$a_1$. Body surface thickly beset with large hemispherical bosses ..... *Proceratium*
$a_2$. Body surface without bosses or with only 1 pair on the prothorax ..... *Discothyrea*

Group E

1. Mandibles typhlomyrmeciform (Fig. 18, Id) .... ..... *Typhlomyrmex*
2. Mandibles onychomyrmeciform (Fig. 18, IVa) .. ..... *Onychomyrmex*

## REFERENCES CITED


**Arnold, G.** 1914. Nest-changing migrations of two species of ants. Proc. Rhodesian Sci. Ass. 13: 25–42.

**Brown, W. L.** 1958. Contributions toward a reclassification of the Formicidae. II. Tribe Ectatommini. Bull. Mus. Comp. Zool. Harvard Coll. 118: 175–362.

1960. Contributions toward a reclassification of the Formicidae. III. Tribe Amblyoponini. Ibid. 122: 145–230.

1963. Characters and synonymies among the genera of ants. Part III. Some members of the tribe Ponerini. Breviora 190. 10 p.

1965. Contributions to a reclassification of the Formicide. IV. Tribe Typhlomyrmecini. Psyche 72: 65–78.

**Brown, W. L., and R. W. Taylor.** 1970. The Insects of Australia. Superfamily Formicoidea. Div. Entomol., C.S.I.R.O. University of Melbourne Press. p. 951–9.

**Clark, J.** 1951. The Formicidae of Australia. Vol. I. Subfamily Myrmeciinae. Commonw. Sci. Ind. Res. Organ., Melbourne, Australia. 230 p.

**Emery, C.** 1911. Hymenoptera, Fam. Formicidae, Subfam. Ponerinae. *In* Wytsman's "Genera Insectorum". Fasc. 118, 125 p.

**Gotwald, W. H., and W. L. Brown.** 1966. The ant genus *Simopelta*. Psyche 73: 261–77.

**Kempf, W. W.** 1966. A synopsis of the Neotropical ants of the genus *Centromyrmex* Mayr. Stud. Entomol. 9: 401–10.

**Taylor, R. W.** 1965. A monographic revision of the rare tropicopolitan ant genus *Probolomyrmex* Mayr. Trans. Roy. Entomol. Soc. London 117: 345–65.

1967. A monographic revision of the ant genus *Ponera* Latreille. Pac. Insects Monogr. 13. 112 p.

**Wheeler, G. C., and J. Wheeler.** 1952. The ant larvae of the subfamily Ponerinae. Amer. Midland Natur. 48: 111–44; 604–72.

1957. The larva of Simopelta. Proc. Entomol. Soc. Washington 59: 191–4.

1964. The ant larvae of the subfamily Ponerinae: supplement. Ann. Entomol. Soc. Amer. 57: 443–62.

1970. The larva of Apomyrma. Psyche 77: 276–9.

1971. The larvae of the ant genus Bothroponera. Proc. Entomol. Soc. Washington 73. (In press.)

**Wheeler, W. M.** 1918. A study of some ant larvae, with a consideration of the origin and meaning of the social habit among insects. Proc. Amer. Phil. Soc. 57: 293–343.

1922. The ants collected by the American Museum Congo Expedition. Bull. Amer. Mus. Natur. Hist. 45: 39–269.

**Wilson, E. O.** 1958. Studies on the ant fauna of Melanesia. III. Rhytidoponera in western Melanesia and the Moluccas. IV. The tribe Ponerini. Bull. Mus. Comp. Zool. Harvard Coll. 119: 303–71.


# Observations on the Morphology and Biology of the Ladybird Beetle *Stethorus punctum*[1,2]


RICHARD COLBURN AND DEAN ASQUITH[3,4]

Department of Entomology, The Pennsylvania State University, Fruit Research Laboratory, Arendtsville 17303



## ABSTRACT

*Stethorus punctum* (LeConte) (Coleoptera: Coccinellidae) is an important native predator of the European red mite, *Panonychus ulmi* (Koch), in southcentral Pennsylvania. The only definite means of separating this species from others of the genus is by the genitalia, which are illustrated with comparative measurements for *S. punctum* and *S. punctillum* Weise. There are 3 generations a year of *S. punctum* in this area. About 25 days from the time the adult emerges from the pupal case it begins to lay eggs. The incubation period is 5 days. The larva passes through 4 stages in a total of 12 days. The pupa completes development in 5.5 days. The adults overwinter in the duff near the trunk of apple trees, entering overwintering quarters in late October, and emerge into the trees in mid-April of the following year.


