

REPORT OF WORK
OF THE
EXPERIMENT STATION
OF THE
HAWAIIAN SUGAR PLANTERS' ASSOCIATION

**Leaf-Hoppers and their
Natural Enemies**
(*PT. VII. ORTHOPTERA, COLEOPTERA
HEMIPTERA*)

BY O. H. SWEZEY

HONOLULU, H. I.
DECEMBER, 1905

LETTER OF TRANSMITTAL.

Honolulu, T. H., December 1, 1905.

To the Committee on Experiment Station, H. S. P. A., Honolulu, T. H.

Gentlemen:—I herewith submit for publication the seventh part of the *Bulletin* on "Leaf-Hoppers and their Natural Enemies," which deals chiefly with predaceous insects established in the cane-fields, and has been prepared by my assistant, Mr. O. H. Swezey.

Yours obediently,

R. C. L. PERKINS,
Director, Division of Entomology.

INTRODUCTORY REMARKS.

Since the cane leaf-hopper has become so abundant in the Hawaiian Islands, certain predaceous insects have taken to feeding upon them and have likewise increased in abundance; so that they are now found as constant inhabitants of the cane-fields wherever leaf-hoppers are abundant, and are of no little value in helping to check the increase of the latter.

Of the insects treated in this Part the grasshopper (*Xiphidium*) is by far of the most importance. It is not indigenous to the Islands, but from whence it came is not known. Its introduction was accidental about 15 years ago. There are many species of this genus in all parts of the world. I have seen no mention of any species being insectivorous, they being chiefly grass feeders. It is not unlikely that our species has developed its partial insectivorous habit since its introduction here, and since the increase of the leaf-hoppers to such an abundant food-supply.

The bugs (Hemiptera) treated of, with the exception of *Zelus perezgrinus*, are native to the islands, and have become adapted to a leaf-hopper diet by reason of the fact that this pest furnishes a convenient and bountiful food supply. They are not feeding exclusively upon this new source of food, but may be found as well in their former habitats feeding upon their original prey.

The ladybugs treated of are primarily Aphis feeders, and have all been introduced from Australia. When found in cane-fields there is no doubt but that they have been especially attracted by the cane Aphis, which is usually more or less present in fields of young cane. *Coccinella repanda*, the ladybug which has been the longest introduced, is very common in all parts of all the islands; when in cane fields, it also preys upon young leaf-hoppers, especially when its food-supply of Aphis is scarce or has become exhausted. It is very probable that the recently introduced species will do the same when they have become established and generally distributed, and that they will be a valuable addition to the present force of predaceous insects preying upon the leaf-hopper pest.

Heretofore the life history of none of the insects herein treated has been studied. In the observations recorded in this paper, a number of new and interesting facts pertaining to life history have been brought out.

ORTHOPTERA.

LOCUSTIDAE.

Xiphidium varipenne, sp. nov. (Pl. XIV.)

(1). Distribution.

This insect, described below, has been present in these Islands (Oahu at least) for about 15 years. It was recorded by Brunner as *X. fuscum* in 1895. It was also collected by Schauinsland in 1896-97, and published under the same name by Alfken. It must have been introduced at Honolulu, and did not get spread far from there for several years, as Perkins says concerning it in *Fauna Hawaiiensis*, II, p. 14, 1899, "Only in and around Honolulu." The fact of its depositing its eggs beneath the leaf-sheaths of sugar cane makes it easy of distribution in "seed" cane, and probably accounts for its present distribution to all of the islands. It is at present very generally distributed, in fact, it might be said that they are everywhere: lowlands, valleys and mountains, gardens, pastures, and cane-fields. It is called by different names in different localities: Longhorned Grasshopper, Red-tailed Grasshopper, Brown-tailed Grasshopper, and Green Cricket being names commonly used.

(2). Feeding Habits.

Being a grasshopper of the family Locustidae, it would naturally be taken for a grass and foliage feeder, as are the majority of the grasshoppers; but observation proves it to be largely insectivorous. Whether they have always been so, may not be determined; but recently, their being abundant in sugar cane-fields and that, too, where but little evidence is seen of their having eaten cane, has led to investigation by the entomologists, and planters as well, with the result that this grasshopper is found to feed to a large extent upon sugar cane leafhoppers and other insects. They probably catch the adult leafhoppers mostly by lying in wait till a leaf-hopper approaches or alights near. In one instance an adult leaf-hopper was seen to alight immediately in front of an adult grasshopper; the latter

pounced upon it instantly, securing it by means of the mandibles, and it was soon eaten. They have the habit of lurking about the axils of the upper leaves, or the crown of the cane stalk just where the leaf-hoppers congregate in large numbers in young cane, and it is easy for the grasshoppers to capture an abundance of their prey, especially the young leaf-hoppers. When confined in a breeding cage with growing cane for several days, very little eating of the cane was done; but when leaf-hoppers were introduced they were at once devoured.

Young grasshoppers were bred from the egg to maturity, being fed entirely upon leaf-hoppers and aphids. Very young grasshoppers were seen to capture and eat nymphs of leaf-hoppers of nearly their own size.

Freshly hatched grasshoppers, fed with tender *manianic* grass, died after 5 days, without having eaten a particle. Other freshly hatched grasshoppers were tried upon tender cane leaves. They died after 6 days without having eaten anything. Young grasshoppers have been seen eating the blossoms of *Canna*, *Lantana*, and other plants, so that they are not entirely insectivorous. In eating *Lantana* blossoms they ate through the tube of the corolla at the place where the stamens are located inside, apparently to obtain the pollen.

The eating of cane done by this insect is of no consequence. It occasionally does some ragged eating of the younger leaves near the tip. In cane-fields, I have observed them feeding to a large extent upon the leaves of *Honohono*, and the flowers of various kinds of weeds; and I have also seen them eating the seed capsules and young seeds of *Canna indica* to a considerable extent. They were very numerous in a patch of this plant growing in Makiki Valley, above the H. S. P. A. Experiment Station grounds. Examination of crops of adults and nearly full-grown nymphs collected in this patch and vicinity showed that 8.82% contained insect remains, and 91.18% contained vegetation.

Examination of the crops of a large number of grasshoppers collected on Mt. Tantalus, by Mr. W. M. Giffard, Nov. 6, 1904, gave the following results:

21.2% contained insect remains, of which 6.6% contained only insects, 14.6% contained both insects and vegetation, 78.6% contained vegetation only.

A number of grasshoppers caught in a cane-field where there were plenty of leaf-hoppers, were examined, and the crops of 30% of them contained fragments of leaf-hopper. On examination of crops of grasshoppers gathered in cane at H. S. P. A.

Experiment Station grounds, 33.3% were found to contain insect remains; leaf-hopper fragments were found in 15.5%; 15.5% contained vegetation; 40% empty.

Examination of their crops does not prove to what extent they eat leaf-hoppers, for they do not always swallow the hard parts of these. Often in the breeding cage they were seen to chew up leaf-hoppers, and reject them after sucking the blood and juices. However, from these examinations, and field and insectary observations, it is certain that this grasshopper is very extensively insectivorous, and that when present in cane-fields, leaf-hoppers form the chief part of its diet, and it therefore should be classed as a beneficial insect, and a highly valuable enemy of the leaf-hopper.

(3). Egg Parasite.

