THE BIOLOGY OF THE FILBERT APHID, *MYZOCALLIS CORYLI* (GOETZE), IN THE CENTRAL WILLAMETTE VALLEY

by

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THE BIOLOGY OF THE FILBERT APHID, *MYZOCALLIS CORYLI* (GOETZE), IN THE CENTRAL WILLAMETTE VALLEY

INTRODUCTION

The rapid expansion of filbert growing in the Pacific Northwest of the United States in the past twenty years has brought with it the problem of insect pests; one of these is the filbert aphid, *Myzocallis coryli* (Goetze). Since nothing is known of the biology, such studies are deemed advisable.

The studies reported here were carried on primarily in the field under natural conditions to study in considerable detail the life history and habits of *Myzocallis coryli*.

These investigations were conducted at Corvallis, Oregon and were begun in the summer of 1957. These studies dwell particularly on the following points:

1. Effects of temperature and relative humidity on the development of the insect.
2. Factors affecting egg deposition.
3. The effect of daily light exposure on the production of the sexual forms of this aphid.
4. Distribution of the aphid on the tree, on leaves of different ages and within the individual leaf.
5. The effect of the aphid injury on filbert quality.

DISTRIBUTION

The filbert aphid (Myzocallis coryli) was first described from Europe by Goetze in 1778. It was reported for the first time in the United States of America by Clarke in 1903 from Berkeley, California (2, p. 249). Since then it has been reported from Colorado and Utah (16, p. 72); Oregon (12, p. 11); Chicago, Illinois (5, p. 418).

Outside the United States of America, it occurs in Vancouver, British Columbia (1, p. 10) and England (17, p. 330).

The author collected it in Vancouver and on the campus of the University of Washington at Seattle, Washington in summer of 1957.

In a conference with the author, Dr. E. O. Essig of the University of California at Berkeley, stated that this aphid also occurs in Argentina, Tasmania, Belgium, and New Zealand.

ECONOMIC IMPORTANCE AND DESCRIPTION OF DAMAGE

McWhorter et al. (15, p. 15), reported that in Oregon the filbert aphid causes serious damage to leaves. Also, Lovett reported that this aphid disseminates the filbert blight disease (12, p. 11). Thompson found that arsenical foliage burn was aggravated by the presence of the aphid honey dew (18, p. 195).

The filbert aphid feeds by inserting its stylets into the leaf tissues of the plants. The turgor pressure of the tissues aids in pushing up the plant sap into the stylets.

Aphids begin feeding on the unfolding buds in early spring. Later, they feed on the underside of the leaves when these appear. Leaves of all stages of growth were infested, but the young and old leaves have the highest infestation. Also aphids seem to feed on small nuts early in the season and on the husks with the result that these nuts appear inferior to the uninfested ones. In addition, the aphid secretes large quantities of honey dew which causes severe smutting of the leaves and the staining of the nuts.

HOST PLANTS

Myzocallis coryli was reported by Davis (5, p. 417) to feed on both cultivated and wild hazel shrubs. In addition to these hosts, Wilson and Vickery gave the following host list (19, p. 63): Alder, *Alnus glutinosa* Gaertn.; birch, *Betula* sp.; hornbeam, *Carpinus betulus* L.; common or European filbert, *Corylus avellana* L.; European ash, *Fraxinus excelsoir* L. and sweet gale, *Myrica gale* L. It was also reported by Theobald (17, p. 335) to feed on oak, *Quercus* spp. and potatoes.

Examination of ash and alder plants by the author showed no aphids on these plants. Potatoes planted adjacent to filbert trees were not infested by this species. The filbert aphid is present on filberts in Oregon throughout the entire season of the year.

The writer has been unable to check the identity of the specimens reported on other hosts. The literature records are based on collecting and not on actual biological studies.

TAXONOMIC POSITION

This insect is known by the common name of filbert aphid. The scientific name *Myzocallis coryli* (Goetze) taxonomically is treated in various ways, but for the purpose of this paper, the concepts of Gillette and Palmer in their "Aphididae of Colorado" will be used. This is as follows: Order, Homoptera; Family, Aphididae; Subfamily, Aphidinae; Tribe, Callipterini; Subtribe, Callipterina; Genus, *Myzocallis*; Species, *coryli*.

Historically the species has been successively transferred from genus to genus as follows (17, p. 332):

Aphis coryli Goetze, Ent. Beitrage, II, page 311, 1778.

Corylaphis Amyot, Annals de la Societe Entomologique de France, 2nd series, page 479, 1847.

Callipterus Koch, Die Pflanzenlausen, page 215, 1857.

Myzocallis Passerini, Aphid. Ital., 54, 4, 1863.

OCCURRENCE OF SEASONAL FORMS OF FILBERT APHID

Overwintering Forms

The filbert aphid lays its eggs on the filbert tree where they are deposited singly. The eggs are laid in crevices, leaf scars, around the buds and under the scales of the bark. However, most of the eggs are laid on twigs and branches two and three years old. Very few eggs are laid on twigs that are one year old. Such twigs are smooth and devoid of scales. Eggs are in the field from October to the first part of April. Hatching begins about the middle of March. Eggs can be found in large numbers in the field. Thousands of them were collected from the field during this study.

Early Spring Forms

Upon hatching, the egg gives rise to the stem mother or fundatrix. Hatching begins in March and continues for 3 to 4 weeks. The nymphs first begin feeding on the swelling buds and later on the underside of the leaves. They mature in 2 to 3 weeks, molting 4 times and almost immediately give birth to young parthenogenetically after the last molt. The adult stem mother in contrast to other species of aphids is winged. In order to avoid repetition later, it is well to indicate at this point that all summer generations except the last one of the sexual forms, are agamic females that reproduce parthenogenetically.

Stem mothers are found in Oregon in large numbers during April but their numbers begin to decline during May.

Summer Forms

The progeny of the stem mother are called the viviparae. This form makes its appearance in the last days of April and May. They feed on the underside of the leaves, husks and also on the small nuts at that time. Adults begin reproducing immediately after the last molt. They give birth to 6 or 8 young on the first day and the number tapers off to 1 or 2 young per day during the entire life of the female.

Summer forms are in great abundance in May and June. Their numbers decline appreciably during July at the time when high temperatures first occur (Figure 1). During summer and fall the populations are much lower than during the cooler season in the spring.

Fall Forms

Sexupara

Upon the approach of fall, the summer forms, which persist on the filbert trees, give birth to a generation of winged forms, the sexupara. These forms

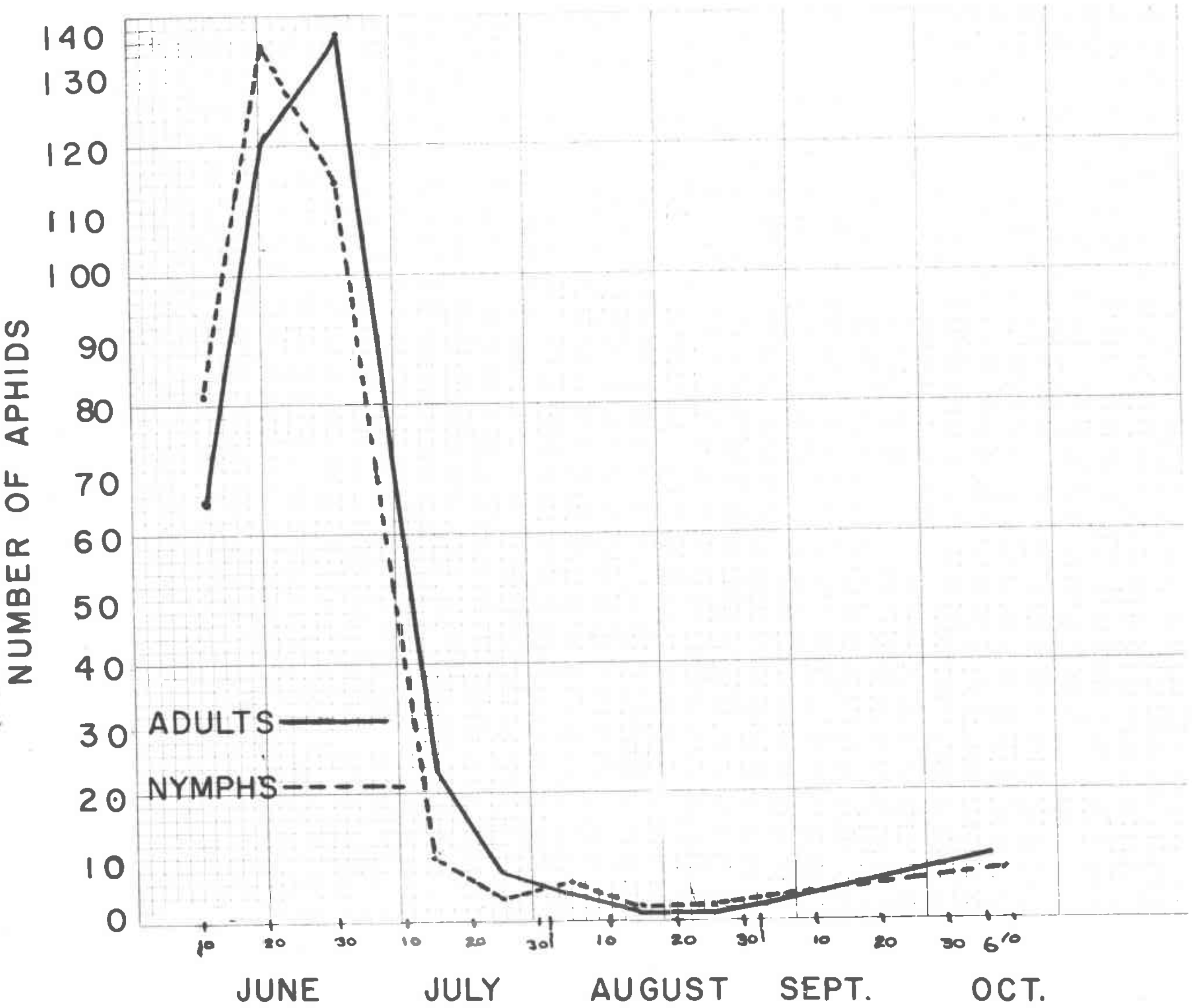


Figure 1. Abundance of summer forms of *Myzocallis coryli*.

in turn give rise to the sexual generation of males and females.

Sexuales

Female. The adult ovipara or egg-laying females first appeared in October in the Corvallis area during 1958. This form is the only one that is wingless in the entire life history of this insect. They begin feeding on the underside of the leaves, which are either old or very old at this time.

Mating first occurs in the middle of October on the underside of the leaves. Occasionally, it occurs on the branches while females are active in laying eggs. Males will mate with females in captivity when both sexes are kept in "clip-on" leaf cages used in the study of life history. Because males have secondary sensoria on antennal segments III, IV, V and VI in contrast to all other forms of this aphid as is shown in Table 1 and since these sensoria are believed to be sense organs, it is presumed that they help males to locate females for mating.

