BIOLOGY AND CONTROL OF THE BLACK CHERRY APHID, *MYZUS CERASI* (FAB.), IN THE WILLAMETTE VALLEY

by

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BIOLOGY AND CONTROL OF THE BLACK CHERRY APHID, *MYZUS CERASI* (FAB.), IN THE WILLAMETTE VALLEY

INTRODUCTION

The decision to undertake a complete biological study of the black cherry aphid was precipitated by problems dealing with the control of this insect in the Willamette Valley over the past several years. It had been noted in many cherry orchards throughout the valley that even though standard spray recommendations were followed in applying insecticides during the dormant and green tip stages, infestations consistently developed during the late spring and early summer. This phenomena seemed contrary to existing concepts since it was generally concluded by most observers that the winged forms of this aphid, when they appeared in the late spring, migrated directly to their alternate host plants without first dispersing to other cherry trees.

Since the issue seemed in doubt and since this insect is of considerable economic importance in the Willamette Valley, it was deemed advisable to conduct a study of this nature. Since considerable other information was also lacking, with regard to the habits of this pest in the Valley, it was considered important to include such factors as temperature relations, alternate hosts, general information regarding the seasonal history of the pest, predators and parasites, control studies and other pertinent factors which might be considered of importance as the study progressed.

DISTRIBUTION

The black cherry aphid is a native of eastern Europe (5, p. 44), where it was originally described by Johann C. Fabricius in 1775. It was first mentioned in North American literature by Fitch (32, p. 59), in 1851, in his Catalogue of the Homoptera of New York. He suggests that it was introduced to America on the tree which it infests. Since its introduction to the North American continent, it has spread throughout the important cherry growing regions of the northern half of the United States and Canada. In Western North America, it has been reported from British Columbia, Washington, Oregon, California, Idaho, Nevada, Utah and Colorado (10, p. 251). The pest is also found in England, Africa, Australia and New Zealand (40, p. 197).

TAXONOMIC POSITION

The common name of this insect is the "black cherry aphid". The taxonomic position, insofar as the higher ranks are concerned, is handled in various ways by different authors. For purposes of this paper, the taxonomic position of this species, as set forth by Essig (10, pp. 229, 251) will be used. This is as follows: Order, Homoptera; family, Aphididae; genus, Myzus; species, cerasi (Fabricius).

This species has been placed in the following genera (22, p. 6):

Aphis cerasi Fabricius, Systema Entomologiae, p. 735; Muller,

Zoologiae Danicae Prodromus..., p. 110, 1776.

Myzus cerasi (Fabricius), Passerini, Gli Afidi, p. 27, 1860.

Myzoides cerasi (Fabricius), Van der Goot, Tijdschr. Ent. 56:84, 1913.

The following species (22, p. 6) are synonyms:

Aphis aparines Kaltenbach, Monographie der Familien der Pflanzenlause, p. 46, 1843.

Aphis asperulae Walker, Zoologist 6:2248, 1848.

Aphis euphrasiae Walker, Zoologist 7:app. li, 1849.

Myzus quasipyrinus Theobald, Aphididae of Great Britain, v. 3, p. 337, 1929.

HOST PLANTS

The most important and preferred host of the black cherry aphid is the sweet cherry, Prunus avium. Many other host plants are recorded by various writers, however, as follows: Cutright (5, p. 44) reports sour cherry, Prunus cerasus; mahaleb cherry, P. mahaleb; wild black cherry, P. serotina; choke cherry, P. pennsylvanica; common European plum (rarely), P. domestica; peach (rarely), P. persica and an ornamental shrub closely related to mountain ash, Photinia serratala, all as hosts of this particular aphid at various times. In addition to these plants, Ross (32, p. 61) reports several Crucifers such as Lepidium apetalum, Brassica arvensis, Erysimum cheiranthoides, Capsella bursa-pastoris, and probably other members of the family, as being the alternate host

plants upon which the summer migrants of the black cherry aphid establish after leaving the cherry trees. Gillette (12, p. 241) reports that the species has been found in small numbers on water cress, Roripa nasturtium-aquaticum, in Colorado. Other host plants which have been reported are Lepidium sativum (29, p. 129), Galium spp., Asperula odorata, Euphrasia officinales and pear (22, p. 7).

ECONOMIC IMPORTANCE AND DESCRIPTION OF DAMAGE

The black cherry aphid constitutes one of the most persistent pests with which cherry growers have to contend (18, p. 12). Although it has been known in this country for well over one hundred years and much has been written concerning its control, it continues to plague cherry growers year after year in certain sections of the country.

The aphid has piercing, sucking mouthparts and feeds by inserting the stylets of it's beak into the plant tissue and extracting plant juices. Ordinarily, damage to sour cherries is slight but occasionally these plant lice may become numerous enough to cause alarm. They are quite destructive to sweet cherries, however, especially to young trees. The aphids feed in large numbers on the undersides of the tender leaves at the terminal ends of the growing shoots. They also attack the blossoms and fruit, especially the stems. Infested leaves become tightly curled (Fig. 1) and when badly attacked turn brown and die. Young shoots on trees severely injured by aphis may look as if they had been scorched by

fire. The fruit may also be dwarfed and may ripen unevenly (33, p. 61). The aphids excrete large amounts of honeydew which collects on the leaves and fruit and a sooty fungus grows in the honeydew, making the fruit practically unmarketable (24, p. 58). Heavily infested trees are also generally lacking in vigor.

In addition to the damage wrought upon the cherry tree itself, the black cherry aphid also presents several other objectionable features. Pickers sometimes object to working in heavily infested trees due to the presence of large amounts of sticky honeydew which causes a certain amount of discomfort. Also the presence of aphids on fruit which is to be used for canning and brining purposes is objectionable.

The characteristic curling of the leaves results from the numerous feeding punctures on the lower surface of the leaves. Cells on the lower surface of the leaf and along the midrib are injured in the feeding process and growth is consequently stopped or slowed down. The cells on the opposite side of the leaf, however, are not affected and growth continues at the normal rate. The result, therefore, is twisting and curling of the leaves, with the midrib acting as a puckering string.

SEASONAL HISTORY AND HABITS

OVERWINTERING FORMS

The black cherry aphid overwinters in the egg stage on cherry trees. The eggs are deposited around the buds, in

crevices, leaf scars and other places where rough bark protects them. They are generally found on two year old wood and rarely on one year old growth (8, p. 2). Eggs are found from early November until late March or early April. They begin hatching during the early spring as the buds are swelling and may all be hatched for as long as two weeks or more before the buds actually burst (32, p. 61).

In comparisen with other species, eggs of the black cherry aphid are not found in great abundance in the field. Counts which were made during the 1956 season indicate an average of approximately 20 eggs per 100 shoots. The shoots examined were approximately 2 - 3 feet in length.

EARLY SPRING FORMS

Upon hatching, the egg gives rise to the form known as the stem mother or fundatrix. These forms crawl onto the buds where they settle and feed on the green tissue of the expanding buds. After the buds have unfolded they attack the young leaves and the blossom buds. These are very hardy individuals, being able to withstand near freezing weather which may be common at this particular time of year. They mature in approximately three or four weeks, at which time they begin reproducing. In order to avoid repetition, it should be mentioned at this point that, with the exception of the last generation, which are the sexual forms, all individuals are agamic females and reproduce parthenogenetically, giving birth to

living young. Eichmann (8, p. 2) states that the aphids reach maturity by moulting three times. Ross (32, p. 62), however, reports four moults for all forms. The findings of this study agree with those of Ross in this respect. Ross, in the same publication, also reports that the stem mothers produce an average of approximately 150 young during their lifetime which averages approximately 70 days.

In this study, field observations were made in Benton, Linn and Marion counties. The stem mothers first appeared between March 15 - 20, 1956, while the buds were swelling. By March 28, when the buds were in the green tip stage, all eggs apparently had hatched since none were found after an extensive search of several orchards. The stem mothers began reproducing on April 18, at the time the cherry trees were in full bloom. Reproduction took place slowly at first but increased in intensity within two or three days. On April 25, the first injury, in the form of leaf curling, was noted. At this time reproduction was taking place rapidly. Trees were still blooming quite heavily at this time.

SUMMER FORMS

The progeny of the stem mother are referred to as the apterous vivipara. All reports indicate that the entire progeny of the stem mother are apterous. This apterous form persists on cherry trees until the fall of the year.

As mentioned in the preceding section, this form makes it's appearance, in the Willamette Valley, about the time the trees

are in full bloom and the nymphs immediately begin feeding on the lower sides of the tender leaves. As the leaves reach maturity and begin to harden, the aphids migrate to new portions of the tree, invariably congregating at the terminal ends of the growing shoots where new leaves are continuously being produced. This migration continues, always toward the growing tips of the shoots, resulting, eventually, in rosette-like clusters of curled leaves at the terminals (Fig. 1).

During the 1956 season, the apterous viviparous forms matured in approximately 15 days and immediately began reproducing their kind. These apterous individuals also matured in approximately 15 days and began reproducing. By this time, the aphid population had built up to such an extent that there was considerable crowding on terminals of infested trees. The fourth and succeeding generations, therefore, consisted of both apterous and alate forms, the latter being discussed in a subsequent paragraph.

By the latter part of May, natural enemies of the aphid were present in large numbers. Reproduction of aphids, however, was continuing at such a rapid rate that they were not being controlled. The aphid population continued high through the harvest season until July 19. At this time the population was drastically reduced, almost overnight, when unseasonably hot weather prevailed for three or four days. Thereafter, until late in the season, aphids were found only in small isolated colonies on water sprouts and other parts of the trees which remained in a succulent condition.

Those aphids escaping the effects of the hot weather were usually located in large trees where they apparently gained sufficient shade and other protection from the direct rays of the sun.

Other writers, (8, p. 4; 19, p. 2 and 32, p. 62) reporting on the life history of this insect, state that the aphids normally diminish in number or disappear entirely from cherry trees by midsummer. These writers do not correlate weather with the diminishing population but instead attribute this phenomena to migration of aphids to alternate hosts.

As mentioned earlier, the winged forms began making their appearance in the fourth generation. These early winged forms are referred to as the spring or summer migrants.

During the 1956 season, the first adult alatae were observed on May 29. These were seen in small numbers at first and appeared to reach a peak by the latter part of June.

FACTORS WHICH PRODUCE ALATAE

Ross (32, p. 64) suggests three factors which possibly contribute to the production of winged forms. These are: "(1) the influence of overpopulation, (2) the instinct to migrate, and (3) to a small extent, at least, the influence of generation."

Observations in the present study indicate that the influence of factors associated with overpopulation are the primary, if not the only factor involved in the production of the early winged forms. This assumption is based on the fact that apterous forms were reared on cherry foliage, in uncrowded

conditions, throughout the entire summer without the production of a single alate form. Appearance of winged sexuparae or fall migrants, are probably related to a combination of factors such as length of day and temperature. This theory is also based on rearing experiments wherein numerous alatae were produced in the fall, even in uncrowded conditions. No experimental data was obtained during the present study to support such a theory, however.

DISPERSION AND MIGRATION

Some difference of opinion exists as to the dispersion and migration habits of this insect. Russell (35, p. 63) states that the summer migrants do not migrate from cherry to cherry but instead migrate directly from cherry to their alternate hosts. Lloyd (20, p. 84), on the other hand, states that they disperse from tree to tree and continue to reproduce on cherry. The majority of writers share the viewpoint of Russell with regard to the matter.

Evidence was obtained, in the present study, that there is considerable movement of these winged forms from cherry tree to cherry tree where both feeding and reproduction occur. Much of the experimental work for this study was carried out in a small orchard at the Oregon State College entomology farm. The orchard contained four rows of young cherry trees, 1 - 3 years of age, each row containing approximately 20 trees. Rows were spaced 15 feet apart. Until late in the summer, a single outer row was used for experimental aphid rearing work. On numerous occasions,

during the spring and early summer, all trees in the remaining rows were examined for the presence of aphids. None were found until July 7, when small numbers of summer migrants began appearing on the cherry trees. Within a short time, these migrants began reproducing, while still on the cherry, and a few were observed in the actual process of giving birth to their offspring. It was noted that many of the migrants inhabited a single terminal for only a relatively short period of time, giving birth to 1 - 8 young, and then flying to another terminal, or to another cherry, before giving birth to additional offspring.

Although the fast growing aphid population, at this time, appeared to be developing into a heavy infestation, it did not occur. When the unseasonably hot weather of July 19 occurred, the aphid population was destroyed in the orchard under observation.

Further observations, relative to movement from tree to tree, were made in one of the experimental control blocks set up by Mr. S. C. Jones, Station entomologist. In this experiment, trees in a commercial orchard were treated with insecticides during the dormant stage, to prevent the hatching of aphid eggs. Untreated trees were left interspersed throughout the block to serve as checks. The block was examined and counts were made, on May 24, before the winged migrants began to appear. Most of the treated trees were found to be entirely free of aphids, while nearly all the untreated trees were heavily infested. Counts were again made in the block, on June 22, after the winged forms had developed. Most of the

previously uninfested trees were found to be heavily infested, with winged forms present in large numbers. Counts are shown in table V.

On the basis of this study, it appears that regardless of whether or not this insect migrates to alternate hosts, in the Willamette Valley, there is considerable movement of the winged forms from cherry tree to cherry tree. This finding should be an important consideration in the spray programs of cherry growers.

ALTERNATE HOSTS

Ross (32, p. 62) was the first to report an alternate host for the black cherry aphid, as a result of his migratory experiments in Ontario, in 1917. In attempting to find the alternate host, he set up a series of plants belonging to a wide range of genera and introduced summer migrants on the plants as soon as these forms began to appear. The purpose of the experiment was to determine which plants were susceptible to aphid colonization and the extent of the susceptibility. He reported that strong colonies were immediately established on wild peppergrass, Lepidium apetalum, and such colonies continued strong until the end of the season. He reported that weak colonies were obtained on wild mustard, Brassica arvensis; worm seed mustard, Erysimum cheiranthoides; and shepherds-purse, Capsella bursa-pastoris.