In March, 1905, parasitized eggs of this grasshopper were discovered in cane on H. S. P. A. Experiment Station grounds, and a pale yellow Chalcid parasite was bred from them. The number bred, ranged from 9 to 14 per *Xiphidium* egg, and in one instance a whole cluster of 10 eggs had been parasitized; in another case 13 eggs were parasitized. All the parasites in an egg usually issued from the same hole, (Pl. XIV, fig. 11), the first one to mature probably gnawing a hole out, and the others taking advantage of the opening already made. This tiny round hole is often made through the enclosing sheath of the cane leaf as well, where the eggs are quite tightly enclosed by the latter. Parasitized eggs were examined from which the parasites had not yet emerged. They are a bluish black in color. Larvae were found in some, and pupae in others. The pupae were not enclosed in individual cocoons.

Adult parasites were placed with fresh grasshopper eggs, in which they were soon seen ovipositing. In one case adult parasites emerged in 25 days; in others 22-24 days; in one 20 days; another 31 days; giving a range of from 20 to 31 days for the life cycle.

The shortness of life cycle compared with the length of life cycle of the host (3 months) gives the parasite the advantage, and it is likely that this grasshopper may become reduced in numbers more rapidly than it has increased since its appearance a few years ago. In fact, it has been reported as rapidly disappearing recently in the Kohala District, Ewa Plantation, and some others. This is undoubtedly due to this parasite, though its presence there has not been ascertained. The grasshoppers

have similarly become scarce in the cane of the Experiment Station grounds, during the past summer.

Perhaps this parasite is more or less generally distributed. The writer has found it common where the grasshoppers were abundant on Hilo grass and *Canna indica* up Makiki Valley, about one mile from the Experiment Station grounds.

On a trip to the sugar plantations of Maui, in October, this parasite was found to be very rare, and the grasshopper exceedingly abundant everywhere. In the examination of 300 grasshopper eggs, in a cane-field at Lahaina, only one parasitized egg was found. From this 7 parasites issued.

Mr. Terry found that the parasite was present at Koloa, Kauai, April, 1905; and also reports that the grasshoppers are decreasing in other places on that island.

(4). Life History.

The eggs of *X. varipenne* are 5 mm. long and nearly 1 mm. in greatest diameter, blunt at one end and pointed at the other, which is the one where the head of the embryo appears. They are slightly testaceous in color at first, but become greenish as the embryo approaches time of hatching.

The eggs are laid in clusters of from 2 to 15, side by side, obliquely inserted beneath the leaf-sheaths of cane leaves (Pl. XIV, fig. 11), also those of *Canna indica*, and probably other plants. Their presence can often be noticed by a slight outward bulging of the leaf-sheath. The eggs are inserted with the anterior end outermost. They hatch in about 5 weeks. In one case, adults were placed in a breeding cage, March 28, and young grasshoppers appeared on the 35th day. In another observation, eggs laid April 6th hatched May 14th—a period of 38 days. Eggs gathered June 27th hatched through a period of 16 to 29 days, being in various stages of embryonic growth when gathered. In hatching, the egg splits on one side at the anterior end, about $\frac{1}{3}$ length, but not extending quite to the tip.

The nymphs in all stages are green, with the dorsal, brown, pale-edged stripe of the adult. (Pl. XIV, fig. 2.)

Those bred to maturity molted 6 times (one individual 7 times), counting the final change to maturity. The molts were at intervals of 6-23 days as follows:

First molt	6-11	days.
Second "	7-23	"
Third "	9-12	"
Fourth "	8	"
Fifth "	9	"
Matured	20	"

Record of one individual.

Hatched	June 1.		
First molt	" 7	First Stage	6 days.
Second "	" 30	Second "	23 "
Third "	July 9th	Third "	9 "
Fourth "	" 17th	Fourth "	8 "
Fifth "	" 26th	Fifth "	9 "
Matured	Aug. 15th	Sixth "	20 "

Total 75 days.

One individual matured in 111 days: (embryonic period 38 days, nymphal period 73 days.)

	Body	Wings	Ovipositor
Measurements:			
Just Hatched	4 mm.	.....	.....
First Instar	4-5 "	.....	.....
Second "	6-8 "	.....	1 mm.
Third "	10 "	.....	2 mm.
Fourth "	11-13 "	1-2 mm.	4-5-5 mm.
Fifth "	14-15 mm.	1-3 "	10-11 mm.
Sixth "	15 "	4 "	11-12 mm.

The ovipositor makes its appearance in the second instar (1 mm.), increasing in length with succeeding stadia, but its development is not uniform per instar.

The teeth of male cerci appear in fourth instar, being very small, on inner side, near the apex; in fifth instar they are larger and about the middle of inner side.

(5). Description.

Xiphidium varipenne, sp. nov.

Bright green; fastigium reddish brown and a dorsal stripe of the same color extending backwards the whole length of the body; from the fastigium it widens to the width of the pronotum when it reaches the posterior margin of the latter; a whitish line borders this stripe on either side, sometimes obscure on the abdomen, sometimes yellowish; on either side of the abdomen of female a brownish stripe outside of the whitish line, often red-

dish, fainter behind; abdomen of male beyond the fourth segment bright yellowish brown. Eyes brown. Ocellus white. Antennae greenish, ringed with brown, outer part entirely brown, large basal segment with brownish spots. Mandibles black on biting edges; palpi green, more intense at the enlarged tips. Tiny brownish dots on face. Larger brownish dots on sides of pronotum, and all the femora and tibiae. Knees of posterior femora dark brown, tarsi slightly browned.

Fastigium, viewed from in front, with lateral margins distinctly diverging upwards. Posterior margin of lateral lobes of pronotum nearly straight, slightly concave; callus narrow, slightly convex; two slender prosternal spines. Anterior and intermediate tibiae with six (occasionally 7) pairs of brownish spines on under side. Posterior femora with 2 to 4 (occasionally none, only one, or as high as five) short black spines on their lower outer carinae; genicular lobes bispinose on each side. Posterior tibiae with two rows of 22-32 spines on upper side, 5 to 12 spines on under side, approximately in pairs; 2 movable spurs on each side beneath at apex, and very near the apex an additional spur on each side, the one on the outer side the larger.

Tegmina and wings nearly transparent; veins in long tegmina greenish, in short tegmina reddish in female and greenish in male. Cerci of male obtuse, depressed towards the apex, on the basal third a downward and forward projecting tooth on the inner side. Ovipositor brown, 11-13 mm.

Measurements :		Body	Hind Femora	Tegmina	Antennae	Ovipositor
Male... ..	15-19 mm.	12.5-14.5 mm	6-18 mm.	45-60 mm.	.....
Female.....	15-19 "	13-15.5 mm.	4.5-20 mm.	45-60 mm.	11-13 mm.	

(6). Variation.

The following tables show the variation in length of tegmina, the measurements being in millimeters:

Females.