TABLE 1

Number of secondary sensoria on various antennal segments of different adult forms of the filbert aphid.

Adult Forms	Number of secondary sensoria on segments: III	IV	V	VI
Male	14-22	3-9	4-7	1-3
Viviparous female	3-6	no	no	no
Sexual female	no	no	no	no

Females sometimes will mate with the same male more than once.

Eggs are first laid in the middle of October and egg laying continues to the end of November. The peak of egg laying activity is during the last part of October and the first half of November. Later, this activity declines with lower temperatures and the falling off of the leaves. There was no egg deposition in December and practically all females vanish by this time.

Male. The winged males appear shortly after the egg-laying females on the same trees but are less abundant than oviparous females. The sex ratio is approximately 5 to 1 in favor of the females. This rate is based on counts made of the aphid populations on 160 leaves. As in the case of the oviparous females, this form begins to decline in numbers late in November and they disappear completely by December.

The above information is summarized for the reader in Figure 2. This figure shows the relative abundance of the various forms for the season of 1957-1958.

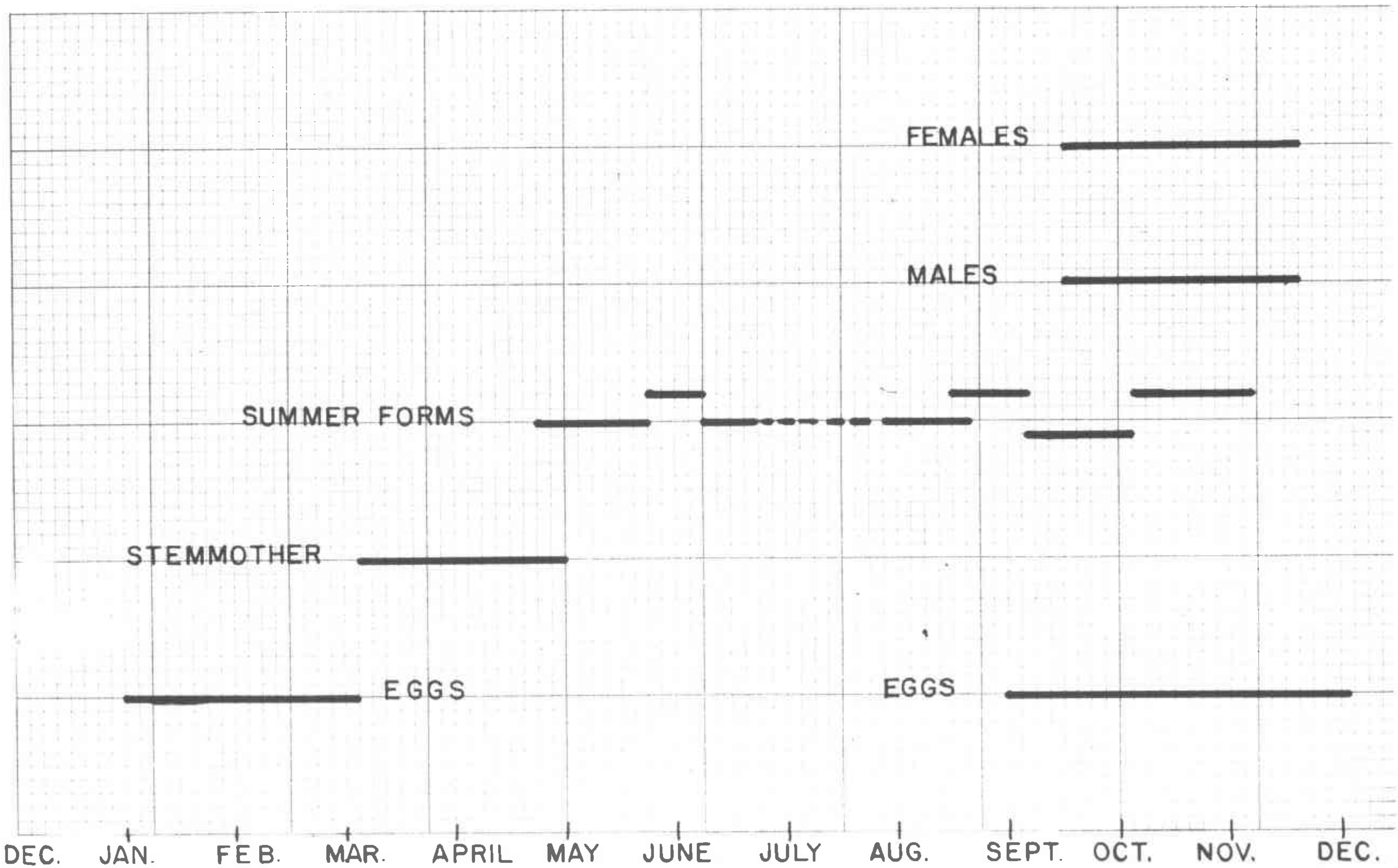


Figure 2. Relative abundance of the various forms of *Myzocallis coryli*.

DESCRIPTIONS OF FORMS AND STAGES

No descriptions of immature stages of Aphis coryli can be found in literature. The writer is describing here these stages for the first time.

Egg

The egg (Figure 3) is pale yellow when first laid, turning shiny black later. Eggs are elongate-oval in shape and round at both ends. They are very small but easy to see with the naked eye.

Table 2 records the measurements of 20 eggs.

Stem Mother

First instar. Upon hatching, the new-born nymphs are whitish or pale yellowish in color. Later, within an hour the general coloration becoming whitish. Head dusky black with chitinized areas of dusky color on each side of the median line and two frontal tubercules, each bearing a capitate seta. Antennae dusky black, four-segmented, segment IV longest, III and IV imbricated, one sensorium on the tip of III and base IV. Eyes bright red. Rostrum dusky, blackish at the tip. Legs dusky black. Cornicles very short and dusky at the tip. Cauda granulated and roundish. Thorax and abdomen with four rows of longitudinal dusky tubercules, each bearing a capitate seta.

Figure 3. Newly-laid eggs and old eggs on a filbert twig.

TABLE 2

Records of the measurements in millimeters for twenty 4-month old eggs of *Myzocallis coryli* selected at random from 5 twigs.

Egg number	Length in mms.	Width in mms.
1	0.43	0.16
2	0.43	0.20
3	0.43	0.20
4	0.43	0.20
5	0.43	0.20
6	0.46	0.20
7	0.46	0.20
8	0.46	0.20
9	0.50	0.20
10	0.50	0.20
11	0.50	0.20
12	0.50	0.20
13	0.50	0.23
14	0.50	0.23
15	0.50	0.23
16	0.50	0.23
17	0.50	0.23
18	0.50	0.23
19	0.53	0.23
20	0.53	0.23
Average and standard deviations	0.48 $\mp$ 0.03	0.21 $\mp$ 0.06

Table 3 gives the measurements of 10 individuals.

TABLE 3

First instar and second instar nymph measurements of 10 individuals of *Myzocallis coryli* in millimeters.

Body Dimension Measured	First instar nymphs			Second instar nymphs		
	Millimeters			Millimeters		
	Average	Max.	Min.	Average	Max.	Min.
Head capsule (across eyes)	0.18	0.21	0.16	0.24	0.26	0.22
Length (vertex to apex of abdomen)	0.60	0.65	0.55	0.86	0.94	0.86
Width (widest part of abdomen)	0.27	0.30	0.25	0.43	0.47	0.41
Antennae (total length)	0.30	0.33	0.30	0.40	0.44	0.39
Antennal segments						
I	0.035	0.04	0.03	0.04	0.05	0.04
II	0.03	0.03	0.03	0.03	0.04	0.03
III	0.10	0.12	0.10	0.10	0.10	0.09
IV	0.14	0.14	0.13	0.06	0.07	0.06
base	0.05	0.05	0.05			
unguis	0.08	0.09	0.08			
V				0.16	0.19	0.15
base				0.06	0.06	0.05
unguis				0.10	0.10	0.09
Cornicles (from point of attachment to tip)	0.01	0.01	0.01	0.04	0.04	0.04
Hind tibia	0.18	0.18	0.17	0.24	0.26	0.22

Second instar. Translucent before first molt, later the entire body, including head becoming pale yellow or whitish. Antennae, 5-segmented, whitish or pale yellowish except the dusky segments IV, V, and tip segment III, segment V longest, one sensorium at the tip of segment IV and base V. Eyes reddish. Rostrum, whitish or pale yellowish except the dusky tip. Legs, whitish or pale yellowish except the dusky tip of tibia and blackish tarsus. Cornicles and cauda concolorous with the body.

Third instar. Translucent before first molt, then entire body, including head, whitish or pale yellowish. Body with capitate setae. Antennae, 5-segmented, whitish or pale yellowish except the dusky tips of III, IV, base and unguis V, segments III, IV, V imbricated, segment III and V imbricated, segment III and V subequal but V being invariably slightly longer, one sensorium on tip of segment IV and the distal end of base V. Eyes reddish. Rostrum, whitish except the tip being dusky. Legs, whitish or yellowish except the dusky tarsus. Cornicles and cauda concolorous with the body.

Fourth instar. Translucent before first molt, later the entire body including head becoming whitish or pale yellowish. Body with capitate setae. Antennae, 6-segmented, whitish or pale yellowish except the tips of segments III, IV, V, base VI, unguis VI being dusky, segment VI longest, unguis being twice longer than base, segments

III, IV, V, VI imbricated, one sensorium at the tip of V and base VI. Rostrum, whitish except the tip being dusky. Eyes, reddish. Legs, whitish or pale yellowish except the distal end of tibia being dusky and blackish tarsus. Cornicles and cauda concolorous with the body.

The measurements are shown in Table 4.

TABLE 4

Third and fourth instar measurements in millimeters of 10 individuals of Myzocallis coryli.

Body Dimension Measured	Third instar nymphs			Fourth instar nymphs		
	Millimeters			Millimeters		
	Average	Max.	Min.	Average	Max.	Min.
Head capsule	0.21	0.26	0.21	0.28	0.29	0.25
Length	1.20	1.30	1.10	1.80	1.90	1.80
Width	0.58	0.62	0.50	0.76	0.84	0.70
Antenna	0.64	0.66	0.60	1.05	1.14	0.97
Antennal segments						
I	0.04	0.05	0.04	0.05	0.06	0.05
II	0.04	0.04	0.04	0.05	0.05	0.04
III	0.21	0.22	0.19	0.26	0.29	0.24
IV	0.10	0.10	0.09	0.20	0.22	0.18
V	0.23	0.25	0.22	0.16	0.18	0.14
base	0.07	0.08	0.06			
unguis	0.16	0.17	0.15			
VI				0.30	0.35	0.27
base				0.10	0.11	0.09
unguis				0.20	0.24	0.18
Cornicles	0.04	0.05	0.04	0.06	0.07	0.05
Hind tibia	0.42	0.44	0.41	0.69	0.71	0.67

Adult

Entire body, pale yellowish or whitish. Antennae, whitish or pale yellowish, tips of segments III, IV, V, base of VI and unguis VI dusky. Eyes, reddish. Rostrum, whitish or pale yellowish except the dusky tip. Legs, pale yellowish or whitish except the tip of the tibia being dusky and blackish tarsus. Cornicles and cauda concolorous with the body.

