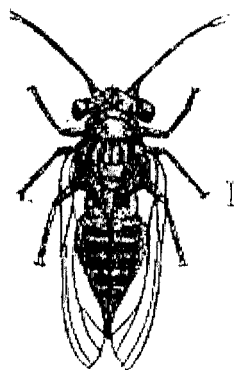


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Cornell University Agricultural Experiment Station
ENTOMOLOGICAL DIVISION.

THE
PEAR-TREE PSYLLA.



By MARK V. SLINGERLAND.

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THE PEAR-TREE PSYLLA.

Psylla pyricola.

Order HEMIPTERA ; family PSYLLIDAE.

The pear-tree has heretofore suffered less from the attacks of insects than other extensively grown fruits like the apple, plum, and others. Recently, however, a minute insect known as the Pear-tree Psylla, *Psylla pyricola*, has inflicted such severe losses upon pear growers that it threatens to seriously interfere with the successful cultivation of this fruit.

During 1891, pear growers, in restricted localities in quite widely separated portions of this and of neighboring states, lost thousands of dollars worth of fruit and many valuable trees through the ravages of this pest which suddenly appeared in enormous numbers early in the season. The pear orchard of Dr. Jabez Fisher, Fitchburg, Mass., was seriously injured ; and Coe Brothers, Meriden, Conn., had two orchards devastated by the pest. In New York State, orchards in the eastern, central and western portions suffered. On West Hill near Ithaca, Tompkins Co., several orchards were severely attacked, some of the trees ultimately dying ; Mr. H. S. Wright's orchard promised six hundred bushels of fruit, but less than fifty bushels matured, and but few trees made any growth. A severe attack prevailed at Menands, Albany County. Mr. G. T. Powell, an extensive fruit grower in Ghent, Columbia County, states that the insects reduced his pear crop from an estimated yield of twelve hundred barrels to an actual yield of less than one hundred barrels of marketable fruit ; the trees made but little growth and several were killed ; his trees have been noticeably losing vitality for two or three years due, no doubt, to the unsuspected attacks of this pest. These facts must convince the pear growers, of New York State especially, where the insect seems to have obtained the strongest foot-

hold, that they have to fear a very serious pest. Although very insignificant individually, this enemy becomes formidable and very destructive when the conditions are favorable for its reproduction in countless numbers.

THE PAST HISTORY OF THIS PEST.

The pest is an old offender; and its recorded history in this country shows that it has been present for many years in or near most of the localities above noticed. The insect was probably first introduced into this country upon young pear-trees imported from Europe in 1832 by Dr. Ovid Plumb of Salisbury, Conn. Dr. Plumb first noticed the insect in 1833; and during the next five years he lost several hundred trees from its ravages. By 1848, when the pest was first brought to the notice of an entomologist, Dr. Harris, it had spread into Massachusetts and into Dutchess and Columbia Counties in New York. In 1879, W. S. Barnard observed the pest in destructive numbers at Ithaca and at Saratoga, N. Y.

The earliest record we have of its appearance further west is in 1871 when Dr. LeBaron recorded a severe attack upon young pear-trees in Illinois. Mr. E. A. Schwarz has found the insect in Michigan. Prof. J. B. Smith of New Jersey has been unable to find it in that State, and we have no record of its occurrence further south.

It is thus seen that the pest is quite widely distributed over the northeastern portion of the United States and has reached the Mississippi Valley in its westward progress. The severe outbreak of 1891 indicates that the insect has been increasing in numbers. It has apparently reached a point, in New York State, at least, where it only awaits favorable opportunities, in meteorological conditions possibly, to repeat its ravages of last year in unexpected localities. Pear growers should be watchful and prepared to fight it early in the season.

ITS CLASSIFICATION.

This pear pest is one of the true bugs belonging to the sub-order *Homoptera*, family *Psyllidae*, commonly known as Jumping Plant-lice from the leaping habit of the adult. Their general name, *Psylla*, is the Greek word meaning a flea. The *Psyllid*

fauna of Europe comprises more than one hundred and fifty described species and has been thoroughly studied. Dr. Franz Löw of Vienna added much to our knowledge of the classification of this group and he has described the life history and habits of several species.* Dr. E. Witslaczil of Vienna has written exhaustively on the anatomy of the family†.

In the United States but little attention has been paid to the *Psyllidae*, and less than twenty species have thus far been recognized.

Three species of *Psylla* infest the pear-tree in Europe,—*pyrisuga*, *pyricola*, and *pyri*; *pyrisuga* does the most damage, and *pyri* is comparatively rare. We have, as yet, no native species of *Psylla* feeding on the pear-tree. Our pest, *Psylla pyricola*, although it was observed in this country in 1833, received its name in Europe fifteen years later, or about the time Dr. Harris's attention was called to it here. Previous to 1848, European writers had referred to the species as *Psylla pyri*, not distinguishing it from that species; and nearly all of our entomologists have written of it under this name. *Psylla pyricola* sometimes attacks the apple-tree in Europe, but it seems to confine its attacks to the pear in this country.

INDICATIONS OF ITS PRESENCE.

Among the first indications that pear growers, who suffered from this pest in 1891, had of its presence was the noticeably lessened vitality of their trees early in the season. Old trees, especially, put forth but little new growth. Where new growth started, in many cases, the shoots began to droop and wither in May as if from a loss of sap. A little later, whole trees put on a sickly appearance; the leaves turned yellow and the fruit grew but little. By midsummer nearly all the leaves and half-formed fruit fell from many trees; this fact suggested the design on the title page of this Bulletin.

Another peculiar phase of the attack was the immense quantities of a sweet water-like fluid called honey-dew which covered the twigs, branches and trunks of the trees. In some instances

*In Verh. der K. K. Zool.—Bot. Ges. in Wien, 1862–1886.

†Zeit. für Wissensch. Zool. XLII, 569, (1885).

it appeared in such quantities that it literally rained from the trees upon the vegetation beneath ; in cultivating the orchard the back of the horse and the harness often became covered with the sticky substance dropping from the trees ; in gathering what little fruit matured the hands and clothing would become smeared with the sticky fluid. This honey-dew appears on the trees soon after the leaves expand and is found throughout the season. It attracts thousands of ants, bees, and wasps which feed upon it. If copious showers fall during the early part of the season much of this honey-dew is washed off, making it less noticeable.