During spring and summer of 1967 a predator survey was initiated in south-central Pennsylvania apple orchards as a preliminary step to a more thorough study of some of the principal predators of the European red mite, *Panonychus ulmi* (Koch) (Horsburgh and Asquith 1968). One of the most frequently collected predators was a small, black ladybird beetle, *Stethorus punctum* (LeConte). Because Horsburgh and Asquith (1968) reported this predator as being in commercially sprayed orchards, this study was undertaken to determine the morphological characters and life history of *S. punctum* in south-central Pennsylvania.

*S. punctum* was described by LeConte in 1852 as *Scymnus punctum*. Differences between *S. punctum* and *S. punctillum* Weise, in the male and female genitalia, were pointed out by Brown (1950). In addition to a description of the adult of *S. punctum*, Duffey (1891) published a brief description of its full-grown larva and pupa, with illustrations. Robinson (1952) published a brief account of the life cycle of *S. punc-*

[1] Coleoptera: Coccinellidae.


[2] Authorized for publication Mar. 2, 1971 as paper no. 3938 in the journal series of the Pennsylvania Agricultural Experiment Station. This research was supported in part by USDA, Agr. Res. Serv. grant no. 4023. Received for publication Mar. 11, 1971.



[3] Graduate Assistant and Professor of Entomology, respectively, Department of Entomology.



[4] Acknowledgment is made of the valued assistance of Vincent W. Spangler.

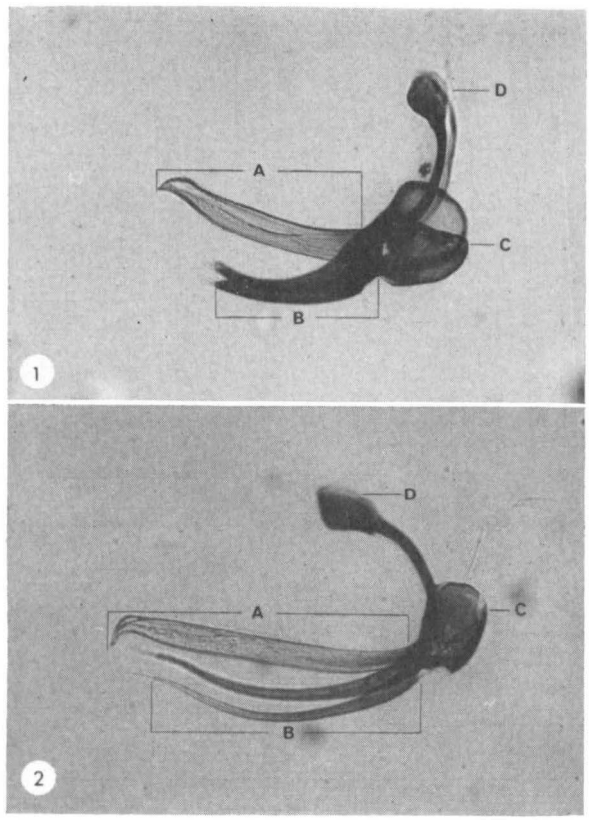


FIG. 1, 2.—*Male* genitalia of *Stethorus*. 1, *S. punctum*, 2, *S. punctillum*. (A, aedeagus; B, parameres; C, basal plates; D. trab. 150×.)

*tum* in Manitoba. More recently, Sweetman (1958) published a short resume of the biology of the species. It occurs from Lake Superior to Pennsylvania and Delaware, North Carolina, and Kansas.

