Studies on North American Oecanthinae (Orthoptera): I. Physiological variation in the snowy tree cricket, Oecanthus niveus De Geer, II. Tree crickets of Oregon, III. Geographical variation in the nigricornis group of Oecanthus

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UMI
STUDIES ON NORTH AMERICAN OECANTHINAE (ORTHOPTERA)

I. Physiological Variation in the Snowy Tree Cricket, Oecanthus niveus De Geer.
II. Tree Crickets of Oregon.
III. Geographical Variation in the nigricornis group of Oecanthus.

by

B. B. Fulton

A Thesis submitted to the Graduate Faculty for the Degree of
DOCTOR OF PHILOSOPHY
Major subject Entomology

Approved

Signature was redacted for privacy.
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Signature was redacted for privacy.
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Dean of Graduate College

Iowa State College
1926
PHYSIOLOGICAL VARIATION IN THE SNOWY TREE-CRICKET, OECANTHUS NIVEUS DE GEER.

BY

B. B. FULTON.

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PHYSIOLOGICAL VARIATION IN THE SNOWY TREE-CRICKET, OECANTHUS NIVEUS DE GEER.*

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One of the most copied mistakes in entomological literature is one which was made by C. V. Riley and other writers of his time, on the oviposition of the Snowy Tree-cricket (Oecanthus niveus De Geer). At that time many entomologists did not clearly distinguish between the two species, which in the eastern states are commonly associated in raspberry and blackberry bushes. The more common species in such situations is Oecanthus nigricornis Walker, which deposits its eggs in conspicuous rows in the berry canes, while O. niveus places its eggs singly by the side of the leaf axils, where they easily escape observation. Riley (1) figured the eggs of the former species under the name of the latter. This error has been copied many times and can still be found in new publications at least as recently as 1918.

Observations by several entomologists have led to a correct understanding of the habits of the two species. Packard (2) gives an account of O. niveus depositing its eggs singly in elm bark, but did not question the validity of Riley's statement. Houghton (3) (4) in 1904, reared O. niveus from singly deposited eggs in plum bark and in 1909 reared O. nigricornis from eggs deposited in rows in elder. Parrott (5) in 1909, showed by cage experiments that O. niveus preferred apple to raspberry for oviposition and that O. nigricornis was responsible for the rows of eggs in raspberry and blackberry canes. Parrott and Fulton (6) in 1913, describe and illustrate the eggs of O. niveus, as they are deposited on raspberry and blackberry, in the thickened cortex by the side of the leaf axils, rarely at other points, and never extending into the pith, (Fig. 1, B). The insect is here following the same method, which it uses on apple and other trees, that of depositing the eggs singly in the bark,

*Contribution from the Dept. of Zoology and Entomology, Iowa State College. Acknowledgments are due to the Oregon Agricultural Experiment Station, with which the writer was connected while much of the data given in this paper was being obtained.
but on berry canes and other thin barked plants the cortical layer is not thick enough for their purpose except at the leaf axils. *O. nigricornis* prefers to oviposit in close set rows in pithy plants and the eggs lie in a slanting direction, imbedded in the pith, (Fig. 1, A). When this species occasionally oviposits on a woody plant, such as apple, it places the eggs in the young twigs in the same manner.

Shortly after the writer moved to Corvallis, Oregon, he was called upon to identify some tree-cricket eggs deposited in a raspberry cane in a long compact row, exactly as described above for *O. nigricornis*. Without hesitation he named them as such. The piece of cane was not thrown away and on the following day, June 13, four young crickets were found with it. An examination of these specimens revealed not young *O. nigricornis*, but something identical with the first instar *O. niveus* as observed in the east. It was something of a surprise to the writer to have his firmly established conceptions about the oviposition of tree-crickets so rudely upset. The only possible explanation seemed to be that this was a new species closely related to *O. niveus*. Curiously enough, the known species most closely related to *O. niveus*, namely *O. angustipennis* Fitch and *O. exclamationis* Davis, both have egg laying habits very similar to the first species. So far as known the habit of placing the eggs in rows in the pith was confined to the closely related species *O. nigricornis* Walker, *O. quadripunctatus* Beutenmuller and *O. pini* Beutenmuller.

This type of oviposition, i.e., rows of eggs in the pith, was found very commonly among raspberries, blackberries and loganberries in western Oregon. No eggs could be found deposited after the method of *O. niveus* on such plants, i.e., singly by the leaf axils. An examination of prune and apple trees showed that they also contained tree-cricket eggs, deposited singly in the bark in the same manner employed by *O. niveus* on these trees in New York State.

**Two Races of Oecanthus niveus in Oregon.**

In late summer, when the tree crickets had matured, it became apparent that the crickets, which were so numerous on berries as well as those found on prune and apple trees, were practically identical with the *O. niveus* of the east. Series of specimens collected both from bushes and trees were carefully
and minutely compared with each other and with specimens of *O. niveus* from Geneva, New York. No morphological or color characters could be found which would separate any one group from the others.

Observations on the song of the Oregon tree crickets showed that they had the intermittent, rhythmical, whistling notes characteristic of *O. niveus* in the east, but in this connection a most remarkable situation was found—in that those living in the fruit trees had a frequency of notes almost twice as great as those living on the berry bushes. This difference could not be accounted for on the basis of temperature or other environmental factors.

It seemed evident that there were two races of the Snowy Tree-cricket in Oregon, one living on berry bushes and the other on fruit trees. The writer set out to make a more detailed study of the life habits and ecological distribution of each form and to see if they retained their habits if transferred from one environment to the other.

For convenience in describing further the habits of the two races they will be designated as *O. niveus* A for the arboreal form and *O. niveus* B for those living in bushes.

**ECOLOGICAL DISTRIBUTION.**

The *O. niveus* of the eastern states is not only found on a great variety of trees, but is also a regular inhabitant of berry bushes and many other low shrubs.

*O. niveus* A is strictly arboreal. In the vicinity of Corvallis, Oregon, this form is most common on prune and apple and in the native growths of white ash and Gary Oak. I have also heard it singing in cherry, maple and poplar trees. It is usually more abundant among the higher branches and could be heard singing in the tops of quite large trees. The only berry bushes I have found it in were tall, coarse blackberries growing under trees.

*O. niveus* B is preeminently a bush inhabiting form. It is very common on loganberry and raspberry, and to a somewhat less extent, on blackberry. It occurs abundantly in the wild rose thickets, which are so common in the Willamette Valley. It is widely distributed though not abundant, among the brake ferns and associated plants in old burned areas in the Coast Range.
At the edge of a deciduous woods where there is a scrubby growth of young trees and bushes the ecological ranges of the two forms come together, but the extent of such contact is relatively small. Occasionally in such places both races may be heard singing in the same bush or small tree.

In this connection it is interesting to note that *Oecanthus nigricornis*, which is the most common inhabitant of berry bushes in the east, is not found in such situations in western Oregon. The closely related species or western variety, *O. argentinus* Saussure, is rarely found on berry bushes. Its distribution is usually confined to medium sized weeds in open fields and prairies.

**Oviposition.**

The eggs of *O. niveus* A are placed singly in the bark of trees, (Fig. 1, C). In prune and ash trees they were found in branches from one to three inches in diameter. On ash trees they were usually located near side branches where the bark is somewhat thickened and rough. Eggs found on a vertical or sloping branch were most often located above the puncture, but there is considerable variability on this point. On horizontal or sloping branches, 75 per cent or more were located on the lower side. The females evidently prefer to work head downward on the lower side of a branch. Our observations on the species at Geneva, New York, show that the females there usually oviposit head uppermost on the upper side of a branch. A pellet of excrement is often used by *O. niveus* A to stop up the hole after the egg is deposited, as is the case in the eastern states. In cage experiments with form A, it was later found that plugs of chewed bark were sometimes used. This we have never observed in the eastern form.

The eggs of *O. niveus* B are placed in compact rows with the eggs all slanting across the pith, (Fig. 1, A). Most rows average about one egg per millimeter, but occasionally they are more scattered. The number of holes per row varies from 2 to 40. Rows of 10 to 20 are common. In vertical stalks the eggs usually extend downward from the point of oviposition, or in other words, the female works head uppermost, which is at variance with race A, but agrees with *O. niveus* in New York and Iowa. On horizontal or sloping branches most of the punctures are drilled on the underside. This habit agrees with race A, but
in the east *O. niveus* usually oviposits on the upper side of a branch. After depositing the egg, race B covers the puncture with chewed bark, removed from a point just above the hole. The resulting scar is used as a starting point for the next drilling operation. This habit is exactly like that of *O. nigricornis*, which differs from race B in its oviposition only in its decided preference for the upper side of a stalk.


The eggs of the two races of *O. niveus* in Oregon show no differences in the ornamentation of the cap at the cephalic end. Series of fifty of each kind showed slight relative differences in the total length and length of the cap. The average measurements in mm. are as follows: Race A, length 3.16, width .07, length of cap .50, width of cap .52. Race B, length 3.01, width .68, length of cap .40, width of cap .52.
### Oviposition Experiments with *Oecanthus niveus*, A.

<table>
<thead>
<tr>
<th>Exper. No.</th>
<th>Caged on September 9</th>
<th>September 14</th>
<th>September 22</th>
<th>October 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1</td>
<td>Apple 14 mm. diam., Loganberry 6 mm. diam. (indoors)</td>
<td></td>
<td>25 eggs in apple. All placed singly in bark. No eggs on loganberry.</td>
<td></td>
</tr>
<tr>
<td>A 2</td>
<td>Loganberry 3 mm. and 6 mm. diameter. (indoors)</td>
<td></td>
<td>24 eggs in larger cane, all imbedded in cortex and wood. Transferred to blackberry. 9 mm. diameter.</td>
<td>Cricket alive. 13 eggs all in cortex and wood.</td>
</tr>
<tr>
<td>A 3</td>
<td>Apple branch 20 mm. diameter with 2 small side spurs.</td>
<td>Several punctures observed.</td>
<td></td>
<td>Cricket dead. 14 eggs in bark, all but 2 on under side.</td>
</tr>
<tr>
<td>A 4</td>
<td>Loganberry cane close to ground.</td>
<td>No punctures on loganberry. Transferred to prune 20 mm. diameter.</td>
<td>Cricket alive. Punctures observed but not counted.</td>
<td>Cricket dead. 23 eggs deposited singly in bark. All but 4 on under side of branch.</td>
</tr>
<tr>
<td>A 5</td>
<td>Loganberry, 6 mm. diam.</td>
<td></td>
<td>Cricket alive.</td>
<td>Cricket dead. No eggs.</td>
</tr>
<tr>
<td>A 7</td>
<td>Loganberry, 8 mm. diam.</td>
<td></td>
<td>Cricket alive.</td>
<td>Cricket dead. No eggs.</td>
</tr>
<tr>
<td>A 9</td>
<td>On apple, watershoots. 5 and 8 mm. diam.</td>
<td></td>
<td>Cricket alive.</td>
<td>Cricket dead. No eggs.</td>
</tr>
</tbody>
</table>
# Oviposition Experiments with Oecanthus niveus, B.

<table>
<thead>
<tr>
<th>Exp. No. of Female</th>
<th>August 29</th>
<th>September 7</th>
<th>September 14</th>
<th>October 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 1, B 2, B 3, B 4, and B 5.</td>
<td>Apple branch 20 mm. diameter with small side spurs. 5 eggs in pith of green growth at tip of side spur. 2 incomplete punctures in large branch. Transf. to ornamental rose.</td>
<td>Row of 8 eggs in twig of 2-3 mm. diam. All in pith. 3 others in wood of larger twigs. Transf. to loganberry. 5-10 mm. diam.</td>
<td>Crickets dead.</td>
<td>95 eggs in 23 compact rows of 2 to 9 eggs. All but 8 in larger branch. All imbedded in pith.</td>
</tr>
<tr>
<td>B 6, B 7</td>
<td>Prune branch 20 mm. diameter. No side spurs. No eggs. No punctures.</td>
<td>Compact row of 7 eggs, all slanting across pith. 7 incomplete punctures.</td>
<td>Crickets dead.</td>
<td>No eggs.</td>
</tr>
<tr>
<td>B 8</td>
<td>Prune branch 10 mm. diameter. No side spurs. No eggs. No punctures.</td>
<td>Transf. to grape, 5 mm. diameter, present year's growth.</td>
<td>No eggs.</td>
<td>Transf. to apple watershoots.</td>
</tr>
<tr>
<td>B10, B11</td>
<td>Apple branch 30 mm. diameter, with watershoot 4 mm. diameter.</td>
<td></td>
<td>Crickets dead.</td>
<td>Row of 8 eggs in watershoot. Underside of large branch with 18 eggs.</td>
</tr>
<tr>
<td>B12, B13, B14</td>
<td>Wild rose, various sizes snowberry, 5 mm. diam. (indoors)</td>
<td>20 eggs in 3 mm. branch of wild rose. In 4 compact rows. All imbedded in pith.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 15</td>
<td>Apple branch 16 mm. diameter. Loganberry 6 mm. diam. (indoors)</td>
<td>(Sept. 22) 45 eggs in loganberry in 4 compact rows of 7, 9, 12 and 17 eggs. All imbedded in pith.</td>
<td>Cricket dead.</td>
<td>22 eggs in sprout. Rows of 2, 4, 4, 8. Four single eggs in cambium. All imbedded in wood and pith.</td>
</tr>
<tr>
<td>B 16</td>
<td>1 apple branch 12 mm. diameter. With side spurs. (indoors)</td>
<td>(Sept. 22) No eggs. 4 incomplete punctures in spurs which had become dry. Transf. to apple branch 16 mm., watershoot, 6 mm.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Oviposition Experiments.