At first the honey-dew is clear like water, but soon a black substance appears and, spreading rapidly all through it, gives it a disgusting blackish appearance as if the trees were covered with smoke from a factory. This black growth is a fungus, *Fumago salicina*,* which grows luxuriantly within the honey-dew, but does not attack the tree. It forms, however, with the honey-dew, a coating which must close many of the breathing pores of the tree and thus materially affect its healthy growth. Many trees appeared as though treated with a thin coat of black paint.

The attention of the Entomological Department of this Station was first called to the pest by Mr. H. S. Wright, Ithaca, N. Y., in the latter part of November, 1891 ; or not until the insect had done its damage for the season. A visit to his orchard a few days later revealed a most deplorable state of affairs. The whole orchard appeared as though a fire had swept quickly through it and scorched the trees, blackening the trunks, large branches and the smallest twigs ; both young and old trees of dwaff and standard varieties had been attacked, the Bartlett and Dutchess varieties suffering the most ; most of the trees had made little or no new growth during the season, and many buds were then dead. Neighboring orchards were similarly affected ; and Mr. G. T. Powell reported that his orchards at Ghent, N. Y., presented a similar appearance. Several trees in some orchards died before spring.

Although the indications of the presence of some enemy is

*W. S. Farlow, Bull. Bussey Inst., Mar. 1876, p. 404.

thus so conspicuous, the depredator is an insect so small as to be easily overlooked.

THE APPEARANCE OF THE INSECT.

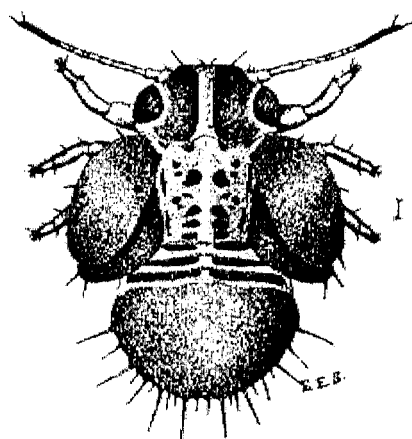


FIG. 1.—Full grown nymph, dorsal view.

inch in diameter; the natural size is indicated by the hair line at the right of the figures. These full grown nymphs are oval in shape, and of a general blackish color often tinged with red; the eyes are of a bright crimson color. A very conspicuous feature is the large black wing-pads on each side of the body. The whole body is very much flattened, being only one-fifth as thick as long.

The adult insect. Fig. 3:—From the full-grown nymph, the change is to the adult insect. In this form the pest strikingly resembles a Cicada or Dog-day Harvest-fly in miniature. It would take nine or ten of them placed end to end and about forty placed side by side to measure an inch; the hair line beside the figure indicates the natural size of an adult. From the wide blunt head, the body tapers considerably to the sexual organs at the

The immature insect. Figs. 1 and 2:—These curious minute, oval, immature forms are called nymphs. When first hatched they are of a translucent yellow color, and hardly visible to the unaided eye; eighty of them placed end to end would scarcely measure an inch. They increase in size quite rapidly and undergo gradual changes in color and form until they measure .055 of an inch in length and .045 of on

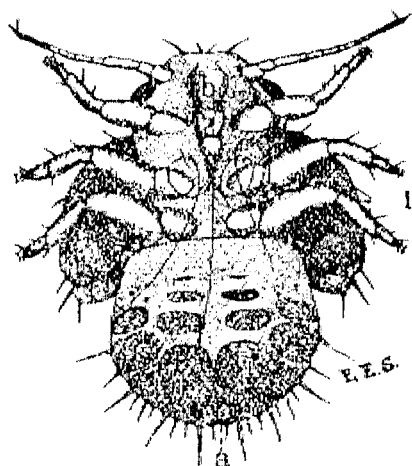


FIG. 2.—Full grown nymph, ventral view; a, anus; b, beak.

caudal end. When the insect is at rest, its two pairs of large, nearly transparent wings slope roof-like over the sides of the body. The general color is crimson with broad black bands across the abdomen. The legs have thickened femurs to aid the insect in leaping. The sexes are easily distinguished; in the male (Fig. 5) the abdomen terminates in a large trough-shaped segment from which project upward three narrow organs used in copulation; the end of the abdomen of a female (Fig. 6) resembles a bird's beak, an upper and a lower pointed plate coming together and enclosing the egg-sheath between them.

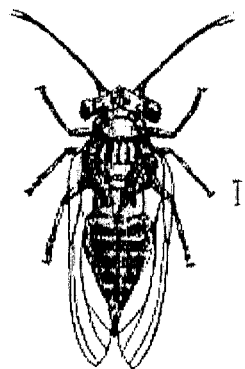


FIG. 3.—The adult insect.

THE LIFE HISTORY OF THE INSECT.

The life history and habits of every insect which becomes of economic importance should be accurately determined in order to ascertain, if possible, the stage when it can be most successfully combated. Observations upon the habits of the two worst enemies to fruit growers, the Plum Curculio, *Conotrachelus nenuphar* and the Codlin Moth, *Carpocapsa pomonella*, revealed peculiar habits which made it practicable to combat them with the cheapest and most easily applied of the insecticides,—the arsenites. The adult Plum Curculio's habit of feeding upon the fruit and foliage left it open to attack by the arsenical spray. The eggs of the Codlin Moth were found in the apex of the forming fruit soon after the blossoms had fallen; the fruit then being in an upright position the arsenite lodges in the apex and is eaten by the newly hatched larva when it attempts to enter the fruit. A knowledge of the habits of injurious insects will also often enable the farmer to so manage his land and crops that the insects are placed under very unfavorable and often destructive conditions. Wheat sown as late as it is safe to do so is usually secure from the attacks of the fall brood of the Hessian fly, *Cecidomyia destructor*. By harvesting the first crop of clover for hay early in June, the bulk of the first brood of the Clover-seed Midge, *Cecidomyia leguminicola*, will be destroyed and the second crop of seed be thus saved. Fall plowing destroys many cut-worms and the tender pupæ and

adults of wireworms which are hibernating. Many similar instances might be given where a knowledge of the habits of injurious insects have been of incalculable value to the fruit growers and farmers. In fact, were it not for such observations upon the life histories of insects, fruit growers and farmers would not now be so successfully fighting many of their insect foes.

Of the life history of the Pear Psylla but little has been recorded either in Europe or in this country, although the insect has been known here as a pest for nearly sixty years. As the attention of this Department of the Station was first called to this pest at the beginning of winter, our study of its life history naturally began with the stage in which the insect was then hibernating.

