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BIOLOGY and CONTROL of the HACKBERRY NIPPLE and BLISTER GALL MAKERS

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BIOLOGY and CONTROL of the HACKBERRY NIPPLE and BLISTER GALL MAKERS

JAMES E. APPLEBY and R. B. NEISWANDER

INTRODUCTION

Members of the family Psyllidae (Chermidae), order Homoptera, commonly called the jumping plant lice, are small insects usually measuring not over 1/5 of an inch in length. The family contains 17 genera according to Tuthill (1943). All seven species of the genus *Pachypsylla* feed on the hackberry tree, *Celtis occidentalis* L. The immature stages stimulate the plant tissues to produce abnormal growths referred to as galls. The following study is primarily concerned with the life cycle of the hackberry nipple gall maker *Pachypsylla celtidismamma* (Riley). This species causes the characteristic mammiform galls on the underside of the hackberry leaf. Another species, *Pachypsylla celtidisvesicula* Riley causes the formation of blister-like leaf galls. The latter species is much more common than the former. The life cycle is very similar to that of the nipple gall maker. In Figure 1 the galls of both species are shown.

Several contributions, particularly those by Smith and Taylor (1953) and Moser (1958), present information on the life histories of the hackberry psyllids. Smith and Taylor also report on control experiments. More recently, work has been conducted by H. E. Thompson (1960). Studies in this report were conducted during 1960-61, primarily in Wayne, Ottawa, and Franklin Counties, Ohio.

THE HOST PLANT

The hackberry is a medium-sized tree occurring east of the Rocky Mountains from Idaho to Massachusetts south to northern Florida, Arkansas, and Kansas. In Ohio the tree is commonly found throughout the state except in the northeastern counties. The nipple and blister gall makers being specific on hackberry are thus limited to their host's range.

Hackberry is planted primarily as a shade tree although at times it is used for lumber. The tree would probably be more popular with homeowners if it were not for the early leaf drop in the late summer, the numerous galls appearing on the leaves, and the abnormal formation of stunted compact twigs occurring irregularly on the branches.

Hackberry grows under a rather wide range of soil conditions, and for this reason H. E. Thompson (1960) speculates that the tree may gain some popularity as a replacement for the American elm where it has been killed by Dutch elm disease and phloem necrosis. The tree will probably be better known in the future, especially since some materials have proven effective in killing the gall makers.

LIFE HISTORY

The hackberry nipple gall maker, *Pachypsylla celtidismamma,* has one generation a year. The adults overwinter in crevices in the bark of hackberry trees, and in cracks and crevices of nearby buildings. During the first warm days of April the adults become active and fly to hackberry trees. Mating and egg laying begin during late April and continue until the end of May (Smith and Taylor 1953). Soon after mating, eggs are deposited on the new leaves of hackberry. About a week later the eggs hatch. The nymphs are motile for only a short time, then begin feeding. The leaf tissues soon cover the nymphs. An interval of 10 to 12 days occurs between hatching and gall formation. The nymphs live

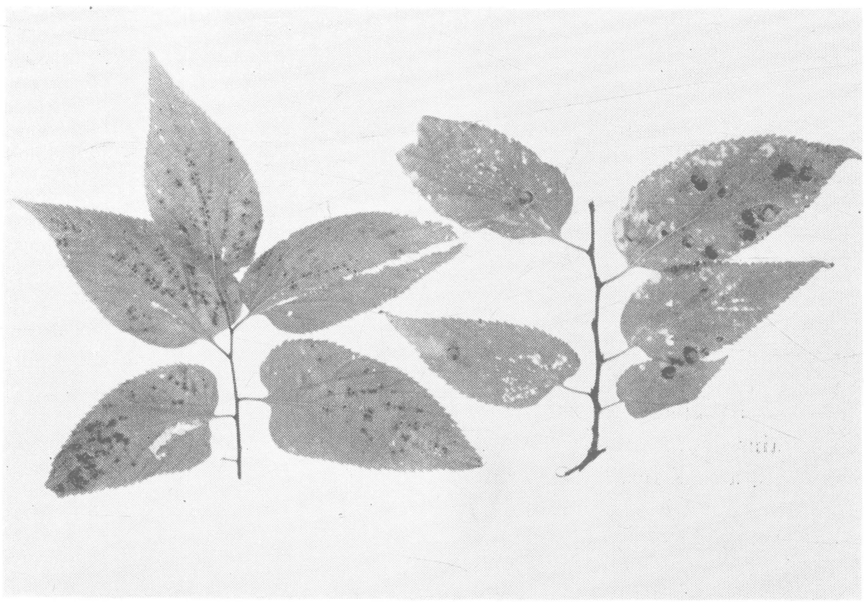


Fig. 1.—Galls on the Lower Surface of Hackberry Leaves. Blister Galls on the Left and Nipple Galls on the Right.

inside the galls throughout the summer, emerging about the middle of September.

THE EGG

The egg of *P. celtidismamma* is ovoid and shining white. The basal end is broadly rounded whereas the apex is pointed (Figure 3, f). Moser (1958) records the average length at .38 millimeters while that of *P. celtidisvesicula* is .30 mm. Eggs that are about to hatch have a slight yellow cast and two red eye spots on the apical third.

THE NYMPHS

There are five nymphal stages of *P. celtidismamma.* The nymph is enclosed within the gall in from 10 to 12 days after hatching. The second, third, and fourth instars are all spent within the interior of the gall.

At intervals throughout the spring and summer of 1960, galls were opened and the nymphal stages were measured and determined to instar. These data are summarized in Table 1. The approximate duration of each stadium is given in Figure 2.

TABLE 1.—The date and length in millimeters of nymphs and adults of P. celtidismamma during 1960.

Date	6/7	6/29	7/15	8/12	9/2	10/15	10/15
Instar	1	2	3	4	5	Adult Male	Adult Female
Number	15	15	15	20	20	10	10
Mean	.35	.71	.95	2.08	3.09	3.70	4.03

FIRST INSTAR (Figure 3, a)—When nymphs of both *P. celtidismamma* and *P. celtidisvesicula* were examined with the aid of a compound microscope, it became apparent that one could identify the first instar of each species irrespective of the gall from which it came. The first instar of *P. celtidismamma* is uniformly light yellow except for the red compound eyes, and light gray markings on the dorsal abdominal segments. The nymphs of *P. celtidisvesicula* are very similar, but differ in having gray markings present on the dorsum of the thorax. The general body shape of *P. celtidismamma* is somewhat more oval than *P. celtidisvesicula,* but this is not true in all cases. The apical enlargement of the abdomen as well as the two, long, terminal, antennal setae are common characteristics of the first instar of both species.