A short time after this experiment, Ross reported that he found these aphids infesting Lepidium apetalum, in the field, within

two hundred yards from an infested orchard. He did not find them on any other species of plant, in the field, but was inclined to believe that other crucifers also acted in the capacity of alternate hosts.

In Colorado, Gillette (12, p. 241), after several years of searching, finally reported taking the species in small numbers from water cress, Roripa nasturtium-aquaticum. Other plants which have been reported as alternate hosts include garden cress, Lepidium sativum (29, p. 129); the bedstraws, Galium spp. and sweet woodruff, Asperula odorata (22, p. 7).

This particular aphid has never been found on an alternate host along the Pacific Coast (10, p. 251) and it was not found on such hosts during the course of the present study.

Specimens of all known alternate host plants were checked at the Oregon State College herbarium to determine whether or not the plants occurred in the Willamette Valley and, if so, the most likely habitats in which they might be found. Information obtained at the herbarium indicated that wild peppergrass and wormseed mustard do not occur west of the Cascade Mountains. Garden cress, sweet woodruff and the bedstraws apparently are cultivated in gardens, to some extent, in the Willamette Valley but do not occur naturally. One specimen of wild mustard (Brassica arvensis), from Clatsop county, was found in the collection but this species apparently does not occur in the valley. Watercress occurs in the area, in extremely moist habitats, in early spring but apparently is scarce during the comparatively dry summer. Shepherds-purse,

however, was reported to be very abundant in the valley throughout the spring, summer and fall.

Numerous attempts were made, between the middle of July and the latter part of October, to locate this aphid on an alternate host in the field. These efforts, however, met without success even though shepherds-purse and other crucifers were found in abundance in and around many infested cherry orchards. Several streams and other moist habitats were searched but no watercress plants were found.

During the latter part of August, several shepherds-purse plants were transplanted to flower pots and cages placed over the pots. Black cherry aphids were then introduced onto the plants to determine whether or not they would colonize. Weak colonies were established and maintained until the latter part of September, at which time they all died.

Ross (32, p. 65) states that the progeny of the summer migrants, on the alternate hosts, are apterous. He refers to these as the secondary apterous viviparae and reports that several generations of these apterous forms are produced, until fall, at which time they give rise to return migrants and winged males. During the feeding experiments involving shepherds-purse, in the present study, apterous forms similar to those described by Ross, were produced.

Although no definite conclusions can be reached, with regard to the relationship of this aphid to an alternate host in the Willamette Valley, it seems likely that such a host occurs and

may be involved in a portion of the life history of the insect.

FALL FORMS

SEXUPARAE

As fall approaches, the apterous forms, which have persisted on the cherry trees through the summer, begin giving birth to alate forms. In 1956, these first appeared, in small numbers, in the tenth generation. Approximately one-half of the eleventh and twelfth generations consisted of alate forms. These forms are referred to as the winged sexuparae and they give rise to the egg-laying or oviparous females. These winged forms are very similar to the summer migrants. The first adults of this form were observed on September 15 amid colonies of the apterous forms. Within a few days, the winged forms had begun to disperse to uninfested cherry trees. Here they inhabited leaves throughout the entire tree, with apparent disregard for the age of the leaf. Usually no more than two or three winged adults were observed per leaf. In cases where more than one individual inhabited a single leaf, they were observed feeding at opposite ends of the leaf, surrounded by what appeared to be their own progeny. The winged adults continued dispersing, through the month of October, until they were heavily established throughout nearly all cherry orchards in the area, inhabiting sweet and sour cherries alike.

Ross (32, p. 65) states that winged migrants are produced on the alternate host plants from the middle of September to the

latter part of October. He reports that these migrate back to the cherry trees where they give birth to egg laying females. He refers to these forms as the return migrants and reports that they are identical to the forms produced on cherry.

SEXUALES

Female. - The oviparous or egg laying females, which are the progeny of the winged sexuparae, were first observed on September 22, 1956, at which time they were first being produced. Due to the effects of cool weather, which appeared shortly thereafter, the nymphs were slow in maturing and it was not until October 20 that the first adult sexual females were found.

The adults continued feeding on the cherry foliage for approximately two weeks before they began mating. Egg laying began shortly thereafter, the first eggs being found on November 5. Counts which were made from rearing experiments indicate that the oviparous females lay an average of approximately 4 - 5 eggs each. The oviposition period lasted for only a relatively short period of time due to the fact that many of these forms perished as the leaves began to fall. A heavy leaf drop occurred in most orchards in the valley between November 5 - 10, with the result that these forms dimished rapidly in number during this period. As the leaves continued falling, further reduction in numbers of these forms occured until finally the remnants of the population was killed by frost on November 19.

Male. - The first males were observed on November 2,

at which time they were found in several orchards mating with the wingless oviparous females. Field counts of 100 leaves were made on November 2 and again on November 5. These counts indicated that males were less abundant than females, the sex ratio being approximately 2:1 in favor of the females.

As in the case of the oviparous females, the males also began to diminish in number as the leaves began falling and all remaining individuals were killed by the November 19 frost.

Ross (32, p. 66) states that no males are produced on cherry, these forms being produced exclusively on the alternate host plants. He therefore concludes that in spite of the tendency of the black cherry aphid to lead a monophagous life on cherry, it is still dependent on the alternate host to complete it's life cycle.

During the present study, full advantage was taken of rearing experiments on cherry to check the findings of Ross in this regard. Observations were made of all winged forms produced, during October and November, to determine the sex. Some 200 winged individuals were examined during this period but none of these proved to be males. This finding adds considerable support to the conclusion of Ross that males are produced only on unknown alternate host plants and thence migrate to cherry to mate with the sexual females.

DESCRIPTION OF FORMS AND STAGES

EGG

The egg is pale or watery green in color when first laid but turns a shiny black color within a few days. Eggs are elleptical in shape and minute, averaging approximately 0.68 mm. x 0.32 mm. in size (32, p. 61).

STEM MOTHER

Upon hatching, the stem mothers are very small and dark greenish black in color. Approximately the same color is retained by the insect throughout it's nymphal and adult life. The adult (Fig. 4) is dark shining black and the body is globose in shape, averaging approximately 2.07 mm. x 1.44 mm. in size, with five segmented antennae (32, p. 62).

Following is a taxonomic description of this form, as taken from the works of Mason (22, p. 6).

> Antenna shorter than body, 5 segmented; I and II dark, somewhat imbricated; III light, darker toward tip; IV and V dark; hairs minute and not numerous; no secondary sensoria. Length of antennal segments: III, 0.29 - 0.38 mm.; VI, 0.14 - 0.21 mm.; V, base 0.10 - 0.14 mm., unguis, 0.14 - 0.18 mm. Antennal tubercles short, broad, imbricated; distance between them 0.10 - 0.11 mm. Head 0.39 - 0.46 mm. across eyes. Beak reaching posterior coxae. Abdomen with lateral dark patches. Cornicle 0.35 - 0.46 mm. in length, dusky, somewhat curved, heavily imbricated throughout. Cauda 0.14 - 0.21 mm. long, conical, not constricted, dark, with two hairs on each side.

With regard to the number of hairs on the cauda, Palmer

(28, p. 335) reports three lateral hairs on each side of the structure. Observations of mounted specimens, collected during the course of this study, agree with those of Palmer (Fig. 14C).

APTEROUS VIVIPARA

NYMPHS

First Instar (Fig. 6). - When first born, these nymphs are light tan in color and the pigmentation of the eyes is bright red. The legs, antennae, rostum and cornicles are translucent at this time. Later the body color becomes a dark tannish brown and the pigmentation of the eyes ranges from a deep dark red to black. The antennae, rostrum and the extremities of the leg segments become lightly pigmented with black. The cornicles become brown in color. The head contains a longitudinal suture along the mid-dorsal line, with a slightly raised, oval, sclerotized area present on each side of this suture. The suture splits in the moulting process, making it possible for the nymph to shed the old skin. The shape of the body of the newborn nymph (dorsal view) is sub-rectangular. The lateral edges of the abdomen later become slightly rounded, increasing in width, as feeding and subsequent growth take place.

The first instar possesses five-segmented antennae (Fig. 16 A). The cauda is poorly developed, being visible only as a slight posterior protrusion, with one lateral hair on each side. The antennae and cornicles are lightly imbricated. The

cornicles are flanged at the tips (Fig. 16 B). The rudimentary cauda is somewhat more heavily imbricated, appearing to have a granular-like texture (Fig. 16 C).

Measurements of 20 individuals were as follows: Head capsule (across compound eyes), maximum 0.30 mm., minimum 0.27 mm., average 0.29 mm. Length (vertex to tip of abdomen), maximum 0.91 mm., minimum 0.61 mm., average 0.75 mm. Width (widest part of abdomen), maximum 0.44 mm., minimum 0.41 mm., average 0.42 mm. Antenna (total length), maximum 0.52 mm., minimum 0.47 mm., average 0.49 mm. Antennal segments (average length, I 0.05 mm.; II 0.03 mm.; III 0.11 mm.; IV 0.06 mm.; V 0.24 mm. (base 0.07 mm., unguis 0.17 mm.). Cornicle (point of attachment to tip), maximum 0.13 mm., minimum 0.12 mm., average 0.13 mm. Hind tibia (length), maximum 0.30 mm., minimum 0.30 mm., average 0.30 mm.

Second Instar (Fig. 7). - Nymphs of this instar are quite similar in appearance to those of the preceding stage. Upon moulting, the appendages such as legs, antennae, rostrum and cornicles are translucent. In order to avoid further repetition, it should be stated that this condition exists in freshly moulted individuals of all stages. As pointed out for the preceding stage, pigmentation soon begins to appear in these translucent areas and increases in intensity with each succeeding stage.

The body color of the second instar ranges from tannish brown to amber and, in general, is slightly darker than the first instar.

The antennae are again five-segmented (Fig. 17 A). The

cauda becomes somewhat expanded with two lateral hairs being visible on each side (Fig. 17 C). All other features are similar to those described for the preceding instar.

Measurements of 20 individuals were as follows: Head capsule, maximum 0.34 mm., minimum 0.30 mm., average 0.31 mm. Length, maximum 1.02 mm., minimum 0.85 mm., average 0.88 mm. Width, maximum 0.54 mm., minimum 0.44 mm., average 0.49 mm. Antenna, maximum 0.66 mm., minimum 0.61 mm., average 0.63 mm. Antennal segments, I 0.05 mm.; II 0.03 mm.; III 0.16 mm.; IV 0.09 mm.; V 0.28 mm. (base 0.08 mm., unguis 0.21 mm.). Cornicle, maximum 0.17 mm., minimum 0.13 mm., average 0.15 mm. Hind tibia, maximum 0.37 mm., minimum 0.30 mm., average 0.34 mm.

Third Instar (Fig. 8). - Nymphs of this stage are the same in appearance as the preceding instar except that the antennae are six-segmented (Fig. 18 A).

Measurements of 20 individuals were as follows: Head capsule, maximum 0.37 mm., minimum 0.34 mm., average 0.37 mm. Length, maximum 1.42 mm., minimum 0.85 mm., average 1.16 mm. Width, maximum 0.84 mm., minimum 0.61 mm., average 0.71 mm. Antenna, maximum 0.88 mm., minimum 0.80 mm., average 0.84 mm. Antennal segments, I 0.05 mm.; II 0.03 mm.; III 0.14 mm.; IV 0.12 mm.; V 0.12 mm.; VI 0.36 mm. (base 0.09 mm., unguis 0.28 mm.). Cornicle, maximum 0.24 mm., minimum 0.22 mm., average 0.23 mm. Hind tibia, maximum 0.54 mm., minimum 0.50 mm., average 0.51 mm.

Fourth Instar (Fig. 9). - In this stage the body color becomes a shining, dark chocolate brown. The antennal tubercles

become somewhat more pronounced and more heavily imbricated and the cauda becomes considerably more extended than in the previous instars, with three hairs being visible on each side (Fig. 19 C). The antennae, particularly segment III, are considerably increased in length (Fig. 19 A). All other features, however, are similar to those of the preceding instars.

Measurements of 20 individuals were as follows: Head capsule, maximum 0.41 mm., minimum 0.37 mm., average 0.40 mm. Length, maximum 1.52 mm., minimum 1.12 mm., average 1.33 mm. Width, maximum 0.98 mm., minimum 0.85 mm., average 0.92 mm. Antenna, maximum 1.31 mm., minimum 0.94 mm., average 1.27 mm. Antennal segments, I 0.07 mm.; II 0.07 mm.; III 0.40 mm.; IV 0.17 mm.; V 0.15 mm.; VI 0.44 mm. (base 0.10 mm., unguis 0.34 mm.). Cornicle, maximum 0.31 mm., minimum 0.25 mm., average 0.27 mm. Hind tibia, maximum 0.63 mm., minimum 0.55 mm., average 0.58 mm.

ADULT

Upon moulting to the adult stage, the body color at first is dark brown. Within a few hours, however, the color changes to a dark shining black. The shape of the body is similar to that of the stem mother except that it is somewhat narrower and slightly less bulky in appearance (Fig. 5). Unlike the stem mother, this form possesses six-segmented antennae (Fig. 15 A).

Following is a taxonomic description of the adult form as taken from the works of Mason (22, p. 7).

