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THE LIFE HISTORY AND BIONOMICS OF APHIS RUMICIS

by

JOHN LOUIS HORSFALL

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INTRODUCTION

The identity of *Aphis rumicis* Linn. has been of interest to aphidologists in various countries for many years. The early practice of naming species of aphids from the host plants upon which they commonly occurred, while of value to a large extent in aiding in the future recognition of the species, resulted in some cases in the making of synonyms. With the advent of careful life history studies and the recognition of the fact that aphids may select plants widely removed botanically from their summer hosts upon which to hibernate, the synonymy of many aphids has been worked out with more certainty. In the case of *Aphis rumicis* Linn., we find that forms occurring on different host plants were described as separate species when, in many instances, the only differentiating character given by the author was the general body color, a character which is of little specific value, in the tribe Aphidini as a whole, in separating closely related species.

I have pursued detailed studies on the biology of this species during four seasons and from these data have secured definite evidence on the identity of forms occurring on widely dissociated species of host plants at different periods during the year. Although the number of food plants reported for *Aphis rumicis* is extremely large, nine additional species are given in these studies. Detailed life history studies and generation experiments are reported for the first time. Among the records of natural enemies will be found the names of several interesting forms not, as yet, connected with *Aphis rumicis* in literature. My own material has been collected in Iowa and Eastern Pennsylvania. The English material was obtained through the courtesy of Professor F. V. Theobald, and the California specimens, representing collections of Swain and Davidson, were kindly loaned by Professor G. F. Ferris of Stanford University. I wish to express my appreciation to Professor H. F. Wickham, State University of Iowa, for his valuable criticism in the preparation of these studies, to Dr. A. C. Baker, Bureau of Entomology, United States Department of Agriculture, for his suggestions while I was examining material in the collection of the Bureau and the notes of Dr. Asa Fitch and

Mr. Theo. Pergande, and to Messrs. A. B. Gahan and H. E. Ewing of the United States National Museum for their determinations of parasitic material.

PREVIOUS WORK ON THE PROBLEM

For a century and a half after publication of the original description of *Aphis rumicis* by Linnæus, all printed references related to its occurrence in different localities on various host plants with occasional descriptions of the summer forms. The first record of biological observations on the species, which has come to my attention, was published by Walker (97) who noted the fact that this aphid hibernated on the common furze. Buckton (2) made transfers from foxglove to common broom with negative results.

Biological observations of a detailed nature were published by Theobald (88), in 1912, and were based on collections and notes from England and on other European material. He outlined two cycles: one starting with ova and fundatrices on *Euonymus europæus* and migrating to poppies, mangolds, dahlias, etc. for the summer generations; the other starting on dock and migrating to broad beans for the summer. Theobald's statements indicate that he depended mainly upon structural characters to determine the identity of the forms occurring on the winter and summer hosts. He gave the specific names which he considered to be definitely established as synonyms, as well as other possible synonyms, a comprehensive list of food plants, descriptions of the apterous viviparous female, the nymph, and the winged viviparous female. He also called attention to the differences in color of similar forms on different hosts and to differences in number of antennal sensoria in the winged viviparous female.

In America, scarcely any biological observations of *Aphis rumicis* founded upon experimental data have been published. Osborn and Sirrine (65) by means of transfer tests established the cycle from *Euonymus* to some of the summer food plants. Ohlendorff (62) in an unpublished manuscript outlined the first born generation series on *Euonymus europæus* and *Viburnum opulus* for one season, a description of forms, and a limited number of transfer tests which have been discussed in another section of this paper.

In England, Davidson (15-20) has recently published a series of papers dealing with several phases of the biology of *Aphis rumicis*. His studies include a short description of the adult

forms, a generalized life-cycle with *Euonymus* as the winter host, detailed transfer experiments on many varieties of beans, rearings to determine causal factors which determine the appearance of winged forms and sexes, and a study of the sources of food supply in the plant tissues.

Attention is called to the fact that this paper presents the first published record of detailed life history data, including first-born series, the detailed information on reproduction derived from these records, and the complete life-cycle on herbaceous plants. Practically all of the transfers presented are new since they include the common hosts of *Aphis rumicis* in the Eastern and Central United States.

ECONOMIC HISTORY AND DISTRIBUTION

In Foreign Countries: Evidently the first mention of this aphid as an insect of economic importance was by Scopoli (79) who, in 1763, noted the fact that colonies of *Aphis fabæ* rendered the broad bean, *Vicia faba,* sterile. Other early European entomologists included it under the name of *Aphis rumicis* or one of the numerous synonyms in their lists, but made no particular reference to it as a pest upon plants of economic importance. In 1815, Kirby and Spence (48) called attention to it, under the name of *Aphis fabæ,* as a pest on beans. Curtis (13), in 1860, gave an interesting account of the ravages of *Aphis rumicis* as follows: "In 1833, the beans were almost totally destroyed in Yorkshire. In 1841, they (the aphids) were abundant in my garden near the Regents' Park; but in 1842 I never saw one on the spot, yet the beans around Sandgate in the same year were very much injured by them. On the 5th of June, 1846, I could only find apterous specimens on broad bean tops; but on the 11th I detected some winged specimens and the beans in the potato rows were smothered with them, whilst those in a separate bed were free and by topping them the crop escaped."

Buckton (2) spoke of the common names, collier and black dolphin, given to this aphid by the "rustics". He said, "the stalks of the broad bean also are very liable to be similarly encrusted by them, and then both the garden and the field crops are totally destroyed. In 1854, its ravages in the turnip fields of Yorkshire were very marked, many hundred acres being entirely ruined." Theobald (88) said that in England *Aphis rumicis* is best known as a bean and mangold pest. He spoke of the fact that

the numerous individuals frequently swarmed over the young pods of the broad bean and destroyed them. He recorded the fact that he had seen whole beds of Shirley poppies, and also the tops of onions and leeks killed by this aphid.

In America: *Aphis rumicis* is generally considered to be indigenous to the Old World. We have no data which give us any hint as to the date of its introduction into America. Fitch (32), in 1870, included *Aphis rumicis* among the injurious insects reported from New York. An unpublished note by Dr. Fitch (33), telling of injury to *Euonymus,* is of interest in this connection: He wrote as follows: "*Aphis evonymi* Fab. Trees killed by it—July 9, 1873.—A spindle tree in my front yard had every leaf upon it withered and the tree died over a month ago. A large spindle tree in front of Judge Allen's house in Salem village, some 12 feet high with large spreading limbs, has its leaves mostly dropped off and the few remaining ones rolled up and wilted past recovery, and the tree is killed beyond hope of its surviving this disaster." Thomas (93) gave the synonymy, food plants then reported, and a description of the viviparous forms in his eighth Illinois report for 1878. The species was not listed by Riley and Monell (73), in 1879, as having been taken by them in the territory west of the Mississippi River. Oestlund (60) recorded it from Minnesota in 1887, as occurring on *Chenopodium album* and *Rumex crispus,* and in 1893 Osborn and Sirrine (65) described its occurrence on *Euonymus,* Dock, and *Chenopodium album.* In 1895, Gillette and Baker (38) listed it from Colorado on *Rumex crispus.* In 1908, Sanderson (75) said, "The bean aphis caused injury to beans in Massachusetts and Wisconsin; to celery, horseradish, and strawberries in California; and to rhubarb, beets and broad beans in New Jersey". Gillette (37), in 1910, published collection records of *Aphis rumicis* from Oregon, Illinois, New York and Washington, D. C., taken on *Rumex crispus,* garden beets, yellow dock, burdock, and *Chenopodium album.* He did not speak of the aphid as of particular economic importance. Britton (8) in 1916, stated that this insect had caused some injury in a field of seed beets in Connecticut. The infestation was chiefly around the edges of the field and plants of *Chenopodium album* along the borders of the field were also found to be infested.

Headlee (44) called attention to an outbreak of this aphid on beans in New Jersey in 1916. Cory (11), in 1918, said that it

was a serious pest in places on bush Lima beans in Maryland, and made the statement that the species migrated from snowball to dock in the spring. He gave no experimental data to substantiate this statement. Orton and Chittenden (64), in 1917, listed this insect as a pest of beans in all parts of the United States, especially on early beans in California. Other workers who have reported it as a pest on beans in the United States include Smith (8) in Virginia, Talbert (86) in Missouri, Stewart (83) in Utah, DeOng (24), Essig (25), and Gilbert and Popenoe (36) in California.

In 1905, Fletcher (34) noted the fact that *Aphis rumicis* was a serious pest on horse beans in Europe, but that it was only occasionally serious in Canada since the crop was little grown there. Reports in 1909 and 1917 by Bethune (5, 6) tell of the difficulty in obtaining satisfactory crops of Windsor Beans and horse beans in Canada due to the attacks of this black aphis. Sanderson (76), O'Kane (63), and Crosby and Leonard (12) listed this aphid as a pest of beans in their texts.

The following observations may be drawn from these representative reports of the occurrence of *Aphis rumicis* in Europe and in North America. The earliest records give various indigenous weeds and shrubs as the hosts of this aphis. Reports indicating that the species was of economic importance are found first in European literature and only in comparatively recent years in North America. The reports of severe infestations of an economic nature in North America have come from sections of the country where some variety of beans is grown as a staple crop, with occasional reports on *Euonymus*.

Distribution records include England, Italy, France, Belgium, Germany, Holland, Sweden, Russia, Egypt, India, Japan, Formosa, Canada, and practically all of the United States.

SYNONYMY

Aphis rumicis Linnæus

1758. *Aphis rumicis* Linnæus, Syst. Nat., Ed. X, I, 451.
1746. *Aphis rumicis* Linnæus, Fn. Suec., 217.
1758. *Aphis craccæ* Linnæus, Syst. Nat., Ed. X, I, 452.
1763. *Aphis viburni* Scopoli, Ent. Carn., 136.
1763. *Aphis fabæ* Scopoli, Ent. Carn., 139.
1775. *Aphis aparines* Fabricius, Syst. Ent., 735,
(*nec aparines* Fab. Oestlund).

1775. *Aphis euonymi* Fabricius, Syst. Ent., 736.
1775. *Aphis atriplicis* Fabricius, Syst. Ent., 737, (*nec atriplicis* Linn.).
1776. *Aphis papaveris* Fabricius, Gen. Ins., 303.
1781. *Aphis viciæ* Fabricius, Spec. Ins., II, 390.
1801. *Aphis thlaspeos* Schrank, Fn. Boic., II, 118.
1802. *Aphis armata* Hausmann, Ill. Mag., I, 439.
1841. *Cinaria rumicis* Mosley, Gard. Chron., I, 747.
1847. *Viburnifex* Amyot, Ann. Soc. Ent. Fr., 2me. Serie, V, 478.
1847. *Evonymaphis* Amyot, Ann. Soc. Ent. Fr., 2me. Serie, V, 478.
1847. *Rumicifex* Amyot, Ann. Soc. Ent. Fr., 2me. Serie, V, 478.
1847. *Meconaphis* Amyot, Ann. Soc. Ent. Fr., 2me. Serie, V, 478.
1847. *Craccifex* Amyot, Ann. Soc. Ent. Fr., 2me. Serie, V, 478.
1852. *Aphis hortensis* (Fab.) Walker, List Homop. Brit. Mus., IV, 981.
1879. *Aphis atriplicis* (Linn.) Buckton, (in part), Mon. Brit. Aphides, II, 87.
1919. *Aphis euonomi* (Fab.) Swain, U. Calif. Publ. Ent., III, No. 1, 101.

Aphis rumicis was originally named and described by Linnæus in 1746, in his first edition of the Fauna Suecica (49). The description from page 217 is as follows:

708. *Aphis Rumicis*
Habitat in Rumicibus 293. 295.
Descr. Corpus nigro-æneum. Antennæ nigræ vel albæ apicibus nigris. Pedes albidi geniculis nigris. Cauda acuminato-cornuta. Alarum basis virescens; Appendiculi atri, filiformes, longitudine caudæ.

Linnæus did not repeat this description in Systema Naturæ, Edition X, 1758 (50), but referred to the description in Fauna Suecica. He also listed *Aphis craccæ* in Systema Naturæ, Edition X, but the description of the species was published in Fauna Suecica, Editio Altera Auctior, 1761 (51). Kaltenbach redescribed *craccæ* under the same name in 1843 (46). After an examination of the material determined as *craccæ* at Washington and a con-

sideration of the original description and that of Kaltenbach, I have placed *craccæ* as a synonym of *rumicis.*

Scopoli (79), in 1763, described a black aphid from *Viburnum* under the name of *Aphis viburni.* This has been accepted as a distinct species by most workers, but Hunter (42) considered it to be a synonym of *rumicis.* Although Theobald wrote me that *rumicis* did not occur on *Viburnum opulus* in England, Mordwilko recorded it *(evonymi)* from Russia, and Passerini listed it *(papaveris)* from Italy on this host. In America, Essig, Patch, and Wilson have recorded *rumicis* from *Viburnum.* Essig (25) published the following note in reference to *rumicis*:—"H. F. Wilson believes this species to be *A. viburni* Scop." Kaltenbach stated that the character which separated *viburni* from *rumicis (evonymi)* was the presence of a row of marginal spines or tubercles on the abdomen of the larva of *viburni,* which were absent on *evonymi,* but that the winged forms of the two species could scarcely be distinguished. This character is hardly of specific value since I have found wide variation in the number and prominence of these tubercles on larvæ of *rumicis* from *Viburnum, Rumex, Arctium,* and *Tropæolum.* The tubercles on segments one and seven are fairly constant, but there is considerable variation in the size of the tubercles on the intervening segments. Theobald (89) and Haviland (41) have suggested that *Aphis grossulariæ* Kalt. may be *viburni* Schr., but this is hardly the case since Kaltenbach's description of *grossulariæ* calls for an aphid with cornicles and cauda greenish-yellow, while in *viburni* they should be black. After a consideration of my results from transfer tests and cross-copulation experiments, and the examination of my own material, I have reached the conclusion that Scopoli described the spring generations of *Aphis rumicis* on one of its primary hosts and therefore I have included *viburni* as a synonym. Scopoli (79) also described forms from *Vicia faba* under the name of *Aphis fabæ.* Kaltenbach and Passerini listed *fabæ* as synonymous with *A. papaveris* which is considered in this paper to be a synonym of *rumicis.* Schouteden, Theobald and others have placed *fabæ* as a synonym of *rumicis.* My own material and some received from Theobald taken on *Vicia faba* is most certainly *rumicis.*

In 1775, Fabricius (28) described, as new, three species which are now considered to be synonymous with *Aphis rumicis* by many workers; i. e. *Aphis aparines* from *Galium aparine, Aphis euonymi*

from *Euonymus europæus,* and *Aphis atriplicis* on *Atriplex hortensis.* I have concluded that Fabricius in his original description of *aparines* and Schrank in a later description referred to *rumicis.* Kaltenbach incorrectly credited the authorship of *aparines* to Schrank in listing it as a synonym of *A. papaveris.* Later authors evidently followed Kaltenbach in designating Schrank as the author. Schouteden and Theobald listed *aparines* as a synonym of *rumicis.* I found the following in an unpublished note by Dr. Asa Fitch (33). "Specimens taken on *Galium* vines, side of meadows on under side of leaves. Nov. 1870, is not this the *Aphis rumicis* Linn., the *A. aparines* Fab., the *A. galii* Schrank? Dec. 8, 1870, This I have scarcely a doubt is the *Rumicis."* *Aphis aparines* Fab. of Oestlund is evidently a distinct species distinguished from *rumicis* by absence of tubercles on the prothorax and smaller number of sensoria on the antennæ.

I have taken forms in spring and fall on two species of *Euonymus* which fit the descriptions of *A. euonymi* Fab. as given by Fabricius, Schrank, Koch, and Kaltenbach. I have not been able to separate these specimens on the basis of structural characters or biology from forms taken on the same dates from *Viburnum opulus, Chenopodium album, Rumex crispus* and other host plants of *A. rumicis.* I have also proven to my own satisfaction, by numerous transfers and cross-copulation tests, the identity of the form from *Euonymus* with that from numerous other host plants and thus regard *euonymi* as synonymous with *rumicis.* Fabricius described *Aphis atriplicis* as a black aphid infesting *Atriplex hortensis.* Linnæus had previously used the name *atriplicis* for a green aphid which caused the leaves of *Atriplex* to roll longitudinally and form boat-shaped galls. The description of *A. atriplicis* Fab. agrees with that for *A. rumicis* Linn. and since *rumicis* is found on species of *Atriplex* at the present time, I have considered *atriplicis* Fab. to be a synonym.

In 1776, Fabricius (29) described forms from *Papaver somniferum* as *Aphis papaveris.* This name has been considered to be synonymous with *rumicis* by Schouteden, van der Goot, Theobald, and others. I have compared material from England and California from the poppy with my own collections of *Aphis rumicis* made in Pennsylvania and can distinguish no more than seasonal differences. *Aphis viciæ* was first used by Fabricius (30) in 1781, but he credited Linnæus with the authorship, citing Fauna Suecica,

species number 986. This citation is *Aphis craccæ* Linn. as indicated by Linnæus' practice of designating the name of the species described in the margin of the page. As I have previously indicated, *A. craccæ* is considered to be a synonym of *A. rumicis* and thus *A. viciæ* Fab. also goes into synonymy.

I have followed Schouteden, Theobald, and others in listing *Aphis thlaspeos* Schrank as a synonym of *A. rumicis* on the basis of the original description and the fact that *rumicis* is known to occur on shepherd's purse, the host from which Schrank's material was collected. Schrank (77) called attention to the similarity in appearance of *thlaspeos* with the species on dock, *A. rumicis*, although he considered them to be distinct.

Several workers have placed *Aphis armata* Hausm. as a synonym of *rumicis*. After a careful consideration of Hausmann's original description (40) it seems certain that he referred to *A. rumicis* and I have consequently listed *armata* as a synonym. *Cinaria rumicis* Mosley has been correctly listed by various authors as synonymous with *Aphis rumicis*. Mosley (57) adopted the suggestion of Curtis and used the name *Cinaria* for a section of the genus *Aphis*.

In 1847, Amyot (1) proposed as new names for *A. rumicis* and other names which I have listed as synonyms, *Rumicifex, Viburnifex, Evonymaphis, Meconaphis* and *Craccifex*. As there seem to be no reasonable grounds for making such a change, I have considered these as synonyms of *A. rumicis*.

Walker (98) listed *Aphis hortensis* Fab. as a synonym of *rumicis*, but his citation refers to *atriplicis* Fab. Although Fabricius wrote the name *Aphis atriplicis hortensis* at the beginning of the description, he designated *atriplicis* as the specific name in the margin according to his usual practice. Since *atriplicis* Fab. is a synonym of *rumicis, A. hortensis* Fab. of Walker also becomes a synonym.