Hibernation.—Observers have differed in their statements in regard to the stage in which this insect passes the winter. Dr. Franz Löw, speaking of the three Pear Psyllids (Verh. der Zool. Bot. Ges. in Wien, 1886, p. 154) sums up the general European opinion on this point in saying that the adults hibernate and lay their eggs in the spring; not in the fall and spring as translated in Insect Life, IV, 127. Barnard, Thomas, and Ashmead (see bibliography for references) in this country have doubted that the adults of *Psylla pyricola* wait until spring to lay their eggs. Dr. Lintner (Country Gentleman, August 6th, 1891) says the winter is passed in the egg state. Some species of *Psylla*, as *P. mali*, appear to pass the winter in the egg state according to the observations of Schmidberger (Kollar's Treatise, p. 278) and English observers (Miss Ormerod's Fourteenth report, p. 4, 1891).

An examination of Mr. H. S. Wright's orchard in December, 1891, revealed a hibernating brood of adults. Notwithstanding the great numbers in which the insect had appeared during the summer, comparatively few of these adults could be found. Most of them were hidden in the crevices under the loosened bark on the trunk and large limbs of the tree; a favorite hiding place on some trees was in the cavity formed by the bark growing about the scar of a severed limb; on account of its being quite warm at the time, some adults were crawling about on the branches. The adults were not easily seen as they were so minute and their color so closely imitated the bark of the tree. Both sexes were found in about equal numbers, and an examination of the females in De-

cember showed no mature eggs. The trees were examined several times during the winter; the adults remained in their hiding places, and none were seen in copulation, nor were any eggs seen before April 7th, 1892. It was thus evident that *Psylla pyricola* does not pass the winter in the egg state, but that there is a hibernating brood of adults whose eggs are not laid until spring.

Oviposition of the winter brood.—A few days of warm spring weather occurred about April 7th, 1892, and many of the hibernating adults were seen in copulation, and a few eggs were also laid. Spring then opened and by April 18th a majority of the eggs had been deposited. The eggs were placed in the creases of the bark, or in old leaf scars, about the bases of the terminal



FIG. 4.—Egg.

buds of the preceding year's growth; some were seen about the side buds near the terminal ones. They were usually laid singly but rows of eight or ten were sometimes found. The eggs (Fig. 4) are scarcely visible to the unaided eye; it would take eighty of them placed end to end to measure an inch. They are elongate pyriform in shape, smooth and shining, and of a light orange yellow color when first laid, becoming darker before hatching. A short stalk on the larger end attaches the egg to the bark, and a long thread-like process projects from the smaller end.

The temperature conditions in the spring influence not only the time of oviposition of the winter brood, but also the duration of the egg stage. Eggs brought into the warm Insectary on April 7th hatched in eleven days. Other branches containing eggs were tied to trees near by, the end of the cut branch being kept in a vial of damp sand; these eggs hatched in seventeen days. The weather remaining cool, the eggs upon the trees under natural conditions did not hatch before May 10th, or more than a month after oviposition began. By May 18th, most of the eggs had hatched; and the hibernating adults had disappeared.

Habits of the nymph.—Immediately after emerging from the egg, the minute nymph seeks a suitable feeding place and is soon at work sucking the sap with its short beak which appears to arise from between the front legs. The favorite feeding places of the nymph, and to which their much flattened bodies are

well adapted, are in the axils of the leaf petioles and stems of the forming fruit. A few nymphs emerged in the spring before the leaves had expanded ; these nymphs crawled into the buds out of sight. When the axils of the fruit-stems and leaves become full, the nymphs gather in closely packed clusters about the base of the petioles and stems ; if very numerous they gather on the under side of the leaves along the mid-rib and often on the petioles of the leaf. The nymphs move about but very little, sometimes becoming covered with their own honey-dew ; if disturbed they crawl about quite rapidly. The only times when the nymphs seem to stop feeding is during the casting off of their old skin which has become too small, and which gives place to a new and elastic skin formed just beneath the old one. At the last moulting of the skin, which occurs about one month after the nymph's emergence from the egg, the adult insect appears.

Habits of the adult.—The adult insect has quite different habits from what it had when a nymph. The strong legs and wings of the adult enable it to spring up and fly away with surprising quickness upon the slightest unnatural jar or the near approach of the hand to its resting place. The hibernating forms, however, are quite sluggish in their movements and are readily captured when found. The summer forms fly readily from tree to tree and could easily be borne by winds for long distances, and thus infest neighboring orchards. The adults are provided with a beak with which they feed upon the tissues of the leaves and tender twigs of the tree. They seem to have no favorite feeding place.

Oviposition of summer broods.—Three or four days after their transformation from the nymph stage, the adults of the spring and summer broods copulate and egg-laying begins for another brood. These eggs are usually laid singly, sometimes several in a row or group, not on the twigs but on the under side of the tenderest leaves among the hairs near the midrib, or on the petiole near the leaf ; sometimes the female very adroitly places an egg or two in each notch of the toothed edge of the leaf. The eggs of the summer broods do not differ from those laid by the hibernating adult. The summer eggs, however, hatch in from eight to ten days under the warmer and more even temperature conditions.

Detailed account of a single generation.— A detailed study was made of the second generation of the pest to ascertain any peculiarities of any of its stages which might be of interest, or of aid in combating the insect. The breeding was done in the Insectary and field observations were made to verify the results as far as possible. The cages used consisted simply of a common lamp chimney set on the surface of the soil in a small flower pot; the top of the chimney was covered with Swiss muslin and a vial of water sunken into the soil kept the pear branch fresh for several days. These cheap and simple cages have been found very convenient and useful in breeding such small insects, or in getting the number of moults of larvæ isolated in them.

The females of the spring brood began to appear about June 10th, 1892, and many were laying eggs by the 20th. On the 21st, several females were placed in cages on uninfested pear leaves. Eggs were laid the following day. An egg is described and figured on page 168. When first laid they were tender and easily crushed; but in a few hours the shell became hard and the egg could be dislodged and quite roughly handled without injuring it. The shell was found to be impervious to several oils and weak alkalis. The acids and strong alkalies penetrated the shell and killed the embryo. The eggs hatched in from eight to ten days; a day or two before hatching the crimson eyes of the embryo could be plainly seen through the shell near the larger end of the egg.

