Tree Crickets Injurious to Orchard and Garden Fruits

P. J. Parrott and B. B. Fulton.

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TREE CRICKETS INJURIOUS TO ORCHARD AND GARDEN FRUITS.

P. J. PARROTT AND B. B. FULTON.

SUMMARY.

The more common and injurious species of tree crickets in plantings of garden and tree fruits in the State of New York are the snowy tree cricket (Oecanthus niveus De Geer), the narrow-winged tree cricket (O. angustipennis Fitch) and the striped tree cricket (O. nigricornis Walker). These display great similarity in external appearance but show marked differences in habits and economic status. In common with insects of their kind, during their early nymphal existence they possess pronounced predaceous habits. As they approach maturity they exhibit phytophagous and mycophagous tendencies, subsisting on floral organs, foliage, fruit and minute fungi. The crickets have five nymphal instars. Eggs are deposited during the latter part of August and throughout September. Hatching occurs during early June and the adults make their appearance in August.

The snowy tree cricket oviposits in a great variety of plants. In the region about Geneva eggs are most abundant in apple, plum and cherry, and they are somewhat common in raspberry and walnut. The eggs occur singly in soft, fleshy bark. They are distributed promiscuously and are not arranged in a series in a row. On raspberry, oviposition takes place in the fleshy area at the side of the bud in the axils of the leaves, and usually there is not more than one egg on each side of a bud. This species subsists on a rather wide assortment of foods of animal and vegetable origin. In addition to other species of insects, microscopical examinations of crop contents have shown that the San Jose scale may, under certain conditions, form a large part of the diet of this cricket. It has also been observed to eat holes in raspberry and apple leaves, and is reputed to attack ripening fruits. This species derives its reputation as an orchard pest chiefly from the occurrence of diseased
areas about oviposition wounds in the bark of apple trees. The areas of infection in their external appearances and effects resemble superficially certain stages of the common apple cankers. Cultural and microscopical studies indicate that during 1913 a fungus, *Leptosphaeria coniothyrium* (Fckl.) Sacc., was, in the majority of cases, the infecting organism.

The narrow-winged tree cricket has feeding habits similar to the foregoing species. It is common in apple orchards, and has been observed in considerable numbers on alders and scrub and burr oaks. As with *niveus*, various disorders of bark may attend oviposition in apple trees.

The striped tree cricket, unlike the preceding species, prefers, for the reception of its eggs, plants which have a central pith surrounded by a woody outer layer. Oviposition occurs in many plants, but the eggs are deposited most abundantly in raspberry, blackberry, *Erigeron canadensis*, and the larger species of *Solidago*. The eggs are placed in a series, forming a single row in the current year's growth, and with raspberries have ranged in number from two to eighty or more eggs in a row. This species feeds on anthers and petals of flowers, raspberry leaves and fruit. Leaf tissues, fungus mycelium and spores constituted a large part of the crop contents of a number of specimens that were examined. This species has attained its standing as a destructive pest because of its injurious work on raspberry and blackberry. The injuries it causes arise from the long series of punctures which it produces in canes during the process of egg laying. As a result of the rupturing of woody tissues the cane splits at the point of injury and becomes so weakened that it eventually breaks down from the weight of the upper growth or from twisting by the wind.

These insects have, throughout their normal range of distribution, a number of natural enemies. The most common and efficient of these are egg parasites, of which there are eight species. These are hymenopterons, three species belonging to the Chalcidoidea and five species to the Proctotrupoidea. Of the species of tree crickets discussed, *nigricornis* appears to be most subject to parasitism.

Tree crickets are amenable to standard orchard operations. Cultivation to destroy foreign vegetation, as weeds and brush, about and in plantings of fruit, and to keep the ground about trees
and vines clean is an efficient measure for the prevention of damages. While the susceptibility of these insects to arsencals has not been conclusively demonstrated it is believed that the numbers of the tree crickets are reduced by summer applications of these poisons. Raspberry canes showing extensive oviposition should be removed in the course of winter or spring pruning and burned to destroy eggs contained in them.

INTRODUCTION.

Certain species of tree crickets have long been included in the category of injurious insects, and economic treatises seldom fail to contain an account of them. But as common and widely distributed as are these creatures, no little confusion has existed as to their identities, and moreover there has been very little detailed knowledge of their various activities as fruit pests. The studies herein described were undertaken for the purpose of ascertaining the life histories, habits and economy of *Oecanthus niveus* De Geer, *O. angustipennis* Fitch and *O. nigricornis* Walker, which are the most injurious species attacking bush and tree fruits in New York.

TREE CRICKETS AND THEIR WORK.

GENERAL CHARACTERS.

The tree crickets discussed in this bulletin belong to the genus *Oecanthus*\(^1\) of the family Gryllidae. They are orthopterons and are near relatives of such insects as grasshoppers, locusts, etc., and, as would be expected from such relationships, they have in their structures and in certain habits points in common with them. As implied in their popular name, the tree crickets exhibit arboreal habits, living principally on trees, shrubs, weeds and even low-lying plant growth. In addition to their preference of plants for their various activities they exhibit also marked differences in shape and color from the robust, dark-colored house and field crickets which are familiar to most readers. They are slender creatures, usually light green in color, and possess transparent wings and wing covers; the latter are in the case of the males very broad and when at rest lie

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\(^1\) This presumably means "flower-inhabiting" and is derived from the Greek words *οἶκος*, house, and *ἄνθος*, flower.
flat over the abdomen. The antennæ are delicate and threadlike, and are with some species from two to two and one-half times the length of the body. The first and second segments of these appendages are frequently ornamented with black markings, which are constant with the different species; and, as pointed out by Hart, these may furnish important distinguishing characters. The tree crickets for the most part deposit their eggs preferably in the annual growth of plants, and during their early nymphal existence they show pronounced predaceous habits. As they approach maturity they display phytophagous and mycophagous tendencies, feeding on the floral organs of various plants as well as foliage and fruits of different sorts, and even minute fungi that may occur on bark or decaying vegetation.

DISTRIBUTION.

Representatives of the genus *Ecanthus* occur in southern and central Europe, southern Asia, the East Indies, Africa, North and South America, and one species is recorded as rare in Australia. Each geographical region has its distinct fauna and, with the present state of systematic knowledge, none of the species seem to have been influenced by commerce to become cosmopolitan in their distribution. One species only, *pellucens*, is found in Europe, and this occurs solely in the warmer latitudes. The American continent appears to be especially rich in the numbers of these insects, and according to Kirby no less than sixteen species out of a total of twenty-seven species listed by him are recorded from this region. Of the species occurring in North America, none apparently are known to range farther north than southern Canada. From available records *niveus* is the most generally distributed of the species occurring in the United States, ranging from Massachusetts to the Pacific Coast and from the Province of Ontario on the north to as far as Mexico on the south. Such species as *nigricornis*, *quadripunctatus*, *angustipennis* and *latipennis* are common insects in the region east of the Rocky Mountains.

ECONOMIC IMPORTANCE.

The tree crickets derive their economic importance largely from their predatory habits, in subsisting upon other forms of insect life,

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and from their injurious work upon various cultivated crops. They are also suspected of acting as carriers of various plant diseases. Many writers upon these insects have commented upon their carnivorous tendencies, and from this standpoint alone some have concluded that the tree crickets are beneficial rather than inimical to the farmer. The fondness of various species of these insects for plant lice is well known, and when these occur in abundant numbers they constitute an important item in the diet of the crickets. Bruner has noted the predaceous habits of latipennis and states that it feeds on saw-flies, leaf-hoppers and tingitids. Conspicuous constituents in the food of tree-inhabiting species, as niveus and angustipennis, are scale insects. An examination of the crop contents of a number of specimens of niveus from an apple orchard infested with the San Jose scale has revealed the presence of varying numbers of pygidia of this coccid which were intermingled with numerous fragments of plant tissues and bristles, pieces of chitin, etc., of larger insects. Unquestionably many other kinds of insects aside from those mentioned fall as prey to these crickets. The actual importance of tree crickets in this role deserves more careful consideration, but on the basis of our studies it appears that their beneficial services have, in the main, been over-rated because of their relatively small numbers in comparison with other groups of predaceous and parasitic insects.

Their status as depredators on cultivated plants is more clearly understood. One of the most injurious species is nigricornis, which may seriously damage raspberry plantations, and it is widely distributed. The injuries are due primarily to the slitting of the canes as a result of extensive oviposition, which weakens a stalk so that it dies or breaks at the point of the wounded area from the weight of the foliage or as a result of a strong wind. Certain species have attained some distinction because of their depredations on various fruits. Garman has observed niveus and angustipennis feeding on ripening plums and peaches, and latipennis on grape clusters. The attacks of the latter species were considered especially injurious, as the rupturing of the epidermis of the fruits apparently facilitated the spread of black rot. Wounds in the other fruits also became centers of infection with brown rot. Saunders of Canada has

likewise noted the destructive capacities of these insects in a similar role. Mally\textsuperscript{7} of Cape Town, South Africa, states that an apparently indigenous species, \textit{capensis} Sauss., has become quite troublesome in peach orchards because of the small, round, surface wounds in peaches especially grown for exportation. Tree crickets also feed on foliage of various plants, and in the case of tobacco they have been reported as causing damage of a more or less serious nature. McCarthy\textsuperscript{8} states that in North Carolina \textit{niveus} (\textit{nigricornis}?) often damages tobacco in fields much infested by blackberry bushes. Metcalf\textsuperscript{9} reports that in North Carolina a light greenish tree cricket eats round holes through the tobacco leaves, and states, also, that he has seen tobacco plants set in new ground, surrounded on all sides by heavy growth of blackberries, which were seriously damaged by both nymphs and adults. He says also that tree crickets do not ordinarily frequent tobacco fields that are removed from weeds and brush. In his memoir on "The Principal Insects of the Tobacco Plant," Dr. Howard\textsuperscript{10} makes the statement that young tree crickets are occasionally found upon tobacco, eating the leaves to some slight extent. Both \textit{niveus} and \textit{angustipennis} have also been observed to feed on foliage of apple trees, but the consumption of leaf tissues appeared to be small and unimportant.

In considering the economy of tree crickets reference should also be made to their suspected role as vectors of plant diseases. Apparently the first writer to call attention to the activities of these insects in this capacity was Hopkins\textsuperscript{11} of West Virginia who noted that the puncturing of bark by an unknown species of tree cricket often resulted in a blighted condition of apple wood. In New York there is seemingly a similar association between \textit{niveus} and some infectious organism which results in diseased areas in the bark of apple trees, especially noticeable in orchards that are neglected or given little care. Detailed information dealing with the intimate relation of \textit{niveus} to bark diseases is wanting and, although there is strong presumptive evidence, no conclusive experimental proof has so far been presented that this species actually serves as an agent in the transmission of such disorders of fruit trees.

