WOOLLY PEAR APHIS[1]

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INTRODUCTION

For some years a species of Eriosoma has been known to attack pear roots in California. It has, however, been considered to be the woolly apple aphis, *Eriosoma lanigerum* Hausmann, since both in habit and in structure the two species somewhat resemble each other. To the species on the pear, which, after careful study, proves to be undescribed, the name *"Eriosoma pyricola"* is herein given, and a brief account of the species is attempted.

HISTORY OF THE INSECT

Mr. Frank T. Swett is authority for the statement that the woolly pear aphis has been in California for more than 20 years. Ten years ago he says the species ruined about 2,000 French seedlings in one block, while occasional apple seedlings, planted along with them, made normal growth. Attention has frequently been called to the immunity of apple seedlings planted close to infested pear seedlings in nurseries and orchards.

During September and October, 1897, Mr. Theodore Pergande received specimens of a species of Eriosoma on pear roots from Prof. F. M. Webster, of Wooster, Ohio. Through the kindness of Mr. Pergande we have been able to examine these specimens, and they prove to be identical with our California material. It is quite possible, therefore, that the species may be present in other parts of the country, notably in Oregon. It is noteworthy that the Ohio specimens were taken from roots of pear stock received from France the preceding spring.

The species occurs over practically all the pear sections of northern and central California, and in some regions is a very destructive pest. To entomologists the extent of its presence has been known only for the last three or four years, but reports from orchardists and field observers indicate that it has been parasitic upon pear roots for a much longer period.

HABITS OF THE INSECT

The insect works entirely underground. The species that has been found feeding on the aerial portions of Nelis, Easter Beurré, and other pears is the woolly apple aphis, *E. lanigerum*. The woolly pear aphis

[1] What is probably the same species has been treated as a pear pest in California under the name *Eriosoma lanigera* by Geo. P. Weldon. (The woolly aphis as a pear pest. *In* Mo. Bul. State Com. Hort. [Cal.], v. 4, no. 9, p. 441–444, fig. 94–95. 1915.)

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appears to attack the roots of all types of pears, and it is especially injurious to the French wild stock so largely used in California as a stock for the Bartlett. Quince roots are fed upon, but much less freely, and the quince may be credited with a considerable degree of immunity. The Kieffer stock is attacked, but it is possible that Japanese stock may show immunity to a satisfactory degree. Observations to date indicate that both these stocks are more resistant than that from France. It should be said that the individual plants of the wild stock from France vary greatly, and there appears to be among the plants some variation in intrinsic vigor or in power to resist the woolly aphis. However, the majority of the imported seedlings show no satisfactory evidence of a power of resistance, and a different stock is very desirable.

The insect works especially upon the smaller fibrous rootlets and may be encountered on any such rootlets within the topmost 3 feet of soil and perhaps deeper. Infestations are usually heavier on the rootlets near the trunk, but frequently the aphides are as abundant 10 or 12 feet from the stem. In a badly infested orchard the soil on being overturned may in places be found to be white with the wool and skins of the insects. The aphides attack less frequently larger roots up to ¼ inch in diameter and sometimes settle on still larger roots or on the main stem where abrasions have set up a callus growth. They often colonize the underground portions of sucker growth, feeding on the succulent stalks. After the insects have forsaken a rootlet, fungi sometimes appear and complete its destruction.

This method of feeding upon the fibrous rootlets is somewhat analogous to the habits of the grape phylloxera (*Phylloxera vitifoliae* Fitch) on the resistant types of grapevines in that chiefly the smaller rootlets are attacked. It is directly opposed to the habits of the woolly apple aphis and of the grape phylloxera on nonresistant types of vines, for both these insects feed upon the larger roots and cause the formation of tuberlike lesions. The woolly pear aphis rarely forms any perceptible lesions, but it destroys great numbers of young rootlets, especially in late summer and autumn. In old trees this sometimes results in a dwarfing of growth and in a generally unthrifty appearance and condition. The majority of old infested trees do not show evident injury ascribable to the aphis, although it is presumable that they are suffering to some extent. They remain thrifty on account of their intrinsic vigor. In many instances where old trees were showing injury, extra cultivation of the soil and better irrigation practice resulted in the establishment of thrifty conditions, even though this method did not appear to reduce the numbers of the aphis. The effect on the crop is hard to estimate and can not be satisfactorily specified, but in general it is such as may result from the diversion of the flow of sap in the tree.

