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OF

The Entomological Society of America

VOLUME XI, 1918

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ANNALS
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Number 1

THE SEGMENTATION OF THE ABDOMEN OF THE
HONEYBEE (*Apis mellifica* L.).

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The determination of the number of segments represented in the insect body has proved sufficiently interesting to attract the attention of a considerable number of morphologists. In this field the segmentation of the head has been the more perplexing part of the problem as well as the more difficult, in contrast with the segmentation of the trunk. The latter, however, has the advantage of being capable of a reasonably certain solution. The earlier workers in this field regarded the trunk of the insect as consisting of ten, or in some cases, of eleven segments. The tenth or eleventh segment, recognized as in most respects comparable to those anterior to it, was regarded as constituting the terminal or end segment, bearing the anal opening. For instance, in *Hylotoma* the eleventh segment bears appendages and possesses a neuromere (Graber 1890) and in *Xiphidium* this segment also bears a pair of appendages, the cerci (Wheeler 1893). Heymons (1895, 1895a), paid especial attention to this problem and introduced the conception, now generally accepted, of a terminal segment or telson—stated to be especially evident in *Gryllotalpa*—comparable to the telson of the *Crustacea*, containing the anus but differing from the other segments in not having paired appendages or other strictly metameric organs. In addition to the appendages of the eleventh segment Heymons found in *Phyllodromia* well defined coelomic sacs in this segment. In later papers (1896, 1897), Heymons has elaborated this conception, finding plain

evidence of twelve segments in representatives of the *Odonata*, and *Ephemeridæ*, and also in *Lepisma* and other representatives of the *Apterygota*.

This subject has since received but little attention. Carriere and Bürger (1897) state that the abdomen of embryos of the mason bee is composed of ten segments and a telson (p. 330). Further on it is said that eleven pairs of ganglia are present in the abdomen of embryos (p. 368). The latter statement is probably from the pen of Bürger, and clearly indicates the presence of eleven true segments in addition to the telson. This is also seen in the figures. Hirschler (1909) reports finding in *Donacia* "20 Körpersegmente (eventuell 21, wenn wir aus theoretischen Gründen das 12 Abdominalsegment zurechnen)." His figures—especially figures 62 and 64—show clearly eleven abdominal segments in addition to the hypothetical telson.

In the honeybee Bütschli (1870), in one of the earliest accounts of the embryology of this insect, expressly states that there are 17 pairs of ganglia in the ventral chain, and clearly shows three ganglionic swellings in the terminal ganglion in his figure 40. This observation has apparently been overlooked by all subsequent writers on this subject. For example, Grassi (1884), the next investigator after Bütschli to study the embryology of the honeybee, states that the ganglionic chain in the trunk consists of only 13 ganglia.

The writer (1915) reported finding eleven segments bearing neuromeres in the abdomen of embryos of the honeybee and gave figures of the posterior end of embryos showing the development of this part of the ventral chain. Ten pairs of ganglia and the rudiments of the eleventh pair are formed in the abdomen, the 9th, 10th and rudimentary 11th pairs uniting to form a compound ganglion. The evidence was in this instance rather briefly presented and in fact on review appeared rather unsatisfactory. For this reason it appeared to be desirable to present the evidence in a more complete form and also to add some observations regarding the conditions obtaining in larvæ.

At about the stage designated X by the writer (1915), when the rudiments of the antennæ and gnathal appendages are well formed and the development of the organ systems is well under way, sagittal sections, either optical or actual, clearly show that the abdomen is divided into eleven segments, in each of which is a neuromere, representing a pair of ganglia. A few hours

later, at Stage XII, the ventral nerve cord becomes split off from the hypodermis. The 9th, 10th and 11th abdominal segments are now very distinct (text Fig. 1A) and are also shorter than the rest. In these segments the ganglia are still in intimate contact with the hypodermis. Shortly afterwards the separation of the nerve cord is completed and the three pairs of

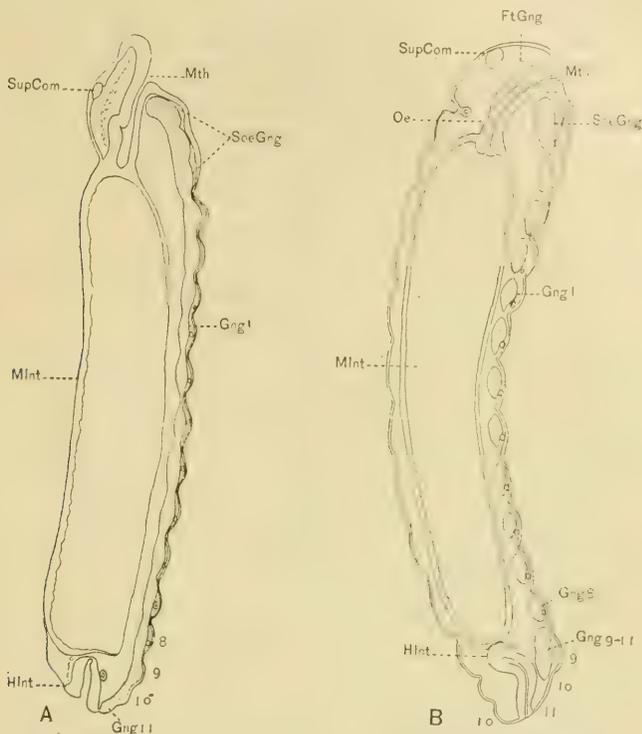


Fig. 1. *A*—Sagittal section through an embryo of Stage XIII. *B*—Sagittal section through recently hatched larva. Nervous system stippled, other organs shown in outline only. *FtGng*, frontal ganglion; *Gng 1-11*, abdominal ganglia 1-11; *HInt*, hind-intestine; *MInt*, mid-intestine; *Mth*, mouth; *Oe*, oesoph-agus; *SoeGng*, suboesophageal ganglion; *SupCom*, supraoesophageal commissure. Abdominal segments indicated by numerals. From camera drawings.

ganglia belonging to these segments appear as a compound ganglion consisting of two evident pairs of simple ganglia equipped with double transverse commissures (indicated in the figures by a lighter shade) and the rudiment of a third pair (Pl. p. 6, Fig. 1). The limits between abdominal segments 9, 10 and 11 are still well defined. Shortly afterward, when the larva has emerged from the egg, the boundaries between the 10th

and 11th abdominal segments can no longer be determined with certainty (text Fig. 1B and Fig. 2). The terminal compound ganglion (*Gng 9-11*) has become shorter and thicker and now lies almost entirely in the 9th abdominal segment. This displacement is due to a lengthening of the trunk and not to an actual shortening of the nerve chain.