General color black or purplish black, the head somewhat paler. Antennae slightly shorter than body, imbricated; no secondary sensoria; III to V yellowish white; remainder of antenna black. Length of antennal segments: III, 0.25 - 0.48 mm.; IV, 0.16 - 0.31 mm.; V 0.14 - 0.23 mm.; VI, base 0.09 - 0.13 mm., unguis 0.21 - 0.40 mm. Antennal tubercles strongly convergent, heavily imbricated; distance between them 0.05 - 0.09 mm. Head 0.34 - 0.46 mm. across eyes. Beak reaching to posterior coxae. Prothorax with a small tubercle on each side. Femora mostly dusky, the bases dirty yellow; tibiae dirty yellow, the tips black. Abdomen with small lateral tubercles. Cornicle 0.33 - 0.58 mm. in length, slender, heavily imbricated, distinctly flanged. Cauda 0.11 - 0.15 mm. long, triangular, and with 3 hairs on each side.

ALATE VIVIPARA

NYMPHS

Observations made during the course of this study indicate that the first two instars of the alate form are the same in appearance as their counterparts of the apterous form. One possible exception may be that the body color of the alate form is generally darker, approaching a dusky brown to black color. The antennae of the first and second instars are five-segmented, becoming six-segmented in all stages thereafter. In all specimens observed, wingpads made their first appearance on the third instar. These first appeared as slightly raised, milky white areas on the thorax and showed a slight increase in size as the nymph developed. When viewed from above, the wingpads gave the nymph somewhat of an hour glass appearance (Fig. 10).

ADULT (Fig. 11)

Following is a taxonomic description as taken from the works of Mason (22, p. 7).

> General color black. Antenna longer than body, dark, heavily imbricated; hairs inconspicuous; III with 12 - 20 sensoria along entire length, not in a row; IV occassionally with one sensorium. Length of antennal segments: III, 0.38 - 0.51 mm.; IV, 0.21 - 0.37 mm.; V, 0.19 - 0.27 mm.; VI, base 0.10 - 0.14 mm., unguis 0.34 - 0.53 mm. Antennal tubercles small, slightly convergent, plainly imbricated; distance between them 0.05 - 0.10 mm. Head polished black 0.34 - 0.42 mm. across eyes. Femora and tibia dull yellow, the apices black; tarsi black. Abdomen blackish brown, with greenish tinge. Cornicle 0.30 - 0.40 mm. in length, polished black cylindrical, heavily imbricated, distinctly flanged. Cauda 0.11 - 0.16 mm. long, somewhat constricted, thickly covered with dark sclerotic points, and with three hairs on each side.

THE OVIPARA

NYMPHS

Nymphs of this form range from tan to dusky brown or black in color. In all other respects, these nymphs are similar in appearance to those of the apterous viviparous form.

ADULT (Fig. 13)

Palmer (28, p. 336) gives the following brief description of this form:

Apterous. Body length 1.10 mm.; across eyes 0.35 mm.; antenna 0.80 - 0.85 mm.; hind tibia with proximal half slightly swollen and bearing about 20 sensoria.

To this description, Ross (32, p. 67) adds the following:

The general color of the ovipara is dark brown. The abdomen may be tinged with green. The size is approximately 1.8 mm. x 0.8 mm.

Since these descriptions are rather vague, further observations were made from specimens collected during the present study. Observations of the writer agreed substantially with those of Palmer except with regard to the number of sensoria on the hind tibia. Some 20 individuals were examined under a phase microscope and, in every case, approximately 50 sensoria were found on each hind tibia (Fig. 21 D). The observations made in this study were also in substantial agreement with those of Ross.

Measurements of 20 individuals were as follows: Head capsule, maximum 0.37 mm., minimum 0.35 mm., average 0.36 mm. Length, maximum 1.49 mm., minimum 1.22 mm., average 1.42 mm. Width, maximum 0.98 mm., minimum 0.74 mm., average 0.85 mm. Antenna, maximum 1.05 mm., minimum 0.88 mm., average 0.96 mm. Antennal segments, I 0.07 mm.; II 0.05 mm.; III 0.21 mm.; IV 0.15 mm.; V 0.15 mm.; VI 0.33 mm. (base 0.10 mm., unguis 0.23 mm.). Distance between antennal tubercles, maximum 0.07 mm., minimum 0.05 mm., average 0.05 mm. Cornicle, maximum 0.32 mm., minimum 0.27 mm., average 0.28 mm. Hind tibia, maximum 0.64 mm., minimum 0.51 mm., average 0.55 mm.

THE MALE (Fig. 12)

The following taxonomic description is taken from the

works of Gillette (11, p. 363).

> Alate. Length 1.30 mm.; general color deep black the abdomen a little lighter than the other portions of the body and in some specimens appears to be dusky brown, with narrow transverse bands upon the segments between the cornicles, and back of them it may be entirely black; prothorax with lateral tubercles weak or lacking; wings hyaline, stigma a little dusky brown, nervures dark brown; length of antenna 1.70 mm.; joints of antenna: III, .40; IV, .28; V, .23; VI, .11; VII, .50 mm.; length of wing 2.50 mm.; length of cornicles .23 mm., cylindrical and black. Joints 3, 4 and 5 of the antennae are strongly tuberculate, with a large number of similar circular sensoria. The sensoria are most abundant on joint 3. Antennae on distinct frontal tubercles that are slightly swollen, first joint distinctly gibbous.

During the present study, further observations were made of the tuberculate secondary sensoria scattered over the surface of antennal segments III, IV and V (Fig. 22A). The average number of sensoria found on these segments was approximately as follows: III, 50; IV, 25; V, 14. The presence of sensoria on antennal segments IV and V, plus the fact that the male genital organs are visible externally, serve to readily distinguish the male from the alate viviparous form.

Measurements of 20 individuals were as follows: Head capsule, maximum 0.42,mm., minimum 0.37 mm., average 0.40 mm. Length, maximum 1.46 mm., minimum 1.29 mm., average 1.39 mm. Width, maximum 0.68 mm., minimum 0.61 mm., average 0.63 mm. Antenna, maximum 2.07 mm., minimum 1.73 mm., average 1.90 mm. Antennal segments I 0.07 mm.; II 0.07 mm.; III 0.49 mm.; IV 0.28 mm.; V 0.26 mm.; VI 0.72 mm. (base 0.12 mm., unguis 0.60 mm.). Cornicle, maximum 0.32 mm., minimum 0.30 mm., average 0.31 mm.

Hind tibia, maximum 1.02 mm., minimum 0.85 mm., average 0.92 mm.

REARING TECHNIQUES

LABORATORY TECHNIQUES

In conducting life history studies of the black cherry aphid, several techniques were tried. During the early spring, before leaves had developed on the trees, twigs were brought into the laboratory and placed in vials of water and in turn placed under lamp chimneys. Aphids were then placed on the buds to feed and develop. Although a certain amount of data was obtained by use of this technique, it was not considered satisfactory due to the fact that the area of confinement was too large to permit compilation of data on moulting and reproduction with any degree of accuracy.

Another rearing technique, which was used in the laboratory, was the use of petri dish leaf cages (Fig. 25). This type of cage was set up as follows: A number of small vials were first selected and a small hole made in the side of each. Holes were easily made by heating a spot on the side of the vial with a small torch-type burner and then blowing through a piece of rubber tubing fitted over the mouth of the vial. Thus the holes were literally popped in the sides. After filling the vials with water and fitting a cork stopper in place, leaves were placed in the vials by inserting the petiole through the hole in the side. The leaves and vials were then placed in petri dishes with the undersides of the leaves facing up. A single newborn aphid nymph was then introduced into

each petri dish to feed on the leaf therein. A piece of snug fitting white filter paper was generally placed in the bottom of each petri dish in order to provide a background to facilitate the location of cast skins. This technique was used quite successfully although it was necessary to supply new leaves every third day. This procedure presented a rather serious disadvantage since considerable time was spent in refilling vials, changing leaves, and transferring aphids throughout the rearing period.

A third rearing technique which was employed in the laboratory was the use of plexiglass leaf cages (Fig. 23-24). This was the most successful and expedient technique which was found for laboratory use. The component parts of this type of cage were as follows: A strip of masonite 4 x 18 inches, used as a back or bottom; cheesecloth pad, folded to the same dimensions as the strip of masonite backing; a strip of plexiglass, cut to the same dimensions as the masonite back and approximately one-fourth inch in thickness. The plexiglass, used in this study, contained five holes, approximately one and one-half inches in diameter, spaced evenly along the length of the strip. Plastic tops, 3 x 4 inches, were used to cover these holes. In order to allow air circulation and to prevent moisture condensation, holes, approximately three-fourths inch in diameter, were drilled in the plastic tops and covered with fine mesh lumite screening. Figure 23 shows an unassembled plexiglass cage of this type.

In assembling the cage, the cheesecloth pad was placed on the masonite back and saturated with water. Leaves were then placed

flat on the pad, with the undersides of the leaves facing up, and spaced at appropriate intervals. The plexiglass strip was then placed over the leaves so that each of the holes in the strip fit directly over a leaf. Aphid nymphs were next introduced into the wells, thus formed, to feed on the leaf tissue therein. The plastic tops then were placed over the holes and clamped in place. Figure 24 shows an assembled cage of this type, with the leaves in place.

Here again, it was necessary to supply new leaves approximately every three days but the entire transferring operation took less time than with the petri dish cages.

FIELD TECHNIQUES

Considerable difficulty was encountered in attempting to develop a suitable technique for conducting studies of individual aphids in the field and it was not until the middle of June that a satisfactory type of cage was found.

Raine (30, p. 58), in conducting life history studies of leafhoppers, utilized a type of "clip-on" leaf cage for work of this nature. Similar cages were constructed for use in the present study and were found to be excellently adapted for aphid studies.

Cages were constructed as follows: A piece of plastic hose, one and one-fourth inches outside diameter and one inch inside diameter, was sliced into sections or rings approximately one-fourth inch in thickness. A spring was then fashioned for each cage from a piece of piano wire, approximately eight inches in length. The end of the piano wire springs were easily inserted through the

plastic rings by heating the wire. After this had been accomplished, a piece of nylon mesh was glued tightly over the top of one of the plastic rings and a felt ring was glued to the bottom surface of the same plastic ring. The felt ring served to seal any cracks between the surface of the leaf and the bottom of the cage. Aphid nymphs were then placed on selected leaves and the cages placed over the top of them and clipped in place. Figures 26, 27 and 28 show various aspects of this type of cage.

REARING EXPERIMENTS

LABORATORY STUDIES

Laboratory studies were conducted as a means of making observations and compiling data which could not be easily or conveniently done in the field. Ample opportunity was thus afforded to observe many of the biological processes which required the aid of magnification for detailed study. The following text contains observations of biological phenomena as well as rearing data compiled from laboratory studies.

REPRODUCTION

Aphids were observed, on several occasions, giving birth to their offspring. In so doing, the nymph emerges, caudal end first, by a series of muscular contractions on the part of the parent female. The legs and antennae of the nymph are tucked under it's body until nearly free of the female. At this point, the nymph moves these

appendages to their normal positions and begins waving it's legs as if seeking to gain a foothold on a solid surface. The female then lowers the tip of her abdomen to the surface of the leaf and allows the nymph to gain a foothold thereon. Once this has been accomplished the female is easily able to free herself from the body of the nymph. The entire process requires approximately 8 - 10 minutes.

MOULTING

Although the interval between moults is much shorter with aphids than with many other insects and large colonies produce frequent moults, these insects are very inconspicuous and difficult to detect in the moulting process. During the present study, only one nymph was observed in the act of moulting to the winged adult stage. Several of the apterous forms were observed in the act of moulting, however. In moulting to the winged adult, the nymph first sets it's claws firmly into the surface of the leaf. The head is pointed downward so that the dorsal surface is straight ahead. A split then occurs along the mid-dorsal surface of the head and thorax. The aphid proceeds to work it's way out of the old skin, first by withdrawing the antennae, followed by the legs, forcing itself forward at all times until finally the entire body of the aphid emerges through the opening in the top of the head and thorax. The wings of the newly emerged adult are folded in the shape of the nymphal wingpads and are milky white in color. Upon freeing itself from the cast skin, the aphid moves away a short distance

whereupon it raises it's back, with the tip of the abdomen pointing downward, in order to obtain leverage and by using muscular pressure, begins to unfold the wings. The wing unfolding procedure requires approximately 2 - 3 minutes and when finally unfolded, the wings possess somewhat of a crinkled appearance. The fore and hind wings, on each side, are held together in a vertical position with each pair of wings being held apart at an angle of approximately 45 degrees. The aphid assumes a position of rest, until the wings and exoskeleton dry and harden. After approximately fifteen minutes, the wings have dried and they are then moved to the normal position, held rooflike over the body.

The transformation from nymph to adult requires approximately thirty five minutes. Moulting of the apterous forms is similar to that described above, except that a shorter period of time is involved in completing the operation. Here the moulting process requires approximately ten minutes.

MATING

In order to accomplish the mating act, the winged male seeks the wingless sexual female. In so doing, the male migrates to the cherry probably from an alternate host and, upon locating a female, identifies her with his antennae. The antennae are provided with numerous sensoria presumably for this purpose. After the identification has been made, the male mounts the back of the female, grasping her with his long legs. The tip of his abdomen is then bent underneath the abdomen of the female, where

the genital organs unite and copulation takes place. The mating act usually requires approximately thirty minutes.