SECOND INSTAR (Figure 3, b)—The absence of the gray markings, the strongly concave tip of the abdomen, and the increase in size are all features that can be used in the identification of this instar. The red compound eyes are persistent as in all subsequent instars.

THIRD INSTAR (Figure 3, c)—The anterior margin of the head is more or less truncate. Wing buds are now apparent. The median of the abdomen is widened longitudinally. Short setae appear on these segments. While the abdominal segments of the first and second instars were yellow, the posterior segments in the third instar are a light tan. The abdomen is tapered caudally into two forked spines which are to become even more noticeable in the next instar.

FOURTH INSTAR (Figure 3, d)—The colorless wing pads have now expanded. Setae are more prominent on the abdomen. The posterior abdominal segments are a darker tan and are also more heavily sclerotized than in the previous instar; apical spines are more highly developed than in the third instar.

FIFTH INSTAR (Figure 3, e)—The reddish brown apical spines reach their fullest development in this instar. That portion of the abdomen upon which they appear is dark brown. In contrast the remainder

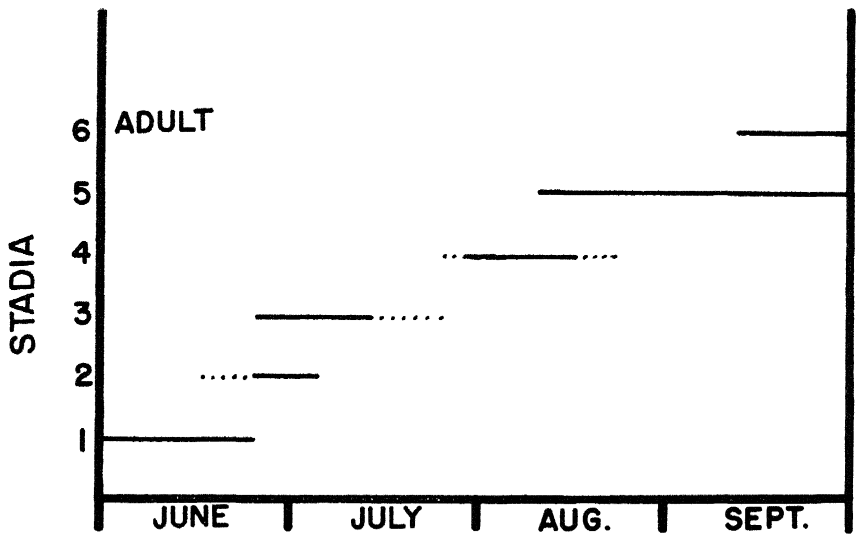
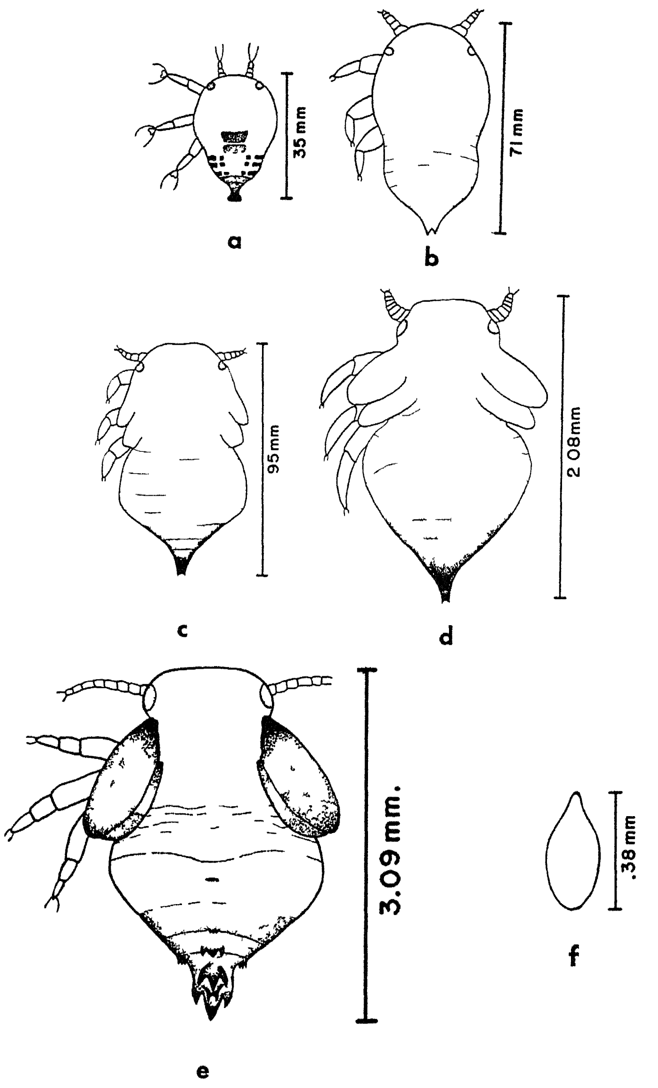


Fig. 2.—Duration of Stadia of P. celtidismamma. (Dotted line indicates possible extension based on information from Moser (1958).



STAGES OF P. C. MAMMA

Fig. 3.—Camera Lucida Drawings of P celtidismamma with Measurements Indicating Average Length of Various Stages: a, First Instar; b, Second Instar; c, Third Instar; d, Fourth Instar; e, Fifth Instar, f, Egg.

of the abdomen appears a light green. The edges of the abdominal segments are often pink. The thorax is yellow-orange, while the wing pads may be of the same coloration, but generally are a light brown. The red pigmentation of the eyes which was prominent in all previous instars is now much darker, becoming almost brown in the latter stages of this instar.