The formation of a ganglion—or pair of ganglia—in the 11th abdominal segment also occurs in *Lepisma* (Heymons 1897), *Grylotalpa*, *Periplaneta*, *Gryllus* (Heymons 1895), *Odonata* and *Ephemerida* (Heymons 1896), *Leptinotarsa* (*Doryphora*) (Wheeler 1889), *Donacia* (Hirschler 1909), *Hylotoma* (Graber 1890) and *Chalicodoma* (Carriere and Bürger 1898). The fusion of the terminal ganglia of the ventral cord to form a compound ganglion is apparently general among insects. The number of ganglia thus united varies, but appears in young larvæ to be usually three or four, more frequently the latter number. Of the forms above listed, the Ephemerida, as well as embryos of *Hylotoma* and *Chalicodoma* agree with the young honeybee larva in having a terminal ganglion made up of three ganglia. In all cases in which a ganglion rudiment is formed in the 11th abdominal segment this rudiment is distinctly smaller than the others and very usually forms only a vestigial, or at least much reduced ganglion, as in the honeybee. Hirschler (1909) makes the suggestion that in those species of Coleoptera, such as *Hydrophilus*, in which the ganglion of the 11th abdominal segment has not been observed, this ganglion rudiment has suffered reduction to the point of disappearing altogether. This assumption may of course be extended to other insects than those of the order Coleoptera, such as *Forficula*, in which Heymons (1895) could find no neuromere in the 11th abdominal segment.

At the time of hatching, the dorsal hypodermis shows no evidence of an eleventh abdominal segment, only ten of these being indicated by constrictions (text Fig. 1B). Since the formation of the dorsal hypodermis is completed only shortly prior to hatching, it seems reasonable to conclude that only the sternal part of the eleventh abdominal segment is present. This, as is sufficiently evident, unites with the sternal part of the 10th segment. A similar condition obtains according to Heymons (1896) in the true Orthoptera, the *Plecoptera* and some *Odonata* (imagines), the tergum of the 11th abdominal segment being absent in these forms.

The presence of a telson or anal segment in insects seems to be well established on the evidence afforded by the Odonata and Ephemera, as well as on theoretical grounds (Heymons 1896). The abdomen of the honeybee may therefore be considered as consisting of 12 segments. There is, however, in the honeybee embryo some direct evidence indicating the presence

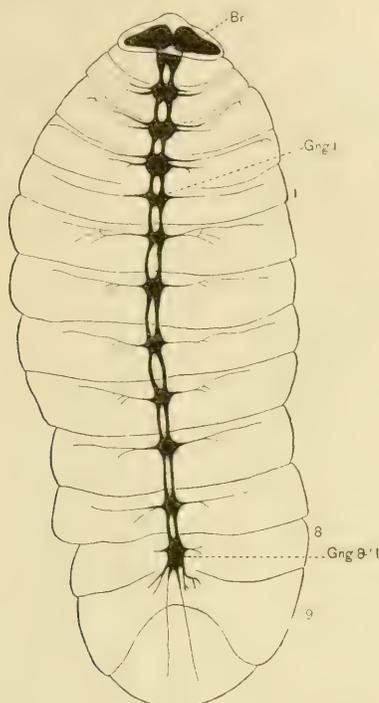
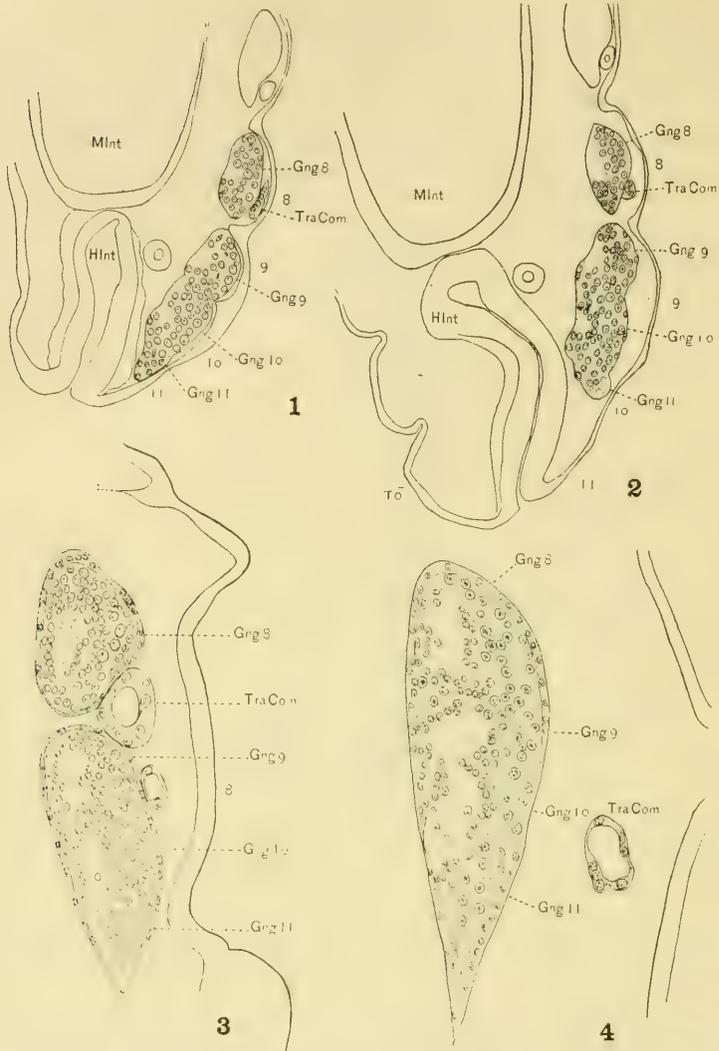


Fig. 2. Nervous system of mature larva. *Br*, brain; *Gng 1-11*, abdominal ganglia 1-11. Abdominal segments indicated by numerals. From camera drawing of a dissection.

of an anal segment. At Stage XII (text Fig. 1A) the ventral hypodermis just cephalad of the proctodæum is indented internally by a deep notch or transverse groove, internally by a shallower one, directly opposite to one another and reducing the intervening hypodermis to one layer of cells. These notches may readily be interpreted as corresponding to intersegmental constrictions and therefore as marking the limits between the 11th abdominal and anal segments. Vestiges of this separation are also to be seen in later stages, but disappear by the time embryonic development is completed.



EXPLANATION OF PLATE.

Fig. 1. Sagittal section through the posterior end of an embryo of Stage XII. $\times 260$.

Fig. 2. Sagittal section through the posterior end of a recently hatched larva. $\times 260$.