\textsuperscript{7} C. W. Mally. Letter of Oct. 15, 1913.
\textsuperscript{8} Gerald McCarthy. N. C. Agr. Exp. Sta. Bul. 78, p. 17. 1891.
GENERAL DESCRIPTIONS OF LIFE STAGES OF TREE CRICKETS.

Egg.—The eggs of the species belonging to the genus *Ecanthus* are elongate, cylindrical, and slightly curved. At the time of deposition they are semi-transparent, but later they grow more opaque and become slightly swollen. The cephalic end possesses a whitish opaque cap, which is covered with minute projections, arranged in spiral rows after the fashion of the scales of a pine cone. At the extreme base of the cap, only shallow rhombic depressions occur, but above the first few rows short projections appear between the indentations and gradually increase in size in each successive row. The entire surface of the egg, exclusive of the cap, is etched with what appears to be very minute, cross-hatched scratches. The number and size of the spicules vary considerably with different species and are useful characters for distinguishing the eggs of certain of the crickets.

Nymph.—First instar (Plate I, fig. 1): The newly-hatched tree crickets are pale and delicate creatures, with slender legs and long antennæ. After feeding, the size of the abdomen is increased and the contents of the alimentary canal show through the body wall, giving the insects a slightly darker color and more robust appearance. The pronotum, when viewed from above, is rectangular in form, a little wider than long, with sides broadly rounded and margined with a scant fringe of small bristles. The meso- and metanotum are each about equal to the pronotum in width and a little more than half as long. The hind margins of both bear a few small bristles which are directed posteriorly. The cerci are conical, about four times as long as width of base. This stage may be distinguished from the succeeding instar by two characters: (1) The antennæ have thirty-four segments. (2) The sides of the meso- and metanotum do not project, and extend downward scarcely as far as do the sides of the pronotum. (Fig. 1, a.)

Second instar (Plate I, fig. 2): This stage differs but little from the preceding instar. The side margins of the pronotum flare outward slightly. The metanotum is a little longer than the mesonotum. Both extend down the sides as far or slightly farther than the pronotum; the side margins are free and lap over the pleura. (Fig. 1, b.) The number of antennal segments is about double that of the preceding stage. The females show the anlage of the ovipositor
in the form of two small, rounded projections on the ventral side of both the eighth and ninth abdominal segments. They are close together and are most pronounced at the posterior margins of the segments.

Third instar (Plate I, fig. 3): The pronotum is a trifle longer than broad; marginal bristles very numerous. The metanotum is about one and one-half times as long as the mesonotum. The sides of both bear rudimentary wing pads reaching nearly to the middle coxae. (Fig. 1, c.) The cerci are noticeably longer, about five times as long as width of base. The antennal segments are relatively shorter than in preceding stages and the normal number of segments is increased to nearly one hundred. The anlage of the ovipositor consists of four backward-pointing papillae. The front pair is smaller and lies in contact with the lower surface of the hind pair.

Fourth instar (Plate I, fig. 4): The wing pads, in comparison with earlier instars, are greatly increased in size and instead of projecting downward are folded back over the meso- and metanotum. (Fig. 1, d) The bases of the first pair are covered by the hind margin of the pronotum and their tips reach the first abdominal segment. The second wing pad covers the lower part of the first and reaches to the middle of the second abdominal segment. The four components of the ovipositor are longer than before and form a compact body, extending a trifle beyond the tip of the abdomen. The sterna of the eighth and ninth segments are reduced and almost
completely taken up by their appendages. The sternum of the seventh segment is longer and touches the base of the ovipositor.

Fifth instar (Plate I, fig. 5): The first pair of wing pads reaches to the second abdominal segment and the second pair reaches to the third or fourth segment. (Fig. 1, e.) Ceri and ovipositor are twice as long as in preceding stage. Front tibiae have a swelling near the proximal end, at which point in the leg of the adult insect a tympanum occurs.

Adult (Plate I, fig. 6).—Body slender. Long axis of head in life nearly horizontal. Pronotum slightly elongated; disk narrowed in front; sides nearly vertical at hind edge, flaring outward in front part. Abdomen composed of ten segments, including the last which bears the ceri and anus. First segment much reduced ventrally. Antennæ filiform; over twice the length of body. Legs slender; hind femora a little thickened. Hind tibiae with a double row of teeth on posterior side, intermixed on distal half with longer spines; with three pairs of spurs at the tip. Anterior tibiae with a tympanum near the base.

The hind wings of both sexes are folded and generally extend beyond the tip of the fore wings.

Males have the forewings much broader than body. A longitudinal fold occurs about one-third way from the costal margin; the inner two-thirds lies horizontally over the back and the remainder is deflexed toward the sides.

The fore wings of the female are regularly reticulated, much narrower than those of the male, and are wrapped closely around the body. A longitudinal bend of about ninety degrees is located about half way between the two margins.

NATURAL ENEMIES.

The tree crickets of the genus Ecantis are, throughout their normal range of distribution, subject to the attacks of a number of natural enemies. The most common and efficient of these are egg parasites, of which there are eight known species. These are hymenopterons, three species belonging to the Chalcidoidea and five species to the Proctotrypoidea. In view of the confusion which has existed in regard to the identity of the different species of tree crickets, we cannot feel sure that the hosts of the parasites have been correctly recorded. Judging from the statements that accompany the descrip-
tions of these hymenopterons it seems probable that most of them were reared from eggs of *nigricornis* or possibly *quadripunctatus*. The following is an annotated list of these insects:

   *Rileya* sp.  
   Bred from *Ecanthus* eggs in twigs. The species of tree cricket was not named, but it was probably *nigricornis* or *latipennis*.

   “Captured in act of ovipositing in eggs of *fasciatus*” (*nigricornis*).

   Recorded by several writers from eggs of *Ecanthus* in raspberry, resin weed, *Grindelia*, etc. The eggs were probably those of *nigricornis* in all cases. We have reared this species from eggs of *nigricornis* in raspberry.

4. *Teleas (?)*  
   Recorded as a parasite of *nivesus*, but since the eggs were taken from the pith of elder they were probably those of *nigricornis*.

5. *Caloteleia* sp.  
   Bred from twigs containing eggs of *Ecanthus*.

   Eggs of *nivesus* (probably *nigricornis*), Nebr.

   Eggs of *nivesus* (probably *nigricornis*), Kans. and Ind.  
   Eggs of *latipennis*. Mo.  
   We have reared this species from eggs of *nigricornis* in raspberry and have the larval and pupal stages.

8. *Idris* sp.  
   Recorded from eggs of *nivesus* (probably *nigricornis*) in raspberry canes.

An adult of *Polynema bifasciatiptenne* (Fig. 2) was found on September 17, 1910, running about a portion of a raspberry cane in which eggs of *nigricornis* had been deposited. On September 26 a small larva which was a little over 1 mm. long was found attached to an egg of this species of cricket taken from the same planting. It was thought that this was a larva of *Polynema* but we were unable to rear the insect to the adult stage.

In 1912, from a box containing raspberry canes with eggs of *nigricornis*, an adult *bifasciatiptenne* emerged on August 24, another on September 3, and a third specimen on September 4. The adults are slender insects about 2 mm. long, with long legs and peduncled abdomen. The color is yellowish brown. The fore wings are broad
and have a narrow dark band near the base, a broad one across the middle, and a broad one near the tip. The hind wings are extremely narrow.

The antennæ of the female are about half the length of body and are 9-jointed, the last joint being the largest. The antennæ of the male are filiform, longer than the body and are 13-jointed. (Fig. 2, a.)

A number of eggs of *nigricornis* were examined on July 22, 1912, and some of them which remained unhatched contained larvæ of a parasite which proved to be *Cacus acanthi*. The larvæ were about full grown and measured 2.3 mm. in length by .5 mm. in diameter. (Fig. 3, a.) The body is made up of eleven segments, each of which, except the last, has two rounded protuberances on each side, while segments 2 to 7 inclusive have a pair of small but prominent protuberances on the dorsal side. The margins of the segments are elevated, especially on the sides of the body. The color is generally a translucent white, but segments 2 to 6 inclusive appear yellowish, due apparently to some internal organ.

The pupæ were formed near the end of July. (Fig. 3, b.) They were white at first but later turned black and had all the characters of the adult. On September 5,
1912, three adults emerged in the box containing eggs of *nigricornis* and on the following day one more appeared. (Fig. 4.) The adult is 2.3 mm. in length. The body is entirely black except the legs which are dark brown. The abdomen is 6-jointed, slender, flattened, and club-shaped. The front wings have the submarginal vein meeting the costa just beyond the middle; the stigmatic vein is curved, oblique, and terminates in a knob. Both sexes have 12-jointed antennæ; in the male they are filiform (Fig. 4, a); in the female the first joint or scape is very large; the second, third and fourth slender, the fifth and sixth transverse, and the remaining six segments form a compact club.

*A dipterous parasite.*—On August 29, 1912, a puparium of some dipterous insect was found in a bottle with a sickly, yellowish-looking specimen of *quadripunctatus* in the fifth nymphal instar, which was still alive. By dissecting a number of specimens of tree crickets we found one which contained a larva of the same parasite. This larva was large and ovoid in shape, and of a pale yellowish color. It occupied the abdominal cavity above the alimentary canal and below the fat body. The cricket was alive when cut open, but it was of an abnormal yellowish color and the abdomen was distended. The parasitic larva pupated but we were unable to rear adults from the two puparia.

*Mermis* sp. In our rearings of tree crickets we have occasionally noticed examples of parasitism with hairworms. Individuals that were parasitized became quite sluggish in their movements during the last stages of life and were more or less discolored. The tip of the abdomen was generally blackish and there were also indications of a dark-colored discharge from the anus. Nymphs of the fourth
and fifth instars seemed to be most affected, and only one hairworm was observed to make its escape from each insect, which was accomplished through the anus. The extent to which hairworms occur in tree crickets seems to show considerable variation from year to year, and was greatest during July and August in 1908 and 1909. In subsequent years they have been observed much less frequently. As orthoptera generally are subject to parasitism by these creatures, specimens of the hairworms were sent for identification to Dr. B. H. Ransom of the U. S. Bureau of Animal Industry who reported that they were larvae of a Mermis sp. Because of their immature condition it was stated that it was not possible to determine definitely if they were the same species as exist in other kinds of crickets and grasshoppers.