Body pear-shaped, prolongated toward the posterior end. Antennae, 6-segmented, segments III, IV, V, VI imbricated, segment III longest, unguis VI at least twice longer than base, three to six large circular sensoria near the base of III, one sensorium near the tip of V and base VI. Cornicles, truncate. Cauda, knobbed. Anal plate, distinctly bilobed. Wings, hyaline, fore wings with radial sector faint, media twice forked.

Table 5 presents the measurements of the adult stem mothers of Myzocallis coryli.

Summer Forms

To avoid repetition, it might be well to mention here that all summer forms are translucent before the first molting.

First instar (Figure 4). Entire body, including head, whitish or greenish yellow. Antennae, 4-segmented; yellowish or whitish except the dusky distal end of segments III and IV; segment IV longest; one sensorium at the tip of III and base IV; segments III and IV imbricated. Eyes, bright red. Rostrum, whitish or greenish yellow except the

TABLE 5

Adult stem mother measurements in millimeters of 5 individuals of *Myzocallis coryli*.

	Millimeters		
Body Dimension Measure	Average	Max.	Min.
Head capsule	0.27	0.28	0.26
Length	2.44	2.46	2.42
Width	0.99	1.05	0.94
Antennae	1.70	1.71	1.70
Antennal segments			
I	0.08	0.08	0.08
II	0.05	0.05	0.05
III	0.52	0.53	0.52
IV	0.33	0.36	0.31
V	0.29	0.30	0.29
VI	0.40	0.41	0.39
base	0.11	0.11	0.11
unguis	0.28	0.29	0.27
Cornicles	0.065	0.07	0.06
Hind tibia	1.11	1.15	1.08

dusky tip. Legs, whitish or greenish yellow except the dusky tarsus. Cornicles and cauda concolorous with the body.

Second instar (Figure 5). Entire body, including head, whitish or greenish yellow. Antennae, 5-segmented; segments III, IV, V dusky at the tips and imbricated; segment V longest; one sensorium at the tip of segment IV and base V. Eyes, reddish. Rostrum, whitish or pale yellowish except at the tip being dusky black. Legs, whitish or pale yellowish except the dusky tarsus. Cornicles and cauda concolorous with the body.

The measurements for the first and second instar of the summer forms are presented in Table 6.

TABLE 6

First and second instars of summer forms in millimeters for 10 individuals of Myzocallis coryli.

Body Dimension Measured	First instar nymphs Millimeters			Second instar nymphs Millimeters		
	Average	Max.	Min.	Average	Max.	Min.
Head capsule	0.11	0.12	0.10	0.22	0.26	0.21
Length	0.57	0.62	0.50	0.77	0.82	0.73
Width	0.20	0.21	0.18	0.28	0.30	0.27
Antennae	0.37	0.39	0.35	0.49	0.51	0.47
Antennal segments						
I	0.04	0.04	0.03	0.04	0.05	0.04
II	0.03	0.04	0.03	0.03	0.04	0.03
III	0.12	0.13	0.12	0.12	0.13	0.11
IV	0.16	0.18	0.15	0.07	0.07	0.06
base	0.05	0.06	0.05			
unguis	0.11	0.12	0.10			
V				0.20	0.21	0.20
base				0.06	0.07	0.05
unguis				0.14	0.14	0.13
Cornicles	0.01	0.01	0.01	0.25	0.27	0.24
Hind tibia	0.16	0.19	0.13	0.25	0.27	0.24

Third instar (Figure 6). Entire body, including head, whitish or greenish yellow. Antennae, 5-segmented; whitish or pale yellowish except the tips of III, IV, base and unguis V being dusky; segments III, IV, V imbricated; one sensorium at the tip of IV and tip of base V; segment V longest; unguis V being twice longer than base V. Eyes, reddish. Rostrum, whitish or pale yellowish except the dusky tip. Legs, whitish or pale yellowish except the dusky tarsus. Cornicles and cauda concolorous with the body.

Fourth instar (Figure 7). Entire body, including head, whitish or greenish yellow. Antennae, 6-segmented; whitish or yellowish except the tips of segments III, IV, V, VI being dusky; segments III, IV, V, VI imbricated; segment VI longest; unguis VI at least twice longer than the base; segments IV and V subequal; one sensorium at the tip of segment V and at the tip of base VI. Eyes, reddish. Rostrum, whitish or yellowish except the dusky tip. Legs, whitish or yellowish except the tarsus being dusky. Cornicles and cauda concolorous with the body. Wing pads extend alongside the body.

Measurements for the third and fourth instar of *Myzocallis coryli* are presented in Table 7.

Adult (Figure 8)

Myzocallis coryli was first described by Goetze in 1778 as follows: "Corpus albidum, inter minores, in follis coryli" (9, p. 311). Davis gave a taxonomic description of the adult as follows (5, p. 418):

"Entire body, including head, pale yellow. Antennae whitish excepting the tips of III, IV, V, distol half of base VI, and filament VI; segment III longest, it being fully a half longer than IV, IV, V, and filament VI subequal, but IV being invariably slightly the longest of

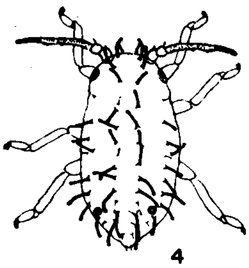
Nymphs of ovivivparous female.

Figure 4. First instar.

Figure 5. Second instar.

Figure 6. Third instar.

Figure 7. Fourth instar.



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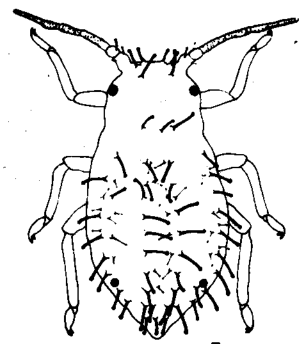

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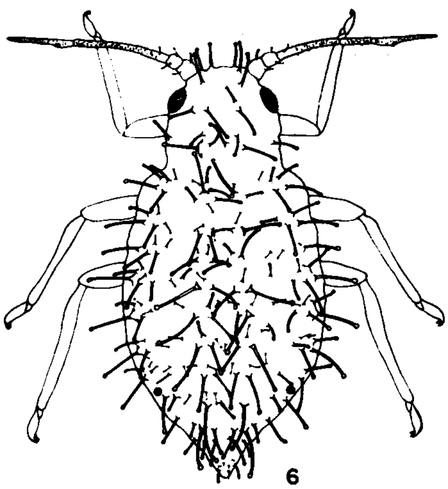

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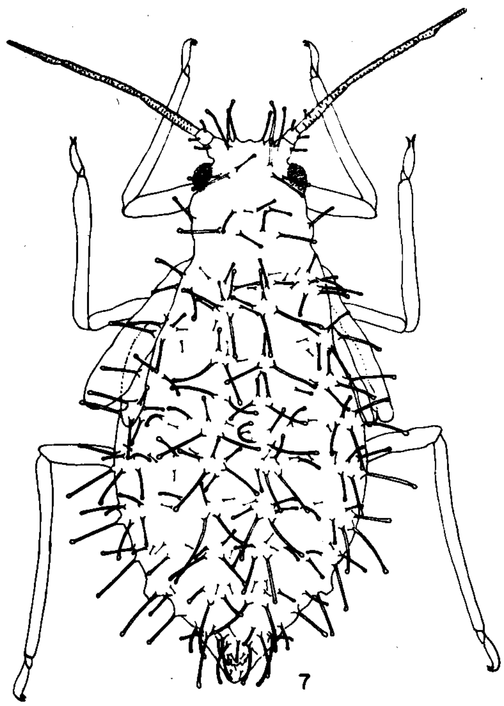

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Figure 8. Oviviviparous, Adult.

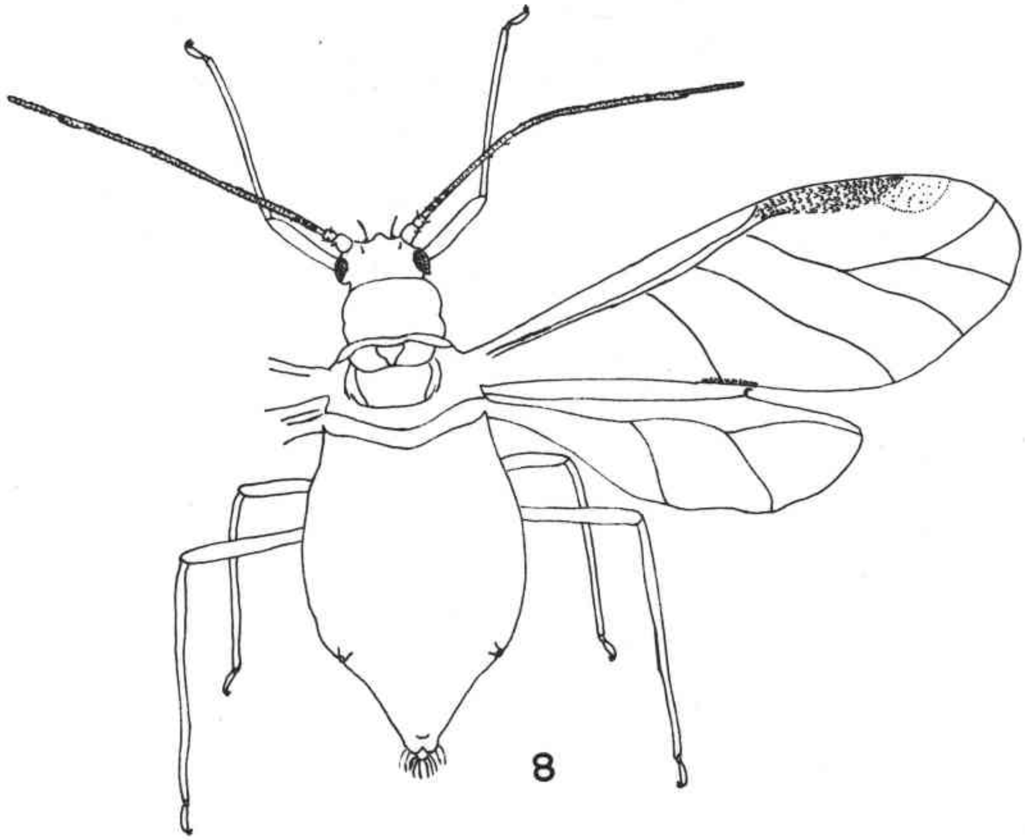

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TABLE 7

Third and fourth instars of the summer form
measurements in millimeters
of 10 individuals of *Myzocallis coryli*.