With trees under 4 years of age, conditions of injury are different. Heavy infestation of a tree of weak vigor or resistance may result in the death of the tree. Badly stunted growth and the early falling of foliage are characteristic of aphis injury on young trees. Injury and death are due to heavy summer and autumn infestations on the fibrous rootlets and to the inability of the tree to replace the destroyed roots quickly enough to afford plant food for the vegetative portion. Frequently the trees are saved and relief comes from the production in the fall months of a high percentage of migrants which leave behind them for the winter only a small infestation of wingless individuals; and since the aphides increase but slowly in spring, the tree is enabled to send forth new rootlets without danger of having them rapidly destroyed. Sometimes young trees in no wise stunted have been observed to cast their leaves prematurely, and upon examination have been found to be heavily infested with the aphis. It would appear from the absence of stunted growth that these trees did not have, or were not adversely influenced by, an infestation until their summer growth was about completed, and that the simultaneous destruction of feeding rootlets cut off the flow of sap suddenly. The fact that trees were stunted was an indication that the injurious effects of feeding by the aphides were felt earlier in the season.

In addition to trees noticeably stunted and others prematurely defoliated are found still others which show no external evidence of infestation and yet upon examination prove to be heavily infested. This phenomenon is frequently noticeable among young trees or in nursery rows, and hints at a power of resistance.

In orchards and districts where conditions favor large productions of winged forms, or migrants, spring and early summer infestations are small, denoting that few insects passed the winter on the roots. After the month of June, however, such infestations multiply rapidly and become very large by September, the month in which the fall migrants are produced in greatest abundance. After September there remain small wingless colonies which increase but little until the summer following. The winged forms are produced in abundance on heavy dry clay soils which crack in summer and autumn. Irrigated orchards produce them in smaller numbers than those that receive no moisture from May to October. On loam, silt, and light-clay soils the winged forms are much less abundantly produced. On such soils the infestation remains largely or wholly wingless the year around, and the conditions are generally unfavorable to such heavy infestations as occur on the heavy clays. The aphides appear to lack freedom of movement, and frequently their colonies are unable to increase perceptibly through summer. Occasionally the wingless infestations are severe the year round; where this is so, in the early part of the year there is caused a considerable stunting of growth and more or less

weakening, unless the trees can put out plenty of new rootlets to replace those injured and destroyed. This condition has been noted especially on light-clay soils where poor cultivation was employed.

SPREAD OF THE INSECT

In nurseries under favorable conditions the spread of the insect may be rapid. A half-acre pear nursery examined on June 9, 1915, failed to show infestation, though the aphis was probably present. When visited four months later, on October 16, it was found that more than half the trees examined were infested, some quite heavily. In large orchards where the soil is permeated throughout with rootlets the aphis doubtless is very easily diffused through the soil. In young orchards conditions indicate that not much spread takes place from tree to tree. Infested young orchards generally point to the nursery as the source of infestation, but the possibility of infestation through the winged forms, or migrants, must be considered. A knowledge of the full life cycle of the insect alone can clear up this point.

BIOLOGY AND DESCRIPTION OF THE INSECT

The wingless individuals live chiefly on the small rootlets and less frequently on roots and the underground portions of the sucker growth. They are always somewhat elongate and are for the most part pale yellowish red, but they may vary from a pale pink or yellow to deep red. They are rather sparsely clothed with long, curling, woolly, or cottony filaments, of which there are four or six on each segment. Toward the end of each instar these filaments are longer than the body—often three times as long. There is a sparse whitish powder on the body, more abundant at the caudal end. The cornicles appear as dusky-rimmed pores. The young are pale yellowish red and elongate.

