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THE TREE CRICKETS OF NEW YORK: LIFE HISTORY
AND BIONOMICS.

BENTLEY B. FULTON.



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SUMMARY

Most of the tree crickets found within the boundaries of New York State are generally distributed over the eastern United States, while some range as far as the Pacific Coast states. They include seven species of the genus *Œcanthus* and one species of the genus *Neoxabea*.

The interest in these insects centers chiefly about their remarkable reproductive structures and instincts and their peculiar oviposition habits. The song of the male, which serves to attract the female, is produced by a minute rasp on the under side of the forewing which is scraped by a structure on the inner edge of the opposite wing. In producing the sound the wings are raised at right angles to the body and vibrated rapidly. When the wings are so raised, there is exposed on the metanotum a glandular hollow, the secretion of which is very attractive to the female. The latter climbs over the abdomen and feeds on the gland. The male takes advantage of the position and inserts the barbed capillary tube of a spermatophore into the genital opening of the female and the sperms pass into the seminal receptacle. The spermatophore is formed in a peculiar pouch at the tip of the abdomen, by the hardening of a viscous liquid about a mass of sperms.

The female prepares for oviposition by chewing a small pit in the bark of the plant. The drilling is accomplished by quick downward thrusts of the ovipositor and a slower twisting motion. After the egg is deposited a quantity of mucilaginous substance is discharged into the hole, and with most species the female plugs up the opening with chewed bark or excrement.

The species of *Œcanthus* can be divided into three natural groups according to their morphology, coloration and habits. The first group includes *niveus*, *angustipennis*, and *exclamationis*. These are pale whitish crickets, very similar in appearance. All have an intermittent song and deposit their eggs singly in the bark of trees and bushes. The song of *niveus* consists of a series of clear, rhyth-

mically repeated whistles with a pitch about C, two octaves above middle C. The number of notes varies from about sixty to over a hundred and fifty per minute according to the temperature. The songs of *angustipennis* and *exclamationis* are non-rhythmical and have longer notes and rests, generally not more than fifteen per minute.

The second group of species includes *quadripunctatus*, *nigricornis* and *pini*. The song of these crickets is a continuous, shrill, high-pitched whistle. All three species place their eggs in rows in the pith of small stalks or twigs. *Quadripunctatus* deposits its eggs in loose rows in small or medium sized weeds. The eggs of *nigricornis* are placed in compact rows in large weeds or in the twigs of trees and bushes. *Pini* oviposits only in pine twigs, so far as known.

The third type is represented by a single species, *latipennis*. The song of this cricket is a loud, clear whistle with a musical, ringing quality. The female oviposits in grape vines and weed stalks. A single hole in the outer woody layer of the stem serves for the deposition of from four to twelve eggs, which are placed side by side in the pith in two groups, one above and one below the opening.

Neoxabea bipunctata is closely related to crickets of the genus *Ecanthus* and was formerly classified with them. Although generally distributed over the eastern half of the United States, it does not extend very far north and is known to occur in this State only in the southeast corner. It has been collected from oak, willow and grape vines, and deposits its eggs singly in the bark or cambium.

INTRODUCTION.

In our studies dealing with the economic aspects of tree crickets, we extended our observations to several species which do not affect cultivated crops, considering especially certain interesting habits which have little or no bearing on the horticultural importance of the insects as a group. These accumulated data have been brought together in this bulletin. The species discussed include only those which inhabit the eastern United States. Several other species of *Ecanthus* occur in the southwestern states, but living specimens of these could not be obtained and therefore they were not considered in this investigation.

It seemed advisable to include in the present work some material that has already been presented, at least briefly, in Bulletin No. 388, and a few parts, such as technical descriptions, have been copied literally.

All descriptions and measurements are taken from living or recently killed insects, which may differ considerably from dried and shriveled specimens.

GENERAL CHARACTERISTICS.

The term "tree cricket" is commonly applied to any of the tree- or bush-inhabiting insects of the family Gryllidæ. The commonest and best known of these, however, belong to the genus *Æcanthus*, of which there are about twenty-seven known species. According to Kirby^{(31)*} sixteen of these are found on the American continent, while, of the remaining species, one occurs in Europe and the others inhabit various parts of Africa, Asia and the East Indies, with one extending as a rare species into Australia. All members of the sub-family *Æcanthinæ* known to exist in our fauna are included in this genus, except one species which has been placed in a separate genus, *Neoxabca*. These insects are among the most specialized of the Orthoptera and they are characterized by their slender shape, pale color and arboreal habits. From all other members of the Gryllidæ, the *Æcanthinæ* can be readily distinguished by the following characters: The tarsi are three-jointed, and the second segment is small and compressed. All the legs are very slender and in *Æcanthus* are armed with two rows of minute teeth interspersed with a number of delicate spines. The males have very broad and flat tegmina which lie in a horizontal position over the abdomen, while those of the female are narrow and wrapped closely about the body. The two basal segments of the long, filiform antennæ are generally ornamented with peculiar and distinctive black markings which are fairly constant and serve as convenient characters for separating the different species.

The various species of *Æcanthus* in this faunal region seem to fall naturally into three groups as indicated by their morphology, coloration and habits. These groups are typified by the species (1) *niveus*, (2) *nigricornis* and (3) *latipennis*. The first group includes those which live mostly among woody plants, either bushes or trees, and deposit their eggs singly in various places in the bark of the plants. The second group comprises those species which deposit their eggs not in the bark but in the inner pith cavity of small stalks or twigs, making a separate puncture for each egg and grouping them more or less closely in long rows. The third type is represented here by only one species, which places several eggs in the central pith through the same opening in the outer woody layer of the stem, arranging them in two groups, one above and one below the opening. The structural and color characters separating the three groups are indicated in the following key to the species that occur in this region.

* Numbers in () refer to Bibliography, pp. 46 and 47.

KEY TO THE SPECIES OF *Æcanthus* FOUND IN EASTERN NORTH AMERICA.

A Basal segment of antennæ 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. 1, a)
niveus De Geer

BB Basal antennal segment with a J-shaped black mark. (Fig. 1, b) *angustipennis* Fitch

BBB Basal antennal segment with a straight club-shaped black mark. (Fig. 1, c)
exclamationis Davis

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. (Fig. 1, d)
quadripunctatus Beut.

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. 1, f, g)
nigricornis Walker

BB Head, thorax and antennæ reddish brown. Wings in life with conspicuous green veins. Marks on basal antennal segment broad but seldom confluent. (Fig. 1, e)
pini Beut.

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. (Fig. 1, h)
latipennis Riley

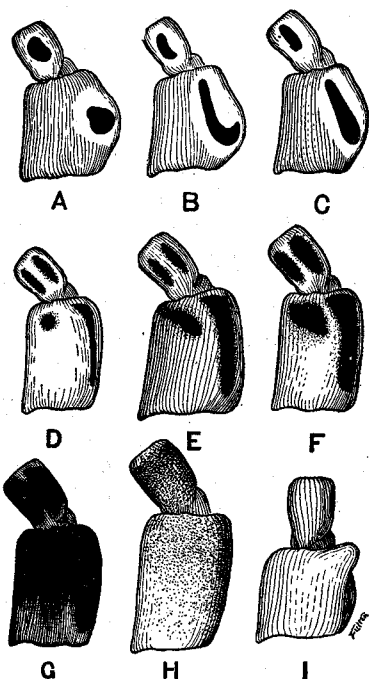


FIG. 1.—BASAL ANTENNAL SEGMENTS OF TREE CRICKETS.

a, *Æcanthus niveus*; b, *Æ. angustipennis*; c, *Æ. exclamationis*; d, *Æ. quadripunctatus*; e, *Æ. pini*; f, *Æ. nigricornis*; light form; g, *Æ. nigricornis*, dark form; h, *Æ. latipennis*; i, *Neozabea bibuncinata*.

GENERAL DESCRIPTIONS OF LIFE STAGES OF *ÆCANTHUS*.

Egg.—The eggs of the species belonging to the genus *Æcanthus* 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 appear 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.—The newly hatched nymphs are very pale and delicate. After feeding, the size of the abdomen is increased and the contents of the alimentary canal show through the body wall and give the insect a darker color and more robust appearance. The appearance of the nymphs and the characters distinguishing the different instars are shown in Plate I and Fig. 2. The first instar is characterized by having only thirty-four segments in the antennæ while the sides of the meso- and metanotum do not project, and they extend downward scarcely as far as do the sides of the pronotum.

The second instar differs from the first by a slight downward extension of the sides of the meso- and metanotum. The edges are free and lap over the pleura. The antennæ have about double the number of segments of the first stage. The third instar is characterized by a still further prolongation of the sides of the meso- and metanotum so that they appear as distinct and rudimentary wing pads. The antennal segments are increased to nearly one hundred. On the fourth instar the wing pads are folded back over the thorax and reach to the second abdominal segment. In the fifth instar they reach to the third or fourth segment.

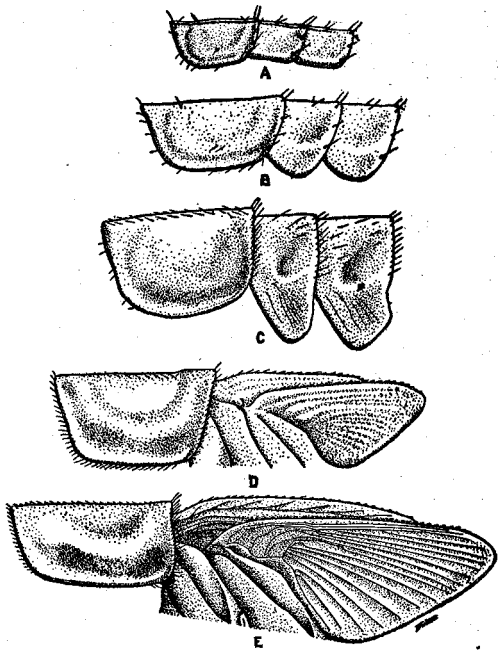


FIG. 2.—THORACIC SEGMENTS OF THE FIVE NYMPHAL INSTARS.

The differences between the three groups of species are plainly evident in the first instar (Fig. 3). In the *niveus* type the nymphs are white with a few fine black marks on the head and thorax; in the *nigricornis* type they are pale greenish yellow with a slight dorsal infuscation and a pale median line; and the nymphs of *latipennis* are white with a purplish red dorsal area and a pale median line.

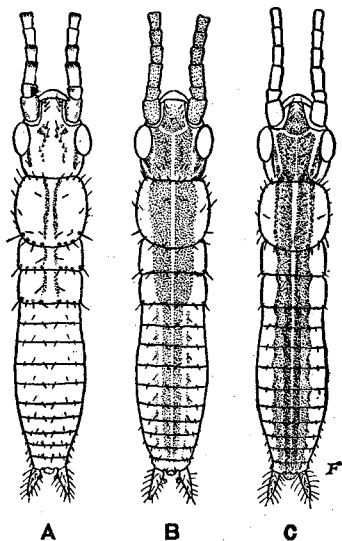


FIG. 3.—NYMPHS OF THE FIRST INSTAR, ILLUSTRATING THE THREE TYPES OF *Ecanthus*.

a, *niveus*; b, *nigricornis*; c, *latipennis*.

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 cerci and anus. First segment much reduced ventrally. Antennæ filiform; over twice the length of body. Legs slender; hind femora a little thickened. Hind tibiæ 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 tibiæ 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 fore wings 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.

HATCHING.

The time of hatching seems to be fairly uniform for the four species of which data on this process were obtained, namely *E. niveus*, *angustipennis*, *nigricornis* and *quadripunctatus*. For average years in western New York it begins from the tenth to the middle of June and the insects may continue to appear until about the twentieth of that month. Farther south the time of hatching is correspondingly earlier.

The process of hatching is best explained by the accompanying figure (Fig. 4). The egg becomes slightly swollen, preceding the period of hatching, apparently due to an increase in internal pressure. The end of the cap breaks off, and the embryo slips out (Fig. 4, b). It retains its embryonic form until about half way out, then the thorax becomes strongly arched upward (Fig. 4, c, d). The nymph continues to work itself out by muscular contractions of the abdomen and by moving the body up and down and from side to side. A delicate membrane projects from the egg puncture and clings to the body, making it difficult for the nymph to free the hind legs and antennæ. The latter are finally grasped by the mouth parts and worked out

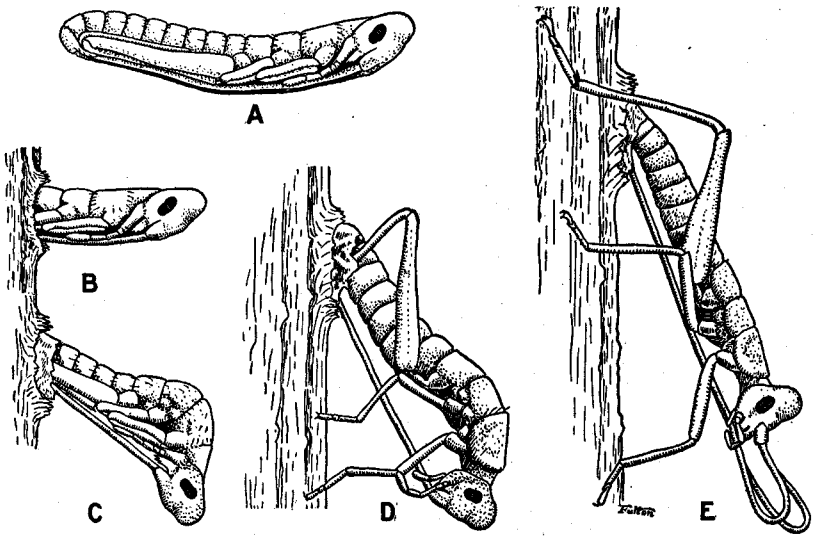


FIG. 4.—HATCHING OF TREE CRICKETS.

a, Position of embryo in egg; b, c, d, e, Successive stages in emergence of nymph.
Drawings made from *Æ. quadripunctatus*.

by movements of the head (Fig. 4, e). Within about ten or twelve minutes the nymph is free and crawls upward on the plant. A prominent watery bump on the head, which formerly filled out the end of the egg, gradually diminishes in size and within half an hour is not apparent. Some nymphs never succeed in freeing themselves from the egg and these are often devoured by their more fortunate companions.

In all cases observed the ventral side of the embryo lies next to the outer curve of the egg, thus if the egg curves downward in the plant, the embryo will emerge ventral side up. The eggs of *Æ. quadripunctatus* generally turn upward in the stalk, while those of

Æ. nigricornis turn downward in nearly all cases. The eggs of the other species turn downward much more often than upward.