## MATERIALS AND METHODS

All life stages of *S. punctum* were collected in apple orchards and returned to the laboratory for examination of morphological characters and biological development. Measurements were made on a calibrated Stereo-Zoom microscope equipped with a micrometer disc. The lengths and widths of 20 adults, 30 eggs, 20 first-stage larvae, and 20 pupae were measured.

Male genitalia were dissected from 15 *S. punctum* and 5 *S. punctillum*.[5] The genitalia were then cleared and mounted according to the procedure outlined by Wirth and Marston (1968). Measurements were made of the length of the parameres and aedeagus (Fig. 1, 2). Photographs were taken with a Leitz Laborlux® microscope (E. Leitz, 468 Park Ave. S, New York, N. Y. 10016).

To study the life cycle of *S. punctum* and to determine the number of generations a year, cages were set up in the field in 1969. Overwintered adults of *S. punctum* were collected when they first appeared, Apr. 18 and 22, 1970, in orchards at Quincy (population 1) and Biglerville (population 2), respectively. They were collected by brushing them from apple leaves into styrofoam cups with a camel's hair brush.

The beetles were transported to The Pennsylvania State University Fruit Research Farm at Biglerville where they were placed into 6×6×7-ft saran cages (Lumite Division, Chicopee Mills Inc., Cornelia, Ga. 30531). These cages were over 5-year-old 'Red Delicious' apple trees which were heavily infested with European red mites. Numbers of mites were kept constantly high by regularly placing mites in the cages to assure a sufficient food supply for the beetles' development. The cages were examined every other day to determine the stage of the beetles. Adult beetles were allowed to lay eggs in the cages and then the adults were removed as soon as the 1st larvae appeared. The larvae were allowed to feed and pupate. After emergence, the adults were moved to a clean cage identical to the original cage and with an ample food supply. These steps were followed for each generation throughout the summer.

Studies of overwintering were conducted for 2

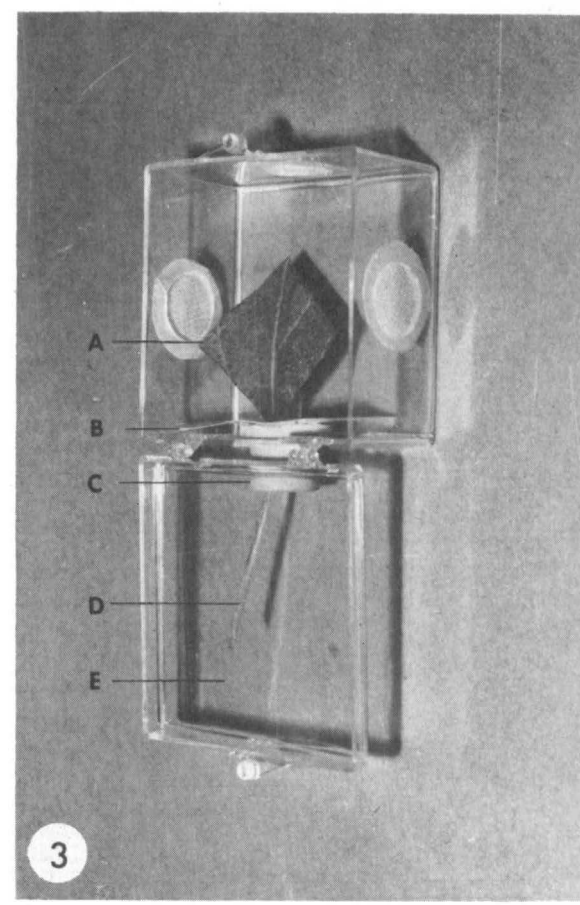


FIG. 3.—Cage used to confine *S. punctum* adults and larvae during feeding-rate test. (A, 1-in.² apple leaf; B, 1×1½-in. paper with Tanglefoot; C, stopper; D, petiole; E, lid.)

[5] Specimens from Canada Department of Agriculture, Entomology Research Institute, Central Experiment Farm, Ottawa, Canada.

years to attempt to locate the beetle's hibernaculum. In the spring of 1969, screens, coated with Bird Tanglefoot® (The Tanglefoot Co., 314 Straight St. S.W., Grand Rapids, Mich. 49502) were placed around the bole of apple trees and a 3-ft-high screen was suspended 2 ft from the ground around the circumference of an apple tree to determine where the beetles first appeared in the apple tree.