Aphis atriplicis Linn. of Buckton (2) is in part synonymous with *Aphis rumicis*. His descriptions of varieties 1 and 2 of the apterous viviparous female and that of the winged viviparous female certainly refer to *rumicis* on *Chenopodium*.

Swain (84), in 1919, published excellent descriptions of forms of *Aphis rumicis* from various host plants. He raised the question as to the identity of *A. rumicis* Linn. and proposed that *rumicis* Linn. of American and late European workers should be considered as synonymous with *Aphis euonomi* Fab. He gives, as the basis

TABLE I—COMPARISON OF SPECIES

Species and Host	Antennæ III	IV	VI	Cornicles	Cauda	Hind Tarsus
Aphis rumicis Linn. *Rumex crispus* Spring migrant	Longer than IV Slightly shorter than VI unguis 9 - 15 sensoria	Equal to V or slightly longer	Unguis 3 base Base nearly equal to hind tarsus	Shorter than III, Equal to IV Almost 2x hind tarsus	Slightly more than ½ of cornicles Slightly longer than hind tarsus	Slightly longer than VI base
Aphis laburni Kalt. *Genista tinctoria* Det. Pergande	Longer than IV Slightly shorter than VI unguis 4 - 5 sensoria	Equal to V	Basal area large Unguis 2x base.	Shorter than VI base about ½ III	Longer than cornicles by ½	Shorter than VI base, equal to cornicles
Aphis laburni Kalt. *Laburnum vulgare* Det. Pergande	Equal to or slightly longer than IV. Equal to VI unguis 4 - 6 sensoria	Equal to V	Unguis 2x base.	Longer than III or VI unguis		
Aphis hederæ Kalt. *Hedera helix* Summer migrant	Equal to IV Hardly more than ½ VI unguis 3 sensoria	Equal to V	Unguis 3x base Base shorter than hind tarsus	Shorter than III or IV. Longer than hind tarsus and VI base by ⅓	Shorter than cornicles, equal to hind tarsus. Restricted at base.	About equal to VI base

for this proposal, the distinction as to host plants and color of the winged form. I have quoted the original description of Linnæus in which it will be noted that the color given for the winged form is "black-bronze". I have often taken specimens of *rumicis* on *Rumex* which exhibited this blackish-brassy tinge to the body due to the obscure dark olive cast from the body contents. Nor can it hardly be argued that *rumicis* of American authors is not *rumicis* Linn. just because *Rumex* is the only host mentioned in the original description. In the history of aphidology, probably the majority of species have been described from a single host many years before the complete life history was understood or the alternate hosts, if any, were known. I have examined some of Swain's material and find that it agrees with similar forms which I have taken in Iowa and Pennsylvania, and with material from Theobald in England. Therefore, I feel that we are not justified in making the change proposed by Swain, and since his specific name, *euonomi*, varies in spelling from the original *euonymi*, it must be considered as a synonym of *Aphis rumicis* Linn.

Several other names have been incorrectly listed by various authors as synonyms of *A. rumicis.* Schrank's *Aphis gallii Scabri* (77) I consider to be distinct from *rumicis* since his description of the wingless viviparous female from bristly *Galium* calls for an aphid with "cornicles and cauda short appearing as scarcely more than elevated spots."

Aphis dahliæ Mosley has been incorrectly cited as a synonym since Mosley (57) described an amber-colored aphid with legs, tubercles (cornicles) and antennæ of the same color as the body.

TECHNICAL DESCRIPTIONS

Egg: (Plate VIII, A) Elongate, cylindrical, slightly flattened along one side, bluntly rounded at the ends. Olive-green when first deposited, soon turning to shiny black. Average length 0.5 mm.

Stem Mother: (Plate V, I). Velvet black tinged with olive. Body oval, broadly rounded behind. Head without ocelli, with a few scattering hairs. Eyes black, with prominent accessory tubercles. Antennæ with five segments. Prothorax distinct with pair of lateral tubercles. Mesothorax and metathorax merged in outline with the abdomen which is arched and swollen. Lateral tubercles on first and seventh abdominal segments and sometimes on intervening segments. Cornicles black, tubular, imbricated,

flanged at the mouth. Cauda black, distinctly conical, not tapering as in apterous viviparæ, furnished with several curved hairs on the margin. Legs shorter and stouter than in apterous viviparæ but similarly colored. Described from specimens taken on *Viburnum opulus* in April and transferred to *Rumex crispus* for generation series. Measurements: Length of body, vertex to tip of cauda, 1.896 to 2.292 mm.; Antennæ, I, 0.068 mm.; II, 0.051 mm.; III, .310 to 0.379 mm.; IV, 0.137 to 0.172 mm.; V base, 0.103 mm.; V unguis, 0.103 to 0.137 mm.; Cornicle, 0.155 to 0.206 mm.; Cauda, 0.172 mm.; Hind tarsus, 0.103 to 0.120 mm.

First Instar: (Plate IV, G). (Approximately 7 hours old). Head dark purplish green with slight longitudinal median carina and narrow lateral light-green bands bordering the eyes, about four hairs on vertex; Eyes dark red each with lateral tubercle of five or six facets. Antennæ pale, faintly tinged with green, four-segmented, the distal end of III and all of IV dusky. Prothorax olive-black with a lateral tubercle on each side. Mesothorax, metathorax, and abdomen olive-green with a purplish tinge, entirely covered with faint, whitish bloom. Abdomen with a distinct submarginal groove on each side extending back to the cornicles in which are distinct pits, segmentally arranged. Sides of each abdominal segment bearing a small hair. First and seventh segments with a small lateral tubercle on each side. Lateral tubercles often present on intervening segments. Cornicles dusky-black, short, tubular. Cauda black, short, triangular, with fringe of about five hairs on each side. Legs stout, clumsy, whitish, faintly tinged with green, the distal ends of femora and tibiæ and all of tarsi blackish. Femora sparsely hairy, tibiæ distinctly hairy. Measurements from specimens freshly mounted in balsam: Body length, 0.756 mm., width, 0.369 mm.; Cornicles, length, 0.047 mm., width, 0.035 mm.; Antennæ, I, 0.044 mm.; II, 0.035 mm., III, 0.140 mm., IV base, 0.061 mm. VI unguis, 0.140 mm.

Second Instar: (60 to 70 hours old). Similar to first instar, but darker with five-segmented antennæ, longer cornicles, and lateral tubercles on abdomen more distinct. Measurements from specimens freshly mounted in balsam: Body length, 0.739 mm., width, 0.404 mm.; Cornicles, length, 0.052 mm., width, 0.035 mm.; Antennæ, I, 0.052 mm., II, 0.035 mm., III, 0.088 mm., IV, 0.070 mm., V base, 0.052 mm., V unguis, 0.158 mm.

Third Instar: (170-173 hours old). Similar to first instar with five-segmented antennæ. Measurements from specimens freshly

mounted in balsam: Body length, 0.950 mm., width, 0.528 mm.; Cornicles, length, 0.073 mm., width, 0.038 mm.; Antennæ, I, 0.051 mm., II, 0.044 mm., III, 0.140 mm., IV, 0.082 mm., V base, 0.070 mm., V unguis, 0.170 mm.

Fourth Instar, Apterous Form: (208-216 hours old). Similar to first instar with six-segmented antennæ. Measurements from specimens freshly mounted in balsam: Body length, 1.443 mm., width, 0.862 mm.; Cornicles, length, 0.114 mm., width, 0.070 mm.; Antennæ I, 0.070 mm., II, 0.056 mm., III, 0.158 mm., IV, 0.132 mm., V, 0.132 mm., VI base, 0.088 mm., VI unguis, 0.246 mm.

Fourth Instar, Pupa: (Plate IV, F): General shape elongate-oval. Head and prothorax black with greenish-brown hue, slightly powdered. Pair of lateral tubercles on prothorax. Prominent lobes of mesothorax and the entire metathorax grayish-green. Abdomen black shaded with olive, with prominent white pulverulent patches as follows: a pair of round areas on the first segment, a broad band, often broken into paired spots, on either side of a median line on each of the next three segments, pairs of spots close together on the sixth and seventh segments and faintly showing on the eighth segment. These white areas are absent from fifth segment. Lateral tubercles present on the first and seventh abdominal segments. Antennæ, wing-pads, cornicles, and cauda black. Legs colored as in winged viviparous female. Measurements: Length of body, 2.103 mm.; Antennæ, I, 0.046 mm.; II, 0.046 mm., III, 0.241 mm.; IV, 0.172 mm.; V, 0.163 mm.; VI base, 0.094 mm.; VI unguis, 0.258 mm.; Cornicles, 0.181 mm.; Cauda, 0.120 mm.; Hind tarsus, 0.137 mm. Described from specimens on *Chenopodium album* and *Rumex crispus,* October 1923. The pupæ of the males are comparatively smaller in size but resemble in color the pupæ of the winged viviparæ as given above.

Winged Viviparous Female, (Plate II, F): Morphological characters:—Antennæ, measurements given in Table II.; Segments III to VI inclusive imbricated, armed with scattering hairs, which are about equal in length to width of each segment on which they are borne; III bearing 10 to 22 round sensoria unevenly distributed over the segment, the distal 4 or 5 arranged in a row, IV with 0 to 7 sensoria, V with the usual prominent sensorium near the distal end and sometimes bearing an additional proximal one, base of VI with the usual compound sensorium. The numbers of sensoria vary on the corresponding segments of the two antennæ of the same indi-

vidual. There is also a consistent variation in the number of antennal sensoria of the spring and summer migrants and of the fall migrants or sexuparæ alatæ, III of the fall migrant usually bearing about 4 more secondary sensoria than III of the spring or summer alatæ and IV of the spring forms usually without sensoria while IV of the fall form may have as many as 7 or 8, and V of the fall form may also bear 1 or 2 in addition to the usual primary sensorium. Eyes large, with prominent lateral tubercle. A single ocellus contiguous to inner margin of each eye a little distance behind base of antenna, a third ocellus at center of vertex, slightly protruding. Extending back from the median ocellus is a slight carina. Prothorax distinct, bearing a pair of prominent lateral tubercles. Præscutum, scutellar lobes, and scutellum distinct. Abdomen ovate, suddenly tapering behind, lateral tubercles always present on segments 1 and 7 and sometimes on the other segments. Cornicles imbricate, tubular, tapering slightly, with flange at the mouth, length 0.224 to 0.310 mm., slightly shorter in fall migrants. Anal plate rounded, beset with numerous hairs and short spines. Cauda cylindrical, with bluntly pointed tip, numerous short spines and 4 to 5 long curved hairs on each side, length 0.137 to 0.206 mm., shorter in fall migrant. Legs slender, with numerous short hairs, length of hind tarsus 0.123 to 0.146 mm. Length of body, vertex to tip of cauda, 1.534 to 2.068 mm. The fall migrants are slightly longer, as will be seen in accompanying table.

Color characters:—General color to unaided eye jet black with legs dirty yellow. Under the binocular, head and thorax shining black; eyes brownish-black, ocelli lighter; antennæ dark brown to black with lighter area at base of III; labium yellow with black tip; legs dusky yellow with middle and hind femora, distal one-fourth of tibiæ and tarsi black. Wings transparent, veins brownish with stigma smoky. Abdomen varying from deep olive-green to blackish-brown with black dorsal markings which become distinct in balsam mounts as follows: median black bands on each abdominal segment, those on the first six segments separate and distinct, with those on the seventh, eighth and ninth confluent. Black patches on the lateral edges of each segment separated more or less from the median bands, those on the sixth segment more extensive than the others forming distinct black areas behind the base of each cornicle. The extent of these black markings on the abdomen is subject to considerable variation among different in-

TABLE II—COMPARATIVE MEASUREMENTS OF WINGED VIVIPAROUS FEMALES

Spring Migrant	Length mm.	III mm.	IV mm.	V mm.	VI base	VI unguis	Corn.	Sensoria III	Sensoria IV	Sensoria V
Rumex, May	1.672	0.344	0.241	0.241	0.120	0.396	0.232	15	0	0
,, ,,	1.534	.327	.241	.241	.112	.362	.224	12	0	0
,, ,,	1.620	.327	.258	.241	.120	.344	.258	11	0	0
,, ,,	1.724	.362	.275	.258	.137	.379	.258	14	0	0
,, ,,	1.586	.327	.258	.241	.120	.396	.241	11	0	0
,, ,,	2.034	.396	.293	.258	.120	.344	.310	13	0	0
,, ,,	1.948	.362	.275	.258	.120	.379	.310	12	0	0
Euonymus, May	2.068	.344	.258	.224	.120	.362	.275	11	0	0
,, ,,	1.982	.353	.258	.215	.112	.310	.241	12	0	0
Viburnum, May	1.775	.327	.258	.241	.129	.353	.310	12	0	0
,, ,,	1.982	.362	.310	.224	.120	.310	.293	16	1	0
Fall Migrant										
Rumex, Nov.	2.552	.352	.272	.255	.123	.360	.228	20	7	0
,, ,,	2.358	.360	.246	.237	.114	.316	.237	15	7	0
,, ,,	2.200	.334	.264	.246	.140	.281	.228	22	3	1
Chenopodium, Oct.	2.252	.343	.258	.220	.123	.316	.193	17	4	0
,, ,,	2.534	.369	.220	.228	.123	.308	.193	17	3	0
,, ,,	2.376	.360	.281	.246	.123	.316	.228	18	3	1
Arctium, Nov.	2.464	.343	.281	.246	.123	.369	.220	20	5	0
Philadelphus, Oct.	2.129	.352	.264	.237	.132	.360	.237	18	8	0

dividuals of the same generation on the same host plant, some specimens having only disconnected black areas in place of median dorsal bands. Cornicles black; cauda green at base, distal half black. General body color of fall migrants as noted from unmounted material varied with the host. Specimens from *Euonymus, Philadelphus,* and *Hydrangea* were blackish-brown while those taken on *Chenopodium* and *Rumex* at the same date were of a deep olive cast. Described from specimens taken on *Rumex crispus* and *Euonymus atropurpureus* at Bustleton, Pa., in May. Measurements from balsam mounts.

Apterous Viviparous Female, (Plate III, B): Morphological characters:—Antennæ shorter than body; segments V and VI distinctly imbricated, III and IV faintly so; a single primary distal sensorium on V, the usual compound sensorium at base of VI unguis. Eyes large with ocular tubercle at the outer posterior angle. Prothorax with a pair of distinct lateral tubercles, other two thoracic segments more or less merged in outline with the abdomen. Abdomen ovate, swollen, often with segmentation obscure. Lateral tubercles present on the first and seventh abdominal segments, sometimes present on intervening segments but not as distinct, a submarginal row of pits on each side of abdomen arranged segmentally in front of the cornicles. Cornicles imbricated, cylindrical, tapering slightly toward the mouth which is flanged, length 0.224 to 0.396 mm. Anal plate hemispherical, furnished with hairs and short spines as is the genital plate. Cauda cylindrical, tapering to a blunt point, four or five curved hairs on each margin, covered with small spines, length 0.172 to 0.275 mm. Legs slender, sparsely hairy, length of hind tarsus 0.114 to 0.137 mm. Length of body, vertex to tip cauda, 1.758 to 2.465 mm. In the fall, the apterous forms (sexuparæ) are relatively larger than the summer apteræ but the cornicles and cauda are shorter.

Color characters:—General color to the unaided eye dull black, sometimes with white pulverulent patches on the back. Very often, in mid-summer, individuals have a distinct olive green cast to the abdomen, especially when reared in shaded situations. In the fall, individuals of a shiny bronze color are to be found in colonies on *Rumex crispus* and *Arctium lappa.* Many of these forms when examined under the microscope are found to be intermediates. Specimens of the summer forms on balsam mounts usually show a row of small black submarginal spots marking the location of the

pits on either side of the body and a black streak at the base of the cauda. Antennæ dirty yellow with I, II, distal end of V, and all of VI blackish. Eyes brownish-black. Legs dirty yellow with distal two-thirds of middle and hind femora, distal one-fourth of tibiæ, and tarsi black. Individuals which had three to five pairs of pulverulent patches on the abdomen were reared and collected in the fall. Described from specimens taken on *Rumex crispus* in June and *Rumex crispus* and *Arctium lappa* in October, 1923, at Bustleton, Pa.

TABLE III

COMPARATIVE MEASUREMENTS OF APTEROUS FEMALE

Spring Forms	Length Body mm.	III mm.	IV mm.	V mm.	VI base mm.	VI unguis mm.	Corn. mm.
Rumex, June	1.89	0.370	0.284	0.258	0.137	0.396	0.310
,, ,,	1.75	.396	.293	.241	.120	.310	.344
Chenopodium, June	2.46	.448	.249	.224	.129	.327	.344
,, ,,	2.06	.413	.275	.241	.120	.379	.396
Fall Forms							
Rumex, Nov.	2.37	.387	.228	.211	.105	.299	.228
,, ,,	2.56	.316	.202	.184	.105	.281	.220
,, ,,	2.42	.316	.246	.220	.114	.325	.255
Chenopodium, Nov.	2.46	.316	.228	.211	.114	.325	.264
,, ,,	2.28	.352	.228	.228	.114	.255	.211
,, ,,	2.62	.348	.228	.193	.114	.272	.228

Oviparous Female, (Plate V, B): Morphological characters:—Antennæ: I, 0.044 to 0.061 mm.; II, 0.035 to 0.047 mm.; III, 0.184 to 0.220 mm.; IV, 0.096 to 0.158 mm.; V, 0.123 to 0.158 mm.; VI base, 0.096 to 0.105 mm.; VI unguis, 0.176 to 0.237 mm.; Segments V and VI distinctly imbricated, IV faintly so. A very few hairs along the entire length of the antennæ, scarcely as long as width of respective segments, a single circular sensorium at distal end of V and the usual compound sensorium at the base of VI unguis. Eyes distinct with the usual lateral accessory eye on each. Prothorax distinct with a pair of distinct lateral tubercles. Other thoracic segments somewhat indistinct and merged in outline with the abdomen. Abdomen ovate, more tapering caudad than the apterous viviparous female, a pair of lateral tubercles present on first and third abdominal segments, smaller tubercles sometimes found on other segments. Cornicles cylindrical, imbricated,

flanged at the mouth, length 0.105 to 0.158 mm. Cauda conical with bluntly rounded tip, armed with numerous papillæ and several long curved hairs, length 0.096 to 0.123 mm. Anal plate hemispherical, papillate, with several distinct hairs. Genital plates papillate, two in number. Legs hairy, the hind tibiæ flattened and bearing numerous small round sensoria. Length of hind tarsus 0.105 to 0.123 mm. Length of body, vertex to tip of cauda, 1.408 to 1.988 mm.