A series of experiments were carried out to determine the effect of transferring the two races from their normal host plants to those of the other form.

The insects were collected from pure stands of each race as determined by the character of vegetation, by the songs of the males and by the presence of eggs deposited in the characteristic manner. Race B was taken from loganberries and race A from apple, prune and oak trees. At the time the experiments were started the tree crickets had been mature about a month and had fully formed eggs in the body. All of them were fed on aphids during the experiments. They were caged on growing plants except where it is indicated that the experiment was performed indoors. The cages were made to surround a portion of a branch without cutting it off.

Notes on Oviposition Experiments.

A1. Of 25 eggs, all but two are directed upward from the puncture. Most of the holes are plugged with chewed bark, but some were plugged with excrement.

A2. On loganberry. Only four of the 24 eggs were placed at the side of leaf axils after the manner of O. nivens in the east, except that in these cases the eggs extended upward from the puncture. The other eggs were imbedded partly in cortex and partly in the underlying woody layer. Some of them reached the pith but none extended into it.

On blackberry.—Seven eggs and three empty punctures were found at leaf axils. Six eggs and numerous partially completed punctures were found in various other parts of the bark. The soft cortical layer was only about a half millimeter thick, so that most of the eggs were imbedded in the underlying woody layer, which was about a millimeter thick. Two eggs extended partly into the pith and one was almost entirely in the pith, but in these cases the eggs lay just under the woody layer and parallel to it, (Fig. 1, D), instead of slanting across the pith as when deposited by form B.

B1 to B5. In the first cage these females refused to oviposit in the large apple branch. A row of five eggs was found in the green terminal growth of a side spur, (Fig. 1, F).

The crickets were then confined on ornamental rose on twigs varying from 10 mm. in diameter to very small ones. Numerous attempts were made by the crickets to bore through the wood of the larger twigs, but apparently it was too hard for all the punctures terminated in the wood. Three eggs were found in holes which did not reach the pith. The only rows of eggs were in a small terminal twig; a row of five where the twig was 3 mm. in diameter and a row of three where it measured 2 mm.
After transfer to loganberry this same series of females deposited 95 eggs in the characteristic manner.

B10 and B11. These crickets were in a cage which included an apple branch 30 mm. in diameter and a small apple watershoot 4 mm. in diameter. Many attempts had been made to oviposit in the shoot, but few were successful. Most of the punctures were incomplete and terminated in the wood. There were two rows of 4 and 5 incomplete punctures besides several single ones. At the end of one of these rows, an egg had been deposited and toward the smaller end of the shoot there was a row of 8 eggs, all of which extended across the narrow pith. Apparently this watershoot was too hard for oviposition. The green tip was not included in the cage.

Twelve eggs were found in the bark on the underside of the large branch. These were placed in the usual slanting position with the distal ends imbedded in the wood. There were two sets of two placed one in front of the other about 1 mm. apart, as if forming an incomplete row, (Fig. 1, E).

B16. This female was given a choice of an apple branch of 16 mm. diameter and an apple watershoot of 6 mm. diameter. The 22 eggs were all placed in the shoot. All but four were imbedded in the wood and narrow pithy core. This wood was apparently almost too hard for the purpose and in six cases had turned the ovipositor so that the hole extended along the cambium layer parallel to the surface. In four of these holes eggs had been deposited and in such cases the position of the egg was like that of form A (Fig. 1, G). This was evidently due to force of circumstances and not from choice, but it shows that the habit of placing eggs singly in the bark could possibly have originated from the habit of placing them in rows in the pith. Of the four eggs mentioned, three were placed singly and the other was at the bottom of a row.

**Summary of Oviposition Experiments.**

**Race A.**
1. The females oviposited readily in the bark of prune and apple branches.
2. Females confined on grape and small apple shoots and most of those on loganberry canes, did not oviposit at all.
3. One female deposited eggs in loganberry and blackberry but in this case she placed the eggs in the cortex and woody layer in as near the normal manner as the physical character of the plant would permit, (Fig. 1, D).

**Race B.**
1. The females oviposited readily in loganberry and wild rose, placing the eggs in the pith in compact rows.
2. On ornamental rose, grape, and apple watershoots the same method of oviposition was used or attempted, but on these
plants the wood was a little too hard for drilling, as shown by the numerous partially completed punctures.

3. Four females confined on prune branches, (16–25 mm. diam.) did not oviposit at all. One of these was transferred to loganberry and it began oviposition on the following night.

4. Twelve eggs were deposited in the bark of an apple branch, where the only alternative was a watershoot which was too woody to be drilled into easily. The eggs did not lie nearly parallel to the surface as those of race A, but slanted at a forty-five degree angle and the distal ends were imbedded in the wood, (Fig. 1, E).

SONG.

As mentioned before, the songs of the two forms of \textit{Oecanthus niveus} in Oregon are very different. A more detailed study of the stridulation was made in order to make comparisons with the same species in the east.

The song of \textit{O. niveus} has probably been written about more than that of any other American insect. By many writers it is considered the most musical of all insect sounds. It exhibits the interesting phenomenon of synchronism and has been much discussed in past numbers of the \textit{American Naturalist} with reference to the relation between frequency of notes and temperature.

The stridulating organ of the tree cricket consists of a transverse vein near the base of the wing, which bears minute teeth on the underside. This is scraped by a thickening on the inner edge of the opposite wing. When the tree cricket sings it raises its wings perpendicularly over the back and vibrates them in a transverse direction. In the case of \textit{Oecanthus niveus}, the vibrations are interrupted at regular intervals so that the song is a rhythmically repeated, whistling note.

\textbf{Frequency of Notes and Temperature.}

No study of the frequency of notes can be made without considering the temperature for the rate varies directly with the temperature. This relation of wing movement to temperature is present in all singing insects which the writer has observed, but only with those species whose song has a rhythmical beat, which is indefinitely repeated, can an accurate study of the correlation be made. In 1897, such a study was recorded by
Dolbear (7) who reduced the temperature correlation to an algebraic formula. He did not name the species of cricket but from his description of the song it was evident to later workers that he was dealing with the snowy tree cricket. A year later C. A. and E. A. Bessey (8), published a more detailed account with a graph made from a large number of records taken in Nebraska, (Fig. 2). Soon after that another article appeared by Edes (9) with a chart of observations made by himself and Faxon independently, (Fig. 3). Although both workers lived in New England the counts taken by the latter averaged a few notes less at the same temperatures. Edes states that his own
records might have been more accurate if the thermometer had been on the same side of the house as the bush in which the crickets were singing.

**Comparison of the Song of O. niveus A and B.**

Numerous observations at various temperatures on the songs of the two races of *O. niveus* in Oregon, both out-of-doors and in the laboratory, are recorded in Fig. 4. It can be seen from this that there is a wide range of difference between the songs of the two forms. For instance, at 70° F., race A stridulates at a rate of about 160 notes per minute, while race B has only 90 notes per minute. Such a difference as this can not be accounted for by any physical difference in the environment. Actual cage experiments show that the males of each form retain the same relative difference, regardless of surroundings. During several years of observation on these crickets, in many situations, I have never heard one which seemed to be intermediate between the two forms in regard to song.

Another slight difference in the method of singing was observed one night when the temperature had gone down to 48° F., which is near the lower limit of the singing range of the cricket. The slight quaver in the note, which is noticeable even at higher temperatures, was then so reduced in speed that the undulations of sound came no faster than I could count. In the case of race B, each note consisted of a series of four brief phases. This was observed for several individuals. By throwing a flashlight on the singing insect it could be plainly seen that the wings rubbed past each other four times for each note. In the case of race A the notes were noticeably shorter and observations on several individuals showed that this form made only three strokes of the wings per note.

**Causes of Variation in Charted Data.**

In charting the data on the song of the tree cricket, the points do not line up in a regular curve, but will be found scattered within rather narrow limits. In other words, all observations made at the same temperature do not agree. Shull (10), in attempting to find some factor other than temperature which might influence the frequency of notes, investigated the relation of wing length to rate of chirping and found no correlation.
He concluded that the variations were probably due to humidity, individuality and physiological state. In my work on the tree cricket song I tried to discover some of the sources of error. An accurate thermometer should be used, preferably one with fractions of degrees marked. Records taken out of doors are not accurate for the reason that the temperature varies slightly from place to place and from time to time. In taking a record it is not possible to have the thermometer close to the cricket for it stops singing at a slight disturbance. I found that under the foliage of loganberries it was often a degree colder than just above if a slight breeze was blowing in the evening. The tops of apple trees would be sometimes two degrees warmer than near the ground. On one night the temperature was found to fluctuate over a range of nearly four degrees F. within a few minutes. In a rising or falling temperature there will be an error, for the temperature of the cricket will not rise or fall at the same rate as the thermometer.

Aside from error in temperature I believe that the greatest cause for irregularities in the song charts is slight individual variations. There is no doubt but that some males have a rate of stridulation slightly higher or lower than the average. I had one cricket confined in a cage in the house that was noticeably slower, about five notes per minute, than the others when it sang alone. When more than one cricket is singing in the same room, they assume a common rate and all sound their notes together in perfect harmony. The rate of such a chorus would depend to some extent on the individuals that composed it.

Fig. 5 shows a series of observations taken on one male cricket in a room. Records were taken only when the temperature was holding fairly constant. The bulb of the thermometer touched the side of the cage in which the cricket was confined. Each count was carried on for three consecutive minutes to avoid error in counting. Even in this case there is some fluctuation from a straight line, but it is much more regular than a chart of observations made out-of-doors on various individuals. It is possible that the element of fatigue may cause some variation in the frequency, but I have not had access to equipment necessary to determine this point.
SYNCHRONISM.

There seems to me no doubt about the synchronism in the song of the Snowy Tree-cricket, although it has been questioned by some, who claim that an auditory illusion is responsible for the belief that the notes of neighboring crickets are sounded simultaneously. As Allard (11) (12) has pointed out, there are other insects having an intermittent, rhythmical song which do not give such an effect, because they do not synchronize their notes. Not all of the Snowy Tree-crickets in an orchard or berry patch will have their notes perfectly synchronized, although on warm evenings there are times when the chorus seems to come very close to this condition. In a single tree or among any group of crickets that are not more than a few yards apart, the singers usually keep up a perfect synchronism. On very cool evenings, near the lower temperature range of stridulation, synchronism becomes imperfect or almost lacking. The phenomenon can be best observed with caged crickets indoors. When one male is singing and another begins the second one will make a few weak notes until it can catch the proper rhythm and then its notes sound simultaneously with the other.

COMPARISON OF SONG OF \textit{O. nivcus} IN THE EAST AND WEST.

If the graphs made from the stridulation records of the two races of \textit{O. nivcus} in Oregon are compared with those made by the Besseys and Edes, it can be seen that both forms differ from the same species in the east in regard to song, (Fig. 6). Also it can be seen that the Besseys’ records, which were taken in Nebraska, differ slightly from those of Edes and Faxon, which were taken in New England. Barring errors by the use of a defective thermometer, it would appear that \textit{O. nivcus} in Nebraska sings faster than it does in New England and that race A in Oregon sings still faster.

HUMIDITY.

One might suppose from this that the humidity of the air which in general increases from west to east during the summer, might be responsible for this difference. Shull (10) thought that humidity influenced the rate of chirping, but admitted that the evidence on the point was not conclusive. The writer has
one observation on this point. Two crickets were confined indoors where the temperature was kept fairly constant, one in a cage consisting of ordinary fly screen on all sides, and with no green plants inside, while the other was confined in a lamp chimney with a cotton plug in the top and many fresh green leaves inside. Moisture was condensed over the inside of the glass, showing that the atmosphere within was saturated.

The cricket in the lamp chimney did not chirp often, probably on account of the abnormal conditions in the cage, but on one occasion it sang for a time and its notes synchronized with those of the cricket in the wire cage. When each was permitted to sing alone, the rate was the same. The relative humidity of the air in the room was only 54% as determined by a sling psychrometer (dry bulb 66° F., wet bulb, 55° F.). This experiment was not tried on other crickets, but it shows that the effect of humidity on the rate of stridulation could at most not be greater than individual differences between crickets.

In the summer of 1923, the writer succeeded in taking to Oregon alive, two male crickets collected on apple in Ohio and two males collected on scrub oaks at Grand Canyon, Arizona. These were placed in separate cages in the same room with two males of the Oregon race A. When this lot was observed after dark, none of the usual synchronism of notes could be heard, but instead there was a confusion of sound, resulting from the crickets of each locality singing at somewhat different rates. One of the Arizona crickets was a most persistent singer and would be the first to start after they were stopped by a disturbance. An Ohio cricket would then apparently attempt to start in unison, but after a few notes would lose cadence and stop. After several such attempts it would sing independently at a somewhat slower rate. Counts of the three species taken within a half hour, with the temperature of the room holding close to 71° F., gave the following: Ohio 130, Arizona 140, Oregon A, 155.

This observation and the comparison of the song records taken by different workers in widely separated parts of the country, indicate that the average frequency of notes in the song of the Snowy Tree-cricket is not the same in all localities and that this variation is not dependent on the local physical conditions of the environment.
CROSSING.

A male of race B was confined with a female of race A, and two males of A were confined with females of race B. Although these cages were examined frequently at night, no mating was observed for any of the three pairs. However, the cages could not be kept under constant observation and since few cases of mating were observed in the other cages where the sexes of the same race were confined together, it is entirely possible that crossing occurred. The females were already fertilized before capture. The writer had planned to start crossing experiments another year with immature crickets, but departure from the state prevented the carrying out of these plans.