EMERGENCE FROM GALL

The nymph of the fifth instar appears "restless" just before emergence from the gall. It positions itself in such a way that the tip of the abdomen is directed towards the basal portion of the gall or Area A in Figure 4. With repeated thrusts of the abdominal spines against this area, a passageway is made to the surface of the leaf. Upon completion of the exit the nymph turns and crawls head foremost out of the opening and onto the upper surface of the leaf. It moves a short distance from the gall and remains there until the final molt which usually occurs about 30 minutes later.

ADULTS

The adults of *P. celtidismamma* are dark insects having the general appearance of small cicadas (Figure 5). The females are larger than the males and can be distinguished from the latter by the pointed abdomen. The last segment of the male abdomen is formed into a forked genital process. The jumping behavior of both sexes is somewhat simi-

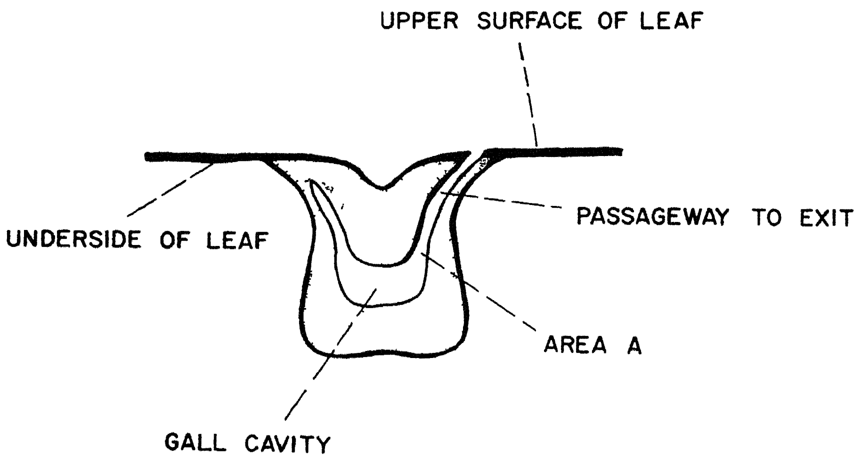


Fig. 4.—Internal Structure of a Nipple Gall, Lateral View (Partially diagrammatic).

lar to that of spittlebugs. Adults of *P. celtidisvesicula* are similar to those of *P. celtidismamma* and behave similarly, but are somewhat smaller in size.

PSYLLIDS AS PESTS—During the autumn months, homeowners with hackberry trees in the vicinity are usually annoyed with the adults invading their buildings. If outdoor painting is attempted during the period of adult emergence, the insects become extremely troublesome by accumulating in the fresh paint.

OVERWINTERING—Observations, made at Columbus, Ohio between January and April, 1960, revealed many inactive adult psyllids overwintering in crevices in the bark of sycamore, hackberry, and oak trees. Sycamore trees that were in the vicinity of hackberry had more psyllids under the bark than did the hackberry. As many as 45 adult psyllids were counted under one 2-square-inch piece of sycamore bark. The hackberry blister gall maker was always more common than was *P. celtidismamma.* In the count of 45 adults only 4 nipple gall makers.

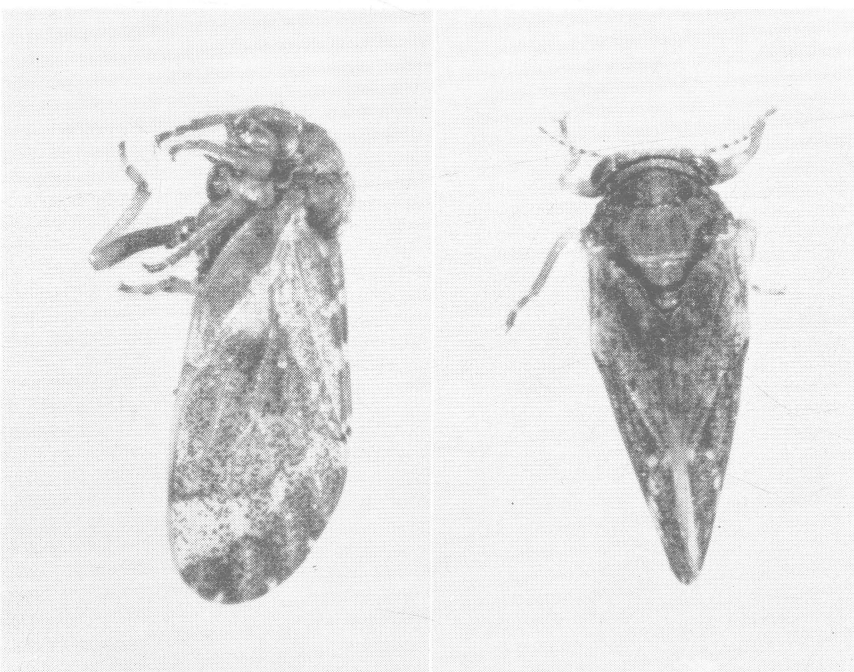


Fig. 5.—An Adult of P. celtidismamma.

On April 13, 1960, the temperature rose to 78° at Columbus, at which time many psyllids were found hopping on the hackberry branches and on nearby bushes, but no mating was observed. On April 18, after several days of cold weather, psyllids were again found under bark. Obviously, during short periods of warm spring weather the adults become active and may be found on the twigs of hackberry, but as the temperature drops, they again move to the shelter of the bark. This behavior was also noted by Mally (1894).

MATING AND EGG LAYING—At the Experiment Station on April 25, mating of *P. celtidisvesicula* was observed on hackberry trees in the Secrest Arboretum. Copulation takes place on the twigs or on the newly opened leaf buds of hackberry. Both adults face in the same direction. The male positions itself beside the female and raises its inner forewing slightly over that of the female's wings. The female is held by the male's prothoracic leg which extends over her head or thorax. While this action is occurring, the male's abdomen is curved so that the apical genital organs meet with those of the female.

Eggs were found deposited near the tips of the hackberry leaves, which were partially exposed from the leaf bud. Since the leaves had not yet unfolded, the upper surface of the leaf was unexposed to the psyllids. However, occasionally a psyllid will insert its ovipositor between the tips of the folded leaves, and deposit eggs on the upper surfaces. Of eggs counted on April 28, only 4 percent occurred on the upper leaf surface.

The eggs are usually laid between the leaf veins. They are protected by the pubescence of the hackberry leaf and a cementing substance secreted by the female during egg laying.