REARING DATA

Rearing experiments were conducted almost exclusively by use of the plexiglass leaf cages mentioned in the section dealing with techniques. In setting up these rearing experiments, it was desirable to begin with nymphs as near the same age as possible. In order that this might be accomplished, several adult aphids were usually placed in a petri dish leaf cage, late in the evening, and left overnight. By the following morning a sufficient number of nymphs, born during the interim, had been produced to set up the desired experiment. Nymphs were introduced singly into each well of the plexiglass cages and observations were made once daily to determine the rate of development as well as reproduction and other pertinent data. The rate of development was determined by the frequency of moulting, which was in turn determined by the presence of cast skins at the time daily observations were made. During the rearing period (May and June), the air temperature in the laboratory ranged consistently from 70 - 80° F. The rate of development of these nymphs was much faster with less variation in the length of stadia, than when reared in the field. This difference was attributed to the mild and moderately uniform temperatures which prevailed in the laboratory. It was noted, however, that even though these aphids matured faster, they were distinctly smaller than those which were reared in the field under

normal conditions. This condition was thought to be brought about by a nutritional change which possibly occurs in the leaves after cessation of growth, although a solution to the actual cause was not pursued during the present study. It was noted that the longevity of these aphids was considerably reduced when reared in the laboratory under semi-artificial conditions.

Rearing data obtained from these experiments are summarized in tables I and II. Standard deviations have been computed for all data and are also shown in the tables.

TABLE I

LABORATORY DATA ON LENGTH OF NYMPHAL STADIA OF THE BLACK CHERRY APHID

PERIOD OF OBSERVATION	NO. INDIV. OBSERVED	AVERAGE LENGTH OF STADIA (DAYS)			
		1	2	3	4
MAY 25-JUNE 10	6	1.7 ± 0.5	1.8 ± 0.8	2.0 ± 0.0	2.0 ± 0.0
JUNE 5-JUNE 29	7	2.0 ± 0.0	2.3 ± 0.9	1.6 ± 0.5	1.7 ± 0.4
JUNE 23-JULY 14	8	1.0 ± 0.0	1.9 ± 0.3	1.6 ± 0.5	2.0 ± 0.8

TABLE II

LABORATORY DATA ON REPRODUCTION OF THE BLACK CHERRY APHID

PERIOD OF OBSERVATION	NO. INDIV. OBSERVED	AVE. NO. DAYS BIRTH TO REPRODUCTION	REPROD. PERIOD (DAYS)	TOTAL NO. NYMPHS (AVE.)	AVE NO. NYMPHS PER DAY
MAY 25-JUNE 10	6	10.0 ± 1.7	3.3 ± 1.5	4.3 ± 2.5	1.4 ± 0.8
JUNE 25-JUNE 29	7	8.7 ± 0.5	9.8 ± 3.9	21.0 ± 7.5	2.2 ± 0.4
JUNE 23-JULY 14	8	8.1 ± 1.2	7.6 ± 2.6	13.1 ± 4.6	1.8 ± 0.4

FIELD STUDIES

Rearing experiments in the field were begun on June 14, as soon as suitable cages had been devised for conducting experiments of this type. From observations made in the field up to this time and also from results of subsequent rearing experiments, it was estimated that these experiments were begun with individuals of the sixth generation. These experiments were conducted in their entirety in a small cherry orchard at the Oregon State College entomology farm. The orchard consisted of young trees, 1 - 3 years of age.

In setting up these experiments, twenty newborn nymphs were placed singly on succulent leaves at the terminal ends of the growing shoots and clip-on cages placed over each nymph. As was done in the laboratory experiments, observations were made once daily to determine the rate of development, rate of reproduction and other pertinent data. Since these aphids normally maintain a steady migration toward the terminal ends of the growing shoots, the experimental aphids were periodically moved to younger leaves, as soon as such leaves were large enough to accommodate the cages. All aphid transferring was done with a soft camel hair brush to facilitate handling and to prevent injuries.

Again, the frequency of moulting, which was determined by the presence of cast skins, was used as the gauge for determining the rate of development. Cast skins were usually quite easily located, by use of a hand lens, through the nylon mesh

screening in the top of the cage. Cast skins were removed after each moult. Each individual underwent four moults and began reproducing, usually within one day after reaching the adult stage. Offspring were removed from the cages every second day in order to avoid overcrowding.

After the aphids had matured and reproduction was underway, newborn nymphs were transferred singly to separate cages in order to determine the number of generations produced during the year and to collect data on each generation. A total of seven generations, plus a partial eighth, were obtained from these rearing experiments. Since the experiments were probably originated with members of the sixth generation, it is estimated that a total of twelve generations, plus a partial thirteenth, were produced for the entire year. Data compiled for each generation are shown in tables III and IV. Standard deviations, which have been computed for all data, are also shown in the tables.

TEMPERATURE RELATIONS

A hygrothermograph was maintained in the experimental orchard throughout the course of the rearing experiments. Daily mean temperatures and average relative humidities were compiled and an attempt was made to correlate these data to the length of nymphal stadia. Results are shown on the graphs in figure 29, 30, 31 and 32. These results indicate that temperature has an effect on the length of stadia, the trend being toward an increase in length of stadia as the temperature decreases. However, the

TABLE III

FIELD DATA ON LENGTH OF NYMPHAL STADIA
OF THE BLACK CHERRY APHID

GENERATION	NO. INDIVIDUALS OBSERVED	AVERAGE LENGTH OF STADIA (DAYS) 1	2	3	4
6	18	4.3±0.5	3.2±1.2	2.7±1.7	3.8±1.2
7	10	2.7±1.0	3.1±0.5	4.6±1.3	4.6±1.4
8	5	4.0±2.0	5.8±0.8	4.4±0.5	6.0±1.6
9	7	2.4±0.6	2.0±0.8	2.7±0.4	2.8±1.1
10	6	4.2±1.8	3.2±1.7	2.7±1.2	5.8±3.9
11	10	3.8±1.3	3.7±0.9	3.5±1.4	3.5±1.6
12	15	5.7±1.1	8.4±2.3	6.1±2.3	15.8±3.2

TABLE IV

FIELD DATA ON REPRODUCTION
OF THE BLACK CHERRY APHID

GENERATION	NO. INDIVIDUALS OBSERVED	AVE. NO. DAYS BIRTH TO REPRODUCTION	REPROD. PERIOD (DAYS)	TOTAL NO. NYMPHS (AVE.)	AVE. NO. NYMPHS PER DAY
6	18	15.7±2.6	13.8±4.0	27.5±17.3	1.9±0.8
7	ALL APHIDS KILLED BY HOT WEATHER - NO DATA				
8	5	25.7±7.1	4.3±4.0	4.7± 2.4	1.1±0.3
9	7	11.3±1.6	12.1±8.8	14.7±13.8	1.4±0.6
10	6	17.0±2.6	10.3±5.7	14.6± 8.5	1.4±0.3
11	10	15.7±2.4	17.6±4.6	20.3± 7.9	1.1±0.3
12	13	35.9±4.1	7.1±4.5	6.6± 4.0	1.1±0.3

erratic distribution of points on the graph indicate that some other factor or factors at times had a greater effect on aphid development than temperature. Evidence was obtained that leaf condition has a considerable effect on the development of the aphid.

Relative humidity also appears to be related to the length of stadia to some extent. As shown on the graphs in figures 29, 30, 31 and 32, the trend appears to be toward a lengthening of nymphal stadia at the extreme relative humidity readings. Again the slowing down of development during the eighth and portions of succeeding generations probably was correlative with the leaf condition.

EFFECT OF LEAF CONDITION

Leaf condition was found to be very important in the growth and development of the black cherry aphid. As pointed out previously, aphids normally migrate from older leaves, as soon as leaf growth has ceased, and inhabit the young growing leaves at the tips of the shoots. During the latter part of July, following a period of extreme hot weather, growth of several of the experimental cherry trees ceased with a resultant hardening of the leaves, even at the tips of the shoots. Aphids of the eighth generation were being reared on these trees at the time. These individuals were much slower in maturing than those reared on succulent leaves. The fecundity was also considerably reduced and all individuals were much smaller than normal, being similar to individuals reared in the laboratory

in this respect. Longevity of these individuals was much greater than normal, however. Individuals appeared to enter a state of semi-quiescence, feeding in the same exact location for as long as a week or more, apparently without moving. It will be noted on the graphs in figures 29, 30 31 and 32, that the trend of the distribution curve is toward a shortening of the length of stadia, as the temperature increases, with periods of deceleration in the rate of development between the extreme temperatures. The effect of leaf condition is indicated by these periods of deceleration which were brought about by a hardening of the leaves and a consequent increase in the length of stadia of aphids feeding on these leaves.

CONTROL

PREDATORS AND PARASITES

The soft bodies of these aphids, together with their inactivity and their habit of congregating in large colonies on the foliage of their hosts, make them easy prey for their natural enemies, of which there are many. The literature (32, p. 68 and 36, pp. 124-127) lists the following predators which take huge tolls of this aphid annually.

Coccinellidae (Coleoptera)

Adalia bipunctata L.

Coccinella novemnotata Herbst.

C. transversoguttata Fab.

C. trifasciata L.

C. sanguinea L.

C. venusta Mels.

Anatis 15 punctata Oliv.

Hippodamia 13 punctata (Herbst)

Hippodamia convergens Guer.

Harmonia picta (Rand)

Megilla maculata (De Geer)

Scymnus collaris Melsh.

Syrphidae (Diptera)

Syrphus americanus Wiedemann

S. ribesii L.

Allograpta obliqua Say

Cecidomyiidae (Diptera)

Aphidoletes meridionalis Felt

Chrysopidae (Neuroptera)

Chrysopa sp.

Parasites listed (41, p. 75) are as follows:

Aphidiidae (Hymenoptera)

Aphidius cerasi Marsh

A. ribis Hal.

Ephedrus lacertosus Hal.

Lygocerus aphidivorus Kieff.

Braconidae (Hymenoptera)

Praon ceraphis Fitch (9, p.77).

Ladybird beetles (Coccinellidae) appear to be of primary importance as predators, in the Willamette Valley, both from the standpoint of abundance and because aphids are attacked by both larvae and adults. The larvae of these beetles are particularly voracious in their feeding habits. Half grown larvae of this predator were observed to consume as many as 30 - 35 aphids each, during a 24 hour period. As did all predators observed in this study, the ladybirds feed by sucking the body juices from the aphids. The ladybird larva, upon coming in contact with an aphid, grasps it firmly with it's large, stout mandibles. The maxillary and labial palpi, as well as the front legs, are used to help in grasping the aphid securely. The aphid is then lifted from the surface of the leaf and held in the air while the larva feeds. The feeding operation requires approximately 5 - 10 minutes, after which the crushed and collapsed body of the victim is cast aside and the larva scurries off in search of more prey. These important predators are found on cherry trees at various times throughout the growing season.

Next in importance as predators, in the Willamette Valley, appear to be Syrphid fly larvae (Syrphidae). These are green fleshy maggots, thick and blunt behind and pointed in front. Their mouths are furnished with a "triple-pointed dart" (36, p. 127),

with which they sieze and pierce their prey and elevating it, deliberately suck it dry. They are blind but the eggs from which they hatch are deposited by the parent flies in the midst of aphid colonies, where they grope about and obtain an abundance of food with little trouble (36, p. 127). The parent flies are black with transparent wings and ornamented with yellow bands across their bodies (36, p. 127). Larvae were found on cherry trees from early June until the latter part of October.

A third important group of predators, found in the Willamette Valley, are the larvae of lacewing flies (Chrysopidae). During the 1956 season, however, these did not appear until late in the summer and were relatively few in number when found. As in the case of the two preceding groups, these larvae were voracious feeders, grasping the aphids firmly with their long pointed mandibles and extracting the body juices.

During the latter part of May, it was noted that many of the aphids in large colonies appeared to be swollen and distended. Several leaves, with colonies containing such individuals, were brought into the laboratory and placed in cages. Within a few days, a number of small hymenopterous parasites appeared. These were determined by the writer to belong to the family Braconidae.

Comstock (4, p. 922) gives an interesting account of the habits of this parasite as follows:

> The female approaches an aphid and identifies it with a few taps of her antennae. She then stands high and ducks her abdomen down between her legs and forward in front of her head to plunge her ovipositor into the plant louse. In a few days the developing

parasite larva has eaten out the inside of the aphid. It cuts a hole in the bottom of the aphid's empty skin and through this glues the carcass to the substratum. It then makes it's cocoon in the aphid's abdomen. The adult braconid emerges by cutting a circular lid. Plant lice with braconid cocoons inside have an inflated appearance and a brownish color that makes them conspicuous among a colony of living aphids.

In attempting to determine the relative importance of these parasites, thirty leaves were examined for parasitized aphids on June 9. From a total of nearly 3600 aphids on these leaves, 630, or approximately 17 percent, were found to be parasitized.

Specimens of predators and parasites were sent to the Insect Identification and Parasite Introduction Section, Plant Industry Station, Beltsville, Maryland, for identification. Determinations were as follows:

Predators

Coccinellidae (Determined by E. A. Chapin)

Adalia bipunctata (L).

Hippodamia 5-signata ambigua Muls.

Cycloneda polita Csy.

Syrphidae (Determined by P. H. Arnaud)

Syrphus vitripennis Meigen

Chrysopidae (Determined by S. Parfin)

Chrysopa sp., plorabunda group.

Parasites

Braconidae (Determined by C. F. W. Muesebeck)

Ephedrus nitidus Gahan

Aphidius (Lysiphlebus) knowltoni Smith

With the exception of *Adalia bipunctata* (L.) and possibly *Chrysopa* sp., it is assumed that the above list represents a new record of predators and parasites of the black cherry aphid since a careful search of the literature failed to disclose any of these species as attacking this particular insect.

Several secondary parasites, belonging to the family Pteromalidae, were also submitted for identification. These specimens were determined by B. D. Burks to be *Pachyneuron* sp.