Body	Tegmina	Body	Tegmina	Body	Tegmina	Body	Tegmina
15	4.5	16.5	6	15	6	17	7
16	4.5	17	6	15	6	18	7
17	4.75	17.75	6	17	6	17	7.25
17	4.75	16.5	6	17	6	16.5	7.5
16	5	16	6	16	6	17	8
17	5	16.25	6	16.5	6.25	16	8.5
16.5	5	17	6	17	6.25	18	10
18	5	19	6	18	6.5	18	11
16	5	16	6	18	6.5	18	12
17	5	18.75	6	19	6.5	18	12
16.5	5	17	6	17	6.5	19	13
15	5	17	6	18.5	6.5	16	15.5
17	5	17	6	18	6.5	18	17
15	5	18	6	17.75	6.5	17	17
14	5	17	6	17	6.5	18	17
17	5	16	6	19	6.5	17.5	17.5
15.5	5	18	6	19	6.5	18	17.5
14	5.25	16	6	18	6.5	17	18
19	5.5	16	6	16	6.5	19	18
16.5	5.5	16	6	18.25	6.75	17	18
16	5.5	17	6	17	7	18	18.25
16	5.5	17.5	6	17.5	7	17	19
14.5	5.5	18	6	19	7	18	20
16	5.75	16	6	18	7	.....	.....
16	5.75	.....	.....	.....	.....	.....	.....

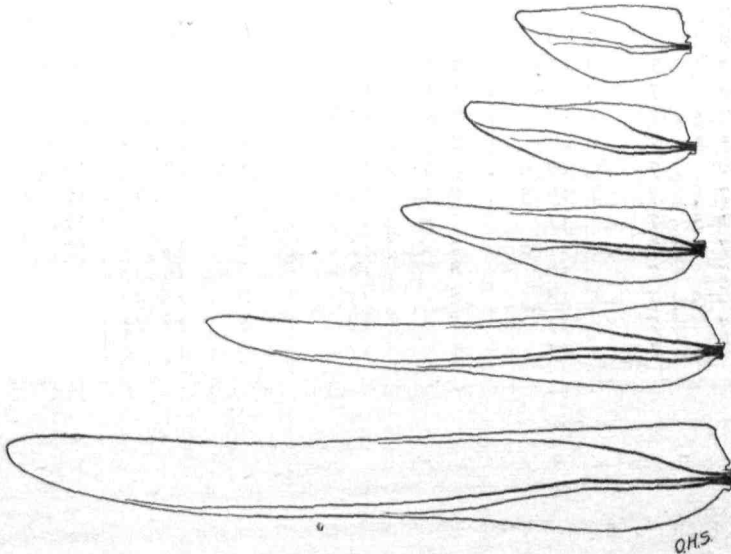
Males.

Body	Tegmina	Body	Tegmina	Body	Tegmina	Body	Tegmina
17	6	16	7	17.75	8	17	8
16.5	6	16	7	16	8	17	8
17	6.25	16	7	17	8	16	8.5
15.5	6.25	16	7	18	8	17	8.5
16	6.5	15.5	7.25	16	8	16.5	8.5
17.5	6.5	15.25	7.25	16	8	16.5	8.5
16	6.5	15.25	7.25	17	8	17.5	9
15	6.5	17	7.5	17	8	17	9
16.5	7	17.25	7.5	16.5	8	17	9
17.5	7	17	7.5	15	8	17	9
15	7	17.5	7.5	18	8	17	9
16.5	7	16	7.5	18	8	17	9.25
16	7	16	7.5	17	8	17	10
18	7	15	7.5	16.5	8	16	10.5
18	7	17	7.5	17	8	16.5	11.5
17.5	7	18	7.5	17.5	8	17.5	14.5
15.5	7	16	7.5	17	8	16.75	16
16	7	16	7.5	18	8	17	16
17	7	16.5	7.5	19	8	18.5	17
16.5	7	17	7.5	16	8	16	17
17.5	7	17.5	8	17	8	19	17
17	7	16	8	18	8	16	17
16.5	7	18.5	8	17	8	16.5	17.25
17	7	17	8	17	8	17.25	17.25
16.5	7	17	8	17	8	17	18

Specimens for the above tables were collected in Makiki Valley, Honolulu, March, 1905.

These tables show the range of variation in length of tegmina, and that the length of tegmina is not in accordance with variations in size of the body of the insect. It also shows proportionate number of specimens having the different lengths of tegmina. It is seen that specimens with short tegmina are much the most numerous in this particular locality; whereas, Mr. Perkins states that when first it became common around Honolulu about 5 years ago, there were no short-winged forms.

In the females, when the tegmina are 4.5-6.5 mm. long they extend over 3 or 4 segments of the abdomen, and the wings are slightly shorter; when tegmina are 7.5 mm. long they extend over 6 segments of the abdomen, and the wings are 1.5 mm. shorter; when the tegmina are 12 mm. long they extend about to the tip of the abdomen, and the wings are 2 mm. shorter; when the tegmina are 17-18 mm. long they extend beyond the tip of the abdomen reaching about to the apex of the femora, and the wings extend about 4-5 mm. beyond the tegmina, about to the tip of the ovipositor.



Series of tegmina of adult females, in outline, x $\frac{5}{8}$.

In the males, when the tegmina are 6.5-8.5 mm. long, they extend over 5 to 7 segments of the abdomen, and the wings are .25-1 mm. shorter; when the tegmina are 10.5 mm. long, they extend over 8 segments of the abdomen, and the wings are about 1 mm. shorter; when the tegmina are 11.5 mm. long, they reach the tip of the abdomen, and the wings are about the same length; when the tegmina are 17 mm. long they extend to the apex of the femora, and the wings are 4 mm. longer.

Observations were taken in different months of the year to determine whether the season made any difference in the length of tegmina. The following table shows the percentages of the different forms as they occurred in Makiki Valley, about one mile above the Station:

1905

		1905				
TEGMINA		March	July 12	Aug. 7	Sept. 20	Nov. 15
Short-winged form	(male 6-10.5 mm.	89 %	91.2 %	89.2 %	94. %	92. %
	(female 4.5-8.5 "	81.5	85.5	85.7	88.	82.
Intermediate	(male 11.5-14.5 "	2	1.1	3.1	2.	2.
	(female 10-13 "	5.1	4.5	2.4	4.	2.
Long-winged form	(male 16-18 "	9	7.7	7.7	4.	6.
	female 15.5-20 "	13.4	9.	11.9	8.	16.

From this, there is obviously no apparent seasonal variation.

Observations in the cane-fields of the Station grounds were not in accord with this, however. In March, 1905, they were nearly all the shortwinged form; but in August, there were none but the long-winged form. They were quite scarce at this time, however, only 25 adult specimens being seen in a half-hour search. In September the condition was similar. Of 36 adults seen in a half-hour search there was but one of the short-winged form.

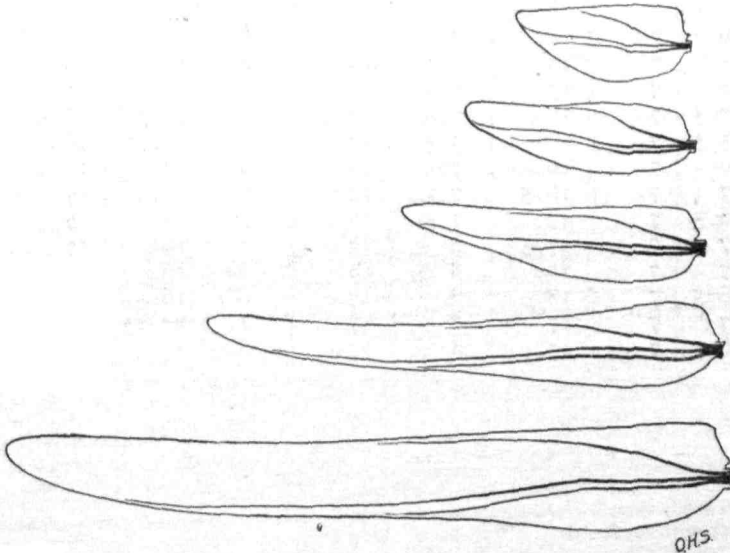
The following table shows that the proportion of long and short-winged forms varies considerably in different localities:

	Iao Valley, Wailuku, Maui, Sept. 30, 1905	Kipahulu, Maui, Oct. 9, 1905	Pacific Heights, Honolulu, Oct. 28, 1905	H. S. P. A. Ex. Station, Honolulu, Nov. 10, 1905
Short-winged form.....	18%	16%	87%	.....
Intermediate.....	2%	2%	2%	.....
Long-winged form.....	80%	82%	11%	100%*

Specimens for the above tables were collected in Makiki Valley, Honolulu, March, 1905.