In mid-May 1970, with the knowledge of several specific regions where *S. punctum* adults were active up to hibernation the previous fall, a study was instituted to determine if *S. punctum* did actually hibernate in the orchard. Random samples of duff, enough to fill a 1-qt plastic bag, were taken from various areas beneath each of selected apple trees. The samples were returned to the laboratory where each bag's contents were placed separately into a sifting box. The contents of each box were shaken vigorously over a white collecting tray. The material that fell through the screen was then examined and any *S. punctum* adults were collected with a camel's hair brush and placed into styrofoam cups.

When we had established the fact that *S. punctum* adults were present in the duff beneath trees, a frame was designed to take a more even-size sample from the 1st 5 ft along a radius from the trunk. The frame was 5 ft long and 1 ft wide and was divided into five 1-ft$^2$ sections. Samples were taken from each 1-ft$^2$ area and brought back to the laboratory for examination.

Adult and larval feeding-rate studies were conducted in 1970. Twenty adults and 20 larvae were collected from each of 3 apple orchards in Biglerville, Aspers, and Idaville. These insects were tested for feeding rate in a specially designed cage (Fig. 3). The cage was constructed from a 2×2×1⅛-in. plastic box. A ½-in. hole was drilled in each of the 4 sides of the box and 3 of these holes were covered with Dacron-ninon screening which was glued in place. A rubber stopper was used in the other hole to hold the leaf in position. The leaves to be used in the test were all cut to 1 in.$^2$ and brushed clean of mites and mite eggs. The petioles left on the squares of leaf were then placed in vials and a small tray containing mites was placed next to the leaves so mites could crawl onto the test leaves. Thus there were no mite eggs on the test leaves, only active mites. After a 1-hr exposure to mites in the tray, the test leaves were placed under a microscope and the mites on each leaf were counted. The leaf petiole was then circled with Vaseline® to keep the mites from crawling off and then the petiole was pushed through a hole in a 1×1½-in. piece of paper that had been coated with Bird Tanglefoot to catch any mites that might fall from the leaf during the test. The leaf in the stopper was placed in the plastic box and the box with the leaf was placed on a styrofoam base through which the petiole protruded, enabling the leaf to get water which was in the bottom of a pan beneath the styrofoam. A beetle or a larva was put on the leaf and timing of the test was begun. We watched the beetles and larvae throughout the test to be sure they remained on the leaf. If they fell from the leaf the count was disregarded. Counts of mites consumed were made every hour. Twenty replicates for adults and 20 replicates for 2nd-stage larvae were run from each location.

Table 1.—Measurements (in mm) of *S. punctillum* and *S. punctum*.

| Structure | No. sampled | Range | Mean (± SD) |
|---|---|---|---|
| | | *S. punctillum* | |
| Aedeagus | 5 | 0.350–0.383 | 0.363±0.0125 |
| Paramere | 5 | .300– .350 | .330± .0163 |
| | | *S. punctum* | |
| Aedeagus | 15 | .250– .300 | .274± .0160 |
| Paramere | 15 | .200– .217 | .207± .0082 |
| Adult length | 30 | 1.300–1.500 | 1.404± .0382 |
| Adult width | 30 | .950–1.450 | 1.034± .0410 |
| Egg length | 30 | .333– .433 | .372± .0255 |
| Egg width | 30 | .200– .250 | .225± .0158 |
| Larva length[a] | 20 | 1.030–1.570 | 1.238± .1127 |
| Pupa length | 20 | 1.270–1.430 | 1.359± .0365 |
| Pupa width | 20 | .870–1.070 | .970± .0514 |

[a] 1st-stage larvae immediately after emergence.