CLIMATIC FACTORS

Weather agencies play a very important part in checking the multiplication of aphids (32, p. 68). Heavy rains wash off large numbers of aphids, especially in the spring before the leaves have developed enough to offer protection. Late frosts in the spring may destroy eggs which have begun development as well as young aphids recently hatched (3, p. 31). Early frosts and windstorms in the fall may destroy countless numbers of immature sexual females by causing foliage to drop prematurely (32, p. 68). Early and prolonged cold weather in the fall reduces the percentage of fertilized sexual females since the aphids are relatively inactive in cold weather (3, p. 31). Also alternate freezing

and thawing, during the winter months is detrimental to aphid eggs (3, p. 31). It was also found during the present study that these aphids are apparently unable to withstand extremely hot weather.

CHEMICAL CONTROL

IMPORTANT INSECTICIDES

Nicotine Derivatives. - The classical spray materials which have been used for aphid control, on a worldwide scale, since 1872 are tobacco and nicotine. In the United States, the most commonly used derivative has been 40 percent nicotine sulphate, sold under the trade name of "Black Leaf 40" (27, p. 8). This material is used at the rate of 3/4 - 1 pint per 100 gallons of water and applied either at the green tip or popcorn stage for best results (24, p. 59 and 37, p. 5). This material is classified as a contact insecticide and the bodies of the insects must be hit by the spray material in order to obtain the desired results. Consequently, thorough coverage of trees during the spraying operation is of utmost importance in aphid control work with this type of insecticide. It can be readily seen that control must be carried out before the leaves have fully developed. After foliage has developed and the leaves become curled, the aphids are protected and the chances of the insecticide coming in contact with these insects are considerably reduced. The insecticide therefore becomes

ineffective at this stage.

Dinitro Compounds. - Other spray materials, which have been used extensively, include the dinitro compounds, such as Elgetol, Krenite, Dowspray dormant, etc. (6, p. 52), applied during the dormant stage in the early spring. These compounds are directed against the overwintering eggs, thus killing them before they hatch. Trees must be completely dormant when using these compounds in order to avoid injury. The dinitros first came into use in 1934 (7, p. 59) and are still being used quite extensively. These materials are normally used at the rate of 1 - 2 quarts per 100 gallons of water, for the emulsion, and approximately 1 pound per 100 gallons of water, for the wettable powder.

Tar Distillate Sprays. - The tar sprays were developed in England and introduced to the United States (7, p. 59). These usually consisted of combinations of tar oil and petroleum oil, at the rate of 5 - 7 gallons per 100 gallons of water. The combinations were used in order to control other insects in addition to aphids. The tar sprays were used most widely in the 1930's but were never too popular due to the hazard of skin injury to the hands and face of the operator (7, p. 59).

Organic Phosphate Insecticides. - With the development of the organic phosphate insecticides following World War II, a new era in aphid control work was introduced. These insecticides include such materials as parathion, TEPP and malathion. More recently, such systemic insecticides as systox and thimet have

been developed but these are still in the experimental stage insofar as their uses on cherry trees are concerned.

Parathion and malathion offer the advantage of residual action and the materials remain effective against aphids up to two weeks after application, in the Willamette Valley. These materials should not be applied within three weeks of harvest, however, in order to comply with residue tolerances established by the U. S. Food and Drug Administration. TEPP, being a highly volatile material, is almost entirely lacking in residual action and may be used up to the day before harvest without danger of violating residue tolerances.

Normal application rates of these materials are as follows:

Parathion

25 percent wettable powder, 1/2 - 1 pound per 100 gallons of water

25 percent emulsion, 1/2 - 1 pint per 100 gallons of water.

1 - 2 percent dust, 40 - 45 pounds per acre.

Malathion

25 percent wettable powder, 2 pounds per 100 gallons of water

57 percent emulsion, 1 pint per 100 gallons of water.

4 percent dust, 40 - 45 pounds per acre.

TEPP

20 percent emulsion, 1/2 - 1 pint per 100 gallons of

water.

2 percent dust, 40 - 45 pounds per acre.

Other Insecticides. - Other materials which have been successfully used in controlling the black cherry aphid include BHC, pyrethrum extract, dormant oils, and oil plus cresylic acid.

CONTROL EXPERIMENTS

During the 1956 season extensive control work was carried out, by the Oregon State College Experiment Station, in two commercial cherry orchards and, to a limited extent, on a number of cherry trees at the horticulture farm, owned by the college. The writer assisted Mr. S. C. Jones in these experiments.

Experimental Block No. 1. - This experiment was carried out in a commercial orchard and consisted of spraying the trees with several dinitro compounds during the dormant stage. The spray materials were applied on March 15 and were directed against the overwintering eggs.

The block consisted of 63 trees of two age groups, containing 14 trees 1 - 3 years of age, with the remainder approximately 25 years of age. Four replicates of approximately 4 - 5 trees per replication were used. Counts were made on May 24, before winged migrants began to appear and again on June 22, after these winged forms had developed. Counts were made by recording the total number of infested terminals on trees in each replicate. The number of infested trees in each replicate were also recorded (Table V).

TABLE V

APHID COUNTS
IN EXPERIMENTAL CONTROL BLOCK NO. 1

MATERIALS AND CONCENTRATION	NO. TREES	INFESTED TIPS PER REP. A	B	C	D	TOTAL TIPS INFESTED	TOTAL TREES INFESTED
		MAY 24, 1956					
NIAGRA DN W.P., 1 LB.-100; OIL, 2½ GAL.	19	0	18	0	0	18	1
ELGETOL, 1½ QTS.-100	14	50	0	5	2	57	4
DOW DN 289, 2 QTS.-100	17	0	1	0	0	1	1
CHECK (UNTREATED)	13	41	84	9	32	166	10
		JUNE 22, 1956					
NIAGRA DN W.P., 1 LB.-100; OIL., 2½ GAL.	19	79	115	25	9	228	11
ELGETOL, 1½ QTS.-100	14	179	43	198	16	436	13
DOW DN 289, 2 QTS.-100	17	14	5	10	13	42	10
CHECK (UNTREATED)	13	577	410	211	92	1290	13

The counts shown in table V indicate that dormant applications of dinitro sprays are very successful in reducing black cherry aphid populations in the early spring. The experiment demonstrates, however, that there is considerable movement of the winged forms from cherry tree to cherry tree where feeding and reproduction take place. In order to maintain effective control, the movement of winged forms from tree to tree should be considered and the dinitro materials followed up later in the spring by such materials as the organic phosphates,

particularly if unsprayed trees are present nearby or if thorough coverage was not obtained with the dormant spray.

Experimental Block No. 2.- This experiment was carried out in a commercial cherry orchard, as was the previous experiment. The experimental block consisted of 105 large Royal Anne cherry trees interplanted with English walnut trees. The block was divided into four plots in order to facilitate a comparison of spray materials, as well as a comparison of combinations of spray materials. Plots 2A and 2C, containing 33 and 13 trees respectively, were sprayed with Niagra dinitro wettable powder at the rate of 1 pound, plus 2½ gallons of dormant oil emulsion, per 100 gallons of water. Plots 2B and 2D, containing 45 and 14 trees respectively, were treated with Elgetol at the rate of 1½ quarts per 100 gallons of water. In addition, plots 2C and 2D were treated with malathion wettable powder at the rate of 2 pounds per 100 gallons of water at a later date.

The dinitro materials were applied on March 14, during the dormant stage. The malathion sprays were added to plots 2C and 2D on April 6, as the buds were beginning to break. All materials were applied with a speed sprayer. In accordance with the desires of the grower, no untreated check trees were used in this experiment.

All plots were examined on June 14 and the number of infested terminals per tree in each plot recorded (Table VI).

Results shown in table VI indicate a significant reduction in the number of infested terminals where malathion sprays were

added at a later date to control aphids which had escaped the effects of the earlier dinitro sprays.

TABLE VI

APHID COUNTS
IN EXPERIMENTAL CONTROL BLOCK NO. 2

PLOT NO.	MATERIAL AND CONCENTRATION	NO. TREES PER PLOT	NO. TREES INFESTED	TOTAL TIPS INFESTED	AVE. NO. INFESTED TIPS
2 A	NIAGRA DN W.P., 1 LB. -100; OIL, 2½ GAL.	33	8	360	10.9
2 B	ELGETOL 1½ QTS.-100	43	19	483	11.2
2 C	NIAGRA DN W.P., 1 LB.-100; OIL, 2½ GAL. MALATHION W.P., 2 LB. -100	13	2	43	3.3
2 D	ELGETOL 1½ QTS.-100 MALATHION W.P., 2 LB. -100	14	2	76	5.4

Experimental Block No. 3. - In this experiment a number of cherry trees at the Oregon State College horticulture farm were treated with systox, a systemic insecticide, at the rate of 1 pint per 100 gallons of water. The spray material was applied April 13, immediately preceding the bloom stage. The trees in the block consisted of seven year old Mazzard seedling trees planted in a windrow. Trees were spaced eight feet apart. A break of twenty-four feet occurred in the spacing, approximately midway in the row, leaving a division of ten trees on one side and six trees on the other side of the break. The ten trees up to the break were treated with the spray material while the remaining trees

were left untreated. Commercial varieties were not used for this test due to the danger of toxic residues being present in the harvested fruit.

Results of this trial were spectacular. The block was examined for the first time on May 22 and the total number of infested terminals recorded. A total of 150 infested terminals were counted on the six untreated trees while none were found on the treated trees. The block was again examined on June 23 and a total of 650 infested terminals were recorded for the untreated trees and a single infested terminal was found on the treated trees. The infested terminal on the treated trees consisted of a small colony of nymphs inhabiting a single leaf. These nymphs apparently had been produced by a winged migrant since no adult aphids were found. The colony was removed in order to determine whether or not further migration to the treated trees would occur. Although these trees were examined periodically for the remainder of the growing season, no further aphids appeared. The systemic action of the insecticide apparently was of sufficient strength and duration to destroy all aphids present at the time of the initial application and to repel further attacks by the winged migrants.

Cherry samples were taken from both treated and untreated trees in this block and shipped to Chemagro Corporation, manufacturers of systox, in order that a residue analysis might be obtained. As of the date of this writing, however, a report had not yet been received.

On the basis of these results, systox appears to be one of the most promising insecticides yet developed for black cherry aphid control. More extensive trials, coupled with additional information on residual toxicity should be obtained, however, before definite conclusions are reached.

SUMMARY

The present investigation was undertaken following several years of unsatisfactory attempts to control the black cherry aphid in the Willamette Valley. It had been noted that even though this insect was controlled satisfactorily early in the spring, heavy infestations often developed during the late spring and early summer. One of the primary objectives of the present study was to determine whether or not the winged forms (summer migrants) were responsible for these late spring and summer infestations.

It was demonstrated that there is considerable movement of the winged forms from cherry tree to cherry tree where feeding and reproduction take place. These individuals were therefore responsible for later infestations of previously uninfested trees.

Although the literature contains reports of wild peppergrass, garden cress, shepherds-purse, water cress and other crucifers as being alternate host plants, the black cherry aphid has never been reported from an alternate host along the Pacific coast. None were found on alternate host plants during the 1956

season although shepherds-purse was found in abundance throughout the area. Ross (32, p. 66) reports that the winged males are produced only on the alternate host plants and the insect is therefore dependent on such plants to complete it's life cycle. During October and November, some 200 winged individuals, from controlled rearing experiments on cherry, were examined but no males were found. This finding adds considerable support to the findings of Ross.

Nymphs of both apterous and alate forms were found to possess five-segmented antennae on the first two instars and six-segmented antennae on succeeding instars. Observations of the nymphal stages of the alate forms indicate that wingpads first appear on the third instar.

Rearing experiments were conducted both in the laboratory and in the field. Aphids reared in the laboratory matured faster, although they were smaller and lived a shorter length of time than those reared in the field. "Clip-on" leaf cages were found excellent for aphid rearing work in the field. Seven generations, plus a partial eighth, were obtained from field rearing experiments and it was estimated that a total of twelve generations, plus a partial thirteenth, were produced for the entire year.

Temperature and relative humidity were found to have an effect on the length of nymphal stadia. At times, however, leaf condition apparently had a stronger effect on the length of stadia than either of the two preceding factors.

The following new species of predators and parasites

were recorded: Hippodamia 5-signata ambigua Muls., Cycloneda polita Csy., Syrphus vitripennis Meigen, Ephedrus nitidus Gahan, Aphidius (Lysiphlebus) knowltoni Smith.

It was demonstrated that dinitro compounds are effective in reducing aphid population early in the spring but that trees treated with these materials alone are subject to reinfestation later in the spring. Significant reductions of infested terminals occurred where trees were treated with malathion later in the spring, following the dormant application of dinitro sprays. Preliminary trials with systox were spectacular. The systemic action of this insecticide apparently was of sufficient strength and duration to destroy the initial aphid population at the time of application and to repel further attacks by the winged migrants when they appeared later in the season.