No eggs of either species were found after May 31.

INITIAL FEEDING OF NYMPHS—Upon hatching the nymphs of *P. celtidisvesicula* move to the upper surface of the leaf where they begin feeding and become stationary. About a week later they are enclosed within the leaf tissues. Tuthill (1943) indicates that the nymphs of *P. celtidismamma* feed on the lower side of the leaf and are soon enclosed within the gall.

STRUCTURE OF GALL

A typical gall of *P. celtidismamma during* September is cylindrical, and occurs on the underside of the hackberry leaf. The apical portion is usually somewhat enlarged. A slight depression occurs on the upper side of the leaf opposite the gall. Variation in shape of galls was noted.

In some instances, fusion of galls was observed. Figure 4 illustrates the internal structures of a gall during mid-September.

The tissues surrounding the cavity are hard and gritty. The cavity is crescent shaped and narrow. M. T. Cook (1904) mentioned that four well defined zones occur in young galls, but later in development most of the areas became quite hard possibly due to the abundance of sclerenchyma cells.

PARASITES AND PREDATORS

At Wooster, Ohio during 1960, parasites played an important role in the control of the nipple gall maker. Of 100 gall cavities examined on August 19, 47 percent of the psyllid nymphs were parasitized. Another count made on September 17 showed 51 percent parasitism. This increase can be attributed to the internal parasites which were not recognizable on August 19. The relative abundance of each parasite is indicated in Table 2.

Most life cycles of the parasites of *P. celtidismamma* are complex and beyond the scope of this report; nevertheless two of the more common parasites are mentioned. Moser (1958) gives much more complete information on the life histories.

TABLE 2.—Percent of P. celtidismamma nymphs destroyed by natural enemies per 100 galls counted. Wooster, Ohio. 1960.

August 19, 1960	Percent	September 17, 1960	Percent
Torymidae **Torymus pachypsyllae**	32	Torymidae **Torymus pachypsyllae**	22
Eulophidae **Moserina sp.**	7	Encyrtidae **Psyllaephagus pachypsyllae**	12
Eulophidae **Hypertetrastichus sp.**	4	Eurytomidae **Eurytoma semivanae**	12
Cecidomyiidae **Parallelodiplosis sp.**	3	Eulophidae **Monserina sp.**	4
Curculionidae **Conotrachelus buchanani**	1	Eulophidae **Hypertetrastichus sp.**	2
Total	47	Total	52

TORYMUS PACHYPSYLLAE (ASHMEAD)

A common parasite of the nipple gall maker is *Torymus pachypsyllae* (*Hymenoptera*: *Torymidae*). It overwinters as a larva inside the gall cavity of the fallen leaf. A ventral view of a larva is shown in Figure 6. The numerous setae are characteristic of this larva.

Galls from the previous year were collected at Columbus on April 18, 1960, and placed in rearing cages in the insectary at Wooster. Adults of *T. pachypsyllae* began emerging from galls on July 28, and continued until August 22.

Due to the time interval during which they appear, and the brilliant green of the head and thorax of both sexes, the adults are easily identified. The female differs from the male in having a triangular

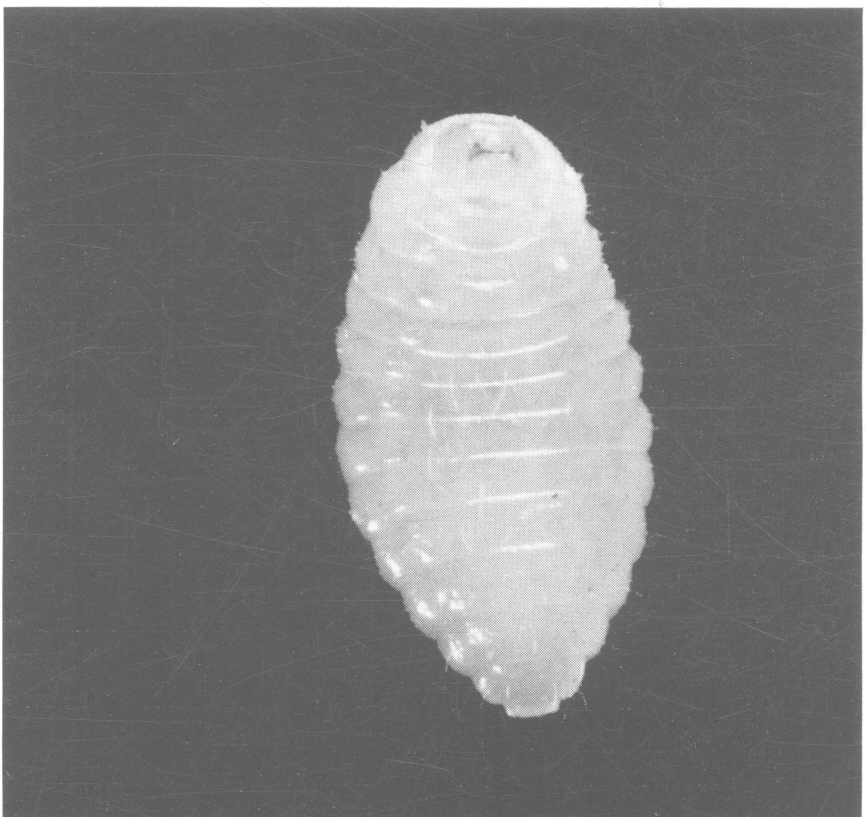


Fig. 6.—Ventral View of a Torymus pachypsyllae Larva.

shaped abdomen and long ovipositor (Figure 7). The ovipositor alone measures 2.3 mm. which is almost as long as the remaining parts of the body combined.

On August 19 three females were seen inserting their long thin ovipositors into the sides of nipple galls. Moser (1958) notes that oviposition requires about one-half hour during which time the nymph is stung and the egg is deposited near the host. The parasitic larva lies beside the paralyzed host and eventually removes most of the liquid contents of the body.

Two generations occur each year. Adults from the first generation begin to emerge around September 5, and produce the second generation which will overwinter in the galls; however, not all of the first generation pupates in the fall.