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.

FEEDING HABITS.

The food of the crickets consists of a great variety of materials of both plant and animal origin, which are soft enough to be masticated by their comparatively weak mandibles. In the breeding cages the crickets were fed almost entirely on plant lice, which were readily available and on which the crickets seemed to thrive well. Any cricket which was injured or in any way unable to defend itself was generally devoured by its companions. They also ate numerous small holes in raspberry leaves, and chewed at the cambium layer of apple branches in places where it was exposed by a cut. They ate the anthers and other floral parts of the wild carrot (*Daucus carota*) and also chewed out patches of the outer tissue of the stalks. Tree crickets confined on branches with ripe peaches and plums ate round holes in the sides large enough to insert their heads in order that they might feed on the inner pulp. They would also subsist on slices of ripe apples placed in the breeding cages, but at no time did they touch the whole fruit that was sound, apparently being unable to penetrate the outer skin. Tree crickets in the breeding cages readily fed on San José scale on badly infested apple branches. They devoured both the protective covering or scale and the insect itself. One nymph of *niveus* in the fourth stage, which was confined to this diet, ate on an average about four hundred scales during a night, counting both mature and immature insects, and on one night devoured over nine hundred individuals of this coccid.

For further information on the natural feeding habits of the tree crickets, the crops of a number of specimens of *niveus* and *angustipennis*, from apple and *nigricornis* from raspberry, were dissected out and the contents examined under a microscope. In most speci-

mens a large part of the diet consisted of plant tissue in which could be recognized chlorophyll-bearing cells, leaf hairs, vascular tissue, mycelia and spores of various fungi. Crops from *niveus* and *angustipennis* usually contained a small amount of insect material, and in some specimens this was the main constituent. In many cases, it was possible to detect parts of aphids, scale insects and what appeared to be the cast skins of the crickets although these materials were usually much broken up and barely recognizable. Two crops contained a few lepidopterous wing scales and in another the leg and wing of a small hymenopterous insect were detected. Specimens of *nigricornis* always appeared to feed more extensively on plant tissue, although in some specimens a few insect remains could be distinguished.

DIGESTIVE ORGANS.

The digestive organs of tree crickets have some peculiarities worthy of notice. The crop (Fig. 5, d) is large and thin walled and reaches to about the middle of the body; the proventriculus (Fig. 5, e) is spherical and lies between the two anterior lobes of the stomach. The ventriculus or stomach is divided by a constriction into two parts; the anterior, thick walled portion (Fig. 5, f) bears two cœca at the anterior end and one on the right side about the middle; the posterior, thin walled portion (Fig. 5, h) bears a cœcum at the anterior end; the posterior end suddenly narrows down before passing into the hind intestine. At this point a small duct enters (Fig. 5, i) which arises at the junction of the numerous, long malpighian tubes (Fig. 5, g). The proctodæum or hind intestine is short and has only one bend in

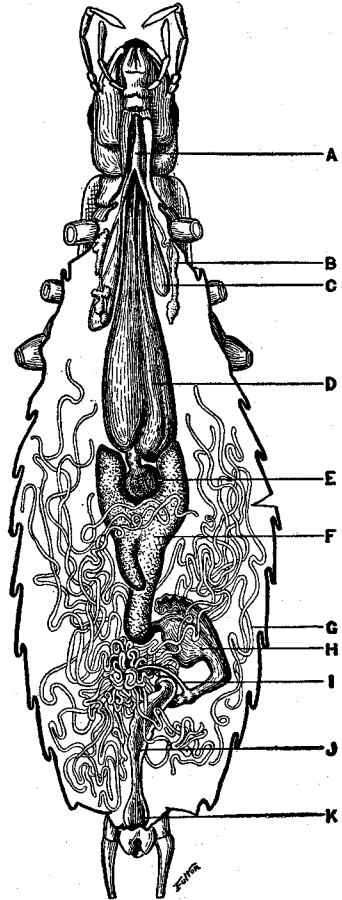


FIG. 5.—DIGESTIVE SYSTEM OF TREE CRICKETS.

- a, Common salivary duct; b, salivary gland; c, salivary reservoir; d, crop; e, proventriculus; f, fore part of ventriculus; g, malpighian tube; h, hind part of ventriculus; i, common duct from malpighian tubes; j, hind intestine; k, rectum.

it (Fig. 5, j).

The pair of salivary glands lie in the thorax (Fig. 5, b). The ducts from each receive a branch from the associated thin walled reservoir (Fig. 5, c) and unite under the oesophagus into a common salivary duct (Fig. 5, a) which opens under the hypopharynx.

MUSICAL ORGANS AND SONG PRODUCTION.

The songs of tree crickets form a considerable part of the insect sounds to be heard in late summer and autumn. The males generally place themselves in some hidden retreat among the leaves, with only their long antennæ projecting to warn them of approaching dangers. They stop singing at the slightest jar of the ground or movement of the plants in which they are located, but at night a strong light can be thrown on them without appreciably disturbing them.

In preparing to sing the male raises the fore wings or tegmina perpendicular to the body. This movement automatically unfolds them so that the inner portion, which normally lies horizontally over the back, and the inflexed outer portion, come to lie in the same plane when the wings are raised. The sound is produced by the fore wings vibrating rapidly in a transverse direction, so that the overlapping inner portions rub against each other.

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

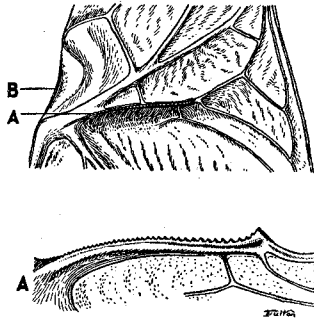


FIG. 6.—LEFT WING OF *C. latipennis*, SHOWING RASP (A) AND SCRAPER (B).

to form a minute filiform rasp (Fig. 6, a). It is from one to one and a half millimeters long, according to species, and bears from twenty to fifty short teeth which are inclined slightly toward the opposite wing. In all of many specimens examined the right wing laps over the left. The latter has a fine thickened ridge along the inner edge just opposite the file (Fig. 6, b). This scrapes against the teeth of the file on the right wing and thus produces the sound vibrations. The underside of the left wing has a file practically identical to the other but this is apparently seldom, if ever, used. In fact it is doubtful if it ever could be used, for the scraper on the right wing is imperfectly formed and in most cases at least lacks the chitinous ridge along the edge.

MATING HABITS.

The peculiar mating habits of the Gryllidæ have aroused the interest of a number of entomologists both in this country and in

Europe. The first careful and detailed study of the subject was made by Lespès^(2, 3) in 1855. In recent years their activities in this respect have been carefully considered by Hancock,^(29, 42) Houghton,^(34, 35) Baumgartner⁽⁴⁰⁾ and Jensen^(36, 43) in this country and by Cholodkovsky,⁽⁴¹⁾ Boldyrev⁽⁴⁶⁾ and Engelhardt⁽⁴⁸⁾ in Russia. My own observations show that the mating habits of *Ecanthus* are similar in many respects to those of *Gryllus* and *Nemobius* as studied by Baumgartner.

The male calls vigorously until a female comes near him, in which case he sidles toward her, without any cessation in his singing and keeping his head in an opposed direction. If he succeeds in attracting her attention she climbs over his body and begins to feed on the secretion of a glandular cavity on the metanotum, which is described by Hancock as an "alluring gland." The male stands with legs spread wide apart and the tegmina are held at an angle of about 45 degrees above the abdomen (Plate II, Fig. 1). His body sways and twitches considerably and the hind wings, which lie folded along the back have a peculiar jerky movement whenever the female bites at the gland. The antennæ are waved about wildly and are often thrown back so as to cross and rub against those of the female. After about half an hour, the male reaches back with

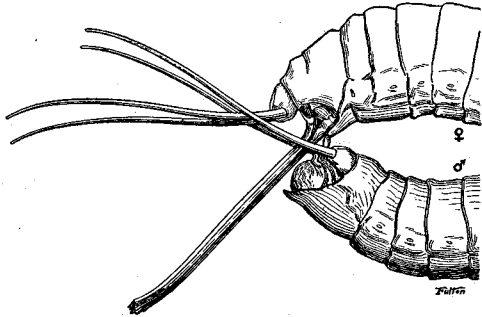


FIG. 7.— POSITION OF BODIES OF MALE AND FEMALE WHILE TRANSFERRING SPERMATOPHORE.

his abdomen and the female bends her abdomen downward. This enables him to slip a pair of small, laterally compressed blades into the notch at the tip of the female's subgenital plate. (Fig. 7.) At this time the barbed capillary tube of a spermatophore is pushed into the vagina and when the tip of the abdomen is withdrawn the bulb of the spermatophore is drawn out of its pocket in the male and remains fastened to the female. The latter does not leave immediately but continues to partake of the secretion of the gland for a half hour or more. She finally crawls away to some secluded spot and arches up her back, bringing the tip of the abdomen forward beneath and pulls off the spermatophore with her mouth. She straightens out again and proceeds to eat the capsule in a leisurely way, after which she doubles up again and works at the ovipositor with her mouth, as if endeavoring to clean it.

In fastening the spermatophore to the female, the male places his cerci on opposite sides of the ovipositor, and they appear to guide him in striking the proper opening. A male from which both cerci

had been removed at the base, was observed trying to copulate. When he succeeded in striking the base of the ovipositor, the female turned the tip of the abdomen down as usual. The male then passed the pair of chitinous blades up and down the ovipositor but was unable to strike the opening at the base and after several attempts the pair became separated.

METANOTAL GLAND.

The exact function of the gland on the metanotum of the male has been a matter of doubt. Hancock⁽²⁰⁾ first described it as an "alluring gland," claiming that it served to attract and hold the attention of the female until copulation could take place. Boldyrev⁽⁴⁶⁾ and Engelhardt⁽⁴⁸⁾ of Moscow, Russia, have concluded from observations on the European species, *C. pellucens* Scop., that its chief function is to hold the attention of the female after the spermatophore has been attached, and thus prevent her from devouring it before the sperms have had time to pass into the seminal receptacle. These two theories are not diametrically opposed, and from my own observations it seems that the gland may serve both purposes equally well. In no instance did the male transfer the spermatophore before the pair had been together less than a quarter or half an hour. During both periods, before and after passing the spermatophore, the female would occasionally start to crawl away. At such times the male would begin to sing and follow after her, placing himself in front of her and taking such a position as to expose the alluring gland. Usually the female would return, but sometimes she would leave to stay, even before the spermatophore had been fastened to her. Considering the length of time for the first part of the mating process, and the willingness with which the female departs from the male, it seems doubtful if the male, without the help of the gland, could hold the attention of the female long enough to place the spermatophore in the genital opening. On the other hand, the female devours the spermatophore very soon after leaving the male, and if the insects separated immediately after the spermatophore was given over, only a small part of the sperms would have time to flow into the seminal receptacle.

In this connection it is of interest to note that a female nymph of the fifth instar was at one time observed eagerly feeding on the gland of a mature male. This behavior of the nymph would indicate that the mature females probably have a taste for the secretion of the metanotal gland independent of the act of copulation with the male.

Externally the metanotal gland appears as a triangular depression situated in the center of a broad rounded disk, between the bases of the hind pair of wings (Fig. 8 and Fig. 10, a). Most of the surface of the disk is thinly clothed with long delicate hairs. The

triangular hollow, the apex of which is directed anteriorly, is densely clothed with shorter hairs. On the sides are two paired rows of

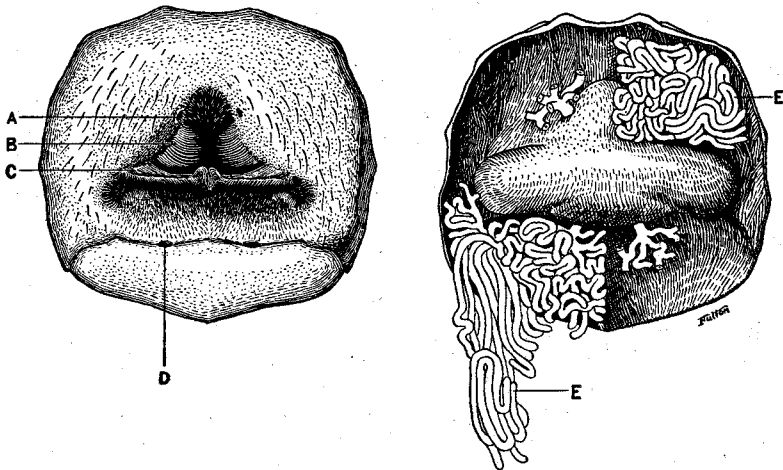


FIG. 8.—METANOTAL GLAND.

Left, dorsal view; right, ventral view of internal structures; a, Opening of anterior tubular gland; b, anterior tuft of hairs; c, posterior tuft; d, opening of posterior tubular gland; e, tubular glands.

larger curved bristles. The hairs of the anterior row are distinctly separated and do not reach to the median line (Fig. 8, b). The posterior row forms a dense brush which reaches to the median line, and at the tip the bristles curve sharply forward and then point backward. (Fig. 8, c.) Two pairs of openings can be discerned with difficulty; the anterior pair on the sides of the depression just above the anterior ends of the first row of bristles (Fig. 8, a) and the second pair in the transverse suture at the extreme posterior edge of the depression (Fig. 8, d).

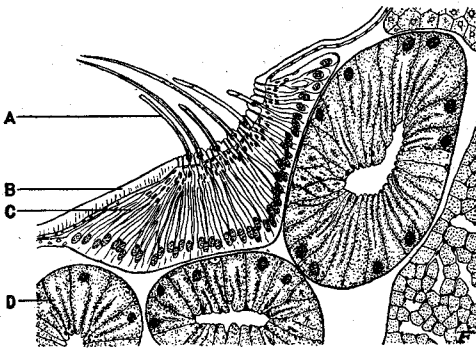


FIG. 9.—METANOTAL GLAND.

Section through anterior tuft of hairs; a, hair; b, cuticle; c, hypodermis cells; d, tubular gland.

By dissection it can be shown that these paired openings lead from much branched internal glands (Fig. 8, e, and Fig. 9, d).

These glands occupy most of the space immediately beneath the metanotum and many long tubes from the posterior pair extend back into the abdominal cavity. Stained sections show that the hypodermis underlying the hairy parts of the gland is unusually thick and that it is composed of long spindle- or club-shaped glandular cells (Fig. 9, c). Certain of these cells pass through minute pores in the chitinous cuticula (Fig. 9, b) and into the hairs (Fig. 9, a), which contain a cavity running clear to the tip. Other minute pores open out between the bases of the hairs. The larger hairs bear several spindle-shaped nuclei. All of the hairs on the interior of the cavity appear to be glandular but the largest cells are found under the two paired tufts of bristles as described above.

