

thorax with a narrow black line on the anterior dorsal margin; eyes brick red; legs dusky; wing insertions yellow, apex of beak dusky, remainder, unicolorous with body. Cauda distinct. The median dorsal glands larger than either the lateral or the submedian.

Pupa—Length of body, 3.09 mm.; width, 1.39 mm.; length of antennæ, .83 mm.; separation between joints, III and IV, not distinct; sensoria, not distinct. Cauda, distinct, .22 mm. long. Rostrum reaches second coxæ, sometimes beyond.

Color—(Unmounted, examined with hand lense.) Yellowish green; wing pads, whitish. (Mounted, examined with compound microscope.) Whole body light green with a yellow tinge, sometimes yellowish white, depending on age after moulting; antennæ, wing pads and legs whitish; eyes, brick red. The last abdominal segments are crescent shaped, producing an indenture each side of the cauda.

Fundatrix—Length of body, 3.66 mm.; width, 2.74 mm.; length of antennæ, .87 mm. (Joint I, .087 mm.; II, .12 mm.; III, .24 mm.; IV, .14 mm.; V, .14 mm.; VI with unguis, .15 mm.); separation between III and IV not distinct in immature forms. Beak, barely reaching second coxæ.

Color—(To naked eye) Greenish purple; (mounted, examined with compound microscope) olive green with a yellow tinge.

HACKBERRY PSYLLIDÆ FOUND AT AMES, IOWA.

BY CHAS. W. MALLY.

The insects now under consideration belong to the family *Psyllidae*; sub-family *Psyllinae*; and the genus *Pachypsylla*. The genus, according to Dr. C. V. Riley, "has no equivalent in the European fauna; but some allied, still undescribed, genera occur in the New World."

The species which first attracted attention was *Pachypsylla celtidis-mamma*. Some observations were recorded during the autumn of 1891, but no regular observations were made till March, 1892. At this time the weather was cold, and the adult insects were hidden away in the cracks and creases of the hackberry bark. It was difficult to find them at first, because their general color closely resembles that of the bark. Large numbers of the adults were found on the sticks and pieces of bark that were lying around under the trees. The old hackberry leaves were examined with special reference to the galls that remained over winter, and in no case was a gall found that contained a living larva, proving that in this case, at least, they had issued from the gall in the fall and transformed to the adult stage. Some difficulty was experienced in finding the old leaves as they had probably been carried away by the wind. If any of the larvæ fail to issue in the autumn, the evidence seems to prove that they perish in the galls.

The chief hiding-place of the adults is in the rough sheltering bark of the

trunks of trees. Toward the top of the tree the bark is younger, less roughened, and therefore furnishes less protection for the insect. Consequently, very few of the adults are found in the top of the tree and out toward the end of the branches.

During the latter part of March, as the days grew warmer, the adults became active, but moved about very little. During the afternoon of April 7th, which was warm and pleasant, they were out toward the ends of the limbs; but as night came on most of them went back to the trunk of the tree, only a few remaining on the slight excrescences of the bark, in the angle between two twigs, or at the base of a large bud. They could be removed from the last named places by simply shaking the limbs. Hence, if they settled down for the winter on the twigs, the many fierce winds would soon sweep them off and carry them to destruction.

About April 30th the buds of the trees began to swell and open out for the year's growth. The Psyllidæ now begin to migrate to the buds and probably feed on the juices of the young tissue.

The first eggs were found on the young leaves May 5th. After this time the adult females could be found depositing eggs in the opening buds and on the underside of the expanded leaves. In the opening buds, where the leaf veins are small and close together, they tend to deposit the eggs in rows between the veins; but as the leaves expand to their full size, they are deposited at random and in large numbers.

Adult females of different species are often found depositing eggs on the same leaf. Hence the larvæ, and later on the galls of all the species are found on one leaf. The time of first egg deposition depends largely on the season and the location of the tree. If, for example, a tree is located in a warm, sheltered place, the adults become active, the young leaves put forth and consequently the eggs will be deposited earlier. If the tree is in a cold, exposed place, the development of both tree and insect is retarded. More time is required for the eggs to develop on exposed trees than on those more favorably located. This indicates that a low temperature retards the development of the embryo. In general the eggs seem to develop best at the temperature most favorable to the healthy growth of the leaves. During the month of May eggs are continually deposited. May 27 a number of eggs on one tree were compared, and judging by their general appearance, some were recently deposited, while others were quite well developed. On a tree very favorably located a number of the young larvæ were found on the upper surface of the leaf. After searching sometime for larvæ, a leaf was found bearing a small gall already closed around the insect. On the upper side of the leaf this gall was but slightly raised, having a small cone-shaped projection. On the under side the gall was roundish and covered with a white frosty pubescence. Careful dissection of the gall revealed a young larva which proved to be identical with those on the surface of the leaf.