These tables show the range of variation in length of tegmina, and that the length of tegmina is not in accordance with variations in size of the body of the insect. It also shows proportionate number of specimens having the different lengths of tegmina. It is seen that specimens with short tegmina are much the most numerous in this particular locality; whereas, Mr. Perkins states that when first it became common around Honolulu about 5 years ago, there were no short-winged forms.

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Series of tegmina of adult females, in outline, x $5\frac{1}{2}$.

In the males, when the tegmina are 6.5-8.5 mm. long, they extend over 5 to 7 segments of the abdomen, and the wings are .25-1 mm. shorter; when the tegmina are 10.5 mm. long, they extend over 8 segments of the abdomen, and the wings are about 1 mm. shorter; when the tegmina are 11.5 mm. long, they reach the tip of the abdomen, and the wings are about the same length; when the tegmina are 17 mm. long they extend to the apex of the femora, and the wings are 4 mm. longer.

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The following table shows that the proportion of long and short-winged forms varies considerably in different localities:

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Short-winged form.....	18%	16%	87%
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There is no described species which varies so much in length of tegmina as ours does. In Redtenbacher's Monograph of the Conocephalidae, the long-winged species of *Xiphidium* are separated specifically from the short-winged species. It seems probable that many of the species described as short-winged, may be but short-winged forms of the long-winged species, or vice versa.

In the United States five species of *Xiphidium* have been observed to have dimorphism in the wings.

- X. ensiferum* Scudder, Usually short-winged; "long-winged forms are found occasionally"^o
- X. nigropleurum* Bruner, "Tegmina are usually abbreviated." "An occasional specimen is to be found in which the wings are fully developed."^o
- X. strictum* Scudder, "Dimorphic, the long-winged forms, however, being very scarce."^{**}
- X. attenuatum* Scudder, Dimorphic, but only short-winged forms mentioned for Minnesota.^o Both forms in Indiana, about equally abundant in the northern part, only the short-winged form in the southern part of State.^{**}
- X. saltans* Scudder, Usually short-winged. "A long-winged pair August 9, 1903."^{***}

I have found no mention of intermediate forms in connection with the dimorphism of these species.

Blatchley † says of the Genus *Xiphidium*, "Variations in length of wings seem to be abrupt with no intervening forms. There are long-winged and short-winged forms of the same species, but none with the wings of medium length. Four of our eight species are thus dimorphic as regards the length of the wings, the short-winged individuals, as far as my observation goes, far outnumbering those with the wings fully developed."

From my table of measurements it will be seen that there is a small proportion of individuals of *X. varipenne* which have wings of medium lengths. I am of the opinion that intermediate forms may yet be found in other species; and further, that more of the species may be found to be dimorphic as regards wings.

Our species was referred to *X. fuscum* Fab. by Brunner, "Orthoptera of the Sandwich Islands," P. Z. S., London, p. 894, 1895. The same name is used by Perkins, Fauna Hawaiensis,

^o Lugger, Bull. 55, Minn. Ag. Exp. Station, pp. 331, 2, 3, 1897.

^{**} Blatchley, 27th An. Rep. Dep. Geol. and Nat. Resources, pp. 379, 381, 1902.

^{***} Walker, Can. Ent. XXXVI, p. 340, 1904.

† Orthoptera of Indiana, 27th An. Rep. Dep. of Geol. and Nat. Resources, p. 371, 1902.

II, p. 14, 1899. It is the *Xiphidium fuscum* (Fab.) mentioned by Kirkaldy in "A Preliminary List of the Insects of Economic Importance Recorded from the Hawaiian Islands," The Hawaiian Forester and Agriculturist, I, p. 184, 1904. It differs from descriptions of *X. fuscum*, however, in the following respects: the posterior margin of the lateral lobes of the prothorax are more nearly straight, not "strongly sinuate;" cerci of male are obtuse, not "acuminate," and the teeth are differently placed (Pl. XIV, figs. 8, 9); subgenital plate of male is truncate, and not "slightly triangularly emarginate." *X. fuscum* is an European species and less likely to have reached these islands than some species from the western coast of North America, or from Asia or Australia. Our species differs from all described species from Asia and Australia. It comes nearer to *X. spinosum* Morse, (Can. Ent., XXXIII, p. 201, 1901), occurring in California. It differs from the latter species, however, by its coloration, being green, not "testaceous;" the spines on under side of posterior femora are not "strong;" the antennae are much longer; and the ovipositor is much longer, in fact our species is quite distinctly larger in all measurements. At present the original habitat of our species is a matter of considerable doubt.

Described from numerous specimens collected in Honolulu and elsewhere in the Hawaiian Islands.

Xiphidium latifrons Redtenbacher.

Redtenbacher, Monographie der Conocephaliden, ° p. 212, 1891.

What appears to be this species was collected at Bundaberg, Australia, by Mr. Perkins. It agrees with Redtenbacher's description except that it is the long-winged form; whereas, he described it as being only short-winged.

Another closely related *Xiphidium* was collected by Mr. Perkins. These species swarmed in some cane fields of Australia.

° Reprint from Verh. der k. k. Zool. Bot. Ges. Wien, pp. 315-562, 1891.
X. latifrons on p. 526 of this publication.

COLEOPTERA.

COCCINELLIDAE.

Callineda testudinaria, Mulsant.* (Pl. XV, figs. 1-4.)

Two specimens of this species of Ladybug, collected at Bundaberg, Queensland, Australia, by Messrs. Koebele and Perkins, and received at the Experiment Station, Dec. 6, 1904, survived. These proved to be a male and a female, and egg-laying began Dec. 15th and continued for several weeks till the death of the female. 944 eggs were produced. These hatched, and the larvae were reared to maturity. Some were sent out to sugar plantations, while others were retained for breeding. They have been breeding with some interruptions at the Station and from time to time lots of 25-50, or more, have been sent out to the plantations to start colonies of them in the cane-fields. Many plantations have been supplied already, and others will be as soon as they are bred in sufficient numbers.