DESCRIPTION OF THE SPERMATOPHORE.

The spermatophore is ovoid in shape, with one end tapering into a conical neck which terminates in a long capillary tube (Fig. 11, v). The main body varies somewhat in size with the different species, from about .6 mm. long and .5 mm. wide in *C. angustipennis* to about 1.1 mm. long and .9 mm. wide in *C. latipennis*. The wall consists of two translucent coats. The outer (Fig. 11, m) is white and rather easily crushed and forms only a thin film at the tube end, but gradually becomes very thick at the opposite end; and it is this that gives the spermatophore its oval shape. The inner coat (Fig. 11, k) which forms a nearly spherical body, is very hard and firm, of a pale brown color, darker near the inner cavity and has a uniform thickness of about one-sixth the entire diameter of the spermatophore. The inner cavity (Fig. 11, j) is filled with sperms at first but if the spermatophore is removed from the female after mating, it is nearly or entirely empty. The tube is nearly one and one-half millimeters long and is bent in the form of a hook, with the distal half straight and pointing back over the main body (Fig. 11, e). It has an outside diameter of about .03 mm. near the base and gradually tapers to a very fine point. Just distal to the bend of the tube is a thin blade-like barb. The cavity of the body of the spermatophore is continuous with that of the tube.

When the spermatophore is fastened to the female the sperms start to pass out rapidly through the tube. I have watched this process in the spermatophore of *Gryllus pennsylvanicus* but not in the spermatophore of *Ecanthus* species. The spermatophore was removed from the male and placed on a slide with a little water around the tip of the tube but not around the bulb. A granular looking substance came out slowly at first. Then the spermatozoa began suddenly to shoot out rapidly through the tube, which was so small as to allow only a few to pass through side by side. After about fifteen minutes the sperms were all out and these were followed

by a brownish substance which was discharged for a short time. The bulb of the spermatophore did not collapse and seemed to retain its normal size after the loss of its contents.

MALE REPRODUCTIVE ORGANS.

The testes are irregularly oval, pale yellow bodies located in the anterior part of the abdomen (Fig. 10, b.). The seminiferous tubules, of which each one is made up, converge into a sinus near the anterior end. The vas deferens is a minute tube which runs from the sinus back between the tubules and emerges near the posterior end of the organ (Fig. 10, c, and Fig. 11, d). It continues along the side of the body to the posterior extremity where it turns forward and becomes much enlarged and coiled, forming an oval body surrounded by yellow fatty tissue (Fig. 10, g, and Fig. 11, c, g). This enlarged portion is filled with sperms and no doubt serves the function of a seminal vesicle. The short remaining portion of the vas deferens is straight and of larger diameter, and continues anteriorly to join the large sinus into which hundreds of glandular tubules empty (Fig. 10, d, and Fig. 11, b). These tubules are filled with a homogeneous substance which probably forms the wall of the spermatophore. From the sinus a large common duct (Fig. 10, e) leads to the spermatophore mold at the end of the abdomen (Fig. 10, h). That this duct is not a true ejaculatory duct,

either in origin or function, has been pointed out by Baumgartner in his work on *Gryllus*. It arises as an invagination from the outside and is not used as a sperm carrier during copulation.

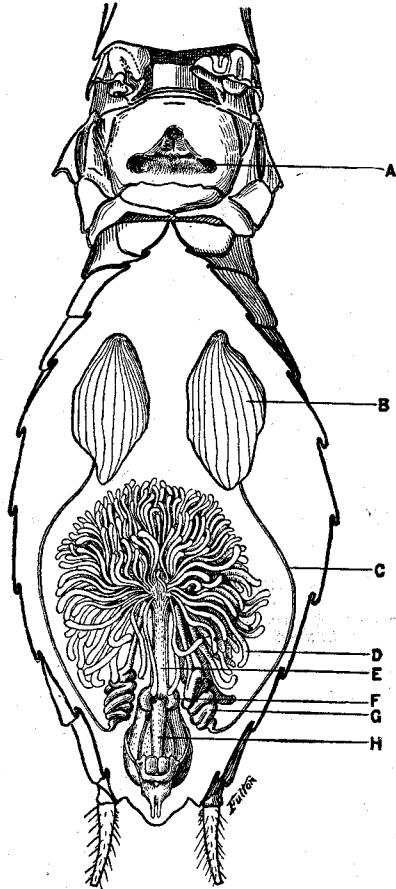


FIG. 10.— MALE REPRODUCTIVE ORGANS.

a, Metanotal gland; b, testis; c, vas deferens; d, glandular tubule; e, common duct; f, accessory pouch; g, enlarged portion of vas deferens; h, spermatophore mold.

The spermatophore mold lies in the ninth abdominal segment, the sternum of which forms the large subgenital plate. The part of the wall of the mold which contains the body of the spermatophore consists of two pliable flaps which meet on the median line dorsally and ventrally. These are collapsed when empty but conform to the bulb of the spermatophore when one is present (Fig. 11, l). At the anterior end a groove or out-pocket of the mold starts in and passes first dorsally and then posteriorly (Fig. 11, f). This groove is

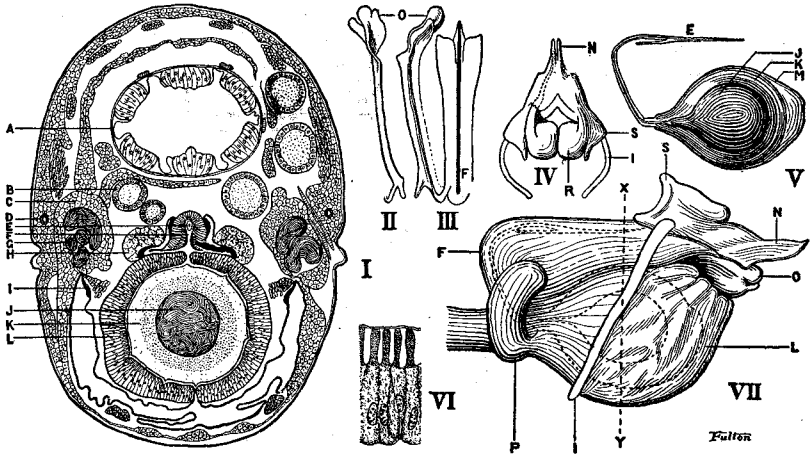


FIG. 11.— MALE REPRODUCTIVE ORGANS: I, CROSS SECTION OF ABDOMEN THROUGH SPERMATOPHORE MOLD. II, LATERAL VIEW OF TRI-LOBED, PADDLE-SHAPED STRUCTURE. III, VENTRAL VIEW OF SAME AND GROOVE OF SPERMATOPHORE MOLD. IV, VENTRAL VIEW OF COPULATORY BLADES AND BASAL STRUCTURE. V, SPERMATOPHORE. VI, PORTION OF EPITHELIUM SURROUNDING SPERMATOPHORE. VII, LATERAL VIEW OF SPERMATOPHORE MOLD.

a, Rectum; b, glandular tubule; c, fat-tissue; d, vas deferens; e, spermatophore tube; f, groove of spermatophore mold; g, enlarged portion of vas deferens; h, muscle; i, chitinous supporting rod; j, sperm cavity; k, inner layer of spermatophore wall; l, wall of spermatophore mold; m, outer layer of spermatophore wall; n, copulatory blades; o, paired paddle-shaped structure; p, accessory pouch; r, paired cavity and tube running into copulatory blade; s, basal structure and point of attachment; x-y, location of accompanying cross section.

supported by chitinous walls and terminates in a sharp point, and just before the tip it bears a pair of horizontal wings which together resemble a fish-tail in shape. The groove holds the tube of the spermatophore (Fig. 11, e). On each side at the level of the groove is a movable, spoon-shaped piece, which is three-lobed at the tip and connects with the groove support at the base (Fig. 11, o). Dorsal and posterior to the end of the groove is a pair of laterally compressed, blade-like appendages which lie close together and

terminate in a slightly hooked point (Fig. 11, n). These blades are inserted into the genital opening of the female when the spermatophore is transferred. At the base they widen out and are united on the median line. Still farther anteriorly the heavily chitinized part divides into two large basal structures, which are connected with the posterior edge of the lateral walls of the ninth segment and constitute the main supporting structure of the spermatophore mold (Fig. 11, s). Between these structures near the median line is a pair of closed cavities, each with a tube extending posteriorly into the corresponding blade-like appendage to near its tip (Fig. 11, r). If these tubes have an opening in the blade it is very minute and could not be detected. A pair of curved chitinous rods are attached to the basal structure and extend obliquely around the mold to nearly the ventral median line (Fig. 11, i) and help support the soft flaps covering the body of the spermatophore. A pair of elongated pouches arise at the junction of the spermatophore mold and the common duct, and extend dorsally along the side of the groove (Fig. 11, p). Their function is not known.

Stained sections show that the lining walls of the mold including the groove are formed of a rather thick layer of columnar epithelium (Fig. 11, VI). This is of ectodermic origin and the side next to the inner cavity is bordered by a thin layer of cuticle which becomes thicker in parts of the groove. The cells show a peculiar, sharply demarked differentiation of the ends toward the inner cavity, where about one-third of the length is much narrower and rod-shaped, and the intervening spaces are wide. This narrow part is darkly and uniformly stained while the wide nucleated portion has a granular appearance.

FORMATION OF THE SPERMATOPHORE.

The exact process of spermatophore formation is as yet only a matter of conjecture. It seems very probable, however, that a mass of sperms which have collected in the enlarged portion of the vas deferens move out into the mold and are later surrounded by a quantity of secretion from the glandular tubules which hardens around them and in some way forms the spermatophore. The tube is probably formed in the groove, but why it develops as a tube and not as a solid rod is a mystery.

A new spermatophore is usually formed soon after the last one is removed. In mating it was observed that in about ten minutes after the spermatophore is passed to the female and while the latter is still feeding at the metanotal gland, the collapsed mold begins to swell out and in another minute or so is fully distended and remains so. In one case a male was examined about half an hour after the mold became distended. The mold contained a white, globular mass of sperms with a long attenuated thread at one end. It appeared to be enclosed in a delicate membrane although this

could not be distinguished. It was surrounded by a clear viscid liquid of about the consistency of egg albumen. I removed the sperm mass with forceps and the liquid began to congeal. A small drop on the point of a needle could be pulled out into a very fine thread which would harden very quickly. The hardening continued even after the mass was placed under water and resulted in a hard substance like the wall of the spermatophore.

Another male which had disposed of a spermatophore was examined in an hour and three-quarters after the mold had become distended and it was found to contain a fully formed and hardened spermatophore.

FEMALE REPRODUCTIVE ORGANS.

In order to follow the course of the sperms after the deposition of the spermatophore it is necessary to understand a little of the anatomy of the female reproductive system. The ovaries occupy a large portion of the central part of the abdominal cavity. They are made up of a large number of separate egg tubes, each of which contains several ovarian follicles in various stages of development (Fig. 12, a). The tubes all converge into the broad, thin-walled oviduct (Fig. 12, d) and these unite to form the vagina (Fig. 12, e) which continues as a straight tube to the ovipositor. A single tubular accessory gland (Fig. 12, f) opens above the vagina at the base of two short rods which are between and hidden by the four large rods of the ovipositor. This gland probably furnishes the mucilaginous substance exuded at the time of oviposition. The notch at the end of the subgenital plate opens into the ventral side of the vagina

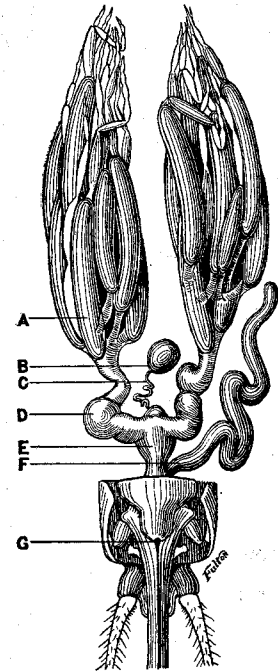


FIG. 12.— FEMALE REPRODUCTIVE ORGANS.

a, Ovary; b, seminal receptacle; c, duct leading to seminal receptacle; d, oviduct; e, vagina; f, accessory gland; g, copulatory opening.

(Fig. 12, g). Just anterior to this on the dorsal wall of the vagina is a hard plate, which is slightly hollow on the inner side and bears a small hole in the center. This hole passes through and opens on the dorsal side into a small convoluted duct which leads to an ovoid seminal receptacle lying just anterior to the junction of the two oviducts (Fig. 12, b, c).

A female bearing a spermatophore was killed and dissected. The tube was inserted in the notch at the end of the subgenital

plate, and the point was directed into the hole in the plate on the dorsal wall of the vagina. It would appear that the sperms discharging through the tube would thus be directed into the duct of the seminal receptacle.

OVIPOSITION.

For this operation the female selects a suitable spot on the plant and prepares to oviposit by first chewing a small hole in the bark. 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). It takes from five to twenty-five minutes according to the resistance of

the wood, to force the ovipositor to its base the first time. After this it is pulled nearly out and drilled in again several times, each operation requiring from one to five minutes or more. When the hole is sufficiently reamed out and the ovipositor drilled in for the last time, the female rests a moment and then arches up the middle of the abdomen and forces an egg down into the ovipositor. The body quivers and shakes a little during the operation, which lasts about twenty seconds, and then the ovipositor is slowly withdrawn, twisting from side to side. When only

the tip remains in the hole the female pauses and discharges a small quantity of mucilaginous substance which fills up the opening. She then removes the ovipositor and plugs up the mouth of the hole, using such material as the instincts of the various species determine. She spends several minutes packing it in and smoothing it out so that the wound is neatly capped. The whole process of oviposition, from chewing the bark to sealing the wound may require from a quarter to nearly a whole hour.

The ovipositor is made up of two pairs of long chitinous rods which fit together in such a way as to make a compact organ nearly circular in cross section. It was observed that, in drilling, the upper pair of rods remain stationary except for the twisting movement while the lower pair slide up and down with each thrust. The upper and lower rod on each side can not be separated readily and in cross section it can be seen that they are firmly united by a tongue of the upper fitting into a groove in the lower (Fig. 13, b, c). At the tip the lower pair are wedge shaped and fit in between

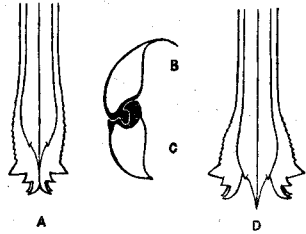


FIG. 13.—OVIPOSITOR.