Even if crossing did take place between individuals of the two races confined in a cage, it would not be a frequent occurrence in nature because of the sharply limited ecological distribution. As stated before, the two races occur on the same plants only at the dividing line between deciduous forest or orchard and areas of low bushes.

GEOGRAPHICAL DISTRIBUTION.

*Oecanthus niveus* is the most widely distributed of all our native tree-crickets. It occurs over most of the North American continent from Maine, Ontario and British Columbia, southward. It is not common in southeastern U. S. and has never been recorded from Florida. It occurs in Cuba and is recorded from Guatemala and several widely separated points in Mexico. Besides having studied the species in New York and Oregon, the writer has made limited observations on its habits in Ohio, Iowa, Colorado and Arizona. The egg laying habits, both on trees and berry bushes, are essentially the same in New York, Ohio and Iowa. At the Grand Canyon, Arizona, the species was found living in junipers and small oaks, but no eggs were found. A few song records taken in Ohio agree with those taken by Edes and Faxon in New England. Records taken in Iowa, Colorado and Arizona occupy a middle ground near those taken by the Besseys in Nebraska. In no other place besides Oregon has the writer found any evidence of the existence of two races. It would be interesting to have for comparison some knowledge of the habits of the species in Cuba and Mexico.
The race A of *Oecanthus niveus* in Oregon does not differ greatly in song or egg laying habits from the same species in the east. Since the song of the species varies slightly in different parts of the country, it seems likely that there might also be slight geographical variations in other habits and that race A merges by gradual stages with the *O. niveus* of the central and eastern states.

Race B, however, is something more distinct. If its differences from the other form were morphological rather than physiological, it would constitute a separate species. It can be called a physiological variety. I have never observed it anywhere except in Oregon west of the Cascades. There it is widely distributed and is most abundant in the valleys, but is also found in burned areas in the Coast Range and lower Cascades. The race undoubtedly occurs also in western Washington, where conditions are practically identical to western Oregon. I believe that it also occurs in eastern Oregon and Washington in the Columbia and Snake River valleys. This assumption is based on tree-cricket eggs found at Walla Walla, Washington. They were in rather large wild rose bushes and were deposited in rows like the eggs of race B in western Oregon. They did not appear to be eggs of *O. argentinus*, which sometimes oviposits in small rose bushes, but usually in pithy weeds.

**Other Examples of Physiological Varieties.**

There have come to my attention, a few instances described in literature, of varieties of a species having a distinct difference in habits accompanied by slight or no morphological characters of separation. No doubt there are other cases scattered through the literature. I believe that a more intimate acquaintance with the habits of widely distributed species will show that such physiological varieties are not uncommon among insects.

I will describe briefly a few of the more striking examples. Howard (13) gave an interesting account of a fly, *Parexorista cheloniae*, which is parasitic on the Brown-tail Moth. The species exists both in America and Europe and is apparently identical in the two places, but the American race seems to be without defence against the poisonous barbed hairs of the caterpillar. The European race has become adapted to the Brown-tail physiologically and parasitizes it with impunity.
The European race was brought to America and colonized by thousands. It was found that they hybridized with the native race and after a few generations, with greatly diluted European blood, were no longer immune to the Brown-tail hairs.

Patch and Wood (14) have worked out the life history of the Blueberry Maggot, which is considered to be a small race of the ordinary apple maggot, *Rhagoletis pomonella*. There appears to be no difference between the two races except in size, but the food habits of the two are very distinct.

Among the Orthoptera, several instances have been described of varieties having a different song. Allard (15) states that “very marked differences of stridulation may characterize certain species in different parts of their range.” He described differences in the song and other habits of the common field cricket, *Gryllus assimilis*, an extremely variable species morphologically. In New England, the song consists of intermittent chirps, while in northern Georgia a race occurs which has a prolonged, trilling note.

In the case of the Striped Ground Cricket, *Nemobius fasciatus* De Geer, also an extremely variable species, Allard (16) has discovered in Massachusetts two singing forms in the same locality, but having a different ecological distribution. One race occupies the dry, grassy upland fields and pastures and sings with a high pitched, prolonged trill. In damp marshy ground in fields and pastures, this race is replaced almost entirely by pure colonies of a form having brief intermittent notes. Only where wet and dry conditions overlap is there a noticeable intermingling of the two forms.

The writer has also found a race of the same species living on damp ground near Ames, Iowa, which appears to fit the description of Allard’s intermittent singer. This was found only in grassy places near streams. An examination of a series taken from a pure colony of this form showed no characters to separate it from the common form. The song of the low ground race could be imitated by rubbing the edge of a fine-toothed comb lightly with the finger in short strokes. At 77° F. one of these crickets chirped from 24 to 30 times in ten seconds. There was no constant rhythm to the song and the frequency varied with different individuals, some chirping as much as 40 times in ten seconds. I watched a male singing and it appeared to make just one comparatively slow stroke of the wings per note.
Caged specimens of this race were observed to sing only in the manner described.

The song of the common form of *Nemobius fasciatus* is very different in quality and much louder. It has a very rapid wing movement and each stroke produces a sharp chirping note. The frequency is much faster than one can count at ordinary temperatures, and the song seems to be one prolonged note, having a distinct, tinkling quality.

At Mt. Pleasant, Iowa, in the southeastern part of the state, the writer found another differently singing variety of *N. fasciatus*, occurring in woods. This race was paler and more reddish in color than the common form, but some individuals of the pale color had the ordinary type of song. The song of this woodland variety differed only in the frequency of chirps which seemed to be just about half that of the common form. The notes were slow enough to be easily counted on cool days and even at higher temperature could be easily estimated by tapping a paper with a pencil in the same cadence and then counting the dots made in a certain period of time. At about 70°F the frequency was close to five chirps per second. Male specimens of the woodland form, as well as the common form, were confined in separate cages with females. They always stridulated in their characteristic manner, but each form was found to have two songs. What might be termed the calling song was the one most commonly heard and is the song which I have described for each form. In it there was a constant cadence or rhythm which varied only with the temperature. When first starting to sing or when the male was actively courting the female, a slower frequency of chirps with less regular intervals, was used by each form, but the same comparative difference between the two forms was retained. At about 70°F, the common *N. fasciatus* would start chirping about 4 or 5 notes per second, but soon the speed would increase a little and then suddenly break into the regular tinkling song. The woodland form would chirp about twice per second in its preliminary song and then abruptly change to about five notes per second. If a female came near a calling mate, he would change to the slower song and follow her about with a nervous jerking of the body. At such times the song would be very irregular, varying both in loudness and frequency.
The woodland race of *N. fasciatus* was not found near Ames, nor was the lowland race found at Mt. Pleasant. In woods at Ames, only the song of the typical form was heard, as was also the case in low places along streams near Mt. Pleasant.

**Summary and Conclusion.**

1. Two races of *Oecanthus niveus* DeGeer are found in Oregon, which differ only in their habits. One form lives in bushes and the other in trees.

2. The habits of the tree inhabiting race differ but slightly from those of the same species in the eastern states.

3. The bush inhabiting form in Oregon is a distinct physiological variety.

4. The characteristic song and oviposition habits of the two forms of *Oecanthus niveus* in Oregon remain fixed when the adults of one form are confined to the normal environment of the other form.

5. The females of each form select plants for egg laying, which best meet the requirements of their characteristic mode of oviposition. This probably is the main factor in determining their ecological distribution.

6. The average frequency of notes in the song of *Oecanthus niveus*, at the same temperature, varies in different parts of the country. Slight individual variations in frequency occur in any one locality, but such differences are modified to synchronize the notes when more than one cricket is singing. Individuals brought together from certain widely separated parts of the continent find it difficult or impossible to synchronize the notes on account of the greater difference in frequency.

7. Physiological varieties of other species of insects have been recorded in literature. Among the Orthoptera, there are several species which have one or more varieties differing in type of song.

8. Three singing forms of *Nemobius fasciatus* are present in Iowa. The common form is found in all open fields and pastures. In the southeastern portion of the state, a different form is found in woodlands. In central Iowa a still different form occurs in low places.
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THE TREE CRICKETS OF OREGON

The tree crickets are a small group of crickets, which live among foliage and not on the ground as in the case of the well known field crickets. Not all of them live in trees as might be expected from the name, but some species live among bushes and others on tall herbaceous plants.

They are of interest to the fruit grower because of the fact that certain species become destructive at times. In Oregon there are three species of tree crickets. The most destructive one occurs in two races, one living in orchards, and the other on berry bushes.

Economic Importance.

The injury caused by tree crickets is due to the feeding habits and to the deposition of eggs. Although they are not generally considered as serious pests of plants, yet there are places where conditions have favored the increase of certain species over a period of years until they have become very destructive. The plants most liable to be affected are prune, apple, peach, loganberry, raspberry, and blackberry.

Fruit Injury. Destructive feeding habits of tree crickets have been noted from time to time. They have been reported injuring tobacco leaves, but on most plants the consumption of foliage is negligible. In the case of fruits, even if the amount of material consumed is relatively small, the injury may be severe due to numerous surface blemishes and to subsequent rot infec-
The tree crickets chew holes through the skin of the fruit and often enlarge the cavities below the surface by further feeding on the pulp with the head projecting into the hole. The adults feed more extensively than the young crickets.

Garman (1) has observed tree crickets in Kentucky, feeding on ripening plums, peaches, and grapes, the injury causing brown rot infection in the stone fruits and black rot in the grapes. In more recent years fruit injury by tree crickets has been reported in the western states. A fine crop of peaches in the Sacramento Valley was reported by Urbahns (2) to be materially damaged by the snowy tree cricket eating holes in the ripe peaches causing extensive infection by brown rot with a resulting loss of about a hundred tons of peaches in a single orchard. Wakeland and Whelan (3) have described a similar outbreak on prunes in the Boise Valley of Idaho and adjacent parts of Oregon. In a large commercial orchard at Parma, Idaho the tree crickets had been a pest of considerable importance for a number of years and in 1921 caused a loss of about one-fourth of the crop. Yothers (4) in a later account of the same outbreak, stated that the annual loss in prune orchards of Southern Idaho amounts to hundreds of thousands of dollars. He says that crickets in the last two stages before maturity feed on the half grown prunes,
gnawing holes in the surface. The injury starts about the first of August and increases in extent as the crickets mature and the prunes ripen. It often happens that the percent of injured fruit is so great that it does not pay to harvest, sort, and pack the crop. The injured fruit often starts to decay after being packed causing a slime which spreads and renders the whole box unmarketable. According to Wakeland the number of individual tree crickets in this infestation may be as high as 1386 in a single tree.

Oviposition Injuries. Certain species of tree crickets have become injurious by their method of depositing eggs. Egg punctures in the bark of trees and bushes permit the entrance of organisms causing bark diseases. Under some conditions tree crickets actually inoculate the plants with certain parasitic fungi. (5). In Oregon bark diseases associated with tree cricket egg punctures have been found on prune and apple. The bark canker develops as a circular discolored area surrounding the puncture. Later the dead portion is separated from the healthy bark by a distinct line or narrow crack. Egg punctures in raspberry are sometimes associated with a disease known as raspberry cane blight.

In berry bushes oviposition by tree crickets often causes injuries of a purely mechanical nature. The canes break or split easily at points where a row of eggs has been deposited. Unusual numbers of eggs in canes may permit evapo-
ration to the extent of killing the tips. This effect is more common in loganberries.

Control.

The fact that tree crickets are always rare or absent in apple orchards that are regularly sprayed for codling moth shows that their control is not a difficult matter. One spraying with lead arsenate while the crickets are young is usually all that is necessary to control them. This was demonstrated in a small orchard at the edge of Corvallis, belonging to H. M. Wight. During the summer of 1922 this orchard was uniformly infested with tree crickets. A large number of males could be heard singing in each tree and many females were observed ovipositing in the branches. Early in the summer of 1923 these trees received one spray after the tree crickets had hatched, with lead arsenate at the usual strength of 1 pound to 50 gallons. After the tree crickets had matured no males could be heard singing in the orchard except in one tree which was in contact with a large unsprayed blackberry bush. Adjoining unsprayed cherry trees still contained tree crickets, showing that the nearly complete extermination of the insects was due to the spray and not to parasitism.

Control of tree crickets on loganberries by means of a sweetened arsenical spray was demonstrated on the J. L. Johnson farm near Eugene. The loganberries contained numerous
egg punctures. All plants were affected and on many of them several hundred punctures could be found in a single cane. Those most severely attacked were dying at the tips due to loss of moisture. On July 11, 1922 the bushes were sprayed with the following mixture:

Water----------------------5 gallons
Lead arsenate---------------½ pound
Molasses--------------------1 quart

The spray was applied with a compressed air hand sprayer. No effort was made to spray the bushes thoroughly, but each was given a few dashes as the operator walked along. One part was treated in the afternoon and the other in early evening so that when the crickets became active at dusk they would find the material still liquid.

On November 11, 1922, the experiment was checked. No difference was noticed between the plots sprayed in afternoon and evening but both showed a remarkable difference in number of egg punctures from the condition in early summer. A search of a whole row in the part sprayed in the evening revealed only one cane containing eggs, of which there were 23, scattered in several short rows. A similar examination of a half row in the other plot disclosed only one short row of eggs.

The control had been aided by the disposal of the old canes immediately after the last of the crop had been removed. They had been carried away and burned taking many crickets with them. However in the unsprayed plot where this practice was also carried
out, eggs could be readily found, but were not numerous enough to be serious.

Life History.