The nymphs which emerged were oval in form and of a pale translucent yellow color with the abdomen more opaque and darker. The crimson eyes were large and distinct. The curious creatures were scarcely visible to the unaided eye, measuring only .013 of an inch in length. A slight constriction of the body marked the beginning of the abdomen which is fringed with eight or nine long and several short hairs. The wing-pads were not yet distinguishable. The antennæ had but three joints, two short basal and a long terminal joint tipped with two long bristles. The short stout legs terminated by minute claws enabled the nymphs to soon find a suitable feeding place. Several nymphs were immediately transferred to other cages, only one being placed in each cage. The next day the location of the

nymph was often readily determined by a globule of honey-dew several times larger than the little creature which had secreted it. After feeding thus for six or seven days the nymphs became too large for their skins which burst open along the middle of the head and back and the insect crawled forth clothed in a new and elastic skin that had formed beneath the old one. After thus moulting the nymph usually sought a new feeding place, leaving its old shriveled skin attached to the globule of honey-dew it had secreted.

In their second stage the nymphs increased about one-third in size, but were of the same general color except the tips of the antennæ which were black. There were four joints in the antennæ, a division of the third taking place at the moult. The segments of the abdomen were more distinct and the wing-pads were developing. The nymphs remained in this stage about four days, when the second moult occurred.

At the third stage the nymphs measured .027 of an inch in length. The wing-pads were larger and blackish; and the other black markings which distinguish the full-grown nymphs were faintly outlined. Six or seven joints were now distinguishable in the antennæ, the last three being black.

About three days later, the third moult occurred. The nymphs differed from those of the third stage in having eight antennal joints; the wing-pads were larger; the nymphs were .038 of an inch in length; and the eyes had become of a dark crimson hue. In some cases the nymphs in this stage were very distinctly marked, differing from the full-grown nymphs only in having fewer and larger black spots on the thorax. The duration of this stage was about four days.

At the fourth moult, the markings which had been faintly visible since the second moult now came out very distinct. This proved to be the last nymph stage. The general appearance of the full-grown nymph is described on page 165. The black markings are represented in figures 1 and 2.

After feeding five or six days, the nymphs moult for the last time; at this moult the adult insect crawls from the nymph's skin. European observers have recorded but four moults for the nymphs of several species of *Psyllidae*. The observations at the

Insectary were made upon several individuals isolated in small cages which were under daily observation from the emergence of the nymph from the egg to the appearance of the adult insect.

In each stage the nymphs secreted globules of honey-dew several times larger than themselves; sometimes the globule completely enveloped a nymph. After each moult the nymphs usually sought a new feeding place, leaving the old skin attached to the drop of honey-dew. The old moulted skins, of the last moult especially, often retained their form almost perfectly. So life-like did some of them appear, with the legs and antennæ naturally placed, that it often required close examination with a lens to determine whether the object was a live nymph or only the cast-off garment of one.

The whole life cycle of the generation studied, from the laying of the egg to the appearance of the adult insect, was about one month. The adults upon emerging are of a delicate greenish color; the blackish markings soon appear, however, and in two or three days the green changes to the normal reddish brown color. Although the adults are so distinct sexually, there seems to be nothing about the full-grown nymphs which would indicate the sex of the adult soon to emerge from the nymph's skin.

The adults begin feeding at once after emerging but do not increase visibly in size. They appear to secrete no honey-dew but void considerable quantities of a whitish excrement. Adults of the summer broods lived for several days in cages in the Insectary; how long they live under natural conditions has not been ascertained, probably less than a month. The adults which hibernate, however, remain alive for at least six months.

About a week after the summer broods of adults emerge, copulation takes place and the deposition of eggs soon begins. The winter brood, as has been said, do not, however, copulate and oviposit until spring. Several of the adults were observed with a lens while in copulation. The operation was of particular in-

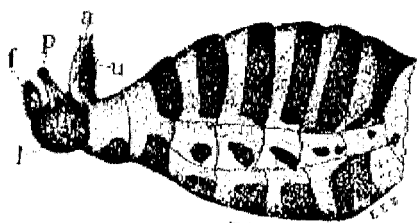


FIG. 5.—Abdomen and genital organs of the male, side view; a, anus; f, forceps; l, lower genital plate; p, penis; u, upper genital plate.

terest ; for a glance at figures 5 and 6 of the sexual characters and abdomen will show that the male organs (Fig. 5, *a, f, l, p, u.*) are so peculiarly situated as to seemingly render the grasping of the female organ (Fig. 6, *a, e, l, u.*) no easy matter. It was found, however, that the caudal segments of the abdomen of the male were very flexible and enabled the trough or lower male genital plate (Fig. 5, *l*) to be curved upward, thus bringing the forceps (Fig. 5, *f*) in a position to grasp the upper genital plate (Fig. 6, *u*) of the female ; this allowed the penis (Fig. 5, *p*) to enter between (at *e*, Fig. 6) the valves of the female organ, and the upper male genital plate (Fig. 5, *u*) to simply lie along the venter of the lower genital plate (Fig. 6, *l*) of the female. A further slight side twist of the abdomen brought the male beside

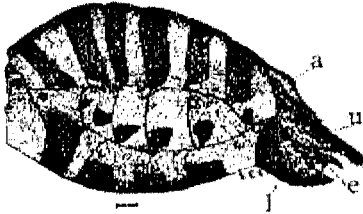


FIG. 6.—Abdomen and genital organs of the female, side view; *a*, anus; *e*, egg-sheath; *l*, lower genital plate; *u*, upper genital plate.

or in some cases upon the female ; the wings of both remained in a resting position. The hair lines beneath figures 5 and 6 represent the natural length of the abdomen including the genital organs. Copulation lasts for several minutes, and one male may copulate with more than one female.

The number¹ of broods.—The pest may be said to be many brooded, the number varying with the conditions of the season. The weather at the opening of spring greatly influences the time of appearance of the hibernating brood, and the date of the laying and hatching of the eggs. An overlapping of the broods occurs, so that after June 1st all stages of the insect, eggs, nymphs, and adults may be seen on the trees at the same time. This is due to the facts that the eggs of any female are not all laid the same day, and thus do not hatch at the same time ; and the duration of the stages of the nymphs vary slightly, thus varying the time of the appearance of the adults.

Observations at the Insectary and in the field have shown that during the present year, 1892, there has been at least four broods of the pest. The hibernating adults oviposited in April, and adults of this spring brood appeared about June 15th. The adults of the summer broods were the most numerous on or about the

following dates, July 20th, August 20th, and Sept. 25th; or a brood appeared about once a month. All stages of the insect were found on the trees as late as Sept. 20th; evidently winter must overtake some of them before they reach the adult state. The adults emerging in September and later were found to be all of the hibernating form.