- a, Tip with rods in normal position; b, c, cross section of upper and lower rods on one side; d, position of rods when ventral pair are thrust downward.

the ends of the upper pair, which have four stout spurs on each side. When the lower rods are thrust downward their chisel-shaped points push into the bottom of the hole and at the same time they wedge apart the ends of the upper rods causing them to widen the hole (Fig. 13, d).

The ovipositor first makes its appearance in an incipient stage in the second instar in the form of two small rounded projections on the ventral side of both the eighth and ninth abdominal segments. In the third instar it consists of four backward pointing papillæ—the anterior pair being smaller and lying in contact with the lower surface of the hind pair. In the fourth instar it forms 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. In the fifth instar the ovipositor is much longer and bears much resemblance to the adult organ. The sternum of the seventh segment is enlarged and forms the subgenital plate.

KEY TO EGGS AND OVIPOSITION HABITS OF THE TREE CRICKETS.

- A Eggs white or only slightly yellowish; deposited singly in the bark or cambium of trees and bushes.
 B Egg cap with long finger-shaped projections. *niveus*
 BB Egg cap with knob-like projections, not much longer than thick. *angustipennis*
 BBB Egg cap with low rounded elevations. *exclamationis*
 AA Eggs yellow; deposited in rows, and lie in the pith of stems of herbaceous plants and twigs or small branches of woody plants.
 B Eggs in loose rows, in small herbaceous stems, 5 mm. or less in diameter. Projections of cap, finger- or club-shaped. *quadripunctatus*
 BB Eggs in compact rows, in stems 5 mm. or over in diameter. Projections of cap with length not more than one and a half times the width. *nigricornis*
 BBB Eggs in pine twigs. Projections of cap transversely elliptical in cross section. *pini*
 AAA Eggs pale yellow; deposited in two groups in the pith, one cluster on each side of the hole made in the outer woody layer of the stem. The holes may be in rows but in such case are a centimeter or more apart. *latipennis*

CECANTHUS NIVEUS De Geer

HISTORICAL NOTES.

This insect was described from a Pennsylvania specimen as early as 1773 by De Geer,⁽¹⁾ who called it *Gryllus niveus*. Its status has been clearly established in systematic literature but in economic writings it has long been confused with *nigr. cornis* and regarded as the cause of an oviposition injury to raspberries performed by the latter species. Walsh⁽⁶⁾ and Riley⁽⁷⁾ evidently did not distinguish between the two species for both describe partly black varieties which never occur in *niveus*. Later Riley⁽¹⁰⁾ states that he considers

both *nigricornis* and *fasciatus*, which are synonymous, as dark varieties of *niveus*. The uncertainty as to the identity of these species by economic writers has probably led to the subsequent confusion concerning their oviposition habits, which still persists to a less degree.

DISTRIBUTION.

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. It is found 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), Indiana (Blatchley), 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).

HABIT.

Æcanthus niveus is a tree- and bush-inhabiting form. It is found most abundantly in apple orchards and is more or less common in plantings of other fruit trees and in raspberry plantations, shrubberies, vines and bushy fence rows. Among forest trees it is less common, although a few can often be heard singing in such places, especially along the edge of a wood. In general this species prefers a cultivated region to a wilderness. However, in orchards that are regularly sprayed with arsenicals the crickets do not become very abundant.

DESCRIPTION OF LIFE STAGES.

Egg (Fig. 14, g).—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. 14, f) 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. 14, e) are long and finger-shaped, 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. Antennæ 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. Distal part of antennæ with gray annulations on alternate segments. Length 4.5 to 5 mm. Antennæ 10.7 mm.

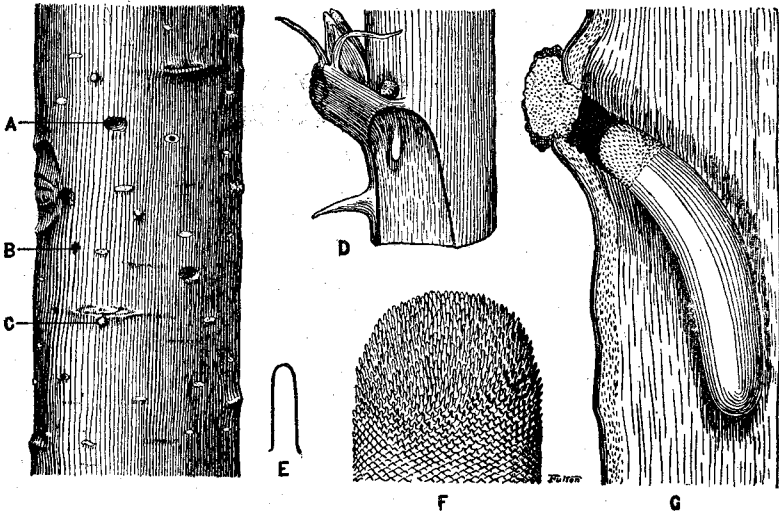


FIG. 14.—*Ecanthus niveus* DE GEER.

a, Egg puncture of previous year healed over, in apple bark; b, recent egg puncture without plug; c, egg puncture with plug (all $\times 1\frac{1}{2}$); d, egg in raspberry ($\times 2\frac{1}{2}$); e, projection of egg cap ($\times 500$); f, egg cap ($\times 50$); g, egg in apple bark ($\times 15$).

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. Antennæ 13 mm.

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

Fifth instar (Plate I, Fig. 5 and Plate III, Fig. b): 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. Antennæ marked similar to adult. Length 11 to 12 mm. Antennæ 23 mm.

Adult (Plate I, Fig. 6 and Plate V, Fig. a): Moderately slender. Pronotum as broad as long. Color very pale green. Top of head between eyes and antennæ

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. Fore wings of male very broad. Antennæ white, with gray annulations in the distal 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. 1, a.) The second segment is white with a similar spot. Length to end of abdomen 14 mm. Fore wing of male 13-14 mm. x 6 mm. Fore wing of female 12-13 mm.

SONG.

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. This phase of the subject has been studied by Bessey⁽²¹⁾, Edes⁽²²⁾ and Shull⁽²³⁾ and formulas have been worked out by which the temperature can be computed from the average number of notes per minute.

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.

Scudder⁽¹⁵⁾ has described *niveus* as having two distinct songs, one for day and one for night. This certainly is not true, for none of our species have more than one type of song. Scudder made observations on two different species and admits in the same article that at the time he did not distinguish between the species. His "day song" would apply to *nigricornis*, *quadripunctatus* or possibly *latipennis*, although the last does not usually sing by day. His "night song" describes well the song of *angustipennis*.

OVIPOSITION.

In ovipositing the female *niveus* prefers to stand on the upper side of a branch, and when on a vertical or sloping surface generally

works with the head uppermost. Another peculiarity which has been observed in only one other species, namely *exclamationis*, is the use of excrement to plug up the puncture. Just before depositing the egg and while the ovipositor is imbedded for its full length in the bark, the female forces out a drop of excrement, which by stretching out the tip of the abdomen she fastens to the bark just below the hole. After withdrawing the ovipositor she moves back, picks up the drop with her mouth and places it over the opening. Several minutes are then spent in packing it in and smoothing it out (Fig. 14, c).

The eggs are deposited in the soft inner bark of a number of trees and bushes. In most cases a part of the egg lies in contact with the wood, which is grooved by the ovipositor but not drilled into to any extent. In the process of healing, the puncture becomes surrounded, in most plants, by a hard woody callus. In trees having a soft fleshy bark, *niveus* prefers to oviposit in branches from one to three inches in diameter. The eggs may be placed in almost any part of the bark, but the lenticels are favorite places, probably because they are less resistant to the drilling operations.

In bushes and in trees which have a hard bark covering the larger branches, the eggs are commonly laid in the smaller branches in thick places in the bark at the sides of buds or small twigs. In raspberry canes, where this species is sometimes fairly common, the eggs are deposited singly in the fleshy area at the side of the bud in the axil of the leaf, and they never extend through the woody layer into the pith (Fig. 14, d).

In breeding-cage experiments from one to thirteen eggs were deposited in a night by a single individual. A number of the insects laid a few eggs every night during the whole period of oviposition, while others suspended operations on several nights. 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.

About Geneva the eggs of *niveus* are found most abundant in apple, plum and cherry trees, and are locally common in walnut and raspberry. One small elm tree was observed to contain a large number of them, and in this case the eggs were deposited in the corky areas of the bark and did not extend into the cambium layer. A few eggs were found in peach, witch-hazel, chestnut, butternut, wild crab-apple, 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.

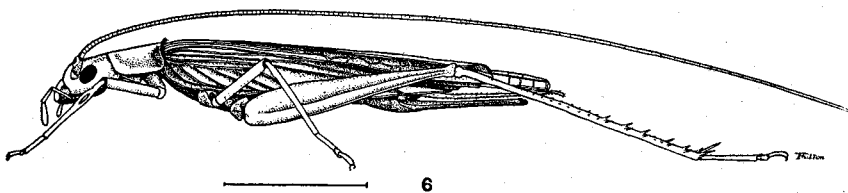
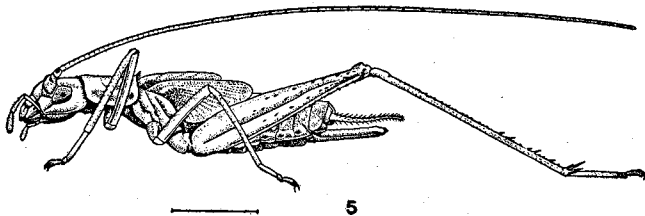
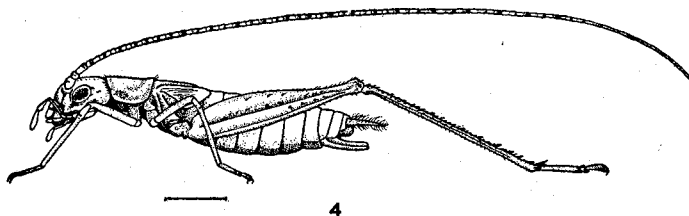
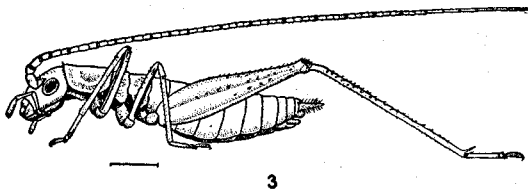
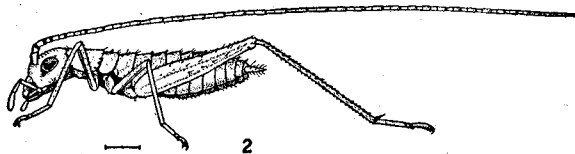


PLATE I.— LIFE STAGES OF *Ecanthus niveus*; NYMPHAL INSTARS AND ADULT.

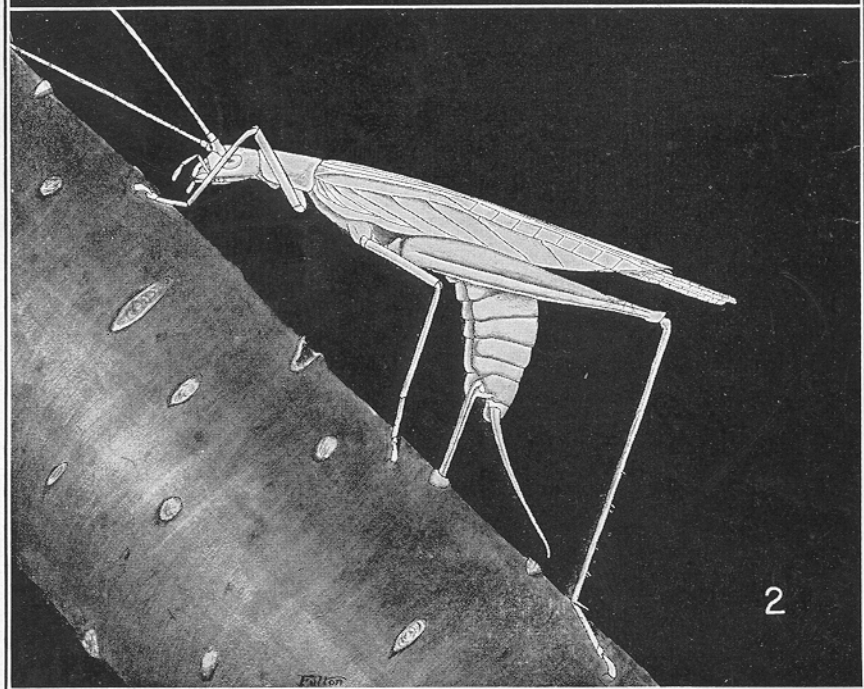
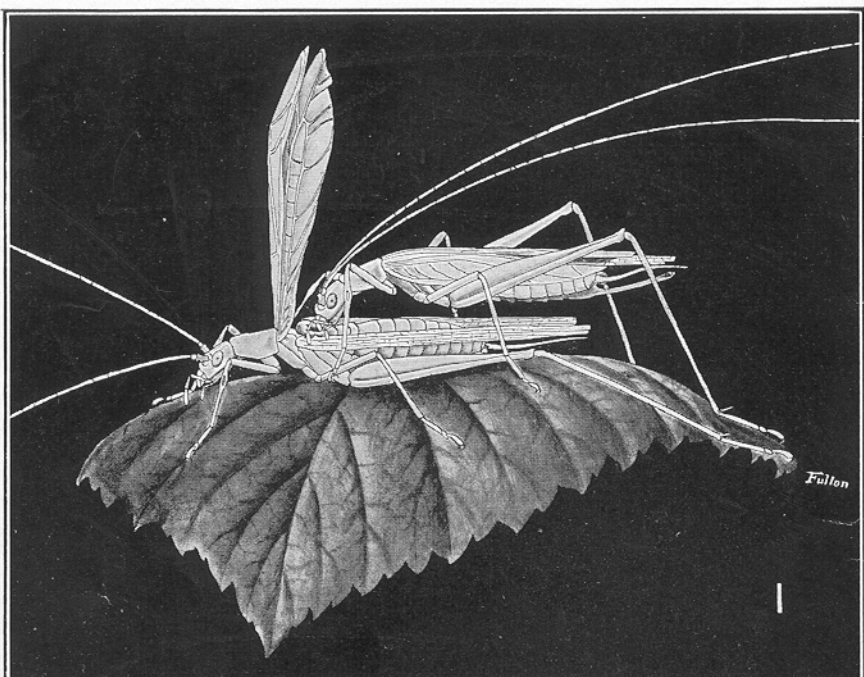


PLATE II.—1, FEMALE OF *Ecanthus niveus* FEEDING ON METANOTAL GLAND OF MALE;
2, CHARACTERISTIC POSTURE OF FEMALE WHEN OVIPOSITING.