Fig. 3. Sagittal section through the 8th abdominal and terminal ganglia of a larva three days old. $\times 260$.

Fig. 4. Sagittal section through the terminal ganglion of a mature larva. $\times 260$.

Abbreviations: *Gng 8-11*—abdominal ganglia 8-11; *H Int*—hind-intestine; *M Int*—mid-intestine; *TraCom*—tracheal commissure of the 8th abdominal segment. Abdominal segments indicated by numerals.

As already stated, the ventral nerve cord of the young bee larva consists, in addition to the subœsophageal ganglion, of eleven single (paired) ganglia, and a terminal ganglion composed of three ganglia, the third being much reduced. In mature or nearly mature larvæ (4-5 days old) the ventral nerve chain contains only ten single ganglia and one elongate terminal ganglion situated in the 8th abdominal segment instead of the 9th, as in young larvæ (text Fig. 2). Longitudinal sections through this ganglion show that it is made up of four ganglia, the 8th, 9th and 10th and rudimentary 11th abdominal ganglia (Fig. 4). This ganglion has now a very compact structure, the transverse commissures of the 9th and 10th abdominal segments being brought close together. Sections through younger larvæ of different ages show that the incorporation of the 8th abdominal ganglion into the compound terminal ganglion takes place slowly, being preceded by a gradual approximation of the 8th and the terminal ganglia extending over almost the entire larval period. As the larva increases in size the 8th and 9th (terminal) abdominal ganglia move up into the 8th abdominal segment, as shown in Figure 3, which represents a section through the last two ganglia of a larva three days old. This cephalad migration indicates a relative shortening of the entire ventral nerve cord, probably caused by the evident failure of the nervous system to keep pace with the rest of the larva in respect to increase in size. The terminal ganglion of an old larva possesses four pairs of lateral nerves, the first two having a common root, innervating the 8th abdominal segment while the other two pairs innervate the 9th and 10th abdominal segments and are referable to the ganglia originating in these segments.

The fusion of the four last ganglia of the ventral nerve cord in the larva evidently foreshadows the imaginal condition, although there is no further union of ganglia during the larval period. The composition of the ventral cord in the young larva, the mature larva and the imago may be expressed in the following formulæ, the ganglia of the thoracic segments being indicated by Roman, the abdominal by Arabic numerals, and the ganglia united together to form compound ganglia being enclosed by brackets:

Newly hatched larva. . I, II, III, 1, 2, 3, 4, 5, 6, 7, 8, [9, 10, 11].
 Mature larva. I, II, III, 1, 2, 3, 4, 5, 6, 7, [8, 9, 10, 11].
 Imago (Snodgrass 1910). I, [II, III, 1, 2], 3, 4, 5, [6, 7]. [8, 9, 10, 11].

SUMMARY.

1. The embryos of the honeybee afford plain evidence of the presence of 12 segments in the abdomen, (assuming the presence of a telson), the 11th abdominal segment being represented by its sternite and by the rudiment of a pair of ganglia.

2. In newly hatched larvæ the last three abdominal ganglia, including the rudimentary 11th abdominal, unite to form a compound ganglion situated in the 9th abdominal segment. As the larva grows older the compound terminal ganglion and the ganglion of the 8th abdominal segment move closer together and both come to lie in this segment. In mature larvæ (4-5 days old) the ganglion of the 8th abdominal segment finally becomes incorporated in the terminal compound ganglion, which has then the same composition, as regards number of ganglia, as the terminal ganglion in the imaginal ventral nerve cord.

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OBSERVATIONS ON THE LIFE HISTORY AND BIOLOGY
OF *AGROMYZA LATERELLA* ZETTERSTEDT. (Diptera).*

P. W. CLAASSEN.

In the spring of 1916, while studying the interrelation of insects to certain swamp plants near Ithaca, New York, my attention was called to the occurrence of galls on the common wild blue flag, *Iris versicolor*. The plants then were from six to ten inches high, with three or four leaves out. The galls were always found on the outer leaf of the leaf-bundle, the



FIGURE 1

affected leaf ceasing to grow. This formation of the gall and the subsequent cessation of growth of the leaf very often affects the second or next inner leaf in a peculiar manner; the tip remains caught in the gall for some time, the growing leaf is bent out and in its rapid growth produces a number of wavy or undulating folds. Fig. 1 shows a photograph of a small group of plants with several galls and the characteristic appearance of the second leaf.

*Contribution from the Entomological Laboratory of Cornell University.

On cutting the gall open a small dipterous puparium was found inside. These puparia were taken to the laboratory, placed in vials, and on the 26th of May adult flies began to emerge. These were identified by Dr. O. A. Johannsen as *Agromyza laterella*.

In going over the literature on this species, I find that Thompson† reports having bred *A. laterella* (equals *magnicornis* Loew) from galls on blue flag. His paper is accompanied with an illustration of an iris leaf showing the gall. A short description of the gall is given. He suggests that the larval life seems to be completed the previous fall, but has not investigated this assumption.

With the adults emerging the latter part of May, the question naturally arose as to where the eggs would be placed, or in what stage the summer and fall would be spent, assuming that the winter was passed in the pupal stage. With this object in view a number of the adults were placed in cages with iris plants, in an effort to induce the flies to mate and oviposit; they failed, however, to reward the observer with either of these performances in captivity. It was found, though, that the adults were very common around iris plants, especially during the middle part of the day. At such times the females were carefully observed. They appear very nervous, darting here and there, and are easily disturbed. It was noticed that the females were stopping often to exert their ovipositors and work them on the tissue of the leaf. Such a leaf, later, showed a speckled appearance as shown in Plate II, Fig. 11. A number of these leaves were taken into the laboratory and an effort made to locate the eggs, but although these punctures or abrasions were very apparent, the eggs were not found.

It was while observing this "oviposition," that Dr. Needham suggested the possibility of having a case here, where the first generation of flies took on the leaf-mining habit, while the later, or second generation would be the ones producing the galls. Should this alternation of habits occur in the same species of insect, it would help to substantiate the theory that leaf-mining and gall-making are very closely related, the main

†Millet B. Thompson, *Psyche* Vol. XIV, 71-74, 1913. "Three galls made by *Cyclorrhaphous* Flies."

difference lying in the time of attack. The stimulus for the formation of the gall being given while the plant is young and the tissues are still forming; on the other hand, oviposition and the entrance of the larva into the leaf later, when the leaf has reached its main growth, does not stimulate the tissues to form any swelling whatsoever, the result being a mine.