The pupæ develop on the same portions of the tree as the wingless forms. They are very elongate in form and are clothed as are the wingless. The wing pads are inconspicuous and are white or light gray. As a rule pupæ on a rootlet develop almost simultaneously. The winged forms issue together, after which the narrow, elongate, cast pupal skins are conspicuous in little heaps, and are easily distinguishable from those of the wingless forms.

In the Walnut Creek district pupæ and winged migrants were collected in appreciable numbers from August 25 to November 17, and as late as December 22 a nymph was found. These forms were most abundant in September, and this observation apparently holds true for other localities in California. Wingless colonies collected at San Jose, Cal., on June 10 and thereafter, kept in Petri dishes with moist sand in a cellar, produced pupæ on July 20 and migrants from July 24 to August 7. This appeared to be abnormally early in the year for the production of winged forms, and

it may be that the environment and conditions hastened it. Under favorable conditions of soil the migrants were produced in great abundance on both young and old pear trees. In many cases, especially on young trees, it appeared that fully 90 per cent of the aphides observed at one time were pupæ, and in other instances observations in October and later after the winged forms had departed indicated that almost the entire infestation had developed into migrants. On old trees there remained on the average a larger residue of wingless forms. On unfavorable types of soil the winged forms are produced in far less abundance. It appears to be a rule that the heavier and drier the soil the larger the percentage of pupæ developing. It sometimes happens that the migrants are unable to rise to the surface of the ground and become imprisoned in pockets in the soil. In one instance two living sexual females were found in such a pocket beside dead migrants.

The winged forms have been noticed on pear foliage and on the trunk, but with one exception [1] no deposition of sexes has been observed on the pear. On cork and American elms (*Ulmus* spp.) migrants were observed to deposit the sexes in cracks in the bark and on the lower surface of leaves. In one instance the migration from a nursery of pear trees to a group of young elms 200 yards distant could be traced. The migrants fly readily and strongly and are stimulated by the sun's rays, being more active on warm than on cool days. On the elms they were more abundant on trees with rough bark than on the smooth-barked plants.

The migrants vary considerably in size. They are rather elongate, shining black or dark green, with a tuft of white wool on the caudal segment; otherwise, there is no flocculence. The lower surface is dark green, sparsely powdered at the sutures. The antennæ, eyes, and a portion of the legs are black. The base of the femora and the middle portion of the tibiæ are yellowish brown or amber. The wings have narrow black veins and a greenish blue stigma. The wing insertions are sometimes brown, but are more often yellowish. In recently molted individuals there is sometimes a smoky-brown patch at the base of the fore wings.

To obtain the sexes, migrants were confined in stender dishes and in small rubber cells mounted on microscope slides with cover glasses as lids. Some were kept in a lighted room in which the temperature varied very considerably, at times rising to 75° and at other times falling to 55° F. Others were kept in a dark cellar where the temperature varied but little and averaged about 61° F. Under cellar conditions the migrants deposited more sexual forms than under the conditions obtaining in the room. Some of the dishes were kept dry and others moistened to different degrees. In the moistened dishes the sex pro-

[1] In August, 1911, at San Jose, Cal., a migrant was noticed depositing sexes on the upper surface of a pear leaf.

duction was better than in the dry ones, although too much moisture prevented the sexual forms from freeing themselves from the pellicles. Whether the migrants had flown or not did not seem to bear any influence on the deposition of the sexual forms. In most of the dishes more than half of the sexed forms were not extruded, but died unborn. In the rubber cells five-eighths of an inch in diameter and three-sixteenths of an inch in height the migrants did best singly, while the larger stender dishes provided space for a number. In all the dishes pieces of pear or elm bark were provided, but the migrants rarely deposited the sexes on these, nearly always extruding them on the filter paper also provided. It frequently happened that the sexes after having been extruded became entangled with the wings or legs of the parents or with each other. The sexes were deposited in rapid succession. The migrants rarely lived beyond three days after they were placed in the dishes, whether they deposited sexual forms or not. None lived longer than six days. They died immediately after the sexes had been extruded and very few deposited their full complement.