Color Characters:—General color to unaided eye dull black, suffused with olive green or reddish-brown, depending upon the host upon which they are feeding. Those from *Euonymus* and *Philadelphus* had the reddish cast while those on *Viburnum*, *Maclura pomifera*, *Chenopodium album*, and *Rumex crispus* had the olive green cast. Antennæ blackish with the exception of segments III and IV which are dirty yellow in color. Cornicles and distal half of cauda black. Anal and genital plates black. First and second pair of legs yellowish with tips of tibiæ and tarsi black. Hind pair of legs black. Described from specimens taken on *Euonymus alatus* at Bustleton, Pa., in November. Measurements from balsam mounts.

Winged Male, (Plate II, A): Morphological Characters:—Antennæ; Segments III to VI inclusive are imbricated, armed with scattering hairs which are more prominent than those on the alate female; III bears 24 to 41 prominent sensoria, unevenly distributed, IV with 15 to 25 sensoria, V with 7 to 16 sensoria in addition to the usual prominent sub-apical sensorium, base of VI with the usual compound sensorium at the base of the unguis, the numbers of sensoria on segments III, IV, and V may vary considerably, as shown in Table IV. Eyes large, each with prominent lateral tubercle of several facets. A single ocellus on either side of head, contiguous to inner margin of eye and somewhat removed from base of antennæ, a third prominent ocellus, somewhat protruding at center of vertex. Prothorax distinct, slightly narrower than width of head, bearing a pair of prominent lateral tubercles. Præscutum, the two scutellar lobes, and the scutellum prominent and distinct. Abdomen ovate, relatively shorter antero-posteriorly than in alate female, lateral tubercles present on 1st, 7th and sometimes other abdominal segments. Cornicles distinctly imbricated, tubular, with distinct flange at mouth, length 0.088 to 0.149 mm. Anal plate rounded, with numerous fine hairs. Cauda cylindrical, tapering distally to a blunt point, with 6 to 8 curved hairs, length

0.086 to 0.140 mm. Legs slender, hairy. Length of hind tarsus 0.103 to 0.137 mm. Length of body, vertex to tip of cauda, 1.137 to 1.900 mm.

Color characters:—General color to the unaided eye is shining black with legs lighter. Under the binocular the head and thoracic segments are seen to be shining black, with eyes brownish-black. Labium dusky yellow with black tip. Antennæ deep brown. Legs dusky yellow with femora of middle and hind legs, distal tips of front femora, one-fourth of all tibiæ, and all tarsi black. Wings transparent with blackish veins and smoky stigma. Abdomen almost black with an olive-green tinge through which the jet-black markings are discernible. Black bands, irregular in outline and extent, on each of the first five segments, sometimes reaching the two lateral margins but often broken to form a central band and lateral spots. Behind the cornicles, the entire dorsum of each segment is black. Cornicles and cauda black. Described from specimens taken on *Chenopodium album* and *Euonymus alatus*, at Bustleton, Pa. Measurements from balsam mounts.

TABLE IV—COMPARATIVE MEASUREMENTS OF MALES

	III mm.	IV mm.	V mm.	VI base	VI unguis	Corn. mm.	Sensoria III	Sensoria IV	Sensoria V
Chenopodium	0.352	0.193	0.176	0.105	0.290	0.088	28	16	13
,,	.334	.228	.190	.102	.334	.105	31	16	12
,,	.334	.211	.176	.096	.272	.088	34	17	16
,,	.334	.193	.158	.096	.264	.088	39	22	12
,,	.334	.246	.220	.114	.343	.132	30	18	14
Rumex	.352	.311	.272	.132	.369	.149	26	17	7
,,	.369	.281	.246	.123	.369	.140	30	17	7
Maclura	.334	.299	.237	.123	.334	.140	34	18	10
,,	.325	.246	.211	.114	.334	.105	36	20	10
Calycanthus	.396	.313	.241	.137	.310	.103	37	25	11
,,	.343	.284	.189	.094	.241	.103	35	21	8
,,	.362	.262	.206	.103	.336	.120	31	25	6
Euonymus	.413	.310	.258	.120	.336	.137	31	22	12
,,	.343	.241	.206	.103	.275	.137	25	17	11
,,	.396	.275	.241	.120	.379	.103	32	17	9
,,	.379	.275	.215	.103	-----	.120	38	19	14
,,	.413	.275	.241	.103	.343	.137	41	21	12

Intermediates in the Aphidæ are of interest because of their possible phylogenetic significance. Apterous forms with traces of alate characters seem to indicate that the wingless forms evolved from the winged individuals. Baker and Turner (3) stated that they had noted an intermediate in *Aphis rumicis*, but they gave

no description of the form. In my studies, intermediates of several forms were collected or reared.

Intermediate Male, (Plate III, A): Color and appearance very nearly that of the alate male. Measurements of one individual as follows: Antennæ, III, 0.413 mm. bearing 5 secondary sensoria of normal size and many microscopic sensoria, IV, 0.293 mm. bearing about 10 tiny sensoria, V, 0.258 mm. bearing about 10 tiny sensoria and the usual primary distal sensorium, VI base, 0.137 mm., unguis 0.344 mm.; Cornicles 0.155 mm., Cauda, 0.155 mm., Hind tarsus, 0.103 mm. Ocelli present on head as in alate form. Mesothorax chitinized but with only a slight indication of lobes. The wings are represented on both thoracic segments by small buds which are visible by transmitted light. A second specimen has the normal number of sensoria, i. e. III, 32; IV, 19; V, 12; and indication of thoracic lobes, and wings represented by four small pads.

Described from three specimens taken with winged males on *Arctium lappa*, October 11, 1922, Bustleton, Pa.

Intermediate Viviparous Female, (Plate V, G). General size and form of body approaching that of the apterous sexupara. Color of antennæ, cornicles, cauda, and legs similar to apterous form. Abdomen with distinct black bands segmentally arranged as in alate form, black patches present at the base of the cornicles, but absent from the abdominal margin. Rows of small black spots marking the pits same as in apterous form. Thoracic lobes distinct, præscutum and scutellum present, but reduced in size. Wings represented by four flaps projecting from the sides. A second specimen on the same slide has the black markings on the abdomen similar to those described above but not as distinct. Alate characters of the thorax exhibited in a chitinized surface and a faint groove showing a division into the two lobes. Wings indicated only by four small buds.

Described from two specimens taken on *Rumex obtusifolius*, November 3, 1923, at Bustleton, Pa. The following note was made at time of collection, "shiny, viviparous female." A third specimen collected on *Chenopodium album*, November 1, 1923, had markings similar to the first specimen described above, but had 5 secondary sensoria on segment III of antennæ, and 5 sensoria on IV, unguis of VI was aborted.

Intermediate Oviparous Female, (Plate V, H.): General form and appearance of the apterous viviparous female. Antennæ

shorter than the viviparous form but longer than the true oviparous form. Segment III, 0.275 mm.; IV, 0.172 mm.; V, 0.155 mm.; VI, base, 0.103 mm.; VI unguis, 0.224 mm. All of IV, V, and VI blackish, distinctly imbricated, III faintly imbricated. The hind tibiæ are slender as in the viviparous female, but about one-fifth shorter. Three full sized ova are clearly seen within the abdomen of one specimen.

Described from three specimens reared in generation series, October, 1922, Bustleton, Pa. Two of these females mated with males taken from *Arctium lappa* in the field and the third with a male reared on *Rumex crispus*. Ova were deposited by these females on *Rumex obtusifolius*.

LIFE HISTORY STUDIES

METHODS OF STUDY

The rearing experiments were carried on at the Pennsylvania State College Field Laboratory, Bustleton, Pa., during the summers of 1920-21-22 and 23 in the insectary and in the field cages. A series was also reared from September 1921 to June 1922 in the greenhouse of the Department of Botany, State University of Iowa, Iowa City, Iowa. The insectary consisted of a shelter roof with open sides. Protection from beating rains was provided by using side curtains of thin muslin (Plate IX, A). Some of the plants were grown in a dirt bench and some were planted in seven inch pots. The soil used was a fairly rich compost of sand, clay soil, and manure. Growing potted plants were used for all generation and transfer experiments, with the exception of the generations on woody plants. Cuttings placed in water or damp sand were used for the experiments on *Euonymus, Viburnum, Hydrangea* and *Maclura*.

Two types of cages were used in the rearing work. One type consisted of ordinary glass lantern globes over the top of which thin covers of cheese cloth were fastened. The second type or field cage, the same as used by Smith (81), was made by stretching muslin over wooden frames of inch material. The corner strips extended six inches below the bottom level of the cage and, when sunk into the ground, served as anchorages (Plate IX, B). The entrance was provided by running a width of cloth around one side of the frame which had been left uncovered. When this was sewed together at the two loose ends, it formed a sleeve enveloping

the body while examinations were being made and prevented escape of winged forms or entrance of parasites. This cloth was gathered to the center and tied when the cage was closed. The cages were of two sizes, 14″x14″x30″ and 30″x30″x30″. Maximum and minimum temperatures were recorded throughout each season.

In the generation experiments the usual method was followed. The viviparous female was removed by means of a small brush at the end of her first day of reproduction. She was then placed on a growing plant free from aphids, and data on the number of young, etc. were thus obtained each day of her life. As Davis has suggested, the method of leaving several new-born young instead of a single individual insures, almost to a certainty, the continuation of the line. These first-born young were checked at maturity in order to determine the presence or absence of winged individuals. The series for 1923 outlined in detail in Tables VI and VIII are representative of the generation experiments of the previous three years.

FOOD PLANTS

Aphis rumicis Linn. is an exceptionally polyphagous aphid. The majority of the species of the Aphidæ are restricted in their feeding habits to a small number of plants, but this insect has adapted itself to a wide range of hosts. Wilson and Vickery (99) have listed, under *Aphis rumicis* or the synonyms included in their paper, 189 species of host plants. Patch (66, 67, 68, 70, 71) has cited, in the various parts of her Food Plant List, 17 additional hosts and in the Hemiptera of Connecticut (10) 3 other species. Swain (84) records 8 species of plants not included in the above lists and I have collection records for 9 additional hosts. This brings the total number of recorded hosts for *Aphis rumicis* to 226. A few of these may be incorrect citations since they may refer to species of aphids which have been erroneously placed as synonyms of *Aphis rumicis.* Only one other aphid approaches *rumicis* in its wide range of accepted hosts, i.e. *Myzus persicæ Sulz.*, for which Wilson and Vickery list 175 food plants.

My additional records are as follows: Primary hosts:—*Calycanthus fertilis, Euonymus alatus, Hydrangea paniculata, Maclura pomifera,* and *Chenopodium album;* Secondary hosts:—*Aster* sp., *Chenopodium ambrosioides, Galinsoga parviflora, Polygonum scandens* var. *dumetorum,* and *Stellaria media.* Other plants upon which I have collected or reared this aphid are given in the

Seasonal History Chart (Table XII). The large number of hosts upon which this insect is able to exist accounts in part for its abundance and cosmopolitan distribution. The ultimate result of this polyphagous habit may be that several physiological species may arise which, in time will exhibit distinctive morphological characters.

TRANSFER TESTS

During the four seasons in which life history studies on *Aphis rumicis* were being conducted, considerable attention was devoted to transfers of aphids from one host plant to another at various seasons of the year. It was desirable to obtain these data for two reasons: first, to establish more certainly the specific identity of forms collected from different host plants but having no distinct morphological differences of apparent specific value; second, to verify the summer and winter host plants upon which this species lives in localities covered by these studies. The data were obtained in the following manner. The desired host plants were grown in 6 and 7 inch pots in an out-of-doors insectary. These plants were covered with lantern globes, the tops of which were covered with a single thickness of cheese cloth. Specimens were reared from ova or were collected from colonies breeding in the field or at the insectary on the host of a different species than that to be tested. In most cases several aphids were transferred to the potted plant by means of a soft brush and observations made from time to time. Whenever possible winged females were used in making the test and no experiment was considered successful until progeny of the transferred form matured and produced young. These tests necessitated the use of twenty-two species of host plants grouped in forty-three different combinations. In addition, notes were taken in the field on transfers effected by the insects themselves, under conditions which were very reliable. These transfers included combinations in addition to those used under controlled conditions. These records will be indicated as such in table V so that, unless specifically stated, the experiments as tabulated were under controlled conditions. It might be well to explain here that such experiments are of peculiar value in working out authentic hosts, since aphids are particularly selective in their feeding habits. Individuals, when placed upon plants which are not the normal food of the species, will crawl from the plants to the sides or top of the cage and remain there until they die rather than feed upon this foreign plant.

TABLE V—TRANSFER EXPERIMENTS, *APHIS RUMICIS*

Transfers to	From	Remarks
Chenopodium album	*Viburnum opulus*	
,, ,,	*Viburnum opulus*	
,, ,,	*Daucus carota*	unsuccessful
,, ,,	*Dahlia* sp.	
,, ,,	*Gladiolus* sp.	
,, ,,	*Spinacia oleracea*	
,, ,,	*Rumex crispus*	
,, ,,	,, ,,	
,, ,,	*Arctium lappa*	
,, ,,	,, ,,	
,, ,,	*Chenopodium album*	
,, ,,	*Rheum rhaponticum*	
Beta vulgaris	*Rumex crispus*	(Davidson, *R. sanguineus*)
,, ,,	*Chenopodium album*	
Rumex crispus	*Rheum rhaponticum*	
,, ,,	*Rumex crispus*	(Davidson, *R. sanguineus*)
,, ,,	*Begonia* sp.	
,, ,,	*Arctium lappa*	
,, ,,	*Dahlia* sp.	
,, ,,	*Gladiolus* sp.	
,, ,,	*Chenopodium album*	
,, ,,	*Daucus carota*	
,, ,,	*Viburnum opulus*	(Osborn and Sirrine)
,, ,,	*Euonymus atropurpureus*	(Davidson, *R. sanguineus*)
,, ,,	*Maclura pomifera*	
Rumex obtusifolius	*Amaranthus retroflexus*	
,, ,,	*Pisum* sp.	(Ohlendorf)
,, ,,	*Chenopodium album*	
Phaseolus sp.	*Rumex crispus*	unsuccessful
Papaver sp.	*Chenopodium album*	
Mirabilis jalapa	*Tropæolum minus*	
Arctium lappa	*Viburnum opulus*	
,, ,,	*Tropæolum minus*	
,, ,,	*Chenopodium album*	
,, ,,	*Rumex crispus*	
Rheum rhaponticum	*Viburnum opulus*	
,, ,,	*Rumex crispus*	
,, ,,	*Arctium lappa*	colony weak
,, ,,	*Chenopodium album*	
Spinacia oleracea	*Viburnum opulus*	
Amaranthus retroflexus	*Pisum* sp.	
Asparagus sp.	*Rumex crispus*	
Stellaria media	*Chenopodium album*	
Viburnum opulus	*Chenopodium album*	Ova
Euonymus atropurpureus	*Chenopodium album*	
Maclura pomifera	*Chenopodium album*	field
Oenothera biennis	*Chenopodium album*	field
Galinsoga parviflora	*Chenopodium album*	
Rosa sp.	*Chenopodium album*	field
Gladiolus sp.	*Tropæolum minus*	field
Dahlia sp.	*Tropæolum minus*	field
Pisum sp.	*Tropæolum minus*	field
Capsella bursapastoris	*Chenopodium album*	

Osborn and Sirrine (65) made successful transfers of this aphid from *Euonymus atropurpureus* to *Viburnum opulus* and from this stock on *Viburnum* to shepherd's purse, curled dock and beans. They failed to establish aphids from *Viburnum* on *Euonymus*. It may be that in making this latter test they were using *Aphis viburniphila* Patch, another dark form on *Viburnum*. Theobald (88) reported that he had made transfers of *Aphis rumicis* from *Euonymus europæus* to broad beans (*Vicia* sp.). Swain (84) failed to secure colonies of this aphid on *Hedera helix* or *Rumex* sp. when material was transferred from *Vicia* sp. Ohlendorf (62) made successful transfers from *Philadelphus, Euonymus,* and *Viburnum opulus* to *Euonymus europæus* and *Viburnum opulus*. The same worker failed to make successful transfers from nasturtium to *Euonymus* or from *Rumex obtusifolius* to apple, lima bean, or turnip. He did succeed in securing colonies upon nasturtium, navy bean, and pea from stock on *Rumex obtusifolius*.

Davidson (15-20), who has done the most work with *Aphis rumicis* along this line, recorded successful transfers from *Euonymus* to broad bean, horse bean, dwarf French bean, peas, poppies, *Rumex* sp. and *Euonymus*. He also secured colonies on *Euonymus* from stock on broad bean. From material which he transferred to *Rumex* from *Euonymus,* he secured colonies by re-transfer on broad bean, horse bean, dwarf French bean, peas, poppies, *Rumex* sp., mangolds, red beets, and sugar beets.

The combinations which I used in making my tests were largely determined by the common hosts upon which I had taken colonies of *Aphis rumicis* in the field. For this reason there is a distinct departure from the combinations used by Davidson in the experiments which he followed in England. Three combinations of hosts which are similar to those used by Davidson are indicated in the table. However, he used *Euonymus europæus* and *Rumex sanguineus*. In one unsuccessful case which I have listed, transfers were made successfully to another known host. Thus aphids from stock on *Daucus carota,* when transferred to *Chenopodium album,* did not colonize the second host, but did colonize *Rumex crispus*. Since repeated transfers were successfully made between *Rumex crispus* and *Chenopodium album,* the failure mentioned did not throw out *Daucus carota* as a host plant of *Aphis rumicis*.

Since the aphids collected in the field from the various host plants and those used in these tests do not differ from each other by

TABLE VI *Aphis rumicis*—1923—Bustleton, Pa.

Date	Temp.		First-born Generation Series												
	Max.	Min.	1	1-1	1-2	1-3						2	2-1	2-2	
April 4	70	54	b*												
5	74	56	x												
6	66	42	x												
7	69	36	x												
8	62	40	x												
9	50	28	x												
10	56	30	x												
11	64	35	x												
12	61	38	x												
13	56	42	x									b#			
14	42	34	x									x			
15	43	32	x									x			
16	58	34	3	b								x			
17	55	35	3	x								x			
18	53	31		x								x			
19	59	32		x								x			
20	82	34		x								x			
21	84	47		x								x			
22	72	58		x								x			
23	68	53		x								x			
24	60	37		x								x			
25	66	44		x								3	b		
26	68	56		x									x		
27	73	63		3	b								x		
28	75	47		2	x								x		
29	64	53			x								x		
30	61	44			x								x		
May 1	66	36			x								x		
2	70	39			x								x		
3	71	41			x								x		
4	81	41			x								x		
5	78	43			x								x		
6	74	49			x								x		
7	77	48			x								x		
8	75	48			x								5	b	
9	66	40			x									x	
10	56	36			3	b								x	
11	67	32			6	x								x	
12	76	55			5	x								x	
13	72	55			4	x								x	
14	73	45			e	x								x	

b—born d—died e—incomplete record x—dev. period

* Stem mother from eggs on *Chenopodium album*, all generations reared on *Rumex crispus*.