Although no eggs were found, the plants were carefully watched for mines. On June 22, 1916, very delicate mines were found on the innermost leaves of the leaf-bundle. These mines are first noticeable on the outer surface, under the very thin epidermis of the leaf. The larvæ remain very close to the outer skin. The mines at first are so delicate as to be hardly perceptible to the naked eye, but with the aid of a magnifying glass, could be traced to the so-called egg-punctures, but no signs of the eggs were found.

In form the mine is linear, enlarging slightly as the larva proceeds downward and increases in size. The mine zigzags quite a little in its course, frequently the larva suddenly changes to the opposite side of the leaf, so that the mine is no longer visible on the upper surface, thus presenting a broken appearance. (Plate I, Fig. 1).

The color of the mine is white and shows plainly on the green leaf, but shows more plainly on the lower part of the leaf, which in the iris is of a purplish color.

The larva proceeds downward just about as rapidly as the new leaves are formed and come out of the leaf-bundle, and passes on, thus being in a situation where the tissue is newest and most tender. Sometimes, however, the larvæ may remain in the outer leaves and mine the entire length of it. This is especially true of the early larvæ. Plate I, Fig. 1 shows one of these outer leaves with the characteristic mines in it. It is not uncommon to find two or three larvæ working side by side in the same leaf, although each one maintains its own mine. The larvæ always maintain a lateral position in the mine, that is with the sides of the body toward the two surfaces of the leaf, always mining towards the base of the leaf; but just before pupation the larva assumes a position with the dorso-ventral sides towards the surfaces of the leaf, and with the anterior end upwards.

Puparia of these larvæ were first observed on July 25, 1916. In cases where larvæ reached maturity in the early or mid-summer, the puparia were always found at the base of one of the large outer leaves. Here the larva mines more to the center of the leaf-base, so that the mine is well within the tissue of the leaf and not visible from the outside. A somewhat enlarged excavation is made here, the larva assumes its position for pupation, and transformation occurs. The base of the leaf around the puparium swells just a little, thus showing a slight tendency toward gall-formation, (Plate II, Fig. 7).

Later in the fall the leaf is often found split open at the base, thus exposing the puparium. These puparia remain in this condition till the following spring.

Owing to the fact that oviposition stretches over a considerable length of time, (adults were seen around the iris plants for three or four weeks) different stages of larvæ were found in the iris all summer.

The larvæ in the fall of the year are always found mining on the innermost leaves of the leaf-bundle, and there in the very latest formed leaf, just as the plant ceases growth before the winter sets in, the larva enters and transforms into the puparium. Plate II, Fig. 9, shows the larva as it enters this inner leaf and Plate II, Fig. 10, shows the leaf after the larva has entered and pupated.

The iris plant does not die down completely in the fall, but the center remains alive, and usually on each side of the plant are formed offsets which produce the new plants the following spring. These offsets then may be regarded as new individuals, while the center represents the overwintering form of the old plant. Both center and offsets are protected from exposure by the old leaves which in the spring gradually drop to the ground and disintegrate. Plate II, Fig. 1 shows a plant with several offsets.

In the spring when the plant resumes its growth, it is the little leaf in the center which contains the puparium, that causes the characteristic gall. The second leaf, crumpled, stands there as an indicator, showing that the gall was formed while the second leaf was still rapidly growing.

All the various pupæ, those found early in the summer, as well as those found in the fall, and those in the galls, were, after emergence, identified as *A. laterella*.

These observations then proved that this was not a case of alternation of different habits in two generations, but it showed that the fly is an essential leaf-miner, that the entire larval stage is spent in leaf-mining; that the majority of the larvæ pupated at the base of the leaves where no typical galls were produced; that only those larvæ that developed slowly, and entered the innermost leaf late in the fall at the time of cessation of growth, were instrumental in bringing about the gall-formation. It would probably be a fair estimate to assume that not over 20-25% of the larvæ enter the inner leaf and form galls.

Just when or how the stimulus is brought about which causes the gall formation has not been determined. There is no sign of swelling in the fall, even after the pupa stage has been reached, but as soon as the plant resumes growth in the spring, the swelling occurs.

The galls and mines are common wherever the iris occurs, often nearly every plant is found to be affected. The fact that the gall is formed on the innermost leaf, explains the reason why only one gall occurs on the same plant. However on October 23, 1917, I found several instances where two larvæ were present in the same plant, both apparently descending down to the much coveted spot, the newly formed inner leaf. In each such instance I found that the second larva remained in the mine about 40-45 mm. above the other one which had entered the usual place, the innermost leaf of the bundle. The "upper" larva had excavated an enlarged place and transformed to the puparium. These puparia, found in this position above the other, are always more perfect in shape than those in the gall-forming leaf.

DESCRIPTION OF STAGES.

The Egg.

(Plate I, Fig. 3).

When dissected out of the ovary, the egg presents a glistening white appearance and measures from .36-.40 mm. in length, and .13-.15 mm. in width in its greatest thickness. The egg is elongate oval, tapering considerably towards one end, and more or less rounded at the other. The egg appears smooth, no markings are visible from the outside.

The Larva.

(Plate I, Fig. 2, and Plate II, Fig. 5).

The young living larva is almost pure white, later becoming a glistening creamy white. A light yellow line running longitudinally through the center of the body represents the alimentary canal. The innermost leaves of the leaf-bundle of the iris, not having been exposed to the sunlight, are of a light yellow color, and the presence of this color material in the alimentary canal is seen through the transparent skin of the larva.

The larva is long, cylindrical, measuring from 5-7 mm. in length, when full grown, and about 1.3-1.6 mm. in diameter. It tapers slightly toward either end. The head bears the black mandible or rasping organ with four teeth, the first two somewhat larger than the other two. (Plate II, Fig. 2). On the dorsal surface of the first thoracic segment, just back of the head, are found the two thoracic spiracles, borne on short brown stalks, flaring at each end with from 14-17 lobed projections on the outer margin. These lobes or tubercles have at the tip little openings which lead to the tracheal tube attached at the base. (Plate II, Fig. 3).

On the ventral surface of the three thoracic segments occur small transverse ambulatory ridges. The ridge on the first thoracic segment is considerably larger than the following ones.

On the last abdominal segment are found two brown anal spiracular projections, each of which ends in three down-curved lobes, at the tip of which are also found the small spiracles. (Plate II, Fig. 4).

Just before pupation the larva shortens and thickens considerably, the little ambulatory ridges are completely withdrawn, while the spiracular projections are fully extended, and the larval skin changes into the puparium.

The Pupa.

(Plate I, Fig. 8).