Stalk-boring insects.—Eggs of nigricornis and quadripunctatus are sometimes destroyed by various species of stalk-borers. These latter are not true parasites, but the effect of their operations, in tunneling through the central pith of weeds and other plants and feeding upon it, is to hollow out stems and stalks, which effectually disposes of any eggs of a tree cricket that happen to be in the path of the boring insect.

KEY TO THE SPECIES OF Ecanthus FOUND IN NEW YORK STATE.

A Basal segment of antennae with a swelling on the front and inner side. First and second segments each with a single black mark.

B Basal antennal segment with a round black spot. (Fig. 5, a.)

BB Basal antennal segment with a J-shaped black mark. (Fig. 5, b.)

BBB Basal antennal segment with a straight club-shaped black mark.

AA Basal antennal segment without a swelling on the front and inner side. First and second antennal segments each with two black marks or entirely black.

Tegmina of male 5 mm. or less in width.

B Head and thorax pale yellowish-green or black or marked with both colors.

C First antennal segment with a narrow black line along inner edge and a black spot near the distal end. Body entirely pale yellowish-green.

CC First antennal segment with black markings similar to above, but broader and usually confluent, sometimes covering the whole segment. Head and thorax often with three longitudinal black stripes; ventral side of abdomen always solid black in life. (Fig. 5, c, d.)

BB Head, thorax and antennae reddish brown. Wings in life with conspicuous green veins. Marks on basal antennal segment broad but seldom confluent.

AAA Basal antennal segment without a swelling on the front and inner side. Basal portion of antenna red, unmarked with black. Tegmina of male about 8 mm. wide.
STUDIES ON TREE CRICKETS OF BUSH AND TREE FRUITS.

THE SNOWY TREE CRICKET.

Ecanthus niveus De Geer

HISTORICAL NOTES AND SYNONYMY.

This insect is one of the most common tree crickets as well as an important species. While its status has been clearly established in systematic literature, strangely enough it has been long confused in economic writings with nigricornis. Because of its mistaken identity niveus has generally been regarded as the author of serious injuries to raspberry, which really are the work of the latter species. The error arose from the failure of early economic workers to dis-

Fig. 5.—Basal Antennal Segments of Tree Crickets.

a, Niveus; b, angustipennis; c, nigricornis, light form; d, nigricornis, dark form.

tinguish the two crickets. Following his description of niveus Walsh² says “that varieties occur in both sexes with legs and antennae almost entirely black” — characters which clearly designate nigricornis, while Riley³ in an early discussion of the same species states “that some specimens have a blackish shade.” Later Riley⁴ says that he considers fasciatus (nigricornis) a dark and rather well-marked variety of niveus, and in this article makes the same statement about nigricornis, which as a matter of fact is synonymous with the above fasciatus. Because the identities of these crickets were not clearly understood, there has been more or less confusion in subsequent literature as to the habits of these insects, which still persists, although to a much less degree than formerly.

²Walsh, B. D. Pract. Ent. 2: 54. 1867.
⁴Riley, C. V. Sup. to 9 Rpts. on Insects of Mo. 60–61. 1881.
PLATE I.—LIFE STAGES OF THE SNOWY TREE CRICKET (G. niveus): NYMPHAL INSTARS AND ADULT.
PLATE II.—SNOWY TREE CRICKET (*E. niveus*).
1. Female feeding on thoracic gland of male; 2. Characteristic posture of female in act of ovipositing.
PLATE III.—THE SNOWY TREE CRICKET (O. niveus).
1, Normal scars on apple; 2, oviposition injuries under bark; 3 and 4, cross sections showing scars and diseased areas.
PLATE V.—SNOWY TREE CRICKET (C. niveus).
1, Young canker showing exudation; 2, more advanced stage; 3, separation of bark about diseased area; 4 and 5, partially and normally healed cankers; 6, woolly aphis in cankers.
PLATE VI.—DISORDERS OF VARIOUS KINDS FOLLOWING OVIPOSITION BY TREE CRICKETS IN APPLE WOOD.

In 2 and 3 note V-shaped oviposition scars by <i>augustipennis</i>.
Plate VII.—Striped Tree Cricket (*E. nigricornis*).

1, 2, 3, Oviposition in raspberry; 4, bark removed showing holes in cane; 5, slitting of canes following oviposition.
PLATE IX.—TREE CRICKET INJURIES.
1, Oviposition by nigricornis in peach wood; 2, brown-rot infection of peaches following feeding, photographed by H. Garman.
A hint as to the true nature of *niveus* was given in a letter to the editor of the *Canadian Entomologist* in 1886 from E. W. Allis\(^5\) of Michigan who states that he has “taken *niveus* entirely about apple and hardwood, and *fusciatus* (*nigricornis*) about raspberries and certain woody weeds. They are more common than *niveus* here and very distinct.” Packard\(^6\) describes the insect as “boring into the corky bark of the elm in the southern states, inserting its eggs irregularly, not in a regular series as when it oviposits in blackberry, raspberry and grape.” As regards the elm, the eggs were probably those of *niveus*, while in case of the latter plants the oviposition was unquestionably by *nigricornis*. Within recent years these crickets have been more closely studied by a number of workers, notably Houghton\(^7\) of Delaware, whose work, with our own, has no longer left any doubt as to the true character of the egg-laying habits of the two species.

**DISTRIBUTION.**

This species ranges all over the State of New York with the exception of forested regions in the northeastern part. It has been recorded in literature from the following states: Massachusetts (Faxon), Connecticut (Walden), New Jersey (Davis), Ontario (Walker), Georgia (Allard), Illinois (Forbes), Kentucky (Garman), Minnesota (Lugger), Kansas (Tucker), Nebraska (Bruner), Michigan (Allis), Cuernavaca, Morelos, Mexico (Rehn), Cuba (Kirby). From specimens examined we can record its distribution in the following states: Colorado and Utah (Titus), Ohio (Kostir), New Jersey, North Carolina, Connecticut (Amer. Mus.), California (Doane); Maine, one specimen (Patch), Cuba (Cardin). From correspondence we have obtained other records as follows: Texas (Newell), North Carolina (Beutenmüller), California and Washington (Melander).

**DESCRIPTION OF LIFE STAGES.**

*Egg* (Fig. 6, c).—The egg is about one-ninth of an inch long and from one-sixth to one-fourth as wide. The color is dull white, often with a slight yellowish tinge. The cap (Fig. 6, d) is a little narrower than the main body; its sides are parallel and the end is broadly rounded. In color it is opaque white, but is often stained a reddish color by the bark. The projections on the cap (Fig. 6, e) are long and finger-shaped,

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having a uniform thickness of about .009 mm. from base to tip, and a length of .020 to .025 mm.

The average measurements of forty specimens of eggs are as follows: length 2.83 mm.; greatest width, .62 mm.; length of cap .51 mm.; width of cap .51 mm.

_Nymph._—First instar (Plate I, fig. 1): Color white. Top of head with two rows of ten to fifteen small bristles, directed anteriorly and each with a small black spot at the base. There is a short black line extending backward from the upper edge of each eye and one or two pairs of brownish transverse spots between the eyes. The pronotum, and sometimes the meso- and metanotum, have a pair of longitudinal brownish stripes situated close to the median line. Basal segment of antenna with a small black spot on the inner side and a brownish spot on the posterior side; second segment with a black transverse line on the inner side; third, fourth, sixth and ninth segments with a narrow black ring at apex; each succeeding segment with faint gray annulation at tip. Hind tibiae with black spots at the base of the small bristles, especially prominent on the outer and upper sides. Length about 3 mm. Antennae 6.3 to 7.5 mm.

Second instar (Plate I, fig. 2): Ground color of abdomen transparent greenish white with two rows of pure white blotches on each side of median line. Basal segment of antenna with a round black spot on the front and inner side, and the second segment with a similar spot on the front side and a transverse dash on inner side. Outer part of antennae with gray annulations on alternate segments. Length 4.5 to 5 mm. Antennae 10.7 mm.

Third instar (Plate I, fig. 3): General color greenish white. Abdomen with several rows of irregular opaque white blotches on each side of median line. The brownish markings on the head and thorax are very faint. Black spot on first segment of antenna on a white prominence. Length 6 to 7 mm. Antennae 13 mm.

Fourth instar (Plate I, fig. 4): Coloration practically the same as in the preceding stage. Length 8.5 to 9.5 mm. Antennae 16 mm.

**Fig. 6.—Snowy Tree Cricket.**
a, Egg punctures and cankers in apple wood, (X 1½); b, egg in raspberry (X 2½); c, egg in apple bark (X 15); d, egg cap (X 50); e, spicule of egg cap (X 500).
Fifth instar (Plate I, fig. 5): Color pale yellowish green. Segments of abdomen with a fairly regular pattern of roundish white blotches; a small one on front and one on hind margin on median line; larger blotches on each side are arranged alternately near the front and hind margins. Outer side of hind femur with numerous black spots extending over the distal two-thirds or four-fifths. Antennae marked similar to adult. Length 11 to 12 mm. Antennae 23 mm.

Adult (Plate I, fig. 6): Moderately slender. Pronotum as broad as long. Color very pale green. Top of head between eyes and antennae orange yellow; occipital area with longitudinal transparent greenish blotches separated by white lines. Wings transparent, with a slight greenish tinge; veins more or less colored with yellowish green. Forewings of male very broad. Antennae white, with gray annulations in the outer part at intervals of about four segments. First segment is pale orange yellow on all parts except the large swelling on the front and inner side which is white and has a conspicuous round black spot in the center. (Fig. 5, a.) The second segment is white with a similar spot. Length to end of abdomen 14 mm. Forewing of male 13–14 mm x 6 mm. Forewing of female 12–13 mm.

HATCHING OF EGGS AND TIME OF APPEARANCE OF NYMPHS.