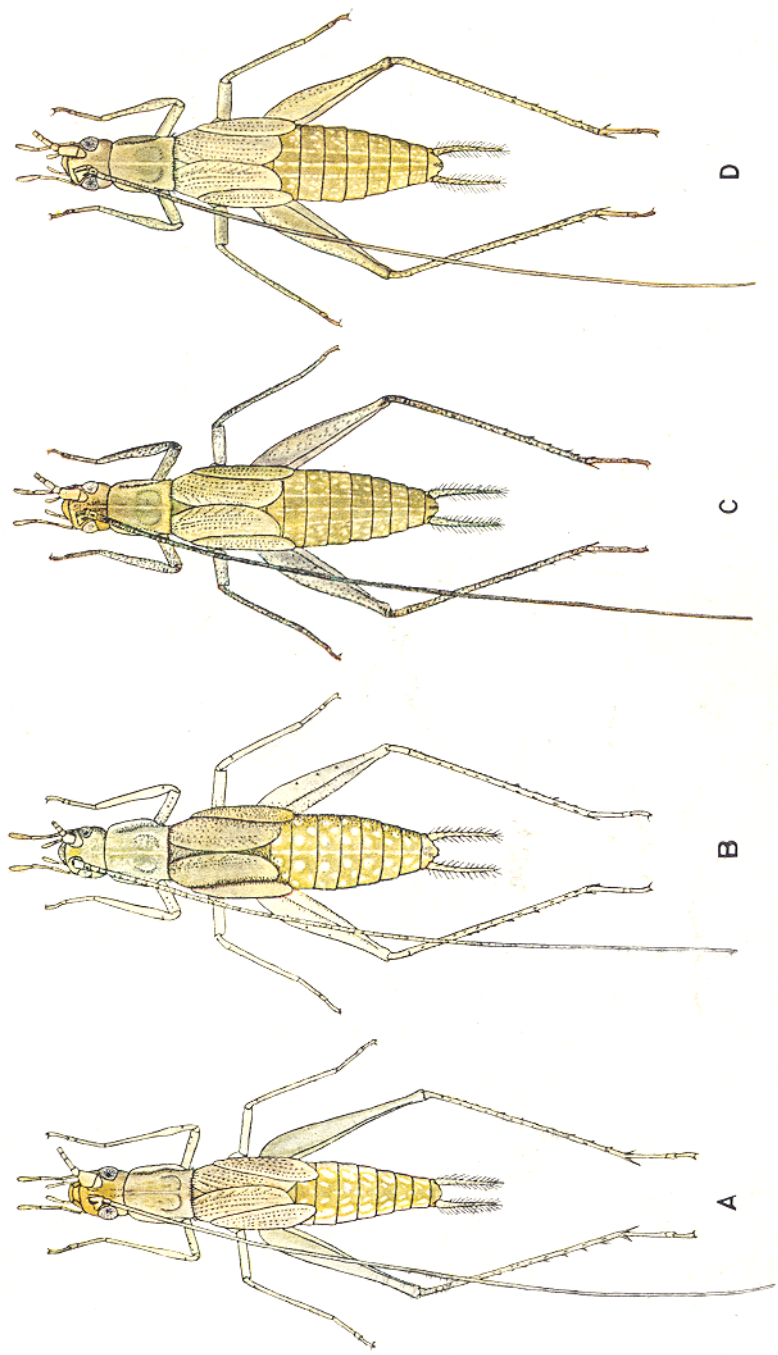


PLATE III.—FIFTH STAGE NYMPHS OF TREE CRICKETS: a, *Ecanthus angustipennis*; b, *niveus*; c, *nigricornis*; d, *quadrivittatus*.

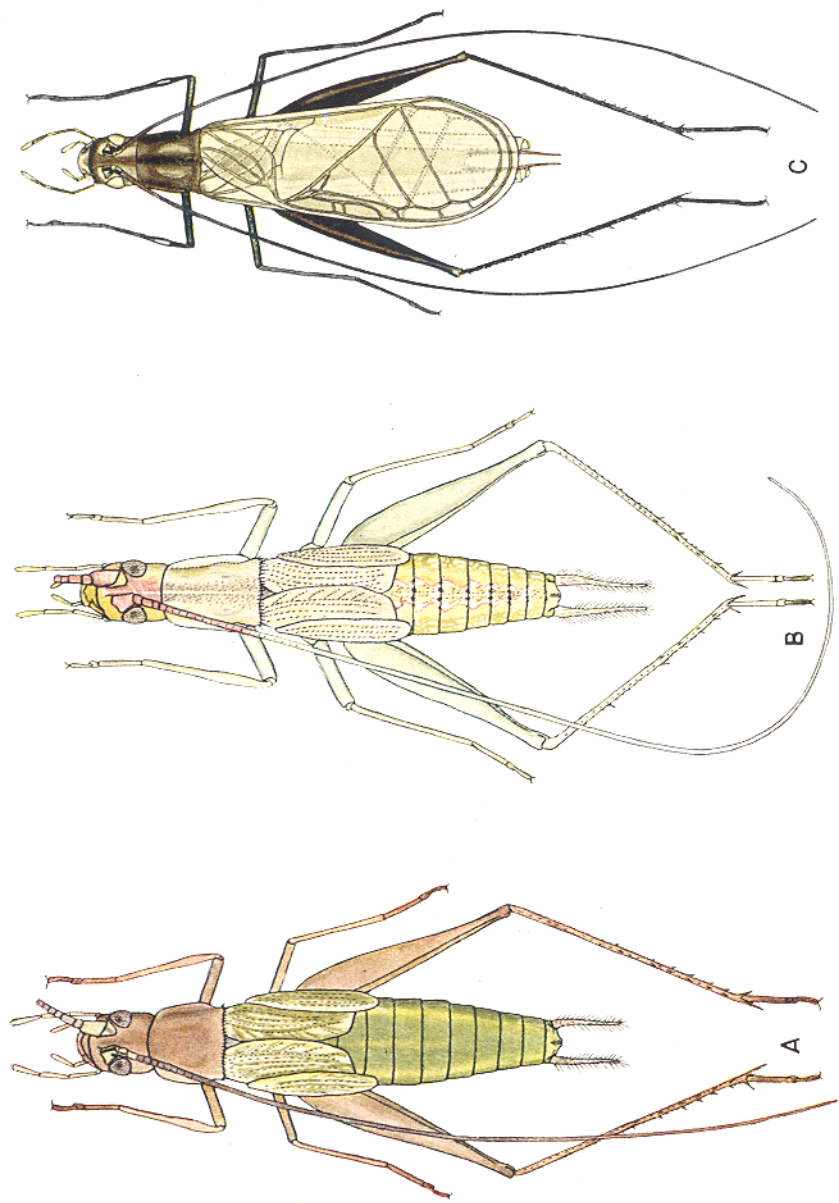


PLATE IV.—FIFTH STAGE NYMPHS OF TREE CRICKETS: a, *Ecanthus pini*; b, *latipennis*, c, ADULT MALE, *nigricornis*.

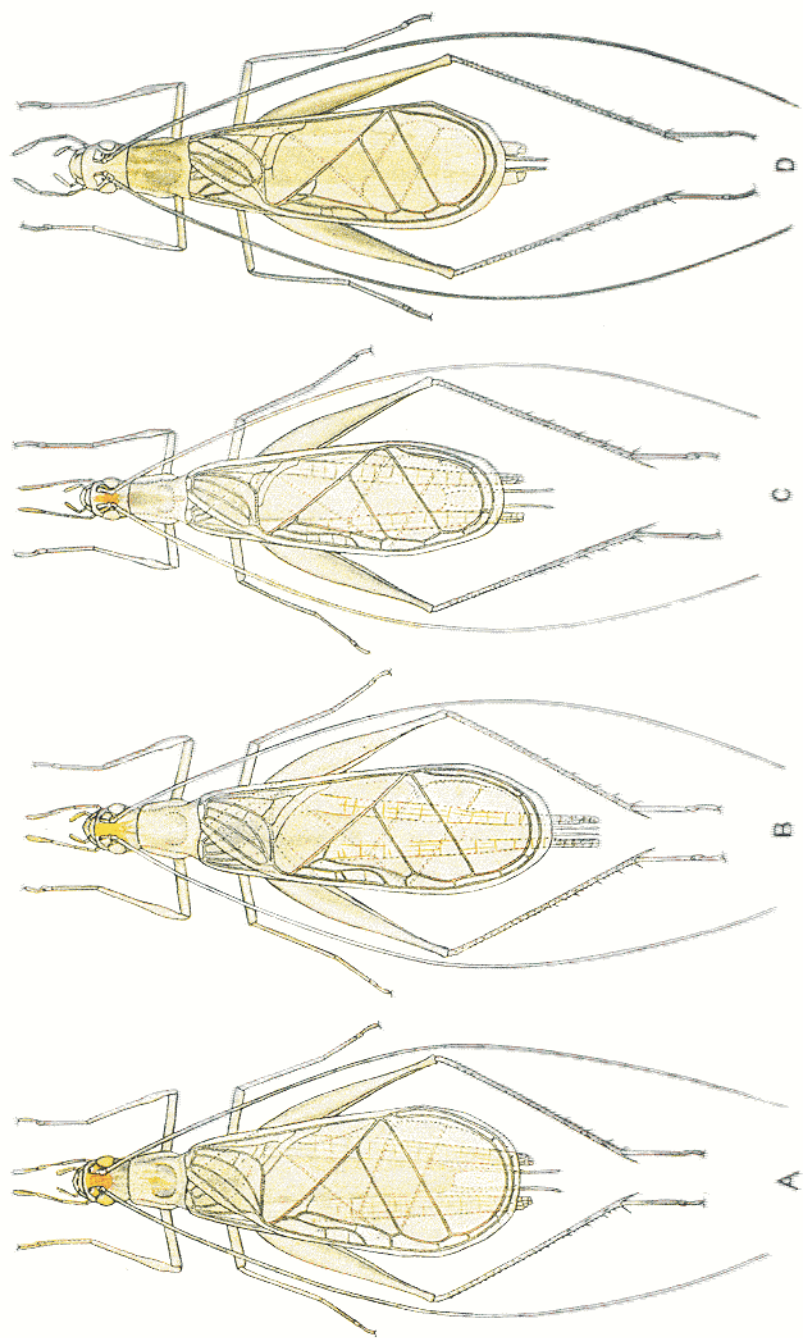


PLATE V.—ADULT MALE TREE CRICKETS: a, *Exanthe nitens*; b, *exclamationis*; c, *angustipennis*; d, *quadripunctatus*.

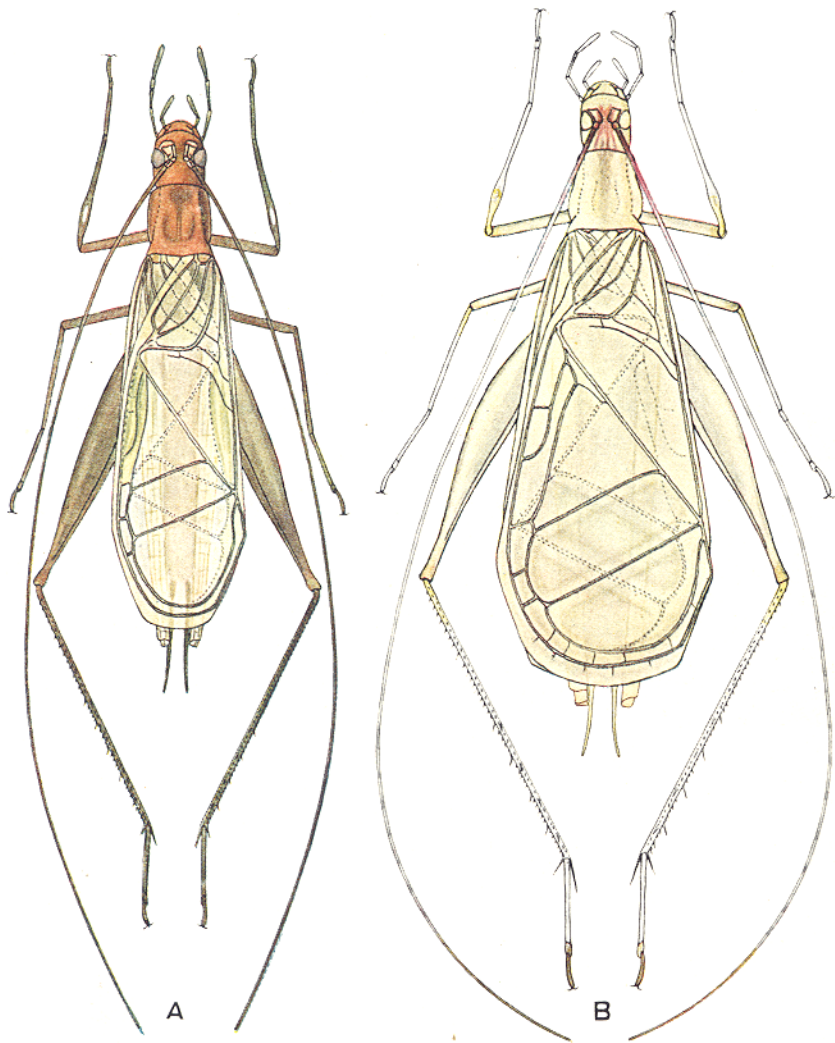


PLATE VI.—ADULT MALE TREE CRICKETS: a, *Ecanthus pini*; b, *latipennis*.

ÆCANTHUS ANGUSTIPENNIS Fitch.

HISTORICAL NOTES.

This name was first applied by Fitch⁽⁴⁾ to a single male specimen which he described as a variety of *niveus*. The description is very brief; and the only characters mentioned are that the tegmina are narrower than *niveus* and the hind wings protrude like tails. The latter character strongly suggests *Neoxabea bipunctata*, the male of which was unknown to Fitch, although the description might apply to *Æ. quadripunctatus* or the species now understood by this name. Beutenmüller⁽⁴⁷⁾ states that "whether the species has been correctly determined or not can never be definitely ascertained, as Fitch's type of the species, as well as his other species of *Æcanthus*, have been destroyed. I would propose that the name *angustipennis* nevertheless be retained for the species so well known by this name."

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), Indiana (Blatchley), Illinois (Forbes), Kentucky (Garman), Kansas and Texas (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.

HABITAT.