\# Stem mother from eggs on *Viburnum opulus*, generations 2 to 15 reared on *Rumex crispus*, 18 to 20 on *Chenopodium album*.

TABLE VI (Cont.) *Aphis rumicis*—1923—Bustleton, Pa.

Date	Temp.		First-born Generation Series									
	Max.	Min.	1-3	1-4	1-5	1-6	1-7	2-2	2-3	2-4	2-5	2-6
May 15	16	45	x					x				
16	77	58	x					x				
17	77	53	x					x				
18	71	48	x					x				
19	75	54	x					x				
20	76	49	x					x				
21	73	54	x					x				
22	70	56	x					x				
23	72	54	x					x				
24	72	56	x					5	b			
25	80	56	2	b				6	x			
26	83	62	8	x				2	x			
27	85	60	8	x				11	x			
28	80	54	5	x				4	x			
29	88	56	2	x				10	x			
30	80	57	3	x				5	x			
31	75	56	3	x				5	x			
June 1	80	49	2	x				6	x			
2	93	59	4	x				9	6	b		
3	89	62	5	11	b			8	11	x		
4	87	61	9	10	x			5	6	x		
5	87	70	4	8	x			10	7	x		
6	88	75	0	8	x			3	e	x		
7	81	68	d	11	x			6		x		
8	78	60		2	x			2		x		
9	69	55		2	x			2		x		
10	78	51		6	x			2		4	b	
11	76	57		8	2	b		0		7	x	
12	80	54		1	1	x		0		2	x	
13	70	56		3	3	x		0		2	x	
14	86	60		2	2	x		0		4	x	
15	82	59		7	6	x		1		5	x	
16	81	59		3	0	x		0		2	x	
17	88	60		4	9	x		d		3	x	
18	91	54		2	8	x				3	2	b
19	90	57		1	1	x				1d	2	x
20	100	66		2	5	1	b				6	x
21	98	80		0	4	2	x				6	x
22	92	69		0	4	3	x				0	x
23	87	60		0	4	2	x				7	x
24	99	80		d	4	4	x				e	x

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TABLE VI (Cont.) *Aphis rumicis*—1923—Bustleton, Pa.

Date	Temp.		First-born Generation Series														Last-born Gen. Series		
	Max.	Min.	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12	2-6	2-7	2-8	2-9	2-10	2-11		1-8a	1-8b
June 25	96	67	2	4	x						x								
26	91	79	4	5	x						x								
27	87	67	0	d	x						x								
28	87	64	2		x						4	b							
29	75	59	3		2	b					3	x							
30	81	59	0		3	x					2	x							
July 1	84	49	0		3	x					2	x							
2	83	54	0		3	x					3	x							
3	76	56	0		2	x					1	x							
4	85	61	0		4	x					0	x							
5	92	60	0		2	x					3	x							
6	86	68	0		2	x					1	x							
7	85	59	0		6	4	b				1	2	b						
8	84	55	d		1	1	x				1e	3	x						
9	83	59			3	2	x					3	x						
10	91	66			3	3	x					5	x						
11	88	70			3	11	x					6	x						
12	87	70			d	8	x					4	x						
13	89	65				3	x					8	x						
14	86	60				4d	2	b				5	x				b		
15	82	67					5	x				5	2	b			x		
16	88	67					2	x				6	3	x			x		
17	87	62					5	x				2	2	x			x		
18	90	63					0	x				4	2	x			x		
19	85	57					0	x				3	3	x			x		
20	90	55					1	x				1	2	x			1		
21	97	67					1	x				2d	4	x			10		
22	91	67					0	2	b				5	x			5		
23	81	58					d	7	x				5	x			6		
24	77	57						2	x				2	x			2		
25	83	65						2	x				3	x			3		
26	82	58						4	x				2	1	b		4		
27	82	55						3	x				2	2	x		3		
28	80	65						4	x				3	4	x		3		b
29	89	68						4	x				1	2	x		3		x
30	81	67						d	1	b			1d	1	x		d		x
31	67	62							1	x				1	x				x
Aug. 1	70	60							3	x				2	x				x
2	84	62							2	x				0	x				x
3	89	68							1	x				2	x				x
4	90	70							2d	x				1	2	b			x
5	88	72								x				6	4	x			x

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TABLE VI (Cont.) *Aphis rumicis*—1923—Bustleton, Pa.

Date	Temp.		First-born Generation Series													Last-born Gen. Series			
	Max.	Min.	1-12	1-13	1-14	1-15	1-16	2-9	2-10	2-11	2-12	2-13	2-14	2-15		1-8b	1-8c	1-8d	1-8e
Aug. 6	90	65	x					6	5	x						5			
7	89	67	1	b				3	5	x						5			
8	89	72	1	x				1	3	x						1	b		
9	84	76	2	d				d	2	x						d	x		
10	84	69	1	b					3	x							x		
11	81	75	d	x					0	x							x		
12	84	70		x					2	3	b						x		
13	81	68		x					d	2	x						x		
14	80	62		x						2	x						x		
15	88	66		x						4	x						x		
16	77	57		x						4	x						1		
17	71	59		x						2	x						2	b	
18	83	62		x						3	x						d	x	
19	83	53		2	b					0	x							x	
20	81	62		4	d					d	x							x	
21	86	52		1						3	b							x	
22	82	53		1	b					2	x							x	
23	72	56		d	x					2	x							x	
24	78	53			x					0	x							x	
25	81	60			x					1	x							x	
26	82	62			x					2	x							x	
27	81	54			x					2	x							x	
28	84	64			x					e	x							x	
29	81	64			x						x							2	
30	85	61			x						x							1d	b
31	84	56			2	b					4	b							x
Sept. 1	83	59			4	x						3	x						x
2	87	67			3	x						3	x						x
3	85	61			5	x						3	x						x
4	91	68			1	x						4	x						x
5	80	64			1	x						4	x						x
6	81	61			2	x						3	x						x
7	83	62			2	x						3	x						5
8	82	66			1	x						1	x						2
9	80	57			0	x						3	x						4
10	75	62			0	2	b					3	2	b					4
11	77	62			0	3	x					1	3	x					2
12	79	57			0	2	x					2	2	x					2
13	77	58			0	2	x					3	0	x					2
14	69	58			d	2	x					0	1	x					3
15	68	42				2	x					1	2	x					3
16	70	50				3	x					d	1	x					2

TABLE VI (Cont.) *Aphis rumicis*—1923—Bustleton, Pa.

Date	Temp.		First-born Generation Series												Last-born Gen. Series	
	Max	Min.	1-15	1-16	1-17	1-18	1-19	2-14	2-15	2-16	2-17	2-18			1-8e	1-8f
Sept. 17	72	40	2	x				0	x						1	
18	74	38	0	x				0	x						2	
19	82	60	2	x				2	x						2	
20	80	64	6	x				4	x						6	b
21	73	67	3	x				1	4	b					d	x
22	73	66	2	2	b			2	4	x						x
23	80	66	3	3	x			2	4	x						x
24	83	65	5	2	x			2	5	x						x
25	85	60	4	1	x			0	1	x						x
26	79	58	1	0	x			1	d	x						x
27	78	61	3	2	x			4		x						x
28	80	58	1	1	x			3		x						x
29	81	58	4	1	x			0		1	b					4
30	68	50	0	2	x			1		2	x					2
Oct. 1	67	44	d	0	x			d		1	x					0
2	72	52		d	x					2	x					2
3	68	45			x					1	x					1
4	73	44			x					2	x					2
5	62	37			2	b				3	x					2
6	62	40			1	x				0	x					3
7	63	32			0	x				0	x					0
8	64	34			0	x				1	x					0
9	68	40			0	x				0	x					3
10	70	38			0	x				1	x					2
11	67	45			0	x				0	x					4
12	73	43			4	x				0	x					2
13	70	50			2	x				0	x					2
14	77	55			0	x				0	2	b				3
15	72	59			3	x				0	4	x				6
16	73	54			2	x				0	1	x				4
17	70	41			1	x				0	1	x				3
18	74	43			1	x				0	1	x				2
19	66	49			2	x				2	1	x				2
20	66	53			0	x				2	e	x				1
21	64	50			0	3	b			1		x				5
22	60	38			2	1	x			1		x				2
23	50	43			0	0	x			0		x				0
24	58	43			2	0	x			0		x				0
25	58	40			2	1	x			0		x				2
26	54	44			0	0	x			0		x				2
27	62	37			0	1	x			1		x				0
28	60	31			0	0	x			1		x				1

TABLE VI (Cont.) *Aphis rumicis*—1923—Bustleton, Pa.

Date	Temp.		First-born Generation Series											Last-born Gen. Series		
	Max	Min.	1-17	1-18	1-19		2-16	2-17	2-18	2-19					1-8f	1-8g
Oct. 29	67	48	0	2	x		4		x						1	
30	72	46	1	3	x		3		x						4	
31	65	42	0	2	x		0		x						2	b
Nov. 1	48	39	0	0	x		d		x						0	x
2	53	27	0	0	x				x						0	x
3	60	26	0	0	x				2	b					d	x
4	63	27	1	1	x				1	x						x
5	63	53	0	0	x				1	x						x
6	57	46	1	3	x				1	x						x
7	50	43	1	d	x				1	x						x
8	47	37	0		x				1	x						x
9	44	26	0		x				0	x						x
10	51	24	0		x				0	x						x
11	58	31	1		x				1	x						x
12	51	39	1		x				1	x						x
13	53	34	0		x				1	x						x
14	60	37	0		x				0	x						x
15	49	35	0		x				1	x						x
16	48	42	0		x				0	x						x
17	49	40	0		x				1	x						x
18	51	39	0		x				0	x						x
19	41	30	1		x				1	x						x
20	48	20	1		x				0	x						x

All experiments terminated Nov. 20.

On Nov. 20:

1-17 Apterous viviparous female alive.
1-19 Pupæ of males with wing pads.
2-18 Apterous viviparous female alive.
2-19 Practically mature apterous viviparous female.
1-8g Nymphs in 3rd and 4th instar.

First hard frost Nov. 6-10.

variations greater than those found in a collection of individuals reared from known stock on one host such as *Rumex crispus*, I concluded that these belong to the one species, *Aphis rumicis* Linn. The question as to the possibility of physiological species being present on different hosts has been suggested, but my experiments seem to indicate, as did Davidson's that such is not the case.* In the cage experiments, sexuparæ from *Chenopodium* migrated to *Euonymus* and oviparæ developed and laid eggs on the *Euonymus* while eggs were also secured on *Chenopodium album* from the same strain. Strains from *Chenopodium album* laid eggs on *Viburnum opulus* and those from *Maclura pomifera* produced eggs on *Rumex crispus.*

NUMBER OF GENERATIONS

During the seasons of 1920-21-22-23, eight first-born generation series were conducted. The data obtained from two series of 1923 are presented in Table VI. Series 1 was started by collecting eggs on *Chenopodium album* which had remained out of doors all winter. These eggs, on small bits of the dried stems, were brought into the insectary March 27 and placed on the soil at the base of potted plants of *Rumex crispus.* The first eggs hatched on April 4 and the young began feeding on the leaves of the *Rumex.* The experiments were transferred to the insectary on April 27 and all succeeding generations were reared out of doors. All generations of Series 1 were reared on *Rumex crispus* and *Rumex obtusifolius.* From April 4 to Nov. 20, the date the experiments were closed, twenty first-born generations occurred in this series. The series closed with a male in the last nymphal instar. During the summer, a total of six days were lost, three days between generations 12 and 13 and three between 13 and 14.

Series 2 was started with a mature stem mother taken from *Viburnum opulus* on April 27. It is probable that this individual

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*Additional transfer experiments conducted during the spring of 1924, confirm my contention that physiological strains, confined to certain host plants, are not demonstrable. Stem mothers in the first instar from eggs on *Viburnum opulus* were transferred to *Rumex obtusifolius.* These aphids matured normally on this food plant and individuals of the third viviparous generation were present when the experiment closed. Stem mothers in the first instar taken on *Rumex obtusifolius* in the field, contemporaneous with hatching of eggs on *Viburnum*, matured and founded colonies on *Rumex* in the insectary. Progeny from this stem mother on *Rumex* were successfully transferred to *Viburnum opulus, Euonymus alatus, Celastrus scandens, Maclura pomifera,* and *Philadelphus coronarius.*

hatched from the egg about April 10 and matured April 25. First-born young which were two days old, comprising the second generation, were taken with the stem mother. Series 2 closed on Nov. 20 with a male nymph of 4th instar. This aphid was an individual of the twentieth first-born generation of an unbroken series. The first individual in Series 2 matured on *Viburnum*. Generations 2 to 15 inclusive were reared on *Rumex crispus*. Generations 16 to 20 inclusive were reared on *Chenopodium album*.

The remaining six series of the total of eight were incomplete in that each was started with a winged migrant taken from one of the summer food plants in the field. The possible number of generations which might obtain in the case of each series has been determined by combining the number obtained in each series with the probable number of generations occurring before the date the series started. The probable previous number of generations was obtained by a comparison of the date of starting with the number of the generation maturing on the nearest date to this in series 2 for 1923. The summary of these data will be found in Table VII. It will be noted that from the eight separate series, one had a possible 17 first-born generations, two had 18 first-born generations, two 19 generations, two had 20 generations, and one had 21 generations, the model number of the eight series being 19.

A last-born of last-born series was started on July 14 from the individual born in generation 9 of series 1. The series was closed on Nov. 20 with the 7 generations. During this same time 11 first-

TABLE VII

Date of Experiment	No. Generations	Possible No. of Generations
1920		
August 19 to November 12	8	21
1921		
May 21 to November 11	15	18
1922		
May 30 to November 10	13	17
June 30 to November 10	12	19
July 14 to November 10	10	19
1923		
April 4 to November 20	20	
April 10 to November 20	20	
June 2 to November 20	14	18

TABLE VIII—SUMMARY OF FIRST-BORN GENERATION EXPERIMENTS

Exp. No.	Date of Birth	Date of First Young	Age at Birth of First Young	Date of Last Young	Production Period-days	Total Young	Average Young per Day	Maximum Young in one Day	Period after Last Young	Date of Death or Disappearance	Total Length of Life
	1923										
1	April 4	April 16	12	?	2	6	3.0	3	?	?	14*
1-1	April 16	April 27	11	?	2	5	2.3	3	?	?	12*
1-2	April 27	May 10	13	May 13	4	18	4.5	6	1	May 14	17*
1-3	May 10	May 25	15	June 5	12	55	4.5	9	2	June 7	28
1-4	May 25	June 3	9	June 20	18	91	5.	11	4	June 24	30
1-5	June 3	June 11	8	June 29	19	64	3.3	9	9	July 8	35
1-6	June 11	June 20	9	June 26	7	21	3.0	5	1	June 27	16
1-7	June 20	June 29	9	July 11	13	37	2.8	6	1	July 12	22
1-8	June 29	July 7	8	July 14	8	36	4.5	11	0	July 14	16
1-9	July 7	July 14	7	July 21	8	16	2.0	5	2	July 23	16
1-10	July 14	July 22	8	July 29	8	28	3.5	7	1	July 30	16
1-11	July 22	July 30	8	Aug. 4	6	10	1.6	3	0	Aug. 4	14
1-12	July 30	Aug. 7	8	Aug. 10	4	5	1.2	2	1	Aug. 11	12
1-13	Aug. 10	Aug. 19	9	Aug. 22	4	8	2.0	4	1	Aug. 23	13
1-14	Aug. 22	Aug. 31	9	Sept. 8	9	21	2.3	5	6	Sept. 14	23
1-15	Aug. 31	Sept. 10	10	Sept. 29	20	52	2.6	6	2	Oct. 1	31
1-16	Sept. 10	Sept. 22	12	Sept. 30	9	14	1.5	3	2	Oct. 2	22
1-17	Sept. 22	Oct. 5	13	Nov. 20	47	32	.7	4	0	Nov. 20	60¶
1-18	Oct. 5	Oct. 21	16	Nov. 6	17	17	1.0	3	1	Nov. 7	33
1-19	Oct. 21	Nov. 20	30								¶

2	April 10	April 25	15	?	1	3		3	?	?	?*
2-1	April 25	May 8	13	?	1	5		5	?	?	?*
2-2	May 8	May 24	16	June 15	23	105	4.5	11	2	June 17	40
2-3	May 24	June 2	9	June 5	4	30	7.5	11	1	June 6	13*
2-4	June 2	June 10	8	June 19	10	33	3.3	7	0	June 19	18
2-5	June 10	June 18	8	June 23	6	23	3.8	7	1	June 24	14*
2-6	June 18	June 28	10	July 8	11	21	2.0	4	0	July 8	21*
2-7	June 28	July 7	9	July 21	15	59	3.9	8	0	July 21	24
2-8	July 7	July 15	8	July 30	16	42	2.6	5	0	July 30	24
2-9	July 15	July 26	11	Aug. 8	14	32	2.2	6	1	Aug. 9	25
2-10	July 26	Aug. 4	9	Aug. 12	9	26	2.8	5	1	Aug. 13	18
2-11	Aug. 4	Aug. 12	8	Aug. 18	7	20	2.8	4	2	Aug. 20	16
2-12	Aug. 12	Aug. 21	8	Aug. 27	7	12	1.7	3	1	Aug. 28	16*
2-13	Aug. 21	Aug. 31	10	Sept. 15	16	41	2.5	4	1	Sept. 16	26
2-14	Aug. 31	Sept. 10	10	Sept. 30	21	33	1.5	4	1	Oct. 1	31
2-15	Sept. 10	Sept. 21	11	Sept. 25	5	18	3.6	5	1	Sept. 26	16
2-16	Sept. 21	Sept. 29	8	Oct. 30	32	29	.9	4	2	Nov. 1	41
2-17	Sept. 29	Oct. 14	15	Oct. 19	6	10	1.6	4	1	Oct. 20	22*
2-18	Oct. 14	Nov. 3	20	Nov. 19	17	13	.7	2	1	Nov. 20	38¶
2-19	Nov. 3	Nov. 20	17								¶

*Incomplete record
¶Terminated Nov. 20

born generations had occurred in Series 1. From this known ratio between the number of first-born and last-born generations, we may conclude that *Aphis rumicis* would have a minimum of 12 generations for the entire season.

