were all swept from blue grass on small cleared areas in the woods.

Euschistus euschistoides Voll. Five of the twelve specimens secured at Lake Okoboji, Sioux City, and Estherville are nymphs. The species was found most often in low cultivated or semicultivated areas containing more or less timothy and red clover.

Euschistus tristigmus Say. This species was one of the most abundant woodland forms found in the region, occurring commonly in or along the edges of wooded areas on wild raspberry. Forty specimens were taken three of which are half grown nymphs. Other nymphs also were seen but not retained.

Euschistus variolarius P. B. This species did not prove to be as abundant in northwestern Iowa as in most places in the state where it is perhaps the most common of any of our pentatomids. Forty-seven specimens in all were taken and fifteen of these are nymphs representing all stages of development. At Sioux City in July the present species was found more common than in other localities visited. Other localities are Lake Okoboji, Sibley, Emmetsburg, Clarion, Silver Lake, and Forest City.

Euschistus ictericus Linn. Only two specimens of this species which very closely resembles *E. variolarius* were taken in northwestern Iowa, one at Lake Okoboji the other at Sioux City. Both present the irregular, calloused ruga between the humeri which are lengthened and acutely produced.

Cœnus delius Say. Adult specimens of this species were not taken earlier than July 4 and this seems to be one of the forms that averages later in reaching maturity than many of the others. In no other species except *Apateticus cynicus* was so great a percentage of nymphs taken, for, of the thirty-three specimens collected, twenty are immature, some apparently being in the second instar. The species is most common in timothy and clover fields and along simicultivated roadsides. Localities are as follows: Lake Okoboji, Estherville, Sioux City, Emmetsburg, and Clarion.

Neottiglossa undata Say. This species was not uncommon in open country on blue grass and along roadsides but it has not been found on native prairie grasses. Occasionally a specimen was found in cleared spaces in the woods. Nineteen of the eighty-two specimens secured are immature. Nymphs in first and second instars were taken in the middle of July. Specimens from Lake Okoboji, Estherville, Emmetsburg, Clarion, Sibley, and Forest City.

Neottiglossa sulcifrons Stål. The previously recorded specimens of this species which was first taken in Iowa by the writer in 1915 were collected in the southern one-fourth of the state so it was rather a surprise to discover specimens so far to the northward. In all, ten individuals were secured from Lake Okoboji, Sioux City, and Emmetsburg. At Sioux City seven of the specimens were collected in a hilly orchard thickly grown up in long blue grass and timothy. This offered much the same sort of habitat in which the species was found at Burlington in June, 1915.

Cosmopepla bimaculata Thomas. This was by far the most common species in the vicinity of the Laboratory, particularly during June and the first half of July. It was found commonly in wooded areas and along the edges of woods especially in damp situations. On June 19, this species was swept in great numbers from Black Mustard, (*Brassica nigra* Koch.) growing in a small cleared area in the woods south of the Laboratory. Over one hundred specimens were collected in a few strokes of the hand net. On June 22, the species was found in some numbers on one of the parsnips, (*Thaspium aureum* Nutt.). The localities represented are Lake Okoboji, Forest City, Sibley, Silver Lake, Estherville, and Clarion.

Acrosternum hilaris Say. This large, green pentatomid of which but six specimens were taken, was found most often in or along the edges of woods on wild grape. Although the species has been taken at several places in other parts of the state it appears to be nowhere common and in northwestern Iowa was taken only in the vicinity of the Laboratory. It is sometimes found on wild cherry.

Banasa dimidiata Say. Four specimens only of this species were collected in similar situations to the preceding. One specimen is an adult apparently but recently molted since the body integument was still very soft when taken on August 22. This appears to be a woodland form and the few specimens collected in the state have all been found under or taken on deciduous trees.

Subfamily Asopinæ

Apateticus cynicus Say. Six nymphs and one adult of this largest of the Iowa pentatomids were taken at Lake Okoboji only. The species seems to be more typical of woodlands, apparently being most common in small cleared areas in the woods or at the edges of woods. All the nymphs were taken before the middle of July. As illustrating the predaceous propensities of this species the following incident may be mentioned. On the afternoon of July 4 while out collecting, two half grown nymphs of *Apateticus cynicus* were placed in a small tin box about two inches square together with two nymphs of *Brochymena quadripustulata* of about the same size. A portion of a raspberry and also of a grape leaf was added to the box which was not opened until the afternoon of July 8 when it was found that nothing but the empty skins of the Brochymenas were left, the *Apateticus* nymphs apparently having made a meal of them.

Podisus maculiventris Say. Apparently not a common species in northwestern Iowa. But three specimens were taken at Lake Okoboji and Sibley. At other points in the state it has commonly been taken on clover and timothy.

EXPLANATION OF PLATES

Plate IX—

Fig. 1—Sandy beach south of Laboratory dock, looking south.

Fig. 2—Low area along edge of woods south of Miller's Bay Hotel.

Fig. 3—Marsh southeast of Miller's Bay Hotel with Lake in distant background and Beck canal along edge of woods.

Plate X—

Fig. 1—Beck canal in foreground with marshes, kettleholes and woods in background.

Fig. 2—Lookout, a gravelly knoll west of the Laboratory, looking east. Native prairie in foreground.