Body Dimension Measured	Third instar nymphs			Fourth instar nymphs		
	Millimeters			Millimeters		
	Average	Max.	Min.	Average	Max.	Min.
Head capsule	0.26	0.29	0.23	0.30	0.32	0.25
Length	1.09	1.10	0.96	1.40	1.50	1.40
Width	0.48	0.57	0.43	0.59	0.61	0.57
Antennae	0.63	0.68	0.59	0.87	0.90	0.80
Antennal segments						
I	0.04	0.05	0.04	0.05	0.06	0.05
II	0.04	0.04	0.04	0.04	0.05	0.04
III	0.20	0.21	0.18	0.20	0.22	0.17
IV	0.09	0.10	0.09	0.13	0.14	0.12
V	0.23	0.26	0.23	0.14	0.14	0.12
base	0.07	0.08	0.06			
unguis	0.16	0.20	0.15			
VI				0.30	0.30	0.28
base				0.08	0.08	0.07
unguis				0.20	0.23	0.20
Cornicles	0.04	0.05	0.03	0.07	0.07	0.05
Hind tibia	0.37	0.42	0.36	0.58	0.62	0.54

"the three, VI base being less than half the length of VI filament; three or four large but inconspicuous circular sensoria near the base of three, and the usual ones at the distal ends of V and VI base. Eyes white from above and reddish from below. Beak reaching to the coxae of the second pair of legs. Legs pale (whitish) excepting the pale dusky distal end of tibia and blackish tarsus. Cornicles concolorous with the body; longer than wide but the "length less than twice the breadth. Style concolorous with the body and knobbed. Anal plate conspicuously bifid.

"Measurements (average): Length of body, 1.1 mm.; width, 0.046 mm.; length of wing, 1.8 mm.; width, 0.7 mm.; antenna I, 0.055; II, 0.065; III, 0.42; IV, 0.26; V, 0.20; VI, base, 0.105; VI, filament, 0.23; total, 1.335 mm.; cornicles, 0.065 mm.; style, 0.05 mm."

The writer has these additional comments to make:

Entire body pale yellowish or whitish. Antennae whitish except the dusky tips of III, IV, V, distal end of VI base and unguis VI. Eyes reddish white. Rostrum whitish or pale yellowish except the dusky tip. Legs whitish or pale yellowish except the dusky tip of tibia and blackish tarsus. Cornicles and cauda concolorous with the body.

Body oval. Antennae 6-segmented, segments III, IV, V, VI imbricated, segment III longest, unguis of VI being at least twice longer than base VI, three to six large circular sensoria near the base of III, one sensorium at the tip of V and VI base. Cornicles truncate. Cauda knobbed. Anal plate distinctly bilobed. Wings hyaline, fore wings with radial sector faint, media twice forked.

Table 8 presents the measurements of the summer form adult.

TABLE 8

Adult summer form measurements in millimeters of 10 individuals of *Myzocallis coryli*.

Adult Summer Form			
	Millimeters		
Body Dimension Measured	Average	Max.	Min.
Head capsule	0.25	0.27	0.22
Length	1.60	1.90	1.50
Width	0.58	0.70	0.45
Antennae	1.30	1.50	1.20
Antennal segments			
I	0.06	0.08	0.05
II	0.05	0.05	0.04
III	0.40	0.44	0.35
IV	0.25	0.29	0.22
V	0.21	0.25	0.19
VI	0.35	0.36	0.31
base	0.10	0.11	0.10
unguis	0.24	0.26	0.20
Cornicles	0.08	0.10	0.06
Hind tibia	0.84	0.94	0.73

Ovipara

Nymphs. The nymphs of the oviparous females resemble those of the oviviviparous females in all respects except they lack the development of wings.

Female adult (Figure 9). Davis (5, p. 418) gives a brief description of the ovipara as follows:

"Entire body pale yellowish. Eyes reddish. Antennae pale whitish, excepting extreme distal end of III and the remaining segments, which are more or less dusky. Comparative measurements as winged viviparous. Legs pale whitish excepting distal end of tibia and the tarsus, which are "dusky, hind tibia swollen and bearing rather inconspicuous sensoria on the basal two-thirds. Entire body covered with rather long capitate hairs; on the dorsum is a longitudinal row of tubercules, bearing hairs. Abdomen prolongated at the posterior end. Cornicles and style concolorous with the body.

"Measurements (average): Length of body, 1.5 mm.; width, 0.7 mm.; antenna I, 0.05; II, 0.04; III, 0.26; IV, 0.145; VI, base, 0.09; VI, filament, 0.20; total, 0.945 mm.; cornicles, 0.08 mm."

Oviparous females were collected at Corvallis, Oregon during this study. The writer is making this redescription based on these females.

Entire body whitish or orange yellowish. Antennae whitish or pale yellowish except the dusky tips of segments III, IV, V, base VI, unguis VI. Eyes reddish. Rostrum whitish or pale yellowish except the tip being dusky. Legs pale yellow or whitish except tarsus dusky. Cornicles and cauda concolorous with the body.

Body pear-shaped, prolongated at the posterior end. Antennae 6-segmented, segments III, IV, V, VI imbricated, segment VI longest, being as long as both IV and V segments together, unguis VI at least twice longer than base VI, one sensorium at the distal end of V and base VI. Hind tibia swollen and bearing many circular sensoria on the basal two-thirds. Entire body covered with capitate hairs, on both dorsal and ventral sides.

Male adult (Figure 10). The following taxonomic description is taken from the work of Davis (5, p. 418):

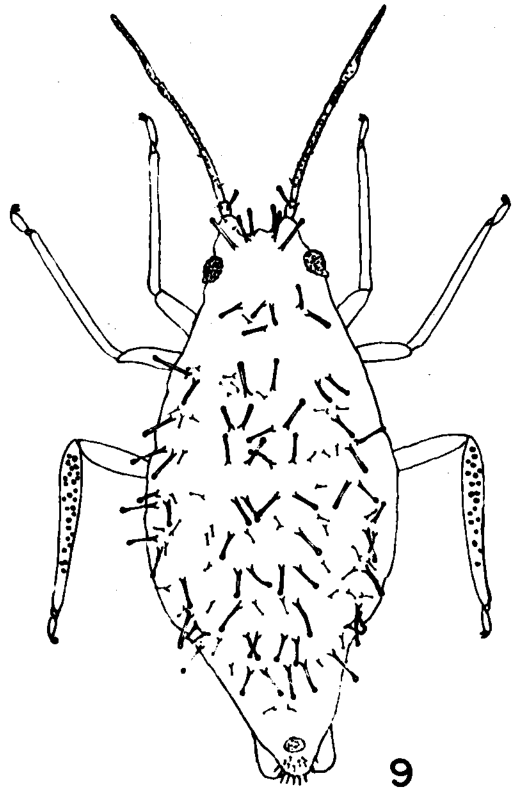
"Head dusky with a faint dark greenish tint; prothorax yellowish with a median longitudinal markings concolorous with head. Thoracic shield shining dark greenish, and abdomen pale yellowish with a median row of short wide transverse black markings and a row of inconspicuous dusky spots on each side. Antennae as follows: I and II dusky, III pale, and dusky at distal end, the remaining segments dusky to blackish; 17-18 roundish oval irregularly placed sensoria on III, 3-5 in a row on IV, 3-5 on V, and 1-3 on base VI, as well as the usual ones at the distal ends of V and base VI; III longest, it being more than a half longer than IV and about twice the length of VI filament, IV and V subequal, the former being invariably slightly the longer, VI base about one half the length of the filament which is subequal to or slightly less than the length of V. Wing veins slightly darker than the female. Legs pale or slightly dusky, excepting the darker distal end of the tibia and the tarsus. Cornicles and style dusky.

"Measurements (average): Length of body, 1.0 mm.; width, 0.35 mm.; length of wing, 2.25 mm.; width, 0.71 mm.; antenna I, 0.05; II, 0.05; III, 0.42; IV, 0.24; V, 0.215; VI, base, 0.10; VI, filament, 0.215; total, 1.29 mm."

The Sexuales

Figure 9. Male.

Figure 10. Female.



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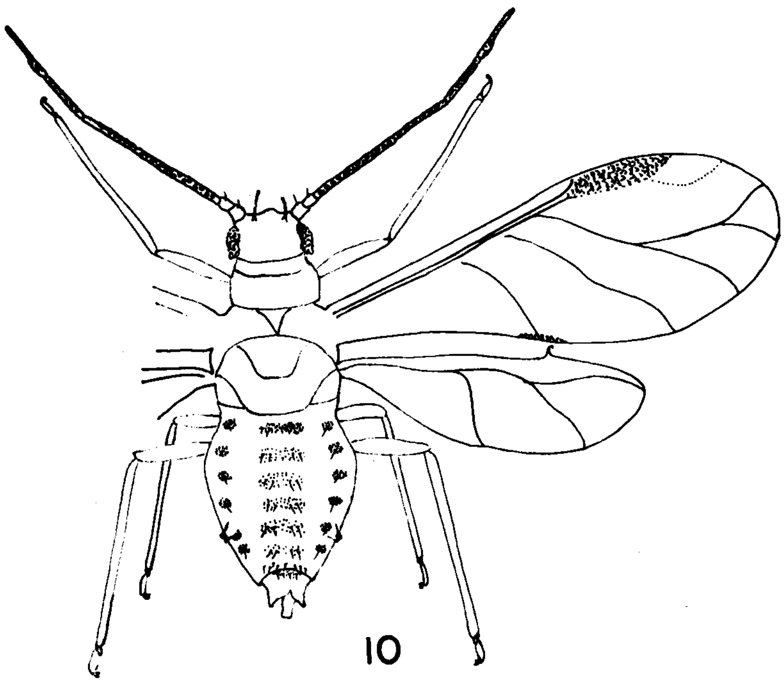

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During the present study, further observations were made on the number of the secondary sensoria on the antennae.

These data are as follows: III, 14-22; IV, 3-9; V, 4-7; VI, base, 1-3.

The presence of secondary sensoria on the antennal segments, the presence of a median row of short wide transverse black markings and a row of dusky spots on each side on the abdomen and the presence of the genital organs which are visible externally very easily differentiate the males from the viviporous females.

The measurements are presented in Table 9.

TABLE 9

Adult male and oviparous female measurements in millimeters of 10 individuals of Myzocallis coryli.