From the above stated facts we learn that there is a great variation in the hatching of the larvæ. This variation continues throughout the larval stage and greatly augments the difficulty of working out the successive stages in their development.

From May 27 to June 22 the larvæ appeared in great numbers and many galls were starting. From this time till August 16 larvæ developed quite slowly. The galls, however, developed quite rapidly and in a short time

the species could be distinguished. Many of the galls contained more than one larva. Some of the typical *P. c. mamma* galls were two-celled. Others had a large cell in the normal position, and three or four smaller ones located just above the normal one and around the cup-like depression. In one or two cases five were found, six being the highest number ever found in one gall.

After the latter part of August the changes in the larva were more rapid the abdominal spines are more rapidly developed, and a short time before changing to the adult stage the larva produces a white cottony substance which is quite abundant on the posterior portion of the abdomen. They also undergo one moult a short time before sawing through the gall. This is quite certain, for cast skins have been found with the larvæ.

THE EGGS.

The eggs are oblong-oval, being widest at the middle, where they measure about .15 mm. Their greatest length is about .3 mm. They are broadly rounded at one end, but taper more strongly at the other, thus giving the eggs a pointed appearance. When deposited on the leaf they have a white, glistening appearance. The first eggs were found May 5th, and the first larvæ May 27th. Judging from this, in a general way, it is safe to say that the eggs hatch in about twenty to twenty-two days.

The Larvæ.—Soon after hatching the young larvæ measure about .15 mm. in length and about the same in greatest width. The head and the divisions of the thorax can be but faintly recognized. The abdomen is drawn cephalad, so that only the first segment is visible for its full width, and only the tip of the seventh and the small eighth or anal segment. The antennæ are invisible at first; tarsi, two-jointed, but very indistinct; claws represented by two very small bladder-like bodies. As the larva grows older, the antennæ make their appearance, at first showing but four joints. The compound eyes soon become larger, and the abdomen develops so that five of the segments are visible. The posterior end of the body now presents a lobed appearance, because the last three segments are very small, and drawn cephalad, pushing the central portion of the first five segments forward, while the sides extend backward, forming a lateral lobe on each side. The lines separating the abdominal segments are most clearly seen on the dorsal surface. In some cases they do not reach the sides as closely defined lines, but seem to terminate in little circular, transparent spots, probably representing the division between the tergum and the pleurum.

From June 1st to June 22d, no very marked changes, except in size, take place. The last three abdominal segments are very slow to develop.

The larvæ examined August 16th showed some important changes. The antennæ increased in comparative length, having from six to ten joints. The compound eyes more prominent, mouth-parts larger, and the different divisions quite distinct; legs much larger, more prominent and furnished with numerous hairs. The two joints of the tarsi are quite inconspicuous, the strong curved claws apparently being attached to the distal end of the tibia rather than the tarsus. The two pairs of wings have begun to develop and appear as small transparent pads arising from the mesothorax and the metathorax respectively, and are immovable. The divisions of the sternum are quite distinct, and the coxæ much more prominent. The abdominal segments are all closely defined; the last three, however, are quite closely

united and are more chitinous. The fleshy anal process of the young larva is represented by a chitinous oval spine. On either side of the base of this oval spine can be seen a small tubercle which may represent some of the developing abdominal teeth. Each segment is provided with conspicuous hairs which are shortest at the division of the segment.

Segments seven and eight contain a tube extending longitudinally, and sends out two small, round branches in the seventh segment and terminates in two short curved branches which extend nearly to the tip of the notched oval process. This tube cannot be traced beyond the seventh segment, and probably represents the developing genital organs.

LARVA AND PUPA.

The full grown larva and pupa are described as follows:

Color, in general, bluish green; antennæ and legs more yellowish; "broadly oval in outline; widest at the middle of the abdomen;" head distinctly separated from the pronotum; "including the eyes it is as wide as the mesonotum at middle;" front margin broadly rounded; but not lobed as in the adult, and furnished with numerous hairs. Frontal cones, obsolete; eyes are of a black color, large, reaching the posterior margin of the head, and have a granular appearance. The antennæ differ from the adult form in being thicker and therefore appear to be somewhat shorter. The lateral hairs are more conspicuous. No essential difference in the mouth-parts.

The anterior pair of legs thicker than in the imago; tarsus about the same width as the tibia, and the articulations not so marked as in the adult, thus giving the tibia and tarsus a more blended appearance. The second pair of legs virtually the same as the first, but the third pair has been developed so that in the adult they will be fitted for leaping.

The mesonotum presents three main divisions, as in the adult, but not so clearly defined.

The metanotum is moderately distinct, having the two divisions but faintly marked, and joins the first abdominal segment by a wavy line.