Fig. 3—Field of red clover, timothy, blue grass, and a few native prairie plants on high prairie along C. R. I. & P. R. R. tracks, Estherville.

CLEISTOGAMY IN HETERANTHERA DUBIA

By Robert B. Wylie

The submersed aquatic plants offer an interesting field for study because of their double adaptations. As land plants they developed complex vegetative bodies and achieved the flower and seed habit. Then as water plants they faced the problem of adjusting that body and their methods of reproduction to radically different conditions from those under which their dominant traits were evolved. Among these plants are found varying degrees of specialization, and doubtless many are in process of transition to the new habitat.

The more highly specialized have elaborate structures and methods for accomplishing cross pollination at the surface of the water or while still submerged at a considerable depth. Among the members of these groups there is a pronounced tendency towards dicliny and most of them are dioecious. On the other hand, the production of perfect flowers in combination with a submerged vegetative body is commonly associated with the habit of raising an inflorescence completely above the surface of the water. In these the method of pollination is still essentially that of the land plant often without special modification. These two tendencies lessen the probability of close pollination in water plants and doubtless account for the infrequent reports of cleistogamy among the submersed aquatics.

Plants having submersed vegetative parts in association with unspecialized inflorescences and perfect flowers have difficulties in cross pollination. *Heteranthera dubia* (Jacq.) MacM. belongs to this group and is without special adaptation to air, surface, or subsurface pollination.

In connection with work at the Macbride Lakeside Laboratory on West Okoboji lake in northwestern Iowa there was favorable opportunity for the study of this species which grows abundantly in the waters of the locality. It was noted that the flowers were frequently close pollinated in the bud, and the writer (1) published a brief account outlining in a general way the observed facts.

Subsequent study has shown that this species in our region is regularly cleistogamous. Under certain restricted conditions the flowers may open at the surface of the water, but in all observed cases these also have pollen tubes entering the style when the flowers open. Moreover nearly all the flowers produced on plants growing under favorable conditions for vegetative growth are so deeply submersed that it is impossible for the stigmas to reach the surface. Yet under all circumstances seeds are developed abundantly through cleistogamous fertilization.

Darwin (2) argues that cases similar to this should not be included under cleistogamy. He says (Chapter VIII) that the flowers of *Ranunculus aquatilis* and *Alisma natans*, for example, "remain closely shut as long as they are submerged, and in this condition fertilize themselves. They behave in this manner, apparently as a protection to their pollen, and produce open flowers when exposed to the air; so that these cases seem rather different from those of true cleistogamous flowers, and have not been included in the list." The writer feels that the case of *Heteranthera dubia* is quite different in that the opening of the flower, when it does occur, reveals an antecedent close pollination. The species seem therefore to have practically abandoned the chasmogamic habit and should be classed as cleistogamous even though it may not have the reduced or dimorphic flowers.

Heteranthera dubia grows luxuriantly rooted at the bottom of shallow, quiet water. While it is but sparingly present on exposed shores of larger lakes it thrives in protected bays, ponds, sloughs, etc., and in such habitats often dominates considerable areas. Since these plants are limited to water of perhaps one meter in depth it is evident that they face a double danger. There is the possibility, on the one hand of becoming too deeply submerged as a result of floods, and the probability, on the other hand, of being stranded through the lowering of the water level during the drier months of the summer. Occasionally plants are found growing on mud, but these are dwarfed to a few centimeters in height whereas under optimum conditions the plant is a yard long.

The stem branches freely in sympodial fashion giving the axis a zig zag look characteristic of this mode of growth. Roots are developed freely at the nodes and if these touch the bottom anchor the plant as it grows forward in its inclined position in the water. The leaves are grasslike with sheathing bases that clasp the stem.

Vegetative propagation is easy for water plants and they spread rapidly by means of rhizomes, buds, runners, etc., or by simply detached branches of the plant that take root and resume growth. Some of them have been known to spread in remarkable way by purely vegetative means. A striking example is seen in *Elodea canadensis*, the pistillate form of which was introduced into Europe about 1836, and overran the continent, and in a short time became a veritable pest in all quieter waters. Not until a few years ago, however, when Dr. Strasburger introduced the staminate plant of this species for experimental purposes was there the possibility of seeds in this form in Europe.

The widespread tendency of the submersed Angiosperms to produce seeds despite their favorable opportunity for vegetative multiplication emphasizes the importance of fertilization or at least of seed production in higher plants. The work of Benedict (3) indicates that the conjugation of gametes inhibits senility in the race and may afford distinct advantage in addition to all the fine strategy of the seed as an organ for plant renewal and dispersal.

The sessile flowers of *Heteranthera dubia* are borne at irregular intervals along the stem and are intermixed with the vegetative leaves. Each flower is invested by a spathe which persists until the seeds are well developed. The tubular perianth, which is about two centimeters long, is divided into six segments which in the open flower are of a pleasing yellow color and suggest by their form the common name "water stargrass." The open flower shows a bilateral arrangement of the perianth-segments and this zygomorphy extends to other members of the flower. The three stamens are inserted in the perianth tube (Fig. 1) and show considerable difference in their structures and arrangement. The single abaxial stamen rises slightly above the two equal and lateral ones, and there is no stamen on the axial or inner side of the flower. The three stamens represent probably both of the original two cycles of these organs. Solms-

Laubach (4) suggests that the abaxial stamen is a member of an outer cycle while the two lateral are members of the inner cycle of stamens.