Body Dimension Measured	Adult female Millimeters			Adult male Millimeters		
	Average	Max.	Min.	Average	Max.	Min.
Head capsule	0.29	0.32	0.23	0.21	0.30	0.13
Length	1.70	2.00	1.60	1.70	1.90	1.40
Width	2.80	3.10	2.60	0.57	0.70	0.42
Antennae	0.95	1.00	0.89	1.40	1.60	1.30
Antennal segments						
I	0.07	0.08	0.05	0.05	0.06	0.05
II	0.04	0.05	0.04	0.05	0.06	0.05
III	0.23	0.26	0.20	0.44	0.47	0.42
IV	0.15	0.22	0.13	0.27	0.31	0.25
V	0.14	0.14	0.13	0.26	0.30	0.23
base	0.09	0.10	0.09	0.11	0.13	0.09
unguis	0.20	0.22	0.20	0.21	0.23	0.20
Cornicles	0.08	0.10	0.06	0.05	0.06	0.04
Hind tibia	0.67	0.73	0.63	0.84	0.88	0.81

BIOLOGICAL STUDIES IN LABORATORY

Rearing experiments in the laboratory were used primarily as a means of compiling data that are difficult to collect in the field.

Plexiglass leaf cages, which were developed by Gilmore during his work on the black cherry aphid, were used in this study (7, p. 28). These cages are very satisfactory for observations of the molting process which is very difficult to observe and determine in the field in the case of the filbert aphid.

Data obtained from these experiments show that the filbert aphid molts four times from the first instar nymphs to the adult stage. In the third instar the wing pads appear as swollen areas along the meso and metatherax. After the third molt, the wings extend externally.

Hatching

The hatching process of aphids from eggs has not been observed by most of the workers of aphid biology. Accordingly, there is very little literature dealing with this process. Gimingham (6, p. 585-586) gave a very precise description for the process of hatching of _Amphorphora lactucae_ Kalt.

During the present study, many over-wintered eggs of the filbert aphid were collected from the Entomology farm at Corvallis, Oregon and brought to the laboratory for close observation of hatching process. These observations were made under the binocular.

Hatching begins by a depression appearing along the mid-line of the egg. The nymph apparently breaks the egg open by the means of a saw-like chitinized egg burster which extends from the vertex to the posterior end of the head along the mid-line. After opening the egg, the nymph appears to stand straight up and almost at right angles to the longitudinal axis of the egg (Figure 11). With the aid of contraction movements, the nymph continues to emerge until held to the egg only by the posterior end of abdomen.

At this stage, all appendages, antennae and legs, are enclosed underneath the body apparently by the embryonic membranes. Then antennae, fore legs and the middle legs are freed one by one, while the nymph is still in upright position supported by the tip of abdomen inside the egg. At last when the posterior legs are freed, the nymph begins to assume an inclined position till it touches the bark of the twig. It is still attached to the egg by a gummy-like substance. The nymph seems to exert a considerable force by its legs to push itself away from the egg. At this stage, the emergence is completed.

The egg burster seems to slide down gradually along the body while the nymph is still in upright position. It

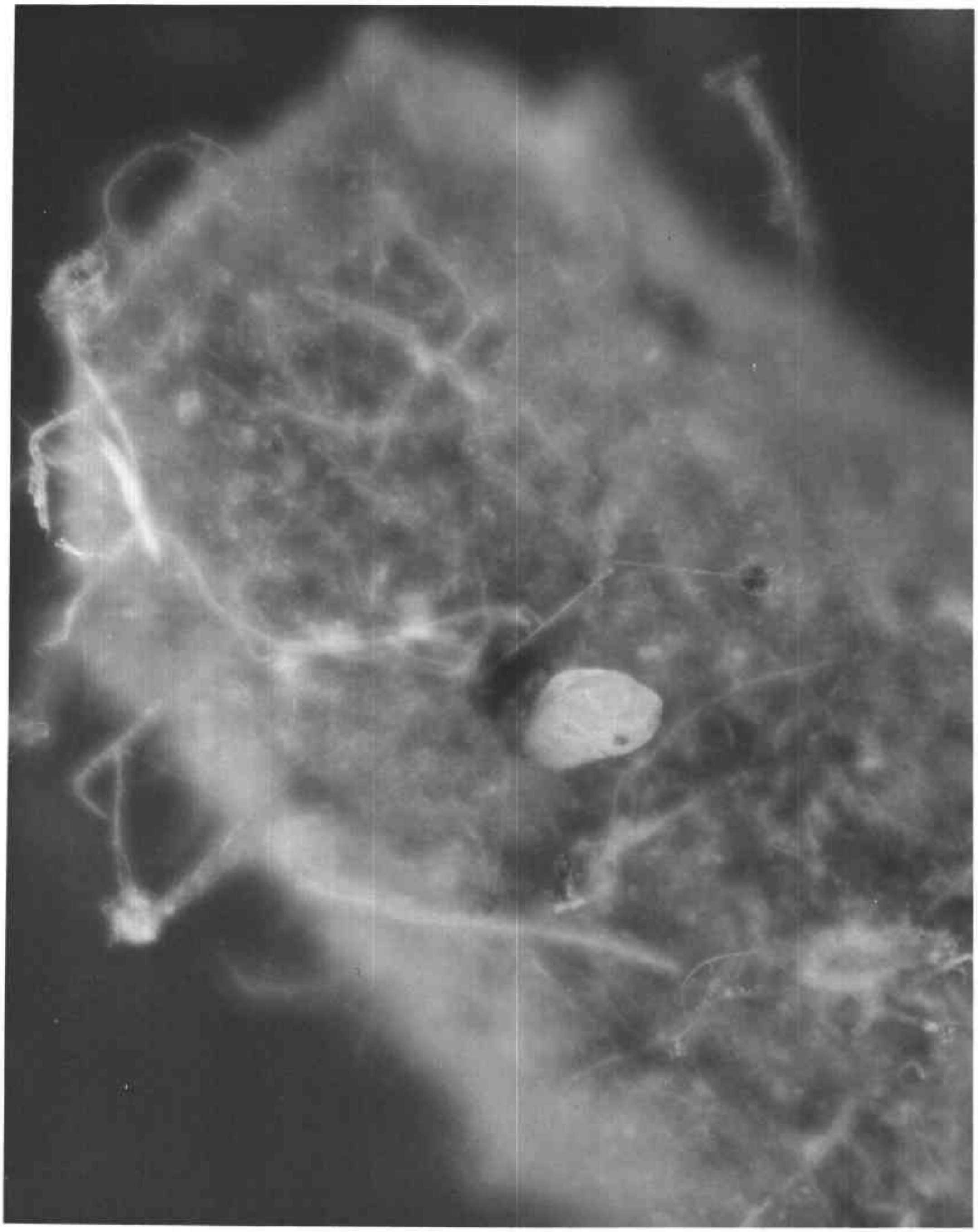

Figure 11. Nymph of stem mother hatching from an egg in the spring.

is cast off near the posterior end of the abdomen after emergence from the egg is completed.

These observations of egg hatching process are in complete agreement with the observations made by Gimingham for Amphorphora lacturae Kalb.

Ovivivlparous Reproduction

Females begin giving birth to young a few minutes after the last molt. In doing so, the female holds fast on the leaf and by the consecutive contractions, the nymph comes caudal end first. At this time, the nymph appears to be hung in the air and does not touch the leaf surface. The appendages, legs and antennae, are folded under the nymph's body. Later, it starts moving its appendages as if trying to get a hold of the leaf surface. At this stage, the female lowers her abdomen, apparently giving the nymph opportunity to hold to the leaf. She repeats the abdominal dipping many times, even after the nymph has left her. The nymphal antennae are the last appendages to be freed. The whole process takes 10 to 15 minutes. Three minutes later, the newly-born nymph starts moving and feeding.

BIOLOGICAL STUDIES IN FIELD

Biological studies of the filbert aphid were made in the field to obtain data such as:

1. Number of generations per year.
2. Effect of temperature and relative humidity on length of the generations.
3. Mating process.
4. Egg laying.

Field Techniques

"Clip-on" leaf cages were utilized by Gilmore (7, p. 29) to study the life history of the black cherry aphid in the field. Similar cages were made and used in the present study. These cages were very satisfactory to determine the length of a generation, but they were not satisfactory for determining the length of the stadia. It was very difficult and almost impossible to find the cast skins after molting, especially those of the early instar nymphs.

Rearing experiments in the field were conducted first in the yard of Dr. Fore of the Farm Crops Department at Corvallis, Oregon. Observations were begun on May 9, 1958. At the time probably the first summer generation was present. After four generations when the leaves had almost dried up and had turned completely brown, the study was moved on August 13, 1958 to the Entomology Farm at Corvallis where young leaves were still present. The trees at the farm were three to four years old.

Initially first instar nymphs were used, individual nymphs being caged on young leaves. The last two generations of the season were raised on old leaves because of lack of young ones. A record of the temperature and the relative humidity was kept by the aid of a hygrothermograph kept at the Entomology Farm during the study.

Number of Generations

Observations on the progress of the development of the nymphs were made once daily at 10 o'clock in the morning. When newly-born nymphs appeared, they were transferred to individual cages with a soft camel hair brush very carefully in order not to injure them. After these nymphs had matured and had begun to reproduce, their progeny in turn were transferred to other individual cages. This process was repeated with the progeny of each generation to determine the number of generations during the season. This study indicates that there are about ten generations a year including the one of the stem mother early in the season.

Temperature and Relative Humidity Relations

A hygrothermograph was maintained near the trees under observation during this study to compile a record of temperatures and relative humidities. Average daily mean temperatures and average relative humidities were calculated and an attempt was made to find if these two factors have an effect on the length of each generation. These data are shown in Table 10.

TABLE 10

Field data on length of generations of the filbert aphid as affected by temperature and relative humidity.

Generation	No. of individuals observed	Average daily mean Temp. F°	Average per cent relative humidity	Days Length of generations
2	8	61.3	77.0	21.6
3	7	67.6	70.7	20.0
6	10	70.0	66.4	18.2
7	9	62.4	72.5	25.7
8	7	59.7	74.8	22.8
9	6	48.1	86.3	29.8

Data in Table 10 shows that there is a definite shortening in lengths of generations with rise of temperature and fall of relative humidity.

The interaction between temperature and humidity would have to be studied in the laboratory before any conclusions could be drawn.

Mating

The sexual forms of the filbert aphid appear in October in Oregon. Mating occurs one or two weeks after first sexual forms appear.

The winged adult male seeks the oviparous wingless female on the underside of the leaves or on branches. After locating her, he mounts the back of the female and clutches her with his legs. Then, the male bending his abdomen and apparently by trial and error, finally contacts the genital organs of the female and then copulation is completed. At times the male misses contact with the female genital organs. Then he moves his bent abdomen over the female until his organs succeed in contacting those of the female.

Egg Laying

Females when ready to lay eggs, move from the leaves to branches. By slowly bending the abdomen downward, the ovipositor contacts the bark of the twigs. When a suitable place for egg deposition is encountered, the female stops. She then extends her abdomen and ovipositor beneath the scales of the bark and lays a single egg. After laying the egg, the female moves along the branch until she encounters another suitable place to lay another egg. Sometimes the female passes by a suitable cranny. Then, she returns and after finding it, the egg is laid. Apparently the surface of the leaves does not stimulate oviposition as does the rough bark on the branches. This was evident with those females that were confined in cages on leaves. Even though fertilized, they did not lay eggs. Such non-laying females are a deep orange in color because the eggs are inside the body. These females died without laying eggs.