Before hatching, the egg becomes swollen, due to internal pressure. The end of the cap then breaks off and the embryo slips out. When it first appears the body is nearly perpendicular to the branch. (Fig. 7, b.) It retains its embryonic form until several abdominal segments have been exposed, then the head bends down and
the thorax becomes strongly arched upward. (Fig. 7, c.) The young nymph continues to work outward by muscular contractions of the abdomen and by bending the body up and down and from side to side. The unexposed parts are wrapped in a delicate membrane which projects from the hole and clings to the body. The palpi and first two pairs of legs become free first and are then exercised in the air. (Fig. 7, d.) The body begins to straighten out again, pulling the antennae with it. The head turns upward and a watery swelling, formed to fit the end of the egg, then becomes a conspicuous lump on the dorsal side. When the body is far enough out the free legs grasp the wood and assist in relieving the remainder of the body. The nymph holds the antennae with the mouth parts and gives an upward pull. This is repeated until these appendages are released. (Fig. 7, e.) At about the same time the hind legs and tip of the abdomen become free. The whole process usually requires ten or twelve minutes, but a few of the insects never succeed in completely detaching themselves from the egg. The young cricket on emerging immediately crawls from the eggshell, usually upward on the branch. The watery lump on the top of the head continues to show for twenty minutes after the insect escapes from the egg, but within a short time after this period its disappears.

In 1909 and 1912 the nymphs began to make their appearance about June 14 and they continued to emerge until about the twentieth day of this month. In 1913 eggs that had been kept in the laboratory for five days commenced to hatch on June 6.

During the summer of 1913 individuals of this species were collected at intervals in the field in order to find out the normal time of appearance of each instar. The record is summarized as follows:

July  1. First specimen of nymph in second instar.
   " 11. Third instar in maximum numbers; some still in second and a few in the fourth stage.
   " 16. Fourth instar outnumbered third by five to one.
   " 19. First appearance of fifth instar.
   " 23. Fifth instar in minority.
   " 25. Over half of insects in fifth instar, remainder in fourth stage.
   " 29. Adults heard singing at night.
   " 30. An adult which had just transformed collected in the field.
Aug.  5. Adults and nymphs in about equal numbers.

In the summer of 1912, which was colder than usual in New York, adults were not taken until August 15, and eight days later were about equal in numbers to the nymphs. On August 27 practically all of the crickets had matured.
SOME HABITS OF THE NYMPHS.

Feeding habits.—During the daytime the nymphs are very inactive and remain for the most part hidden in a curled leaf, with the antennæ stretched out in front and usually projecting beyond the edge of the leaf as if to detect the approach of any intruder. At night they are very active and crawl about to feed. They show signs of restlessness as evening advances and continue on the move throughout the night.

Molting.—When a nymph prepares to molt it first fastens its claws firmly in the bark or in the tissues of a leaf, extends the antennæ backward, and arches up the back. The skin splits along the dorsal median line of the head and thorax. The head is bent down and the thorax works out through the split. The fore and middle legs are pulled out and exercised, while the palpi and antennæ are still held in the skin. The hind legs are pulled upward and forward. The antennæ are partly pulled out by straightening the body, and then they are grasped by the mouth and worked out in the same manner as noted in the process of hatching. When the hind legs are free the nymph grasps the support and pulls out the hind part of the abdomen. Later the skin is eaten by the insect if in the meantime the discarded remnant has not been consumed by some other cricket.

MUSICAL STRUCTURES AND SONG OF ADULT.

The males begin to sing very soon after reaching the adult stage. In doing so they raise the front wings perpendicular to the body, with the inner edge of the right lapped over the left, and vibrate them rapidly in a transverse direction. The mechanism which produces the sound is found near the base of the wing, the broad, expanded distal part serving as a resonator to increase the volume of sound. A short but prominent transverse vein, about one-fourth way from the base, is modified beneath to form a minute filiform rasp. It is about 2 mm. long and bears forty or fifty short teeth inclined toward the opposite wing. Both wings have a rasp but the right always laps over the left, the inner edge of which is thickened at this point to serve as a scraper. From our observations the rasp of the left wing and the scraper of the right wing are little if ever used.
The song of *niveus* is one of the most conspicuous and musical of the insect sounds commonly noted in late summer and autumn. It can be heard from the time the insects commence to mature—early in August in this latitude—until they succumb to frosts of late October or early November. The song begins at the approach of darkness and continues until morning. Occasionally a few of the insects may be heard during the middle of day when the weather is very cloudy. The song consists of a monotonous series of clear, high-pitch trills rhythmically repeated for an indefinite length of time. The quality is that of a clear, mellow whistle and has best been described by the words, *treat* — *treat* — *treat*. The pitch varies somewhat with the temperature but on an ordinary summer evening it is about C, two octaves above middle C, or on a warm evening it may reach as high as D. The rapidity of the notes is directly dependent on the temperature. On a very warm night we counted 155 beats per minute, while on a cool night the number was only 64.

The song of different individuals may vary also in quality, intensity, pitch and rapidity of notes. There is, however, a tendency for the insects in a restricted site—as a raspberry plantation, clump of bushes or a single tree or a small clump of trees—to sing in unison in one synchronous movement.

**MATING HABITS.**

In addition to their musical qualities the males possess another alluring device to attract the females. This is a gland situated on the metanotum, which becomes exposed at the time the forewings are raised in the act of singing. Externally this structure appears as a rounded depression, with elevated margin, which contains numerous hollow, glandular hairs, and also two pairs of openings from much branched internal glands. When a female approaches the singing male, he turns his head away from her, when she usually mounts his back and partakes of the secretion of the gland. (Plate II, fig. 1.) The male now stops singing and stands with his legs widely extended and wings raised to an angle of about 45 degrees. He appears to be in a state of great excitement, as shown by the twitching and swaying of the body and a peculiar jerky movement of the hind wings which lay folded along the abdomen. The antennæ are also waved about wildly and often thrown back so as to cross and rub against those of the female. The latter eagerly
bites and pulls at the thoracic gland, and at intervals stops to rest. During such a pause the male often resorts to singing as if to hold further the attention of the female. After she has fed on the gland for a half hour or more the male reaches back with his abdomen and simultaneously she bends her abdomen downward. He then protrudes a pair of small chitinous hooks, and with his cerci on each side of the ovipositor as guides, inserts these structures into a small notch at the end of the subgenital plate. This enables him to push the barbed capillary tube of a spermatophore into the opening. The abdomen is withdrawn and the spermatophore remains hanging. The latter is a white, hard, ovoid body about .85 mm. long with a central cavity filled with spermatic fluid, and opening out through a fine tube about 1.4 mm. long bent in the form of a hook. The sperms flow out through this tube into the seminal receptacle of the female. Following this act the female continues to feed at the dorsal gland for a quarter or half an hour. If she starts to crawl away the male renews his singing, apparently in an endeavor to dissuade her from departing from him. When she finally leaves she selects a secluded spot where seemingly she will not be disturbed. Later she arches up the back, bringing the tip of the abdomen forward beneath, and then reaches back with the head and removes the spermatophore. She straightens out again and proceeds to eat the capsule in a leisurely way. She then doubles up again and works at the ovipositor with her mouth, starting at the base and continuing out toward the tip, as if endeavoring to clean this organ.

OVIPOSITION.

For this operation the female selects a suitable spot on a tree or bush and prepares to oviposit by first chewing a small hole in the bark, choosing the upper side of a branch in preference to the lower side, and working with the head uppermost when on a sloping or vertical surface. Upon the completion of the cavity she then walks forward a little, arches her back so as to bring the ovipositor about perpendicular to the branch and begins moving it up and down until she strikes the hole. She then starts to drill by giving the ovipositor quick thrusts and at the same time slowly turning it around by twisting the abdomen thirty or forty degrees to each side. (Plate II, fig. 2.) As the ovipositor is forced in it takes a more or less oblique course, according to the thickness of the bark, so that the
egg usually comes to lie nearly parallel to the surface. It generally takes from six to ten minutes to force the ovipositor to its base the first time, but in some cases it takes much longer, depending on the resistance of the bark. After the operation this organ is pulled nearly out and drilled in again several times, each effort taking about one and a half or two minutes. When the hole is sufficiently reamed out and the ovipositor drilled in for the last time the female forces out a drop of excrement and, by stretching out the tip of the abdomen, fastens it to the bark just below the hole. The egg is then forced down and the ovipositor is slowly withdrawn. The female pauses with only the tip remaining in the hole and deposits some mucilaginous substance. She then removes the ovipositor, moves a slight distance backward, seizes the drop of excrement in her mouth and places it over the opening. She then spends several minutes packing it in and smoothing it out so that the wound is neatly capped. (Fig. 6, c.) The whole process of depositing an egg, from starting to drill until the hole for the reception of the egg is sealed, may consume from twenty minutes to three-quarters of an hour. In our breeding cage experiments from one to thirteen eggs were deposited in a single night by one individual. Several of the insects laid a few eggs every night during the whole period of oviposition. On a few nights others did not oviposit at all. The largest number of eggs deposited by a single female was seventy-five, the smallest number twenty-four, and the average of eleven individuals was forty-nine.

The eggs are laid in the soft inner bark. A groove is often cut in the surface of the wood, but generally the hard tissues are not drilled into to any extent. In most plants a hard, woody capsule forms around the egg which completely encloses it with the exception of that portion in contact with the opening made by the ovipositor in the bark.

In trees having a rather soft, fleshy bark, such as apple and plum, niveus prefers to oviposit in fairly large branches from one to three inches in diameter. The eggs may be placed in almost any area in the bark, but a favorite location is in a lenticel where the initial drilling is more easily accomplished. (Plate IV, fig. 1.) In bushes and trees in which the large branches have a tough bark the eggs are commonly laid in the smaller branches in thick places in the bark on each side of the base of a small twig or bud. In raspberry canes, where the eggs are sometimes fairly common, oviposition usually occurs in the fleshy area at the side of the bud in the axils of the
leaves, and we have never found more than one egg on each side of a bud. (Fig. 6, b.) However, the egg never extends through the woody layer into the pith, as is the case with *nigricornis*. On elms, the eggs are mostly placed in the corky area of large or small branches, and they do not usually extend into the inner bark. Peach trees are seldom selected by *niveus* for oviposition. The reason for the apparent dislike of this species for this plant is not clear, since the eggs of *nigricornis* have been observed in considerable numbers in the current year's growth. In this connection it is of interest to note that in one series of breeding experiments *niveus* oviposited quite freely in the trunks and larger branches of a peach tree, but later the formation of gum was so great that the eggs were completely forced out of their positions. Oviposition largely occurs during the latter part of August and September.