All of our species of tree crickets deposit eggs in the stems of plants in the late summer and fall. These remain over winter and hatch early in the following summer, usually near the middle of June in the Willamette Valley. The young crickets grow rather slowly for insects and shed their skin five times before reaching the adult form. Each stage is characterized by the progressive changes in the development of the wing pads and ovipositor. The life stages and other facts concerning the biology of the tree crickets have been described in detail in a previous paper by the writer (6). It will suffice here to give some of the more important features of the life history.

There is but one generation a year and the adult stage is usually reached near the first of August in the vicinity of Corvallis. By that time some of the males can be heard singing and the chorus is augmented later by other individuals until it becomes the most characteristic and most musical insect sound of late summer evenings. The sound is made by vibrating the raised fore wings in a transverse direction, thus scraping a file-like structure located near the base. The song can be heard until the crickets are all killed by heavy frosts, in some years as late as mid November.
A few weeks after the early maturing males begin their song, the females can be found ovipositing in the manner peculiar to their kind. While the placement of the eggs differs for each species the method of drilling the hole in the plant is essentially the same for all.

The female's ovipositor consists of two pairs of rods fitted closely together to form a tube through which the slender eggs can pass. The rods are provided with teeth at the tips and the upper pair can slide on the lower by means of a tongue and groove connection. The female usually prepares a place on the bark by chewing out a few bits. Then she arches the back and brings the tip of the ovipositor perpendicularly against the place selected. The drilling is accomplished by twisting the body so as to rotate the ovipositor in alternating directions and at the same time the lower pair of rods are periodically thrust downward so that their sharp points cut in. The upper rods have small teeth at the tip which ream out the sides of the hole. The completed hole slants backward from the body of the cricket. While the ovipositor is still buried for nearly its full length in the plant an egg is pushed through and the ovipositor is then slowly withdrawn, leaving a small amount of gelatinous substance in the hole with the egg.

The food of tree crickets consists of both plant and animal matter, and their individual diet depends largely on the
kind of food available. Besides their habit of chewing holes in fruit as previously described, they are known to feed to some extent on leaves, floral parts, especially the anthers and fungus fruiting bodies. Tree crickets readily feed on small, easily captured insects such as aphids and scale insects, and no doubt are of some benefit in reducing the numbers of such pests.

How to Recognize Oregon Species of Tree Crickets.

Tree crickets can be superficially distinguished from most other insects by their pale whitish color, the long slender antennae exceeding the body, and the elongated hind legs adapted for jumping. The males are peculiar in having the fore wings broadly expanded and paddle-shaped. They lie horizontally over the abdomen, the right one superimposed on the left.

The outer border of each wing is abruptly bent toward the body concealing the sides of the abdomen. The second pair of wings are folded fanlike under the fore wings. The females present an entirely different appearance for the front wings are narrow and wrapped closely about the body. The tip of the abdomen is provided with a rod-shaped ovipositor about a quarter of an inch long.

The crickets may be distinguished from all related jumping insects by the horizontally disposed wings of the male and the rod-shaped, rather than sword-shaped, ovipositor of
the females. Since the only other species of true crickets occurring in Oregon are dark colored, ground inhabiting insects they are not likely to be confused with the tree crickets.

In Oregon there are three species of tree crickets, one which is divided into two physiological varieties as indicated by their habits and host plants. The following key will enable one to separate the species readily in any stage of the life history.

A. Adult. Nearly pure white, with a slight greenish cast. Two basal segments of the antennae each with single round black spot in front. 

Nymph. Greenish white with a few black dots and lines on the head and thorax.

1. Living in trees.

Eggs deposited singly in the bark. Song, 160 notes per minute at temperature of 70°F. O. niveus A.

2. Living in bushes

Eggs deposited in long rows in the pith stems of shrubs such as wild rose and berries (Rubus). Song, 90 notes per minute at temperature of 70°F. O. niveus B.

B. Adult. Very pale, dull greenish yellow.

In dried specimens a soiled white. Basal segment ornamented in front with a black line and spot which are often connected. Nymph. Pale greenish yellow, faintly suffused with gray on the dorsal area full length of the
body. Eggs deposited in rows in the stems of pithy weeds.  

**O. nigricornis argentinus**

**C. Adult.** Color variable, from pale dead grass color to light brown; in pale specimens, top of head and first two antennal segments tinged with red, or reddish brown, basal antennal segment unornamented or with a single dark line along the inner edge of the front side.  

**Nymph.** Pale yellowish ground color with a light purplish red dorsal band in the early stages, brown band in later stages. Eggs deposited in the pith core of woody stems, in two on opposite sides of the puncture groups.  

**O. californicus**

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**The Snowy Tree Cricket,**  
**Oecanthus niveus** De Geer.  

The snowy tree cricket is the only Oregon species which has so far proved destructive. It is generally distributed over the United States and adjacent parts of Canada and has been recorded also from Cuba, Mexico and Guatemala. As indicated in the key there are in this state two physiological varieties or two races which are alike in form and color but differ in their habits and place of abode. By a series of experiments, reported elsewhere, in which each race was confined on the normal host plants of the other, it was shown that the habits remain fixed regardless of surroundings. The females exhibit extreme reluctance in ovipositing except when on their normal host plants.
The two forms are rarely found on the same plants for one is entirely tree inhabiting while the other lives among bushes. The habits of the former which I have designated for convenience as race "A" differs only slightly from those of the same species in the eastern and central states, but in Oregon it is more strictly arboreal. The other Oregon form, designated as race "B" is quite distinct. It lives in wild rose thickets, wild brambles or cultivated berries (Rubus). Only one race of the snowy tree cricket has been found in the eastern states. There the species inhabits both trees and bushes but all of them have similar habits.

Race "A"

This form of the snowy tree cricket is the one which is found in orchards and which has in some places proved so destructive to prunes and peaches by eating holes in the fruit. In western Oregon, this form is also quite common on the Oregon ash and Gary oak and can be found on other deciduous trees. It is usually more abundant among the higher branches and can be heard singing in the tops of quite large trees. Occasionally it will be found in high bushes, which are near trees.

Oviposition.

The eggs of race "A", are placed singly in the bark of trees in which the crickets live. The eggs are about 3 millimeters or one-eighth inch long and three-fourths of a milli-
meter wide. They are slightly curved, pale yellowish in color
and at the end nearest the bark surface have a whitish cap,
where the surface is covered with minute finger-like projections.
The eggs are imbedded in the cambium layer, but where this is
thin a shallow groove may be gouged out of the sapwood. The
deeper portion of the egg lies nearly parallel to the wood while
the cap end curves slightly toward the outer surface.

The eggs are mostly deposited on branches from one
to three inches in diameter. On the smaller branches, rough-
ened areas around side twigs are favorite places. The females
show a tendency to oviposit on the lower side of branches and
on vertical or sloping branches they usually work head downward
so that most of the eggs have the inner end directed upward.
This is at variance with the habits of the species in New York
where it was observed that the females preferred to work head
uppermost on the upper surface of the branch.

Most of the egg punctures are plugged with pellets
of excrement. The female places this on the bark just before
depositing the egg, and after withdrawing the ovipositor she
forces the pellet into the puncture with her mouth. In some
cases she plugs the hole with particles of chewed bark.

Song.

The song of the males in late summer is a very char-
acteristic sound and once recognized cannot be mistaken for the
song of any other insect. In localities where this tree cricket
has become a pest the song could serve as an indicator, of the
extent and severity of infestation. It may be described as a rhythmical series of short, whistling notes indefinitely repeated. It is one of the clearest and most musical of all insect songs and is peculiar in that the notes of all individual singers in the same tree are sounded simultaneously or synchronized. Especially on warm evenings a whole orchard will seem to throb with the multitude of notes like a great orchestra under the direction of a leader.

The song of race "A" differs from that of the bush inhabiting form in the frequency of notes. In both races the speed varies with the temperature, being faster on warm nights, but there is always maintained a distinct difference in rate between the two races. At a temperature of 70°F, race "A" has a frequency of 160 notes per minute while race "B" has only 90 notes per minute. At 82°F, a record was taken of 230 notes per minute for race "A", while the slowest rate observed for this race was 56 notes at 48°F.

Race "B"

This race of the snowy tree cricket is the one which is found so common in plantings of loganberry, raspberry, and blackberry. Among the wild vegetation it occurs most abundantly in the wild rose and wild blackberry thickets. It is also found more or less commonly in all shrubby growths including the scrubby young oaks, and among the great areas of brake ferns and associated plants in old burns.
Race "B" is widely separated in its song and egg laying habits from other members of the species generally distributed over the United States. The geographical limits of the race are not well known for observations on the living insects are necessary to determine this. The writer has observed it only in Western Oregon where it is most common in the valleys but also occurs in burned areas of the Coast Range and foot hills of the Cascades. The race undoubtedly occurs in Western Washington and possibly in British Columbia. There is reason to believe that it may occur in Eastern Oregon and Washington at least in the Columbia Valley for eggs found by the writer at Walla Walla, Washington, appeared to belong to this variety. It probably also occurs in California.*

Oviposition.

The local distribution of tree crickets seems to depend quite largely on the type of plant material which each species selects for the deposition of eggs. In the case of race "B" of the snowy tree cricket there is an instinctive de-

*E. O. Essig. Injurious and Beneficial Insects of California, p. 31. Under the name Oecanthus californicus an account is given of oviposition habits which correspond to those of race "B", while the excellent photograph (Fig. 27) accompanying the article appears to be O. niveus and is certainly not O. californicus.
mand for woody plant stems with a wide central pith. Cultivated berry canes seems to be ideal for its requirements. Wild plants of the genus Rubus and some of the common species of wild rose are also used. The females usually select stems from 6 to 10 millimeters thick. The eggs are deposited in a series of punctures along one side of the cane. They are imbedded in a slanting direction across the pith. The number in each row varies from two or three to forty or more, but rows of about ten to twenty are most common. The punctures are placed close together, about one to each millimeter but occasionally they are more scattered. On horizontal or sloping stems the females most often work on the underside.

The eggs slant across the pith at about a forty-five degree angle. On more or less vertical stems they are usually directed downward from the point of entrance showing that the females prefer to work head uppermost. After depositing each egg the female plugs the hole with a little wad of chewed bark which she removes from a point just above the puncture. The cavity so formed serves as a starting point for the next drilling operation.

Song.

The song of the male, is like that of race "A" in being rhythmical and of a clear musical quality. It seems to be even more mellow in tone and slightly lower in pitch. The
greatest difference is in the frequency of notes. When one hears both songs at once the divergence is striking. The chorus of race "B" issues from the berry bushes in slow somnolent measures in contrast to the feverish throb of their kin in the nearby orchard.

On cool nights the frequency is slow and the pitch is lower. The slowest rate observed was 25 notes per minute at 47°F. The fastest rate observed was 133 notes at 84°F. At 70°F which is an average evening temperature the rate is 90.

The Prairie Tree Cricket.

*Oecanthus nigricornis argentinus* Saussure

The name Prairie Tree Cricket was selected for this species because it lives in the treeless areas. It is most abundant where certain herbaceous perrenials are dominant. In Oregon the preferred host plant seems to be the gum plant *Grindelia integrifolia* D. C. but it is also found on many others.

Although this tree cricket is probably only a geographic race of the species which is commonest on berry plantings in the northeastern states, it is here seldom found in such situations, and has not yet proved to be injurious to any cultivated plants.

The geographical limits of this race are not definite know.* It is characterized by heavy black antennal. The four-spotted tree cricket, *Oecanthus nigricornis quadripunctatus* Reut. has been found by Wakeland to be common around Boise, Idaho. It may also occur in southeastern Oregon. The race is characterized by the pale body color and extreme reduction in the antennal markings. The writer is making a further study of the relationship of the three races of the *O. nigricornis* group.
markings in combination with pale body color. Typical _O. n. nigricornis_ has some parts of the body infuscated including the abdominal sternites which are usually quite black. Material referable to _O. n. argentinus_ can be found at least as far east as North Dakota and Kansas and as far south as Arizona.

**Oviposition.**

The degree of abundance of this species in any locality seems to depend in part on the prevalence of the coarse perennials which serve as depositories for the eggs. The stem must have a central pith and the dead stalks must be durable enough to harbor the eggs until the following summer. For some reason, the more woody plants such as berries and wild rose are not desirable but in the absence of more suitable material, they are sometimes used, especially the smaller stems.

The eggs are deposited in the pith in rows usually about one egg to each millimeter as in the case of _O. niveus_. The method of oviposition is almost identical with that form except in the size of stems selected. Even if ovipositing on the same kind of plants i.e. loganberry or wild rose, this species selects stems less than five millimeters in thickness and often works in terminal growths not more than one and one-half millimeters thick. In such small stems, the egg practically fills the pith cavity and of necessity the punctures
must be more scattered, at least the length of the egg apart. The small branches of Grindelia, its favorite host plant in Western Oregon, are used for oviposition as often as the larger and parts over six millimeters are seldom selected.

Song

As might be expected from the narrow front wings of the males of this species, the sound is lacking in volume as compared to the other native tree-crickets. The song is indefinitely prolonged rather than intermittent as in case of the snowy tree cricket. The quality as compared to the latter species is somewhat tinny and in late fall some individuals develop a decidedly rasping undertone.

This species sings by daylight as well as at night. In old weedy fields the combined whistling of many males produces a diffused resonance which seems to permeate space and come from nowhere in particular. Although quite loud, it is so continuous, unvaried and monotonous, that it can be likened to the ringing in one's ears after taking quinine. It goes on unnoticed by many people.