All the sexes deposited were not noted; but about four-fifths of them totaled 109 individuals, of which a little over half (58) were females. Only a few matured, and the majority died unmolted. Undoubtedly the cause of this was the abnormal condition of the environment. However, it appears to be proved that the sexes are produced in about equal numbers, and observations in the field corroborate this. Four fall migrants dissected on October 27 and 28 had contained, respectively, 5, 7, 8, and 9 young. In the dishes not more than seven sexes were ever dropped by an individual. The number of males and females deposited by individual migrants was found to range from seven females and no males to five males and one female. Probably a larger series would have furnished a migrant producing only males. As a rule the production of sexes was about evenly divided between male and female.

The sexes have no woolly covering such as that occurring on the sexes of *Eriosoma lanigerum*, but are bare and shining. The female, however, at the time of depositing the winter egg, has a patch of short white wool on either side of her body and with this she contrives to clothe partly the winter or impregnated egg. The sexes are active, the male especially so, both immediately after extrusion and following the casting of their fourth and final skin. Between casting their first and fourth skins they remain inactive unless disturbed. Normally they seek crevices in the bark, but in the dishes they frequently molted on filter paper or on the sides and floor.

The sexes mature in from 7 to 11 days and molt four times—that is, about every other day. Being beakless, they take no food.

The males are smaller than the females, the latter being enlarged by reason of the egg within the body. The male at first is light green, with

hyalin antennæ and legs and black eyes of three facets. The insect becomes darker with age and the mature individual is dark olive-green, sometimes tinted with lilac or purple, the central part of the abdomen being darkest. The male is always narrow in shape. The female varies in color from a light orange to a dark red. The eyes and appendages are as in the male. The majority are orange or a light crimson-lake. They are much stouter than the males and are longer and stand much higher. A mature female measured alive was 0.67 mm. long by 0.33 mm. in maximum width. A mature male was 0.43 mm. long by 0.21 mm. in maximum width.

Copulation occurs as soon as the sexes are mature. It appears that unless the female is fertilized directly after she has cast her last skin she will fail to deposit the winter egg. The male may live at least a week after he is mature, but apparently he can exercise the sexual function only immediately after he has cast the last skin. The females deposit the impregnated egg immediately after copulation, and after its deposition they may live for a day or two at the most. The winter or impregnated egg is laid normally in crevices or scars of the bark of the elm. In the dishes it was laid sometimes on the outside of the bark, and both elm and pear bark were used. It was never laid elsewhere than in the bark. The egg measures about 0.444 mm. by 0.225 mm., is short oval, reddish yellow, and shining. The end first extruded is reddish and bare, while the other extremity is yellowish and usually covered with short white wool provided by the female. Winter eggs were deposited in dishes between October 15 and November 12. Undoubtedly they occur in nature as early as September 5, and may be laid as late as the middle of November. Toward the end of October some were collected under the bark of elms under observation. Table I is a comparison of the biology of *Eriosoma pyricola* with that of *E. lanigerum*.

TABLE I.—*Comparison of biology of Eriosoma pyricola with that of Eriosoma lanigerum in California*[1]

Eriosoma lanigerum on apple and varieties of pear.	*Eriosoma pyricola* on pear.
Aerial and radical.	Radical only.
Attacks trunks, branches, and twigs; causes knotty swellings on roots.	Attacks chiefly fibrous rootlets; rarely causes lesions; occasionally settles on larger roots.
Fall migrants rarely abundant; apparently not influenced by conditions.	Fall migrants very abundant under favorable conditions.

[1] The full cycle of these species has not been worked out in California, but there appear to be no records of spring generations of *E. lanigerum* observed on elm.

The fall migrants of *E. pyricola* may be distinguished from those of *E. lanigerum* and *E. americanum* as shown in Table II.