**SELECTION OF PLANTS FOR PURPOSES OF OVIPPOSITION.**

Oviposition experiments in breeding cages were conducted in the laboratory to determine what kind of plants the females preferred for the reception of their eggs. Each cage contained one or two males, with a single female. In the cages there were placed a short piece of apple limb one or two inches thick, a piece of raspberry cane with foliage, and a bunch of small, pithy weeds, mainly wild carrot (*Daucus carota*). In a number of cages there were also included short sections of branches, about one inch thick, of maple, willow, elm and poplar. Eggs were laid only in apple, raspberry, willow and elm. Of these, preference was shown for apple wood. One cricket laid its eggs entirely in raspberry and two others deposited a small part of their eggs in canes of this plant. One specimen laid a few eggs in willow and another placed four eggs in elm. Observations in the field have shown that this cricket deposits its eggs in a great variety of plants and that it prefers certain of them to others for this purpose. About Geneva its eggs are most abundant in apple, plum and cherry trees, and they are also somewhat common in walnut and raspberry. One small elm tree was observed to contain a large number of them and a few eggs have been found in peach, witch hazel, chestnut, butternut, wild crabapple, hawthorn, red oak, maple and lilac. Oviposition probably occurs in many other plants which possess bark of desirable thickness and not too resistant to the drilling operations of the insect.
DATES OF LAST APPEARANCE OF ADULTS.

In the autumn of 1912 specimens of this species were found on October 29, and males were heard singing on the night of October 30. These had lived through three light frosts, but none of the insects were found after heavy frosts on November 2, 3 and 4. In 1913 a good many females were found in apple trees on October 28 but no males were observed.

FEEDING HABITS.

This species subsists on a rather wide assortment of foods of both vegetable and animal origin, which are capable of being masticated by its comparatively weak mandibles. In rearing the crickets in cages we depended almost entirely on aphids and sugar solution, both of which were easily available and readily eaten by this and other species. The insect also ate holes in raspberry leaves and to a less extent in apple leaves. Under confinement niveus was often seen chewing at the cambium on the truncate ends of a severed branch and eating the green outer layer of wild carrot stalks. A disabled cricket or one unable to defend itself usually fell a victim to more vigorous individuals. For further knowledge of their natural feeding habits we dissected out the crops of a number of individuals and examined the contents with a microscope. The specimens of this species examined were in the fourth and fifth instars and all were taken from trees in a neglected apple orchard. In about half of them the crop contained a large proportion of materials of insect origin, while in the remainder the contents consisted largely of plant tissues. The latter was mostly leaf tissue, including cells with chlorophyll, leaf hairs and vascular tissue. Mycelia and spores of various fungi were present in smaller quantities. The contents derived from the eating of insects was usually so broken up that it was difficult to classify with any degree of certainty the different elements as to their origin. In quite a number of samples we found parts of what appeared to be the cast-skin of a tree cricket, which was probably its own, and in one specimen this was all the crop contained. Broken pieces of faceted eyes, which resembled those of an aphid, and antennæ of probably the same individual were found in several instances. In nearly all specimens remains of San Jose scales were detected, and in the contents of one crop the pygidia
of twenty-four of these insects were counted, and probably the remains of others were present in an unrecognizable condition.

The presence of San Jose scales in the crops led us to perform experiments on feeding the coccid to crickets. A small branch about one-half inch in diameter, thoroughly covered with scales, was placed in a cage with five specimens of niveus in the fourth instar. After two nights the exposed part of the stick, or about three inches in all, was entirely cleaned of the scales. In other experiments only one cricket was confined, this individual being allowed to feed on infested wood on which the number of the scales had first been approximated. In one instance a cricket over night disposed of about five hundred and forty scales, and during the next two nights approximately six hundred and twenty scales. On the fifth night it devoured nine hundred and eighty scales, while on the following night it ate seven hundred and sixty scales. The counts included both mature and immature specimens, and it should also be noted that the crickets ate both the protective covering or scale and the real insect beneath. These results indicate that when the crickets occur on infested trees this coccid, as well as others, probably forms a large part of their diet. Nevertheless, the San Jose scale is constantly spreading in orchards that are well stocked with tree crickets.

Another habit of this cricket which has attracted the attention of some entomologists is that of eating holes in fruits. We have found no examples of such injury in orchards in western New York, but in experiments where fruits were placed in cricket cages or the crickets were confined in cages built about fruits the insects ate round holes in them. The character of the injury is quite easily distinguished from the work of the more common orchard pests, for after making a small opening in the skin of the fruit the cricket works its way into the flesh and feeds with its head concealed within the hole. As a result the cavity increases in diameter below the external opening in the skin of the fruit. Peaches and plums were preferred to other fruits.

**EFFECTS OF OVIPOSITION ON APPLE TREES.**

The effect on the tree of oviposition by the female is to produce in the bark a small opening as if the tissues had been punctured by a coarse cambic needle. With the majority of egg punctures little damage results, since the wounds heal quickly, the only visible
injury being a discolored point or a tiny pit or depression surrounded by a narrow ring of dead bark. (Plate III, figs. 1, 2.) If oviposition were never attended with more serious consequences the work of niveus in this respect could hardly be considered of enough importance to warrant it being listed as a pest of the apple. Such, unfortunately, is not the case; for there is another form of injury which apparently arises from a contamination of the wounds made in the bark by the cricket by some infectious agent and appears as diseased areas. These, in their external appearances and effects, resemble superficially certain stages of the New York apple-tree canker (Sphaeropsis malorum Pk.) or the blight canker of apple trees (Bacillus amylovorus (Burr.) de Toni). The affected spots range generally from one-fourth of an inch to an inch in diameter, while the bark within these limits varies from purplish or reddish-brown to pale brown, depending apparently on the extent and age of the infection. (Plate V, figs. 1, 2.) Usually most of the diseased areas are circular or somewhat oval in form, and occasionally one may observe a large irregular extension of the original infected area as if there had been a renewal of activities by the infectious agent. The bark within the area of infection is generally slightly depressed and may also be separated from the sound bark by a distinct line or narrow crack. (Plate IV, fig. 2, and Plate V, fig. 3.) In more advanced stages cracks develop, separating the dead area from the surrounding tissues, and there is formed a core which adheres loosely to the wood, (Plate V, fig. 4) affording attractive situations for the woolly aphis. (Plate V, fig. 6.) From the wounds made by the insect, located as a rule about the center of the diseased areas, one may observe in April or May more or less flowing of a gummy, reddish-colored liquid which on drying leaves a resinous product about the orifices of the wounds. (Plate V, fig. 1.) Not infrequently there is an entire destruction of the bark which, on sloughing off, leaves the underlying wood core exposed in spots of varying dimensions. In some orchards such injuries occur to a serious extent. These conditions may be quite generally observed on trees along weedy roadsides or ravines or in apple orchards that are neglected or are indifferently managed. Orchards that are given careful attention are usually free from the trouble, although plantings — especially of young apple trees growing near neglected orchards or near raspberry plantations — have occasionally been observed which showed considerable oviposition
by niveus and here and there an egg puncture with the characteristic affected area surrounding it.

Of the insects in this State which produce scarification and disfigurement of bark and wood of apple trees the most prominent species, with the exception of the seventeen-year cicada (Tibicen septendecim), which is restricted to limited areas, are the buffalo tree-hopper and the snowy tree cricket, which are very common and widely distributed. Both insects are most injurious in plantings that lack care with respect to approved orchard practices. Both produce damage to trees as a result of their habits of oviposition, and not infrequently the effects of their work may be observed on the same tree. In the positions selected for the reception of the eggs and in the effects of egg-laying upon the health of the trees, the two insects show characteristic differences. The foregoing tree-hopper (Ceresa bubalus) deposits its eggs in the bark of the newer growth. In the case of young trees oviposition may be so extensive that portions of the tree are stunted and the tree becomes ill-shaped. The vitality of the older trees is generally not seriously affected, the principal damage being scarification and roughening of the bark if the deposition of eggs has been extensive. On the other hand niveus prefers for egg-laying soft, fleshy bark, preferably that of wood from one to three inches in diameter. By reason of this habit apple wood is subject to oviposition by this insect over an extended period of years, which results in considerable pitting, scarring and other disfigurements of the bark. (Plate III, fig. 1) The extent to which apple wood is sought by this cricket for egg-laying purposes is best observed by removing the bark, which will reveal discolored areas in the cambium and wood (Plate III, fig. 2.) and by making cross sections of the wood as shown in Plate III, fig. 3. The chief damage by niveus on apples arises apparently from the establishment of a bark disease in its oviposition punctures, which causes the bark of the older wood to become scarred and roughened or kills the bark on the younger wood, with resultant weakening or death of small branches and twigs.

occurrence of Leptosphaeria coniothyrium about oviposition punctures.

Cultural and microscopical studies by Mr. W. O. Gloyer of the Department of Botany to identify the infectious agent which becomes
established in the oviposition wounds of the tree cricket have revealed the interesting fact that during 1913 the causal organism was in the majority of cases a species of fungus known as *Leptospharia coniothyrium* (Fckl.) Sacc. (*Coniothyrium Fuckelii* Sacc.). According to Duggar 8 this is a fungus which, as a disease-producing organism, has been known only a few years. O’Gara 9 lists it as occurring on apple and rose at Washington, D. C., and on apples in a nursery near Clemson College, S. C. It is stated by this writer that most of the infections took place where the bark of the trees had been bruised or broken by tools or harness in cultivating. In New York this fungus had, up to the time of this investigation on tree crickets, attracted no attention either as an apple or as a rose pest; but since 1899 it has been regarded in this State as the cause of a widespread and serious disease of raspberries, which is popularly known as raspberry cane blight. It is essentially a wilt disease and the principal damage results to the fruiting canes. The whole cane may be involved or only a portion of it. Stewart and Eustace 10 believe that infection occurs in wounds of various kinds and that a break in the epidermis usually precedes the attack. They also state that cane-blight often starts in wounds made by the "heading back" of new canes, by the removal of branches, by the rubbing of canes against each other or against supporting wires, particularly in crotches where the branches are more or less split apart and in wounds made by the snowy tree cricket *Oecanthus niveus* (nigricornis) during oviposition. That infection does actually occur in tree-cricket wounds is shown by the large number of instances in which the cane is covered with *Coniothyrium* pycnidia in the vicinity of the wounds, usually just below them."

The occurrence of *Coniothyrium* about the oviposition punctures of *niveus* in apple bark have suggested that this cricket may act as a carrier of the disease. In studying the feeding and egg-laying habits of this insect it appears that infection of apple bark might take place (1) as a result of wounds produced by the gnawing of the bark by the female as the initial step in the act of oviposition; (2) by means of the ovipositor, the adhesive substance discharged at the time of deposition serving to collect and to hold the spores which

may be left in the holes during the drilling process; and (3) by the introduction of spores in the oviposition punctures on account of the remarkable habit of the insect, which employs its excreta to close the openings in the bark after the deposition of the egg. Experimental proof of such carriage of the disease is, however, lacking, but studies to this end are being conducted by this Station.