MOLTING

Aphis rumicis, like most other aphids, molts four times or passes through four nymphal instars before it reaches maturity. My observations, covering four consecutive years, indicate that the general trend is for the individual to molt between daylight and 9:00 A. M. This is not invariable, since some individuals molted later during the day, but never at night. The following figures represent data obtained from experiments covering the months of June, August and September. The length of the first instar in 40 cases ranged from 1 day to 3 days with a mean period of 2 days. The period between the first molt and second molt varied from 2 days to 4 days with a mean of 2 days in 27 cases. The mean period for the third instar was 2 days for 27 cases with a range from 1 day to 6 days. The mean length of time spent in the fourth instar was 2 days in 21 cases with a range of 1 day to 6 days. The length of time elapsing from the date of the last molt to the birth of the first young varied from 0 days to 9 days with a mean for 14 cases of 1 day. All individuals in these experiments which reached maturity were apterous females. The mean length of the second, third and fourth instars for September was 3 days. This is to be correlated with the data in Table VIII which shows that the generations in the fall required a greater length of time to reach maturity than did those which matured in mid-summer.

AGE AT WHICH FEMALES REPRODUCE

The length of time which was consumed by viviparous females from birth until they gave birth to their first progeny varied according to the time of year in which they appeared. This period ranged from seven days in July or August, to twenty days in late October and early November. The mean length of the developmental period was 10.5 days for all seasons of the year. These figures represent 119 individuals reared in 1920, 1921, 1922, and 1923. It will be noted that this difference in the length of the developmental period is seasonal by referring to Table IX. In this table the mean length of the developmental period has been determined for individuals grouped according to date of birth.

The limits of these several groupings were arbitrarily selected and all individuals born or developing within limits of any one group were classed together. The cases represent records covering the four seasons from 1920 to 1923.

TABLE IX

Period of Birth	*Dev. Period*	*No. of Individuals*
April 4 to June 15	11.6	16 cases
June 15 to August 20	9.0	37 cases
August 20 to November 4	11.6	43 cases

It will be seen that the individuals born from April 4 to June 15 had a mean developmental period of 11.6 days; those born between June 15 and August 20 had a mean developmental period of 9.0 days; those born between August 20 and November 4 had a mean developmental period of 11.6 days.

The data which are given above for *Aphis rumicis* agree very closely with information obtained in the same laboratory on *Myzus persicæ*. The average age of 65 mothers of *Myzus persicæ* was found to be 10.2 days and the seasonal range was practically the same, i.e. 11 days in spring and fall, and 9 days in summer.

This variation in the age of females of *Aphis rumicis* at the birth of the first progeny is illustrated in digrammatic form by Plate I, B. In this figure the lower solid line shows the variation in the age of females at birth of first young for first born generations in 1923. The upper dotted line represents the mean temperatures which obtain for each of these developmental periods for the several generations. In general, the trend shows that in the spring and fall when temperatures are low the developmental period is fairly long, while in the summer when mean temperatures are higher the insects mature in much shorter time.

REPRODUCTION

The shortest period of reproduction, for a single female under observation in any one of the four seasons, was 3 days. Several cases were recorded in which the period extended over 4 days in August and some in which the period was 5 days in July. One female, born on Sept. 22, 1923, was bearing young on Nov. 20 when the experiment closed. The reproduction period for this individual covered 47 days. Other individuals, having a reproduction period of 25 to 32 days were common in late September,

October, and November. The average length of reproductive period for 79 females was 12.6 days. I found that the total number of young produced by a female during her lifetime ranged from 2 to 105 aphids with an average of 24.6 young per mother for 76 individuals. Only those individuals were considered in securing this average which died from natural causes at a definitely determined date. The maximum number of young borne by one mother in a single day was 13.. This mother was feeding on spinach during May. Four other individuals each produced a maximum of 11 young in one day. The average number of young born to one female in a day was 2.1, average obtained from 119 cases.

LONGEVITY

The length of life of females after the birth of the last young varied considerably averaging 2.2 days for 78 cases. Six females died on the same day on which they gave birth to the last young. One female lived 12 days after the birth of the last young and two individuals lived 9 days. The total length of life of individual females in the generation experiments ranged from 10 days to 48 days. The average length of life for 76 females was 23.3 days. It may be noted that the average length of life of *Myzus persicæ* was found to be 23.5 days in work done on that species at the same laboratory.

THE OCCURRENCE OF ALATE FORMS

In general the winged viviparous females of *Aphis rumicis* may be grouped as spring migrants, migrants appearing during the summer generations, and fall migrants. The appearance of the spring and fall migrants is fairly constant and may be looked for (within a certain range) at about the same time each year. The appearance of summer migrants, on the other hand, does not seem to be so definitely defined and may or may not appear in any given summer generation. In my rearing cages considerable numbers of the daughters of stem mothers from *Viburnum* series No. 2 became winged adults on May 8 to 11, 1923. On May 8 of the same year, the first winged female was taken on the flower spikes of *Rumex crispus* in the field. In the same experiment, 90% of all granddaughters of stem mothers or the daughters of the wingless females of the second generation became winged viviparæ on May 23. The first winged forms to appear in the series No. 1 on *Rumex*, from stem mothers hatched from eggs on *Chenopodium* stems and reared

for the first two generations in the laboratory, were of the 4th generation, i.e., were great grand daughters of the stem mothers. These individuals matured May 24 on *Rumex crispus* with 92% winged. Thus, winged forms from the *Viburnum* strain appeared in predominating numbers in the 3d generation and in the *Chenopodium* strain on *Rumex* in the 4th generation, but they matured simultaneously in the insectary. The field collections for four years also indicate that the predominating spring migration takes place about the third week in May, and that the earlier migrants noted in early May, were comparatively of much smaller numbers. Practically all individuals which were taken were migrants on *Viburnum* on May 21, 1920 and again on May 21, 1922. Migrants were noted as leaving *Euonymus atropurpureus* on May 22, 1922. The first record of migrants and young on a summer host plant, *Rumex crispus*, in 1922, was taken on May 21. Infestation by migrants and young on lima beans was noted at Bustleton, Penn., on May 31, 1920. Light infestation, started by migrants on *Arctium lappa*, was noted at Iowa City, Iowa, on May 22, 1922. First infestations on *Chenopodium album* in the spring were on May 31, 1922 and on June 6, 1923. It will be seen that these typical records, and many others of a similar nature, in my files, show that an obvious relationship exists between the aphids migrating from *Viburnum*, *Euonymus* and other plants in the spring and the migrants appearing at the same time on *Chenopodium*, *Rumex* and *Arctium lappa*.

Neither the records made on generation experiments nor notes taken at time field collections were made, serve to clarify the problem as to what actually induces the appearance of winged forms during the summer. In my rearing experiments, these winged forms appeared from time to time, but in no definite generation or time of the season. No correlation was found between date of appearance and host plant or possible differences in materials in plant sap. I found that in Series 1 on *Rumex crispus* all young matured into apterous viviparæ from the 5th generation to the 12th generation. In the 12th generation, maturing on July 31, 1923, 3 out of 9 individuals or 33% were winged. In Series 2 on *Rumex crispus*, individuals of the 4th and 5th generations matured into wingless females, but 25% of the adults comprising generation six in this series matured into winged viviparæ on June 18, 1923. In Series 3, generation 6 (10th in line), on *Chenopodium*

album, 4 out of 8 individuals became winged viviparæ on July 24, 1923. In this same series on *Chenopodium album*, winged individuals appeared on Sept. 14, 1923. At this time, all forms maturing in Series 1 and 2 were wingless. In this grouping, the winged individuals appearing from June 1 to Sept. 15-20 have been considered as summer migrants. By referring to collection records in the food plant list it will be noted that winged viviparæ were taken during each of the months from June to October on a wide range of host plants. I feel that the appearance of the fall migrants or winged sexuparæ is more or less linked up in some way with temperature since they appear consistently in regions of the United States with decline of mean temperature in the fall of the year, but do not appear in California where fall does not bring such a low temperature. It may be as Davidson (18) suggests, that it is attributable to some combination of internal factors, but the direct stimulus would seem to be climatic in nature. In my experiments winged sexuparæ matured Oct. 23, 1921, on *Chenopodium album*, on Oct. 27, 1923, in Series 3 on *Chenopodium album*, in the 18th first born generation, and in Series 1 on Oct. 20-25, 1923, on *Rumex crispus* all but 8 out of 9 became winged sexuparæ. In the field, collections were made of winged sexuparæ maturing on summer hosts from Oct. 6 to Oct. 31 and alighting and bearing young on winter hosts during the same period.

Recent experimental work on this particular problem has resulted in evidence which is largely contradictory in nature. Mason (55) found that changes of environment with which he worked, i.e., effect of injury to food plants, crowding, and the addition of chemical solutions to food plants, had no bearing on production of winged forms in the first generation. He concluded that the young aphid, when born, has its adult condition as regards presence or absence of wings already determined and that there is no positive evidence in favor of such influences even to the third generation. Uichanco (94) failed to obtain fall migrants of *Aphis rumicis* when forms were reared in the greenhouse under optimum temperature conditions. Wadley (96) concluded that the factors of nutrition, parentage, and temperature were all important in causing appearance of winged forms, but that these factors must be applied before the second molt.

APPEARANCE OF SEXES

It is only within recent years that any winter hosts, other than *Euonymus europæus* and *Viburnum opulus* have been known to be selected by *Aphis rumicis*. Theobald (88) reported finding the eggs on petioles of *Rumex crispus*, but, so far as I can learn, did not observe the hatching of these eggs and founding of the colony by the stem mother the following season. Davidson (17) reported the rearing of sexes on broad beans and *Euonymus europæus* under controlled conditions and cites records of sexual females ovipositing on sugar-beet (Gaumont) (1913) and on haricot beans (Malaguin and Moitre) (1914). Davidson made this further observation: "The spindle-tree is undoubtedly a winter host of *Aphis rumicis*, but considering the local distribution of *Euonymus* in Britain it is highly probable that there are other winter hosts." I was so forcibly impressed by the same idea when I began these studies that I made very careful collections from shrubs and summer hosts of *A. rumicis* in order to ascertain these other possible hosts. Conclusions as to the names, which should be included as winter hosts are based on careful determinations of field collections, transfer tests, and copulation experiments. I have conducted many tests in which I selected a male taken from a certain host plant and placed it on a plant upon which an oviparous female was feeding. In many cases this experiment was reversed and the oviparous female from a certain host was crossed with a male from a different host. Although I realize that results of such copulation experiments are not of themselves entirely conclusive it seems that such information is not only interesting, but desirable when it is correlated with results of transfers made at other times during the year. In some of the cases the individuals which were paired were taken from different host plants. In other cases these pairings were made between males and oviparous females from the same host plant. I have been unable to find in literature any mention of similar experiments with this species. The cases in which successful copulation was effected are listed in Table X. In some cases the male was transferred to the plant upon which the oviparous female was feeding by means of a small brush, and the transfer in this case was somewhat aided. In other cases the plant upon which the male was feeding was placed inside a large cage together with the plant upon which oviparæ were feeding. In this case the males migrated to the host of the oviparæ themselves. Only cases in which actual copulation was effected are listed.

TABLE X—COPULATION TESTS

Date	Host of Male	Host of Female	No. of cases
Oct. 18	*Chenopodium album*	*Viburnum opulus*	1
Oct. 20	,, ,,	,, ,,	2
Oct. 25	,, ,,	,, ,,	6
Oct. 25	,, ,,	,, ,,	6
Oct. 15	,, ,,	*Euonymus alatus*	1
Oct. 23	,, ,,	*Chenopodium album*	6
Oct. 28	,, ,,	,, ,,	4
Oct. 23	*Arctium lappa*	*Rumex crispus*	2
Oct. 28	,, ,,	,, ,,	1
Oct. 28	,, ,,	*Arctium lappa*	5
Nov. 29	*Rumex crispus*	*Rumex crispus*	several
Oct. 23	*Viburnum opulus*	*Viburnum opulus*	4
Oct. 30	,, ,,	*Euonymus alatus*	2
Oct. 29	*Euonymus alatus*	,, ,,	2
Oct. 30	,, ,,	*Viburnum opulus*	1
Oct. 23	*Maclura pomifera*	*Maclura pomifera*	several
Oct. 24	,, ,,	*Viburnum opulus*	1

In the field, during October, I have taken males and oviparous females in copulation on *Arctium lappa, Chenopodium album, Viburnum opulus, Euonymus alatus, Maclura pomifera, Celastrus scandens,* and *Philadelphus coronarius.* Sexes were also taken during October from *Rumex crispus, Hydrangea paniculata* and *Calycanthus fertilis* which agreed morphologically with the same forms taken in copulation on the other hosts. It thus appears as Davidson has suggested that the number of winter hosts of *Aphis rumicis* is quite numerous.

In America, the winter hosts which have been recorded, in addition to *Euonymus* and *Viburnum,* include *Celastrus scandens* and *Hedera* in Conn., Patch (10) and *Philadelphus coronarius* in New York, Ohlendorf (62). Ohlendorf substantiated records of *Philadelphus, Viburnum* and *Euonymus* by transfers between these hosts.

I found that the migrants, which are the progeny of apterous viviparæ on summer hosts, were the winged sexuparæ which give birth to oviparous females. These oviparæ are born and develop either on some of the herbaceous hosts such as *Rumex obtusifolius, Rumex crispus, Chenopodium album* and *Arctium lappa* or on the woody shrubs such as *Euonymus atropurpureus, Viburnum opulus, Philadelphus coronarius, Hydrangea paniculata, Celastrus scandens, Maclura pomifera,* etc. The males are the progeny of *apterous sexuparæ* and develop on the so-called summer hosts. The offspring of these apterous sexuparæ are not always males exclu-

sively. In my experiments, males, migrants or winged sexuparæ, and apterous sexuparæ were born by the same mother. The sexuparæ, males, and oviparous females develop during October and early November in Iowa and Pennsylvania.

It should be noted that Swain (84) did not take the true sexes of *Aphis rumicis* in California but found it developing parthenogenetically throughout the year on its summer hosts. I reared this species in the greenhouse on *Rumex crispus* from Sept. 1921 to June 1922. At no time did true sexes appear in these cages. Davidson, (17) under similar conditions in England, obtained a certain proportion of sexual forms in five succeeding generations.

COPULATION AND EGG-LAYING

A male may copulate with more than one female. A male was observed to copulate with two separate females on the same plant. An interval of fifteen minutes to one-half hour elapsed between the times of copulation in three different cases under observation. When the male approached, the female elevated the tip of the abdomen and moved the hind legs vigorously about in the air. In several cases after mounting the female, the male was observed attempting to insert the penis at the head of the female. Failing in this, the male turned slowly about and successfully completed the act.

A series of experiments was conducted to secure data on the number of eggs laid by a single female. At the time the experiments closed on November 21, all females still living were dissected and the number of ova still within the body were counted, (Table X). A series of ten grown females reared on *Chenopodium album* was dissected on Nov. 12 and the number of ova was counted. The counts were as follows: 1, 8 ova; 2, 7 ova; 3, 6 ova; 4, 6 ova; 5, 5 ova; 6, 8 ova; 7, 7 ova; 8, 5 ova; 9, 5 ova; 10, 6 ova. The mean in this case is 6.3 ova per female.

From my observations of cage experiments, the oviparous female does not deposit all of her eggs at one time, but the period of egg deposition is extended over a period of one to two weeks. The eggs when first laid are olive green in color. The coat hardens and within a day becomes shiny-black. Eggs which are laid upon the woody winter hosts such as *Viburnum opulus*, etc., are usually placed in the axils between the bud and the stem. On *Rumex crispus* and *Rumex obtusifolius* they are fastened by the mucilaginous secretion to the underside of the leaf, usually along the

petiole or mid vein. On *Chenopodium album,* the eggs may be found tucked into old scars or breaks in the stem, in the axils formed by the side branches with the main stem, and even glued up and down the main stem unprotected.

TABLE XI

Food Plant of Ovip. Female	Exp. started	Copulation with male	No. of eggs Nov. 21	Notes
Rumex obtusifolius	Oct. 22	Oct. 25	5	dead ♀
Rumex obtusifolius	Oct. 25	Oct. 31	1	dead ♀
Chenopodium album	Oct. 25	Oct. 25	2	dead ♀
Chenopodium album	Oct. 25	Oct. 25	8	3 in ♀
Rumex crispus	Oct. 25	Oct. 25	2	0 in ♀
Chenopodium album	Oct. 31	Oct. 31	3	2 in ♀
Chenopodium album	Oct. 31	Nov. 2	4	1 in ♀

Oviparous females taken from *Maclura pomifera* while in the fourth instar, were transferred to *Rumex obtusifolius* Oct. 22. These matured on *Rumex* and deposited eggs. Oviparous females taken from *Chenopodium album* Oct. 16, when transferred to *Euonymus atropurpureus,* matured and oviposited on *Euonymus.*

The question arises as to whether development of oviparæ on herbaceous plants and consequent egg deposition on the same is accidental in some cases, the chance result of migrants alighting on these plants. Although this may have been the case with *Aphis rumicis* at some previous stage in its development, I have come to believe that here in the Eastern and Central United States, at least, it is an adaptation which helps to insure perpetuation of the species. *Rumex crispus* and *Rumex obtusifolius* are perennials and some of the rosettes of leaves never entirely die, but survive the winter. Other new leaves are shot out at the earliest advent of spring. Aphids hatching in April, from eggs deposited on either of these plants, find the food necessary for development. I have taken stem mothers on *Rumex crispus* and *Rumex obtusifolius* in the spring at the same time they were found on *Euonymus* and *Viburnum.* In the case of aphids hatching from eggs on *Chenopodium album,* it is different for this is an annual. However, it must be remembered that *Chenopodium album* is invariably found in the same habitat with these two species of *Rumex.* It is then probable that the aphids upon hatching from eggs on *Chenopodium album* crawl down the dead stem and seek nearby *Rumex* plants. Young *Chenopodium album* plants are just sprouting at the time the eggs hatch. This supposition is strengthened by the fact that this very pro-

cedure took place in my experiments, not in one case, but in fourteen cases. I have found no record in the literature of observations showing the hatching of eggs deposited on herbaceous plants.