Each anther bears four microsporangia which differ in their relations in the two forms of stamens. The two lateral anthers are alike in appearance (Fig. 3), but the abaxial has its outer sporangia widely separated and its inner, which are much reduced in size, also pulled somewhat apart. In all cases the sporangia are functional and the pair in each lateral half of the anther break together in the customary fashion forming the pollen sacs. These do not dehisce, however, until the flower opens except for a slight break on each side of the anther near its upper end (Fig. 4). The pollen output is liberal, and the spores appear to be uniformly well developed. The pollen grains are ovoid and the exine is encrusted with scale-like thickenings which stain brilliantly in safranin. A few flowers were observed to contain giant pollen grains such as Rogers (5) describes in *Melilotus alba.*

The pistil is long and slender (Fig. 1) and shows also a lack of radial symmetry (Fig. 3). The lateral lobes of the slender style are enlarged and the axial face is nearly a plane (Fig. 3). The stigma bears a tuft of finger-like stigmatic hairs. The three stylar canals, which lead to the ovary below, are initially distinct and each is lined with strongly staining glandular cells. With the passage of the pollen tubes the walls between are more or less disintegrated and sometimes the stylar chambers break together while there remains a foam-like structure filling the cavity. The ovary bears 25-35 anatropous ovules attached to the three partial partitions in the ovary.

Since the maximum elongation of the flower is only two centimeters and it can open only in the air and further is not fitted to endure wave action, the whole floral mechanism seems poorly fitted to meet the requirements of the habitat. If its insertion is more than an inch below the surface of the water the flower can not open, but, as noted above, functions as a cleistogamous bud. Practically the only conditions favoring the opening of the flowers are found along the margins of quiet water where the level is lowering. Then the stems of the vigorous plants, developed while the water at that point was deeper, come to lie horizontal and near enough to the surface to permit the opening of the flowers in the air.

Turning now to the cleistogamous pollination one finds a relation of parts and a series of events of considerable interest. As previously reported, seeds are produced abundantly by flowers at any depth below the surface. Dissection of the mature but unopen flowers showed that the pollen tubes from spores that had germinated in the anthers had already entered the stigma. Sections show that all the pollen usually germinates though one or two cases were found in which the content of but one anther had germinated at the time the material was collected. In every flower examined at the time it was opening in the air it was found that self pollination had already taken place. Such a condition makes cross pollination impossible in any event and means that the whole floral display is now meaningless, — a memory of other days.

Longitudinal sections through the flower show the relations of all parts concerned. During the development of the flower the tip of the stigma remains considerably below the upper end of the anthers (Fig. 1) though it lies in contact all the time with the inner side of these parts. As the flower matures the style elongates and the stigma is shoved up forcibly into contact with the inner side of the anthers at their upper ends (Fig. 2). In this region occurs a slight break in the wall on each side of the anther through which the stigmatic hairs come into contact with a few of the pollen grains. These openings are limited to the upper one-tenth of the anther at this stage, and may be due to downward pressure on the anther-beaks as these press against the closed sepals. The preserved material was slightly shrunken so that one could not be sure from the sections what parts might come into contact or what tensions might be set up in the unopen flower.

The uppermost pollen grains first germinate and the stimulus is gradually transmitted downward until all the spores in the given pollen sac have formed tubes. Some of these pollen tubes pass out through the openings at the upper end of the anther and enter the stylar canals. The tubes are numerous and in favorable sections look like a rope of strongly staining threads as they lie in these cavities. The anthers are firmly cemented to the stigma by these pollen tubes; the entire content of the pollen sac may be pulled out as a single tangled mass of spores and pollen tubes, many of which probably never find their way out of the anther (Fig. 2).

Further elongation of the style throws it into a contorted and folded form as it elongates in the narrow confines of the space within the closed perianth. Despite the many pollen tubes and the favorable conditions for fertilization, many sterile ovules are found. Probably about fifty per cent of the ovules do not develop into seeds but seem to abort immediately following the fertilization stage. With many flowers to the plant, however, and an average of perhaps fifteen seeds to the flower, the total output of seeds per plant for the summer is considerable.

Discussion

Heteranthera dubia has developed a vegetative body well adapted to the submersed life as shown by its vigorous and successful growth. It has failed, however, to attain floral specilization adequate to insure cross pollination. While the reasons for this failure can not be demonstrated, it seems to the writer that they are correlated with the perfect flowers and the ease with which close pollination could be accomplished. This would suggest that cleistogamy in this form is initial and not derived, and that it has perhaps operated to inhibit floral evolution.

The writer has elsewhere outlined (5) the alternatives presented to a submersed aquatic, one or more of which have to be adopted if it is to avoid self-pollination and still reproduce by seeds. Certain of these should perhaps be mentioned at least in relation to the possible adjustments of *Heteranthera dubia*. Many of the submersed aquatics with less highly specialized flowers raise an inflorescence above the surface of the water at the time the flowers mature. The Potamogetons and Utricularias follow this plan which is essentially a continuation of the habits of the ancestral land plants and permits either perfect or monosporangiate flowers to be used in safety. *Heteranthera dubia* can not adopt this plan as its flowers are scattered and intermixed with the vegetative leaves and there is an indefinite flowering period. *Ranunculus aquatilis* with flowers similarly scattered along the axis, gets its blossoms into the air by developing a floating stem, or one that is entirely free floating, which lies horizontal so near to the surface that a slight elevation raises the flowers up out of the water. For our species this is impossible except where subsiding water level has brought the vegetative body developed in deeper water to lie near the surface through subsidence.