The Western Tree Cricket

*Oecanthus californicus* Saussure

This western species is common in brushy thickets in both western and eastern Oregon. Specimens have been taken in Ashland, Gold Hill, Eugene, Corvallis, Hood River and La Grande. It seems to be quite generally distributed over the
western states from the eastern border of the Rocky Mountains to the coast. In the southern states its range extends farther eastward into Texas and possibly beyond. A female specimen in the National Museum collection labeled Hot Springs, Arkansas seems to belong to this species.

The choice of host plants must differ considerably over such a varied range as occupied by the western tree cricket, but everywhere that the writer has observed the species, it loves a dense thicket. In the Willamette Valley it is common about the scrubby young oaks with their attendant miniature jungles of poison oak, wild rose and other plants. In the Rogue River Valley it is commonest on a blue flowered shrub, *Ceanothus integerrimus*. Near La Grande the egg punctures were found in wild rose thickets in mountain side gullies. In northern Arizona the species was found in the lower branches of small pines and junipers, and occasionally in scrub oaks and other low plants under the trees.

I have examined specimens loaned by Claude Hakeland, which he collected from chokecherry, willow and a number of other wild shrubs and weeds, at Banks, Idaho, in the mountains at an elevation of about a thousand feet higher than Boise.

**Oviposition.**

A search for the egg punctures of this species in the scrub oak thickets about Corvallis failed to reveal anything until attention was given to a very small species of rose
with small thorns, *Rosa gymnocarpa* Nutt. This plant was usually found around the borders of the thickets and among weeds.

The smallest of these rose plants, some of them not over a foot high, were the ones most often found with egg punctures, and shoots of the current year's growth are more often selected for oviposition than more woody stems. Stems used are seldom over five millimeters (one-fifth inch) thick, and sometimes are as small as one and one-half millimeters.

The eggs are deposited in the pith in two groups, one above and one below the puncture. The same exit hole serves for all. The eggs lie nearly parallel to the plant stem. The number in each group varies from one to three and is usually the same in the two groups or differs by one egg. Usually there are several punctures in the same stem, sometimes as many as eight, the distance apart varying from seven to twenty millimeters. The punctures are surrounded by a small area from which the bark has been removed and sometimes the hole is closed with a plug of chewed bark.

Near Ashland, Oregon the eggs of this species were found most common in *Ceanothus integerrimus*, a shrub common in southern Oregon, but not in the Willamette Valley. Most of the eggs were concentrated on one or two branches, usually low overhanging ones, five to seven millimeters thick. These would have a series of several punctures an inch or less apart
along the under side. One branch had twenty-eight. The pith core in this plant is rather narrow but the number of eggs in a cluster averaged more than in the rose. Some-four or five would be crowded into a space one and one-half millimeters in diameter.

Song

The song of the western tree cricket is loudest of all the Oregon species. It resembles that of *O. argentinus* in being a continuous whistle. The pitch was determined one evening as E flat above middle C with the temperature at 62°F. The song has a clear bell-like quality and can be heard for a considerable distance. In places where the crickets were widely separated, I have been able to distinguish the song of a single individual from other sounds of the night, for a distance of a hundred yards.

The song of this species usually begins a little while after sunset and continues on after dark. A favorite place of the males for singing is on the underside of an oak leaf with the head sticking up above the edge between two of the lobes.

Description of *Oecanthus californicus*.

Since no English description of *Oecanthus californicus* Saussure has been published it seems desirable to include it here. The identification of this species is based on Saussure's original description in French which agrees closely
with the specimens at hand except that no mention is made of the color which in most specimens is quite different from that of _niveus_ with which it is compared. However, pale specimens occur and it is possible that the type specimens were of that sort. No comparisons have been made with the type, which I am informed by Mr. Morgan Hebard is probably in the Musée de Geneve, Geneva, Switzerland. The species is quite common in California which is the locality given for the type.

If this identification is correct as seems very probable then _Oecanthus marcosensis_ Baker is most likely a synonym for its description corresponds in most respects to dark specimens of the species. The relative lengths of antennal segments are too variable to be used as specific characters. The dark brown lines on the front of the first two antennal segment may be very distinct, faint, or entirely absent in specimens from the same field.

A translation of Saussure's original description is as follows:

"Similar to _O. niveus_ but shorter; with no tubercle or black line on under side of base of antenna; head and pronotum shorter; elytra broader, tip more obtuse; wings sub-abortive."

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of body (male)</td>
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</tr>
<tr>
<td>Length of elytra</td>
<td>11.5 mm.</td>
</tr>
<tr>
<td>Width of dorsal field</td>
<td>6.2 mm.</td>
</tr>
<tr>
<td>Length of pronotum</td>
<td>2.5 mm.</td>
</tr>
<tr>
<td>Width of pronotum</td>
<td>2.3 mm.</td>
</tr>
<tr>
<td>Length of hind femur</td>
<td>9. mm.</td>
</tr>
</tbody>
</table>
Male. This species is more thick set than *O. niveus*. The pronotum is short and quite broad; the latero-posterior angles are broadly rounded, not square as in the species cited, and the posterior border is distinctly bisinuate. The elytra are broader and more obtuse at the end than in *O. niveus*, which renders the mirror a little broader than long and more obtuse, its posterior end forming a semi-circle and not a semi-ellipse as in *O. niveus*, and the anterior angle being distinctly obtuse. There are only 5 oblique veins; the marginal field presents at the base the costal veins less oblique than in the species cited. Finally the wings are noticeably atrophied, for they do not exceed the end of the abdomen, and in repose, only reach to the middle of the mirror of the elytra. Habitat: California.

Saussure's description and the illustration in this bulletin are sufficient for the identification of typical specimens. Over the entire range of the insect there is some variation in the relative width of the male tegmina. In the table below is a summary of measurement (in millimeters) showing the extent of variation. As a matter of comparison some measurements are given for *O. latipennis* in the lower part of the table. These were taken from 14 males from localities as follows: 3 Yankton, S. D. (smallest), 1 Leland, Miss.; 1 Lakehurst, N. J.; 2 Mt. Pleasant, Iowa; 7 Newark, Ohio (largest). The following symbols are used: l= length of
pronotum; \( w \)=width of posterior border of pronotum as viewed from above; \( L \)=length of tegmina; \( W \)=greatest width of dorsal field of tegmina; \( w/l \)=width of pronotum divided by length, an index to relative shape; \( W/L \)=width of tegmina divided by length; \( L/W \)=length of tegmina divided by width of pronotum; (in side column) \( E \)=extremes, \( A \)=average.
<table>
<thead>
<tr>
<th>Locality, Number and Sex of Specimens</th>
<th>Pronotum</th>
<th>Tegmina</th>
<th>Ovipositor</th>
<th>Hind femur</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>l</td>
<td>w</td>
<td>w/l</td>
<td>L</td>
</tr>
<tr>
<td>Corvallis, Oregon, 15 males</td>
<td>2.1</td>
<td>2.5</td>
<td>1.12</td>
<td>11.9</td>
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<td></td>
<td>2.4</td>
<td>2.2</td>
<td>1.23</td>
<td>13.0</td>
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<tr>
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<td>1.9</td>
<td>.88</td>
<td>8.0</td>
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<td>2.4</td>
<td>1.10</td>
<td>11.5</td>
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<td>2.4</td>
<td>1.09</td>
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<td>1.17</td>
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<td>2.4</td>
<td>2.1</td>
<td>.87</td>
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</tr>
<tr>
<td></td>
<td>2.5</td>
<td>2.8</td>
<td>1.12</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>2.4</td>
<td>2.6</td>
<td>1.08</td>
<td>12.3</td>
</tr>
<tr>
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<td>2.2</td>
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<td>9.0</td>
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<tr>
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<td>1.9</td>
<td>2.2</td>
<td>1.08</td>
<td>10.0</td>
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<td></td>
<td>2.5</td>
<td>2.7</td>
<td>1.24</td>
<td>12.0</td>
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<td>2.4</td>
<td>1.14</td>
<td>11.0</td>
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<tr>
<td></td>
<td>2.2</td>
<td>2.4</td>
<td>1.09</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>2.3</td>
<td>2.6</td>
<td>1.13</td>
<td>12.0</td>
</tr>
<tr>
<td>Durango, Colo., 1 male</td>
<td>2.3</td>
<td>2.5</td>
<td>1.09</td>
<td>12.0</td>
</tr>
<tr>
<td>Texas Pass, Arizona, 1 male</td>
<td>2.0</td>
<td>2.1</td>
<td>1.05</td>
<td>10.8</td>
</tr>
<tr>
<td>Oecanthus latipennis, 14 males</td>
<td>2.3</td>
<td>2.3</td>
<td>.92</td>
<td>13.0</td>
</tr>
<tr>
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<td>2.9</td>
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<tr>
<td></td>
<td>2.64</td>
<td>2.66</td>
<td>1.01</td>
<td>14.8</td>
</tr>
</tbody>
</table>
The following color descriptions show the extent of variation in that respect. Corvallis specimens. Ground color a dead grass color or pinkish buff (Ridgway) more or less obscured by fine stippling of light or dark brown. Head between eyes and antennae and two basal antennal segments more reddish brown. Segments 3 to 8, black to dark brown beyond that rapidly fading into the ground color. Hind femora marked with fairly definite pattern of short dark brown dashes, shading to black at distal end. Male tegmina with infuscated pattern as follows: (1) narrow borders along principle veins; (2) lines of variable width giving a blotched or patchy appearance paralleling the main veins on both sides but separated from the dark borders by a narrow clear space; (3) fine streaks following the fine stria in the larger cells; (4) dark patches in cells around the border of the dorsal field. In females the veins only are pale and all cells enclose dark patches giving the tegmina a general dull brown color, snuff brown (Ridgway).

Ashland, Oregon. 3 pale specimens have ivory yellow (Ridgway) ground color devoid of brown stippling. Head with faint red tinge between eyes. Tegmina with a few faint infuscated patches. A fourth specimen is like Corvallis specimens but paler.

*Name taken from Ridgway's Color Standards & Nomenclature, Washington, D. C. 1912.
Banks, Idaho. Similar to pale Ashland specimens.

Fort Collins, Colorado. Also as above except that tegmina show no trace of markings.

Texas Pass, Arizona. As above. Black line along inner edge of front face of basal antennal segment.

Grand Canyon, Arizona, and Durango, Colorado. Most of the body heavily stippled with dark brown or bister (Ridgway) buff ground color most evident on lateral margins of disk of pronotum. Head between eyes and basal antennal segments with more reddish brown. Male tegmina clouded with bister in a pattern similar to Corvallis specimens except that lines are not broken and patchy. Cells bordering the dorsal field and those anterior to the stridulatory vein all infuscated.

Some specimens from every locality represented in the collection show at least a trace of brown (or reddish) lines on the front side of the first two antennal segments. This character varies independently of general body color for some of the pale specimens show it most distinctly while in some of the dark specimens it is entirely lacking. Of 29 Corvallis specimens, the lines are absent in 14, very faint in 8, and distinct on at least the first segment in 7.

The species is most nearly related to the broad winged tree cricket, *D. latipennis*, Riley, which occurs in the eastern half of the United States but has not been found in
the far west. In both species the males have very broad tegmina, the greatest width of the dorsal field averaging about half the length. The lateral field in both becomes rather suddenly expanded at the level of the hind coxae so that the posterior part is about twice as wide as the front portion which has a nearly uniform breadth up to that point. In other species of the genus there is some expansion of the distal part of the lateral field but the costal margin is rather gradually curved. In both species some males have the veins of the tegmina bordered by infuscated lines, very faintly in *O. latipennis*.

*O. latipennis* from the eastern states can be distinguished readily by the purplish red color on the head between the eye and antennae. In states west of the Mississippi many individuals exhibit this color very faintly. *O. californicus* from Banks, Idaho and Fort Collins, Colorado are all much paler than typical specimens from the Pacific Coast, but two specimens from Ashland, Oregon are as pale as any.

Many of these pale specimens show a distinct reddish tinge between the eyes and there is little to distinguish them from *O. latipennis* except the smaller size, stouter pronotum, the relative size of tegmina and pronotum (L/W) and the presence at least in some specimens, of the dark line on the basal antennal segments. The distal segment of the maxillary palp has a hollow on one side in dry specimens which in *O. californi-
icus usually covers the distal half or three-fifths of the segment, while in _O. latipennis_ it is only a third or two-fifths as long as the segment. It is possible that the two species may intergrade in the southern states east of the Rocky mountains. Considering the brush loving habits of both species, one would not expect to find either of them inhabiting the great plains, except possibly along the large river valley.

**Life Stages of _O. californicus_.**

*Corvallis, Oregon.* Egg — Whitish in color, semi-translucent, shining; elongate cylindrical, slightly curved; with an opaque white cap at micropyle end, made up of numerous minute projections arranged in regular transverse rows. Projections on side of cap above the first few rows are expanded transversely at the tip, measuring .020 to .024 mm. in length, .020 tangential diameter at tip and .008 radial diameter. Projections merge by gradual stages from this type on the side to smaller cylindrical ones at the apex, .010 mm. long by .007 mm. in diameter. Measurements of 50 eggs give the following dimensions (in millimeters). Length 2.27 to 5.05, average 2.73; width .39 to .52, average .43; cap length .19 to .33, average .25; cap width .33 to .42, average .37.