The pupæ vary considerably in form and size. A comparison of a number of pupæ showed that they varied in length from 3.10–4.66 mm., in width from 1.10–1.5 mm., and in thickness from 1.0–1.35 mm. Those that are found during the summer and early fall in the base of the leaf are more uniformly shaped being only slightly depressed; while those found later in the gall-forming leaf of the leaf bundle are always decidedly depressed and usually somewhat deformed, so that these pupæ in general appearance do not resemble the ones at the bases of the leaves and could be easily mistaken for another species.

The color of the puparium just after transformation is light brown, but later it becomes dark brown or almost black, especially those in the gall forming leaf; while the other puparia often remain rather light yellowish brown in color, though they also vary from dark brown to almost black.

During the transformation from the larval condition to the puparium, the thoracic and caudal spiracular projections are fully extended and transformed into two pairs of hardened hooks which help in holding the puparium in place in the plant.

The Adult.

(Plate I, Fig. 4).

The adults vary in length from 1.5–2.5 mm. The females are somewhat larger than the males. They are characterized by the proportionally large wings and the large antennæ, the antennæ of the males being larger than those of the females. The general ground color is shiny black or at least very dark brown. The thickened veins at the base of the wings, the halteres, proboscis, and joints of the legs are light yellow in color. Other lemon yellow markings occur along the sutures of the thorax and abdomen. The tibia and tarsi are yellowish brown. In the living flies the yellow markings are much more apparent than in the mounted dried specimens.

A technical description of the adult will be found in the *Annals of the Entomological Society of America*, VI, 300-301, 1913, by J. R. Malloch.

Specimens were found to be very numerous during the latter part of May till the middle or latter part of June, especially in the swamps and wet places where the iris grows in abundance.

EXPLANATION OF PLATES.

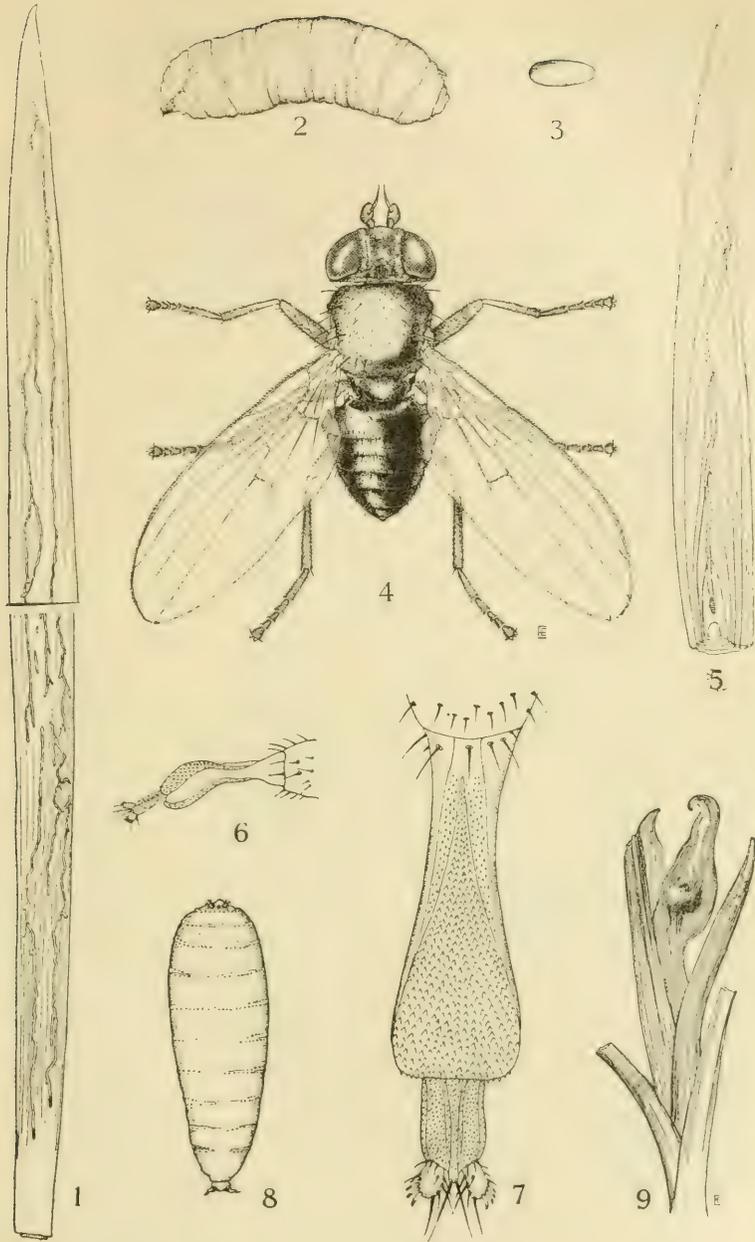
PLATE I.

- Fig. 1. Outer leaf of iris showing the characteristic mines made by the larva of *Agromyza laterella*. The broken places in the mines indicate where the larvae have mined to the opposite side of the leaf.
- Fig. 2. Full grown larva, contracted, just before pupation.
- Fig. 3. Egg, dissected out of the ovary of the female.
- Fig. 4. Adult fly, female.
- Fig. 5. A leaf-bundle cut open to show the course of the larva as it mines down towards the new forming leaf.
- Fig. 6. Ovipositor of female, side view.
- Fig. 7. Ovipositor of female, dorsal view.
- Fig. 8. Pupa, dorsal view.
- Fig. 9. A young iris plant in spring, showing the leaf-gall. Notice the evidence of the mine, indicated by the unshaded part in the tip of the leaf, where the larva entered the gall-forming leaf.