In confinement this Ladybug is a very voracious feeder upon leaf-hoppers and all species of Aphis; and, as is usual with the ladybugs, both larvae and adults are equally voracious. A nearly full-grown larva, in confinement, was observed to eat 15 cane Aphids in 6 minutes; and in 24 hours had eaten 140 Aphids. Another larva ate 17 cane Aphids in 9 minutes; and 153 Aphids in 24 hours. A third larva ate 5 Aphids in 2 minutes, and 100 in 24 hours. A full-grown larva, fed upon leaf-hoppers, ate an adult and 22 medium-sized nymphs in 24 hours. The Aphids were eaten in entirety; but the leaf-hoppers were chewed up, their juices sucked, and the hard parts rejected. The larvae are very cannibalistic, eating those of their own size even, when other food is scarce. They, as well as adults, will also eat the eggs of their own species. In a cluster of eggs, if some hatch before others, the larvae are likely to eat the other eggs or such larvae as hatch later. *

It is hoped that this species will be helpful in the cane-fields against the leaf-hopper. Being larger than *Coccinella repanda*,

* Crotch, Coccinellidae, p. 161; Froggatt, Agric. Gaz., N. S. W., XIII., p. 900.

it should be more effective than the latter, when it becomes as abundant and as generally distributed.

As seen from the number of eggs laid by the original female, they are very prolific and should increase rapidly in the cane-fields when they once get a start. They cling very tenaciously to objects when jarred or blown by the wind.

This ladybug may be easily distinguished by its large size, and striking markings. It is larger than our other ladybugs. It measures 5-6.5 mm. long by 4.5-5.5 wide, and is very convex. The color is a shining light yellow with black markings on the prothorax and the elytra. Those on the elytra mark them off into 5 trapezoidal areas on each elytron, somewhat resembling the plates on the back of a turtle; hence, the name "testudinaria." These black markings vary in intensity and extent; often they are distinct and perfect bands, marking off the 5 areas, but usually some of the markings are absent on the posterior part, or faint, or reduced to elongate spots.

Life History.

In the insectary, adults began copulating 7 to 20 days after reaching maturity, usually about 10 days, and egg-laying began the same day or the day following. The eggs are bright yellow, 1.5 mm. long, cylindrical, tapering at the ends, and are placed on end in clusters on the surface of leaves usually in a somewhat hidden place, as where the margin is dried and curled under. (Pl. XV. fig. 2.) The clusters contain from 9 to 64 eggs, or an average of about 30, and a cluster is deposited every day, or nearly so. One female was observed to deposit a cluster of 32 eggs in 15 minutes; another female deposited 49 eggs in 23 minutes. This is at a rate of about 2 per minute. Records of the number laid by individual females are as follows:

Egg-Laying Period.	Number of Eggs Laid.
Dec. 15th, 1904 to Feb. 1905.....	944
March 22, 1905 to April 28, 1905.....	632
May 31, 1905 to July 24, 1905.....	591

This shows the egg-laying period to be from 5 to 10 weeks. In each case the females laid eggs up to the time of their death, but there were fewer eggs per cluster towards the end. In the third case the female had been laying eggs for a few weeks before any record was taken. It is not unlikely that the egg-laying period would be somewhat longer when the insects are in a state of freedom.

In breeding this Ladybug, it was observed that copulation took place frequently; in fact, a pair kept in a tube by themselves

were observed to copulate almost daily, or after each deposition of a cluster of eggs. The thought arose as to whether this frequent copulation was necessary for the hatching of the eggs, for with insects one copulation is the rule, even with the queen honey bee which lays eggs for a period of two or three years.

To ascertain if such frequent copulation was necessary, a female which had been laying eggs several weeks, having a male present, and copulation occurring frequently, was placed by herself. Egg-laying continued as before, with the following result:

May 31,	35	eggs; hatched.	
June 1,	33	"	"
" 2,	32	"	"
" 3,	23	"	"
" 4,	23	"	"
" 6,	11	"	"
" 7,	30	"	"
" 8,	20	"	"
" 10,	7	"	"
" 11,	24	"	"
" 12,	8	"	"
" 13,	22	"	"
" 15,	20	"	"
" 16,	6	"	"
" 17,	5	"	"
" 18,	15	"	"
" 26,	8	"	"
" 27-8,	26	"	"
" 29,	29	"	"
" 30,	21	"	"
July 2,	7	"	destroyed.
" 3,	12	"	hatched.
" 4-5,	59	"	"
" 8,	7	"	"
" 9,	7	"	"
" 10,	2	"	destroyed.
" 12,	25	"	hatched.
" 14,	18	"	"
" 15,	6	"	destroyed.
" 17,	26	"	only a few hatched.
" 20,	11	"	" " "
" 21,	10	"	" " "
" 24,	3	"	failed to hatch.
" 25,	Died.		
Total	591	eggs.	

It will be seen that she continued laying eggs for fifty-five days, until her death occurred; and that the eggs hatched, up to about the last ten days of her life when only a few hatched of those laid.

This experiment proves that the frequent copulation which had been observed during the egg-laying period was not necessary.

The eggs hatch in 3 to 6 days, usually in 4 days. The larvae molt 3 times before pupating, at intervals of 2 days and there are 5 to 6 days between the 3rd molt and pupation. In the first three stages the larvae are black. There are four rows of spiny tubercles on the back, after the third molt the head is dull yellow; broad sides of the pronotum light yellow, also the four tubercles of the first abdominal segment and the two dorsal tubercles of the 4th, 5th and 6th abdominal segments. The two dorsal tubercles on the 4th and 5th segments are often yellow after the second molt. As the larva approaches full growth it becomes lighter colored, somewhat yellowish, from the stretching of the skin between the black portions of the segments. This is especially so if the larva is very well fed. Size full grown is 11 mm. and this is attained in about 11-13 days, according to the abundance of food supply. (Pl. XV, fig. 3.)

The fullgrown larva suspends itself by the posterior end in some sheltered place, and in a day or two molts again and the pupa is formed. (Pl. XV, fig. 4.) It is about 5 mm. long by 3.5 mm. wide; light brownish yellow with black markings as follows: a pair of triangular spots on prothorax, their bases at posterior margin, often irregular lines extending from their apices to the anterior margin of prothorax; dorsum of mesothorax with 2 roundish spots at posterior margin, from these, 2 black stripes, widening posteriorly, extend backwards across the metathorax; a black line along the inner edge of the wing pads, another line parallel to it a short distance from the margin, often these lines are contiguous; a pair of black markings on each of segments 3, 4, 5 and 6 of the abdomen; those of segments 4, 5 and 6 are triangular with their bases at the posterior margin of the segments; those on the 3rd segment are quite irregular in shape longer transversely; sometimes a pair of small spots on 2nd segment.

The pupal stage lasts for 4 to 6 days, during which the adult is developing and when this is accomplished the pupa splits on the dorsal median line and the adult crawls forth. It is soft

and white at first, but remaining quiet, in a few hours it becomes hardened and its normal coloration appears.

The following is a summary of the life history:

Embryonic Period	4 days
Larval Period	11-13 days
Pupal Period	4-6 days
From maturity until egg-laying begins.....	7-20 days
From deposition of egg till ready to lay eggs again.	25-43 days
Egg-laying period about two months.	

There is practically about a brood per month, throughout the year.

HAB. Southern Queensland, Bundaberg and Brisbane, Australia, on *Aphis* of *Ficus*.

Coccinella repanda, Thunb.* (Pl. XV, figs. 5-7.)

This ladybug was introduced from Australia several years ago, and is now distributed over all the islands. It is very abundant in many places, and feeds upon all species of *Aphis*. It is found in the mountains, in the valleys, in gardens, orchards and grounds, and in sugar cane-fields. Although an *aphis* feeder, in cane fields it feeds to a considerable extent upon young leafhoppers, especially at times when cane *Aphis* is scarce.