## RESULTS AND DISCUSSION

*Adult.*—Of typical scymnid shape, rounded oval, convex, uniformly shiny black, and covered with sparse fine yellowish to white pubescence. For the 1st few hours after emergence from the pupal case, adults light brown. Antennae, tibiae, and tarsi pale yellow. Antennae 11-segmented. Thorax finely and sparsely punctured at the middle, coarsely and densely at sides. Average measurements for 30 *S. punctum* adults given in Table 1, together with measurements of eggs, larvae, and pupae.

Kapur (1948) described and gave the 1st line drawings of the genitalia of *S. punctillum*. Brown (1950) described both the male and female reproductive organs of the 2 closely related species *S. punctum* and *S. punctillum*. Fig. 1 and 2 are the 1st illustrations known to us of the male genitalia of these 2 beetles. Differences in the genitalia furnish a positive means of separating these 2 species. Lengths of the aedeagus and parameres of *S. punctum* and *S. punctillum* are given in Table 1. Measurements were made as indicated in Fig. 1 and 2.

Adults of *S. punctum* are very active when in the apple tree and if disturbed will often fall to the ground. They are good fliers and as a result tend to concentrate where prey is plentiful and to disappear when the prey population becomes low. Adults feed on all stages of the European red mite and other mites present in fruit trees. We found that the beetle can consume 8.75 immature and mature mites per hour. *S. punctum* overwinters as adults beneath trash cover under the apple trees and in other protected habitats near the orchard. When we placed screens about apple trees in April 1969, from the base of trees to the upper portion, we found that *S. punctum* adults primarily appear upon emergence first at the base of

Table 2.—Life history of *S. punctum* in south-central Pennsylvania.

| Generation | Life stage | Population 1 | Population 2 | Avg no. days/stage | Total days/generation |
|---|---|---|---|---|---|
| 1st | Egg | 5/1/69 | 5/3/69 | 5 | |
| | Larva | 5/6/69 | 5/8/69 | 12 | 45 |
| | Pupa | 5/18/69 | 5/20/69 | 5 | |
| | Adult | 5/23/69 | 5/26/69 | | |
| 2nd | Egg | 6/20/69 | 6/15/69 | 5 | |
| | Larva | 6/25/69 | 6/20/69 | 11.5 | 50 |
| | Pupa | 7/7/69 | 7/1/69 | 5.5 | |
| | Adult | 7/12/69 | 7/7/69 | | |
| 3rd | Egg | 8/7/69 | 8/3/69 | 5.5 | |
| | Larva | 8/12/69 | 8/9/69 | 12.5 | |
| | Pupa | 8/24/69 | 8/22/69 | 5.5 | |
| | Adult | 8/29/69 | 8/28/69 | | |
| Hibernation | | 10/17/69 | 10/19/69 | | |
| Emergence | | 4/18/70 | 4/22/70 | | |

the tree. Samples of duff taken from about the trunk of apple trees showed that ca. 100% of the adults that overwinter in the orchard beneath the trees are found within the 1st 5 ft of the base of the tree. When the duff was against the base of the tree ca. 50% of the beetles were found within the 1st foot of the base of the tree and over 80% were within the 1st 3 ft of the trunk. Of those beetles collected, there was a ca. 88% survival rate. When these beetles were confined to a cup cage, mating took place almost immediately. Adults are active in the orchard from mid-April to late October (Table 2).

EGG.—The eggs are very small, pale white, and oval. They become blackish just prior to emergence of the larva. Eggs can be seen on the leaves by the naked eye. For average measurements of 30 eggs see Table 1.

The eggs are laid singly on their sides with from 1 to 10/leaf depending on the mite density. Most of the eggs are laid close to the primary viens of the leaf and adhere tightly to the surface of the leaf. A search of other parts of apple trees revealed eggs in no other location. Of the eggs laid on the leaves, 95% are laid on the under surface of the leaf and 5% on the upper surface. Oviposition occurs from May to mid-August with a developmental period of 5 days (Table 2).

Sweetman (1958) observed *S. punctillum* to lay 800 eggs the 1st season, 500 the 2nd season, and perhaps even more into a 3rd season. He stated: "A single female might have 5 to 6 generations of offspring active at one time."