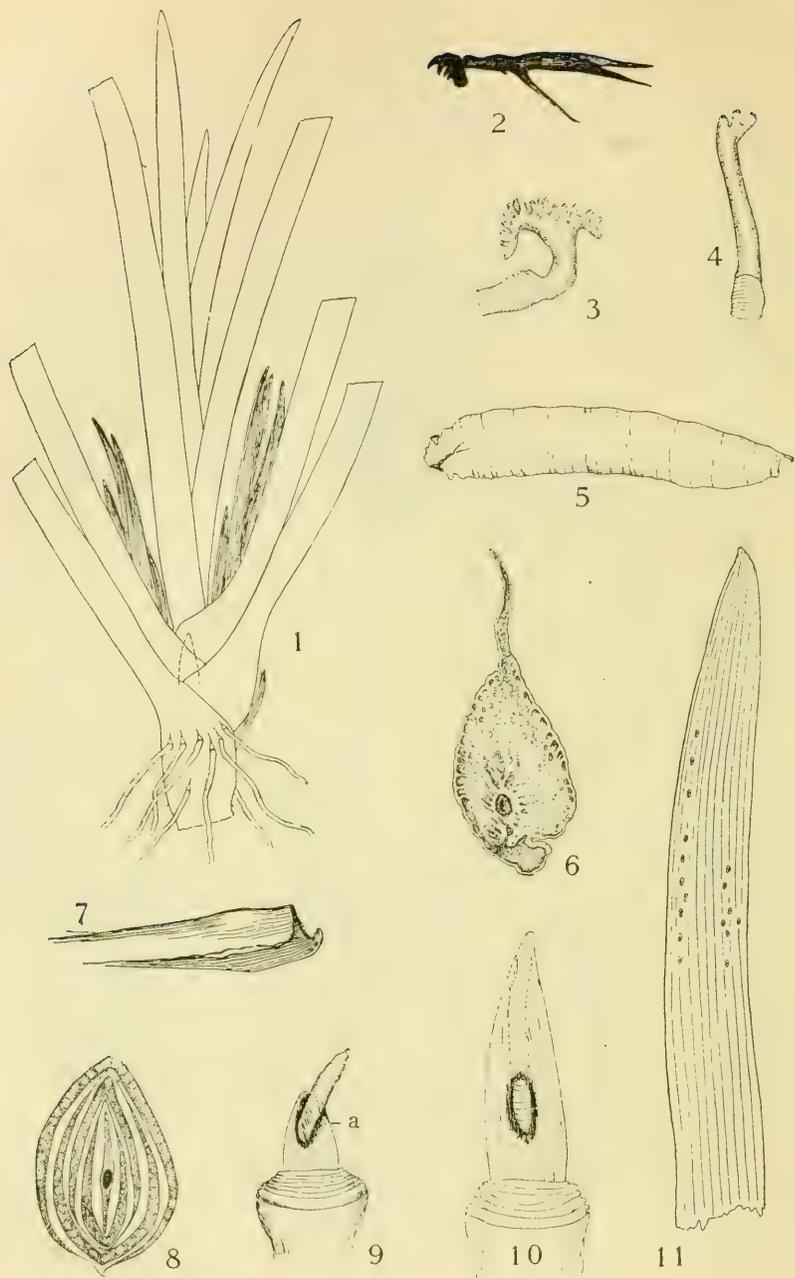
PLATE II.

- Fig. 1. *Iris versicolor*, showing the condition of the plant in late fall or winter. The unshaded leaves represent the old dried or dead leaves. The shaded leaves represent the green offsets which will form next year's growth. In the center of the old plant is found the pupa. This center also remains alive. The innermost leaf is represented by the dotted lines.
- Fig. 2. Mandible or rasping organ of the larva of the iris fly.
- Fig. 3. Thoracic spiracle of the larva.
- Fig. 4. Anal spiracle of the larva.
- Fig. 5. Nearly full grown larva.
- Fig. 6. Cross section of a gall, showing the pupa in the center. Note the spongy nature of the gall.
- Fig. 7. Basal portion of an outer leaf of iris, showing the little swelling produced by the early maturing larvae which pupate in this portion of the leaf.
- Fig. 8. Cross section of an iris plant at *a* in Fig. 9. This shows the arrangement of the leaf-bundle. Each sheath has been separated slightly from the others to bring out the structure more plainly.
- Fig. 9. Outer sheaths of the leaf-bundle torn away to show the larva entering the inner leaf just before pupation.
- Fig. 10. Same as Fig. 9, after the larva has entered and pupated.
- Fig. 11. Egg punctures on the leaf. The structure of the ovipositor indicates that these are abrasions, rather than punctures.

NOTE—Figures 2, 4, 8 and 9 of Plate I, and Figures 6 and 7 of Plate II, have been drawn for me by Miss Ellen Edmonson, of Lawrence, Kansas. The remaining figures are my own.



P. W. Claassen.



P. W. Classen.

A SYSTEMATIC STUDY OF THE ORGANISMS DISTRIBUTED UNDER THE NAME OF COCCOBACILLUS ACRIDIORUM D'HERELLE.

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A large amount of work has lately appeared dealing with d'Herelle's *Coccobacillus acridiorum* and his method of combating noxious grasshoppers. Some investigators have been able to confirm d'Herelle's results; others have been unable to do so, and since the entire subject seems to be in a state of confusion, I undertook a systematic study of a number of cultures which I obtained and which were distributed under the name of *Coccobacillus acridiorum* d'Herelle. As I suspected, some of the separate cultures proved to represent either different species or varieties of the same species. This fact may account for some of the contradictory views held by so many workers and it is my hope that this article will also demonstrate the need for attention to the ordinary principles of bacteriology which seem to be so persistently neglected by many entomologists.

In 1909 Dr. F. d'Herelle, while in the State of Yucatan, Mexico, noticed a heavy mortality in some flights of the destructive South American migratory locust *Schistocerca americana* Drury which arrived in the State from the borders of Guatemala. In 1911 the flights were all visited by this epizoötic and by 1912 it had reduced the number of locusts to such an extent that no invasion into Mexico occurred. In 1910 d'Herelle isolated a bacterium from the intestinal contents of cases of this disease. The organism was named by him *Coccobacillus acridiorum*. He was able to reproduce the disease and death by inoculating healthy grasshoppers with a culture of the Coccobacillus. These results were thought to be important by the Republic of Argentine which in 1911-12 requested d'Herelle to study the action of his bacterium against *Schistocerca paranensis* Burm, with a view towards its possible use in combating the pests. D'Herelle's methods apparently proved highly successful.

*In co-operation with the Bussey Institution of Harvard University (Bussey Institution No. 139).

D'Herelle's method consisted in obtaining a virulent form of his organism by twelve successive passages and then spraying dilutions of his cultures over sections of land infested by grasshoppers. The insects became infected by eating the contaminated food. The passages were performed by inoculation and the organism was considered to be virulent when death occurred in eight hours. The organism at its maximum virulence was supposed to cause death in three hours.

In 1913 Sergent and L'heritier tried out the efficacy of *Coccobacillus acridiorum* against *Stauronotus maroccanus* in Algeria. A general epidemic failed to develop in the field and the authors suggest that this failure may have been due to the presence of two autochthonous bacilli in the locusts which may have had an immunizing effect.

Lounsbury in 1913 attempted to combat *Zonocerus elegans* with d'Herelle's organism, in South Africa, but was unsuccessful.

Barber and Jones in 1913 performed field experiments with *Coccobacillus acridiorum* in the Philippines in an endeavor to check the injurious *Oedalens nigrofasciatus* De Geer and *Locusta migratoroides* R. and F. The experiments failed to show any satisfactory results.

During 1914-15 Béguet, Musso and Sergent conducted a campaign in Algeria against *Schistocerca peregrina* Oliv. These workers used d'Herelle's method in combination with the ordinary mechanical methods used for fighting the pests. It was found that d'Herelle's bacterium could not be used alone for the disease spreads too slowly. The combination of the two methods, however, proved helpful.