Factors Affecting Oviposition

The oviposition activity of the oviparous female of the filbert aphid may be affected by these factors:

1. Temperature and relative air humidity and their interaction.

2. The moisture on the tree, that is whether it is dry or wet. The presence of moisture may be due to either rain or fog.

Studies of the effect of temperature, relative air humidity and moisture on oviposition activity were carried out on the Entomology Farm at Corvallis, during November of 1958. Filbert trees used for these observations were 3 to 4 years old. Ten 2-year old branches, 6 inches long were selected at random from 7 trees. The number of oviparous females on these branches was recorded hourly during the day time. A hygrothermograph and a centigrade thermometer were kept nearby during this study to record relative humidity and temperature.

Effect of temperature and relative air humidity on egg-laying activity. The synoptic method was used in studying the effect of temperature and relative air humidity on the egg-laying activity of the filbert aphid. This was done by making hourly counts of the number of ovipositing females and taking temperature and relative air humidity readings at the same time. This was done on November 14, 16, 20 and 24, 1958 at the Entomology Farm at Corvallis. The 36 observations are shown in Figure 12.

From this figure there is a trend indicating that not as many eggs are deposited at low temperatures and low and and high relative humidity. During these observations none were laid. At the warmer temperatures there was more egg laying at low humidity than at higher humidities. At the warmer temperatures humidity seemed to be a less important factor affecting egg laying.

It is realized by the writer that these data are inadequate to base firm conclusions. However, there seems to be sufficient data to indicate trends.

Effect of wet and dry trees on oviposition. Whether the filbert trees are wet or dry has a very positive effect on the oviposition of the filbert aphid. This phenomenum was observed by making observations throughout a wet day

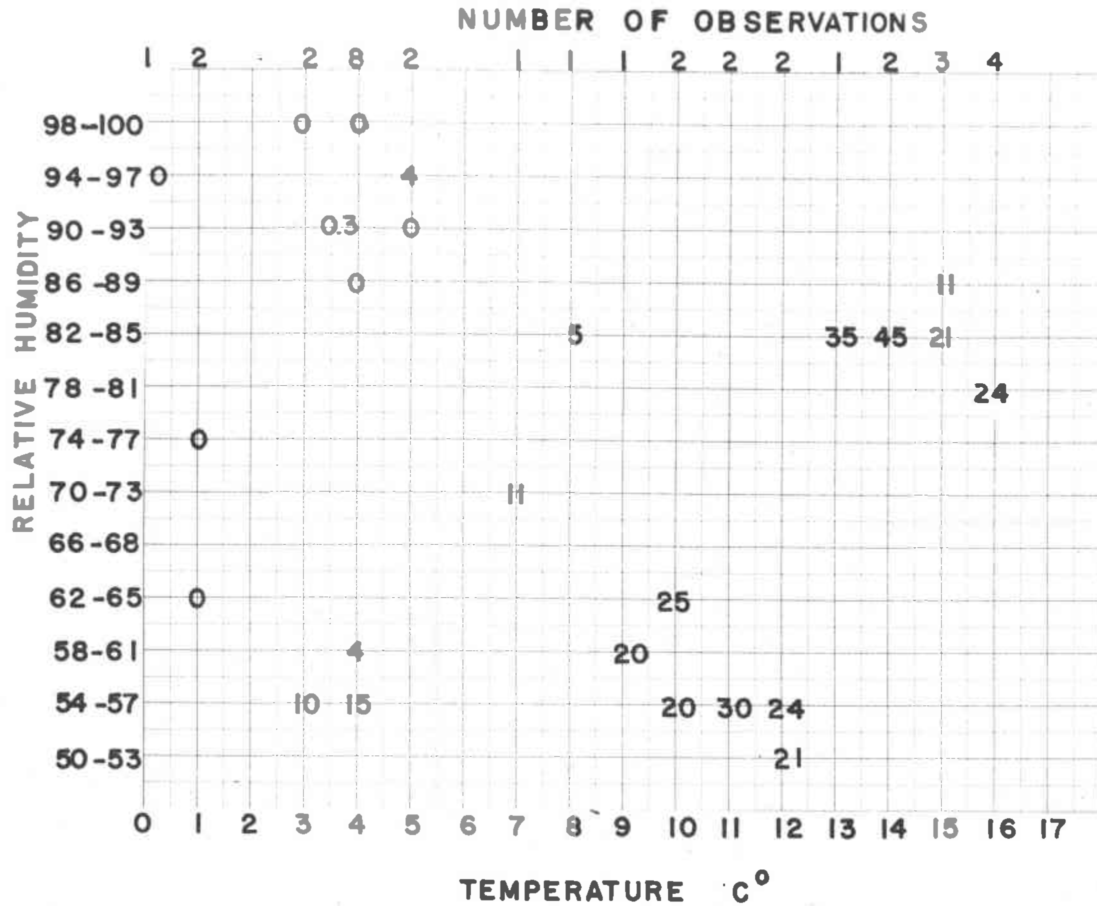

Figure 12. Effect of temperature and relative humidity on the egg-laying activity of the filbert aphid.

that was unfavorable for oviposition and throughout a dry day that was favorable for egg laying.

During the observations the number of females ovipositing was recorded along with the wet or dry condition of the tree at the time of observation. Figure 13 records these data.

On November 21, while there was a heavy fog that kept the trees wet, the relative air humidity was approximately 100 per cent, as indicated in Figure 13.

On November 20, the day was not foggy. The relative air humidity is shown in Figure 13.

During both days the air temperatures were approximately the same and there was not much variation throughout the day.

On the clear day when the trees were dry throughout the day, the female aphids were out in number by 8 a.m., reaching peak numbers between 9 and 10 a.m. and the number of egg-laying females gradually declined during the rest of the day. Approximately 280 females were observed ovipositing on this day.

As Figure 13 illustrates, there was little movement of the aphid females from the leaves of the filbert trees between 8 and 12 noon. At this time the fog lifted and branches began drying. The females began moving to the branches at this time and oviposition began. The peak was

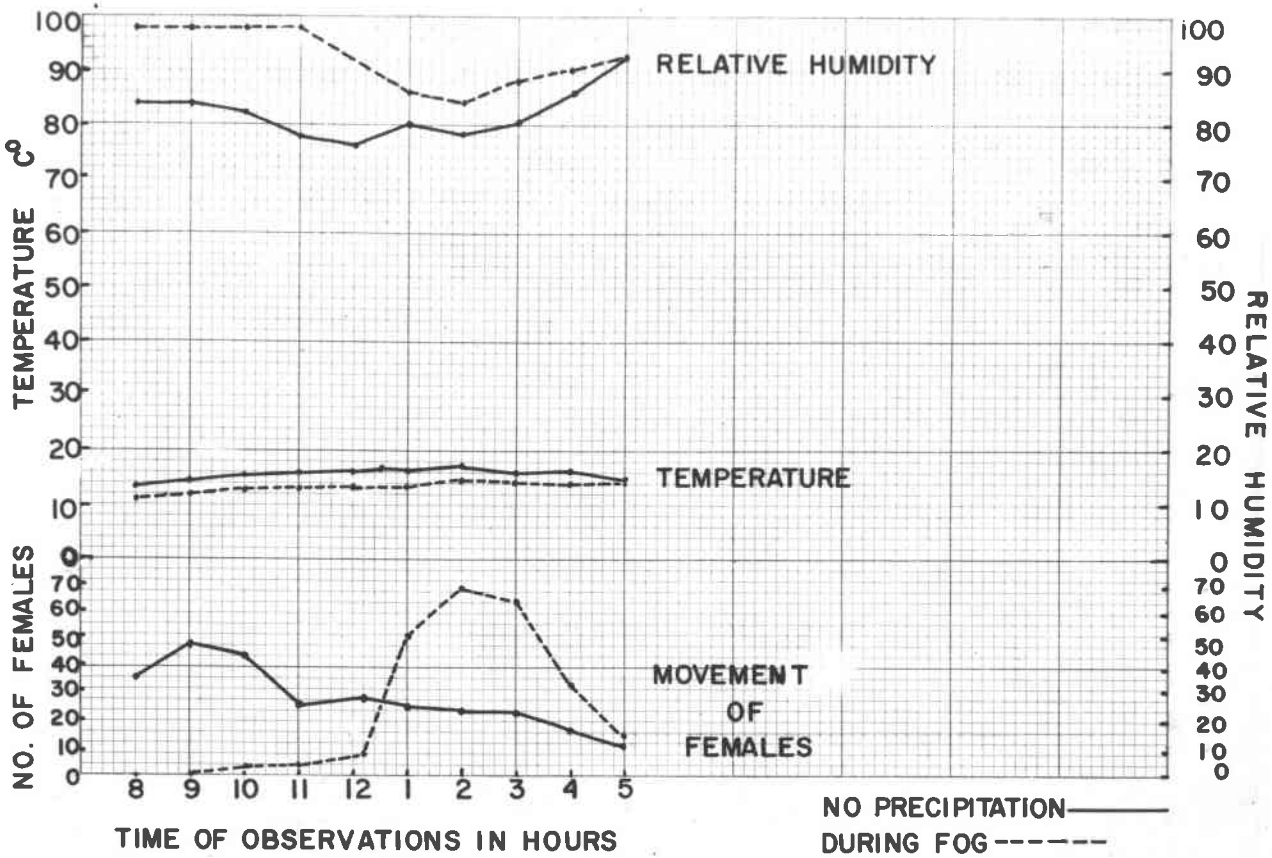

Figure 13. Movement of oviparous females of *Myzocallis coryli* from the leaves to branches and back.

reached between 2 and 3 p.m. On this day approximately 230 females were observed laying eggs.

These data demonstrate that the aphids remain on the leaves when the trees are wet and do not seek the branches for ovipositing, apparently because they are enveloped by drops of water at the time. They start egg-laying activity when the leaves and branches become dry.

In addition to fog, rain is an important factor affecting egg-laying activity. While making the observations reported on the effect of temperature and air humidity on oviposition, there were periods when there was a drizzle of rain. During such periods the female aphids ceased ovipositing and returned to the leaves or stayed inactive on the branches. When the drizzle had ceased, the females returned to the drying branches and renewed oviposition activity.

AGE EFFECT OF BRANCHES ON EGG DEPOSITION

From preliminary observations, oviparous females of the filbert aphid were noticed to be distributed unevenly on branches of different ages during egg laying activity. To extend these observations, this experiment was conducted at the Entomology Farm at Corvallis. Aphids were counted on branches that were one, two, and three years old. Ten branches of each age group were selected at random and an area eight inches long was marked and the total number of females on the branch were recorded. The number of females on these respective branches were counted at different times during the day for a period of three days. These counts are shown in Table 11.