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APPENDIX

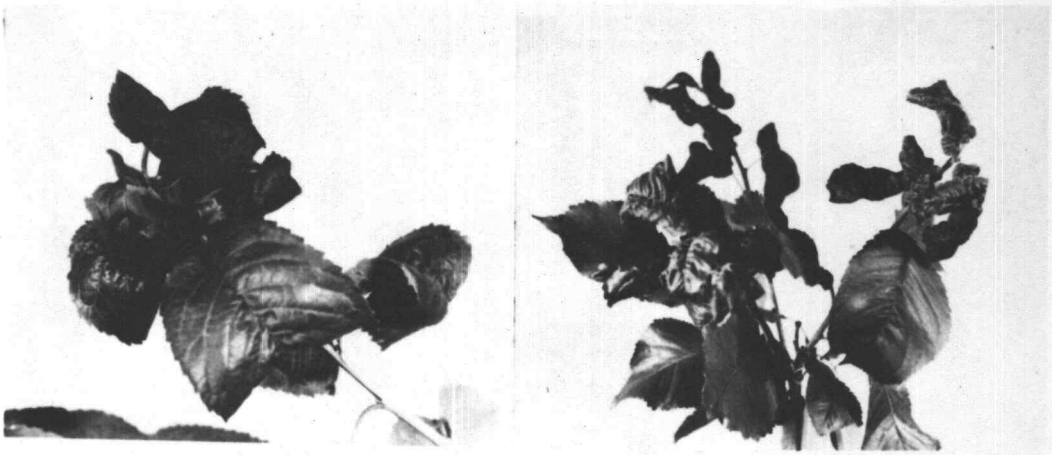


FIG. 1. TYPICAL FOLIAGE INJURY CAUSED BY BLACK CHERRY APHID ON SWEET CHERRY

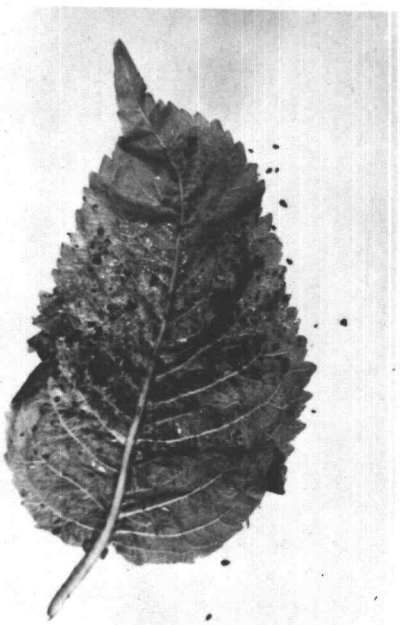


FIG. 2. COLONY OF BLACK CHERRY APHIDS ON UNDERSIDE OF CHERRY LEAF.

FIG. 3. COLONY OF APHIDS CONSIDERABLY ENLARGED.

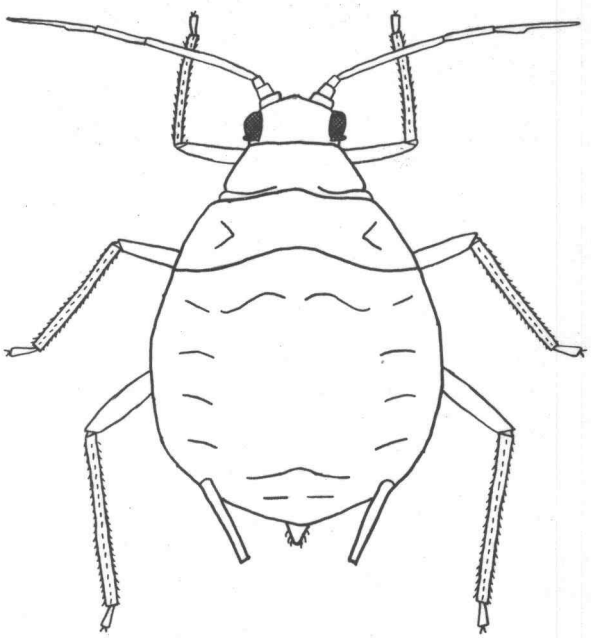


FIG. 4. ADULT STEM MOTHER

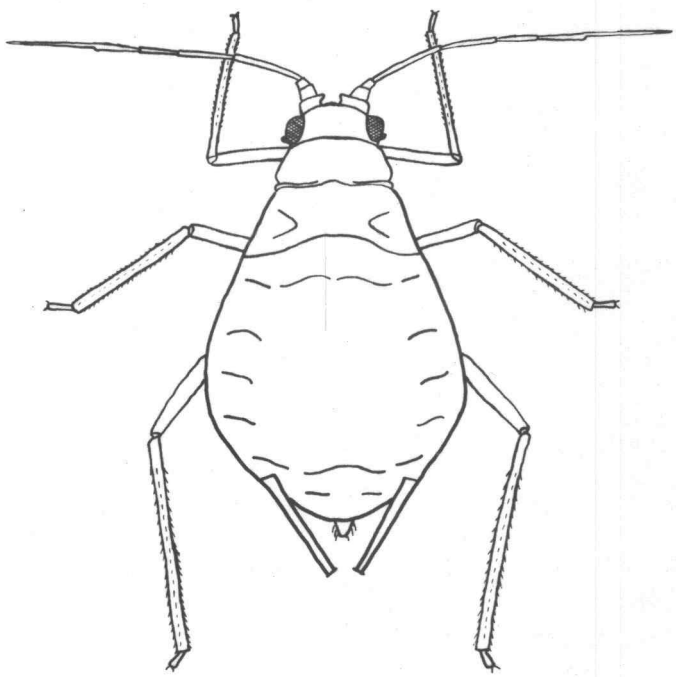


FIG. 5. ADULT APTEROUS VIVIPARA

NYMPHS OF APTEROUS VIVIPARA

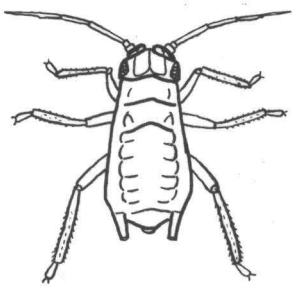


FIG. 6. FIRST INSTAR

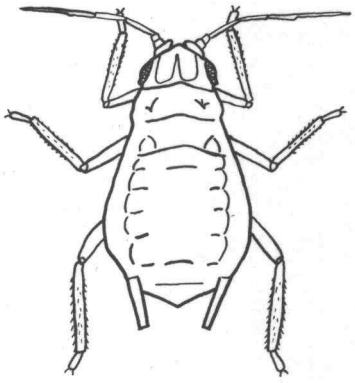


FIG. 7. SECOND INSTAR

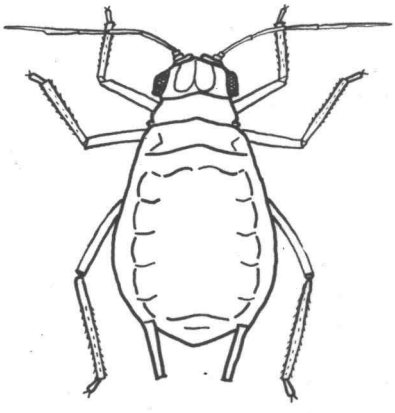


FIG. 8. THIRD INSTAR

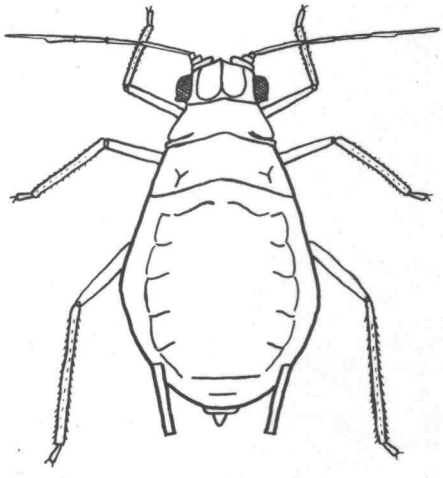


FIG. 9. FOURTH INSTAR

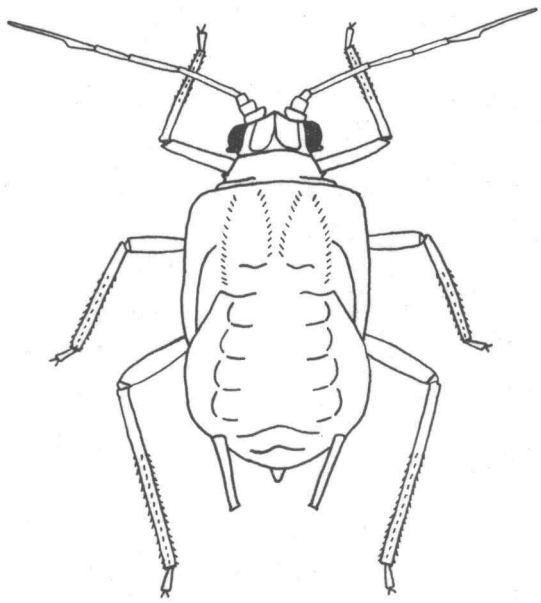


FIG. 10. FOURTH INSTAR OF ALATE VIVIPARA

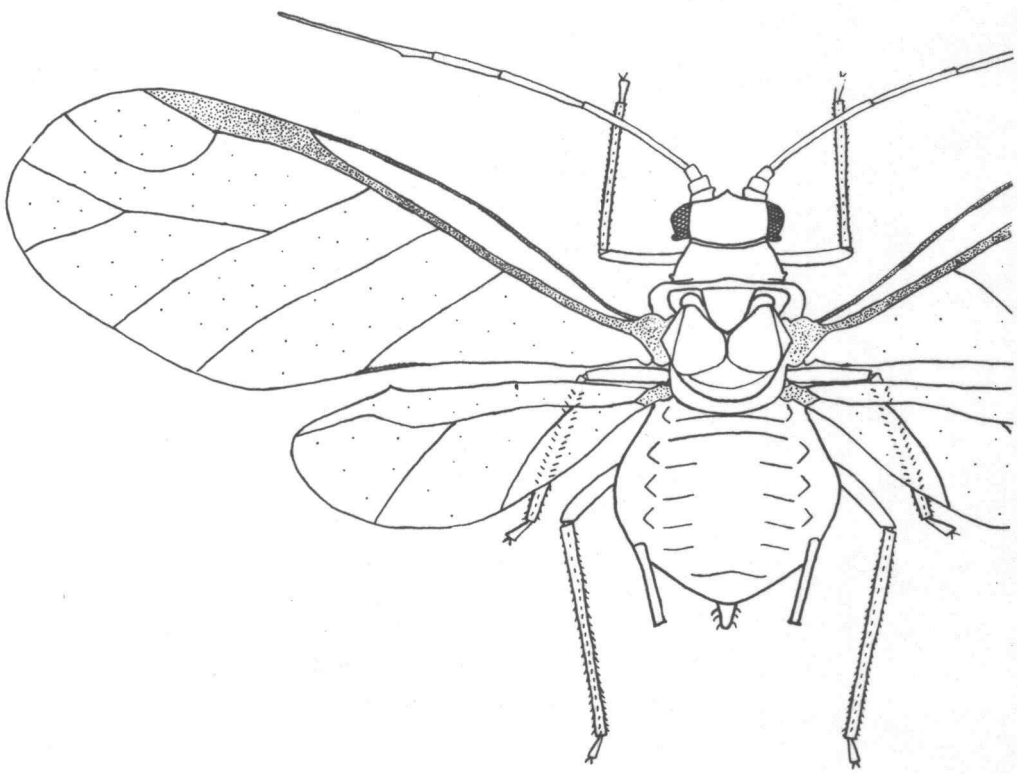


FIG. 11. ALATE VIVIPARA, ADULT

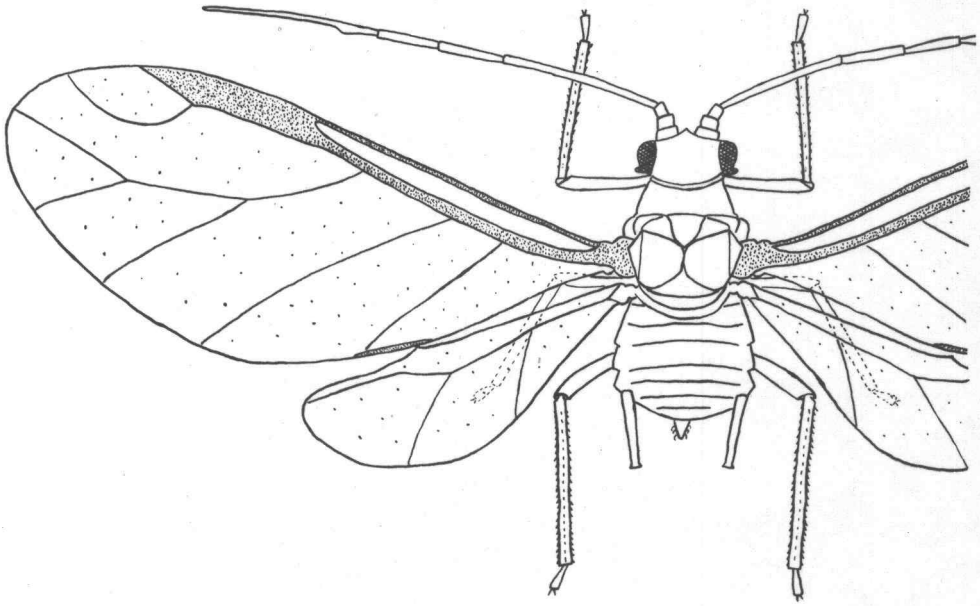


FIG.12. THE MALE

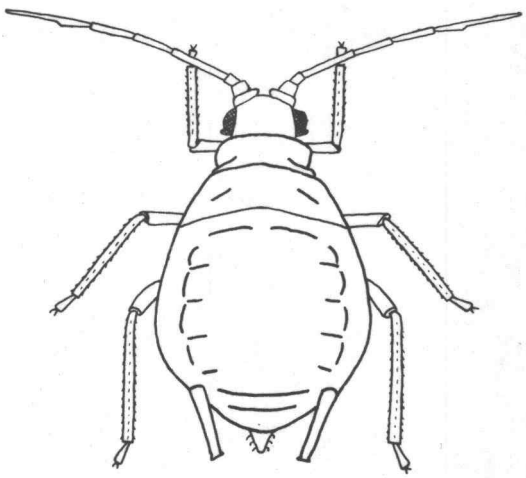


FIG.13. THE OVIPAROUS FEMALE

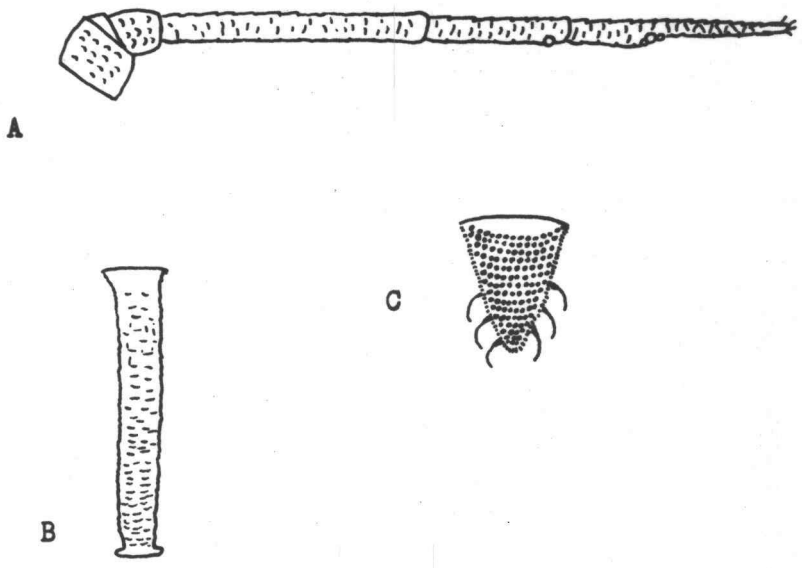


FIG. 14. STEM MOTHER. A, ANTENNA; B, CORNICLE; C, CAUDA.