TABLE II.—*Comparison of the fall migrants of Eriosoma pyricola, E. lanigerum, and E. americanum*

E. pyricola.	*E. lanigerum.*	*E. americanum.*
Stigma short, greenish blue.	Stigma somewhat elongate, yellowish or gray.	Stigma elongate, gray.
Veins narrow without brown margins.	Veins narrow and without brown margins.	Veins broad, with brownish margins.
Body naked except for caudal segment.	Body with some woolly clothing.	Body with slight woolly covering.
Distal sensoria of antennal segments V and VI with fringe.	Distal sensoria of antennal segments V and VI without fringe.	Distal sensoria of antennal segments V and VI without fringe.

The new species is easiiy distinguished from *E. ulmi* Linnæus from the fact that segment V bears prominent transverse sensoria. The wingless forms can be distinguished from those of *E. lanigerum* by the structure of the compound wax pores, and the winged forms by the antennæ. The winged forms of *E. pyricola* are remarkably like those of *E. lanuginosa* Hartig. The proportions are almost exactly the same. The only difference seems to be the fringing of the sensorium on segment V. The wingless forms and the pupæ have the prominent wax pores figured. No such pores occur in our specimens of *E. lanuginosa*, but very similar ones do occur in *E. ulmi*. At first it was thought that two species were present in the collected material, but careful rearing experiments by the junior writer have shown the connection between all the forms. It does not seem probable that such prominent wax-secreting structures would be present in one form of the species and not in all forms.

Eriosoma pyricola, n. sp.

WINGLESS VIVIPAROUS FEMALE.—General form elongate. Antennal segments in length as follows: I, 0.048 mm.; II, 0.048 mm.; III, 0.1 mm.; IV, 0.04 mm.; V, 0.048 mm.; VI, 0.064 mm. (unguis, 0.032 mm.); segments armed with hairs (fig. 1, *E*), which are considerably longer than those met with in *lanigerum* (fig. 1, *D*), and with a large distal fringed sensorium on segments V and VI, as well as some smaller ones on VI. Compound wax pores very prominent and circular (fig. 1, *I*), those on the abdomen containing about 20 cells. Abdomen sparsely covered with hairs about 0.16 mm. long; cornicles circular, their rims more heavily chitinized on their inner margins than elsewhere. Wax reservoir apparently present as in *E. lanigerum* (visible as a clear yellow area in mounted specimens). Hind tibiæ about 0.44 mm. long; hind tarsus, 0.112 mm.; rostrum extending beyond the second pair of coxæ. Length, 1.92 mm.; width, 0.96 mm. The hairs on the antennæ of the young are especially prominent (fig. 1, *J*).

Young forms yellowish pink, older ones pink to red. Antennæ, legs, and labium dusky; eyes dark red, very minute.

INTERMEDIATES.—In the collection, Q. 6399, are a number of specimens which would be taken at first glance for wingless viviparous females. A careful study, however, proves them to be intermediates. No trace of wing pads can be found, but the eyes clearly show the intermediate nature of the specimens. In the normal wingless