The staminate flowers of *Elodea ioensis* (6) and the pistillate flowers of *Vallisneria spiralis* are brought to the surface from considerable depths through the elongation of the pedicel or individual flower stalk. This door is closed to *Heteranthera dubia* as its flowers are sessile on a usually deeply submersed stem. It can not employ the principle of detachment in any event as its flowers are perfect; the staminate flowers of *Elodea canadensis* (7) and *Vallisneria spiralis* may detach and come to the surface to pollinate the anchored pistillate flowers.

Another way to escape close pollination would be to elongate the flower itself, such as seen in the pistillate flower of *Elodea canadensis* (7) and *E. ioensis* (6). If there has been any specialization of *Heteranthera dubia* it has been along this line for the tubular perianth and elongated style operate to push the stamens and stigmas out of the water if only slightly submerged. Since this same form of flower occurs in the terrestrial species of this genus it is evidently an ancient rather than a recent specialization. The slightly longer perianth tube in this species may be correlated with the reduced illumination since approximately one-half of the light is lost at the surface of the water. The total achievement, however, is utterly inadequate to the needs for the flowers can reach the air only when attached at the most an inch below the surface.

The remaining alternative, that of subsurface pollination through the transfer of pollen grains under water, such as is employed by *Ceratophyllum demersum* is impossible for *Heteranthera dubia* as it has perfect flowers that only open at the surface. It is thus cut off from what would seem to be the most desirable method for plants of its habitat, — a type of cross pollination which allows plants to grow and set seeds at as great depth as light permits.

From the above it is seen that all the possibilities of cross pollination except that achieved through flower elongation are closed, or have not been developed at least, so that if seeds are to be set with certainty and in considerable numbers it must be through close pollination under water excepting the relatively few flowers so situated that they can reach the air and these also seem to have acquired the habit of self-fertilization.

It does not follow that perfect flowers in the submersed aquatics necessarily end in cleistogamy. It does seem, on the contrary, as though there were a general tendency away from bisporangiate flowers, possibly to avoid self fertilization. This is evidenced by the frequent occurrence of rudiments of the suppressed parts in flowers of this habitat. In our flora examples are seen in *Elodea canadensis*, *E. ioensis*, *Vallisneria spiralis*, etc., which are now dioecious but display more or less prominent rudiments of the suppressed stamens or pistils. Ceratophyllum, Naias, Zannichellia, Zostera, Phyllospadix, Hydrocharis, Enalus, and many other of these submersed seed plants have functionally monosporangiate flowers, a large per cent of them dioecious, with frequent expression of rudiments.

Myriophyllum spicatum, though flowering slightly above the surface of the water and having a complex inflorescence shows itself to be in transition in an interesting way. The upper part of the spike is composed of staminate flowers, which, as Knupp (8) has shown, contain mere rudiments of pistils. These abortive pistils are increasingly developed in each lower whorl of the spike until near the middle of the inflorescence they are functional in association with the stamens of the perfect flowers found there. Below this region the stamens are abortive becoming smaller in each successive whorl and at the bottom of the spike are represented by mere rudiments. There is thus a reciprocal transition from either end of the spike toward the center and the monosporangiate flowers are here without doubt derived from perfect flowers like those still showing near the center of the series. With these comparisons in mind the close pollination of *Heteranthera dubia* stands in sharp contrast to the highly specialized devices favoring cross pollination found in many of the submersed aquatics. This failure to overcome the barriers to cross pollination may be due to the structure and arrangement of the flowers, as discussed above. On the other hand it would seem that the ease and certainty with which close pollination is accomplished may have operated to inhibit floral specialization.

Ritzerow (9) has called attention to the frequency with which cleistogamic flowers, either accompanied by chasmogamic blossoms or alone, display reduced floral parts. But there is no evidence of suppressed members in this flower other than those which occur also in the terrestrial species of Heteranthera. This strengthens the view that its flowers are unspecialized as a water plant and probably have undergone little modification in the transition.

Nor do the facts support Goebel's view (10) that cleistogamy is correlated with conditions unfavorable for vegetative growth. *Heteranthera dubia* surely suffers no lack of raw materials and its light relation is no more difficult than other plants of the same habitat. Such relation as exists between its vegetative body and its habit of self pollination is due to the vigor of its growth rather than otherwise.

It seems therefore that the cleistogamy of *Heteranthera dubia* is largely accidental and is due to the perfect flowers in relation to the tardiness or failure of the flower buds to open. No doubt this habit has operated to retard floral adjustment to the aquatic habitat through its suppression of cross pollination. The effect would be the same whether the habit of cross pollination was acquired as a land plant or after it had shifted to the water. If the species is now adjusted vegetatively to its new home its homozygous reproduction may perhaps be advantageous rather than otherwise. The species suggests itself as a favorable one for experimental study in plant breeding since it grows readily and if kept submerged sets seeds freely without further attention.