PSYLLAEPHAGUS PACHYPSYLLAE (HOWARD)

Another parasite is *Psyllaephagus pachypsyllae* (*Hymenoptera*: *Encyrtidae*) which overwinters as an exarate pupa inside the dead nymph of the third or fourth instar of *P. celtidismamma* (Figure 8).

Fig. 7.—Lateral View of an Adult Female Torymus pachypsyllae.

The adult possesses a metallic green head and thorax, but differs from *T. pachypsyllae* in emerging at an earlier date (Figure 9). Adults emerged from the galls between May 16-25.

CONOTRACHELUS BUCHANANI SCHOOF

A predator which occurs less commonly than the above mentioned parasites is *Conotrachelus buchanani* (*Coleoptera*: *Curculionidae*). The adult is a small brown weevil about 3.5 mm. in length (Figure 10, a). The light markings are tan.

The larva of this weevil (Figure 10,b) feeds on the interior of the gall as well as the psyllid nymph. Upon completion of its feeding the larva burrows to the exterior, falls to the ground, and there pupates. The larvae make their exit from the galls during the latter part of July and early August.

Larvae emerged from galls that were collected at Columbus on July 28 and stored in plastic bags. A total of 35 larvae were placed in moistened peat moss on August 3; later 23 adults were collected from this material. Similarly 40 larvae were put in top soil, but only 3 adults emerged from this medium. All adults emerged between August 24 and September 2. On September 8, several adults were found feeding

Fig.8.—Dorsal View of a Fourth Instar Nymph of P. celtidismamma Parasitized Internally with Psyllaephagus pachypsyllae.

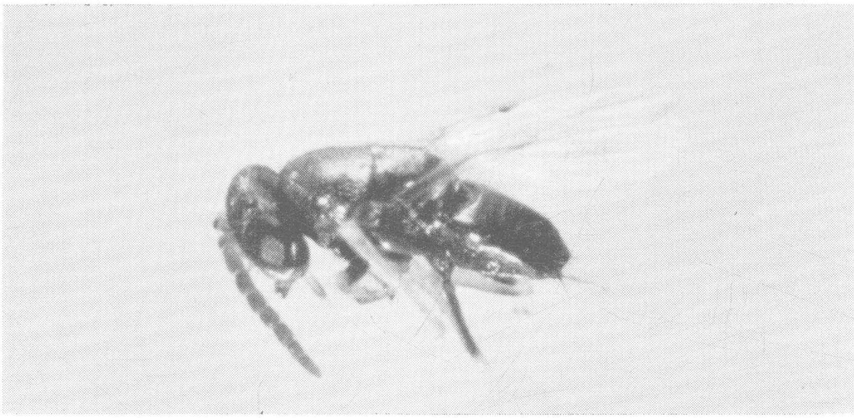


Fig. 9.—An Adult Psyllaephagus pachypsyllae, Lateral View.

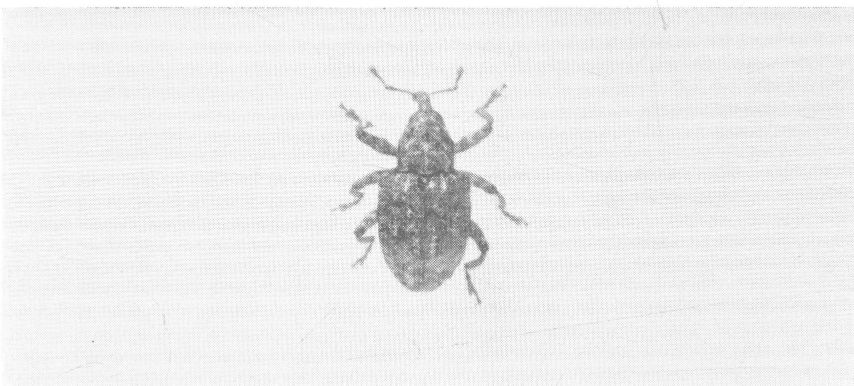


Fig. 10, a.—Dorsal View of an Adult Conotrachelus buchanani.

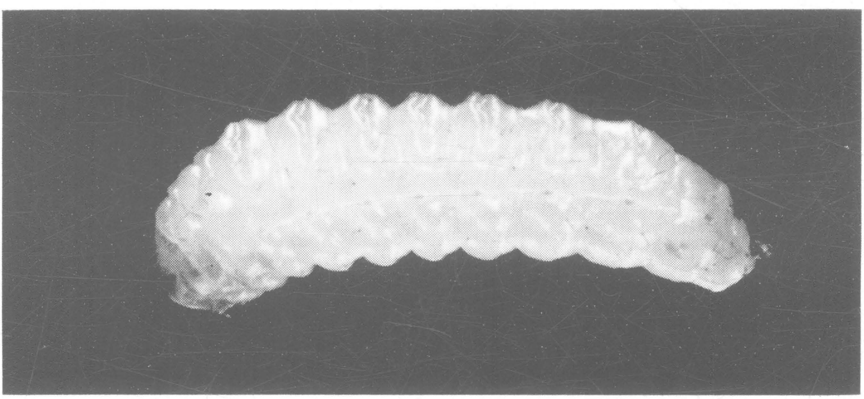


Fig. 10, b.—Contrachelus buchanani Larva, Lateral View.

on the exterior of nipple galls. According to Moser, the weevil overwinters as an adult.

LEAF DROP

Leaves began falling from a hackberry tree at Wooster as early as August 1. These leaves were heavily infested with nipple galls. To determine whether there might be some relationship between the number of galls appearing on a leaf and the early leaf drop, 100 leaves found on the ground were counted on August 11 and the number of galls recorded. On September 16, a similar count was made of 100 infested leaves occurring on the tree. The results showed highly significant differences between the means, indicating that an abundance of nipple galls may cause early leaf drop.

CONTROL INVESTIGATIONS

The psyllid nymphs are enclosed in galls during most of the summer months and thus are protected from the action of most insecticides. The immature insect is exposed only during the period extending from the hatching of the egg to enclosure within the gall. This period normally is 7 to 10 days in length. The problem of control is complicated further by the fact that egg laying occurs during a period of more than one month. Control of adults would seem impossible because of their continued movement from overwintering quarters to hackberry trees.