Angustipennis is quite often found in company with *niveus* and is generally abundant in apple orchards. It is more strictly arboreal than the latter species, and seems to be confined to woody plants, either trees or large bushes. About Geneva it has never been taken on raspberry, grape or weeds of any kind. Among forest trees it is more common than *niveus*. Many specimens have been collected from scrub and bur oaks on Long Island and from alder in a swamp near Geneva. Davis⁽⁴⁸⁾ states that in Florida he found this species among golden rods and other low plants by the road side and that they also occurred among the small oaks and other trees.

DESCRIPTION OF LIFE STAGES.

Egg (Fig. 15, 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. 15, d) measure about .4 mm. in length and breadth, while the long ones (Fig. 15, 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. 15, 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.

Nymph.—First instar: Color white. Markings of head and thorax as in following stage. Antennæ 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. Antennæ 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 antennæ. Thorax with a pair of dark lines near the median line. First segment of

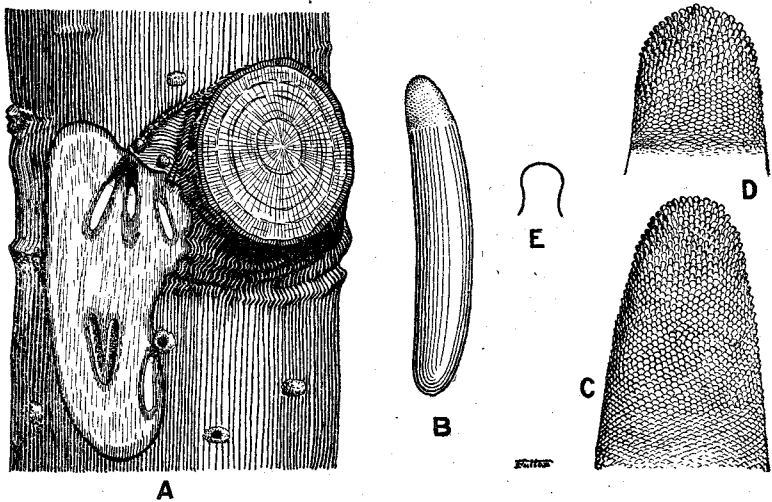


FIG. 15.—*Ecanthus angustipennis* FITCH.

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

antenna with a black spot on the inner edge. Distal 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 (Plate III, Fig. a): 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 (Plate V, Fig. c).—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 antennæ 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. Antennæ 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. 1, b.) Length to end of abdomen 14 mm. Fore wing of male 10–12 mm. x 4–5 mm. Fore wing of female 12 mm.

SONG.

The song of this species is not so loud as that made by *niveus* and is of a more mournful quality. The pitch is about a half tone higher and ranges from C# to D#, two octaves above middle C, depending on temperature and somewhat on individual variation. Like the song of *niveus* it is intermittent, but can be readily distinguished by its longer notes and rests and its non-rhythmical character. Each trill continues from one to five seconds, but most commonly it lasts for about two seconds. The periods of rest vary more and may be from one to eight seconds or longer. The total number of notes per minute varies, even from one minute to the next, and is generally not more than ten, but may occasionally run as high as fifteen. On one occasion a specimen alone in a cage was observed to trill continuously for a minute or more. Out of doors the song might be unnoticed by anyone not endeavoring to detect it. On trees where *angustipennis* occurs in equal abundance with *niveus*, its 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 observed it sings throughout the night and remains silent during the day.

OVIPOSITION.

In trees where *niveus* deposits eggs in branches from one to three inches in diameter, the female *angustipennis* usually selects for this purpose a small branch of about a half or third of an inch in diameter. She generally drills into the thick wrinkled places in the bark where the small twigs branch. Although we have only collected the eggs from apple, it is probable that they occur in all plants on which the adults are known to exist. This species has not been observed to use a drop of excrement for plugging up the opening of the egg puncture. For this purpose she snips off little particles of bark here and there, chews them up and pushes them into the hole. Occasionally when the female has deposited an egg, she does not completely

remove the ovipositor, but starts to drill again in a slightly different direction and places another egg near the first. When cut into, the two punctures appear in the form of a V (Fig. 15, a). After an examination of a large number of egg punctures in apple orchards near Geneva only a few paired eggs were found, and caged crickets from this section deposited very few eggs in this manner. Apple branches from West Virginia and Kentucky contained a large number of the double punctures as well as single ones, and live specimens from Kentucky deposited fully half their eggs in pairs. The crickets of the two localities appear to be identical in every respect and this difference in habit seems to be merely a physiological variation.

ÆCANTHUS EXCLAMATIONIS Davis.

HISTORICAL NOTES AND DISTRIBUTION.

This species was first described by Davis⁽³²⁾ from specimens collected at Staten Island and several localities in New Jersey. It has since been recorded by Engelhardt from Johnson City, Tenn., and by Walden from New Haven, Conn. Mr. C. L. Metcalf writes that the North Carolina Department of Agriculture has a record of its occurrence in the western part of the state. The author has examined specimens taken by H. H. Knight at Hollister, Missouri, and by W. J. Kostir at Cedar Point, Sandusky, Ohio, and has collected the species with Mr. Davis at Central Park, Long Island, where it is fairly common.

HABITAT.

The only locality in which the author has any knowledge of the natural habitat of the species is at the edge of an area of natural prairie land on Long Island, northwest of the village of Central Park. In the zone separating the pine barrens from the open prairie the trees are scattered, and the predominant species are black jack oak (*Quercus marilandica*) and bur oak (*Q. macrocarpa*). *Exclamationis* was found in much greater numbers on the latter oak and in company with *angustipennis*. It was not collected from any other plants in this locality although many other trees were beaten and the weeds and grass were swept with a net.

DESCRIPTION OF LIFE STAGES.

Egg (Fig. 16, d).—The color is dull white, semitransparent and often yellowish when first laid. The cap (Fig. 16, b) is white but sometimes stained reddish from the bark. It is generally a little broader than long and the sides are parallel at base only and the tip is not so broadly rounded as that of *niveus*. The cap bears no spicules but is covered with low rounded elevations which in aggregate appear like scales. Those projections are about .02 mm. in diameter and .005 mm. high (Fig. 16, c).

The average measurements of twenty eggs are as follows: length 2.85 mm.; greatest width, .56 mm.; length of cap, .46 mm.; width of cap, .49 mm.

No specimens were obtained earlier than August 12 and at that time all had matured so that the nymphal stages could not be described.

Adult.—(Plate V, fig. b) Color nearly pure white, with a slight tinge of greenish yellow in places. Top of head between eyes and antennæ pale to medium yellow. Wings with yellowish veins. Antennæ pale, without gray annulations. First segment of antenna with a white opaque prominence on the front and inner side, which bears

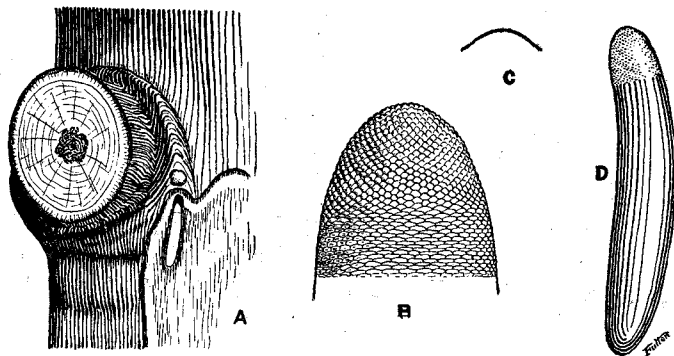


FIG. 16.—*Ecanthus exclamationis* DAVIS.

a, Egg in oak (x 3); b, egg cap (x 50); c, projection of egg cap (x 500); d, egg (x 15).

a black club-shaped mark. Second segment with a shorter black dash directly above; the two marks appear like an inverted exclamation point. The hind pair of wings are generally long and equal the cerci. Length to end of abdomen 14–15 mm. Fore wing of male 13–14 mm. x 5–5.5 mm. Fore wing of female 13–14 mm.

SONG.

The song of *exclamationis* is intermittent and non-rhythmical and most resembles the song of *angustipennis*. The pitch is the lowest of any of the species studied, and reaches only to the second B above middle C. The common length of note and rest is two or three seconds but this varies much, as in the song of *angustipennis*. The beginning of each note is comparatively weak, but the sound increases in volume and slightly in pitch and continues uniformly until it abruptly ends. In quality it most resembles the distant singing of the common toad.

It was observed that the males in the cages kept moving about while singing and that if no females were near they lowered their wings to the normal position between each note. If a female was close by, the male became more excited, kept the wings elevated and repeated the notes in more rapid succession.

OVIPOSITION.

No bur oak (*Q. macrocarpa*) could be obtained near Geneva, so that the females of this tree cricket were not supplied with the wood in which they would naturally oviposit. However they deposited many eggs in branches of red oak which were left in

the cages. Whether the bark of the latter oak is more resistant than bur oak was not determined, but it seemed to require considerable labor for the females to bore the holes, and the whole process of egg laying generally continued for about an hour. In some cases the cricket seemed to be unable to finish the hole and would pull out the ovipositor and chew a pit in some other part of the branch for a fresh start. In the few cases of oviposition observed in detail the female would fasten a drop of excrement to the bark before depositing the egg and after pulling out the ovipositor would pick the pellet up and force it into the hole. She would then chew off small pieces of bark and add them to the plug, and spend five or ten minutes putting on the finishing touches. Although oak branches of various sizes were placed in the cages, the females mostly chose branches between half an inch and an inch in diameter and deposited most of their eggs in the thick bark about the base of side branches (Fig. 16, a).

ECANTHUS QUADRIPUNCTATUS Beutenmüller.

HISTORICAL NOTES.

For many years this light colored species had been regarded as merely a pale variety of *nigricornis*. Beutenmüller⁽²⁷⁾ in 1894 named it as a new species, his claim being that of the many pairs of tree crickets he had observed mating in the field, in no case were these two forms together. Many entomologists today believe that they are only varieties, and there can be no doubt about their close relationship, but careful studies on the two forms have revealed constant differences in habits as well as in body characters, which would indicate that they are quite distinct species.

DISTRIBUTION.

Quadrupunctatus is a common species in most parts of New York State, with the exception of the northern forested areas. Localities in North America have been recorded as follows: Massachusetts (Faxon), Connecticut (Walden), Long Island and New Jersey (Davis), Ontario (Walker), Indiana (Blatchley), Illinois (Forbes), Minnesota (Lugger), Manitoba (Walker), Maryland (Rehn), Georgia (Allard), Kansas and Texas (Tucker), Texas and Colorado (Caudell). From specimens examined it can be recorded from the following states: Massachusetts, Connecticut, New Jersey, North Carolina and Florida (Amer. Mus.), Ohio (Kostir), Minnesota (Patch), Colorado and Utah (Titus) and Arizona (Morrill).

HABITAT.

Although *quadrupunctatus* can sometimes be found in the same locality with *nigricornis* the preferred habitat and places of maxi-

mum abundance of the two species are quite different in character. Upland fields abounding in medium sized weeds such as aster, sweet clover, daisy, golden rod, ragweed, and especially the wild carrot or Queen Ann's lace (*Daucus carota*), form the favorite environment of this species. Quite often in a field of this character where *quadripunctatus* is prevalent, the brushy fence rows surrounding the area will be inhabited by *nigricornis*.

DESCRIPTION OF LIFE STAGES.

Egg (Fig. 17, c).—The color when the eggs are first laid is bright golden yellow but becomes somewhat paler as development goes on. In general they are a trifle yellower than the eggs of *nigricornis*. The eggs average smaller than those of the other species; they are about equal in length to those of *angustipennis* but are more slender. The cap is pure white and comparatively small (Fig. 17 e). In shape it is hemispherical but a little more prolonged than the cap of *nigricornis* eggs. The projections of the cap are long and slightly thickened at the end (Fig. 17 d). Those near the end of cap measure .02 to .025 mm. in length, by .007 to .009 mm. in diameter. Measurements of fifty specimens of eggs average as follows: length, 2.8 mm.; greatest width, .45 mm.; length of cap, .30 mm.; width of cap, .35 mm.

Nymph.—First instar: Color, pale slightly greenish yellow. A slight infuscation extends along the dorsal side from the antennæ back, and is divided along entire length by a narrow pale median line. Just back of the antennæ 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 antennæ are gray all over but darkest toward the extremity. Length 3 mm. Antennæ 6 to 6.8 mm.

Second instar: Pale greenish yellow with scattered whitish flakes. 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: Greenish yellow, mottled with small whitish spots and with a pale median line. Markings of basal antennal segments of the same pattern as in adult but faint. Length 6 to 7 mm.

Fourth instar: Greenish yellow. Most of hairs on body pale in color. Tibial spurs black at tip only. Last two segments of hind tarsi nearly black. Length 8.5 to 10 mm.

Fifth instar (Plate III, Fig. d): Greenish yellow. Body hairs mostly pale. Brown spots at bases of hairs on legs, cerci, top of head and median area of pronotum. Markings on basal segments of antennæ more distinct. Length 11 to 12 mm.

Adult (Plate V, Fig. d).—Body pale yellowish green. Head more yellowish and faintly streaked with green. Abdomen yellowish above and below and greenish

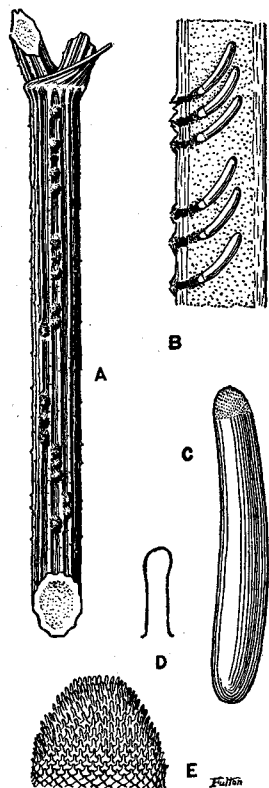


FIG. 17.—*Ecanthus quadripunctatus* BEUTENMÜLLER.

a, Egg punctures in wild carrot ($x 1\frac{1}{2}$); b, longitudinal section of the same ($x 3$); c, egg ($x 15$); d, projection of egg cap ($x 500$); e, egg cap ($x 50$).

on sides. *Ventral area not darkened.* Legs dull yellowish green. Antennae pale yellow at base, outer segments shaded with dull brownish gray which grows darker toward tip. The basal antennal segment is flattened transversely and along the inner edge of the front face is a narrow black line and at the distal end near the middle of the segment is a black spot. The second segment has a pair of black spots on the front side. Forewings of the male are transparent, with greenish yellow veins. Forewings of female with numerous green veins. Ovipositor brownish with black tip. Length to end of abdomen, 12-14 mm. Forewing of male, 11 by 4.5 mm. Forewing of female, 10-12 mm.