EXPLANATION OF PLATES

Plate XI—

Fig. 1—Longitudinal section through an immature flower cut slightly obliquely in the adaxial-abaxial plane. The tip of the stigma lies below the upper ends of the anthers, and the style at this stage is straight.

Fig. 2—Upper portion of an older flower cut in the same general direction as in Fig. 1. The stigma has been shoved up into the upper end of the flower in contact with the tips of the anthers where the stigmatic hairs touch the pollen grains through the breaks in the stamens. Pollen tubes are passing from anther into the stylar chambers. The style is beginning to fold through its excessive elongation.

Fig. 3—Transverse section through a nearly mature flower cut at the level of the anthers. The central style is surrounded on three sides by the stamens. The inner investment consists of the perianth lobes; the outer is the spathe.

Fig. 4—General drawing showing the relations of the upper end of the style to the anthers. The abaxial stamen is shown in face view and the ruptures in its walls may be seen on either side. The lateral stamens are shown in outline only. Stigmatic hairs at end of style.

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Fig. 1

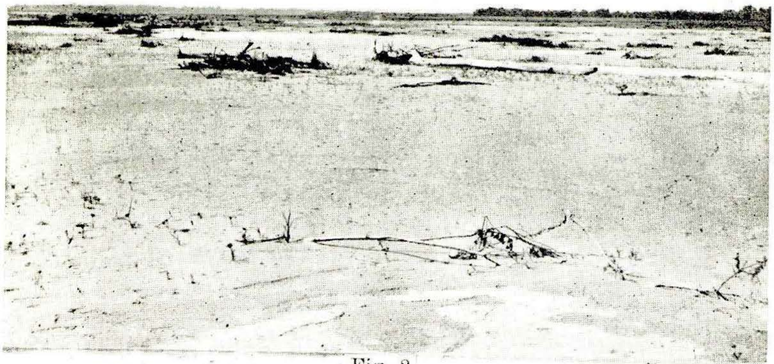
Fig. 2

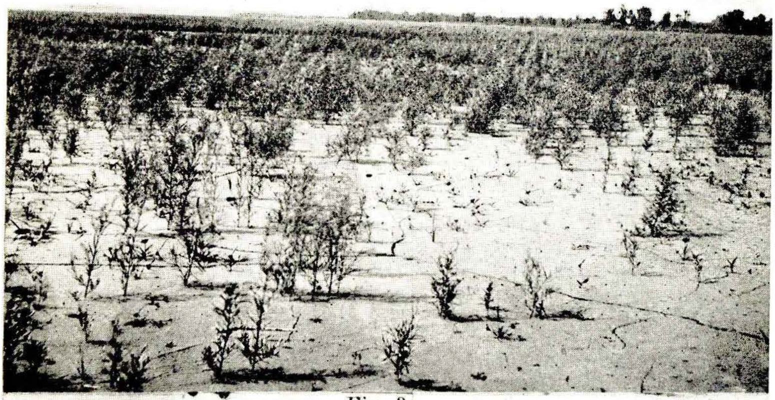
Fig. 3