Some disagreement exists among research workers concerning the effectiveness of specific spray materials applied to hackberry trees when the buds are opening. Nicotine sulfate was long a favorite as a control material. Felt (1930) stated that on a tree on Long Island, New York, sprayed on April 30 and again on May 13 with a mixture of molasses, Black Leaf 40, soap, and water the number of galls formed was reduced by more than 99 percent. Many dead adults were stuck to the leaves.

Two sprays of either lindane (1 lb. emulsion/100 gallons) or dieldrin (1 gal. 24 percent emulsion/100 gallons) applied in the spring is recommended by Severin (1951). The first spray was to be applied to trees when the leaves were about one-third grown, while the second was to be applied two weeks later. These applications did not give 100 percent control, but the differences between the sprayed and the unsprayed trees were striking.

Smith and Taylor (1953) reported that a single spray of Black Leaf 40, soap and water had no effect on the adults. When combined with Superla summer oil the combination reduced the number of blister galls formed between 57 and 83 percent. They also reported that single sprays of DDT and TEPP failed to give suitable control while EPN and BHC were partially effective.

A more recent recommendation by the Wisconsin Department of Agriculture (1960) consists of two to four applications of nicotine sulfate applied at weekly intervals, or a single application of Sevin, chlordane, or dieldrin when the buds are beginning to swell.

Thompson (1960) reported that Sevin, chlordane, and dieldrin produced satisfactory results in control of nipple galls when applied as a single spray at the time when leaves began unfolding.

Schuder (1959) stated that the prevention of nipple gall formation can be accomplished by spraying the newly developing leaves with lindane or BHC early in May.

SPRAYS APPLIED TO THE FOLIAGE

LINDANE

A spray containing lindane at the rate of one pound of the 25 percent wettable powder in 50 gallons of water was applied to hackberry trees at Wooster on May 6, 1960. The leaves were just appearing at that time, and numerous eggs, nymphs, and adults of the blister gall maker were observed.

On August 19 a count of the galls on both treated and untreated leaves showed that the spray was only partially effective. Twenty outer branches were pruned from two treated and two untreated trees. Only the terminal shoot of each branch was considered because its leaves were normally the first to unfold and thus would contain the greatest number of eggs. The leaves appearing on each terminal shoot were numbered from the base to the tip, in the order in which they unfolded. All 20 of the first and second leaves on the twigs that were sprayed with lindane were free of galls, and only one of the third leaves was infested (Figure 11). In contrast all leaves numbered from one to five on the untreated twigs were infested (Figure 12).

In comparing Figures 11 and 12 it will be noted that in all cases a sharp drop in the infestation occurred with the seventh leaf. This can be attributed to the cessation of egg laying. The results of this test indicate that 2 or possibly 3 applications of lindane at intervals of approximately 10 days would be required for complete control.

On June 16 and again on August 16, 1961 infested hackberry trees were sprayed with lindane at the same rate after all psyllid nymphs were enclosed in galls. In records taken during succeeding weeks no mortality due to the lindane could be detected (Table 3). Apparent-

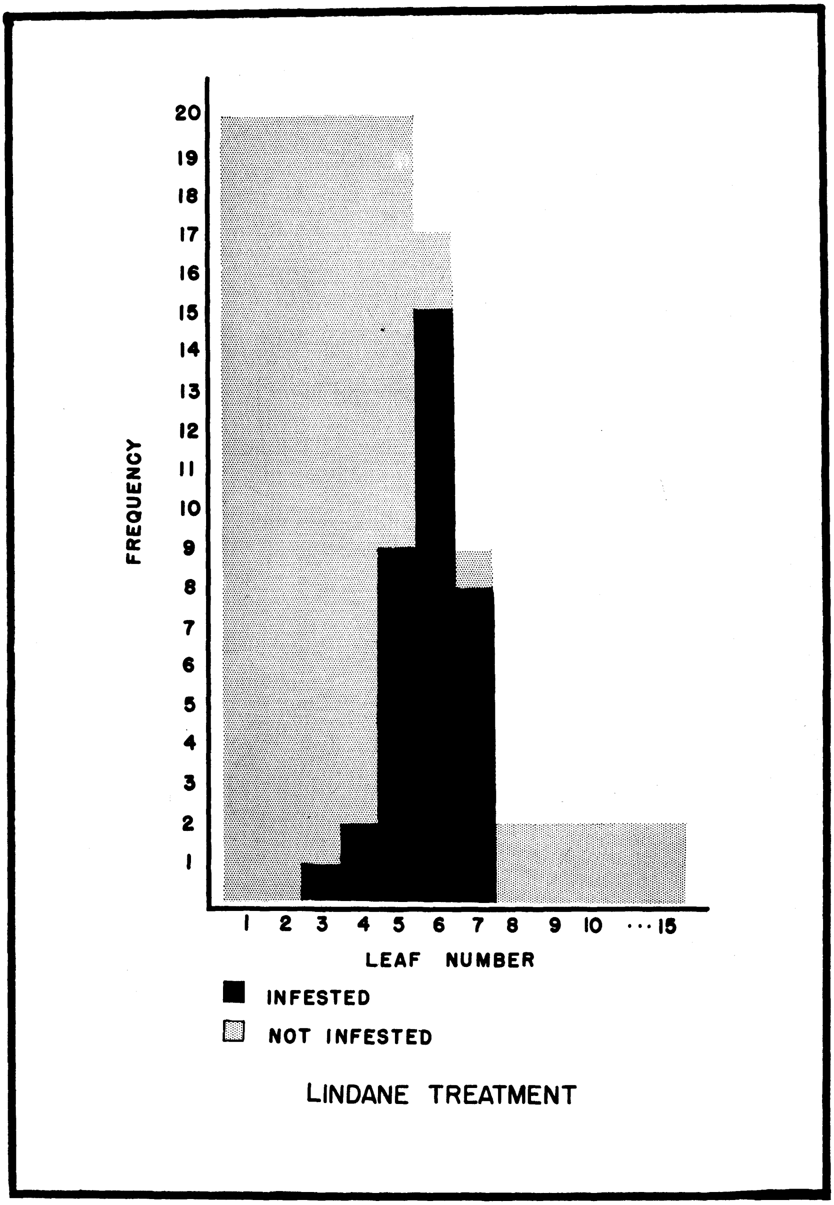


Fig. 11.—Histogram for Data of Leaves Treated with Lindane.