**Susceptibility of Tree Crickets to Spraying and Other Orchard Practices.**

The occurrence of comparatively small numbers of tree crickets in well-cared-for orchards, except as they adjoin raspberry patches and weedy areas, indicate that the conditions that exist in such plantings are not congenial to these insects. The behavior of the tree crickets in this regard is strongly suggestive of the habits of well-known apple-maggot (*Rhagoletis pomonella*) in apple plantings in this State. Both insects thrive best in neglected orchards and are for the most part of little importance in plantings that are carefully managed. It appears that such approved practices as pruning, cultivation and spraying afford protection to the trees from these pests. As with the apple maggot, a satisfactory explanation as to how these operations affect tree crickets is lacking. As yet we have to fall back on suppositions. It does not appear that pruning as ordinarily carried out in commercial orchards would have any appreciable influence on the numbers of the crickets. Clean culture would likely prove unfavorable to them. Following storms and high winds they may sometimes be found on weeds and other undergrowth, and the absence of such plants in cultivated orchards might prove detrimental to the insects by rendering them more exposed to the attacks of birds and other foes. Moreover in view of the phytophagous habits of these creatures a hypothesis which seems quite probable is that as a result of applying arsenate of lead to apples, as is now so extensively practiced in commercial plantings, the crickets actually feed on sprayed foliage and succumb to this poison.

In the absence of data bearing on this latter point it seemed desirable to determine the effects of applications of arsenicals at usual strengths to foliage upon these insects, and to this end two tests were conducted by confining different lots of crickets, of five to six individuals, to sprayed and unsprayed foliage of apple trees. In the
use of the poison the arsenate of lead was allowed to dry before the insects were introduced in their respective cages. As an additional check on these tests a liberal supply of plant lice was supplied to several of the lots after the spray had dried on the foliage. Some of the details of these tests and results of the different treatments are indicated in the accompanying tables.

Table I.—Effects of Arsenate of Lead on Tree Crickets.

On Oecanthus angustipennis.

<table>
<thead>
<tr>
<th>No. of Lot</th>
<th>Treatment</th>
<th>Effect after ten days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead arsenate*</td>
<td>All crickets dead.</td>
</tr>
<tr>
<td>2</td>
<td>Lead arsenate</td>
<td>&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Lead arsenate and a supply of plant lice</td>
<td>&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Lead arsenate and a supply of plant lice</td>
<td>&quot;</td>
</tr>
<tr>
<td>5</td>
<td>Check</td>
<td>All crickets alive.</td>
</tr>
<tr>
<td>6</td>
<td>Check</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

On Oecanthus niveus.

<table>
<thead>
<tr>
<th>No. of Lot</th>
<th>Treatment</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead arsenate†</td>
<td>All dead.</td>
</tr>
<tr>
<td>2</td>
<td>Lead arsenate and a supply of plant lice</td>
<td>&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Check</td>
<td>All alive.</td>
</tr>
</tbody>
</table>

*Poison applied July 16. †Poison applied July 25.

The above tests are not as conclusive as we should desire because of the small numbers of crickets in the different lots and the little freedom given them for foraging activities. However, the results point out the fact that these creatures are, under certain circumstances, leaf-eaters and suggest that they, in common with other species of insects with leaf-eating habits, run risks from arsenical poisoning in well-sprayed orchards.

Preventive and Remedial Measures.

The facts brought forth in this bulletin indicate that the snowy tree cricket is most abundant in neglected orchards and that there is little to fear from this insect in plantings that receive careful attention. Cultivation to destroy foreign vegetation, as weeds and brush, about and in the orchard and to keep the ground about the trees clean is especially recommended. Such treatment seems not only to afford protection from the tree crickets, but in the case of orchards which lack vigor the trees will be stimulated to outgrow the various disorders to the bark that have attended oviposition by these insects. While the susceptibility of this species to arsensicals has not been conclusively demonstrated, it is believed that the
numbers of crickets are materially reduced by summer applications of these poisons. Both of these measures—clean culture and spraying with arsenicals—are fortunately standard orchard operations which are invariably practised by the most successful fruit-growers.

THE NARROW-WINGED TREE CRICKET.

*Ecanthus angustipennis* Fitch.

HISTORICAL NOTES.

This species was first described by Fitch¹ as a variety of *niveus* from a single male specimen. The description is very brief and the only distinguishing character mentioned is the narrow wing covers. Beutenmüller² says that this characterization "applies equally as well to *quadripunctatus* as to the insect determined by recent writers as *angustipennis*. Whether the latter has been correctly determined or not can never be definitely ascertained, as Fitch's type of the species, as well as all his other species of *Ecanthus*, have been destroyed. I would propose that the name *angustipennis* nevertheless be retained for the species so well known to us by this name." This species is not generally as familiar to economic workers as *niveus*, although it has somewhat similar habits. References to the insect are largely found in systematic writings, and as regards its life history and habits very little has heretofore been published.

DISTRIBUTION.

Our knowledge of the extent of distribution of this species in New York is very limited. It is common in the lake region of the western part of the State and on Long Island, and probably the insect ranges over about the same territory as *niveus*. It has been recorded in literature from other states as follows: Massachusetts (Faxon), Connecticut (Walden), Georgia, Florida, Texas (Allard), Illinois (Forbes), Kentucky (Garman), Kansas (Tucker), Minnesota (Lugger). From specimens examined we can record it from the following states: New Jersey, North Carolina, Florida (Amer. Mus.), Virginia (Schoene), Ohio (Kostir). Of the states mentioned, Minnesota represents the most northern limits of distribution, while Texas appears as the most western area of its occurrence.

DESCRIPTION OF LIFE STAGES.

Egg.—(Fig. 8, b) The eggs are white and average a trifle smaller than those of niveus. The cap is narrower than in the latter species and varies greatly in length. Short specimens (Fig. 8, d) measure about .4 mm. in length and breadth, while the long ones (Fig. 8, c) reach .7 mm. in length, have a broad base and taper down to a rather narrow tip. The projections of the cap are short and thick, measuring about .011 mm. in breadth by .014 in length. (Fig. 8, e.) The end of the cap is broadly rounded and the base slightly constricted.

The average measurements of twenty specimens of eggs are as follows: length, 2.77 mm.; greatest width, .51 mm.; length of cap, .48 mm.; width of cap, .42 mm.

Fig. 8.—Narrow-winged Tree Cricket.

a. Egg punctures in apple wood (× 3); b, egg (× 15); c, d, long and short egg caps (× 50); e, spicule of egg cap (× 500).

Nymph.—First instar: Color white. Markings of head and thorax as in following stage. Antennae entirely white; occasionally with a dark spot on the inner edge of the first segment. Hind femora with a few black spots near distal end; hind tibiae with a conspicuous black space at distal end covering about one-sixth of entire length. Length 3 to 3.3 mm. Antennae 8 mm.

Second instar: Color greenish white. Head with a short black line above and back of each eye, and with black specks at the base of minute bristles between eyes and antennae. Thorax with a pair of dark lines near the median line. First segment of antenna with a black spot on the inner edge. Outer half of antenna very faintly annulated. Hind femur with only four or five black spots on the outer side near the distal end. Length 4.5 to 5 mm.

Third instar: Dorsal area of abdomen pale green with a small median white spot on hind margin and a pair of white spots near front margin. Sides pure white. Basal antennal segment with the black spot on inner edge; and most specimens have a more or less distinct short line on the front side near the inner edge. Second segment with a small black spot on the front and inner side. Length 6 to 7 mm.
Fourth instar: Pale green. Head slightly yellowish above. Two median longitudinal lines of pronotum faint. Median area of abdominal segments pale yellowish green; the three white spots are relatively small. Upper part of side of each segment with a large elongate white spot reaching from front to hind margin, constricted or divided in the middle and surrounded by a ground color of pale yellow. Sides below are pure white. Antenna with a rather prominent white lump on the front and inner side and bounded on the outer side by a curved black mark. Second segment with an elongate spot. Length, 8 to 10 mm.

Fifth instar: Top of head between eyes yellow or pale orange. Median area of pronotum greenish; with two faint dark median lines. Abdominal markings as in the fourth instar. White prominence on the first antennal segment, with a black J-shaped mark; and the second segment with an elongate spot. Hind femora with a few black spots near the extremity. Length 11 to 12 mm.

Adult.—Very slender. Pronotum a little longer than greatest breadth. Color very pale green. Light specimens have the top of the head between the eyes and antenae yellow, and have a faint gray longitudinal streak on the pronotum. Darker specimens have the top of head orange yellow or even burnt sienna and the streak on the pronotum is strong brownish gray. Wings transparent, with greenish tinge and greenish veins. Fore wings of male comparatively narrow. Antennae faintly annulated with gray on the distal part. The first segment is yellowish with the exception of a white prominence on the front and inner side, which bears a black J-shaped mark, with the crook turned inward. (Fig. 5, b.) Length to end of abdomen 14–15 mm. Forewing of male 10–12 mm. x 4–5 mm. Forewing of female 12 mm.

DURATION OF NYMPHAL STAGE.

Angustipennis was first discovered in association with niveus on apples during the summer of 1913 when the nymphs were mostly in the third instar, and for this reason we have made very few observations on its early life history. This species passed through the various nymphal stages about a week or more later than niveus, which may have been due to a slower development or to a later time of hatching. On July 16 the nymphs were generally in the third stage and on July 25 they were practically all in the fourth instar, while on these two dates niveus was mostly in the fourth and fifth instars respectively. The adults also matured, on the average, later than the latter species.

During the latter part of October the adults become very inactive and may often be observed clinging to the trunks and larger branches of the trees. At this time the males are apt to be very few in number and apparently they die off earlier than the females. In the fall of 1912 living females of this species were found as late as October 29, and on November 3 dead ones were found on the trunk of an apple tree. In 1913 a large number of females in fairly active condition were taken in an apple orchard on October 28, but no males could be found on this date.
SONG AND MATING HABITS.