**Nymph. First Instar.** Ground color translucent whitish with broad dorsal band of dull purplish pink, (Persian lilac or light vinaceous lilac of Ridgway) enclosing a narrower stripe of medium gray in which lies a narrow pale mid-dorsal
Head with space between antennae entirely pink as far back as a curved transverse pale line, in which the pale mid-dorsal line terminates. Posterior half of inner edge of eye bordered by a black line which extends back on occiput, giving off a branch on the inner side just back of the eye. Pink band on pronotum bounded laterally on anterior half by narrow gray lines. Gray band dark on both ends of pronotum and on posterior edge of each succeeding segment, where each segment bears a pair of prominent black bristles. Cerci whitish with a patch of gray on inner side near the base, bounded by a narrow pink area. Hind femora with faint gray traces of the dark dashes which appear later. Antennae pale with faint gray annulations at distal ends of segments 5, 4, 6 and 9. Length of newly hatched nymph 3 mm. Antennae 7.5 mm.

Second Instar. Ground color yellowish white. Pink color very pale on head and pronotum. Gray band fainter and more diffused, covered with fine stippled or dots at bases of minute bristles. Pale mid-dorsal line more broken; at hind border of each abdominal segment it expands into a prominent white spot, bounded on each side by a dark gray spot. Pink band on abdomen deepest on lateral edges, bounded by clear pale ivory below which sides are mottled with faint brownish blotches.

Third Instar. Mid-dorsal area darkened by numerous small bristle dots only. Head with wide dark area in middle of occiput, paralleled on each side by two dark lines, the out-
er one meeting the inner edge of the eye. Median pink
zone very faint except the lateral borders, which curve
outwardly on anterior half of segments and inwardly on pos­
terior half. Otherwise as in second instar.

Fourth Instar. Characterized by further reduction
of the pink coloration, now confined mainly to a narrow line
bordering a pale yellowish or pinkish dorsal band on the ab­
domen. The number of small bristle dots has increased in each
stage and have taken on a brown color so that the whole insect
has a distinct brownish tone. Dots largest and most numerous
bordering the pale mid-dorsal line. Hind border of each ab­
dominal segment with a white median spot, with black spots on
each side; much larger on the first segment. Antennae pale
brown near base, in some with dark line on first segment.
Wing pads folded up on the sides reaching to second abdominal
segment; marked with brown streaks. Dashes on hind femora
dark brown.

Fifth Instar. Ground color ivory yellow, stippled
with brown dots, more or less over entire body, but most num­
crorous along the mid-dorsal area.
Acknowledgments. The writer is indebted to Claude Wake-land of the Idaho Experiment Station and A. H. Caudell of the U. S. National Museum for the loan of specimens used in obtaining data for this bulletin.
Literature Cited.


Prune, apple, peach, loganberry, raspberry, blackberry and grape are subject to tree cricket injury at times. The injury is due to (1) the habit of feeding on fruits, and (2) the egg laying in stems and bark. Egg punctures are sometimes associated with bark diseases.

Control is easily accomplished by means of a spray of lead arsenate in late June or early July while the crickets are small. On berries they may be controlled by a scattering application of sweetened arsenical spray.

The eggs of tree crickets remain in the host plants over winter and hatch usually in June. The crickets mature about the first of August and live until heavy frosts kill them.

Three species occur in Oregon. One of these exists as two distinct races identical in appearance but differing in habits; one race lives in orchards, the other on berry bushes. A second species lives among tall herbaceous plants and a third on wild shrubs.
Geographical Variation in the *nigricornis* Group of *Oecanthus* (Orthoptera)

B. B. Fulton

There has been some disagreement among taxonomists working with the Orthoptera, as to whether the dark marked tree cricket described by F. Walker as *Oecanthus nigricornis* is really a distinct species from the pale one described later by Beutenmuller as *O. quadripunctatus*. The two insects are very similar morphologically, but differ in color characters and are usually separated by differences in the markings on the two proximal antennal segments. Caudell, Houghton, (1) E. M. Walker (2) and Blatchley (3) have maintained that they are only varieties, that numerous intergrades occur, and that it is impossible to definitely separate the two.

In working with these insects in New York state, F. J. Parrott (4) and the writer became convinced that they were two distinct species. We found a difference in the choice of host plants for oviposition which was associated with the ecological distribution of the two species. *O. nigricornis* was found in berry plantings and on tall rank weeds or brushy growths of more woody plants such as willow, elder, sumac and grape. *O. quadripunctatus* was found only in old fields, especially where the wild carrot, (*Daucus carota*) was abundant. This plant was preferred above all others for oviposition but occasionally other pithy weeds 1 to 2 feet high were used, such as *Aster*, small species of *Solidago*, and
Ambrosia artemisiifolia.

These habit differences were associated with color characters the most constant of which was the color of the abdominal sternites, which is difficult to determine in pinned specimens due to the shriveling and discoloration of the body on drying. We also found a constant difference in the morphology of the eggs of the two species.

Emerson & Hebardi (5), studying these insects in the southeastern states believed that the two species were distinct. They state that in addition to coloration, O. nigricornis may be distinguished from the other by the heavier pronotum, the greatest width of which more closely approximates the length of the same than in that species (O. quadripunctatus) while the head between the eyes is weakly but distinctly depressed, a condition not at all or rarely weakly indicated in quadripunctatus. In the specimens examined by the writer, few of which were from the southeastern states, the depression between the eyes has not proven distinct or constant enough to be of any aid in separating the species. In specimens from Ohio and Iowa the pronotum of nigricornis averages slightly broader in proportion and also slightly larger in relation to the wings, but here again the difference is slight and the maximum for quadripunctatus overlaps the minimum for nigricornis.

When the writer moved to Oregon he found tree cricket eggs in berry canes deposited in a manner similar to O. nigricornis in the east. They proved to be the eggs of a physiological variety
of the snowy tree cricket, *O. nivicus*, an account of which has been published, (6). The former species did not occur there, nor did *quadripunctatus*, but one very similar to both was found abundant in prairie regions where it was closely associated with a certain weed with sticky glandular hairs, called the gum plant (*Grindelia*). This insect had oviposition habits more like *O. quadripunctatus*, but the markings on the proximal antennal segments were very heavy and ventral segments and sides of the abdomen were only slightly darkened if at all. The species agreed with Saussure's description of *O. argentinus* and this identification was sustained by Caudell who stated that he regarded it as merely a variety of *nigricornis*.

The problem of the relationship and distribution of the three species, or subspecies at once suggested itself. From time to time the writer had opportunity to collect series in various parts of the country and to examine specimens loaned by other collectors.

The problem resolved itself into, first, an attempt to determine the western limits of *nigricornis* and *quadripunctatus* and the eastern limits of *argentinus*, and second, to find out if there is any blending between any or all of the species in question.

**Methods.**

In order to facilitate the tabulation of data, it was found advisable to originate a series of arbitrary classes based on the markings of the proximal antennal segments. At first attempts
were made to classify the material in a straight line series from light to dark markings but it soon became evident that this would not work. It was found that dark body color is rather closely associated with certain types of antennal pattern, and that those with a heavy pattern diverge in two directions from a middle ground, one toward typical *nigricornis* with increasing body color and the other toward typical *argentinus*, without essential increase in body color.

After a number of changes twelve classes were decided on, which seemed to have approximately equal value and served well enough to show the differences in the tree cricket population of various regions in regard to this set of characters. Records were also kept on the degree and extent of dark body color, where this was possible. The frail integument of the abdomen makes records on coloration of that part untrustworthy except in fresh or liquid preserved material.

The twelve classes were based mainly on the markings of the first antennal segment. Numerous records showed that the degree of coloration of the second segment was closely correlated in the majority of specimens. The material was therefore classified on the basis of the pattern of the first segment alone except in doubtful cases. The twelve classes are illustrated in Table II, and are described as follows:

1. With no markings.

2. With either the inner or outer elements of the pattern absent and the other reduced.
3. Space between the spot and line at least 3 times the average width of the line.

4. Space 2 times but less than 3 times the width of the line.

5. Space about the width of the line or a little over.

6. Space about \(\frac{1}{2}\) width of line or a little over. Space of fairly uniform breadth or the narrowest part proximad.
Line quite heavy and of nearly uniform breadth.

7. Space distinctly less than \(\frac{1}{2}\) the width of line, and narrowest proximad or spot and line barely contiguous leaving a notch distad. Line very heavy and of nearly uniform breadth or narrower distad. Little or no infuscation of the remainder of the segment.

8. Spot and line distinctly confluent; line very heavy. Little or no infuscation of the remainder of segment.

6'. Space about \(\frac{1}{2}\) average width of line or a little over, narrowest part distad. Line not unusually heavy and broadest distad. Segment often slightly shaded distad and proximad of the spot.

7'. Space distinctly less than \(\frac{3}{4}\) the width of line, narrowest distad, or spot and line barely contiguous distad. Remainder of segment more or less shaded.

8'. Spot and line distinctly confluent but usually leaving a notch of ground color proximad. Segment distinctly infuscated; palest areas bordering the line on both sides.

9'. Pattern decidedly obscured by a general dark infuscation of at least the distal two-thirds of the segment.
In scoring series of specimens on the above plan it is impossible to eliminate the personal element in the interpretation of doubtful specimens. It must be admitted that in series containing many atypical forms, no subsequent examinations would place all specimens in exactly the same classes again. The method serves to give a general idea of the complexion of a series but conclusion must not be drawn too closely. This work was not intended as a study in evolution or heredity, but is merely an attempt to clear up a taxonomic problem. Better conclusions could be drawn from series which numbered in thousands, but the study has been limited to such collections as were available and to limited opportunity for travel. For several reasons these insects are not ideal material for a special study of variation.

The writer is fully aware that there is such a thing as "place variation", that a species varies somewhat in character from generation to generation or over longer periods of time. Only a few of these series were taken at the same place during different years. There the differences found are probably not greater than would be obtained by the law of chance if the second collection had been made the following day. Field observations on these insects covering seven years in New York and five years in Oregon have convinced the writer that they did not vary noticeably in the characters used for separating the species.
Results.

The results of scoring all material examined are summarized in two tables. In Table I are shown the actual numbers of individuals of each class, in Table II the percent of each class is shown graphically only for the larger series. In many of these the number of individuals is much too small for drawing any quantitative conclusions. In several cases nothing is known about the ecological conditions where collections were made. In some series especially those showing two distinct modes the height of each mode depends entirely on the amount of collecting done in each of two kinds of habitats, and not on the relative abundance of the two forms in that particular locality.
<table>
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<tr>
<th>Series</th>
<th>Locality</th>
<th>No. of specimens of each class. Upper rows refer to upper series 6' to 9'.</th>
<th>6-6' intermediate</th>
<th>Total</th>
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<td>2 11 5</td>
<td>3 23 10</td>
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<td>6-6' intermediate</td>
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<td>Pierre, S.D.</td>
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<td>1 7 12 6 1</td>
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<td>49</td>
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<td>1  2  3  4  5  6  7  8</td>
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<td>Forest Grove, Ore. Oct. 1906</td>
<td>-        -        -        -        2 1</td>
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Other specimens examined fell in the above classes as follows: Mineral Springs, Ind., 3 in class 4; Montreat, N. C., 1 in class 9; Pascagoula, Miss., 2 in class 4; Grant Co., Okla., 1 in class 7; Tempe, Ariz., a bottle of specimens collected by R. H. Wilson from alfalfa were examined several years ago and notes taken at the time show that they all had the heavy antennal markings and would fall in class 7 or 8.

Further data on the series of specimens from which data was taken: 2, Newark, Ohio, from Ambrosia trifida, river bottom land, and Daucus carota, upland fields. 3, Gainesville and Newberry, Fla., collected by Fred Walker, the Newberry specimens from dog fennel. 4, Oskaloosa, Ia., from Ambrosia artemisiifolia on side and top of hill pasture, growing in clumps. 5, from Solidago clumps in same pasture. 6, from Polygonum and Bidens in a wet gully, same field as last. 7, from tall Solidago and Ambrosia trifida along fence surrounding above field. 9, Ames, Iowa, from Ambrosia artemisiifolia and other small weeds, river terrace pasture. 10, same place, following year. 11, from A. artemisiifolia, another river terrace pasture 5 miles from No. 9. 12, from Cannabis sativa and Vernonia, creek bottom land, one quarter mile from No. 9. 13, same place following year. 14, from same plants 2 miles down stream from No. 12. 15, from Ambrosia trifida and Helianthus along fence half mile from No. 11. 16, from various kinds of weeds on terrace above creek. 17, 18, 19, 3 collections from same raspberry planting. 21, Sioux City,
Ia., mainly from *Erigeron canadensis* and *Helianthus tuberosus*, all from same field. 22, Lake Okoboji, Ia., from various weeds in low meadow adjacent to lake. 23 to 35 and 36, loaned by H. C. Severin. 23, 24, 25, Brookings & Lake Hendricks, S. D., low prairie. 27, 28, Canton & Yankton, S. D., valley land with natural tree growth. 29, Volin, Prairie. 31, 32, Cape & Pierre, S. D., central part, latter in Missouri Valley, former in a branch valley 35 miles southwest. 33, Martin, S. D., sand hill area with sparse vegetation. 34, Awame, Manitoba, loaned by E. R. Buckell, collected by F. Criddle. 35, Bismarck, N. D., mainly from *Grindelia*, Missouri river bottom land. 36, Whitewood, S. D., in Black Hills, altitude 3700; pine, spruce and oak forest region. 37, Kansas, from University of Kansas collection, a few specimens each from many localities scattered over entire state. 38, 39, collected by Snow, University of Kansas collection. 40, Fort Collins, Colo., mostly from tall weeds in low ground, those in classes 4 and 5 from sage brush. 41, 42, 43, collected by C. J. Drake and H. H. Knight. 44, Williams, Ariz., from *Chrysotherixmus*. 45, Arizona, several isolated records, mostly from University of Kansas collection.