This species is of medium size, 5.5 mm. long by 4.5 broad and very convex. It is recognized by the color of the elytra, being orange-red (often paler) with 9 irregular black spots, and a black line in the middle of the back, produced by the black margins of the elytra where they come together. The prothorax is black on posterior portion; anterior portion yellowish, boundary line between is irregular. Head yellowish, with black eyes.

(1). Life History.

The eggs are yellow, often very pale, 1 mm. long. They are deposited on end, on the under side of leaves and other sheltered places, in clusters of from 2 to 18, 10 or 12 being the usual number. They hatch in 3 or 4 days; the larvae are black with white markings. They grow rapidly and molt 4 times, including the molt which takes place at pupation. The interval between molts is 1 to 2 days, and the whole larval period is 8 to 9 days, depending upon abundance of food supply.

The full-grown larvae are 8 mm. long. (Pl. XV, fig. 6.) They

* Crotch, *Coccinellidae*, p. 117; Froggatt, *Agric. Gaz. N. S. W.*, XIII., p. 899.

are nearly black with a bluish tinge. There are four longitudinal rows of short tubercles on the abdomen. The prothorax has a yellowish posterior margin; and there is a light yellow patch in the middle of both meso- and metanotum, a smaller one at each side of the metanotum. The first segment of abdomen has a light yellow spot in middle and two spots on each side; the fourth segment has yellow patches including 4 tubercles thus producing a nearly complete yellow band; segments, 4, 5, and 6 and sometimes 7 are yellow on the lateral edges. Very similar markings are present on the younger larvae, but are white instead of yellow.

The full-grown larva suspends itself by the posterior end in some secluded place and after hanging curled up for 1 to 2 days a molt occurs, and the pupa is formed, which is yellowish in color with roundish black spots as follows: 2 on the prothorax; 2 on metathorax, and one on the wing pad at each side of these, making a transverse row of 4 spots; 4 on the 3rd abdominal segment; 2 on the 4th abdominal segment. Length of pupa 4.5 mm. (Pl. XV, fig. 7.)

The pupal period is 3 to 4 days. The adults emerge by a dorsal splitting of pupal skin. Some reared in the insectary were observed in copulation 7 days after becoming adults, and eggs were deposited on the following day, giving a period of 23 days from deposition of eggs to the maturity of adults and another generation of eggs deposited.

HAB. China; India; Malay; Singapore; Java; Bali; Flores; Triton Bay; Queensland and N. S. W., Australia; Tasmania; New Caledonia.

(2). Parasite.

Unfortunately a parasite (*Centistes americana*) preys upon this ladybug at some seasons of the year, reducing its numbers, and thus diminishing its effectiveness. This is the same ladybug parasite which is found in the United States, and Mr. Perkins found it in Australia, also, preying upon such species as *Verania lineola*, *V. frenata*, etc.

Verania frenata, Erichs.* (Pl. XV, figs. 8-19.)

This is a medium ladybug (4.5 mm. by 3.5 mm.) introduced from Queensland, Australia, December, 1904. Of the shipment

* Crotch, Coccinellidae, p. 175; Froggatt, Agric. Gaz. N. S. W., XIII., p. 901.

received, 14 were alive. From these, breeding has been going on with some interruptions, and colonies of adults have been sent to some of the sugar plantations. This is an *Aphis* feeder, but also ate young leaf-hoppers in insectary, and no doubt would feed upon them, especially the smaller nymphs, when cane *Aphis* became scarce in the cane-fields. In Queensland, Mr. Perkins found them abundant in grass and cane-fields, feeding on *Aphis*. It may be identified by its tawny yellow color, with the posterior portion of prothorax black; the elytra with broad black margins where they come together in the median line, and an elongate z-shaped black mark in the middle of each.

Life History.

The eggs are bright yellow, 1.25 mm. long, deposited on end, in clusters of 8 to 13 on underside of leaves, or other sheltered places. They hatch in 3 to 6 days, usually 4; the larvae molt 3 times before attaining full growth, at intervals of 2 to 4 days between molts, and about 6 to 7 days between the third molt and pupation; the whole larval period ranges from 15 days to 28 days or an average of about 19 or 20 days.

The full-grown larva (Pl. XV, fig. 9) is 7.5 mm. in length. It is without tubercles, slightly hairy, dark purplish brown, nearly black on dorsal side, with a white streak along the back, composed of large dorsal spots on each segment, beginning with the mesothoracic and terminating on the seventh abdominal segment; the dorsal spot on the fourth abdominal segment is three times as broad as the spots on adjacent segments; a lateral white line on each side, composed of spots on the edges of the segments terminating at the sixth abdominal segment, an additional white spot just above this line on mesothoracic and first and fourth abdominal segments; a median dorsal line on prothorax, widening posteriorly. These markings are not so pronounced in younger larvae.

The pupa (Pl. XV, fig. 10) is about 4 mm. long, suspended in some sheltered place. It is tawny yellow with a pair of black markings on anterior margin of prothorax, another pair on the posterior margin, also a pair on the mesothorax; inner margins of wing-pads black, faint traces of two brownish dorsal streaks on the abdomen. A spine on each lateral edge of the 3rd, 4th, 5th and 6th abdominal segments. The pupal period is 3 to 9 days, usually 4 to 5.

The summary of the life history is as follows:

Egg period 3 to 6 days.

Larval period 15 to 28 days.

Pupal period 3 to 9 days.

Egg to maturity 21 to 43 days.

HAB. Malayan Islands; Queensland, New South Wales, Australia; Tasmania; Balade, New Caledonia.

Verania lineola, Fabr.* (Pl. XV, fig. 11.)

This species was collected in Queensland and New South Wales, Aus., by Messrs. Perkins and Koebele. Several shipments of it were received at the Experiment Station during 1904. Some were liberated directly on Oahu Plantation. In a shipment received October 4, only one pair were alive, and they were retained for breeding. Their progeny were liberated on Oahu Plantation, and the plantation of Hawaiian Agricultural Co., Pahala, Hawaii, before they had increased to large numbers.

It is primarily an Aphis feeder, but ate young leaf-hoppers in confinement, and no doubt would do so in the cane-fields when Aphids were not readily obtainable. In Australia, they were found feeding on Aphis in grass and cane-fields.

In size this species is about 4 mm. long by 3 mm. wide. It is of a dull yellow color with four black spots on prothorax, 2 near the middle and two larger at the posterior margin, and 3 longitudinal black lines on the elytra, i. e., one formed by the black margin of the elytra, where they come together in the median line, and a black line near the middle of each elytron, nearer the outer margin and nearly concentric with it, sometimes terminating without reaching the margin; when it does reach the margin, it is at the inner margin a little distance from the apex.

Life History.

Eggs are yellow, laid on end, in clusters of 6 to 17, on under surface of leaves or other sheltered places; clusters deposited at intervals of 2 to 5 days.

Eggs hatch in 3 to 6 days.

Larvae full grown in 13 to 31 days.

Pupal period 4 to 8 days.

Eggs to maturity 20 to 45 days.

* Crotch, Coccinellidae, p. 176; Froggatt, Agric. Gaz. N. S. W., XIII, p. 901.

From this, it is seen that egg masses were produced at intervals of 2 to 9 days, or an average of 5 days. The eggs hatched in 8 to 10 days.