Peculiarities of the winter brood.—The hibernating adults found in December, 1891, were so different from the descriptions of *Psylla pyricola* that they were believed to belong to another species, perhaps new.* When the summer adults appeared, however, they were readily recognized as the old offender *Psylla pyricola*. The hibernating adults differ from the summer adults in size, being nearly one-third larger; in their much darker coloring, the crimson becoming a dark reddish brown; and especially in the coloration of the front wings. The summer forms or typical *pyricola*, have the veins, even in darker specimens, of a light yellowish brown color, and the whole front wing has a slight yellowish tinge. The veins of the wings of the hibernating adult are invariably of a dark brown or black color; the front wings are quite transparent with more or less blackish shades in the cells and a blackish shade in the basal cell along the whole suture of the clavus. The male genitalia differ slightly in size in the two forms. Figure 3, page 166 represents an adult of the summer form; and the wings shown in figure 8, are also from a summer adult.

The hibernating adults were studied at the Insectary in connection with the descriptions of *Psylla simulans* and Dr. Löw's remarks† upon the difference between the Pear Psyllids. This

*Well marked specimens were submitted to Dr. C. V. Riley, the recognized authority upon American Psyllids. In his reply he says: "Your Pear-tree Psylla is a species which I have never seen before and which is not in my collection. Its general appearance is not that of our native species of *Psylla*, and it has, no doubt, been introduced from Europe. It is unquestionably different from *P. pyricola* which I have from Ithaca, N. Y., Connecticut and Massachusetts. Owing to the difference in the genital apparatus of the male it cannot be identical with *P. pyrisuga* and *pyri*, but agrees perfectly with the description of *P. simulans*."

†Verh. Zool. Bot. Ges. in Wien, 1886, p. 154. A translation of most of Dr. Löw's article occurs in Insect Life iv, 127. Dr. Löw gives a tabular statement

study left but little doubt that *Psylla simulans* was described from specimens of the winter form of *Psylla pyricola*.

This difference between the summer and the winter adults is common among the *Psyllidæ*, and has before led to their being described as different species. It seems not to have been suspected that these insects were truly dimorphic or appeared in two distinct forms during the year. The general impression seems to have been that the adults appearing in the fall were at first the same as the summer form; and that as winter approached, these adults gradually assumed the characteristics of the hibernating form. However, frequent observations upon *Psylla pyricola* in the field during August and September, 1892, have shown that from eggs laid about August 20th by typical summer adults, there hatched nymphs which showed no variations from the typical summer nymphs and from these nymphs there emerged about September 25th the distinct hibernating form *simulans*. The hibernating forms feed until the leaves fall and then seek their hiding places in which to pass the winter. None have been seen to copulate in the fall. But very few summer forms were seen after September 20th. Thus in our Pear-tree Psylla we have a case of true dimorphism. The summer form is the typical *Psylla pyricola*, and may be designated when necessary to refer to this form alone as *Psylla pyricola pyricola*; while the hibernating form should be known as *Psylla pyricola simulans*.

Honey-dew and excrement.—Many have supposed that the honey-dew, so conspicuous a feature in severe attacks of this pest, is the sap of the tree which exudes through the punctures made by the insects. As the honey-dew occurs in such immense quantities it does seem almost impossible that it is wholly the secretion of the little creatures. All of this fluid

of the differences between *Pyrisuga pyri* and *pyricola*, and briefly points out how *simulans* differs from *pyri* and *pyricola*. A serious error occurs in the translation in connection with *simulans*. The sentence preceding the last in the translation should be divided into two, the period occurring after the phrase, "Along the whole fold of the clavus." The remainder of the sentence is not only incorrectly translated but it should form a distinct sentence. Dr. Löw says: "The tip of the clavus is larger with more black and in the hind basal cell there is a brownish or blackish stripe along the whole suture of the clavus. The forceps of the male are as in *Psylla pyricola* only a little wider."

does, however, first pass through the body of the insect. The amount which a single individual will secrete during its lifetime is small, but when many thousands of the insects occur on a tree, the aggregate becomes large. A single nymph isolated in a cage, secreted at least four drops (i. e. four minims) of the fluid before it became an adult. Thus fifteen nymphs would secrete one drachm.

The food of the insect consists entirely of the sap of the tree. The feeding apparatus, both in the nymph (Fig. 2 *b*, p. 165) and the adult stage consists of a short, pointed beak which apparently rises from between the front legs. The sucking organs are three long thread-like setæ which move along grooves in the beak; in many cases, when the nymphs are quickly killed, the setæ are found extruded as shown in figure 2, page 165. In sucking, the point of the beak is placed against the tissue and the setæ are forced into the sap cells. The sap is then drawn up through the beak into the body. In the case of the nymphs most of the food is elaborated into honey-dew; some is assimilated, and the waste matter voided as excrement. The adults, however, seem to secrete no honey-dew, all the food being assimilated. Consequently the adults void considerable quantities of excrement, much more than do the nymphs.

The honey-dew and excrement are very different substances, but the fact does not seem to have been before observed. The honey-dew is a clear water-like liquid and forms into globules when secreted. The excrement, however, is a whitish semi-solid substance which is voided in long cylindrical strings, or minute whitish balls which roll from the anus like quicksilver globules.

In the adult, the anus is situated upon the dorsal surface. In the female it is just at the base of the upper genital plate (Fig. 6, *a*, page 173); in the male, the anus opens upon the tip of the upper plate (Fig. 5, *a*, page 172). In voiding the excrement, the male twists the abdomen downward so that none of the whitish substance adheres to the anus. The females, however, cannot thus twist the body and some of the excrement frequently adheres as whitish flakes; or not dropping freely, it sometimes forms into a string often reaching one-half an inch in length. In the nymphs the anus is situated on the venter near the caudal end (Fig. 2, *a*,

page 165) of the abdomen. It is surrounded by a ring of large wax-cells; a similar ring also surrounds the anus of the adult female. The excrement of the nymphs is usually voided in a string. It has often been seen in the midst of a globule of honey-dew secreted by the same nymph; thus clearly demonstrating that the two secretions are distinct.

Many observations were made to discover, if possible, the manner in which the honey-dew was secreted by the nymphs. It has been supposed that the secretion came, either from the long so-called wax-hairs around the edge of the abdomen, or from excretory pores on the dorsum of the abdomen. Globules of honey-dew were, however, seen attached to the nymphs in such a position that it seemed very improbable that it came from either of the above sources; it seemed that it must have been secreted from the anus of the nymph. A German observer now asserts that the honey-dew secreted by the common plant-lice or Aphids comes from the anus, and not from the honey-tubes as commonly supposed.* Honey-dew thus seems to be what might rightly be called the fluid excrement of the insect.