Dr. Fitch (32) found two newly-deposited eggs on pigweed (*Chenopodium?*) but regarded these as accidental. His notes under heading of *Aphis rumicis* Linn., December, 1870 read: "Where the eggs are laid and how the insect is carried through the winter, has hitherto been a mystery, as Mr. Curtis observes. Upon this important point I am able to shed some light. Upon examining a pigweed infested by these black lice the latter part of October I discovered an egg, slightly adhering to the surface of a dry and crinkled and dead leaf, and another crowded into a crevice in another wrinkled dead leaf, whereby only its end was visible. These no doubt had been newly laid. They were of a dull green color, smooth and shining. Several other infested weeds were examined later in the season, but I was unable to detect any eggs upon them. In November, meeting with a weed that was thronged with pupæ, I transplanted it into a flower pot and brought it in doors to observe whether on maturing, having no other place to lay their eggs, they would not stock this plant with them. But on obtaining wings, they all flew away, without making any deposit of eggs thereon. It was thus evident that the two eggs I found were only placed on the dead leaves by accident, and that they do not lay their eggs upon the plants they inhabit, or at least upon those which decay at the close of the season."

SEASONAL HISTORY

I have outlined, in tabular form, the host plants upon which I have collected *Aphis rumicis* at different periods of the year. This indicates the general occurrence of this aphid as I have found it during the various seasons in Pennsylvania. I found that the eggs on *Viburnum opulus* and *Chenopodium album* hatched about the second week in April. The young stem mothers on *Viburnum opulus* developed on that host while those from eggs on *Chenopodium album* migrated of necessity to *Rumex.* Stem mothers were found developing on *Rumex* in the field during the third week in April. Migrant daughters of stem mothers on *Viburnum opulus* preferred *Rumex* upon which to establish colonies. The migrant granddaughters of stem mothers from *Viburnum* reproduced on *Rumex* and *Arctium.* Migrants from the other winter hosts evidently selected these same plants since colonies were limited to

TABLE XII—

April	May	June	July
Rumex crispus	*Rumex crispus*	*Rumex crispus*	*Rumex crispus*
Chenopodium album		*Chenopodium album*	*Chenopodium album*
Euonymus atropurpureus	*Arctium lappa*	*Arctium lappa*	*Arctium lappa*
Viburnum opulus	*Viburnum opulus*	*Viburnum opulus*	
	Euonymus atropurpureus	*Tropæolum minus*	*Tropæolum minus*
	Euonymus alatus	*Beta vulgaris*	
		Amaranthus retroflexus	*Amaranthus retroflexus*
		Rheum rhaponticum	*Rheum rhaponticum*
		Spinacia oleracea	
		Phaseolus limensis	*Dahlia* sp.
		Rumex obtusifolius	
Ova			
Fundatrices	*Fundatrices*		
Larvæ	*Larvæ*	*Larvæ*	*Larvæ*
	Alate vivip.	*Alate vivip.*	*Alate vivip.*
	Apter. vivip.	*Apter. vivip.*	*Apter. vivip.*

SEASONAL HISTORY CHART

August	September	October	November
Rumex crispus	*Rumex crispus*	*Rumex crispus*	*Rumex crispus*
Chenopodium album	*Chenopodium album*	*Chenopodium album*	*Chenopodium album*
Arctium lappa	*Chenopodium ambrosioides*	*Arctium lappa*	*Arctium lappa*
Lycopersicon esculentum	*Papaver* sp.	*Capsella bursapastoris*	*Viburnum opulus*
Tropæolum minus	*Tropæolum minus*	*Stellaria media*	*Euonymus alatus*
Daucus carota	*Galinsoga parviflora*	*Galinsoga parviflora*	*Maclura pomifera*
Amaranthus retroflexus	*Amaranthus retroflexus*	*Phaseolus limensis*	*Celastrus scandens*
Rheum rhaponticum	*Gladiolus* sp.	*Viburnum opulus*	*Euonymus atropurpureus*
Spinacia oleracea	*Spinacia oleracea*	*Euonymus atropurpureus*	*Philadelphus coronarius*
Polygonum scandens (dumetorum)	*Pisum* sp.	*Euonymus alatus*	*Rumex obtusifolius*
	Dahlia sp.	*Maclura pomifera*	
	Phaseolus vulgaris	*Celastrus scandens*	
	Mirabilis jalapa	*Philadelphus coronarius*	
	Aster sp.	*Hydrangea paniculata*	
	Rumex obtusifolius	*Calycanthus fertilis*	
		Polygonum persicaria	
		Ova	*Ova*
Larvæ	*Larvæ*	*Larvæ*	*Larvæ*
Alate vivip.	*Alate vivip.*	*Alate vivip. (sexuparæ)*	*Alate vivip. (sexuparæ)*
Apter. vivip.	*Apter. vivip.*	*Apter. vivip. (sexuparæ)*	*Apter. vivip. (sexuparæ)*
		Oviparæ	*Oviparæ*
		Males	*Males*

Rumex and *Arctium* during this month. During June, July, August and September, as will be noted, a great variety of hosts may be infested. I was unable to obtain any data which would lead me to believe that migrants from any particular host were selective in their tastes, or in other words, that certain strains of *Aphis rumicis* depending on groups of food plants have been evolved. Theobald (88) has diagrammed a possible dual strain for this species in England. This conclusion was based on his collections and observations in the field.

Fall migrants or sexuparæ, which are the progeny of apterous viviparous females, develop on the summer hosts and in October and early November return to winter hosts where they give birth to oviparous females. Many of the migrants which develop on *Chenopodium album* do not change host species, but may migrate to another plant of the same kind. They take up a position on the under side of the leaf and begin feeding. Here the young oviparæ are born and developed to maturity. At the same time the apterous viviparous females on *Chenopodium album,* feeding along the smaller stems and flower corymbs, are giving birth to young which develop into winged males. On the under surface of leaves of *Rumex* and *Arctium* apterous viviparæ, alatæ, males and oviparous females may be taken at one and the same time. It is from these herbaceous plants that some of the males migrate, in late October and November, to *Viburnum opulus, Euonymus atropurpureus, Hydrangea,* etc., and mate with the mature oviparæ on these plants. Egg deposition takes place in late October and November. It will be noticed that *Chenopodium album* appears in the table for each month but May. In April, it is only as dried stems, upon which eggs are found, that the plant is listed. The aphids have not been taken feeding on this host until June. In October, *Capsella, Galinsoga,* and *Stellaria* serve as hosts in certain locations near heavily infested *Chenopodium* plants. With the killing of *Chenopodium album* by frost in late October and November, the apterous viviparæ and young males migrate to these plants and complete their development. At other times during the summer these plants have not been recorded as hosts nor have I found oviparæ or eggs upon them.

In European countries, the spindle-tree *Euonymus europæus* is the favored host but with the absence of any numbers of that shrub in some sections of America, *Aphis rumicis* has evidently adapted

itself to our conditions and hence the choice as here described, of such a winter host as *Chenopodium album*. Another difference which this insect encountered in its food plants was the absence of the poppy (*Papaver* sp.) in the wild state in Eastern and Central United States.

NATURAL ENEMIES

Aphis rumicis does not increase without check throughout the season because certain parasitic and predaceous enemies reduce the numbers, in some instances destroying an entire colony on a plant. The parasites are particularly common in July and August. I reared *Asaphes americana* Gir. (det Gahan) from parasitized aphids in August. This species has been recorded as a parasite of *Aphis rumicis* by Girault (39). *Lysiphlebus testaceipes* Cress. (det. Gahan) was bred quite frequently from *Aphis rumicis*. Although this parasite apparently has not been coupled with *rumicis* in literature, Mr. Gahan states that he has frequently determined it from this host. I reared two species of *Hymenoptera* which are probably secondary parasites: *Pachyneuron siphonophoræ* Ashm. (det. Gahan) perhaps a parasite of *Lysiphlebus*, and a Cynipid of which Mr. Weld says, "may be *Charips*, *Hemicrisis*, or *Phænoglyphis*." Specimens were also bred of *Aphidencyrtus* sp. (det. Gahan) Mr. Gahan says that no species of *Aphidencyrtus* has been recorded from *Aphis rumicis* and that it may or may not be a secondary parasite.

On June 7, 1923, many individuals of *Aphis rumicis*, with orange-colored mites clinging to them, were taken on *Arctium lappa*. Dr. Ewing wrote me about these as follows: "The mites belong to a species of *Bocharitia* of the family Erythræidæ and are probably the young of one of our common species. Mites of the genus *Bochartia* parasitize aphids in their larval stage. In the nymphal and adult stages these mites are predaceous."

The predaceous beetles which were taken feeding on *Aphis rumicis* were *Megilla maculata* DeG., *Adalia bipunctata* Linn., *Hippodamia convergens* Guer., and *Coccinella 9-notata* Herbst. Larvæ of syrphid flies and lace-wing flies were taken devouring numbers of the aphids.

SUMMARY

Aphis rumicis Linn. has been known in literature under a large number of names because of its polyphagous habits and because of the early belief that species of aphids were largely confined to

single species of hosts. Nineteen of these names are listed here as synonyms. In Europe, the species has been known as a serious pest of varieties of beans, *Vicia faba,* Shirley poppies, mangolds, and *Euonymus.* In America, it seriously infests *Viburnum opulus* in the spring, *Euonymus,* nasturtiums, seed stalks of beets and spinach, and horse beans, where this crop has been introduced. It also lives on a large number of weeds.

During these studies, intermediates of viviparous females, oviparous females, and males have been found and described. The spring and fall migrants are morphologically distinct. Data from cage experiments correlated with field notes have demonstrated the presence of two distinct types of life cycles: one having woody shrubs as primary hosts upon which ova are deposited and the first generations develop in the spring with herbaceous plants as secondary hosts; the other having herbaceous plants such as *Chenopodium album* and *Rumex* as primary hosts and other herbaceous plants with the above named as secondary hosts. Five primary hosts have been added to the list upon which this insect has been known to winter and these records serve to clarify the reasons for the prevalence of this insect in sections where the primary hosts, previously reported, are scarce. The evidence seems to indicate that physiological species are not present.

From the detailed life history experiments it is found that *Aphis rumicis* Linn. may have a maximum of 20 first-born generations in Pennsylvania and a minimum of 12 last-born generations. The model number of first-born generations for four seasons was 19. The average length of the larval periods was 2 days for the first instar, 2 days for the second instar, 2 days for the third instar, and 2 days for the fourth instar. The length of time which elapsed between the birth of viviparous females and the date of birth of the first young varied according to the time of year in which they appeared and is presented in graphical form. This period ranged from 7 days in July and August to 20 days in late October and early November, with a mean developmental period of 10.5 days for all seasons. The average length of the productive period was 12.6 days. The total number of young produced by one female ranged from 2 to 105 individuals with an average of 24.6 young per mother. The maximum number of young borne by one mother in a single day was 13 and the average number born to one female in a day was 2.1 young. The total length of life for 76 females averaged 23.3 days.

Neither the records made on generation experiments nor notes taken in the field serve to clarify the problem as to what factor or combination of factors actually induces the appearance of winged forms although I feel that the appearance of the spring and fall migrants is more or less linked up in some way with temperature conditions. The copulation experiments between males taken from one host with females from a different host, while inconclusive in themselves, are of interest and value when correlated with the results of transfers of the viviparous females. Oviparæ from woody shrubs, when transferred to herbaceous plants, continued to develop and deposit ova on the latter.

The following parasitic and predaceous enemies of *Aphis rumicis* were bred: *Asaphes americana* Gir., *Lysiphlebus testaceipes* Cress., *Pachyneuron siphonophoræ* Ashm., a Cynipid, *Aphidencyrtus* sp., *Bochartia* sp., *Megilla maculata* DeG., *Adalia bipunctata* Linn., *Hippodamia convergens* Guer., and *Coccinella 9-notata* Herbst.

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PLATE I

Fig. A. Line of first-born generations, *Aphis rumicis*, Bustleton Pa., 1923.

Fig. B. Relation between the mean temperature and the developmental period of viviparous females of succeeding generations.

PLATE I

Gen. No	Length Days	APR. 1923	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1	14x	4 — 18 ..?								
2	12x	16 — 28 ...?								
3	17x	27 — 14								
4	28		10 — 7							
5	30		25 — 24							
6	35		3 — 8							
7	16			11 — 27						
8	22			20 — 12						
9	16			29 — 14						
10	16				7 — 23					
11	16				14 — 30					
12	14				22 — 4					
13	12				30 — 11					
14	13					10 — 23				
15	23					22 — 14				
16	31					31 — 1				
17	22						10 — 2			
18	60						22 — 20			
19	33						5 — 7			
20	30x						21 — 29-?			

A

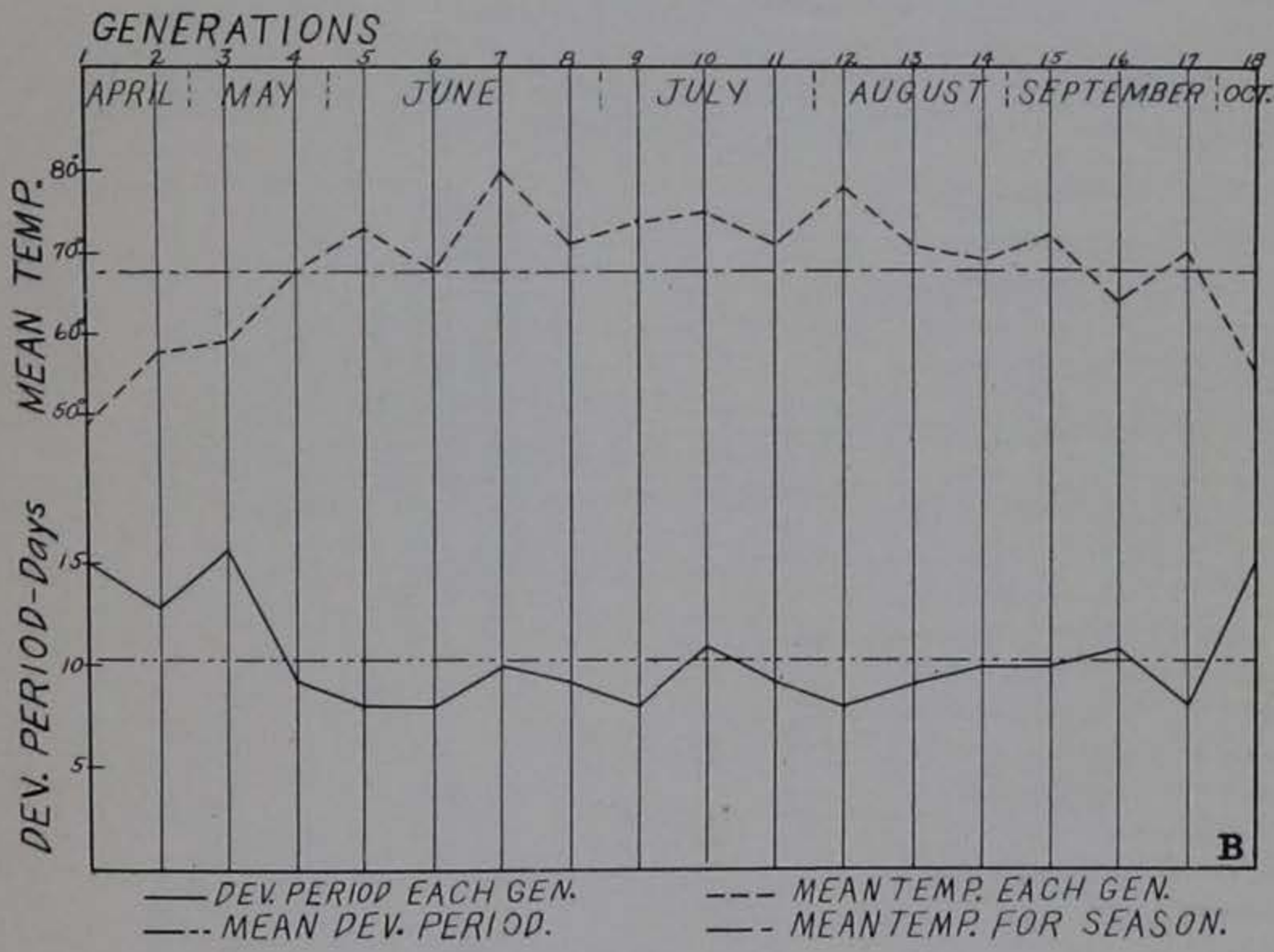


PLATE II

Fig. A. Winged Male, *Aphis rumicis*, greatly enlarged; B, Antenna of same; C, Cornicle; D, Cauda; E, Hind Tarsus.

Fig. F. Winged Viviparous Female, *Aphis rumicis*, greatly enlarged; H, Cornicle; I, Cauda; J, Hind Tarsus.