*Larva.*—The larva is gray to blackish and has many long branched hairs. They have 13 segments exclusive of the head, and have many black patches with each segment of the thorax having a dorsal pair of large irregular black spots. The abdomen is longer than the head and thorax combined. As the larva matures it becomes reddish, first on the edges and then just prior to pupation the entire larva takes on a reddish appearance. As they emerged from the eggs, 20 larvae were measured (Table 1). A 4th-stage larva is between 2.2 and 2.5 mm long.

The larva emerges from a longitudinal slit in the eggshell. It begins to feed immediately upon emergence, draining out the body fluids of the mites and mite eggs. There are 4 larval stages with the average, in the field, of 12 days total time to pass through all 4 stages. The peak periods of larval activity in south-central Pennsylvania are mid-May, mid-June, and mid-August (Table 2). By confining 2nd- and 3rd-stage larvae with a surplus of mite prey, we found that a larva can consume an average of 9.67 active mites per hour. The 4th-stage larvae fastens itself to the leaf on either the upper or lower surface and remains there in a motionless state for 24–48 hr prior to pupation.

*Pupa.*—The pupa is uniformly black, small, and flattened. The wing pads are prominent and the entire body is covered with yellow hairs. For a short period after it is formed the pupa is orange. The anal segments are covered by the cast larval skin, by which the pupa is suspended from the leaf. Measurements of the length and width at widest point of 20 pupae are given in Table 1.

The pupal stage lasts an average of 5.3 days. Although there are pupae constantly in the trees, the peak pupal periods are late May, late June, and late August (Table 2).

By comparing 2 separated populations of *S. punctum* in 1969, we found that this beetle has 3 generations/year in south-central Pennsylvania (Table 2). An average period from the time the egg is laid to the appearance of the adult is 23 days. The adults feed an average of 25 days before beginning to lay eggs. It should be remembered that this time lag between emergence and oviposition is of little consequence because there is such an overlapping of active adults in the trees at all times. Adults that overwinter are mature and fertile when they emerge in the spring and feed on mite eggs both prior to overwintering and upon emergence in the spring.

## REFERENCES CITED

**Brown, W. J.** 1950. The extralimital distribution of some species of Coleoptera. Can. Entomol. 82: 197–205.

**Duffey, J. C.** 1891. Transformation of a carabid *(Plochionus timidus)*, and observations on a coccinellid enemy of the red spider. Trans. Acad. Sci. St. Louis 5: 533–42.

**Horsburgh, R. L., and D. Asquith.** 1968. Initial survey of arthropod predators of the European red mite in south-central Pennsylvania. J. Econ. Entomol. 61: 1752–4.

**Kapur, A. P.** 1948. On the Old World species of the genus *Stethorus* Weise. Bull. Entomol. Res. 39: 297–320.

**LeConte, J. L.** 1852. Remarks upon the Coccinellidae of the United States. Proc. Acad. Natur. Sci. Philadelphia 6: 129–45.

**Robinson, A. G.** 1952. Notes on *Stethorus punctum* (Lec.) (Coleoptera: Coccinellidae), a predator of tetranychid mites in Manitoba. 83rd Annu. Rep. Entomol. Soc. Ontario p. 24–26.

**Sweetman, H. L.** 1958. The Principles of Biological Control. Wm. C. Brown Co., Inc., Dubuque, Iowa 250 p.

**Wirth, W. W., and N. Marston.** 1968. A method for mounting small insects on microscope slides in Canada balsam. Ann. Entomol. Soc. Amer. 61: 783–4.

# Description of the Immature Stages of *Lonchaea corticis*,[1] with Notes on its Role as a Predator of the White Pine Weevil, *Pissodes strobi*[2]

D. M. HARMAN AND J. B. WALLACE[3]

## ABSTRACT

Descriptions are given of the 3 larval instars and puparium of *Lonchaea corticis* Taylor. The 3 larval instars can be differentiated by the cephalopharyngeal skeleton and the anterior and posterior spiracles. The 1st-stage larvae are metapneustic, the 2nd- and 3rd-stage larvae are amphipneustic. White pine leaders were dissected to determine the relative distribution of *L. corticis* and its host, *Pissodes strobi* (Peck), through the infested portions. Most of the *L. corticis* larvae were situated several inches behind the frontal feeding formations of *P. strobi* larvae.