The nymphs molt 5 times including the final change to maturity. The following is the record of one lot bred in insectary:

	Length of Periods	Measurements
May 29th—Eggs deposited	Egg period 10 days	
June 8th—Eggs hatched	1st stage 5 days	1st stage 2 mm.
June 13th—1st molt	2nd stage 5 days	2nd stage 3.5 "
June 18th—2nd molt	3rd stage 5-8 days	3rd stage 5 "
June 23-26—3rd molt	4th stage 5-7 days	4th stage 6 "
June 28—July 3—4th molt	5th stage 9 days	5th stage 10.5 "
July 7-12—5th molt (matured)	Whole nymphal period 29-34 days	Adult 14 "

The nymphs are more or less sticky in all stages. The abdomen is rather ovate in shape and somewhat flattened above; in the younger stages it is much tilted up behind. Eyes red; legs white, ringed and spotted with black; stages 1 and 2 have black spines at tip of abdomen. 3, 4 and 5 have the spines also on the sides of the abdominal segments, increasing in size from before backwards. Full grown nymph is of a light bluish green color, with some reddish yellow markings on dorsum, segmentally arranged. (Pl. XVI, fig. 3.)

One female from the above lot (matured July 7th) deposited an egg-mass of 45 eggs July 23rd; or about two weeks after reaching maturity. This gives a period of 55 days from laying of eggs till the young have matured and themselves laying eggs, or about 2 months, which would give 6 broods per year, providing their development was as rapid at all times of the year. Probably their development would not be so rapid during the cooler months of the year—November to March.

Reduviolus blackburni, White.* (Plate XVIII, figs. 1-4.)

This pale, grayish colored native bug is generally distributed throughout the sugar cañe districts. Adults and nymphs prey upon cane-aphis and young leaf-hoppers.

* "Hemiptera," Fauna Hawaliensis, III, pt. II, p. 155, 1902.

Life History.

Eggs were discovered inserted in the midrib of a cane-leaf, in a cane field at the Experiment Station. The position of the eggs inside the leaf is shown in Fig. 3, Plate XVII. These eggs failed to hatch; in fact, proved to be parasitized by a black mymarid, *Polynema reduvioli*, one parasite to each egg. Mr. Terry has found *Reduviolus* eggs badly parasitized in the plantations of Kauai, also.

A female in confinement deposited 15 eggs, singly, in an irregular row in a cane-leaf. Two of these hatched in 10 and 11 days respectively. The nymphs were slender, of a pale yellow color. They molted 5 times at intervals of about 5 days (3-7), and matured in 24 days.

A darker colored species of *Reduviolus* is common in cane fields on Hawaii, and has similar habits to *R. blackburni*.

ANTHOCORIDAE.

Triphleps persequens, White.* (Pl. XVI, fig. 7.)

This little bug is very common in cane-fields, and also on any plants infested with Aphis. In all stages, they feed especially upon Aphis, but they also eat some of the younger nymphs of the leaf-hopper.

Life History.

The eggs are not known, but are probably deposited on the surface of a leaf similarly to *Physopleurella mundulus*. From some material under observation, (leaves infested with Aphis), a nymph hatched July 18th. It was yellowish in color; very active, running about; fed upon aphis; matured August 1st. Nymphal period 14 days.

Physopleurella mundulus, White.** (Pl. XVI, figs. 4-6.)

This bug is a little larger than *Triphleps persequens*. It is of a light brown color.

Generally distributed in sugar cane districts. Has habits similar to *Triphleps*; being larger, it undoubtedly preys to a greater extent upon young leaf-hoppers, though primarily its food is probably Aphids and Psocids. Both adults and nymphs were

* "Hemiptera," Fauna Hawaiiensis, III, pt. II, p. 125, 1902.

** " " " " " " " " p. 126, 1902.

found on Orange trees, where they were undoubtedly feeding upon Psocids, for they were lurking about the nests of the Psocids.

Life History.

The eggs (Pl. XVI, fig. 5) are .6 mm. long, yellowish, with a raised collar or crown at anterior end, laid flat on a leaf, singly, in secluded place. Some were found under the web or nest of Psocids on Orange leaves. A few laid in confinement hatched in 4 to 5 days. The nymphs (Pl. XVI, fig. 6) are reddish in color and of very lively habits, though keeping secluded generally. I have not as yet bred any to maturity, but their nymphal period is probably about the same as *Triphleps persequens*, i. e., 14 days.

CIMICIDAE.

Oechalia grisea, Bur.* (Pl. XVIII, figs. 5-7.)

Nymphs and adults of this large native bug were found feeding on cane leaf-hoppers in the more elevated parts of sugar plantations on Hawaii, especially where they were near forests, as at Olaa, Pahala, and Naalehu. They feed on larvae of *Omiodes accepta*, also.

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EXPLANATION OF PLATES.

Plate XIV.

1. *Xiphidium varipenne*, female, x 2.
2. " " female nymph, x 2.
- 3-7 and 3a-7a. *Xiphidium varipenne*, dorsal and lateral views respectively of the thorax of the nymphal stages, to show the development of the wings.

8. *X. varipenne*, cerci of male, x 5.
9. *X. fuscum*, cerci of male, x 5. (From Girard, *Traite D'Entomologie*, Plate 62, Fig. 7.)
10. *X. varipenne*, fastigium viewed from in front, x 5.
11. " eggs, nat. size. Showing their location where inserted beneath leaf-sheath of sugar cane. The tiny holes in several of them are where parasites have emerged.

Plate XV. (All figures x 5.)

1. *Callineda testudinaria*.
2. " " cluster of eggs on leaf.
3. " " larva.
4. " " pupa.
5. *Coccinella repanda*.
6. " " larva.
7. " " pupa.
8. *Verania frenata*.
9. " " larva.
10. " " pupa.
11. *Verania lineola*.
12. *Verania* sp.

Plate XVI.

1. *Zelus peregrinus*, x 4.
2. " " nymph, x 4.
3. " " cluster of eggs, x 5.
4. *Physopleurella mundulus*, x 20.
5. " " nymph x 20.
6. and 6a. *Physopleurella mundulus*, eggs on surface of leaf x 15.
7. *Triphleps persequens*, x 20.

Plate XVII. (All figures x 5.)

1. *Reduviolus blackburni*.
2. " " surface of leaf showing external appearance of eggs which are inserted; the tiny holes at the side of several, are where parasites have emerged.
3. *R. blackburni*, section of leaf showing inserted eggs.
4. *R. blackburni*, nymph.
5. *Oechalia griseus*.
6. " " prothorax of another specimen showing variation in the spines at the posterior angles.
7. *O. griseus*, nymph.