The wing-pads are smooth, shining, and diverge posteriorly, not quite attaining the apex of the second abdominal segment. The anterior ones are larger and wider than the posterior ones, but the latter project internally and posteriorly. During the development of the larva the venation and folding of the wings cannot be seen, but when about to transform the venation and folding are usually quite distinct.

The abdomen is composed of eight segments, is widest at the middle; tapers gradually at the base, but strongly at the top. The first segment is quite short, as wide as the metanotum, and the dorsal surface is ornamented with numerous reddish lines passing obliquely outward and forward from the central portion.

The second segment is nearly twice as long as the first and distinctly separated from it. The third is a little longer and wider than the second, the fourth being widest of all, but about equal in length with the fifth. The last three segments are rather indistinctly separated, much shorter, moreover, and beginning at the latter half of the sixth are more chitinous than the preceding ones. The lateral part of the first five segments especially are separated by slight constrictions, giving them a bulged appearance. The sides of the abdomen are furnished with hairs, which are larger and more numerous on the central portion of each segment, growing smaller

and less numerous toward the joint. They are longest on the posterior part of the abdomen, but do not form a fringe. The eighth segment is drawn out into a horny anal process. The last three segments are usually provided with a number of backwardly-directed teeth, which Dr. C. V. Riley has described as follows:

“Sixth joint at middle of hind margin with two or three very small teeth placed transversely, and with no lateral teeth; seventh joint at middle of hind margin with a transverse row of four teeth, and on each side with two or three (often obsolete) teeth or tubercles; anal joint with the horny process about half as long as the joint and pointed at tip, while at the base of the process, on each side, a lateral row of four small closely placed teeth extends to the underside, and finally on the disk of the joint three teeth, triangularly placed, the posterior being the largest; behind this group, and just above the base of the process, is another tooth, nicked at the tip.”

In many specimens the teeth of the sixth segment were simply indicated by a more chitinous texture than the surrounding tissue. In others these teeth are represented by very slight tubercles, while in still others, they were larger, but indistinctly separated.

By examining a large number of specimens it was found that the teeth of the seventh segment were subject to considerable variation. Usually there were three placed transversely. In some there appeared to be four teeth represented, the central one being the largest and most posterior, having a small tooth on one side of its base, and two small ones on the other. In still others there seemed to be five teeth represented. The large one same as before and then two small ones at the base on either side. In the latter case the four basal spines were placed in a gentle curve around the larger tooth.

Is there any way of accounting for the variation in this group of teeth?

In one specimen having four teeth, one of the two basal ones seemed to be very deeply nicked, while the other was not. In the case where five teeth were present we could consider that both of the small basal teeth were very deeply nicked, even to such an extent that the two parts became separated, thus presenting the appearance of four distinct teeth. The first lateral teeth occur on the seventh segment. From a dorsal view some specimens present only one lateral tooth, but further examination reveals two or three. In one case five lateral teeth were found, the central ones being the larger. No important variations were found in the anal segments, although one of the four small teeth on either side of the anal process was difficult to find.

One very attractive feature of the color of the larva is the blending of the bluish-green parts and the rosaceous markings of the abdominal segment.

TRANSFORMATION OF PUPA TO ADULT.

When exposed to the air for a short time the pupa changes to a slightly paler color. Soon the longitudinal muscles of the abdomen begin to contract and draw it forward in the surrounding pupa skin, and thus allowing it gradually to assume its natural position. In this process the displaced portions of the abdomen catch in front of the depressed divisions of the segments, and by tending to assume their former position uses them as points of support from which to force the body forward.

At the same time, irregular movements of the legs and antennae take place. Soon the pupa skin splits on the dorsal side of the head and thorax, and by the longitudinal contractions of the muscles the dorsulum is first forced out, then the head and antennae, the legs, and finally the abdomen is slowly withdrawn and the pupa skin remains attached by the claws.

At first the adults are of a light yellowish green, but soon change to a darker color. Some specimens seem to have great difficulty in starting the tip of the abdomen, it apparently being held by the anal spines.

THE GALLS.

The galls are subject to great variations. The typical gall of *P. c. mamma* has been described by Dr. C. V. Riley as follows: "This gall on the upper side of the leaf is represented by a cup-shaped impression measuring on an average 4.5 mm. across, with the outer rim always regularly circular, and not, or but slightly, elevated above the surface of the leaf; at the bottom of the cup a small medium nipple (often obsolete); walls of the impression greenish, the bottom more yellowish. On the under side of the leaf it is much larger than any of the other leaf galls, conical, either slightly narrowing apically, or, more frequently, slightly enlarged. The sides are vertical or nearly so; the top broadly rounded without medium depression or central nipple, size very variable, averaging in height 6.7 mm. and in diameter at base 4.5 mm. Color, pale greenish yellow, with the tip more brownish; surface opaque, rugosely reticulate; at the base often covered with a whitish pruinescence, rarely with a few scattered hairs at the tip. The walls of the gall are hard and woody, at bottom averaging 1.75 mm., and at roof 0.75 mm. in thickness. The cell is large, and in cross-section much more crescent-shaped than in the preceding species."