PLATE I. LAKE BEACH AND RIVER BARS — Shimek

Fig. 1

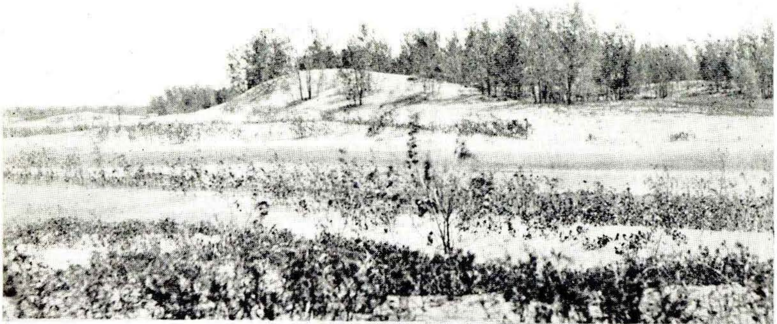

Fig. 2

Fig. 3

PLATE II. SAND-DUNES, HARRISON COUNTY — Shimek

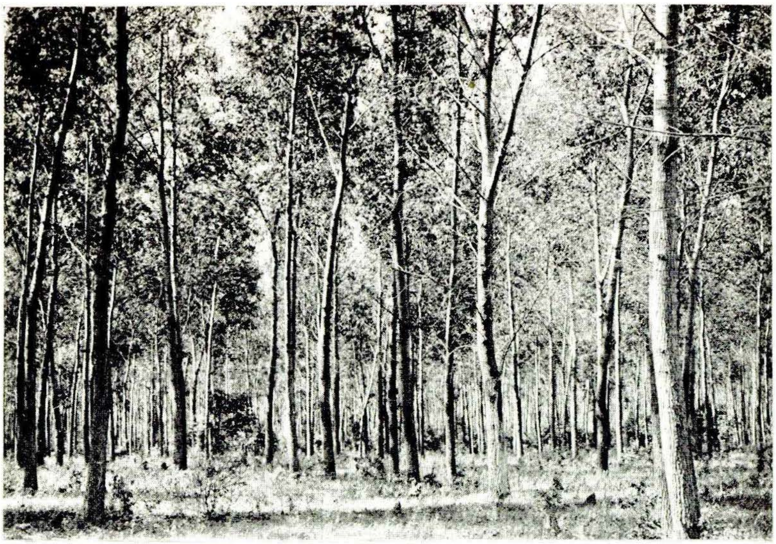

Fig. 1

Fig. 2

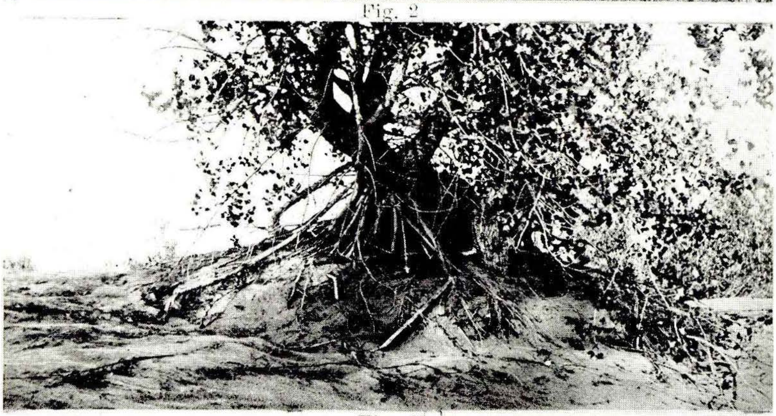

Fig. 3

PLATE III. OLDER DUNES, HARRISON COUNTY — Shimek

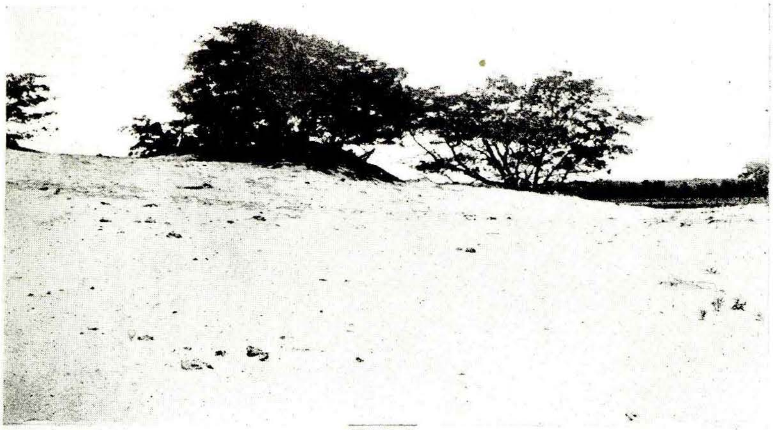

Fig. 1

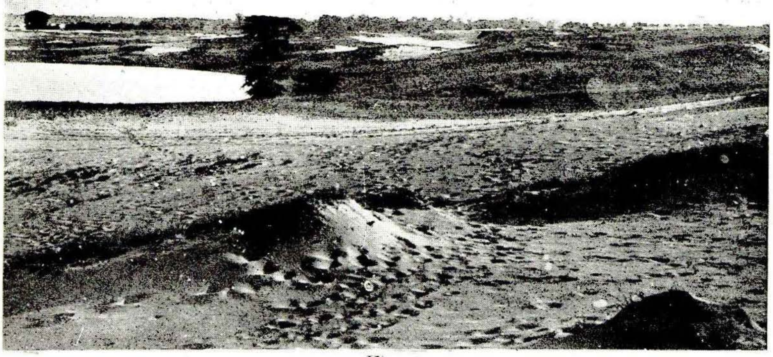

Fig. 2

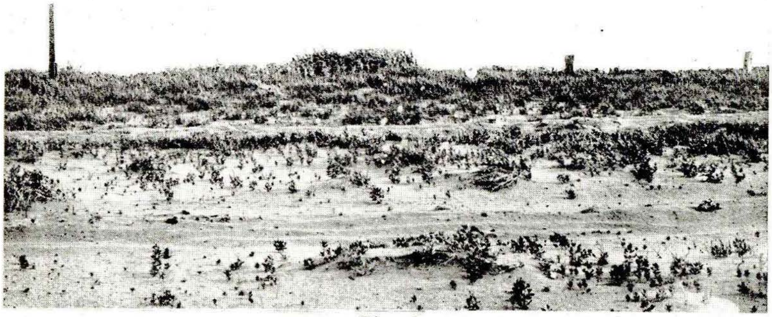

Fig. 3

PLATE IV. SHIFTING DUNES, MUSCATINE ISLAND — Shimek

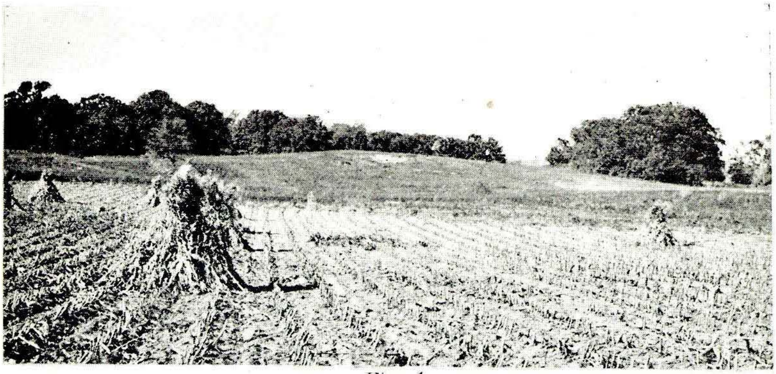

Fig. 1

Fig. 2

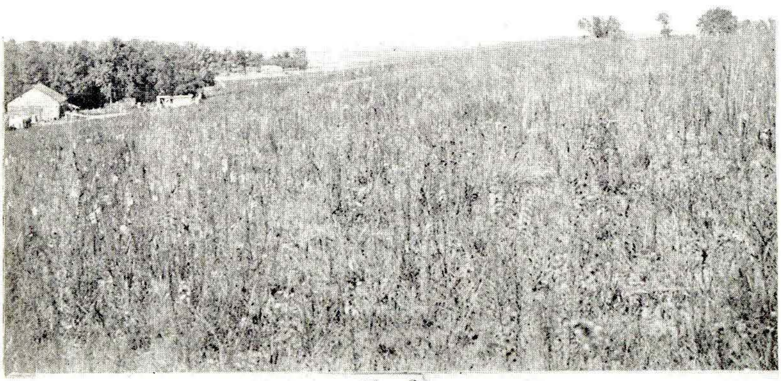

Fig. 3

PLATE V. SAND-DUNES NEAR BAYFIELD — Shimek