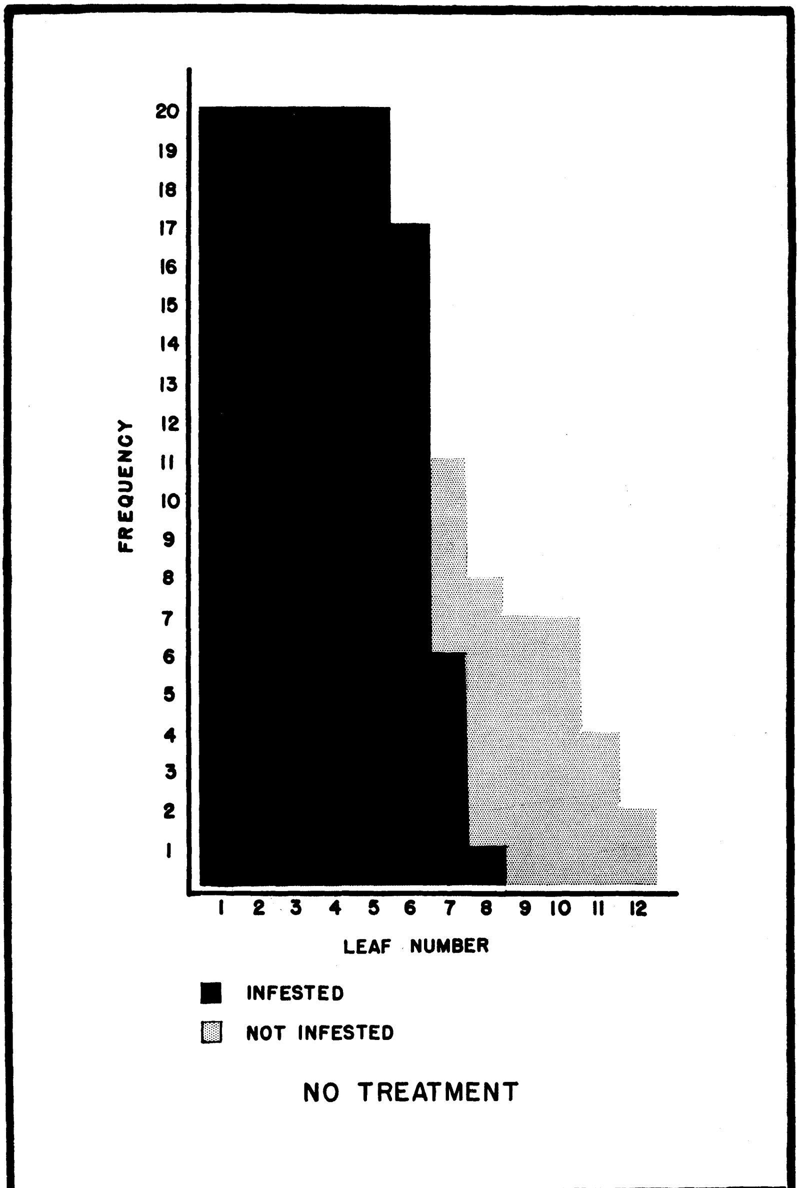


Fig. 12.—Histogram for Data of Untreated Leaves.

TABLE 3.—Spraying experiments for control of the blister gall maker. East Harbor State Park. 1961.

Materials used in 100 gallons water	Date of application	Date mortality recorded	Gall makers		
			No. alive	No. dead	Percent dead
Lindane 25 percent WP, 2 pounds	June 16	July 19	97	3	3
Lindane 25 percent WP, 2 pounds	Aug. 16	Aug. 31	98	2	2
Malathion 57 percent EC, 1 quart	June 13	July 20	—	—	95*
Malathion 57 percent EC, 1 quart	Aug. 16	Aug. 31	73	27	27**
Diazinon 25 percent WP, 2 pounds	June 13	July 20	—	—	95*
Diazinon 25 percent WP, 2 pounds	Aug. 16	Aug. 31	1	99	99**
Check, not treated		Aug. 31	197	3	2

*Nipple gall makers were also killed.
**Nipple gall makers were not killed.

ly the gall makers enclosed within galls were adequately protected from the action of the lindane.

MALATHION

Five hackberry trees at East Harbor State Park were sprayed with malathion on June 13, 1961. The trees were approximately 25 feet in height and were infested with both nipple and blister galls. Gall makers of both species were already enclosed, but the galls were still succulent. Malathion was used at the rate of 1 quart of the 57 percent emulsifiable concentrate in 100 gallons of water.

In order to measure the effectiveness of the spray application, 5 branches approximately 1/4 inch in diameter were taken at random from the sprayed foliage on July 20 by means of a tree pruner with a 9-foot handle. Four infested leaves were taken from each sample, and five galls on each leaf were opened by means of a pointed forceps. The number of living nymphs was recorded. As shown in Table 3, excellent control of both species was obtained. Only occasionally was a blister gall, containing a living nymph, found on the treated leaves. Apparently with the early death of the psyllid nymphs, the galls became incorporated into the leaf tissues leaving no trace of their presence. Thus only an approximate mortality can be given. In no case were any living nymphs found in the nipple galls examined.

Another group of hackberry trees in the same area were sprayed with malathion at a similar rate on August 16. The galls were somewhat hardened and impervious at that time and as indicated in Table 3, the spray was less effective.

DIAZINON

Diazinon was also tested for control of both gall makers at East Harbor State Park. Infested hackberry trees were sprayed on June 13 and on August 16. The Diazinon 25 percent wettable powder was used at the rate of 2 pounds in 100 gallons of water. Mortality records taken in the manner described previously showed that both sprays were effective in control of the blister gall maker (Table 3), but only the earlier application killed the gall makers inside the nipple galls. An approximate mortality is shown in Table 3 for the reason explained under malathion.

SOIL APPLICATIONS OF SYSTEMIC INSECTICIDES

Relatively large and expensive spraying machines are required for the proper spraying of large shade trees. Such machines are seldom available for use by home owners. Consequently, systemic insecticides that are taken up by plant roots when applied on the soil, were tested in control of hackberry gall makers.