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

All of the attempts to prevent the ravages of this pest during 1891 were ineffectual. This was due, in large part, to a lack of knowledge of the life history and habits of the pest. No severe outbreak had occurred within recent years which would call the attention of the fruit growers to the pest. The result was that when the insect appeared in enormous numbers early in the spring of 1891, fruit growers were at a loss what to do and how to do it; and entomologists could only suggest methods which seemed practicable. In most cases the attempts to combat the pest were begun too late; most of the damage had been done, the fruit and new growth being severely blighted; the nymphs had covered themselves with honey-dew, and the very active summer adults had appeared. After several unsuccessful attempts with various substances such as kerosene emulsion, solutions of whale-oil soap, fir-tree oil, and carbolic acid, and London Purple and

*M. Büsgen *Jenaische Zeitschrift* XXV. 339-428 (1891).

Paris Green, the afflicted fruit-growers gave up in despair. Nothing seemed to check the pest. They saw the leaves and most of the fruit fall before midsummer; and some of their trees were left in a dying condition, while others presented a blighted, blackish, desolate appearance. Fruit growers reported two causes which rendered their efforts ineffectual. These were peculiar phases in the habits of the insect. First, the nymphs were so completely enveloped in honey-dew that none of the insecticides reached them. Second, the activity of the summer adults rendered it impossible to reach them with a spray; as soon as the first spray struck a tree, the adults arose instantly and flew to some distance, remaining away till the spraying ceased.

During 1892, the pest has done no perceptible damage in orchards which it devastated last year. Fruit growers noticed that the pest considerably decreased in numbers later in the season last year. This decrease and the scarcity of the insect this year was probably due principally to the fact that the insect feeds almost exclusively upon the tenderest leaves and branches of the trees. As hardly any new growth was formed and as most of the leaves fell off early in the season, the insect was thus deprived of its favorite food and consequently its increase checked. So great was the decrease that but very few of the hibernating adults appeared. On this account we tried no experiments to destroy the adults in their winter hiding places. It seems practicable, however, that a thorough washing of the trunks and larger branches of the trees in winter with kerosene emulsion (at least five per cent. kerosene) or a strong soap solution, would destroy many of the adults.

As soon as the eggs of the hibernating form were found, experiments were begun with a view to the destruction of the insect in this stage. As the eggs were so freely exposed on the bare twigs to the action of any fluid, it was confidently expected that the pest could easily be checked here. Both field and laboratory experiments were conducted. The branches containing the eggs were dipped into the solution in each case, thus making sure that the treatment was thorough. The results obtained were very surprising. Eggs dipped in the following substances hatched a few days afterward:—

Kerosene Emulsion (Hubbard-Riley formula) used full strength ; and diluted with three parts of water heated to 130°F.

Kerosene undiluted.

Turpentine Emulsion diluted with three parts of water.

Turpentine undiluted.

Crude Carbolic Acid Emulsion diluted with ten parts of water.

Resin Wasn used triple strength ; and heated to 130°F.

Whale-Oil Soap and Sulphide of Potash Wash used double strength. These last two washes are successfully used in combating all stages of scale insects.

Concentrated Potash, one pound to one gallon of water.

Benzine undiluted.*

Most of the above substances injured the buds ; Concentrated Potash and Carbolic Acid when used in less dilutions killed the buds. These results made it evident that it was impracticable to fight the pest with insecticides while in the egg state.

However, if the pear growers could wait until about April 15th, before pruning their trees, they could destroy many eggs. Most of the eggs are laid by that date near the tips of the last year's growth ; so it is only necessary to cut back these shoots, as many growers do, and burn them, to destroy large numbers of eggs.

After the unsuccessful efforts to destroy the eggs with insecticides, we could do nothing more until the nymphs appeared. Some of the nymphs appeared before the buds had opened much ; these nymphs immediately crawled into the buds out of the reach of the insecticides. It was feared that all the young and tender nymphs would thus get out of reach. But a majority of the eggs did not hatch this year until many of the leaves had expanded,

*Similar results were obtained by B. S. Goff of Wisconsin while experimenting upon the eggs of Aphids. He found the shell extremely resistant, scarcely yielding to the strongest acids and alkalis. (Insect Life, iv, p. 327).

There seems to be no other records of any careful experiments with the different insecticides upon the eggs of Aphids or of the allied Psyllids. Kerosene emulsion is often recommended, and the eggs of some species of Aphids may, possibly, be thus destroyed. There is need, however, of more observations upon the penetrating and killing power of insecticides upon the eggs, not only of Aphids but of other insects.

thus leaving the nymphs exposed. During a warm early spring the eggs might hatch early but many of the leaves expand in a few days and thus the nymphs would be exposed before they had become more than one-third grown.

Our experiments against the young nymphs were first carried on in the Insectary upon infested branches brought in from the field. It was soon found that the young nymphs were very tender and very susceptible to kerosene. A kerosene emulsion was prepared according to the Hubbard-Riley formula.* The nymphs were dipped in the emulsion diluted with different quantities of water. It was found that every nymph was killed by the emulsion even when diluted with twenty-five parts of water, and thus containing less than three per cent. of kerosene. The nymphs died almost immediately after the liquid touched them. These laboratory results were thus very encouraging.

Field experiments were soon begun to test the practicability of the emulsion. No trees could be found that were very badly infested. But by carefully examining the trees before and soon after spraying it was estimated that from 75 to 90 per cent. of the nymphs were killed by one spraying with kerosene emulsion

*The formula is $\frac{1}{2}$ pound hard or soft soap, 1 gallon water, 2 gallons kerosene.