The above description is for the typical form for *P. c.-mamma*. But when the galls are compared we find that the shape and size of the gall is not at all constant. Besides those that are enlarged and rounded at tip, we find a great many that taper gradually to the apex which in some is slightly rounded, in others almost truncate, and in still others slightly depressed. Some have the basal half large and rounded, but at middle it contracts rather abruptly and tapers more strongly to the top which is rounded. In another variation the basal half and the apical half are both rounded and subequal, but separated by an acute circular constriction at the middle. In another form the sides of the gall begin to curve outward just as they rise from the leaf, giving the gall a general circular outline.

By collecting a large number of the galls and placing them singly in little pill-boxes, the adults that issued from each gall could be noted. It was found that *P. c.-mamma* occurred in all the different variations, thus showing that these variations are not of specific importance.

Besides the typical form of *P. c.-mamma*, a number of variations were found in the galls just mentioned, but as they present such a great number of variations, and no constant characters being found as yet, no attempt will be made to describe these varieties.

DISSEMINATION.

Mention was made of the fact that it was difficult to find the old leaves in sufficient numbers to be of any great value for observation, as they had been carried away by the winds. This is one of the means provided for

the dissemination of these insects. In the autumn of 1891 many of the leaves fell to the ground and were carried away by the winds before the larvæ could issue. Many trees are located on the banks of streams into which the leaves may fall, and in case the larvæ has not begun to issue so that the water cannot enter the gall, they may be carried many miles down stream and cast ashore; then the larvæ issue, transform to the adult stage, migrate to the proper host and are in condition to multiply during the following season. In a number of cases the adults have been found in places quite distant from any hackberry trees. At first thought it might be held that a strong wind caught them while on the wing and carried them away. But this is doubtful, since they may have come from leaves that were carried away.

NATURAL ENEMIES.

A number of parasitized larvæ were taken about September 1. At different times small white larvæ were found in the cell with and devouring the Psyllid larva. Upon further examination it was found that the cause for some of the Psyllid larvæ changing to such a brown color and having such a dry, shriveled appearance was that the egg for this white footless larva had been deposited within the Psyllid larva; others were probably deposited outside the Psyllid larva, and so fed externally.

This parasite belongs to the family Chalcididæ in the order Hymenoptera, and attacks all the species found at Ames, Iowa.

Specimens of the Psyllidæ were sent to Dr. C. V. Riley, U. S. Entomologist, Washington, D. C., for determination and the following species were named:

Pachypsylla celtidis-mamma.

Pachypsylla celtidis-minuta.

Pachypsylla celtidis-asteriscus.

Since then specimens of *Pachypsylla celtidis-gemma* have been found, and also a new species that infests the twig of the hackberry. As far as I know, no mention has been made of it, and so liberty will be taken to give the most prominent characters, *i. e.*, those used in determining the species as shown in the table below.

The following is a table prepared by Dr. C. V. Riley for the classification of the three most common species of the genus *Pachypsylla*.

Perhaps many members of the Academy do not have access to this table, and therefore I take liberty to insert it in this article and also add the characters for separating the species which infest the twig of the hackberry.

"Head and dorsum opaque; front wings submembranaceous or subligatine, not rugose; pterostigma, distinct; both marginal cells very long, narrow, and of about equal size and length; anal style of full-grown larva and pupa long.

Dorsulum and mesonotum alutaceous, glabrous; front wings narrowly rounded at tip, widest in basal half; genital segment of female longer than the rest of the abdomen; anal style of full grown and pupa notched at top.....*venusta*.

Dorsulum and mesonotum rugoso-punctate, with distinct but very short, sparse pubescence; front wings broadly rounded at tip, widest in terminal half; genital segment of female shorter than the rest of the abdomen; anal style of full-grown larva and pupa pointed at tip.....*c.-mamma*.

Head and dorsum shining, without pubescence; front wings somewhat convex, basal half not wider than terminal half, broadly rounded at tip, distinctly rugose.

Pterostigma indistinct; marginal cells less narrow, the first shorter and somewhat smaller than the second; genital segment of female shorter than the rest of the body; anal style of full-grown larva and pupa very short, nicked at tip.....*c.-gemma.*”

Pterostigma distinct black, marginal cells less narrow, the first being shorter and more nearly V-shaped than the second; head and thorax black, marked with yellow; antennæ black; wings with a smoky band along the anal and apical margins, and extending along the branching of the veins toward the base. Full-grown larva and pupa larger than the preceding one, anal style moderately long and notched at tip. (Galls oblong-oval, and are located in the twig or base of the larger limbs, just beneath the bark).....*c.-inteneris*, n. sp,

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