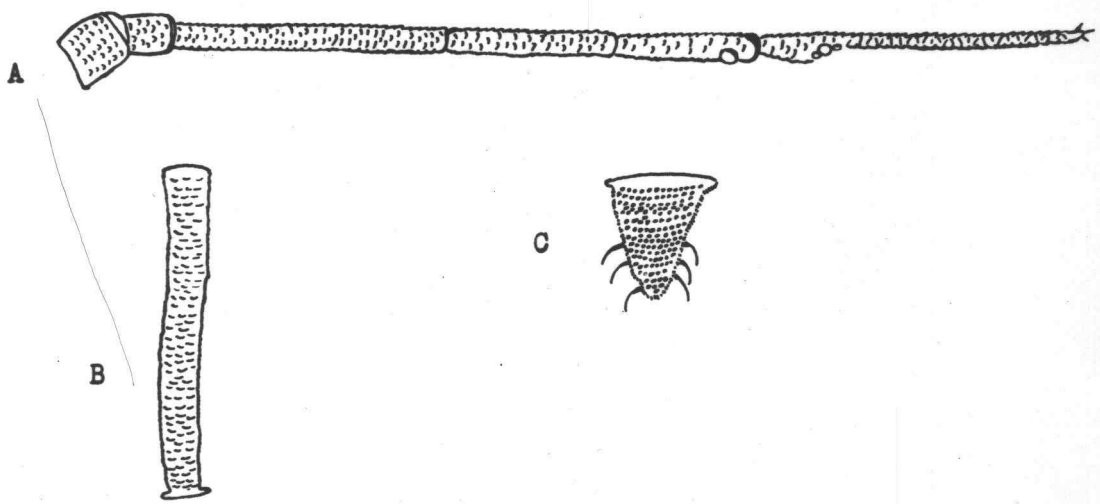


FIG. 15. ADULT APTEROUS VIVIPARA. A, ANTENNA; B, CORNICLE; B,, CAUDA.

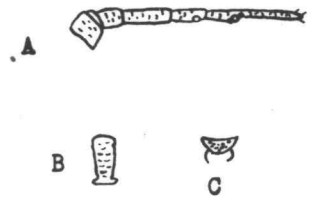


FIG. 16. FIRST INSTAR. A, ANTENNA; B, CORNICLE; C, CAUDA.

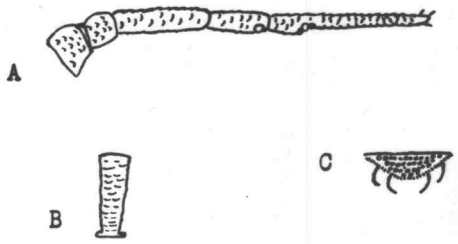


FIG. 17. SECOND INSTAR. A, ANTENNA; B, CORNICLE; C, CAUDA.

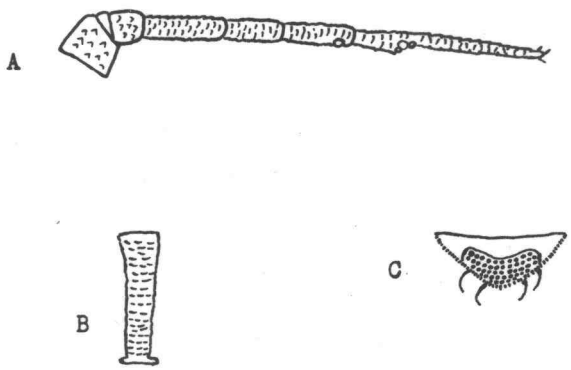


FIG. 18. THIRD INSTAR. A, ANTENNA; B, CORNICLE; C, CAUDA.

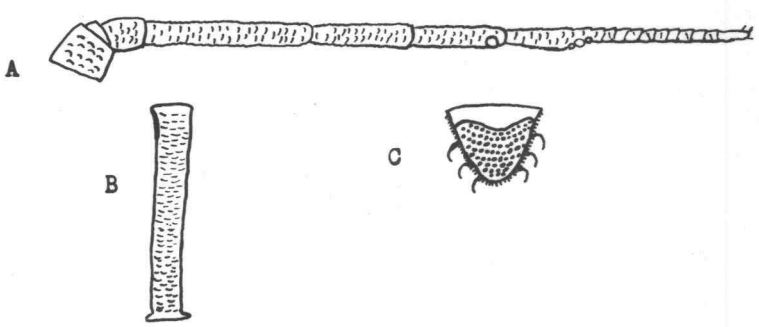
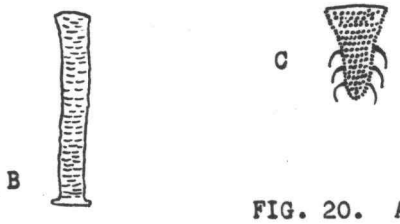


FIG. 19. FOURTH INSTAR. A, ANTENNA; B, CORNICLE; C, CAUDA.

FIGS. 16 - 19. DRAWINGS FROM NYMPHS OF APTEROUS VIVIPARA.

A

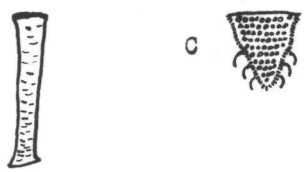


B

C

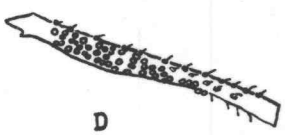
FIG. 20. ADULT ALATE VIVIPARA.
A, ANTENNA; B, CORNICLE; C, CAUDA.

A



B

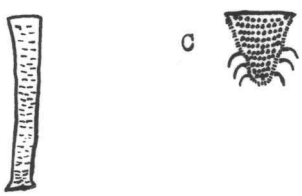
C



D

FIG. 21. OVIPAROUS FEMALE. A, ANTENNA;
B, CORNICLE; C, CAUDA; D, HIND TIBIA.

A



B

C

FIG. 22. THE MALE. A, ANTENNA;
B, CORNICLE; C, CAUDA.

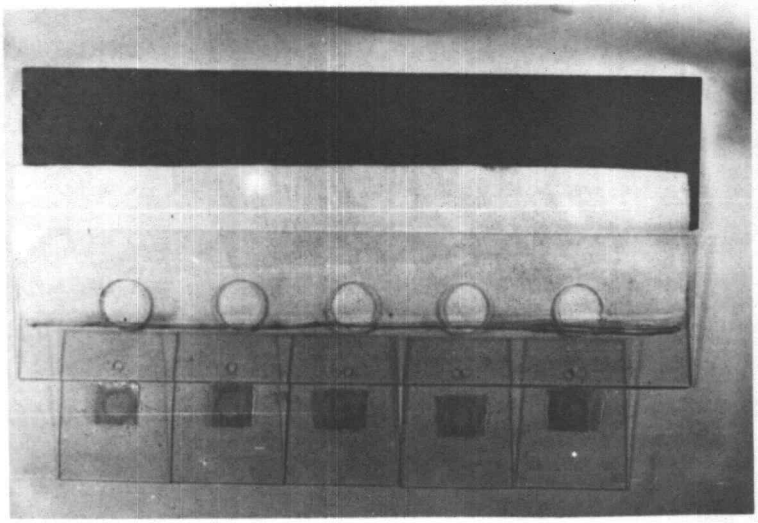


FIG. 23. UNASSEMBLED PLEXIGLASS CAGE USED FOR REARING APHIDS IN LABORATORY. COMPONENT PARTS, LISTED FROM TOP, INCLUDE MASONITE BACK, CHEESECLOTH PAD, PLEXIGLASS STRIP WITH INTERMITTENT HOLES, AND PLASTIC TOPS. LATTER CONTAIN HOLES FITTED WITH FINE MESH LUMITE SCREENING.

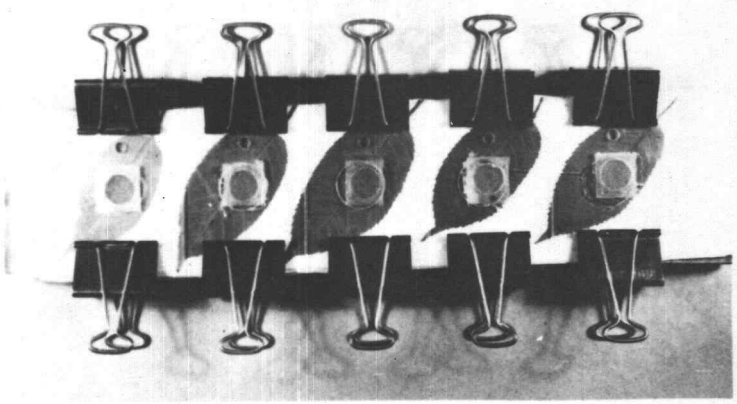


FIG. 24. ASSEMBLED PLEXIGLASS CAGE WITH LEAVES IN PLACE.

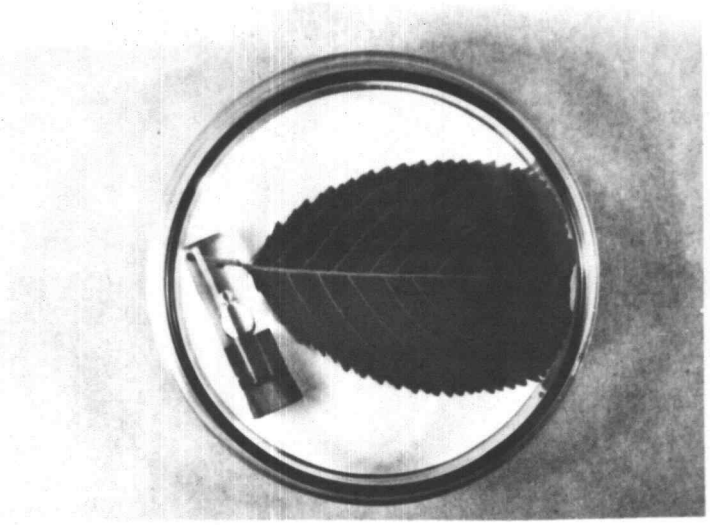


FIG. 25. PETRI DISH CAGE USED FOR REARING APHIDS IN LABORATORY. WATER VIAL CONTAINS SMALL HOLE IN THE SIDE, THROUGH WHICH LEAF PETIOLE IS INSERTED.

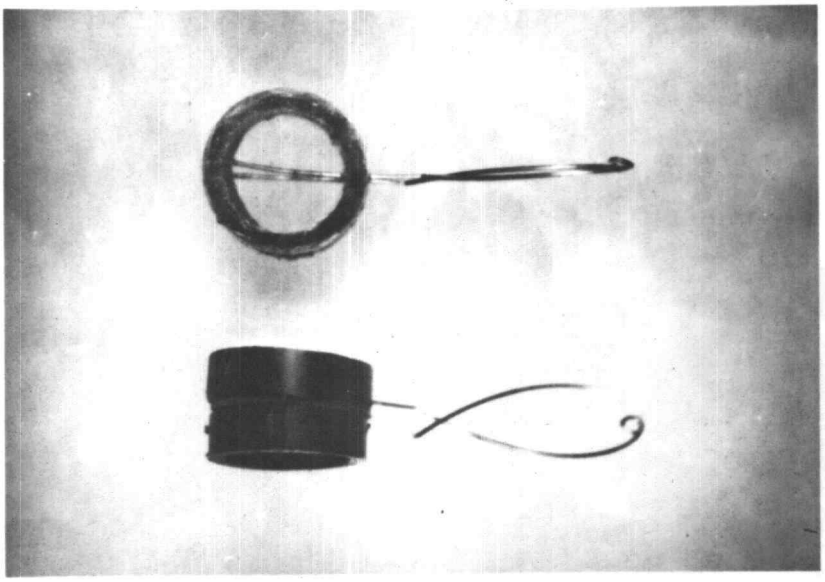


FIG. 26. TOP AND SIDE VIEW OF CLIP-ON CAGES USED FOR REARING APHIDS IN THE FIELD.