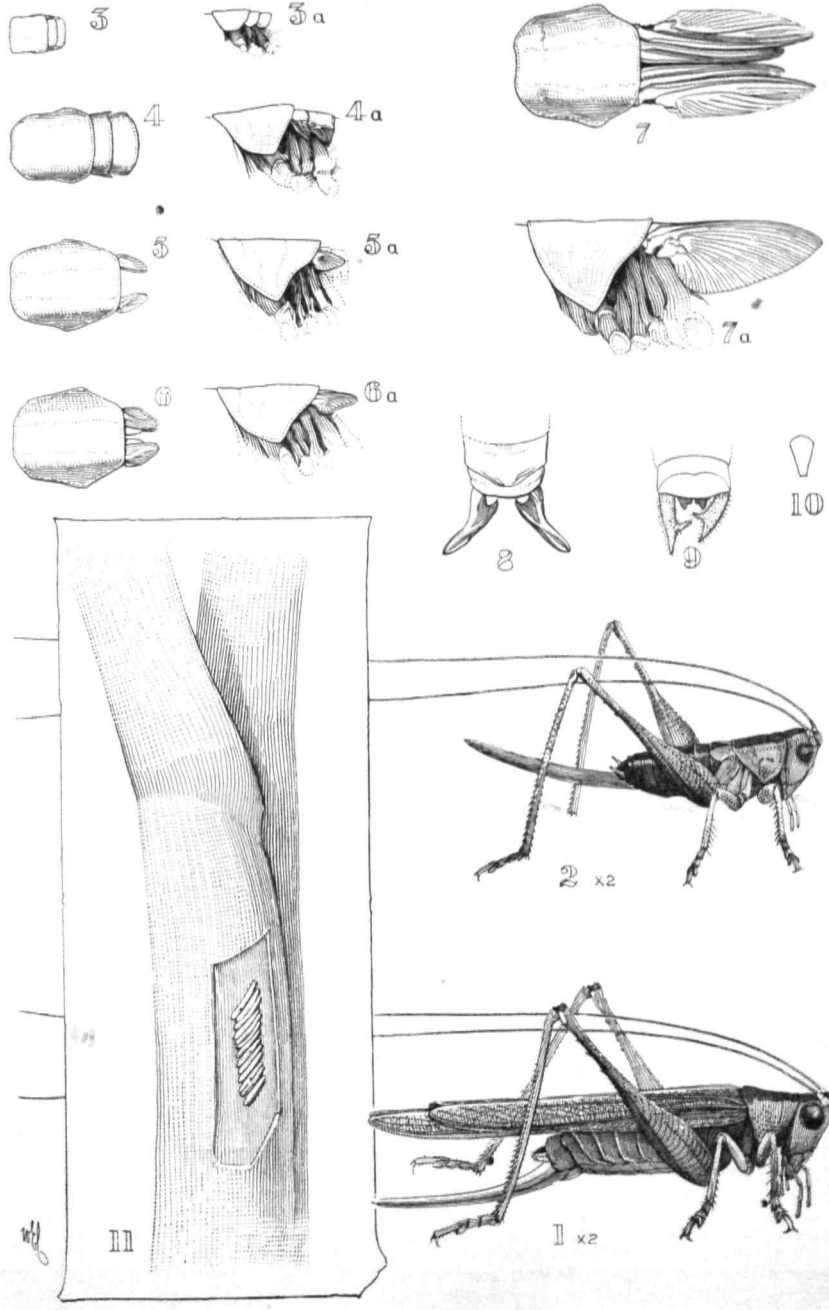
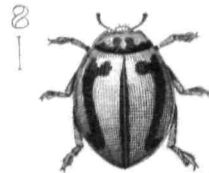
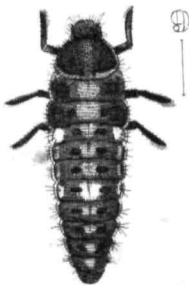
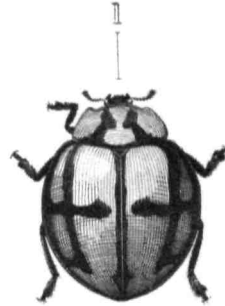
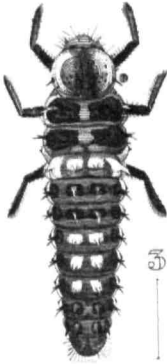
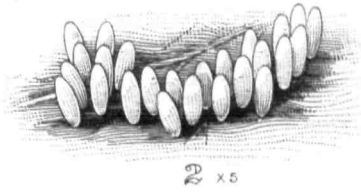


PLATE XIV.



mb.

PLATE XV.

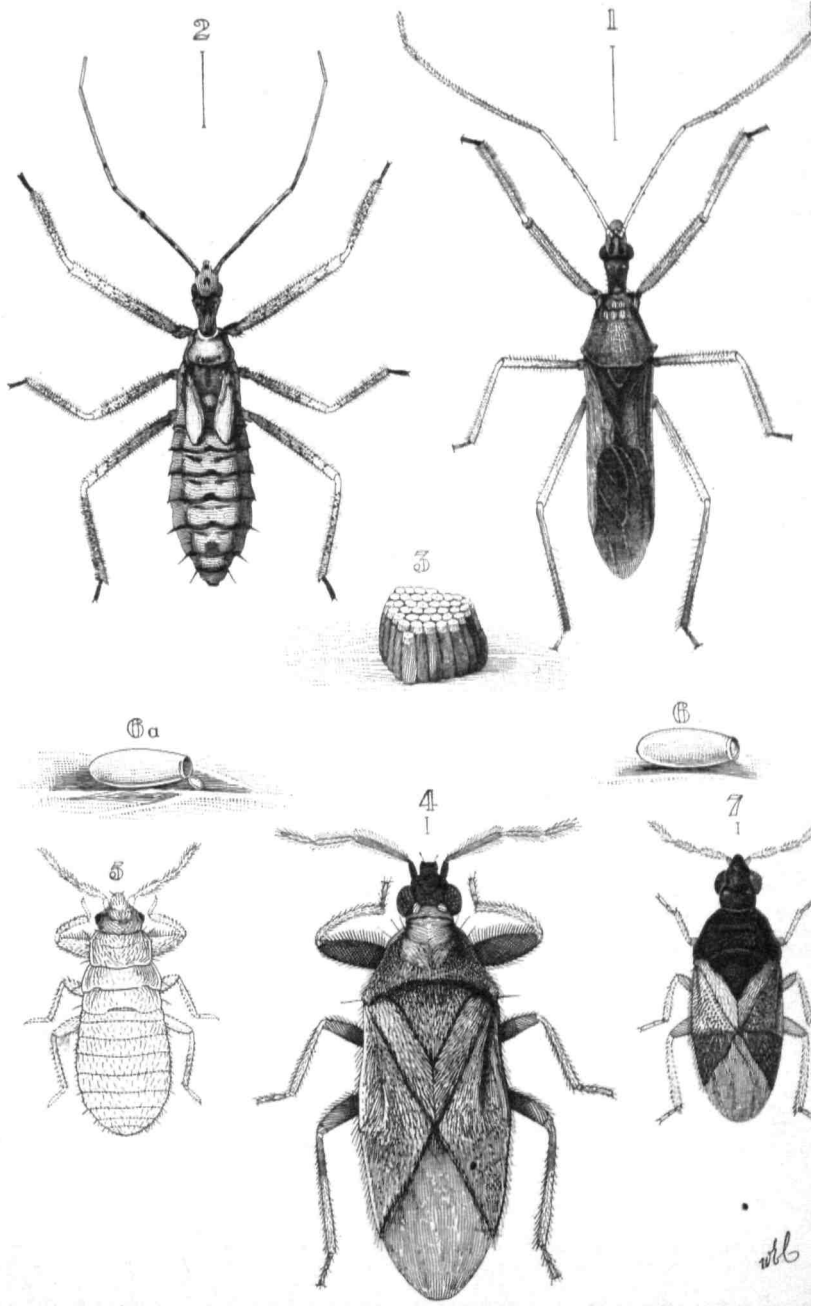


PLATE XVI.

wilb