The adult form of *Lonchaea corticis* was originally described by Taylor (1928) during the course of his studies on the natural enemies of the white pine weevil, *Pissodes strobi* (Peck). Shortly afterward, Taylor (1929) gave an account of the biology of *L. corticis* and commented briefly on the synonomy of *L. corticis* with other species of *Lonchaea* which were mentioned in association with the white pine weevil by Graham (1926), MacAloney (1926[4]), and Barnes (1928[5]). Taylor (1929) also gave very brief descriptions of the egg, larva, and pupa of *L. corticis*.

According to Taylor (1929), *L. corticis* eggs are deposited in the feeding and oviposition punctures made by *P. strobi*, sometimes directly on *P. strobi* eggs. After hatching, the *L. corticis* larvae feed in the burrows of the *P. strobi* larvae. During this time the fly larvae may feed on weevil larvae, or frass, or both. Taylor (1929) reported that they may complete their development on either. In laboratory studies he reared young *L. corticis* larvae on diets of (1) weevil larvae exclusively, (2) frass exclusively, and (3) a combination of weevil larvae and frass. He found that the amount of time required for completion of development was proportional to the amount of weevil protein consumed. He determined in additional studies that about 5% of the total numbers of *L. corticis* larvae in the study emerged in August, and he concluded that these earlier-emerging fly larvae had consumed more weevil larvae and less frass. He added that the maggots which consume fewer weevil grubs overwinter as pupae or larvae. Taylor (1929) stated that *L. corticis* and the weevil larvae may occur in the leaders virtually side by side, but he added that if hatching is delayed in *L. corticis*, the fly larvae may never catch up with the feeding *P. strobi* larvae and must then feed largely on frass and straggling weevil larvae. Taylor alluded to the increased effectiveness of *L. corticis* larvae which are able to attack healthy *P. strobi* larvae in the pupal chambers or in the frontal feeding formation as opposed to those which feed on frass and straggling *P. strobi* larvae which would perish in any case. Little is known about the distribution of *L. corticis* larvae throughout infested leaders. Their spacial relationship to straggling weevil larvae and to the feeding area of the weevil larvae could provide an indication of their effectiveness within a given leader. In Virginia, Harman and Kulman (1968) reared adult parasites and predators from 4-in. sections down infested white pine leaders, beginning at the base of the terminal buds. Highest recovery of adult *L. corticis* occurred in the sections 12–16 in. from the base of the terminal buds. However, dissection of infested leaders provided additional information on oviposition of *L. corticis* eggs and larval activity beneath the bark.

The objectives of this paper are to describe the larval instars of *L. corticis* and to examine the distribution of *L. corticis* larvae throughout infested white pine leaders.

## METHODS AND MATERIALS

Specimens used in the descriptions of larval stages were field collected in western Maryland. Leaders infested with *P. strobi* were clipped and taken to the

[1] Diptera: Lonchaeidae.
[2] Coleoptera: Curculionidae.
[3] Respectively, Research Assistant Professor, University of Maryland, Natural Resources Institute, LaVale; and Assistant Professor, Department of Entomology, University of Georgia, Athens. Part of the research was supported by the Southeastern Forest Experiment Station, USDA Forest Service and Department of Entomology, Virginia Polytechnic Institute, Blacksburg. The authors acknowledge the assistance of Dr. H. M. Kulman, under whose grant portions of this study were initiated. This paper is contribution no. 452 of the University of Maryland, Natural Resources Institute. Received for publication Mar. 1, 1971.
[4] H. J. MacAloney. 1926. The white pine weevil problem in the New England States. Papers presented at the Forest Protection Conference, Syracuse Univ., Syracuse, N. Y. p. 31–43.
[5] T. C. Barnes. 1928. A biological study of the white-pine weevil with especial reference to anatomy, flight phenology, parasitism, behavior, and injuries to young trees. Sc.D. Thesis. Widener Library, Harvard Univ., Cambridge, Mass. 143 p.