First, thoroughly dissolve the soap in boiling water. While this solution is still very hot add the kerosene; if the whole is then left over the fire for a few moments to raise the temperature of the kerosene slightly, it will facilitate the emulsifying process. Remove from the fire and quickly begin to agitate the whole mass through a syringe or force pump of some kind; draw the liquid into the pump and force it back into the dish. Continue this operation for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. If desired for use immediately, it may now be readily diluted with cold water, preferably with rain water. Or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This stock if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold stock emulsion, it is necessary to measure out the amount of the emulsion required and first dissolve it in three or four parts of boiling water; if cold water be used a large quantity of a white flocculent mass rises to the surface and does not dissolve. After the stock emulsion is dissolved, cold water may be added in the required quantities. If all the utensils are clean, and the directions followed closely, no free oil will rise to the surface of the dilution.

diluted with twenty-five parts of water. Some of the nymphs had by this time become nearly full-grown, but these were as quickly and effectually destroyed as were the young ones. The habit of the nymphs of feeding in the leaf axils made it easier for the spray to reach them; the liquid would naturally run down the leaf petioles and twigs and gather in the axils, and thus become very effective. It was found that two quarts of the dilution was sufficient for a large dwarf tree; and thirteen such trees could easily be sprayed in half an hour with a knapsack sprayer. It would, of course, take more time and material to spray the large standard trees, but the whole cost for each tree would not be more than one cent a tree for time and material. The experiments with the kerosene emulsion against the nymphs were so successful that no other insecticides were tried. The emulsion is the cheapest effective insecticide now known for sucking insects; and our experiments have shown that it will prove a very practical and efficient means of checking the ravages of the Pear-tree Psylla if it be used thoroughly and in time.

The honey-dew did not interfere with the action of the insecticide this year, 1892. This was probably due to the fact that many hard showers fell during the early part of the season. The rain washed off much of the secretion. This fact should be taken advantage of by fruit growers in spraying for the pest. Spray soon after a heavy rain-storm if possible; a shower soon after spraying will not lessen the destructiveness of the emulsion as the nymphs are killed almost instantly. There is not the least danger of injury to the trees from the diluted emulsion. All dwarfs and young trees of all kinds may be sprayed with a knapsack sprayer.

The best time to spray is early in the spring just after the leaves have expanded. In 1892, about May 15th, was the best time. Then the first brood of nymphs had all emerged and were exposed in the axils. It was this first brood which did the most damage in 1891. Therefore it is very important that the insect should be checked early in the season. Fruit-growers should examine their orchards when the leaves are expanding in the spring, and if the nymphs are numerous no time should be lost in spraying the trees with the emulsion. A second or even a

third spraying could be profitably applied if the attack were serious, and especially if but little rain had fallen to wash off the honey-dew. The destruction of the nymphs is practicable during a period of two weeks about May 15th. If the spraying is thoroughly done at this time, the pest will be so completely checked as to necessitate but little, if any, further attention during the season. Most of the damage is usually done before June 15th, but spraying after this date will decrease the number from which the hibernating forms are produced; and thus the orchard may be saved from a severe attack the following year.

The summer adults were not numerous enough this year to thoroughly test the effect of spraying upon them. It seems from the experiments made last year by fruit-growers that it is hardly practicable to try to kill the adults by spraying. A few may be destroyed by coming in contact with the emulsion when they return to the tree.

TECHNICAL DESCRIPTIONS.

Full grown nymph.—Length, 1.4 mm.; width, 1.15 mm. Oval in outline, and much flattened, being only about one-fifth as thick as long. General color light yellowish brown often tinged with crimson, and distinctly marked with blackish. The distal end of the antennæ, of the beak, and of the tarsi are black. The large wing-pads, the whole dorsal aspect of the head except a light mesal stripe, and the caudal half of the abdomen both on the dorsum and venter are blackish or brownish black. The dorsum of the thorax and the cephalic half of the abdomen are marked on each side the light meson by sixteen blackish spots; the twenty-six on the thorax are of varying sizes and shapes; the six on the abdomen are narrow elongate. On the venter of the abdomen, eight and sometimes ten similar spots occur, two large oval ones on each side near the lateral edge, and two or three elongate ones farther cephalad on each side near the meson. The eyes are large and of a crimson color. The legs are slightly darker than the body. Oftentimes the light body color between the black markings is strongly suffused with crimson. Stout hairs or bristles project from the following situations: four from the front of the head; the basal and terminal joints of the antennæ each bear two; each leg has several; three project from the costal margin of each front wing-pad, and two from the outer margin of each hind wing-pad; and the caudal half of the abdomen is fringed with eight large and fourteen smaller bristles. The encircling row of wax-cells about the anus has a definite form which may be of specific importance.

Figures 1 and 2, page 165 drawn with a camera lucida, show the position of the anus with its encircling ring (Fig. 2, *a*); also the situation, relative size, and form of the bristles and blackish markings of the nymph.

Summer form of adult, *Psylla pyricola pyricola*, (Fig. 3, page 166): Length of body 2.25 mm.; the wings extend a little beyond the end of the abdomen. In general form they strikingly resemble a *Cicada* in miniature, the head is broad and held nearly vertical; the thorax is strongly built, and the pronotum, all four sclerites of the mesothorax, and the scutum and scutellum of the metathorax are distinct on the dorsum; the abdomen is cylindrical ovate, largest near the fourth segment and tapering to the genital organs. The general color varies from a light scarlet to crimson with black markings. Head (Fig. 7, a) broadly triangular, slightly concave caudad;

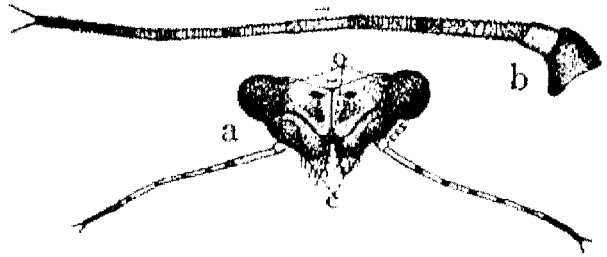


FIG. 7.—A, head of adult, front view; c, cones of clypeus; o, ocelli. B, antenna of adult greatly enlarged.

the hair line just above the head in the figure represents the natural width including the eyes; the clypeus projects ventrad in the form of two separate diverging hairy cones (Fig. 7, c) with white tips and brownish red bases; the mesal suture of the epicranium is black with a lighter border, and a black spot occurs in a slight depression each side of the suture near the caudal border. The eyes are large and prominent, and of nearly the same color as the body except about the ventral aspect which is black; three minute ocelli are situated as shown in figure 7 at c. The antennæ are about one and one-half times as long as the width of the head and tipped with two large bristles; the first joint is reddish, the tenth, ninth, and distal half of the eight joints are black, and the remainder of the joints are light brown darker at their distal ends; the first and second joints are together equal in length to the fourth, the third is one and one-half times longer than the fourth, and the others are of nearly equal length; joints four, six, eight and nine are each furnished with a large sensoria near their distal ends. Figure 7, b, represents an antenna highly magnified to bring out the details of its structure; the hair line above the figure represents the natural length. The three-jointed beak is black, and passes through a deep groove just cephalad of the front coxæ. The pronotum is quite narrow; color, reddish black mesally with a whitish spot each side, and another similar slightly raised spot near the lateral edge within a slightly depressed elongate black spot. The præscutum of the mesothorax is large, convex, triangular in outline broadest caudad; color of cephalic half, except a narrow mesal stripe, black which merges into the crimson of the caudal portion; the lateral angles and a small tooth each side of the meson on the caudal border are whitish. The scutum of the mesothorax which bears the front pair of wings is large, convex and quadrangular in outline; color, a broad crimson mesal stripe wider at the ends with a blackish centre; each side of this a fusiform black stripe which is separated from a wider lateral black stripe by a narrow crimson stripe. The scutellum of the mesothorax