SONG.

The crickets of this species are more diurnal in their habits than those heretofore discussed, and they can often be heard singing at midday. Late in the afternoon more individuals join the chorus and they continue to sing throughout the night. The sound is a continuous, shrill whistle with a pitch about the third F # above middle C. It most resembles a small tin whistle but with a slight rasping or quavering quality. The call continues generally for a period of several minutes without ceasing, and in a field where large numbers are present it gives rise to a shrill, diffused ringing from which the individual sounds can not be distinguished. On cold nights the pitch drops a little and the sound becomes very faint. The call of old males often becomes a weak rasping shuffle. The continuous note distinguishes the song of this species and those following from that of the three preceding species, which have an intermittent call.

OVIPOSITION.

For the purpose of oviposition the female *quadripunctatus* selects small pithy weeds. She nearly always stands head downward on the stalk while depositing the eggs, which consequently are directed upward from the opening (Fig. 17, b). Out of a hundred eggs examined to determine this point only a short row of four were directed downward. The slant of the egg in the pith depends somewhat on the diameter of the stalk. The cap end lies within one-half to one millimeter from the opening and the inner end generally touches the wood on the opposite side if the stalk is not too wide. When the pith is of large diameter the eggs lie at about an angle of forty-five degrees with the long axis of the stalk, but if the pith is narrower the eggs lie more nearly parallel to the stalk, and in some cases the pith cavity is completely filled by the egg. The female works on the upper side of a leaning stem and deposits several eggs in a row. If the stalk happens to be vertical, as it seldom is, the eggs may be thrust in from different directions. The rows do not have the compactness and regularity to be observed in the oviposition of *nigricornis*, but are crooked and broken up into isolated punctures and short rows of from two to five punctures, each group separated by gaps from three to fifteen millimeters long (Fig. 17, a). Within the short rows the holes are placed about one to each millimeter, and seldom more than eight or ten are found in one group. In some

cases the eggs are so scattered along the stem that they can scarcely be said to form a row. After the egg is deposited the female chews off a small patch of the outer tissue of the stalk and pushes the material into the hole at the same time pressing in the frayed edges. The neatly capped puncture is a very inconspicuous object. In the choice of plants for oviposition this species is very partial to the wild carrot (*Daucus carota*). So confined are they to this plant, at least in this region, that after many long searches only two other plants were found bearing their eggs. One of these was a small plant of golden rod and the other a purple aster. Doubtless other small plants with a solid pith are used in localities where the wild carrot is not so abundant. The size of stalk used varies from two to five millimeters in diameter and in this respect the insect shows a marked difference from the closely related *nigricornis*.

CECANTHUS NIGRICORNIS Walker.

HISTORICAL NOTES.

This insect is very generally known in literature under the name *Ce. fasciatus* (De Geer), Fitch, since it was first described by Fitch under that name. It has however been pointed out by Scudder⁽⁵⁾ and later by Beutenmüller⁽¹⁷⁾ that Fitch erroneously identified his insect as De Geer's⁽¹⁾ *Gryllus fasciatus* which is really a *Nemobius*. Therefore he did not give a name to his species and Beutenmüller recommended that the name *nigricornis* be used instead. The original description of the latter by Walker⁽⁶⁾ in 1869, fits this insect very well and is undoubtedly taken from the same species. As stated before Walsh⁽⁹⁾ and Riley^(7,10) considered this species as a dark variety of *niveus* and many collectors at the present time consider this tree cricket and *quadripunctatus* as varieties of the same species.

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), Indiana (Blatchley), Illinois (Forbes), Minnesota (Lugger), Nebraska (Bruner), Oklahoma and Arizona (Caudell), Texas and Kansas (Tucker), California (Baker). From specimens examined we can record it from the following states: New Jersey and Connecticut (Amer. Mus.), North Carolina (C. L. Metcalf), Ohio (Kostir).

HABITAT.

In general *nigricornis* prefers larger plants and more dense growth than *quadripunctatus*, and its habitat is more varied. While

the latter is confined largely to upland weedy fields, the former can be found in tall, rank growths of weeds such as in swamps and river bottoms, in brush or second growth, in fence rows grown up with bushes, briars and vines, in raspberry plantings, vineyards, nurseries and even occasionally in orchards. While the list of plants used for

oviposition, given in a following paragraph, contains many names of trees, it has been our experience that these records are of rare or local occurrence and generally refer to small seedling trees growing among brush, and thus do not convey the proper impression regarding the habitat of the insect.

DESCRIPTION OF LIFE STAGES.

Egg.—The eggs (Fig. 18, c) are of a light or medium yellow color, and brightest when first laid. The cap is rather small, broader than long and hemispherical, the sides being parallel only at the extreme base. (Fig. 18e.) 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. 18, d.) Those near the end of the cap are .012 mm. long by .008 mm. in diameter. The eggs of this species can be distinguished from those of *quadripunctatus* by the much shorter projections on the cap. Average measurements of thirty-six specimens are as follows: Length 2.9 mm.; greatest width .57 mm.; length of cap .33 mm.; width of cap .44 mm.

Nymph.—First and second instars: In these two stages the crickets seem to be identical in every respect with those of *quadripunctatus*.

Third and fourth instars: The differences between *nigricornis* and *quadripunctatus* in these two stages are very slight and only relative. The former is more nearly pure green with less yellowish tinge; dorsal infuscation

is usually plainly visible; hind legs, especially the tibiae, more heavily speckled with black dots; and the black line on the basal antennal segment is broader. These statements are based on averages only. Not knowing where any given specimen was found it would be impossible to state with certainty which species it belonged to.

Fifth instar (Plate III, Fig. c): This is the only nymphal stage in which the two species can be separated. *Nigricornis* averages a little larger, and is not so yellowish in color. Dorsal part of head is slightly brownish. Hairs of body are mostly black

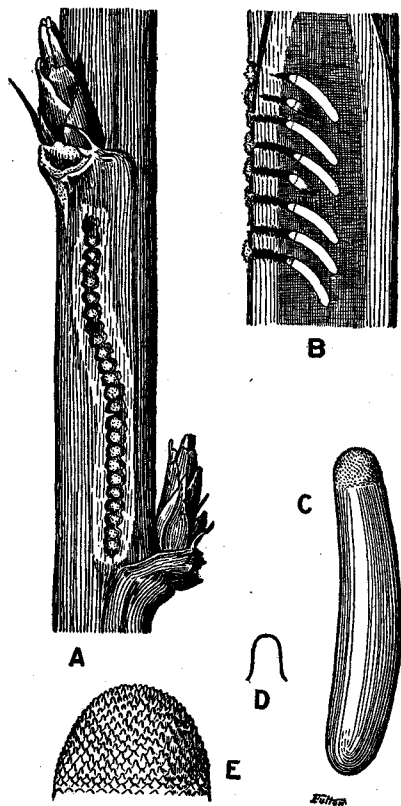


FIG. 18.—*Ecanthus nigricornis* WALKER.

- a, Egg punctures in raspberry (x 1½); b, longitudinal section of the same (x 3); c, egg (x 15); d, projection of egg cap (x 500); e, egg cap (x 50).

or brown instead of pale. The legs appear dark, due to dark hairs and spots. Spurs are black nearly to base. Antennæ are black or nearly so in outer part; the four spots at the base are large and conspicuous. The most constant character, which can not be relied on in dried specimens, is the dark band on the ventral side of the abdomen; the sternum of each segment is slightly infuscated and covered with small brownish spots.

Adult (Plate IV, Fig. c). — 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 antennæ. 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; tibiæ 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. 1, f.) *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. 1, g) and in some specimens both of these segments are almost entirely black. Length of body, 14 mm. Fore wing of male, 10-11 mm. by 4.5 to 5 mm. Fore wing of female 11-12 mm.

SONG.

The song of *nigricornis* so closely resembles that of *quadripunctatus* that it is very difficult to distinguish the two. On the average the song of the former is louder and shriller and with less rasping quality. The pitch of the two is the same, the third F # above middle C, and both species have the habit of singing during the day as well as at night. After a study of the habitats of the two species, however, one can judge fairly accurately in the field, which species he hears from the character of the surrounding vegetation.

OVIPOSITION.

In preparing for oviposition the female generally selects a position well above the ground. She works head uppermost, and if the stalk of the plant leans a little she prefers to operate from upper side. As with other tree crickets the first step in the process is to chew a pit in the bark to start the ovipositor. The length of the drilling operation depends on whether the eggs are being deposited in the stalk of an herbaceous weed or in the hard woody twig of a tree or bush and varies from ten minutes to half an hour. After the egg has been deposited and the mucilaginous substance discharged into the hole, the female removes the ovipositor and chews off pieces of the bark just above the puncture to plug up the opening. The pit made in so doing serves as a starting point for the next drilling operation. This is repeated a number of times and results in a long compact row of eggs, with from seven to ten punctures to each centimeter. (Fig. 18, a.)

The eggs slant across the pith cavity at an angle of from forty-five to sixty degrees with the long axis of the stalk. (Fig. 18, b.)

If the pith cavity is small and the woody layer thick, a part of the capped end of the egg is partly imbedded in the wood. When the punctures are close together the eggs are directed alternately to the right and left so that they do not interfere with each other. In contrast to the oviposition of *quadripunctatus* the eggs of this species are generally directed downward from the opening as the result of the female working head uppermost. In localities where strong prevailing winds have caused all the weeds to lean in one direction, the habit of the female in ovipositing on the upper side of the stalk might give rise to the impression that she always worked on the same side with reference to the points of the compass.

The oviposition period commences during the latter part of August and generally extends through the month of September. 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.

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 peach¹ apple,² 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. 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 *Æ. quadripunctatus*,

¹From material collected by J. L. King at Gypsum, Ohio.

²From material collected by B. G. Pratt, New York City.

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.

In the size of the stalk selected for oviposition *nigricornis* shows a distinct difference in habit from *quadripunctatus*, in that it almost always seeks one of larger diameter. With grape vines and certain weeds, stems less than five millimeters in diameter are seldom chosen and with raspberry canes and elder the common thickness of the wood is not much under a centimeter.

ÆCANTHUS PINI Beutenmüller.

HISTORICAL NOTES AND DISTRIBUTION.

This tree cricket was first described by Beutenmüller⁽⁴⁹⁾ from specimens collected in Windham Co., Conn. It has since been recorded as follows: Gloucester, Mass. (Henshaw); Riverton, N. J. (Rehn); Karner, N. Y. (Felt); Staten Island and Long Island, N. Y., and Bloomsburg, Columbia Co., Pa. (Davis).

HABITAT.

All the above records are from specimens collected on pine trees and apparently this species does not inhabit any other kind of plant. The author in company with Mr. Wm. F. Davis collected a large number of specimens near Central Park, Long Island. In this region as also in the New Jersey pine barrens the pitch pine (*Pinus rigida*) is the predominant species. The trees are rather scattered and closely surrounded by scrub oak and other smaller plants, but in no case were specimens taken on anything but the pines. Mr. Davis informs me that his specimens collected at Bloomsburg, Pa., were taken from the Jersey or scrub pine (*P. virginiana*).

DESCRIPTION OF LIFE STAGES.

Egg.—The eggs (Fig. 19, d) closely resemble those of *nigricornis*. The color is yellow but not so bright as the eggs of *quadripunctatus*. The cap (Fig. 19, e) is a trifle larger than that of *nigricornis* and the projections (Fig. 19, c) are a little larger and flattened, except those on the extreme tip which appear to be cylindrical. The shape of the projections is the most prominent difference between the eggs of the two species. This is most easily seen when the cap end of the egg is raised so that one gets an end view of the projections on the side. Those of *pini* appear transversely elliptical, with one diameter about double the other, while those of *nigricornis* appear round or broadly oval. The projections of the eggs of *pini* measure .018 mm. long, .012 mm. wide and .006 mm. thick. The average measurements of twenty eggs are as follows: Length 3.14 mm.; greatest width .55 mm.; length of cap .35 mm.; width of cap at base .47 mm.

Nymph.—Fifth instar: (Plate VI, fig. a.) Specimens were not obtained of any stage earlier than the fifth nymphal instar, which is as follows: Pronotum short

and broad. Head and thorax light brown, with obscure pale median line and somewhat paler on edge of disk of pronotum. Wing pads green, with dark green veins. Abdomen with a broad dorsal area of dull green, bounded by a streak of pale yellowish green on each side.

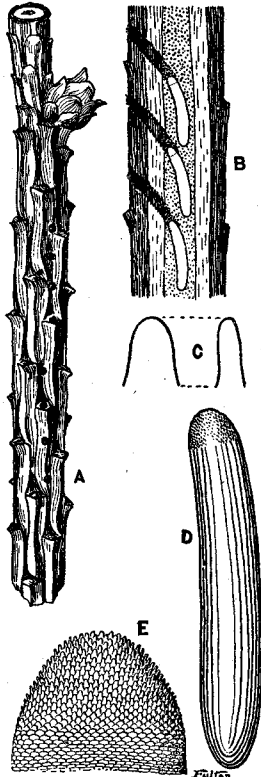


FIG. 19.—*Ecanthus pini* BEUTENMÜLLER.

a, Egg punctures in pine ($\times 1\frac{1}{2}$); b, longitudinal section of the same ($\times 3$); c, projection of egg cap, two views of the same structure ($\times 500$); d, egg ($\times 15$); e, egg cap ($\times 50$).

and continued throughout the night.

OVIPOSITION.

The females in our breeding cages oviposited mostly at night but on a few occasions they were observed drilling in the daytime, both

Sides and under part of thorax slightly pinkish. Antennæ yellowish on first two segments, remainder brown, growing darker toward tip; basal segments with black markings resembling *quadripunctatus*. Legs greenish brown; spines on hind tibiae black. Length 14.5 mm.

Adult.—(Plate VI, fig. a.) Head and pronotum nearly uniform dull reddish brown; pronotum with a paler stripe on each side. Underside of thorax pale yellow with brown blotches. Abdomen with ventral area uniform dull brown, bordered on each side by a narrow, sharply defined cream colored stripe; sides dull brown; dorsal area greenish brown. Antennæ dull brown; two basal segments pale brown with black markings on the front side; first with a black line along inner edge and a transverse, slightly oblique line near the end; second with two elongate parallel black spots. (Fig. 1, e.) Legs dull, olive brown. Wings of male transparent, with green veins; area anterior to the rasp clouded with green; a stripe on the inner edge, beyond the rasp and one along the fold of the wing, solid yellowish green, so that when wing is raised it is seen to be clear, with two green stripes. Wings of female with bright green veins except along the fold where they are pale yellow, giving the effect of a cream colored stripe. Near the base they are tinged with reddish brown. Ovipositor dark brown with black tip. Length of body 15–16 mm. Fore wing of male 13 mm. by 5 mm. Fore wing of female 12 mm.