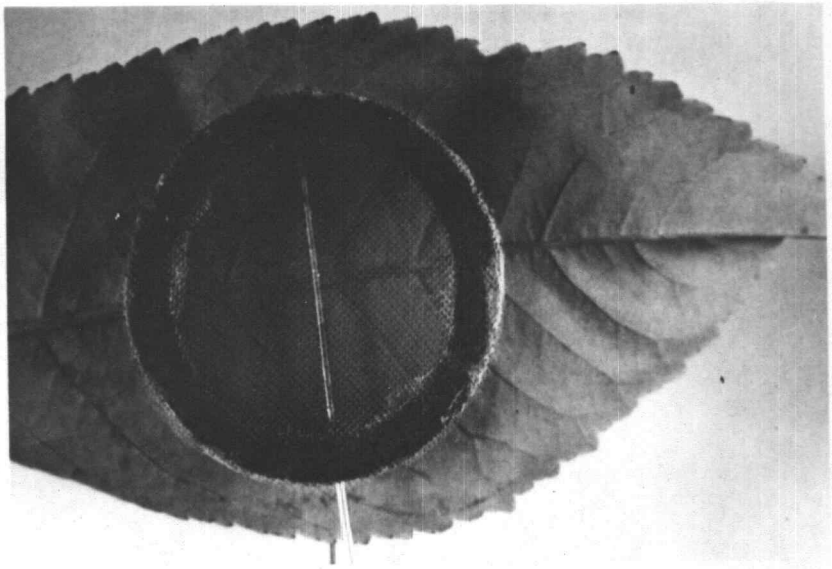


FIG. 27. CLOSE-UP VIEW OF CLIP-ON CAGE ON A CHERRY LEAF.

FIG 28. CLIP-ON CAGES ON YOUNG CHERRY TREE. WHITE TAGS ATTACHED TO CAGES ARE USED FOR NUMBERING PURPOSES.

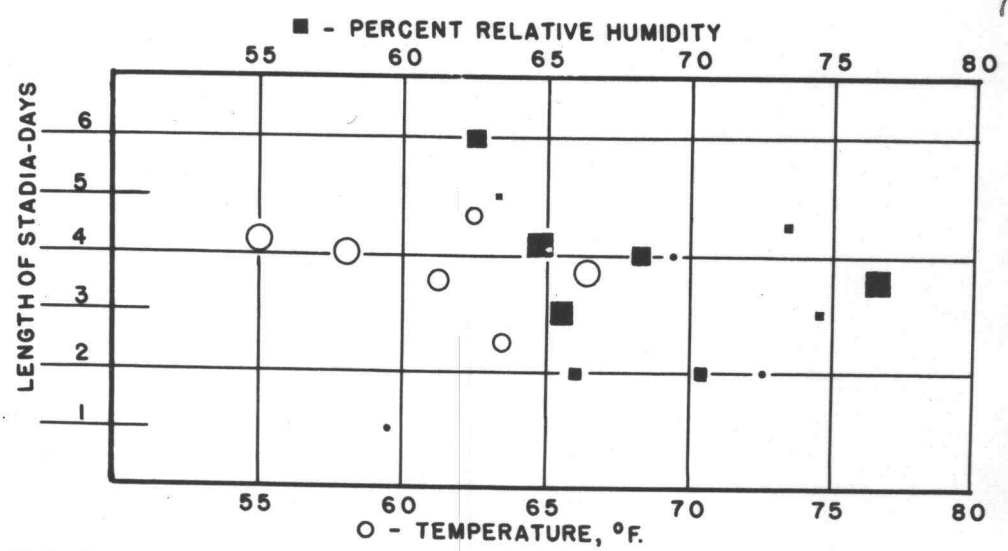


FIG. 29. STUDIES OF THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE FIRST INSTAR OF THE BLACK CHERRY APHID.

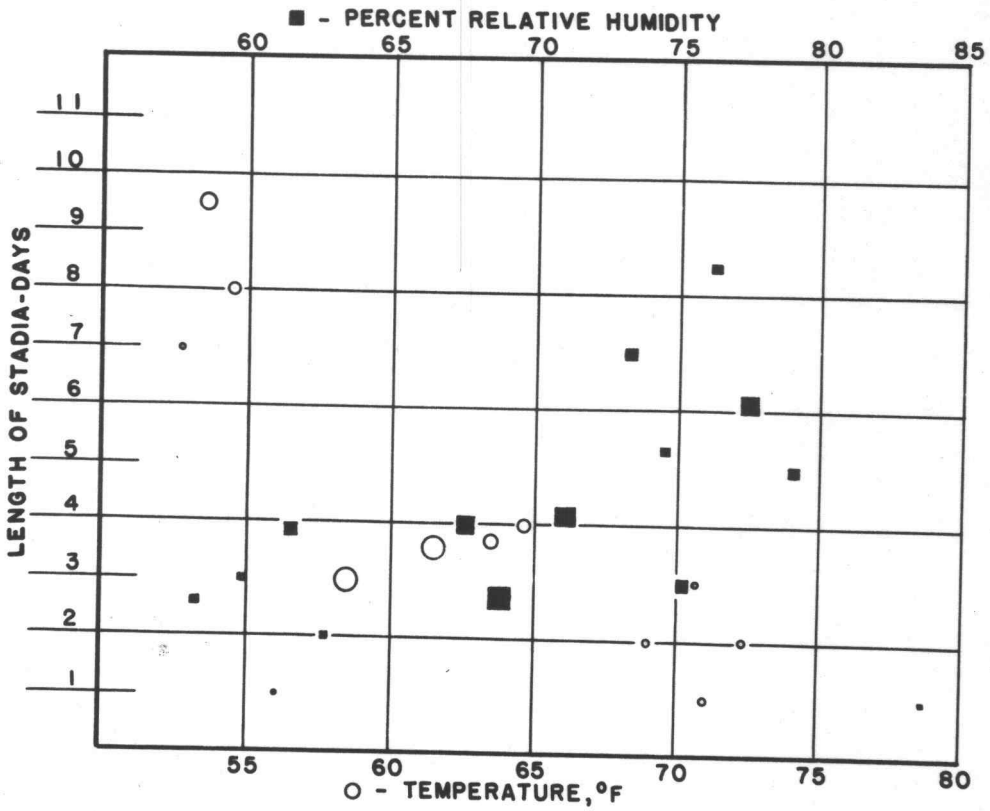


FIG. 30. STUDIES OF THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE SECOND INSTAR OF THE BLACK CHERRY APHID.

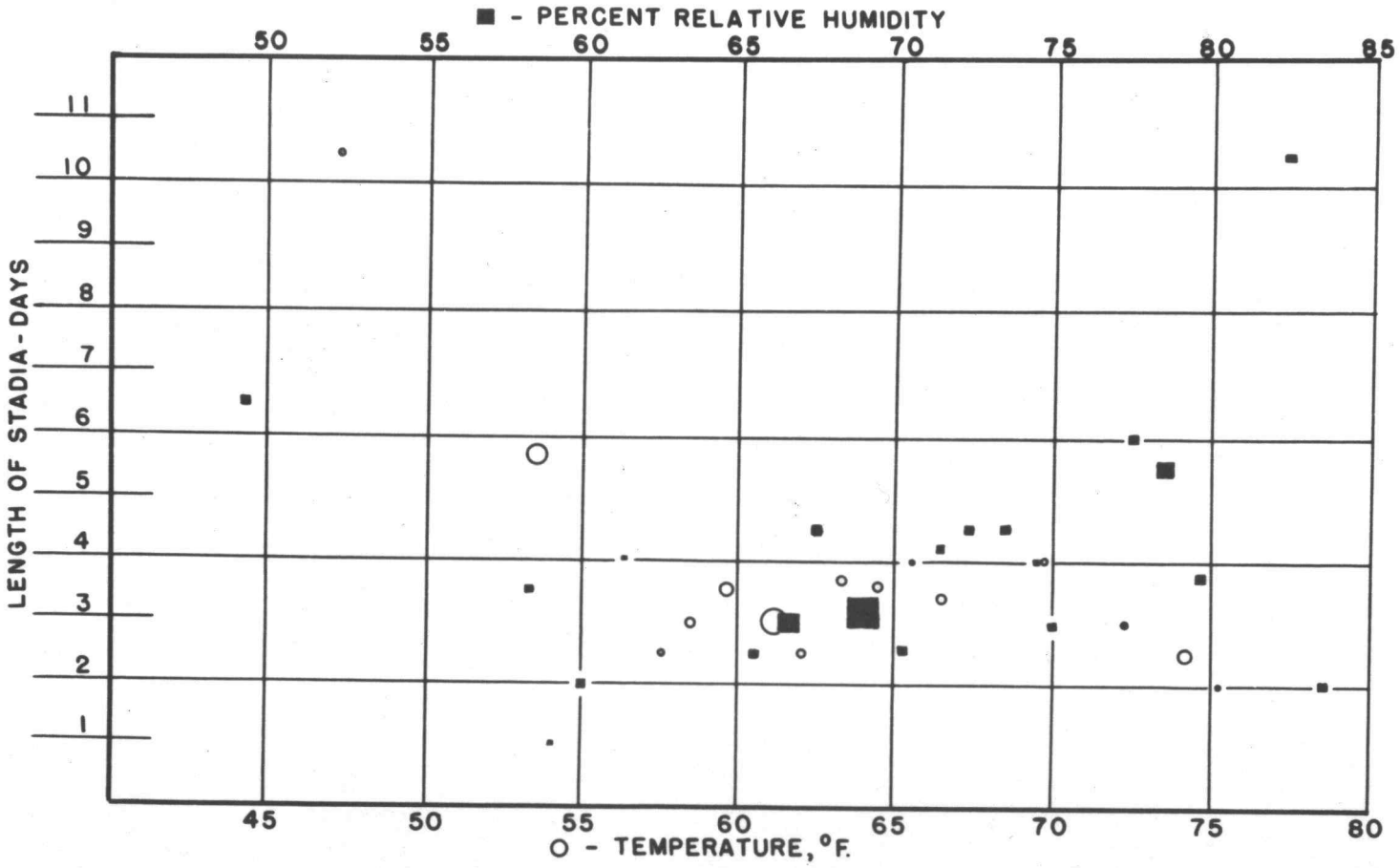


FIG. 31. STUDIES OF THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE THIRD INSTAR OF THE BLACK CHERRY APHID.

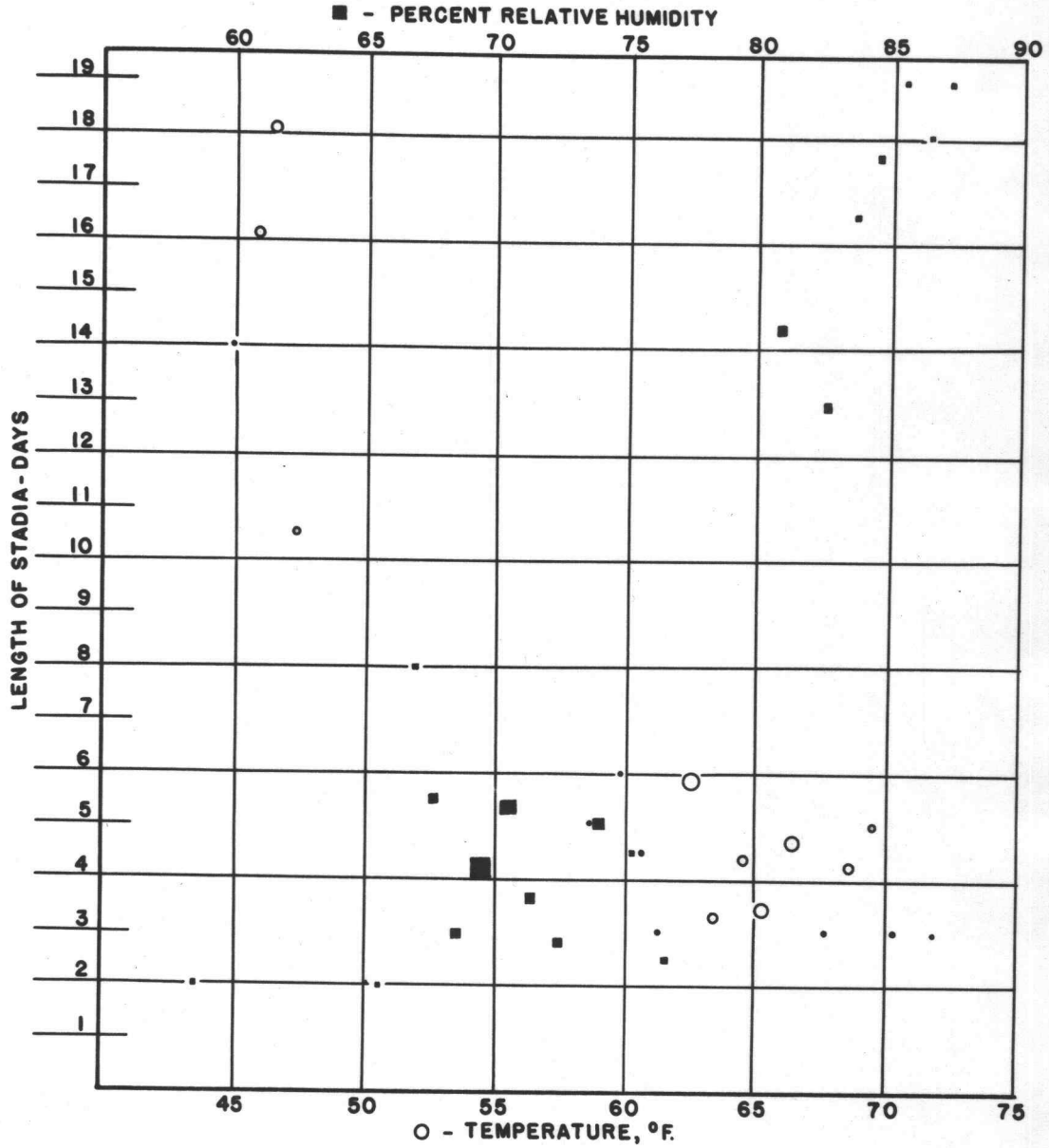


FIG. 32. STUDIES OF THE EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON THE FOURTH INSTAR OF THE BLACK CHERRY APHID.