Localities given: S. Ariz. (2 in class 4), Bill Wm's Fork (1 in class 8), Cochise Co., San Rita Mtn's., Douglas, Tucson, Phoenix. 46, Big Timber, Mont., from *Grindelia* and *Helianthus*, collected by J. R. Parker. 47, Boise, Idaho, loaned by Claude Wakeland. 48, La Grande, from weeds in mountain side gully and field in valley several miles north. 49-53, Corvallis, Ore.,
mainly from *Grindelia*. 49, prairie near creek. 50, dry
fields at foot of hill. 51, hillside prairie, mostly on *Hyperi-
cum*. 52, miscellaneous specimens, all from prairie. 54,
Medford, Ore., from *Grindelia* along railroad.

**TABLE II.**
Discussion of Results.

An examination of the tables shows three general conditions in regard to the populations of these species, corresponding largely to three general regions, the eastern deciduous forest region, the great plains and the Rocky mountain-Pacific coast region.

In the eastern part of the country extending a little west of the Mississippi, *nigricornis* and *quadripunctatus* seem to be fairly distinct, sufficiently so that one would be justified in calling them separate species. A few individuals may be found which would be difficult to place on the basis of anternal markings alone, but with fresh material or specimens in liquid, showing clearly the body color, especially the abdominal sternites. I believe practically all specimens could be properly identified. In this region the two crickets each live in a different set of environmental conditions.

By long experience in collecting these insects the writer can tell at a glance which cricket would be found in any particular plant association in this region. *O. nigricornis* is found among the large, coarse, herbaceous plants with pithy stems or brushy growths of more woody plants or young trees of certain species. *Quadripunctatus* lives only among smaller species of pithy stemmed herbs. This well defined ecological distribution seems to be based on the oviposition habits which may be tested out in cages. If each species is given a choice of a number of different kinds of stems for oviposition, *nigricornis* will
select large stems of about 6 to 10 mm. or even larger while *quadripunctatus* will choose stems of 3-4 mm., or seldom as large as 5 mm. If given only one kind of plant, as raspberry for example, *nicricornis* will oviposit in the main part of the cane while *quadripunctatus* will use the tips or leaf petioles, neither of which would be normal for the latter species.

At Oskaloosa, Iowa, where the two crickets are not as widely separated as they are further east, collections were made in an old pasture extending over a low hill. The fence along the bottom of the hill was surrounded by tall weeds, such as the giant ragweed (*Ambrosia trifida*) and a large species of golden-rod (*Solidago*). In the field, extending over the hill, there were many clumps of somewhat smaller golden-rod and the common ragweed (*Ambrosia artemisiifolia*). Series 4, collected only from the last named plant contained only 3 specimens of *nicricornis* out of 37, and series 5 taken only from the clumps of golden-rod contained 8 of the latter species out of 59. Some of these plants were of such size that the lower stems would come within the normal size range for oviposition by *nicricornis*. Series 6, collected from smartweed (*Polygonum*) and Spanish noodle (*Bidens*) in a wet gully on the side of the hill, contained a considerable proportion of both forms but none of doubtful taxonomic position. Series 7, taken from tall weeds along the lower fence contained only one *quadripunctatus* out of 23. In all the specimens there was close correlation between the type of antennal markings and
body color. All in classes 7' and 8' had black or very dark abdominal sternites and most of them were shaded on the sides of the abdomen, and had the typical dark areas on head and pronotum, as well as dark legs and antennae. Two of the specimens in 6' showed only faint color on the abdomen, the other was typically dark. These results show that at this locality, which is near the western limit of originally extensive deciduous forests, the two forms are fairly distinct both taxonomically and ecologically.

Series collected in the territory included in the Great plains area are more difficult to interpret. This includes territory which is largely prairie but which may have forest in the immediate vicinity of the larger streams. Here we find all three forms present, nigricornis, quadripunctatus and argentinus, and there are also more atypical specimens which are difficult to place. At Ames, Iowa, which is at about the eastern edge of this area, argentinus does not appear to be present, and the other two approach each other more closely and are more often associated than at Oskaloosa, 70 miles to the southeast. Series 11, shows a pure population of quadripunctatus taken on common ragweed (Ambrosia artemisiifolia) and vervain (Verbena sp.), all small plants 1-2 feet high, growing at the top of a river terrace in an old pasture. Series 9 and 10 were taken on 2 successive years on the side and top of another terrace much closer to the stream, from the same plants as above with the addition of a small golden-
rod. In series 10, only one typical specimen of nigricornis out of a total of 74 was found and that at the foot of the terrace. Compare these with series 15 taken from giant ragweed (Ambrosia trifida) and a Helianthus growing along a fence on level ground not over half a mile back from the terrace where series 11 was collected. Here we have only 2 specimens of quadripunctatus out of 33. No such pure populations are found in any of the other series taken around Ames, including those from creek bottom land collected largely from hemp (Cannabis sativa) and iron weed (Vernonia), both large plants. The nigricornis present falls largely in the paler class, 6'. There are many individuals which closely approach typical argentinus and fall in class 6, and many which seem to be intermediate in position between 6 and 6'.

All of the quadripunctatus in series 9, 10 and 11 have entirely pale bodies, while all of the nigricornis in series 15 have dark venters but the typical dark areas of the head and pronotum are faint or narrow. In the other series there is a general correlation between antennal pattern and body coloration but there are many exceptions. Many in the 6' class show no dark color on the venter, some of the 7' class are only faintly colored while on the other hand many in class 5 and even a few in class 4 have a more or less dark colored venter. Specimens from the bottom land and berries are also larger on the average than the typical quadripunctatus from the river terraces.

At Sioux City, Iowa, which is at the western edge of the state and within the strictly prairie region all three forms were
found in the same field both on tall plants (Helianthus) and on small weeds (Erigeron canadensis). Series 21 was collected in a field on the side of a small valley which was fringed with trees but not extensively wooded. There were some intermediate forms but on the whole the three forms were more distinct than would be expected when finding them so closely associated. As can be noted in the percentage graph in Table II, the modes come in classes 5, 7' and 8. Class 6 was almost absent while class 6' and intermediate forms were few in number. There was close correlation between antennal pattern and body color. All in classes 7' had dark venters. One rather doubtfully assigned to 8' had only a faintly colored venter. One in 6' was entirely pale while another was faintly shaded. One specimen in 4 had a faintly shaded venter.

At Lake Okoboji in northwestern Iowa, the three forms were also found associated in low meadow land adjoining the lake. An examination of the several series from the eastern part of South Dakota shows that nigricornis and quadrupunctatus predominate in that region as in Iowa, but that argentinus is present as a minor element of the population or at least certain individuals show definite argentius tendencies. Much the same condition is found in the series from Aweme, Manitoba. The correlation of body color in the last locality was poor like that in the Ames series taken from berries.

In series 25, collected on the Missouri bottom lands at Bismarck, N. D., we find a fairly uniform distribution of specimens
in all classes from 3 to 8, with a minor element in the population showing distinct nigricornis characters. None of those in 6 have a very pronounced dark body color and could not be called typical nigricornis. A small series from Capa, S. D. (No. 21) shows the same condition, and series 36 from Whitewood, S. D. in the Black Hills contains only one specimen similar to the above. The Kansas series contains only two specimens of typical nigricornis, from the northeastern part of the state near the Kansas river.

Typical argentinus forms the largest element in the Kansas series, taken from all parts of the state, a few specimens from each of 36 localities. It also predominates in the Whitewood, S. D. and Fort Collins, Colo. series, both from the western portion of great plains region. At Fort Collins, the specimens in classes 4 and 5 were taken from semi-desert plants, largely Chrysothamnus while the typical argentinus came from a patch of of marsh ground where the crickets were living on tall rank weeds.

Series 23 from the sand hills at Martin, S. D. contained 15 typical argentinus and 40 specimens of what I take to be an extreme form of quadripunctatus. These were different from any other series I have seen in having the antennal pattern extremely reduced. Some other series have a few individuals with one element of the pattern absent but in the Martin series this was the mode and 9 specimens had no trace of antennal pattern. It is not known whether the two groups were associated by nature or not.
Series 30 from Brownsville, Texas, contained many specimens in which the spot of the antennal pattern was reduced relatively more than the line. These fell in class 5, but many of them were not typical of *quadripunctatus*. There were relatively few typical *argentinus* and most of the specimens were somewhat intermediate between the two, with many irregularities in form of pattern.

In comparing the series from the great plains area we find extreme variation in the complexion of the tree cricket populations even in localities not far removed from each other. Most of them show that the three forms are quite close together and field notes show that in some cases they are associated in nature. While in most cases the typical forms outnumber the intermediate forms, there are enough of the latter to indicate hybridization or blending. *Nigricornis* becomes scarce toward the west and loses its typical coloration, *argentinus* extends eastward almost if not entirely to the limits of the true prairie region. *Quadripunctatus* ranges westward as an insect of the higher and dryer prairie and finally becomes an inhabitant of the semi-desert. Whether these last are true *quadripunctatus* seems doubtful on the evidence of the egg characters as brought out later.

In the Rocky Mountain-Pacific region, the classes in *nigricornis* group are entirely absent and classes with light antennal
pattern extend only thru the Rocky Mountains, as indicated by available collections. No series of any size from this region shows a bimodal grouping of the population but all fall into a fairly normal curves. In specimens from southwestern Colorado and Williams, Arizona, and 2 specimens in the Kansas University collection labelled S. Arizona, there is a peculiar reduction of the spot of the antenial pattern and frequently it is divided, leaving a small portion isolated on the extreme distal part of the first segment on the outer edge. In many of these specimens the line is as heavy as in typical *argentinus*. The few specimens examined from various other parts of Arizona (45) were mainly typical *argentinus*. I also have notes taken before the present study was started, on a series of specimens collected by R. M. Wilson on alfalfa at Tempe, Arizona. These were typical *argentinus* as shown by sketches made at the time. The abdomen was marked by lightly infuscated lines extending across all of the abdominal sternites on each side and by rows of lightly infuscated patches in a dorso-lateral position. These specimens must have been almost identical to average specimens from western Oregon, where the same body markings are present.

Series 47 from Boise, Idaho, appears to be typical *quadrimaculatus*. These were collected by Waksland among weeds along irrigation ditches and the collector states that they sometimes oviposit in the twigs of prune trees, a habit which reminds us of *nigricornis* in the eastern states.
Series 46, Big Timber, Mont., collected from Grindelia and Helianthus, falls mainly in the *quadripunctatus* groups but shows decided tendencies toward *argentinus*. Many specimens have the lightly infuscated stripes on the venter, and many have the reduced spot common in the southwestern states. The first named host plant is the favorite of typical *argentinus* in western Oregon. All series from western Oregon (49 to 55) show remarkable uniformity, with nearly all specimens falling in classes 7 and 8. Series 46, from La Grande in eastern Oregon has the same mode but a larger proportion of specimens show a lighter antennal pattern.

**Egg Characters.**

In studying the tree crickets in New York state it was found that the eggs of *quadripunctatus* could be distinguished from those of *nigricornis* by the structure of the cap at the cephalic end. The cap is a white covering delicately moulded into numerous minute ridges and projections which are arranged in spiral rows in two directions similar to the scales of a pine cone. The projections gradually increase in length from the base of the cap reaching a maximum near the apex and decrease again at the immediate apex. Subsequent descriptions of projections apply to those of maximum length unless otherwise stated. *O. nigricornis* eggs were found to be broadly rounded and considerably broader than long, and the projections were short. In *quadripunctatus* eggs the cap tended toward a conical
-35-

shape and averaged only a little broader than long, while the projections were finger-shaped and about twice as long as in the other species.

Comparing the eggs from a number of localities we find that they differ more or less in character in each place. At Newark, Ohio, the eggs of both species agree closely with the descriptions and drawings made of eggs of the same species at Genoa, N. Y., the only difference noted was that the eggs of quadripunctatus from Ohio showed a more pronounced conical shape of the cap and in the majority of them the length of the cap was greater than the diameter. Altho there is the same relative difference in length of cap projections in the 2 species, they are longer for both species in the Ohio eggs. This difference may possibly be accounted for by an improvement in the method of measuring them.

The projections of the Ohio nigricornis eggs are expanded a little near the tip forming a rounded knob, and are slightly flattened so that the diameter measured on a transverse tangent with the egg surface is a little greater than the radial diameter. A few of the projections, especially toward the base of the cap, have a slight shoulder or buttress on the side toward the base, but this is not the rule. In the eggs of quadripunc-

status the projections are also knobbed and slightly flattened at the tip, and usually slightly curved near the tip. Many of them, possibly half, have a more or less abrupt shoulder of
variable height. In some cases this forms a ridge or rib extending to the tip.

Eggs collected at Ames, Iowa, on the sites where series 11 and 15 were collected show even greater differences between the two forms. The *nigricornis* eggs are very similar to those from Ohio, but the *quadripunctatus* eggs exhibit a longer and more conical shaped cap while the projections are longer, more slender, less clubbed and most of them are provided with a shoulder or buttress.

Eggs collected in wild raspberry canes at St. Paul, Minn. and some from Brookings, S. D., in raspberry (3.5 mm. diameter), and a pithy weed stem (7 mm. diameter), are very similar to the *nigricornis* eggs found elsewhere.

Eggs collected at Bozeman, Mont., resembled those from Bismarck but with a more pronounced and more constant development of the shoulder on the projections. At the time these eggs were collected no crickets could be found, but one would not expect them to differ greatly from the Big Timber series (No. 45).

Eggs from Corvallis, Oregon have a short rounded cap, but the projections are quite long and resemble those of *quadripunctatus*. Many of them have a shoulder but probably most of the longer ones do not.