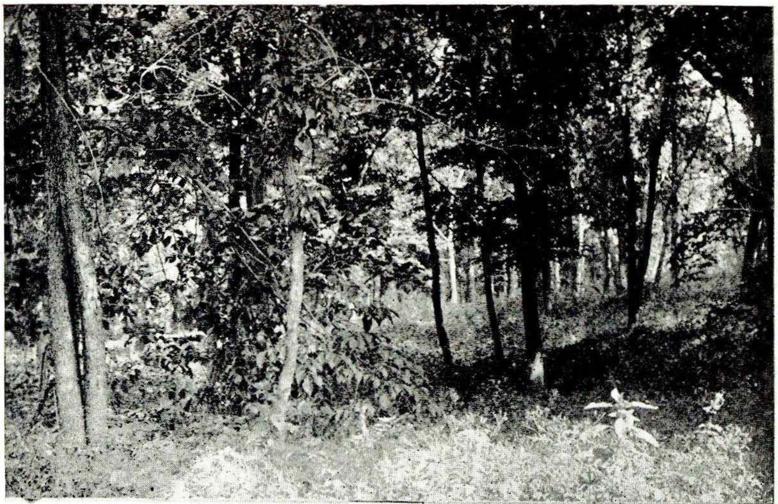

Fig. 1

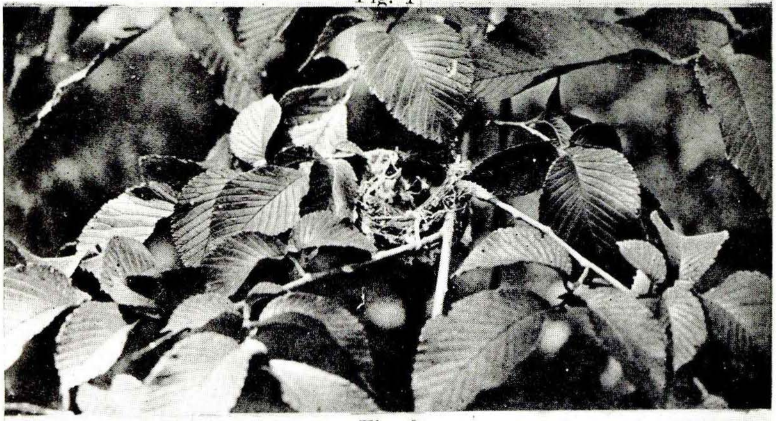

Fig. 2

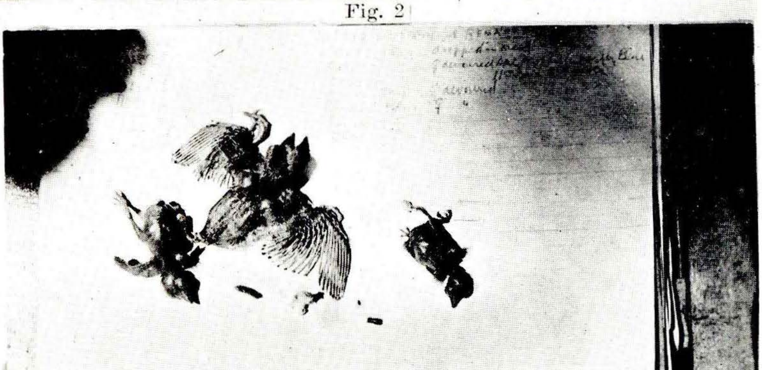

Fig. 3

PLATE VI. NEST AND YOUNG OF RED-EYED VIREO — Stephens

Fig. 1

Fig. 2

Fig. 3

Plate VII. Nest of Red-eyed Vireo — Stephens

Fig. 1

Fig. 2

Fig. 3

PLATE VIII. NEST OF RED-EYED VIREO — Stephens

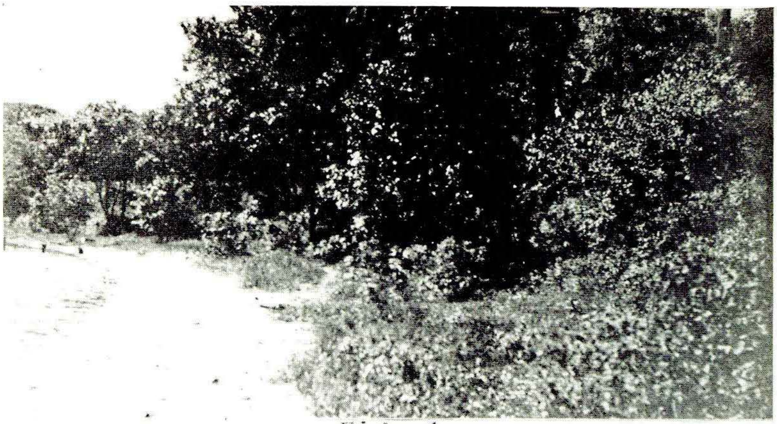

Fig. 1.

Fig. 2.

Fig. 3.

PLATE IX. HABITATS OF OKOBOJI PENTATOMOIDEA — Stoner

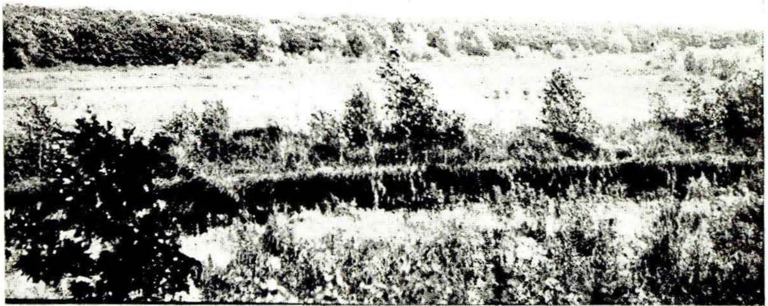

Fig. 1.

Fig. 2.

Fig. 3.

PLATE X. HABITATS OF OKOBOJI PENTATOMOIDEA — Stoner

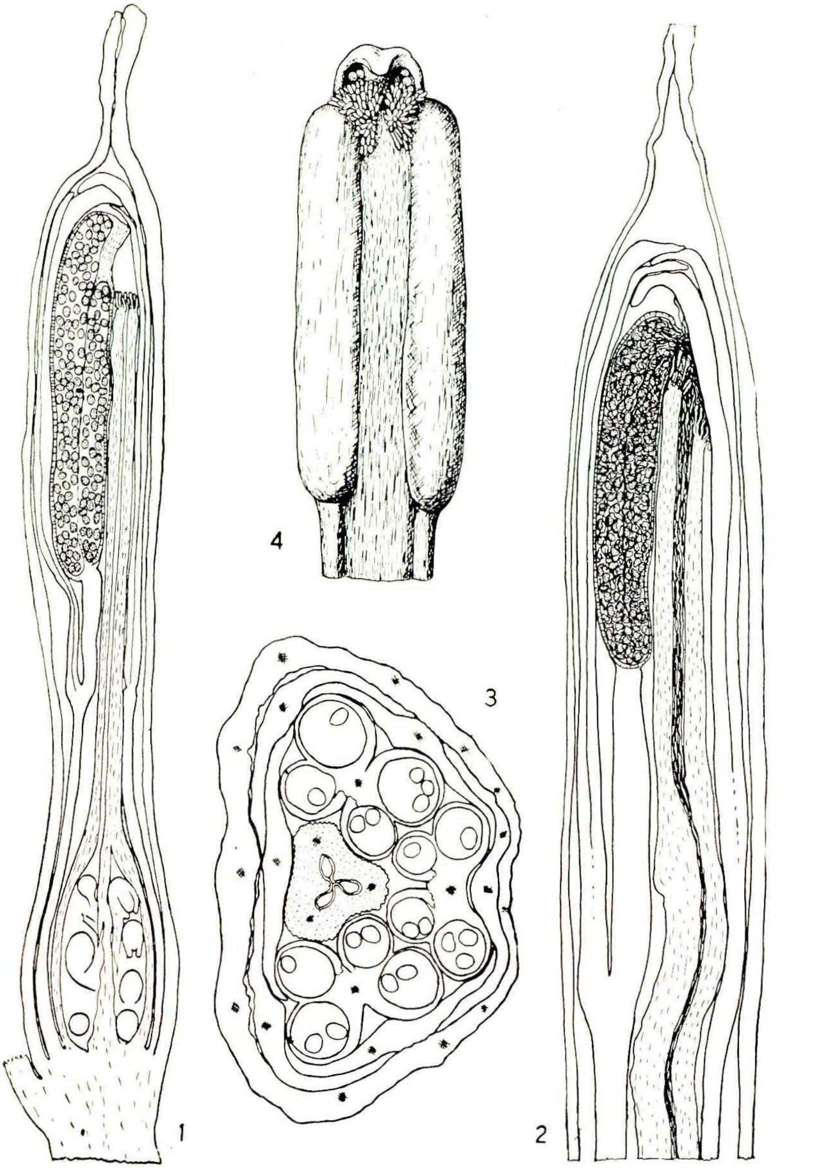

PLATE XI. WYLIE ON HETERANTHERA DUBIA