The song is intermittent but readily distinguished from *niveus* by its longer notes and rests and by its non-rhythmical character. The pitch is from C $\#$ to D $\#$, two octaves above middle C, depending on temperature and somewhat on individual variation. The sound is not so loud as that made by *niveus* and is of a more mournful quality. Each trill continues from one to five seconds, but it lasts most commonly for about two seconds. The periods of rest vary more and may be from one to eight seconds or longer. On one occasion a specimen alone in a cage was observed to trill continuously for a minute or more. Out of doors the song would be unnoticed by anyone not endeavoring to detect it. On trees where *angustipennis* occurs in equal abundance with *niveus* the song is nearly drowned out by the synchronous beat of the latter species and only by listening intently can it be detected. So far as we have observed it sings only at night. The method of producing the sound and the structures that make it possible are essentially the same as described under *niveus*. On account of the narrow forewings, however, the rasp is not so long and the resonating surface is not so great, which may, at least in part, account for the feeble production of sound by this species.

The mating habits are essentially the same as those of the preceding species.

LOCAL DISTRIBUTION.

This cricket occurs quite often on the same trees with *niveus*, but while individuals of this species are very abundant in apple orchards they are, however, not so much confined to these trees as are those of the latter. On Long Island we found this insect quite common on oak trees, especially the scrub and burr oaks, and in a swamp near Geneva there were considerable numbers on alder bushes. We have never taken *angustipennis* on raspberries, grape, or weeds of any kind.

FEEDING HABITS.

An examination of the crop contents of a number of specimens collected on apple trees shows that this species has food habits very similar to *niveus*. Leaf tissue, fungus mycelia and spores, aphids, San Jose scales and moulted skins comprise the bulk of its food. In two individuals we found a number of lepidopterous wing scales while in another specimen a leg and the wings of some small hymenop-
terous insect were detected. The discovery of twenty-eight recognizable pygidia in the crop of one individual shows that this species, like niveus, may feed extensively on certain kinds of scale insects.

OVIPOSITION.

The female usually selects a small branch of about a half or third of an inch in diameter in which to place her eggs. She drills into the thick, wrinkled places in the bark where the small twigs branch. The details of the various operations in connection with egg-laying are, with a few exceptions, as described under niveus. We have not observed this species using a drop of excrement to seal the hole in the bark after the deposition of the egg. For this purpose she bites off particles of bark near the puncture and pushes them into the hole, making a little round pellet. It sometimes happens that the female does not completely remove the ovipositor after laying the first egg but starts to drill another hole in a slightly different direction and deposits a second egg without appreciably changing her original position. (Fig. 8, a.) From examinations of a large number of egg punctures in orchards about Geneva we have found only a few paired eggs, and our caged crickets from this section laid very few eggs in this manner. Apple branches from West Virginia and Kentucky contained large numbers of these double punctures (Plate VI) as well as single ones, and live, caged specimens of this species sent to us from Kentucky deposited fully half their eggs in pairs. This slight difference in habit between individuals of this species living in New York and those collected in West Virginia and Kentucky seems to be merely a physiological variation and is apparently not accompanied by any deviation of importance either in structure or coloration of the nymphs or adults.

ECONOMIC IMPORTANCE.

This insect has habits quite similar to the foregoing species and ranks with it in economic importance. In his studies of the two species in Kentucky, Garman\(^1\) states that angustipennis was the more common in cutting fruit of peaches, plums and grapes. (Plate IX, fig. 2.) A serious result of the rupturing of the skins of these different fruits was the development in the wounds of such destructive diseases

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as brown rot and black rot. In New York we have observed no
damage by this species as a fruit pest. As has been suspected of
*niveus*, there seems to be good evidence that this insect is in some
way connected with the transmission of a bark disease of apples.
Hopkins² has described the occurrence of diseased areas or cankers
which he detected about the egg punctures of a tree cricket in apple
orchards in West Virginia. He states that this peculiar injury to
apple trees appears to be "quite common in all old orchards and is
quite a serious trouble in some localities." The character of the
injury is clearly shown in Plate VI.

"A quite small and nearly round puncture is made through the
outer bark, and from one to two long cavities are formed in the inner
bark and sometimes grooving the outer surface of the wood. The
wound thus made sometimes heals without doing harm but it often
causes a blighted condition of the bark as shown in [Plate VI, fig. 1,]
and if the entire branch does not die, and it often does not, the woolly
aphis attacks the edges of the wound and prevents it from healing.
Thus an ugly scar or deformed place is the result as in [Plate VI,
figs. 2, 3]. Many branches so injured ultimately break off or die, so that the injury to a tree may be such as to cause it
to rapidly deteriorate and soon become worthless as a fruit producer.

"It appears that the insect does not oviposit in rapidly growing
branches on young trees, but selects those which are making slow
growth. Thus when the wound is attended with blight and is
subsequently attacked by the woolly aphis the wound seldom heals,
the exposed wood commences to decay, and the branch dies, breaks
off or becomes unproductive."

The identity of the species was not discovered by Hopkins, but from
his description of the paired egg punctures there can be little doubt
that at least part of the injury as described was due to oviposition
by *angustipennis*. We have examined a number of small branches
from West Virginia which were well covered with cankers. The
branches were about one-half or three-quarters of an inch in diameter,
and some of the cankers showed an area of bare wood in which the
groove made by the ovipositor of the cricket could be plainly seen.
A good many of the egg punctures were paired, and *angustipennis* is
the only species we know which lays its eggs in this manner in the
bark, although it also deposits them singly.

PREVENTIVE AND REMEDIAL MEASURES.

The similarity in the behavior of *angustipennis* to *niveus* in apple orchards suggests that this insect is susceptible to the same measures as outlined in detail for the latter species.

THE STRIPED TREE CRICKET.

*E*canthus *nigricornis* Walker.

This is apparently the insect described by Fitch\(^1\) in 1856 as *E*. *fasciatus* De Geer, but according to Beutenmüller he "erroneously mistook his insect for De Geer's\(^2\) *Gryllus fasciatus* which is a *Nemobius.*" A description at a later date by Walker\(^3\) under the appellation of *E*. *nigricornis* fits the striped tree cricket very well, and for this reason Beutenmüller\(^4\) in 1894 recommended that this name be accepted since Fitch did not really denominate the insect. As stated previously Walsh and Riley considered this tree cricket as a dark variety of *niveus*. Others have also held that *nigricornis* and *quadripunctatus* are varieties of the same species, but in our studies of these two insects we have found constant differences in their habits as well as body characters, which have led us to regard them as quite distinct insects.

DISTRIBUTION.

This tree cricket is very common and is widely distributed over New York and throughout the United States. From literature it is recorded as follows: Massachusetts (Faxon), Connecticut (Walden), New Hampshire (Henshaw), New Jersey (Davis), Ontario (Walker), Tennessee (Morgan), Mississippi (Ashmead), Michigan (Allis), Illinois (Forbes), Minnesota (Lugger), Nebraska (Bruner), Oklahoma and Arizona (Caudell), Texas and Kansas (Tucker). From specimens examined we can record it from the following states: New Jersey and Connecticut (Amer. Mus.), North Carolina (C. L. Metcalf), Ohio (Kostir).

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2 De Geer, Charles. Mémoire pour servir a l'histoire des insectes, Tome III, 522–23, pl. 43, fig. 6. 1773.
DESCRIPTION OF LIFE STAGES.

Egg.—The eggs (Fig. 9, c.) are of a light or medium yellow color, and brightest when first laid. The cap is smaller than that of nivicus, broader than long and hemispherical, the sides being parallel only at the extreme base. (Fig. 9, e.) The color of the cap is dull white but is sometimes stained reddish when in certain plants. The projections are short, cylindrical, and rounded at the tips. (Fig. 9, d.) Those near the end of the cap are .012 mm. long by .008 mm. in diameter. The eggs are more uniform in size than those of nivicus and are generally narrower. Average measurements of thirty-six specimens are as follows: Length 2.9 mm.; greatest width: .57 mm.; length of cap .35 mm.; width of cap .44 mm.

Nymph.—First instar: Color, pale slightly greenish yellow. A slight infuscation extends along the dorsal side from the antennae back, and is divided along entire length by a narrow pale median line. Just back of the antennae the median line meets a pale transverse curved line which arches posteriorly. On the abdomen the shaded area is bounded on each side by a pale line which is in turn bordered by a faint dark line. The antennae are gray all over but darkest toward the extremity. Length 3 mm. Antenna 6 to 6.8 mm.

Second instar: Pale greenish yellow with scattered whitish fakes. Pale dorsal median line present, dorsal infuscation very faint. The two basal antennal segments are pale in color and the first segment has a dark longitudinal streak on the inner edge of the front side. Length 4 to 5 mm.

Third instar: Yellowish green, mottled with small whitish spots and with a pale median line. Legs speckled with fine dark spots at bases of hairs. Markings of basal antennal segments of the same pattern as in adult, but faint. Length 6 to 7 mm.

Fourth instar: Antennal markings distinct. Slight infuscation on head and pronotum, bordering the median pale line. Length 8.5 to 10 mm.

Fifth instar: Dorsal part of head slightly brownish. Hairs on body mostly dark. Legs appear rather dark, due to numerous dark hairs and spots. The spots on the basal antennal segments are large and conspicuous but not confluent. Ventral side of abdomen slightly infuscated and covered with small brownish spots. Length 11 to 12.5 mm.

Adult.—The amount of color in this species varies considerably and newly moulted specimens are lighter than old ones. The light specimens are greenish yellow. Head with blackish or sepia shading on median area, sides and front below the antennae.
Pronotum with similar shading on sides and median area. Wings clear with greenish yellow veins and tinge of green between veins on inner edge. Femora dull green; tibiae and tarsi black. Antennæ black; first and second segments greenish yellow. The first segment has a brownish shading covering the inner and upper part of the front side, and including a heavy black line along the inner edge and a black spot near the distal end, which may be confluent with the black line. Second segment with two elongate black spots. (Fig. 5, c.) Venter of abdomen solid black; the remainder greenish yellow. Dark specimens late in the season have the head, pronotum, legs and antennæ nearly entirely black. Both pairs of spots on the two basal antennal segments are confluent (Fig. 5, d) and in some specimens each of these segments are almost entirely black. Length of body, 15 mm. Forewing of male, 10-11 mm. by 4-5 mm. Forewing of female 11-12 mm.

HATCHING OF EGGS AND DURATION OF NYMPHAL INSTARS.

In 1909 the young of this species began to emerge just before June 17. In 1913, eggs from the southern part of the Hudson Valley hatched June 7; some eggs from Connecticut began to hatch on June 10, while of a shipment received from New Brunswick, N. J., on June 10 a little more than one-half of the eggs had hatched. During this same year eggs of this species collected about Geneva hatched in largest numbers on June 16 and 17.