PLATE II

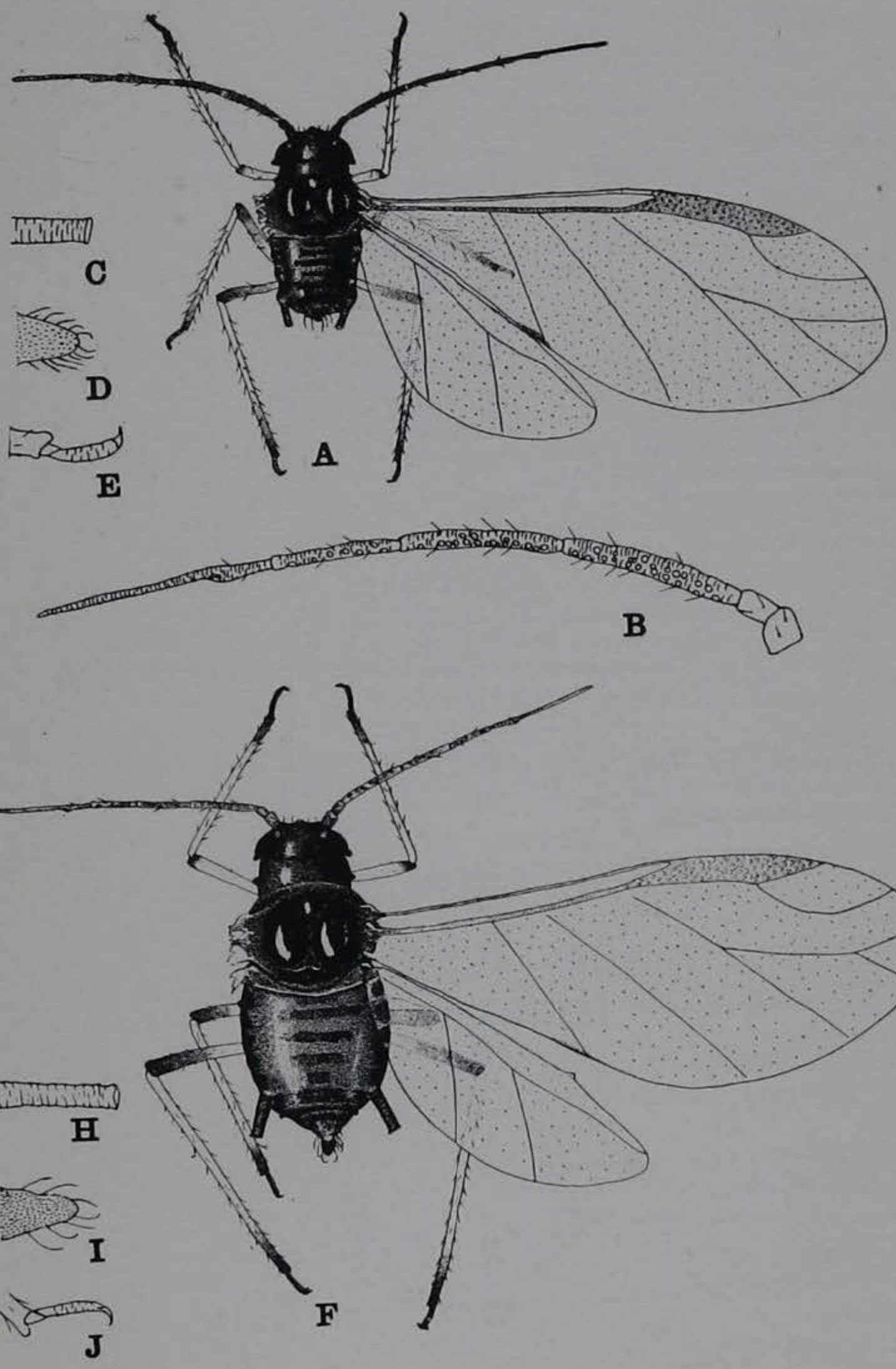
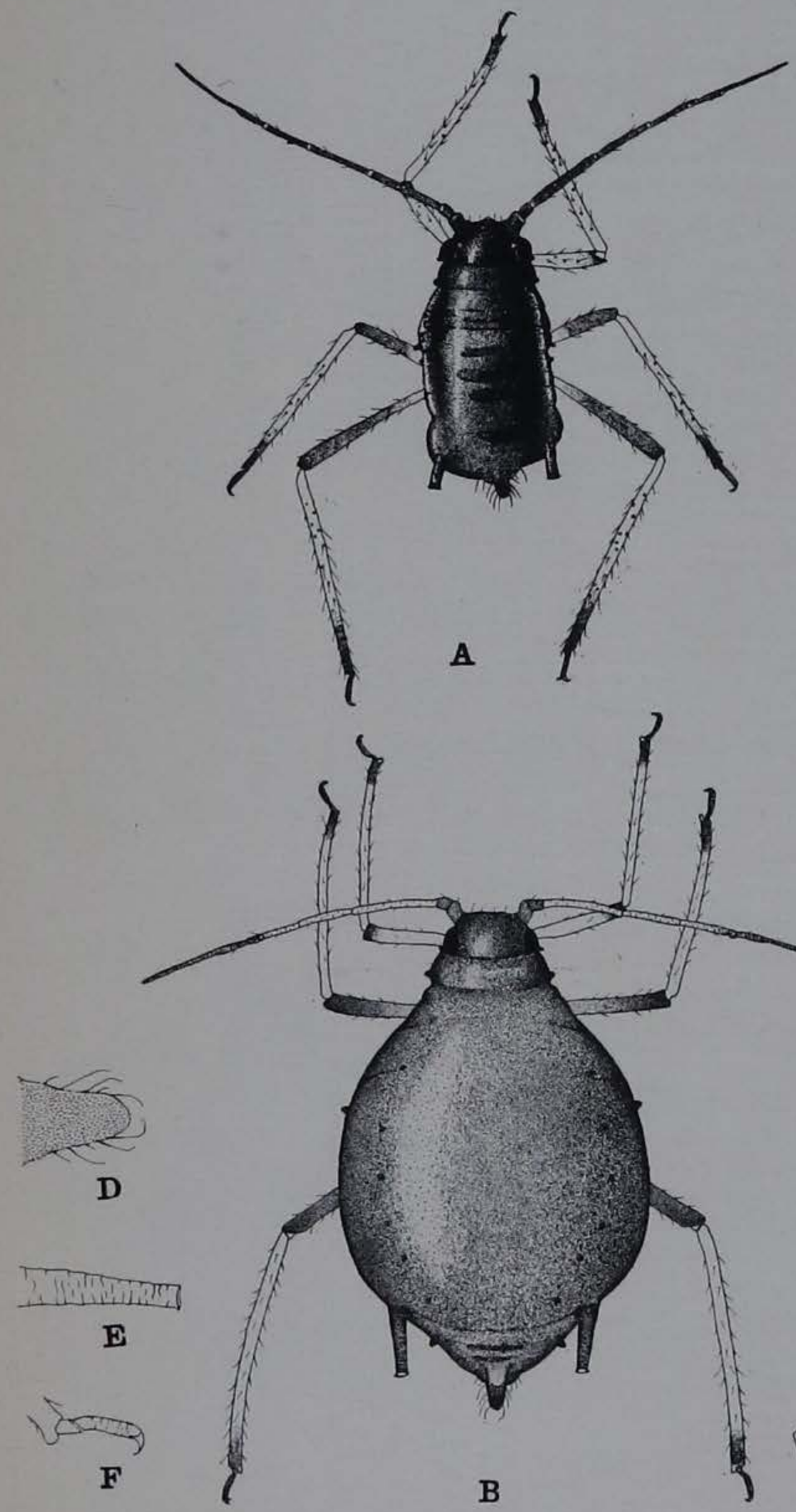


PLATE III

Fig. A. Intermediate Male, *Aphis rumicis*, greatly enlarged. Only traces of winged characters present are tiny buds and a slight sign of division into thoracic lobes.

Fig. B. Apterous Viviparous Female, *Aphis rumicis*, greatly enlarged; C, Antenna of same; D, Cauda; E, Cornicle; F, Hind Tarsus.

PLATE III



A

B

C

D

E

F

PLATE IV

Figs. A, B, C. Antennal segment III of winged males from *Chenopodium album* showing variation in number and arrangement of sensoria.

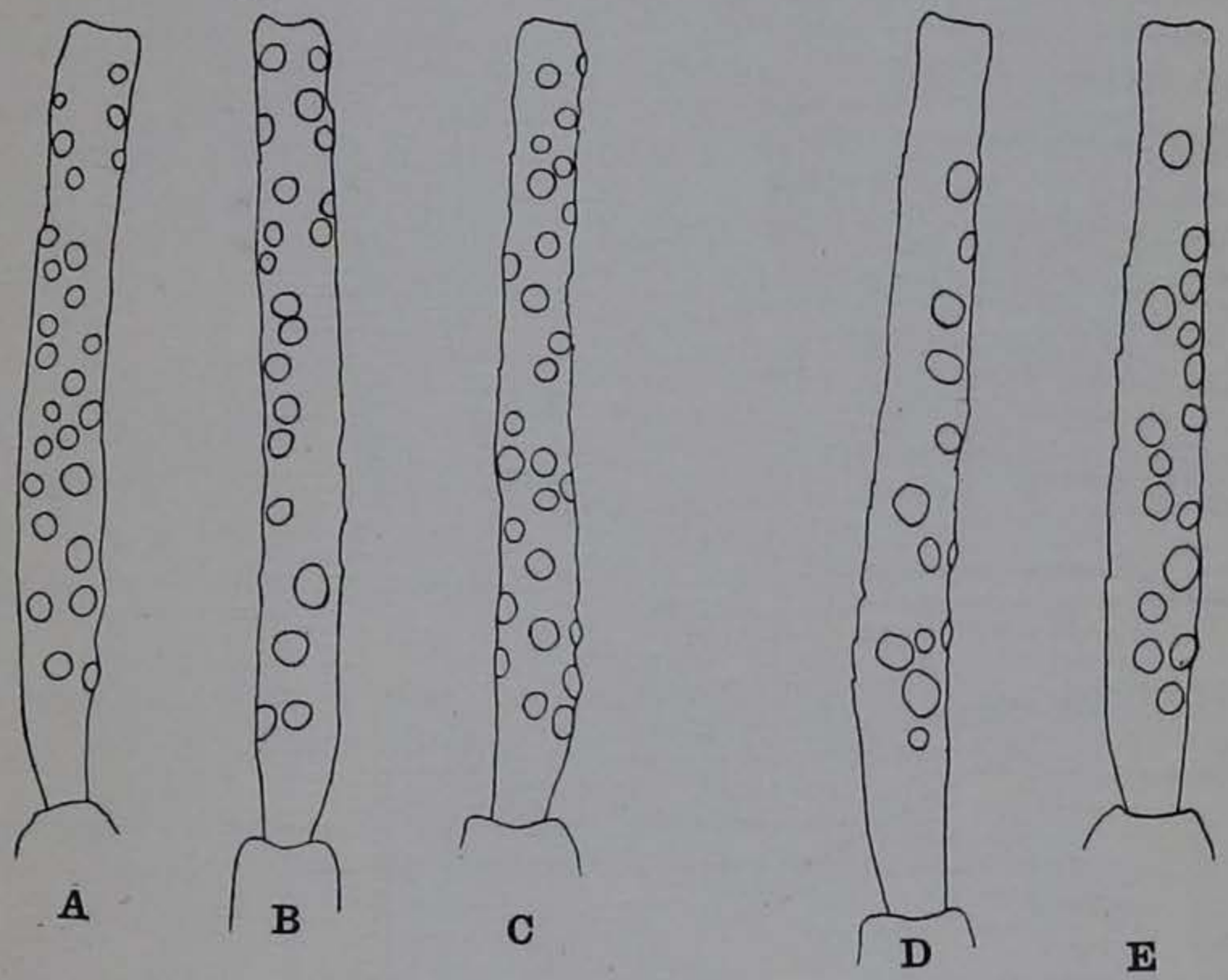
Fig. D. Antennal segment III of spring migrant from *Rumex crispus*.

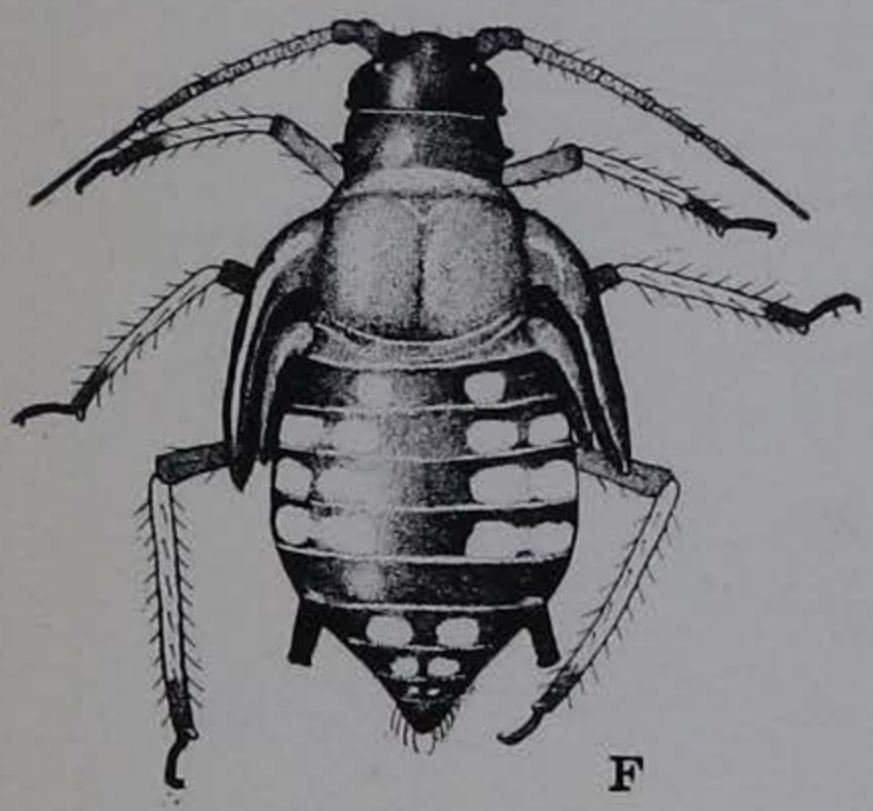
Fig. E. Antennal segment III of fall migrant from *Rumex crispus*.

Fig. F. Pupa, *Aphis rumicis*, greatly enlarged. Note the white pulverulent patches on the abdomen.

Fig. G. First Instar Larva, *Aphis rumicis*, greatly enlarged.

PLATE IV

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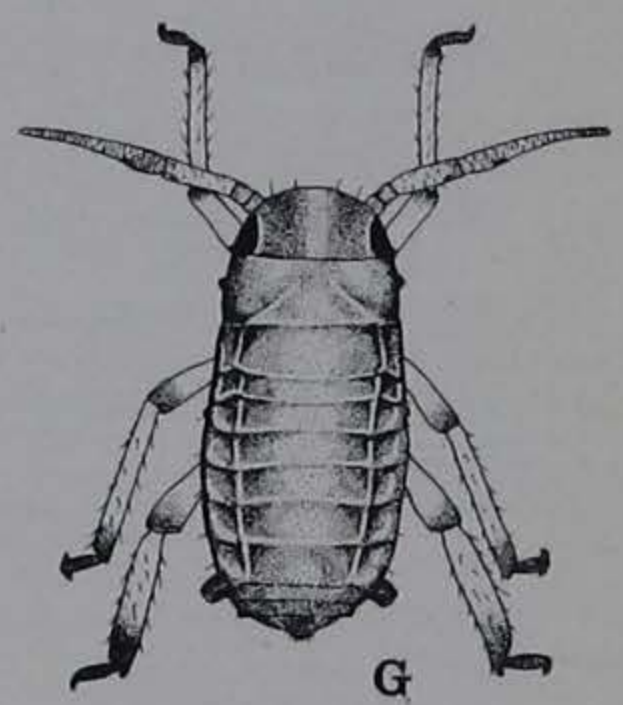
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PLATE V

Fig. A. Intermediate Male, *Aphis rumicis.* Wings represented by conspicuous pads.

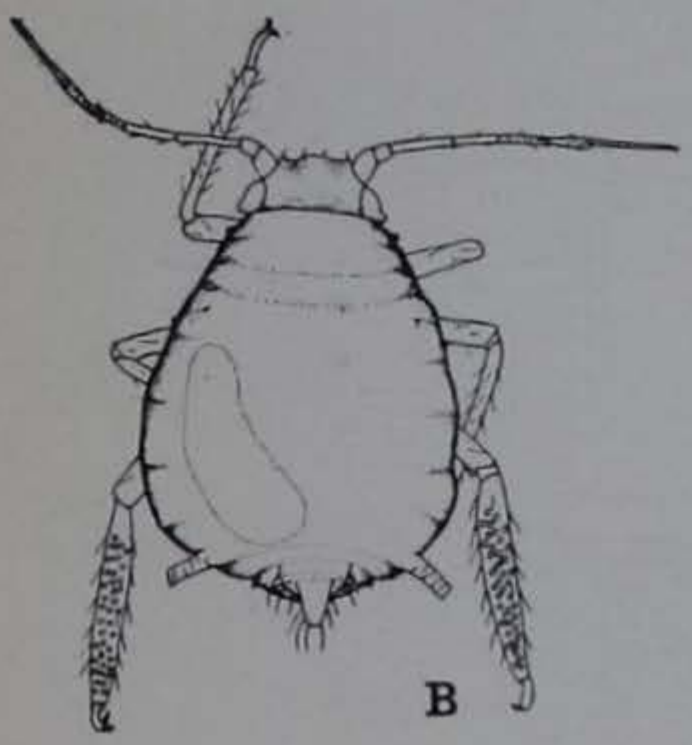
Fig. B. Oviparous Female, *Aphis rumicis.* Note swollen hind tibiæ. C, Cornicle of same; D, Cauda; E, Hind Tarsus; F, Antenna.

Fig. G. Intermediate. A viviparous female with characters of winged form represented in thoracic characters, wing pads, and markings on abdomen.

Fig. H. Intermediate. Oviparous female with eggs present in abdomen. The specimen has the slender hind tibiæ characteristic of the viviparous female.

Fig. I. Stem Mother, *Aphis rumicis;* J, Cornicle of same; K, Cauda; L, Hind Tarsus; M, Antenna.