SONG.

The song of *pini* is a shrill, continuous whistle, which closely resembles the call of *nigricornis* and *quadripunctatus*, but can be distinguished by its lower pitch. It is on the average about a note and a half lower than the song of those species, or the third E above middle C. Beutenmüller⁽¹⁸⁾ describes the sound when many individuals are singing together, as “not unlike the jingling of sleigh-bells at a distance.” The crickets in the cages in the laboratory generally began singing late in the afternoon

in the morning and afternoon. Before beginning to drill a pit is chewed in the bark as with the other species. The pine twigs are rather resistant and the drilling operation requires thirty or forty minutes. On completion of the process the hole is plugged up with bits of chewed bark. One female under observation deposited fourteen eggs in a single night; another, which was caged alone with a male, laid only thirty-one eggs in all. The eggs are placed in rows like those of *nigricornis* but are not so close together; one puncture to every three millimeters is a common distance. A favorite point for oviposition is at the end of one of the elongate scales of bark with which the pine twigs are covered. (Fig. 19, a.) The eggs may slant in either direction in the twigs but of the limited number deposited in the laboratory most of them were directed downward indicating that the females preferred to work head upmost.

In the breeding cages the crickets were first supplied with white pine and Austrian pine, but later some branches of the pitch pine were procured. Some apple twigs and wild carrot stalks were also placed in the cages. The crickets showed a decided preference for pitch pine while it was in fresh condition but later oviposited in the wild carrot stalks and apple twigs. This was probably because the pine twigs became dry and hard and a fresh supply could not be readily obtained. In no case did the crickets oviposit in the other two species of pine. The size of the pine twigs used varied from three millimeters to nearly a centimeter in diameter. Eggs in the narrow twigs were found to lie in the small pith cavity while those in the larger branches were partly or wholly imbedded in the wood.

CECANTHUS LATIPENNIS Riley.

HISTORICAL NOTES AND DISTRIBUTION.

Riley's⁽¹⁰⁾ original description of this insect is accompanied by a brief but correct account of the song and egg laying habits. He had described the eggs in grape in an earlier report⁽⁹⁾ but at that time supposed they were the eggs of *Orocharis saltator*. His specimens were mostly from Missouri, but he had one from Alabama and one from South Texas. Other records obtained from literature, correspondence and collections are as follows: Long Island and New Jersey (Davis); Michigan (Allis); Ohio (author's collection); Indiana (Blatchley); Illinois (Forbes); Minnesota (Dugger); Nebraska (Bruner); North Carolina (C. L. Metcalf); Kentucky (Schoene); Tennessee (Morgan); Georgia (Allard). The list given here would indicate that the range of this cricket does not extend as far north as that of the other widely distributed species. As far as we know it has been collected in this state only in the southeastern part.

HABITAT.

The author is more familiar with the species in southern Ohio, where eggs were obtained for life history studies. There the insect is common in weedy places, in flower beds and shrubberies about farm houses, and especially among grape vines. W. T. Davis writes that in Long Island, Staten Island and New Jersey he has found *latipennis* fairly common among the oak scrub.

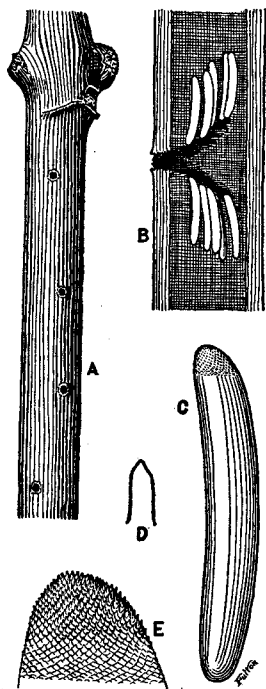


FIG. 20.—*Ecanthus latipennis*
RILEY.

a, Egg punctures in grape ($\times 1\frac{1}{2}$); b, longitudinal section showing eggs in golden rod ($\times 3$); c, egg ($\times 15$); d, projection of egg cap ($\times 500$); e, egg cap ($\times 50$).

DESCRIPTION OF LIFE STAGES.

Egg.—The eggs (Fig. 20, c) are rather long and slender, and of a pale yellow color. The cap (Fig. 20 e) is white but rather inconspicuous; it is broader than long and most resembles the cap of *nigricornis* but is generally a little oblique, that is, the extreme tip is nearer the side of the egg having the lesser curvature. The projections of the cap (Fig. 20, d) are narrow and a trifle longer than those of *nigricornis* and many are obtusely pointed at the tip rather than rounded. The long ones near the end of the cap measure .017 mm. long by .007 mm. in diameter. Measurements of thirteen specimens of eggs taken from several sets show considerable uniformity in shape and size. The averages are as follows: length 3.00 mm.; greatest width .50 mm.; length of cap .28 mm.; width of cap .40 mm.

Nymph.—First instar: Ground color of body pure white. A broad band of purplish red extends full length along the dorsal side and encloses a narrow white median line, which joins a transverse curved line between the eyes. On the concave anterior side of the latter white line is a small patch of red between the antennæ. Eyes are faintly yellow. Antennæ are unmarked. White median line on the abdomen is bordered on each side by a dark brown line of about the same width. Hind margin of each segment with a pair of conspicuous black bristles on the brown lines; all other hairs on abdomen pale and scarcely visible. Cerci with a few specks of red. Legs unmarked; last segment of hind tarsi dark. Length 3.5 mm.

Second instar: Ground color of body slightly yellowish, most pronounced along the sides. Reddish band consists of a pink ground color much mottled and speckled with red, darkest along the median white line and edges. White line widened into a spot on hind border of each abdominal segment. Reddish brown line on each side less well defined than in first instar. Hairs and bristles on red band dark in color. Antennæ white; segments in outer half very indistinct. Cerci pinkish at base. Last segment of hind tarsi black. Length 5 mm.

Third instar: Ground color pale yellow, strongest along sides. Median dorsal band of pale pink ground color, thickly speckled with reddish spots which occur at the bases of minute black bristles. Top of head posterior to and between the eyes marked with longitudinal reddish streaks. In thorax the pink blends into yellow on the sides but on the abdomen the pink area is outlined by a reddish line which is

scalloped or curved toward the median line on the hind part of each segment. Narrow median pale line present, but obscure in places. Posterior edge of each abdominal segment with a white elevated spot on the median line, bounded on each side by smaller black spots, bearing tufts of black bristles. Antennæ pink at base, fading out into white on segments 4 to 6. Length 7 mm.

Fourth instar: General color pale greenish yellow. Outer ends of the transverse pale line between eyes, curl strongly forward. Median reddish band obscure on thorax. Abdomen yellowish green on sides with whitish blotches; upper part becomes uniform pale yellow and lower part cloudy white. Pinkish median band much modified on abdomen. Each segment bears a vase-shaped figure, broad and rounded on the anterior part, constricted just back of the middle and flaring out again on the hind margin. Ground color of figure pale pink, except in the enlarged part where it blends into a spot of pale greenish yellow in the center. Figure has a reddish margin and bears a number of minute dark bristles with a reddish spot at the base of each. Median line paler and slightly elevated; near the hind margin of each segment it is produced into a small white elevation at each of which is a bristly black spot. Length 10.5 mm.

Fifth instar: (Plate IV, fig. b). Head light yellow; upper part from antennæ back dull pink; transverse and median pale lines as in earlier instars. Pronotum yellowish, strongest on sides; dull median band made up of small black hairs and brownish specks. Abdomen colored similar to preceding stage; ground color of vase-shape figures on segments very pale or even white. Basal segment of antennæ yellowish mottled with pink; following segments reddish but fading to white within four or five millimeters. Legs greenish, unmarked. Last segment of hind tarsi black. Length 12 to 13 mm.

Adult (Plate VI, fig. b).—Body whitish. Head and pronotum tinged with yellow. Top of head from antennæ back with a pink patch, occipital region with four longitudinal dusky streaks fading out in front. Pronotum with a median dusky band, darkest in front; this is plain in some specimens and absent in others. Antennæ red at base, fading out near the eighth segment; the first segment has pale yellow ground color mottled with red especially along inner edge. Remainder of antennæ white faintly annulated at intervals with gray; extreme distal part dark gray. Legs white; knees yellowish; hind femur with a small black spot just before distal end. Wings of male transparent; in some specimens the large cells near the tip are bordered by slightly infuscated lines running near and parallel to the veins. Length of body 15–17 mm. Fore wing of male 13 to 16 mm. by 6.5 to 8 mm. Fore wing of female 13–14 mm.

SONG.

The song of *latipennis* is louder than that of any other tree cricket discussed in this bulletin. It is a clear, continuous whistle resembling the call of the preceding species, but is of a lower pitch, and has a more musical and bell-like quality. On an ordinary summer evening the tone is about the third D \sharp above middle C, but on cool nights the pitch may drop a half note lower. In southern Ohio where the author has observed this cricket in the field, the males began singing in full chorus at dusk and continued throughout the night. The reared specimens in breeding cages at Geneva were much more shy than the other species and would not begin to sing until dark and when all was quiet about the laboratory.

OVIPOSITION.

This insect deposits its eggs in a peculiar manner which seems to possess some advantages over the methods employed by other tree

crickets. In depositing the first egg in any part of the stalk the process is essentially the same as that of the three preceding species except that the female seems to prefer working on the underside of a stalk and may start with head either up or down. After the egg is placed the female turns around and chews at the hole for several minutes but does not plug it up. She then inserts the ovipositor in the hole and begins to drill, this time in the opposite direction. Not having the hard woody layer to penetrate, this second drilling reams out a hole in the pith in about five minutes and a second egg is deposited. The insect then turns around, chews at the hole and starts to drill again in the original direction. This process is continued, the female turning around after each drilling until several eggs have been deposited on each side of the hole. (Fig. 20, b.) Apparently no attempt is made to plug up the opening, which, on account of the repeated drillings, is large and conspicuous.

The eggs of this cricket were collected in southern Ohio in grape vines and in large stalks of golden-rod growing near the vines. The parts of the plants most used were the young shoots of the vines, from three to five millimeters thick and the upper ends of the golden-rod stalks where they were about five millimeters in diameter. The holes were most often on the under side and in many cases were arranged in rows, with intervals of about one centimeter or a little more. (Fig. 20, a.) The eggs of each of the two groups lie side by side in the pith and about parallel to the long axis of the vine or stalk. The size of the pith determines the number of eggs that can be placed together. The grape vine has a small pith and will hold only two or three eggs on a side, while in the golden-rod as many as six can be found in a single cluster. Thus a single hole in the outer woody layer may serve for the deposition of from four to twelve eggs.

NEOXABEA BIPUNCTATA De Geer.

HISTORICAL NOTES.

It seems desirable to include in this bulletin an account of the single described species of *Neoxabea*, since it is so closely related to the crickets of the genus *Eccanthus* that it was for a long time considered as a species of the same genus. Riley⁽¹⁰⁾ regarded the differences between this species and the other tree crickets of generic importance and included it in the same genus with *Xabea decora* Walker from Sumatra, to which it seemed more closely allied. Later Kirby⁽³²⁾ established it in a genus by itself under the name of *Neoxabea*.

DISTRIBUTION.

Judging from the meager records of the species in this state it appears to be confined to the southeastern corner. The collection of the American Museum contains specimens from the Ramapo

Mountains, Rockland County, and from Southampton, Long Island. Other records obtained from literature and collections are as follows: Connecticut (Walden); New Jersey (Smith); Pennsylvania (De Geer's type), Ohio (King), Indiana (Blatchley), Illinois (Forbes), Kansas (Tucker), North Carolina (Amer. Mus.), Georgia (Allard), Nicaragua (Baker). Apparently these records indicate that most of New York is too far north to be within the range of this insect.

DESCRIPTION OF LIFE STAGES.

Egg.—Very long and slender and of a pale, transparent yellowish color. The cap is indistinct and consists only of an opaque, minutely roughened portion of the egg, and bears no projections as is common in *Ecanthus* eggs. Near the base the roughness takes the form of shallow depressions arranged in spiral rows, but toward the tip the rows break up and the surface is rugulose. The eggs measure from 3.85 to 4.10 mm. in length and from .45 to .50 mm. in diameter.

Adult.—The generic characters are as follows: hind tibiae without teeth or spurs except at tip; basal segment of antennae with a blunt tooth on anterior side; maxillary palpi with third and fifth segments very long and fourth short; hind wings very long and protrude behind body like tails. The general color is pale pinkish brown. The fore wings of the female bear two large dark brown blotches, one in front of the other. Male wings unmarked. Legs pale pinkish color. Length of body about 16 mm. Fore wings 13 mm. Hind wings 20 mm.

HABITS.

Our knowledge of this insect is confined to observations on a few adult females collected at Cedar Point, Ohio, by J. L. King of the Ohio Experiment Station. The lack of males precluded any observations on the song of the insects but did not prevent the females from depositing eggs. Not knowing at the time the natural host plant of the species it was necessary to place in the cages a number of different kinds of plants, among which was an apple branch about half an inch in diameter. This was selected by the females for oviposition and the eggs were deposited in the bark in about the same manner as those of *niveus*, except that most of them were directed upward from the hole. The crickets seemed to adapt themselves quite readily to the apple, but at the place where they were collected no apple trees exist, and I have since been informed by the collector that the insects were found on oak, willow and wild grape vines at a height of five or ten feet. The trees were along the forest border or standing isolated at the edge of open, sandy areas.

ACKNOWLEDGMENTS.

The author wishes to express his obligations to numerous entomologists for cooperation in determining the distribution of the

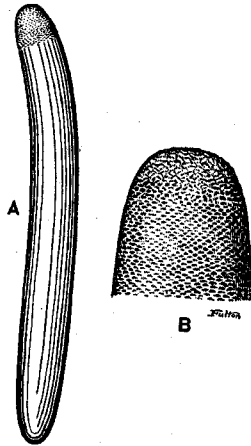


FIG. 21.—*Neoxabea bipunctata* DE GEER.
a, egg (x15); b, egg cap (x50).

insects. He is greatly indebted to Mr. W. T. Davis of Staten Island for information on the habits of the crickets and assistance in collecting on Long Island; to Mrs. L. L. Van Slyke of Geneva for notes on the musical qualities; and to Mr. J. L. King of the Ohio Experiment Station for furnishing living specimens of *Neoxabea bipunctata*.

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