A study of the eggs in their natural positions in the wood shows that generally they slant downward from the hole, and since the dorsal side of the embryo is always next to the concave curvature of the egg the young cricket on hatching first appears upside down. In some observations of young insects in captivity it was observed that they displayed cannibalistic tendencies, and the cricket that emerged first would not infrequently attack those that were in process of emerging from the eggs and devour them.

During the summer of 1913 the first specimen in the second instar was found on July 2. On July 12 five specimens were taken in the third instar, and on July 17 there were about twice as many of the crickets in the fourth instar as in the third stage. On July 25 a few of the insects were in the fifth instar, but the majority of them were in the fourth stage. On August 5 most of the crickets were in the fifth instar, but no adults had so far been observed. However, adults were found several days later.

In 1912 no adults could be found on August 13 but a few of them were detected on August 20. On August 23 adults and nymphs of the fifth instar were present in about equal numbers, and by the 27th nearly all the nymphs had matured. The records for 1912 are probably several days later than normal as the summer was unusually cool.
SONG.

The song is a shrill continuous whistle, whirr-r-r-r-r, which may continue for a period of several minutes. In quality it most resembles the sound of a small tin whistle. The pitch on an average summer evening is F♯, two octaves above middle C. On a very cool night the pitch drops a little and the sound becomes much fainter and is not nearly so easily detected as the clear notes of niveus.

The song of nigricornis can easily be distinguished from the two preceding species, niveus and angustipennis, by its continuous note; the others having an intermittent sound. However, another common species not included in this article, quadripunctatus, has a song so closely resembling that of nigricornis that the two sounds are difficult to distinguish, even by one well acquainted with them. On the average the song of the former is fainter, less shrill and of a more rasping quality. Nigricornis can usually be heard in the vicinity of berry patches and tall weeds during the daytime as well as at night. In the morning only an occasional individual engages itself in singing, but in the afternoon more of the insects participate, and by evening the chorus appears in its greatest numbers and continues in full force throughout the night.

MATING HABITS.

The mating of nigricornis may begin before dark and pairs of the insects can generally be observed late in the afternoon clinging to the stalk of some tall weed or hiding on the undersides of the leaves. The female feeds eagerly at the thoracic gland of the male and, as is the case with the preceding species, he attaches the spermatophore at the base of her ovipositor. Judging from Hancock's¹ account and from our own observations the performance of this function is carried out in all the details as has been described for the snowy tree cricket.

OVIPOSITION HABITS.

In preparing for oviposition the female usually selects a position on the bark which is well above ground, the height depending largely on the diameter of the stalk and the kind of plant. In grape vines and certain weeds, stems not more than five millimeters in diameter

are often chosen, but in raspberry canes and elder the common thickness of the wood in which the eggs are laid is not much under a centimeter. If the stalk is vertical the female apparently manifests no preference as to choice of position, but if the plant slants a little she almost invariably chooses the uppermost side. In places where strong prevailing winds have caused all the weeds in a locality to lean in the same direction it will usually be found that nearly all the eggs are placed on the exposed side of the stalks of the plants. Before drilling, the female chews a small hole in the outer bark. She then arches up her body, brings the ovipositor forward perpendicular to the stalk, places the tip of it in the hole which she has previously made, and begins to drill. It takes about five minutes to push in the ovipositor for the first time. After this operation is done she reams out the hole by pulling the ovipositor nearly out and drilling it in a few more times. The egg is then forced down and she slowly pulls out the ovipositor, pausing with the tip of this organ in the hole to exude a small quantity of mucilaginous substance. In the case of one individual an egg protruded from the underside of the ovipositor when it was withdrawn. The female extracted the egg from its position with her mouth and ate it. Again she chewed the bark about the margin of the hole and then resumed drilling. After about eight minutes she withdrew the ovipositor and as before another egg was caught in this organ, which she disposed of in the same manner as the first one. In both instances a large quantity of mucilaginous liquid was discharged at the time of the extraction of the eggs which she removed from the ovipositor by her mouth before renewing operations. After an egg is deposited the female as a finishing touch to the process of oviposition bites out small pieces of bark just above the egg puncture and places them in the hole, carefully kneading them with her mouth parts to make a neat cap over the opening. The spot where the bark is removed serves as the next position for the drilling operations preparatory to the deposition of another egg. This process is continued until a number of eggs, forming a row, are laid. (Fig. 9, a, and Plate VII.) The total number of eggs deposited varies greatly with individual crickets. In 1910 the records of six pairs confined in breeding cages were respectively as follows: (1) 165 eggs, (2) 64, (3) 26, (4) 78, (5) 52, (6) 31. During 1913 three pairs deposited respectively 22, 51 and 60 eggs. The eggs were deposited in rows
of from seven to twenty-one punctures. Occasionally the number of eggs in a series was increased over night or over a succession of nights at varying intervals by ovipositions by the same female. Observations in a patch of raspberries showed that the number of eggs in a row ranged from two to eighty-seven. The average number in nineteen rows taken at random was about thirty-two eggs. The longest row found in a willow twig had eighty-seven egg punctures, which strangely enough are also the highest figures for oviposition in raspberries.

The eggs are placed in rather compact rows with from seven to ten punctures to each centimeter. They lie in a slanting direction across the central pith cavity, the angle being about 40 to 50 degrees, depending somewhat on the diameter of the stalk. (Fig. 9, b.) The capped end of the egg lies within one or two millimeters from the opening of the hole and the egg usually slants downward from the opening instead of upward, since the female normally stands head up while ovipositing. When the rows are compact the eggs are generally directed alternately to the right and left so that they do not interfere with each other. In plants with a large pith cavity the eggs lie wholly within that part, but in those with a small central pith the cap end is partly imbedded in the woody tissues. The oviposition period for this cricket commences during the latter part of August and may extend through the month of September.

PLANTS SELECTED FOR OVIPOSITION.

This species prefers for the reception of its eggs plants which have a central pith surrounded by a woody outer layer, and there are a great many plants of this character which are selected by the insect for this purpose. Eggs are deposited most abundantly in raspberry, blackberry, Erigeron canadensis and the larger species of Solidago. They are also common locally in elder, grape, sumac and willow. A few eggs may occasionally be found in the twigs of peach2 (Plate IX, fig. 1), apple,3 elm, maple and hickory. Mr. Goodwin of the Ohio Station writes that considerable oviposition by this species occurs in peach orchards and vineyards in northern Ohio, especially on trees and vines which adjoin uncultivated fields. Similar conditions with respect to vineyards have been noted in the grape-growing region in Chautauqua county, New York. Mr. W. T.

2 From material collected by J. L. King at Gypsum, Ohio.
3 From material collected by B. G. Pratt, New York City.
Davis of Staten Island reports that he has also found eggs of this insect in wild cherry, white ash and Baptisia tinctoria. In going over the literature of this species we have found numerous descriptions of the work of this insect in various plants besides those given above, but always under the name of niveus. When the eggs are described as deposited in long rows there is little doubt as to their identity; for the only other widely distributed species with this habit is OE. quadriptunctatus, which deposits eggs only in smaller and more delicate plants. On this assumption additional host plants as recorded in literature are currant, Helianthus, artichoke, Ambrosia, plum, cottonwood, box elder, cherry, dogwood, black locust, honey locust, sycamore and catalpa.

LOCAL DISTRIBUTION OF THE INSECT.

The foregoing list of plants furnishes a very good key to the habitat of this species. It will be noticed that most of the plants named are those which grow best in low, moist places and some are characteristic of waste places. While the list contains quite a number of trees, it has been our experience that oviposition in these is only of rare or local occurrence or as a result of small seedling trees growing among other plants. The two types of localities where these tree crickets occur in greatest abundance are low lands with a dense growth of tall herbaceous plants, such as Solidago, Erigeron, Helianthus, etc., and on land of any kind that has grown up to bushes, briars and wild grape vines. The insects are less common in cultivated berry patches, nurseries and orchards, but even in these situations and especially in raspberry plantings they are sometimes numerous enough to be destructive.

FEEDING HABITS.

We have observed this species in the field feeding on the petals and anthers of flowers and on raspberry leaves and fruit. (Plate X.) Only in the cages have we detected it feeding on plant lice or other insects. An examination of the crops of a number of specimens mostly in the fourth instar collected in a raspberry planting, indicates that they feed more extensively on plant than on animal matter. In a few instances there were distinct insect remains, but these constituted a small part of the entire contents of the crop, which was mostly filled with leaf tissue, some fungus mycelium and spores.
ECONOMIC IMPORTANCE.

Of the known species of tree crickets, this insect has received most consideration in economic treatises. It has derived its reputation as a destructive pest from its work on raspberry and blackberry, especially the former plant. The injuries it causes arise from the long series of punctures which it produces in the canes during the process of egg-laying. As a result of the rupturing of woody tissues, the cane splits at the point of injury and becomes so weakened that it eventually breaks down from the weight of the upper growth or from twisting by the wind. (Plates VII and VIII.)

This species may commonly be observed in plantings of raspberries, and usually more or less numbers of the canes will, during the fall, show the characteristic wounds by this pest. Important damage occurs when there is extensive oviposition, which may result in the destruction of as high as seventy-five per cent. of the bearing wood. Such extreme injury is, however, rare, and in most raspberry plantations the loss caused by the insects is limited to the death of occasional canes.

As previously indicated, Stewart and Eustace state that the oviposition punctures by this insect may afford a lodging place for the spores of *Leptosphaeria coniothyrium* (Fckl.) Sacc. (*Coniothyrium Fucelli*), which is the organism responsible for the disease of raspberries, commonly known as the raspberry cane blight. They further suggest that the well-known tendency of cricket-injured canes to break at the point of attack is probably due, in part, to brittleness induced by the *Coniothyrium* and that the injury done by the cricket may be much aggravated by the cane blight fungus.

PREVENTIVE AND REMEDIAL MEASURES.

For the protection of raspberries and blackberries chief reliance should be placed on the prevention of attacks rather than in the destruction of the insects after they have made their appearance on the vines. Important injury may generally be averted by clean culture and the destruction of weeds in and about plantings of these fruits. Canes showing extensive oviposition and that are splitting should be removed in the course of winter and spring pruning and burned to destroy eggs contained in them. The foregoing measures ordinarily afford the needed protection; but should they fail a permanent reduction in the numbers of the tree crickets could doubtless
be effected by systematic spraying during the months of July and August with arsenate of lead at the usual strengths for foliage treatment.

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