PLATE V



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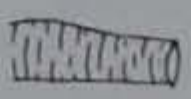

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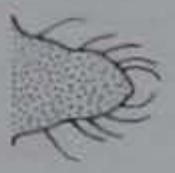

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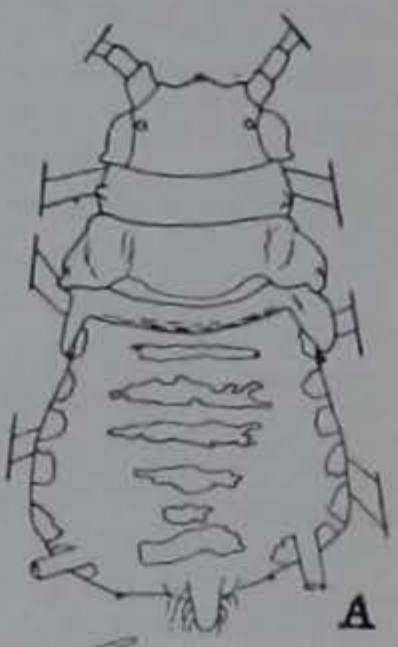

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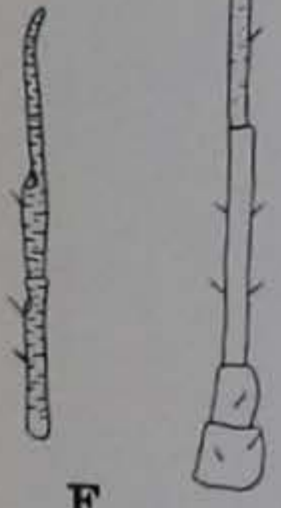

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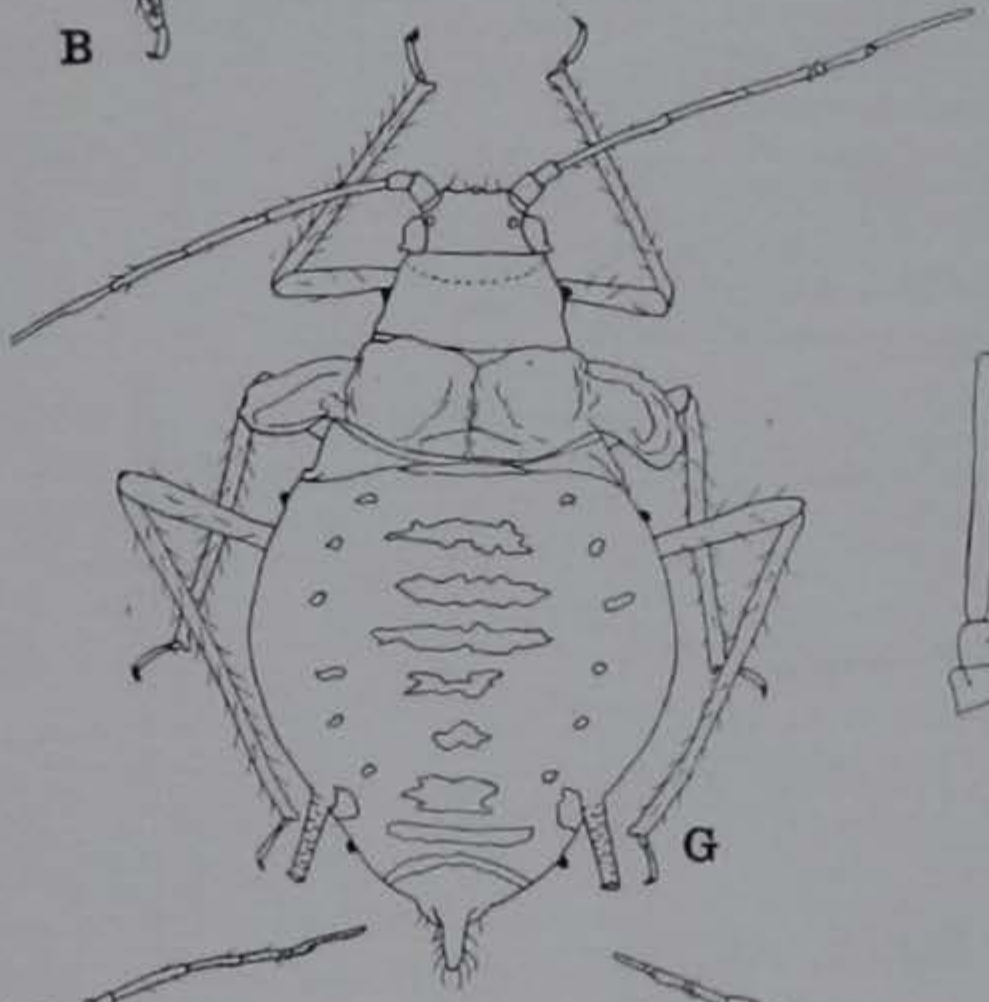

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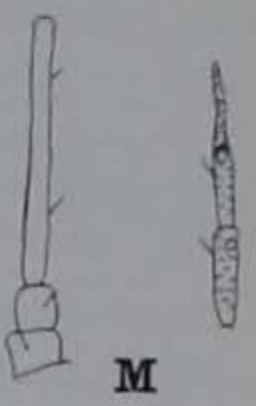
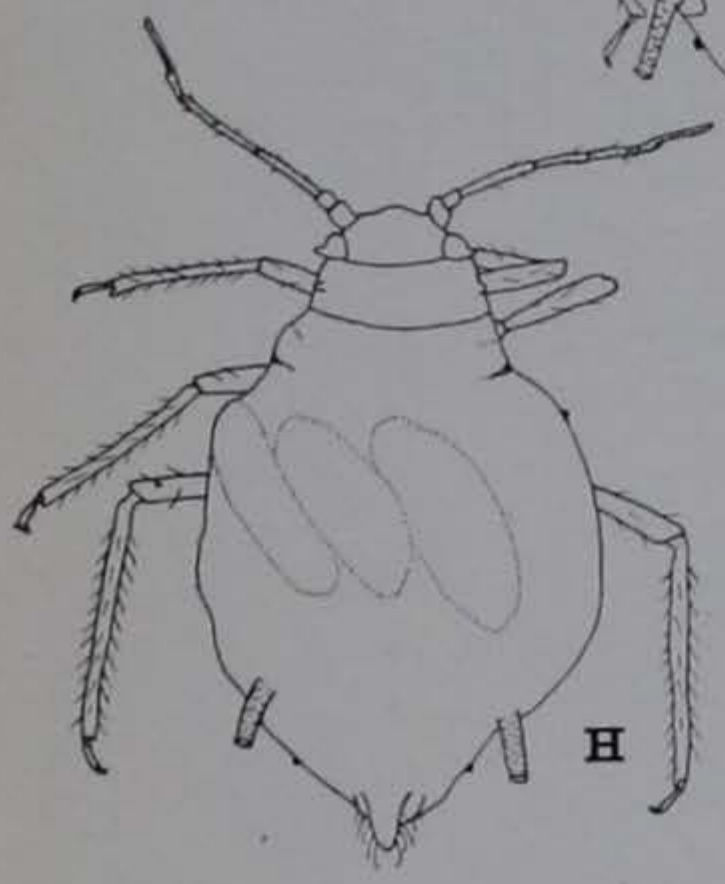


M

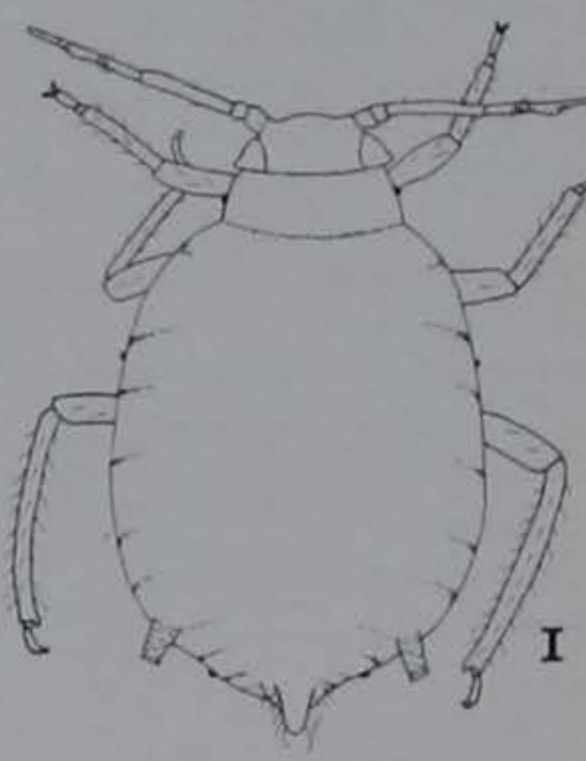


H

J

K

L



I

PLATE VI

Leaves of *Tropæolum minus* infested with colony of *Aphis rumicis*. Note the pupæ with white pulverulent spots on abdomen.

PLATE VI

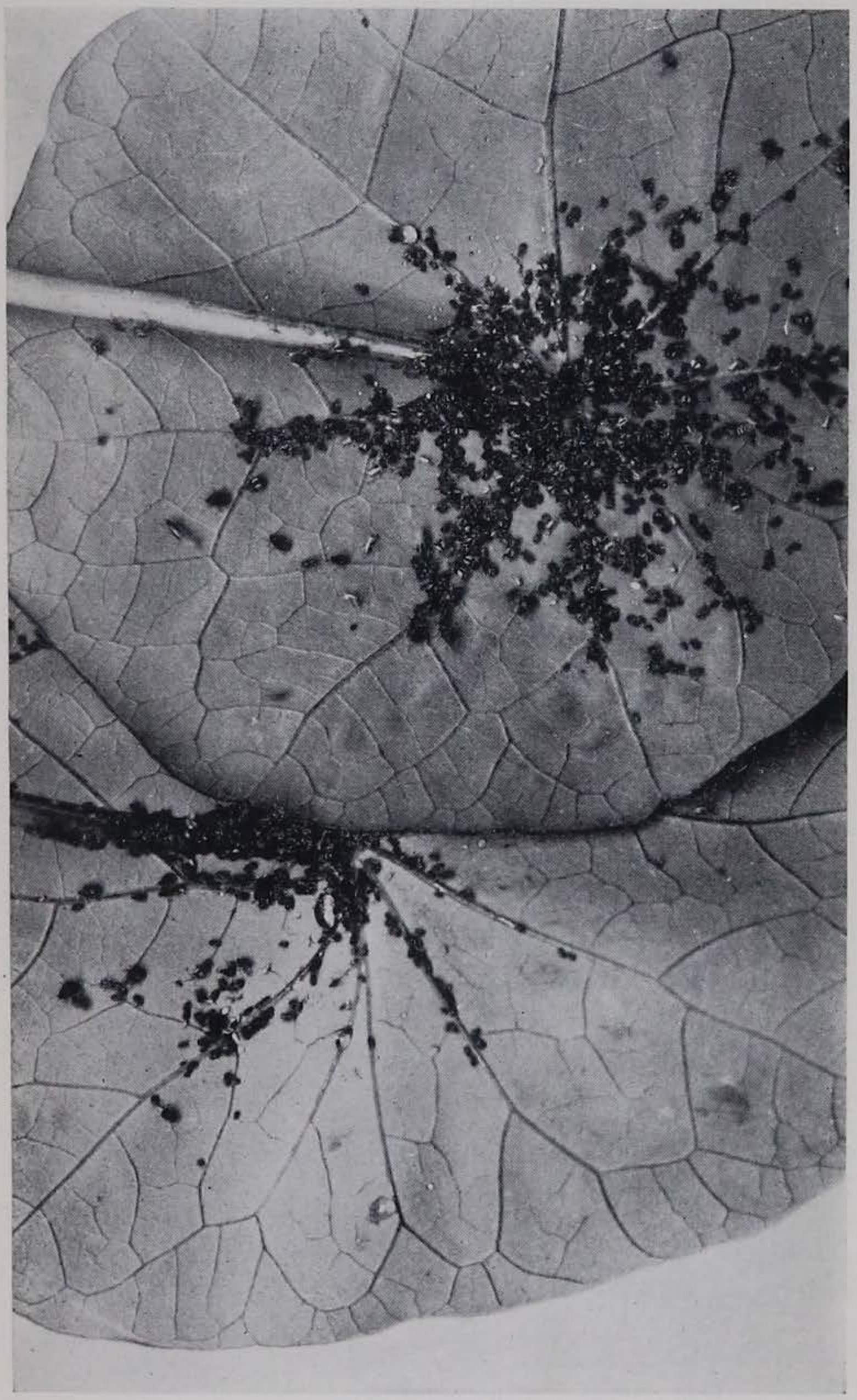


PLATE VII

Plants of *Arctium lappa* infested with colony of *Aphis rumicis*.

PLATE VII

PLATE VIII

Fig. A. Eggs of *Aphis rumicis* on stem of *Chenopodium album*. The stem was broken and healed during the growing period.

Fig. B. Colony of *Aphis rumicis* on stem of *Chenopodium album*.

Fig. C. Colony of *Aphis rumicis* on the flower-stems of *Dahlia* attended by ants.

PLATE VIII

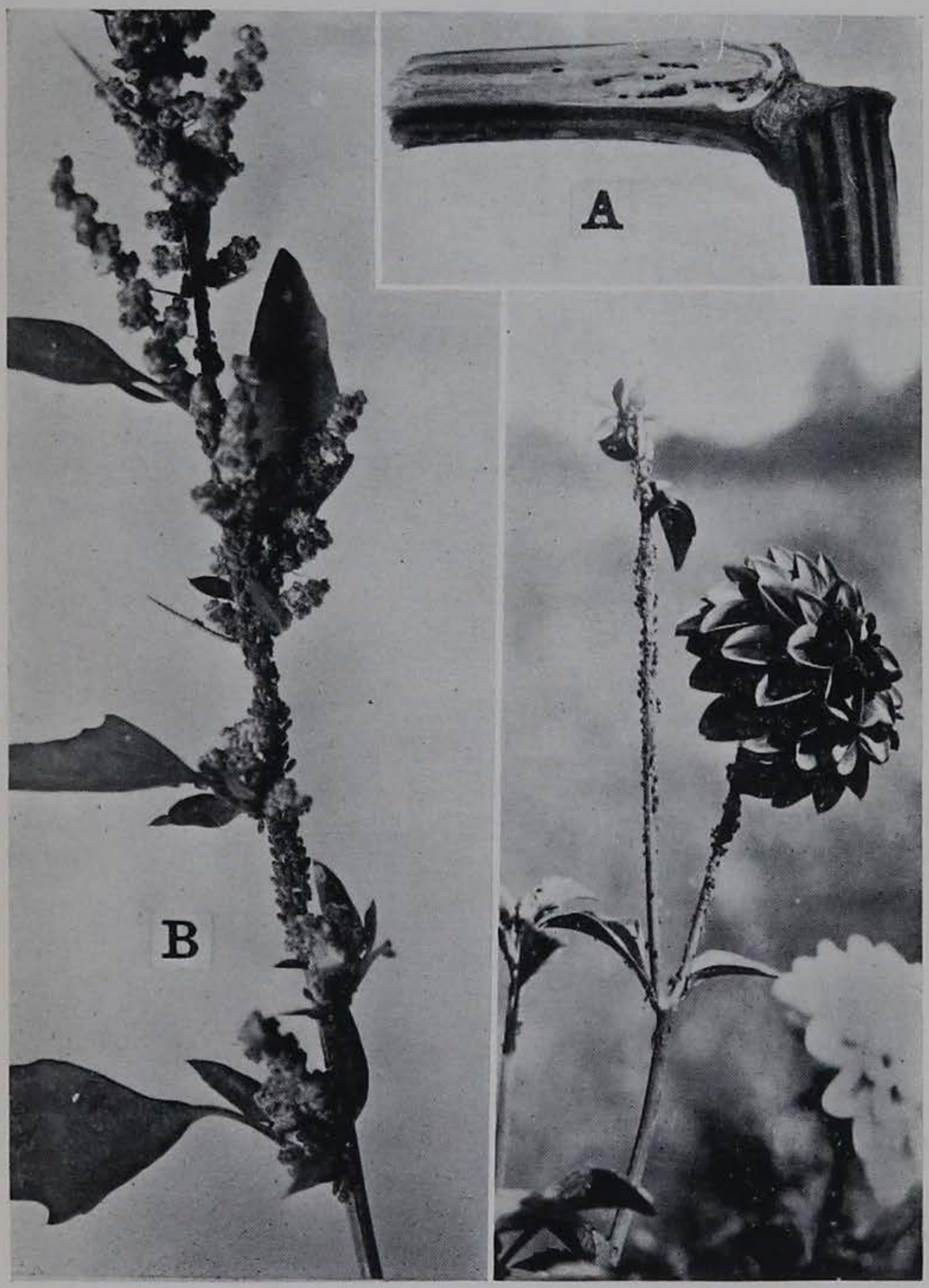
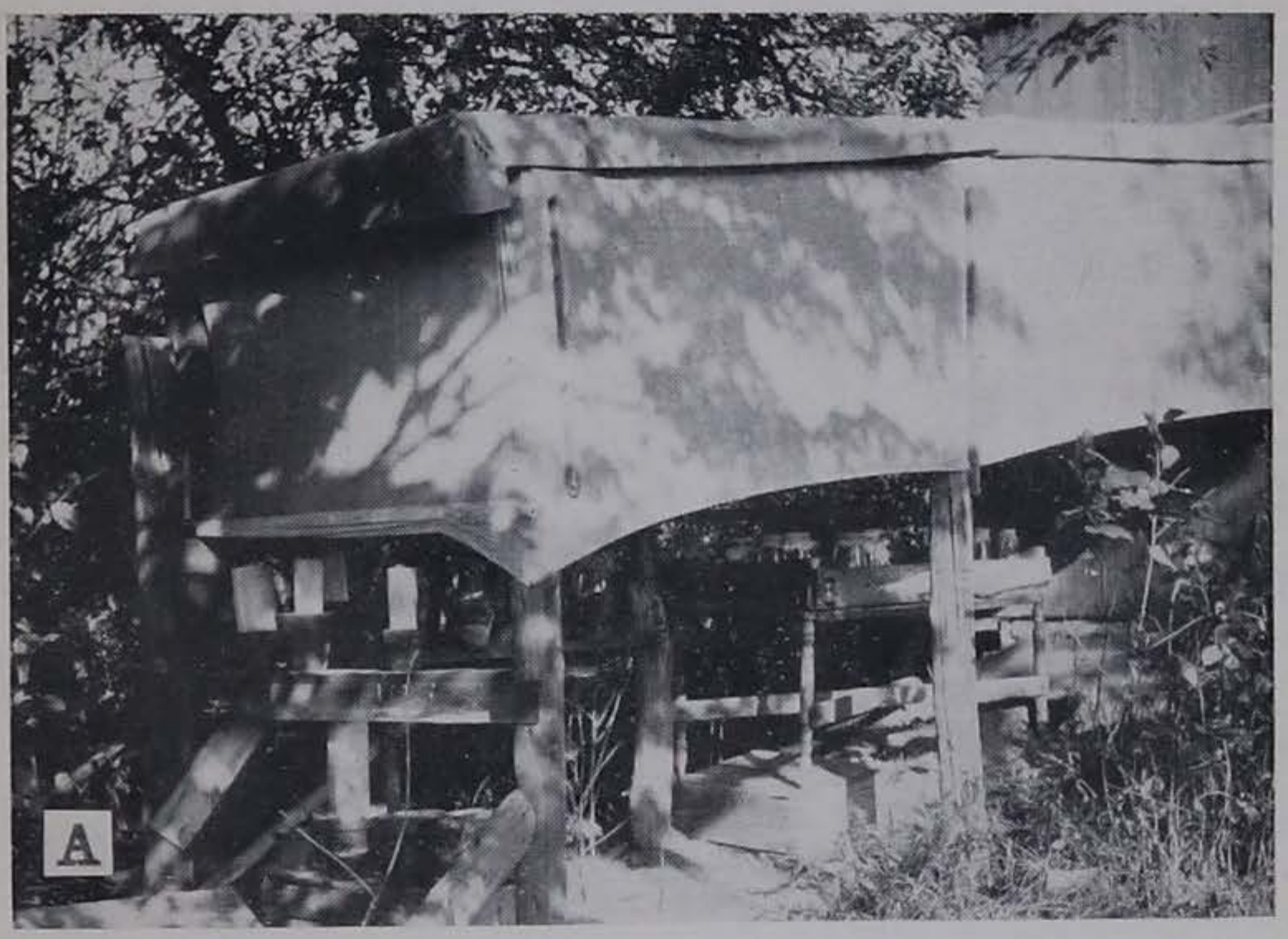


PLATE IX

Fig. A. Type of insect cages used in the field for rearing *Aphis rumicis*.

Fig. B. Insectary used for life history experiments.


A


B

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