In 1915 Rorer reported that he had performed inoculation experiments with *Coccobacillus acridiorum* on *Schistocerca paranensis* and *Tropidacris dux* in Trinidad. He found that the organism was pathogenic to both insects and that the virulence could be increased by successive passages. Field experiments were not attempted.

Laines in 1915 reported that he was able to control grasshoppers in Honduras with d'Herelle's organism. A series of grasshoppers was inoculated from the abdominal substance of a series previously dead of the disease. By successive passages in this manner he claims to have obtained a high degree of virulence for the bacterium.

D'Herelle in 1915 controlled a severe outbreak of *Schistocerca peregrina* Oliv. in Tunisia by combining the use of his organism with the mechanical methods.

Velu and Bouin in 1915 reported that d'Herelle's method gave encouraging results in combating *Schistocerca peregrina* in Morocco.

During September, 1915, Dr. L. O. Howard, U. S. Bureau of Entomology, received what was termed two sub-cultures of d'Herelle's *Coccobacillus* from Dr. Cicilio Lopez Ponce of Honduras. In a letter written by Dr. Ponce the latter says: "Under instructions from the Secretary of the Honduran Commission of Agriculture, who lives in Tegucigalpa, I have the honor of sending you by this post, in a registered package, two tubes of a culture of the *Coccobacillus acridiorum* d'Herrlle. Some time ago I came to this city from the neighboring Republic of Salvador with the object of taking charge of a laboratory devoted to the cultivation and propagation of this parasite, and I am pleased to inform you that the results could not have been more satisfactory."

From their experiments in Canada (1916) Du Porte and Vanderleck concluded that: "The results of our work indicate that d'Herelle's biological method for the control of locusts cannot take the place of the methods now in use under the conditions which obtain in eastern Canada. Should the disease become established, its spread would be extremely slow, owing to the non-migratory and non-cannibalistic habits of the native species. The ideal conditions for the effective use of this method are those such as d'Herelle and others found in South America and North Africa where the locusts were in quickly moving swarms and were markedly cannibalistic in their habits. Indeed, most of these writers have emphasized the fact that "acridiophagy" is the chief factor in the spread of the disease. Another hindrance to the effective use of this method lies in the presence of several native strains of a coccobacillus identical with or closely related to d'Herelle's. These organisms are undoubtedly responsible for the immunity of the locusts to a mild infection of *Coccobacillus acridiorum*."

A perusal of the literature of the subject shows that five out of nine articles report encouraging field results by the use of d'Herelle's *Coccobacillus acridiorum*. These five reports all deal with the genus *Schistocerca* represented by the species *americana*, *paranensis*, and *peregrina*. The unsuccessful reports deal with a variety of grasshopper genera such as *Stauronotus*, *Zonocerus*, *Oedalens*, *Locusta* and *Melanoplus*. The bacterium may be very effective when used against certain species of the

genus *Schistocerca*, whereas it may be impossible to establish an epidemic in the field amongst members of certain other genera. All of the workers reported that the bacteria they used were pathogenic in their laboratory experiments. The field failures may be due to differences between the habits of the members of the genus *Schistocerca* and those of other genera. Differences between the climates of the separate countries where *Coccobacillus acridiorum* was used may also account for the varied results. The natural immunity of different genera or species is another factor worthy of consideration. Shall we therefore, owing to several failures, condemn d'Herelle's method under certain conditions? Obviously not.

D'Herelle and other workers who used his organism and methods successfully consider the following requirements the most necessary to the rapid spread of the disease in the field.

1. Cannibalistic habits of the insects (as very frequently exhibited by the genus *Schistocerca*).
2. Migratory habits (exhibited by the genus *Schistocerca*).
3. Dense hopper infestation.
4. Absence in hoppers of bacteria closely related to the *Coccobacillus acridiorum*. The presence of such organisms may have an immunizing effect.
5. Not an overabundance of normal food. When food becomes scarce due to the hopper infestation, the insects acquire cannibalistic habits which are favorable to the spread of the disease.
6. High temperature. The disease spreads more rapidly at the optimum temperature.
7. Absence of excessive rain. A heavy rain paralyzes the march of the epidemic.

All of the foregoing factors are undoubtedly highly important, but the writer should like to add one more requirement absolutely necessary for the study of this subject, namely:

8. The use of the same organism by the different investigators. Carefully controlled cultures should be distributed and used. The cultural and especially the bio-chemical characters of *Coccobacillus acridiorum* should be referred to constantly. Reference to morphological characters solely, as has been done so often, is worthless.

During December, 1915, I received from Dr. L. O. Howard, Chief of the U. S. Bureau of Entomology, two nutrient agar tubes containing pure cultures of a bacterium. These cultures were forwarded to Washington at the request of Dr. Howard by Dr. Cicilio Lopez Ponce, representing the Secretary of the Honduran Agricultural Commission of Tegucigalpa, Honduras.

The cultures were supposed to represent d'Herelle's *Coccobacillus acridiorum* and Dr. Ponce claimed to have obtained striking results with them in his field experiments.

During February, 1917, I received two cultures of the supposed *Coccobacillus acridiorum* direct from Dr. F. d'Herelle who is now at the Pasteur Institute, Paris. One culture was labeled "Souche Cham" which d'Herelle informed me is identical with the one I received from Dr. Ponce of Honduras. The other culture was labeled "Souche Sidi" and according to d'Herelle represented a strain of *Coccobacillus acridiorum* passed through a series of grasshoppers in Tunisia in 1915.

Also in February, 1917, I received through the kindness of Dr. C. Gordon Hewitt a pure culture of the supposed *Coccobacillus acridiorum* from Messrs. Du Porte and Vanderleck, who have performed some interesting experiments with this bacterium in eastern Canada. Dr. Hewitt, in a letter to me, stated that he received this culture direct from the Pasteur Institute in Paris.

I made a careful systematic study of these four cultures, compared them with one another as well as with the published descriptions of d'Herelle, and those of Du Porte and Vanderleck. The cultures differ from one another more or less. A table on page 25 shows the most salient differences and similarities. Since the bacterium sent by Ponce from Honduras seems to be an organism new to bacteriological literature, I have described it as a new species and named it *Bacillus poncei* in honor of Dr. Cicilio Lopez Ponce. I have also redescribed the three other cultures.*

Bacillus poncei is certainly not a *Coccobacillus*. It is a true bacillus, not in the least pleomorphic, no matter on what media it is grown. In this respect it certainly differs from d'Herelle's description. The latter emphatically states that his organism is highly pleomorphic, all stages between bacilli and cocci being observed in the same pure culture. *Bacillus poncei* produces much acid in milk; *Coccobacillus acridiorum*, according to d'Herelle, strong alkalinity. In so far as the production of ammonia and the fermentation (with gas) of dextrose, levulose and maltose are concerned the two organisms agree. D'Herelle's cultural and bio-chemical descriptions are so meagre that it is difficult to ascertain his exact meaning.