is broadest cephalad and slightly smaller than the præscutum; color, crimson with a whitish curved tooth projecting cephalad from the lateral angles. The postscutellum of the mesothorax is barely visible on the meson but is quite distinct each side the scutellum; color, brownish red. The scutum of the metathorax which bears the hind wings is narrow mesally but nearly as wide as the scutum of the mesothorax laterally; color crimson mesally merging into black at the sides. The scutellum of the metathorax is nearly round, slightly raised, and light crimson in color. Beneath, the thorax is marked with large irregular black spots. The legs are of a light yellowish brown color, except the thickened femurs which are black; all of the legs are thickly set with short hairs and the tibiæ and first tarsal joints of the hind legs are armed at their distal ends with densely black short spurs, five upon each tibia, three being set very close together on the under side, and two on each tarsal joint; the hind coxæ are the largest and have a long spur projecting caudad against the abdomen and which aids the insect in leaping. The relative size and shape, and the venation of the wings are shown in figure 8; the hair line beneath the front wing represents the natural size of the wing. The front

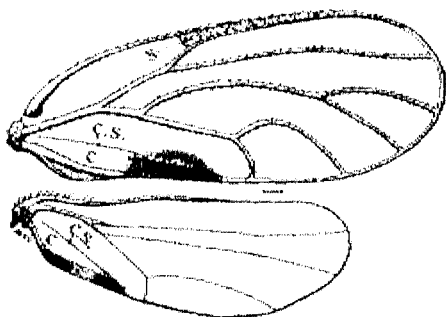


FIG. 8.—Venation of wings; *s*, stigma; *c*, clavus; *c. s.*, claval suture.

wings have a slight yellowish cast which partially obscures their transparency; in some specimens there are also yellowish shades in the cells. The hind wings are transparent and more delicate than the thicker, firmer front ones. The very strong veins of the front wings are always of a light yellowish brown color and are provided with short hairs on each side throughout their length; the stigma (Fig. 8, *s*) is usually but a little lighter in color than the veins; the tip of the clavus (Fig. 8, *c*) is brownish black in color, and a spot of about the same size and a little lighter in color occurs in the basal cell along the claval suture (Fig. 8, *c. s.*) opposite the blackish tip of the clavus. The veins and boundry of the basal third of the hind wings are yellowish and nearly as large as those in the front wings; the remainder of the veins are very indistinct; along the hind margin, the clavus is slightly thickened and is brownish in color especially at the tip and near the basal angle. The first abdominal segment is closely joined to the thorax and has a slightly raised nearly square black spot on the dorsum. The second segment, separated from the first by a distinct suture and slight constriction, has a small black mesal spot on the dorsum and a large irregular black spot on the sides. The following five segments each have a broad black band passing over the dorsum near the cephalic margin of the segments. Along each side on the lateral fold occurs a row of eight irregular black spots, seven of which contain each a spiracle. The second, third, fourth, fifth and sixth segments each have on the venter a broad black band similar to those on the dorsum. In the

female the eighth and tenth segments constitute the lower and upper plates respectively of the genital apparatus; these are black, and on the dorsum at the base of the upper plate is situated the brownish anus. The ninth segment constituting the sheath between the genital plates is brownish. Figure 6, page 173, shows the position of the anus (*a*); the appearance of the genital apparatus (*u*) upper genital plate; (*l*), lower genital plate; (*e*), egg-sheath; and the number, arrangement, and relative size of the black spots on the abdomen of the female as seen from the side; only that portion of the first segment which bears the spiracle is represented. The abdomen of the male (Fig. 5, page 172), differs from that of the female in being slightly smaller and longer; the eighth segment is distinct from the genital apparatus and has a broad black band on its venter in which the seventh spiracle occurs; the trough-shaped ninth segment is black and constitutes the lower plate (Fig. 5, *l*) of the genital apparatus; the upper plate (Fig. 5, *u*) or tenth segment is narrow and arises vertically at the base of the lower plate; this upper plate is blackish in color, lighter about the tips where the anus (Fig. 5, *a*) is situated; the forceps (Fig. 5, *f*) or claspers are a pair of narrow blunt black prongs arising from out the caudal end of the lower plate; these claspers curve slightly laterad before meeting at their tips and thus form an oval opening between them as seen from behind; the penis (Fig. 5, *p*) is also a paired organ arising as two narrow knobbed rods from near the middle of the trough. Figure 5, page 172, shows the arrangement of the markings on the abdomen, and the relative size and shape of the parts of the genital apparatus of the male when viewed from the side. Figure 3 represents an adult female of the summer form with the wings at rest.

Winter form of the adult, Psylla pyricola simulans.:—This form differs from the summer form only in size and coloration. It is nearly one third larger and the predominating color is black, due to the intensely black markings and the general dark reddish brown color of the body. On the head, the borders of the epicranium, about the base of the antennæ, and a spot near each eye are often whitish; about the base of the beak it is black and the cones of the clypeus are blackish with sometimes a whitish tip; the antennæ have their brown portions of a little darker color and the basal joint is often black. The tergum of the thorax varies from being only slightly darker in color than the typical summer form to nearly all black, there remaining only a narrow whitish caudal border on the praescutum of the mesothorax, the reddish mesal stripe on the scutum of the mesothorax appears as two narrow stripes so distinct is its black centre, and the curved whitish teeth of the scutellum of the mesothorax. The coxæ and tarsi are often blackish with the remainder of the legs of a darker brown. The front wings do not have the yellowish tinge and are thus more transparent; the veins are always of a dark brown or black color and more or less distinct black shades occur in the cells; in dark specimens these shades are very distinct; the stigma is slightly lighter than the veins; the tip of the clavus is distinctly black and a blackish spot occupying nearly one half of the basal cell extends along nearly the entire length of the claval suture; another blackish spot occurs on the clavus along the claval suture near its base.

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Psylla sp. Lodeman, Garden and Forest, June 15, 1892, life history, brief.

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