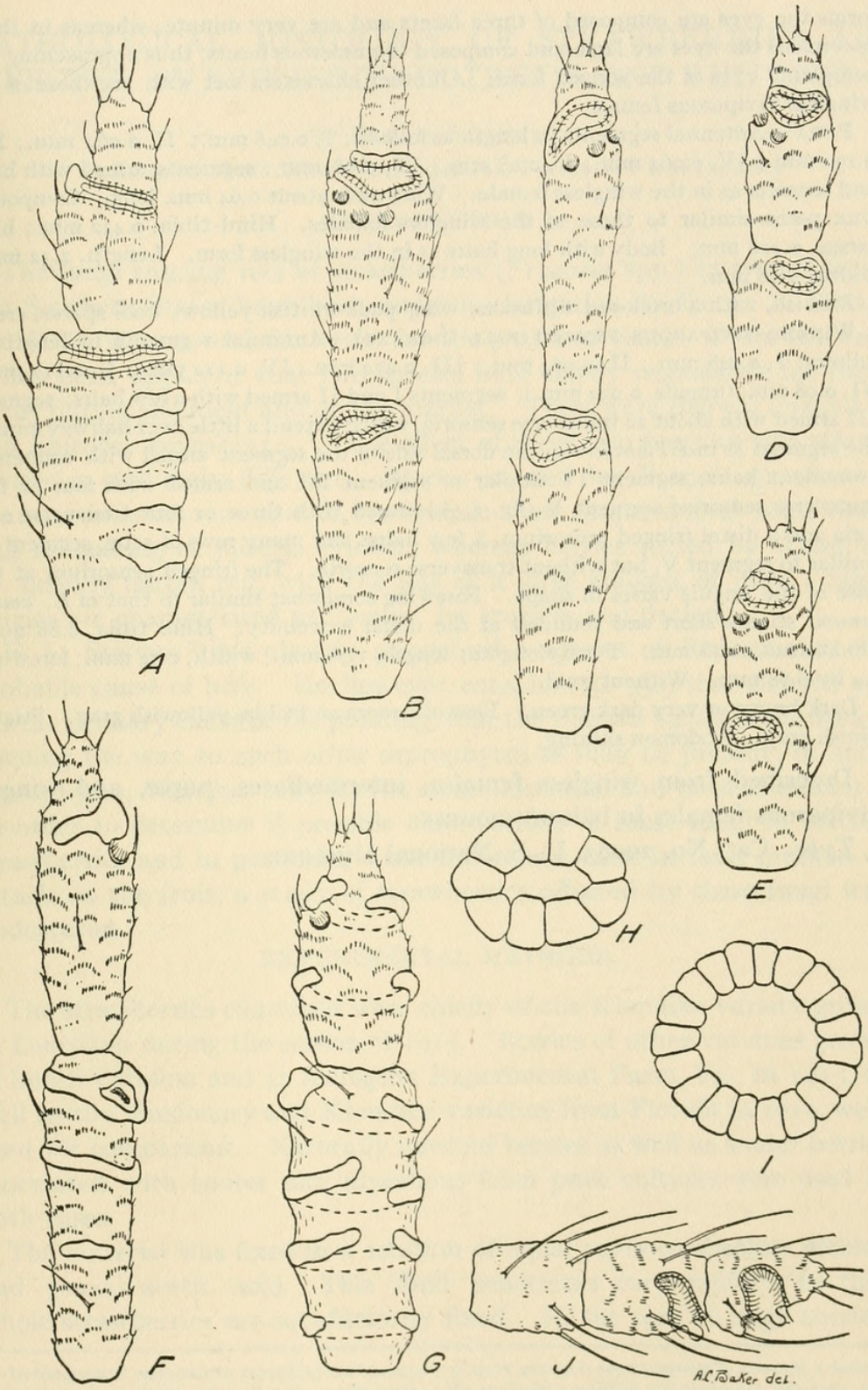

FIG. 1.—Comparative structure of antennæ and wax pores of *Eriosoma* spp.: *A*, distal segments of antenna of winged viviparous female of *E. pyricola; B*, distal segments of antenna of winged viviparous female of *E. ulmi; C*, distal segments of antenna of wingless viviparous female of *E. americanum; D*, distal segments of antenna of wingless viviparous female of *E. lanigerum; E*, distal segments of antenna of wingless viviparous female of *E. pyricola; F*, distal segments of antenna of winged viviparous female of *E. americanum; G*, distal segments of antenna of winged viviparous female of *E. lanigerum; H*, compound wax pore of *E. lanigerum; I*, compound wax pore of *E. pyricola; J*, distal segments of antenna of first instar wingless viviparous female of *E. pyricola*.

Baker, A. C. and Davidson, W. M. 1916. "Woolly pear aphis." *Journal of agricultural research* 6, 351–360.

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