DEMETON AND PHOSDRIN AFTER GALL FORMATION

Two hackberry trees infested with blister galls were treated with Phosdrin and two were treated with demeton on June 15, 1960. Both chemicals were used at the rate of 3.5 pounds of the toxicant per acre. Both commercial preparations used contained two pounds of toxicant per gallon. Fifteen milliters of concentrate was diluted in 2 gallons of water and applied with a sprinkling can to 100 square feet of soil surface. In each case the area under the spread of the branches was treated.

An examination of the psyllid nymphs inside the galls on August 19 showed no mortality that could be attributed to either treatment.

DIMETHOATE AFTER GALL FORMATION

On August 23, 1960 dimethoate was applied at the rate of 30 pounds of toxicant per acre to 1 hackberry tree, and at the rate of 50 pounds per acre to another. In both cases the required amount of concentrate for 100 square feet of soil surface was diluted in 2 gallons of water and applied with a sprinkling can as described above.

Mortality counts made where systemic insecticides were used were similar to those following the use of malathion and diazinon except that a larger number of galls were examined. Five branches were taken from each tree and five infested leaves were taken at random from the composite sample. From 10 to 20 galls were opened on each leaf.

Such a count of the living and dead blister gall makers was made on September 29 and 30 as shown in Table 4. At that time most of

TABLE 4.—Mortality of blister gall makers following soil applications of dimethoate at Wooster in 1960 and at East Harbor State Park in 1961.

Material used	Date of application	No. alive	No. dead	Percent dead
Dimethoate, 30 pounds per acre	Aug. 23, 1960	9	116	92.8
Dimethoate, 50 pounds per acre	Aug. 23, 1960	3	122	97.6
Check-not treated (1960)		115	10	8.0
Dimethoate, 30 pounds per acre	June 13, 1961	0	250	100*
Dimethoate, 20 pounds per acre	July 20, 1961	56	344	86**
Dimethoate, 15 pounds per acre	July 20, 1961	191	9	4.6**
Check-not treated (1961)		197	3	1.5

*Nipple gall makers also killed.
**Nipple gall makers not killed.

the living gall makers had emerged, but the empty galls were evidence of the emergence of living insects and were counted as such. As indicated in Table 4, both treatments killed a high percentage of the nymphs inside the galls.

Several days after the applications were made, although no injury to the trees was evident, severe leaf burn was observed on weeds growing beneath the treated trees. In order to investigate the possibility of injuring lawn grasses, dimethoate was applied to blue grass plots at the rates of 15, 30, and 50 pounds per acre. Two plots of 100 square feet were treated with each concentration. No injury to blue grass could be detected in any plot. White clover was injured slightly by dimethoate at the lowest rate and rather severely at the 50 pound rate but was not killed.

At East Harbor State Park on June 13, 1961, 5 trees approximately 25 feet in height were treated with soil applications of dimethoate at the rate of 30 pounds of the toxicant per acre. On June 30 foliar burning was evident on three of the five trees. By July 20 severe foliage injury was noted on four trees, but all recovered later in the summer. Excellent control of both gall makers was obtained (Table 4).

About 5 weeks later 5 additional hackberry trees were treated with dimethoate at the rate of 20 pounds of the toxicant per acre and 2 trees were treated at the 15 pound rate. As indicated in Table 4, fair control of the blister gall maker was obtained at the 20 pound rate and poor control at the 15 pound rate. In both cases poor control of the nipple gall maker was noted. No foliar damage was observed.

PHORATE AFTER GALL FORMATION

Phorate in the form of 10 percent granules was tested in control of the blister gall maker at East Harbor State Park in 1961. Five trees approximately 25 feet in height were treated on June 13 after galls were formed. The granules were simply broadcast on the ground under the spread of the branches at the rate of 2 grams per square foot of soil surface, or 19 pounds of the toxicant per acre. After the granules were applied the area was watered with a sprinkling can in order to wash the granules into the soil.

An examination of 200 blister galls from the treated trees on July 20 showed that 82 percent were dead. A total of 400 were examined on August 31, and 95 percent were dead.

Relatively few nipple galls were present on the treated trees, but of those examined on July 20 and August 31, nearly all contained living nymphs.

TRUNK INJECTIONS OF DIMETHOATE

Dimethoate was injected into trunks of two hackberry trees on April 18, 1960 in an attempt to prevent gall formation. Three holes, 1 inch in diameter and 2 inches deep, were drilled into the trunks of each of 2 trees about 12 inches above the ground. The trees were approximately 70 feet in height. One tree received 30 milliters of the 46 percent liquid concentrate of dimethoate and the other 50 milliters distributed equally in the 3 holes. Corks were then inserted into the holes.

One month later both nipple and blister galls were present in relatively large numbers on both trees. No reduction in gall formation caused by the dimethoate could be detected.

SUMMARY

The hackberry nipple gall maker, *Pachypsylla celtidismamma,* causes nipple-like galls on the underside of hackberry leaves. *Pachypsylla celtidisvesicula* causes blister galls. The adults overwinter in protected places. Egg laying begins in late April and continues for a duration of a month or more. There are five nymphal stages. Early leaf drop has been shown to be associated with the number of nipple galls appearing on a leaf. Natural control by parasites and predators may reduce the nipple gall maker population by 50 percent or more.

A foliar spray of lindane applied when leaf buds were opening gave only partial control of blister galls. Malathion gave control of both nipple and blister gall nymphs when applied on June 13, but was not effective when applied during mid-August. Results with a single ap-

plication of diazinon on June 13 gave good control of both gall-maker nymphs. This spray was also effective in controlling the blister gall nymphs when applied on August 16, but gave poor control of nipple gall nymphs.

Soil application of dimethoate at the rate of 30 pounds of the toxicant per acre beneath the tree canopy, gave control of both gall makers when applied on June 13, but severe foliar burning resulted. Later in the summer the same rate applied to one tree gave 93 percent mortality of blister gall nymphs and no foliar damage. Slight damage may result to white clover at this rate. Fair control of blister gall nymphs was obtained at 20 pounds technical per acre, when applied on July 20. Poor control resulted from using 15 pounds technical per acre. Phorate at 19 pounds technical per acre as a soil application on June 13 controlled the blister gall nymphs, but was ineffective against the nipple gall nymphs. Demeton and Phosdrin did not control psyllid nymphs when applied to the soil on August 19.