In order to obtain still more information on the egg characters, the dissected eggs from specimens in liquid and also some pinned ones. In most of the series the females did not
contain any well developed eggs if collected before September. Oskaloosa, Iowa, specimens showed the same type of eggs for nigricornis and quadripunctatus as found at Ames. From series sl, Sioux City, all from the same field, eggs were obtained from the following specimens of series 21, Sioux City: 1 from class 3, 4 from class 4, 5 from class 5, 2 from class 7, 4 from class 8, 1 from class 6'. Unfortunately all female specimens in classes 7' and 8' were young and contained no eggs. All eggs from specimens in classes 3, 4 and 5 had the long conical cap with the long projections as at Ames. All other eggs had a short rounded cap. The projections on eggs from classes 7 and 8 were slender, of medium length, many of them with a slight shoulder, and showed points of resemblance both to Corvallis, Oregon, eggs and to eggs from Bozeman, Montana, and Bismarck, North Dakota. Curiously enough, eggs from the one specimen of class 6' had the short stout projections typical of nigricornis from Ohio.

Dissected eggs from crickets collected on raspberry at Ames, all had the short rounded cap with short projections. A specimen of class 5 from the creek bottom land, series 12, also had eggs of this type. Most of the Ames specimens were collected before eggs were developed.

One specimen of quadripunctatus from Newberry, Fla., contained four well developed eggs. The cap was not excessively long and conical as in Iowa, but resembled more the Geneva, N. Y., conditions. The projections, however, were long and slender, as in Iowa specimens.
Eggs dissected from a dried specimen of class 4 from Boise, Ida., had the short rounded cap and short projections. The same was true of eggs from a Fort Collins, Colo., class 7 specimen, and also from a class 5 specimen, but in latter case the projections were obscured. The evidence from the egg characters indicates that the tree crickets found on raspberries and on tall bottom land weeds at Ames, Iowa, are nigricornis whether the antennal pattern is lighter than the typical condition or not. It indicates also that those with the light antennal pattern from Colo., and Ida., are not true quadripunctatus. The egg characters must be fairly constant for the latter species in the east, where the same general type is found in such widely separated localities as New York, Ohio, Iowa and Florida. At Sioux City, Iowa, the meager data seems to indicate that quadripunctatus is distinct there also, yet it seems improbable that it could exist without hybridizing when intimately associated with such closely related forms.

The egg characters point toward a close relationship between nigricornis and argentinus. Nigricornis eggs from Ames, closely resemble those dissected from argentinus specimens from Sioux City, Iowa, and Fort Collins, Colorado.

Conclusions.

The extent to which local environmental conditions may change the character of the tree crickets of the nigricornis
group has not been determined. It seems hardly possible that all the results could be accounted for in this way. The environmental difference between a small ragweed growing in a pasture and a bramble or sunflower ten feet away, is hardly great enough to account for the differences in color, egg structure and habits, found between *nicricornis* and *quadripunctatus*. If environment were directly responsible for the differences, why should all three forms be found in the same field and on the same species of plants as at Sioux City, Iowa? Likewise in western Oregon, apparently similar differences in environment have little or no effect on the color characters, which hold remarkably constant.

On the other hand, we find in the far west little or no difference in the egg characters between series which fall largely in the pale classes of antennal pattern and those which are typical *argentimus*. Considering the extreme environmental differences that may be found in the western mountain regions it seems entirely possible that color characters could be influenced to some extent, at least by the physical environment.

On the whole one is forced to the conclusion that in each locality the crickets have a certain genetic constitution differing more or less from those in other localities. In the eastern portion of the United States and Canada, *nicricornis* and *quadripunctatus* are fairly distinct, sufficiently so to be considered different species if they did not range beyond this
region. Both forms are found in most of the eastern territory but *nigricornis* ranges farther north and reaches the southern states only in the Appalachian mountain regions. In the eastern portion of the great plains area, *nigricornis* becomes less distinct, by reduction of the average antennal pattern and body color, although the eggs retain essentially the same character. In this region it apparently blends or hybridizes with *argentinus*, which has eggs very similar to *nigricornis*. *Nigricornis* predominates in the eastern portion of the area and fades out to the west, while the reverse is true of *argentinus*, which also extends to the Pacific coast states.

The situation in regard to *quadripunctatus* is more uncertain. All known eggs of this form from the eastern states, so far examined have shown distinct characters, even as far west as Sioux City, Iowa. No eggs were obtained of the extreme form found in the sand hills at Martin, S. D., but it seems plausible that this might represent the extreme western extension of true *quadripunctatus*. The few eggs obtained from apparently typical *quadripunctatus* from Colorado and Idaho were not like those found in the eastern states but were more like the eggs of *argentinus*.

This evidence points to a closer relationship to *argentinus*. Either the two forms are less distinct in the far west or else true *quadripunctatus* extends only as far as the eastern portion of the great plains, and similar forms found in the far west are only variations of *argentinus*, possibly due to local environment. From a practical standpoint the best we can do at present is to
consider all series with the light antennal pattern and pale body color as *quadripunctatus*.

Until better characters for separating the tree crickets of this group have been discovered, it seems advisable to consider *nigricornis, quadripunctatus* and *argentinus* as subspecies. The greatest difficulty in identifying them will be found in the central portions of the country. There they exhibit little or no differences in the choice of environment. One would hardly expect such closely related races to be associated on the same plants without hybridizing to some extent. There is no experimental evidence to show whether this is the case or not, but many individuals are found which are intermediate in regard to the characters commonly used in separating them.

Other Species.

The only other known species of *Oecanthus* in the *nigricornis* group is *O. pini* Beutenmuller which has characters distinct enough to justify its rank as a separate species. The antennal pattern is not very distinctive. It is usually like that of class 4 or 5, with the spot on the first segment small and round or with an outward extension along the distal border of the segment. The lines on the second segment are straight, parallel, of uniform width and usually well separated. In some specimens the outer elements of the pattern are faint or absent.

The most distinctive character about the species is the general ground color of the body. It could be confused only with
specimens of related species discolored by too long confinement in the killing bottle. In dry specimens, it is a light yellowish or reddish brown, lighter on the lateral portions of the pronotal disk and ventral side of the thorax, and darkest on the median part of head and pronotum. The pale color is close to clay color, cinnamon, or cinnamon buff in Ridgway's Color Standards and Nomenclature, while the darkest parts are near snuff brown, walnut brown, or burnt umber. The arrangement of the darker color is similar to typical nigricornis, but in the latter the dark color on the pronotum is fuscous or black on a pale buff or ivory yellow ground color. The venter of the abdomen is black in typical nigricornis as compared to dull brown in pini. The first antennal segment is broader in pini, being nearly as wide as long; the ground color of the two basal segments is the same as the palest body color while the remainder of the antenna assumes the darkest body color.

In life pini is easily recognized by the distinct green of the wing veins. The hind femora and dorsal part of the abdomen have enough green to give them an olive color. The head and thorax appear more reddish-brown in life and contrast sharply to the greenish color of the wings. Nymphs have greenish wing pads, a green abdomen with cream colored dorso-lateral stripes; the remainder of the body is light brown; the legs a light olive brown. The species has been found only on or near pines.
Key to North American Oecanthinae.

On the basis of this and other recent work on the tree crickets, I append the following modified key.

A. Front face of the proximal antennal segment with a small but prominent tubercle or knob on the distal border near the middle; no black markings. Hind tibiae armed with terminal spurs only. Wings exceed the tegmina by at least half their length. Deciduous forest and thickets. Conn., to Ga., west to Iowa, Kansas, Texas. Recorded by Saussure from Mexico and Central America.

  Neoxabea bipunctata (De Geer)

AA. Proximal antennal segment without a prominent tubercle on the distal border. Distal half of hind tibiae armed with several long spines and numerous small teeth.

  Oecanthus

B. Front face of proximal antennal segment with a broad, white or ivory colored swelling at the inner edge, ornamented with black. Area between eyes usually tinged with yellow.

C. Swelling with a round or oval, black (or rarely brown) spot. Second segment with a similar spot. Width of dorsal field of male tegmina nearly half of length. Deciduous trees and shrubs. Me., Ont., and B. C., to Ga., Cuba, Calif., Mexico and Central America.

  O. niveus (De Geer)

CC. Swelling with a curved or "J-shaped" black mark; the proximal end curved toward the inner side. Second segment with elongated black mark. Width of dorsal field of male tegmina less than 4/10 of length; length 10 to 12 mm. Pronotum usually with a darker median streak. Deciduous trees and shrubs. Mass., Mich., Minn., S. D., to Fla., Kans., and Tex.

  O. angustipennis Fitch

CCC. Swelling with a club-shaped black mark, broadest proximal. Second segment with elongated black mark. Width of dorsal field of male tegmina less than 4/10 of length; length 12.5 to 14 mm. On certain oaks, sometimes on hickory, beech and other deciduous trees. Conn. and Long Island to Ohio, Tenn., Mo., and Iowa.

  O. exclamationis Davis
BB. Front face of proximal antennal segment without a swelling on the inner edge; this edge nearly straight except at the base and nearly parallel with outer edge.

C. Subgenital plate of female with a broad notch posteriorly, half as broad as widest part of the plate. Width of dorsal field of male tegmina about half the length (in one case as low as 0.44). Front side of proximal antennal segment never ornamented with more than a narrow dark line along the inner edge.

D. Typically pule straw color or ivory, with top of head and base of antennae purplish pink; proximal antennal segment without distinct markings. Large; male tegmina 15 mm. and over, female, 11 mm. and over; ovipositor 6.5 mm. and over. Pronotum width at hind margin seldom greater than length in males, distinctly less in females; pronotum small in relation to tegmina so that width of hind border goes into length of tegmina 5 to 6 times. Hollow on side of terminal segment of maxillary palp rarely covers more than distal third of segment. In thickets of shrubs, vines and tall weeds. Long Island, southern Mich., and Miss., southeastern S. D. to Ga., Miss., and Kans., possibly to Tex.

O. latipes Riley

DD. Brown to ivory with only a reddish tinge on top of head in pale forms; proximal antennal segment in many specimens with a dark line along the inner edge of front face. Smaller; male tegmina 10 to 13 mm.; female, 8 to 11.5 mm.; ovipositor 5 to 6 mm. Pronotum width of hind border generally exceeding length by one-tenth; in females length seldom exceeds width by more than one-tenth. Pronotum larger in relation to tegmina, width of former included in length of latter 4 to 5 times. Hollow on side of terminal segment of maxillary palp covers distal 3/5 to 1/2 of segment. Thickets of shrubs and other low plants. Wash. (?), Ore., Idaho, to Calif., Colo., Ariz., N. Mex., Tex., and Ark. (?).

O. californicus Saussure
Subgenital plate of female with a narrow notch posteriorly, not more than one-fifth of widest part of plate.

Male tergina narrow; width of dorsal field rarely over 4/10 of length. Front side of proximal antennal segment, with few exceptions, ornamented with more than a narrow line along the inner edge.


O. pini Beutenmuller

DD. Head and pronotum typically with a fuscous median stripe on pale yellowish ground color, (or these parts entirely pale or nearly entirely black). Stermites of abdomen typically entirely black; atypically lightly infuscated or pale. Proximal antennal segment ornamented as in classes 6' to 9', atypically as in 5 (Table II). On tall weeds, shrubs or young trees or vines. Typical: Mo., Ont., Minn., S. D., to eastern Kans., Mo., Ky., and Va.; in mountains to Tenn., and N. C. Atypical: Man., N. D., to Nebr., western La.

O. nigricornis nigricornis Walker

DDD. Body entirely pale or with abdomen lightly infuscated along each side of the sternites and dorso-laterally. Proximal antennal segments ornamented as in classes 6 to 8; atypically with line as in 5, but with spot reduced. Generally on woods 1 to 3 feet high, or small shrubs. Great plains and west to Pacific.

O. nigricornis argentinus Saussure


O. nigricornis quadripunctatus Beutenmuller
Summary.

Three tree crickets of the genus Oecanthus, namely nigricornis, quadripunctatus and argentinus, differ from each other mainly in color characters and have been separated by the nature of the black markings on the two proximal antenal segments. There has been some dispute among taxonomists as to whether they represent distinct species.

In order to classify the material from various localities on the basis of the antennal pattern, twelve approximately equal, arbitrary classes were originated. The classes with light pattern (quadripunctatus) run in a straight line series up to a middle point and from there diverge in two directions, toward the extreme types of nigricornis and argentinus.

In the eastern portion of the U. S. corresponding roughly to the country originally largely covered with forest, nigricornis and quadripunctatus are present and distinct in color characters, ecological distribution and habits, as well as having distinct types of eggs. They could be considered separate species if they did not extend beyond this region.

In the great plains region, nigricornis, quadripunctatus and argentinus are found, with many intermediate forms. The three are often associated in the same field on the same kinds of plants. The characteristics which typify nigricornis gradually disappear from the population toward the west, while the reverse is true of argentinus characters, which come no farther east.
than the true prairie regions.

Only argentinus and quadripunctatus are found in the Rocky mountain region and are not clearly separated. The former only has been found in the Pacific coast region.

Quadripunctatus has the same distinct type of egg in N. Y., Ohio, Fla., and Iowa. In the western region the eggs of individuals falling in the quadripunctatus classes of antennal pattern are of a different type and resemble those of typical argentinus.

Until better characters are discovered for separating the three tree crickets of this group, it seems advisable to consider them as subspecies.

A revised key to the Oecanthinae of North America is appended, based on this and other recent work.
Literature Cited.