TABLE 11

The numbers of oviparous females on branches of 1, 2, and 3 years old at the Entomology Farm, Corvallis, Oregon

Age of branches Years	Total number of oviparous females per age group
1	40
2	240
3	390

It is evident from Table 11 that very few oviparous females were on 1 year old branches compared to the numbers on branches 2 and 3 years old. This apparently can be attributed to the fact that oviparous females prefer to lay eggs in crevices and under rough bark of older branches.

A second experiment gave similar results. Ten branches of the same age and length were selected at random; five were left undisturbed while the other five were made smooth by scraping off the bark. Counts were made during the day of the number of the oviparous females on both groups of branches. Twenty females were found on the smooth branches while 115 were on the undisturbed branches.

RELATIVE HUMIDITY EFFECT ON EGG VITALITY

Eggs were collected from the Entomology Farm at Corvallis, Oregon during December 1958 and were brought to the laboratory to study the effect of relative humidity on egg vitality. They were divided into three groups with 100 eggs per group. Each group was kept in a petri dish with a piece of cheese cloth at the bottom. One group of eggs was maintained at average 86 per cent relative humidity by using a potassium chloride solution. The second group was maintained at an average room humidity of approximately 40-45 per cent. The third group was maintained under an average humidity of approximately 90 per cent by adding water to the petri dish every day. All groups were kept at room temperature of 60 to 70°F.

Daily observations were made to check the vitality of each group of eggs. Eggs that were kept at 40 to 45 per cent relative humidity shriveled and all died 10 to 15 days later. Eggs of the other two groups remained viable until February 1, 1959 when this experiment was discontinued. This indicates that eggs to stay viable and hatch in the field, require a high per cent of relative humidity. Temperature alone is not the only factor which influences the viability of eggs, but both temperature and relative humidity and their interaction is the most important point to be considered when working with eggs.

DAY LENGTH AND APPEARANCE OF SEXUAL FORMS

There are a number of diverse opinions in literature concerning the role of day length on the appearance of sexual forms in aphids with respect to these factors:

1. Whether the day length is a factor in inducing the sexual forms appearance or not?

2. Whether day length has a direct effect on the appearance of sexual forms of aphids or it has indirect influence through the change of plant physiology?

Marcovitch (14, p. 449) was able to induce the appearance of the sexual forms of the strawberry root louse, _Aphis forbesi_ Weed, when the agamic female aphids were subjected to a short day length. Davidson also (4, p. 130) was able to obtain the sexual forms of the black bean aphid, _Aphis fabae_ Scop., by subjecting the viviparous females to a short day length.

There are other examples in literature where the short day length failed to induce the appearance of sexual forms in aphids. Marcovitch (13, p. 517) failed to produce the sexuales of the green apple aphid, _Aphis pomi_ De Geer, when it was subjected to a short day length and the same was true with _Aphis spiroecola_.

Davidson (3, p. 133) did not try to determine the effect of nutrition in plants subjected to a short day length on the appearance of the sexual forms of the black bean aphid, Aphis fabae Scop. Marcovitch (13, p. 520-521) pointed out the possibility of the chemical change in plants that are subjected to a short day length in stimulating egg production of the strawberry root louse, Aphis forbesi Weed, but on page 521 of the same article he mentions that the relative day length to which the insects are exposed appears to stimulate the production of the sexual forms. However, he did not try to separate experimentally the direct and indirect effect of relative day length in inducing the appearance of the sexual forms in aphids be studied.

The writer set up a series of experiments to determine if an infested plant kept in light only 8 hours a day would bring about the appearance of the sexual forms as compared with plants exposed to a normal day length.

Adult sexuales of the filbert aphid appeared on July 1, 1958 on plants that were exposed to 8 hours of day light every day. This is about 13 weeks earlier than the normal appearance of the sexual forms of the filbert aphid at Corvallis. However, this experiment did not separate the effects of plant physiology from the effect of light. For this reason additional experiments were planned to study the effects of both factors.

EXPERIMENTS VARYING EXPOSURE OF APHIDS AND PLANTS TO LIGHT

Experiment 1. In this experiment the objective was to compare the time of appearance of the sexual forms of the filbert aphid for aphids exposed to 8 hours of light and aphids exposed to 12 hours of light, the normal length of day at this time of the year. Also, the objective was to cause a change in the physiology of the plants by exposing them to a short day of 8 hours. The aphids and plants were treated as follows, beginning August 1, 1958.

	Three plants per category		
Procedure	Plants A	Plants B	Plants C
Plants in darkness	16 hours aphids always on plants	16 hours	approximately 16 hours
Plants in light	8 hours	8 hours	approximately 8 hours
Aphids on plants		9:30 a.m. - 5:30 p.m. plants in light	5:30 p.m. - 9:30 a.m.
Aphids off plants		5:30 p.m. - 9:30 a.m. plants in dark	9:30 a.m. - 5:30 p.m.

Experiment 2. In experiment 1, the aphids were transferred back and forth on plants receiving 8 hours of daylight giving them a short day. In experiment 2, the physiology of the plants was changed by exposing plant B to 8 hours of light every day and plants C and D were exposed to 8 hours of light every other day. This procedure

introduced more variation in the plants exposure to light. Beginning August 1, 1958, four filbert seedlings were exposed to light and to aphids as follows:

Plant A	Plant B	Plant C	Plant D
	Treatment of Plants		
16 hours in darkness	16 hours in darkness	Alternating 12 hours in darkness and 16 hours in darkness	Alternating 12 hours in darkness and 16 hours in darkness
8 hours in	8 hours in	Alternating 8 hours in light and 12 hours in light	Alternating 8 hours in light and 12 hours in light
	Treatment of Aphids		
on plant 24 hours each day	on plant from 9:30 a.m. - 5:30 p.m.	on plant from 5:30 p.m. - 9:00 a.m.	on plant from 5:30 p.m. - 9:00 a.m.
	off plant from 5:30 p.m. - 9:30 a.m.	off plant from 9:30 a.m. - 5:30 p.m.	off plant from 9:30 a.m. - 5:30 p.m.

Daily observations were made to determine the appearance of the sexual forms.

Sexual forms of the filbert aphid appeared on September 1, 1958 in both experiments when filbert seedlings with their infestation of aphids that were exposed daily to 8 hours of daylight as compared with normal appearance in October. This apparently shows that the sexual forms production of the filbert aphid appears to be governed by the day length to which they are exposed regardless of the number of generations. Obviously the physiology of the plant was affected when the plant was exposed to short day length. However, the change in physiology did not affect the appearance of the sexual forms of the aphid.

APHID DISTRIBUTION ON TREE

Studies were made of the distribution of the filbert aphid with these objectives:

1. Did some one area of the tree become more heavily infested than other areas?

2. Did the aphid distribution change with the leaf age?

3. What is the pattern of aphid distribution within single leaves?

1. Distribution of aphids on various sides of trees.

The writer so far has not been able to find literature dealing with the distribution of other species of aphids over trees.

This study was made to determine if the filbert aphid was or was not uniformly distributed over all sides of the tree. Four trees in the same row were selected at Powell's orchard in Kiger Island, Corvallis. Counts of the number of aphids in nymphal and adult stages were made for 10 leaves selected at random from each side of the tree. Four counts were made during this study beginning June 18 and ending October 13, 1958. The last two counts were made when the sexual forms began to appear. These counts are shown in Table 12.

TABLE 12

Filbert aphid distribution on tree at Powell's Orchard in Kiger Island, Corvallis

Date of Observation 1958	Number of aphids per 10 leaves per one side of tree							
	South		North		East		West	
	Adult	Nymph	Adult	Nymph	Adult	Nymph	Adult	Nymph
June 18	302	3988	314	4466	190	3426	190	3678
July 7	43	597	47	601	69	805	70	748
Total	345	4585	361	5067	259	4231	260	4426
Sept. 26	36	177	16	109	19	113	38	114
Oct. 13	47	355	38	256	35	408	47	493
Total	83	532	54	365	54	521	85	607

As Table 12 shows, aphid distribution over the tree was more or less uniform, the aphids having no preference for any one side of the tree. However, there were more aphids on the north side for the first count. This kind of aphid distribution may be attributed to chance. South and west sides were more heavily infested than north side in the last two counts when the sexual forms began to appear. This shift in distribution again may be a matter of chance.

2. Distribution of aphid and leaf age.

Kennedy, Ibboston, and Booth working with *Aphis fabae* Scop. and *Myzus persicae* (Sulz.) observed that when leaves of all stages of growth are available, the distribution of aphids is highest on the young and the old leaves and is low on the mature leaves and on leaves approaching death (11, p. 675). They gave the following reasons for this kind of distribution (11, p. 676):

1. Young and old leaves have lower concentrations of sugars in the phloem in comparison to the concentration of the nitrogenous substanees which are required for the high fecundity of aphids.

2. Young leaves are places where such nitrogenous substances are being mobilized for protein synthesis and the senescent leaves are places where such places are being made available by demobilization (hydrolysis of protein), whereas the mature leaves are in a static condition.

The writer studied the distribution of the filbert aphid on leaves of three age groups. These groups were based on an arbitrary classification based on the visible characters of the leaves. The categories were determined on the basis of the stage of growth, the color and the position of the leaves on the twigs in relation to each other. The following describes the three types of leaves:

1. Young leaves; were still growing, have light color and are next to the very young leaves near the tip of the branch.

2. Mature leaves; had ceased to grow, were deeper in color and were located next to the young leaves.

3. Old leaves; had ceased to grow, were of a deep color and were with small brown areas. These were next to the mature leaves and nearest to the tree trunk.

Twenty leaves of each of the three groups were picked at random from filbert trees at the Entomology Farm, Corvallis. Counts were made of the nymphs of all stages. These counts are shown in Table 13.

TABLE 13

Filbert aphid in relation to leaf age at the Entomology Farm in Corvallis, Oregon from June 11 to August 25, 1958.

Date of Counts 1958	Total number of aphids per 20 leaves per count		
	Young leaves	Mature leaves	Old leaves
June 11	1407	400	879
20	2558	997	1401
July 1	1850	1440	2300
14	289	250	408
24	110	95	110
Aug. 4	75	25	65
14	24	7	10
25	28	8	22
Total	6341	3222	5195

These data show that when all three classes of leaves are present on the tree in appreciable numbers, aphids occur in the largest numbers on the young and old leaves while the lowest numbers occur on the mature leaves. The reason for such a distribution is probably correlated with the number of leaves of each group that are available for the aphids to infest. Early in the season, the aphid population is highest on young leaves because they are the only ones available at the time. As the season progresses, more leaves of each category become abundant, until a period is reached when the number of leaves in each of the three categories is approximately even. This seems to have occurred on July 24, 1958 when the aphid populations were distributed uniformly over all three groups of leaves. Later in the season, when very few of the young and mature leaves are available, the aphid populations by necessity are highest on the abundant old leaves.

A second experiment was conducted on July 30, 1958 to follow the age change in the leaves and to determine if the aphids actually leave one group of leaves when they pass from one age to another age group.

Initially, 10 leaves of each age group were selected at random and tagged. At the same time counts were made of the number of aphids on each age group and the counts were continued at short intervals until September 4, 1958. With such a plan, the rapid change of the leaves from one category to the next is apparent. Five days after the initial count, the young leaves were in the mature category, while the number of leaves in the latter had increased in numbers. By the eighth day all the tagged leaves were in the old leaves category even though the age differences remained though not identifiable without the tags. The aphid counts are presented in Table 14.

TABLE 14

Distribution of filbert aphid infestation on tagged leaves of three different ages on the Entomology Farm at Corvallis, Oregon

Date of Counts 1958	Young Leaves		Mature Leaves		Old Leaves	
	No. Leaves	No. Aphids	No. Leaves	No. Aphids	No. Leaves	No. Aphids
July 30	10	40	10	10	10	28
August 4			10	11	20	52
August 7					30	69
Average No. of aphids per leaf	4.0		1.0		2.49	

	Old Leaves		
	10	10	10
	Youngest Leaves	Middle Age Leaves	Oldest Leaves
August 9	23 aphids	19 aphids	30 aphids
11	12	12	12
14	3	6	11
18	2	5	12
21	3	4	13
Sept. 4	2	5	17
Total	45	51	95

At the beginning of this experiment, the aphid populations were highest on the young and the old leaves and lowest on the mature leaves.

Approximately 10 days after the leaves had been tagged, there seems to be a shift in the aphid population to the oldest leaves. From August 14 to September 4 the oldest leaves were consistently with the largest aphid populations. Also, there is a trend for the youngest of the old leaves to have slightly lower population than were on the mature leaves that had become old.

Here there is evidently a population difference correlated with leaf age. The number of leaves is constant in each category so that the population size is not correlated with number of available leaves as hypothesized for the infestations prior to July 30.

No reasons can be given to explain this shift in aphid populations.

It becomes apparent that the filbert aphid infestation distribution on the leaves apparently does not depend on one factor but rather on many interacting factors that work together to bring about the distribution observed. These factors include the following:

1. The age of the leaves.

2. How fast the leaves change from one age group to the other. It seemsthat young leaves change rapidly to mature leaves and consequently aphids appear to feed for a short time on the young leaves. In the meantime, the filbert aphid does not seem to be very active in moving from one leaf to the next. The same aphids might remain

on the same leaf but at the same time this might be in the young leaf category, in the mature leaf category or in the old leaf category. This point was not investigated.

3. The number of leaves of each age group available on the tree at different time of the season.

4. The physiology of the tree in general.

3. Distribution of aphid on individual leaves.

Ibboston and Kennedy (10, p. 76-77) working with the black bean aphid, Aphis fabae Scop., reported that there is uneven distribution of aphids on the surface of a single leaf. Most of the aphids being found on the veins of the leaf. They attributed this distribution of Aphis fabae Scop. to (1) the gregarious habit of this aphid and (2) the system of the venation of the leaf.

The writer observed that the filbert aphid always feeds on the veins of the underside of the leaves. This kind of aphid distribution might be attributed to the ease for the aphids to reach the phloem on which they feed. No attempt was made to determine if this aphid has a gregarious habit.

EFFECT OF FILBERT APHID INJURY ON QUALITY OF NUTS

Quality of filbert nuts is very important to the growers. Those who produce high proportions of large sizes and few culls of nuts get more for their crop than those who produce high proportions of small sizes and many culls. Quality is affected by many factors, among which is the insect pests.

The present study was carried out to determine if the filbert aphid is an important factor which affects the quality of nuts.

A randomized block design was used in this test with two treatments and four replicates. Each replicate consisted of one tree. A buffer row of trees was left without treatment between the two rows used for the experiment. Another measure was taken to insure that drift would not reach the check (untreated) by leaving one unsprayed tree between the treatments within each row.

Systox, a systemic insecticide which proved to be a very good control for the filbert aphid, was applied on May 1, 1958 at the rate of one pint per 100 gallons of water. This treatment kept the aphids well under control for almost all season.

The quality of the filbert nuts was judged by these criteria:

1. Their appearance and cleanliness.

2. Weight and size of nuts.

3. Number of blank nuts.

4. The per cent fat in the nuts.

Appearance and cleanliness were judged by 10 students representing different fields of interest. Those people were instructed to score the nuts as poor, good, and very good, according to their appearance without knowing how each had been treated. Weight was recorded in grams for a sample of 80 nuts per replication (tree) taken at random from different sides of the tree. Size was determined by a micrometer and measuring the widest part of the kernel. Fat analysis was made by the Department of Agricultural Chemistry at Oregon State College for one replicate only.

Experimental Data

Almost all the students agreed that nuts of untreated trees were of poor quality compared to those nuts from the treated trees as is shown in Table 15.

TABLE 15

Judgment rating of 80 filbert nuts per replicate by 10 students.

	Judgments rating appearance of nuts as:		
	Poor	Good	Very Good
Treatment	Per Cent	Per Cent	Per Cent
Untreated (check)			
Replicate I	100		
Replicate II	100		
Replicate III	100		
Replicate IV	80	20	
Systox			
Replicate I	10	50	40
Replicate II		80	20
Replicate III	20	70	10
Replicate IV	20	50	30

The average size of kernels of treated trees is slightly larger than those of untreated trees. This is also true for the weight of kernels. Fat analysis did not show any difference between treated and untreated trees. These data are shown in Table 16.

TABLE 16

The effect of controlling the filbert aphid on the nuts quality.

Observations	No. Nuts	Systox	Untreated (check)
Average size of kernels	320	0.79 inches	0.76 inches
Average weight of kernels	320	3.18 grams	2.90 grams
Total number of blanks	320	22	30
Per cent crude fat for replicate I	-	62 per cent	64.87 per cent

These data indicate that the control of the filbert aphid definitely improves the appearance of the nuts. The other categories studied gave inconclusive results concerning the benefits of filbert aphid control.

SUMMARY

This study was undertaken because of the complete lack of information of the biology of the filbert aphid in Oregon. The data collected show that:

1. The filbert aphid does not have a secondary host.

2. Nymphs go through four molts before becoming viviparous adults that give birth to young parthenogenetically immediately after becoming adult.

3. First instar nymphs have 4-segmented antennae, second and third instar nymphs have 5-segmented antennae, while the fourth instar nymphs have 6-segmented antennae.

4. Unlike other species of aphids, the filbert aphid is winged in all forms but the sexual females.

5. The filbert aphid has 10 generations in the field. The length of each generation is influenced by the interaction of temperature and relative humidity.

6. The length of time daily exposed to daylight appears to have an influence on the appearance of the sexual forms of this aphid. The writer was able to obtain the sexual forms 13 weeks earlier than they normally appear in nature by subjecting the aphids to only 8 hours of daylight per day.

7. Temperature, relative air humidity and whether the tree is wet or dry has an effect on the egg-laying activity of the oviparous females. The females have a

tendency to stay on the leaves when the branches are wet during rain or fog, resulting in a decrease in the number of eggs laid on such days. The age of branches is another factor affecting egg laying. Eggs are laid mostly on rough branches that are two and three years old. Very few eggs are laid on the smooth one year old branches.

8. Aphids apparently distributed themselves uniformly on all sides of the tree. However, at times the infestation seemed heavier on one side than on the others.

9. During most of the season aphid populations were high on the young and the old leaves and low on the mature leaves. Late in August the largest numbers were found on the oldest leaves present. They fed on the underside of the leaves, mainly on the veins.

10. Nuts taken from infested trees were inferior in their appearance compared to those taken from trees treated with Systox. However, there was no significant difference in size, weight and fat content between the two groups of nuts.

BIBLIOGRAPHY

1. Andison, H. Fruits and ornamental insects of the season 1950 on Vancouver Island and lower Fraser valley. The Canadian Insect Pest Review 29:1-109. 1951.

2. Clarke, Warren T. A list of California Aphididae. The Canadian Entomologist 35:247-254. 1903.

3. Davidson, J. Biological studies of Aphis rumicis Linn. The penetration of plant tissues and the source of the food supply of aphids. The Annals of Applied Biology 10:35-52. 1923.

4. ______________. On the occurrence of the parthenogenetic and sexual forms in Aphis rumicis L., with special reference to the influence of environmental factors. The Annals of Applied Biology 16:104-133. 1929.

5. Davis, J. J. A list of the Aphididae of Illinois, with special notes on some of the species. Journal of Economic Entomology 3:407-420. 1910.

6. Gimingham, C. T. On the presence of an egg-burster in Aphididae. The Transactions of the Entomological Society of London (73):585-589. 1925.

7. Gilmore, J. E. Biology and control of the black cherry aphid, Myzus cerasi (Fab.), in the Willamette Valley. Master's thesis. Corvallis, Oregon State College, 1957. 73 numb. leaves.

8. Gillette, C. P. and M. A. Palmer. The Aphidae of Colorado. Part I. Annals of the Entomological Society of America 24:827-934. 1931.

9. Goetze, J. A. Entomologische beitrage zu des ritters Linne zwolfter ausgabe der natur systems. Vol. 2. Leipzig, Weidmann, 1778. 318 p.

10. Ibboston, A. and J. S. Kennedy. Aggregation in Aphis fabae Scop I. Aggregation on plants. The Annals of Applied Biology 38:65-78. 1951.

11. Kennedy, J. S., A. Ibboston and C. O. Booth. The distribution of aphid infestation in relation to leaf age. I. Myzus persicae (Sulz.) and Aphis fabae Scop. on spindle trees and sugar-beet plants. The Annals of Applied Biology 37:651-679. 1950.

12. Lovett, A. L. Insects of nut trees. In: Sixth Annual Report and Proceedings of the Ninth Annual Meeting of Western Nut Growers Association, Salem, Oregon, 1923. p. 9-14.

13. Marcovitch, S. The migration of the Aphididae and the appearance of the sexual forms as affected by the relative length of daily light exposure. Journal of Agricultural Research 27:513-522. 1924.

14. ______________. The strawberry root louse in Tennessee. Journal of Agricultural Research 30: 441-449. 1925.

15. McWhorter, O. T. et al. Filbert and walnut pests and diseases. Corvallis, 1934. 16 p. (Oregon State College. Extension Service. Bulletin 470).

16. Palmer, Miriam A. Aphids of the Rocky Mountain region. 1952. 452 p. (Entomological Society of America. Thomas Say Foundation. Publication Vol. 5).

17. Theobald, Fred V. The plant lice or Aphididae of Great Britain. Vol. 2. London, Headley Brothers, 1927. 411 p.

18. Thompson, B. G. Filbert insect pests. In: Proceedings of the Oregon State Horticultural Society, Sixty-ninth annual meeting, December 1954 and Proceedings of the Nut Growers Society, Fortieth Annual Meeting, 1954 46:195-96. 1955.

19. Wilson, H. F. and R. A. Vickery. A species list of the Aphididae of the world and their recorded food plants. Part I. Wisconsin Academy of Sciences, Arts and Letters 21:25-180. 1918.