* The detailed descriptions will be found appended to this article.

Culture "Souche Cham" is highly pleomorphic. Milk is rendered acid, but is not coagulated. D'Herelle's organism should render milk alkaline and coagulate it. In the production of ammonia and in the fermentation (with gas) of dextrose, levulose and maltose, the two organisms agree. As can be seen from the table on page 25 "Souche Cham" differs greatly from *B. poncei*. Strange as it may seem, "Souche Sidi" and "Souche Cham," the two cultures sent by d'Herelle himself differ from one another. "Souche Sidi" is slightly pleomorphic, but this character is not nearly so pronounced as is the case with "Souche Cham." "Souche Sidi" coagulates milk, whereas "Souche Cham" does not. "Souche Sidi" reduces litmus milk; "Souche Cham" does not. "Souche Sidi" does not ferment (with gas) lactose and adonit; "Souche Cham" ferments both of these carbohydrates with the fermentation of gas (Hydrogen + CO₂). "Souche Sidi" does not tally with d'Herelle's description nor with *B. poncei*.

Du Porte and Vanderleck's culture agrees with the culture I received from d'Herelle under the name of "Souche Sidi." Curiously enough, however, my description of Du Porte and Vanderleck's culture does not entirely agree with the description given by these writers. I agree with them in so far as the morphological characters are concerned. My gelatin stabs, however, showed liquifaction after about eight weeks; they claim that gelatin is not liquified. My litmus was reduced; Du Porte and Vanderleck claim "no reduction." I am unable accurately to interpret the results of Du Porte and Vanderleck's carbohydrate fermentation tests for the reason that they do not state whether fermentation was accompanied by the formation of gas and acid or merely acid alone. I assume they mean gas formation, in which case, as will be seen from the table on page 25, our lactose tests differ.

What can one conclude from these results? Only this, namely, that different organisms are being distributed under the name of *Coccobacillus acridiorum*. I should, moreover, like to suggest that d'Herelle redescribe the organism concerned in his grasshopper epidemic more accurately so that other workers may know to which bacterium reference is made. Judging from the morphological descriptions alone I think d'Herelle has reference to the highly pleomorphic organism which he sent me labeled "Souche Cham," but of course, this is merely a conjecture. Du Porte and Vanderleck found several pleomorphic organisms native to grasshoppers in eastern Canada.

TABLE SHOWING MOST STRIKING DIFFERENCES AND SIMILARITIES BETWEEN CULTURES DISTRIBUTED UNDER THE NAME *COCCOBACILLUS ACRIDIORUM* D'HERELLE.

	MORPHOLOGY	GELATIN STAB	MILK	LITMUS MILK	NH ₃ POTATO	NITRATE REDUCTION	INDOL	DEXTROSE	LEVULOSE	SACCHAROSE	MALTOSE	LACTOSE	MANNIT	ADONIT	DULCIT
Bacillus pointed from Jourd'heux	Bacilli	No liquification	Strong acidity. Coagulation.	Strong acidity Coagulation Reduction	+	+	+	+	+	0	+	+	+	+	0
"Sauche-Sali" from d'Herelle	Bacilli and coccoid forms	Liquification	Weak acidity. Coagulation.	Weak acidity Coagulation Reduction	+	+	+	+	+	+	+	0	+	0	0
Cultures sent by Du Ponce & Vandenberg	Bacilli and coccoid forms	Liquification	Weak acidity. Coagulation.	Weak acidity Coagulation Reduction	+	+	+	+	+	+	+	0	+	0	0
"Sauche Cham" from d'Herelle	All stages between bacilli and diplococci	Gas. Liquification	Weak acidity. No coagulation.	Weak acidity No coagulation No reduction	+	+	+	+	+	+	+	+	+	+	0
d'Herelle's Original Description	All stages between bacilli and cocci	Not mentioned	Strong alkalinity. Coagulation.	Not mentioned	+	Not mentioned	+	+	+	Not mentioned	+	Not mentioned	Not mentioned	Not mentioned	Not mentioned
Du Ponce & Vandenberg's Description	Bacilli and diplococci	No liquification	Acidity. Coagulation.	Weak acidity Coagulation No reduction	Not mentioned	+	+	+	Not mentioned	+	Not mentioned	+	0	0	0

EXPERIMENTATION WITH CULTURES.

In order to test the pathogenicity of the separate cultures laboratory experiments were performed with *Bacillus poncei* and with d'Herelle's cultures labeled "Souche Cham" and "Souche Sidi." I attempted no experiments with the culture obtained from Messrs. Du Porte and Vanderleck for the reason that my systematic study showed this culture to be identical with d'Herelle's "Souche Sidi" strain.

In all of my experiments the most painstaking bacteriological technicalities were observed, so I shall not undertake to describe all of the tiresome and well known methods in vogue such as using sterile instruments, etc., for injecting and operating upon a grasshopper. Suffice it to say, that sterile containers in the form of battery jars were found extremely useful in performing my experiments. Glass plates covered the jars in order to keep the hoppers from jumping out. These plates had the further advantage of keeping the corn leaves, with which we fed the insects, fresh. Prior to the injection the hoppers were always washed with 95% alcohol. This must not be used too freely, otherwise, the grasshoppers may die and after its use one must wait a minute or so for the alcohol to evaporate before injecting. A small amount of alcohol entering the wound, however minute, caused by the hypodermic needle usually ends fatally. The inoculations were always performed between the metathorax and the first abdominal segment on the ventral side. In order to avoid rupturing the gut or otherwise injuring the insect, two operators are absolutely necessary to perform successful inoculations. One person must carefully, but firmly hold the insect while the other inoculates. I performed a number of tests in order to determine whether my technical precautions were sufficient and I found them satisfactory. For example: I washed off a large series of grasshoppers with alcohol and then injected with sterile water. Some of the insects I permitted to live until they seemed to die of natural causes; others I killed after periods of one and two weeks in order to inoculate culture tubes with some blood obtained by bathing the trochanter and femur with alcohol and then breaking the joint by a swift movement. The culture tubes remained perfectly sterile.

Experiments with Bacillus poncei.

On reviewing the tables which illustrate my experiments with *B. poncei* and the other bacteria investigators in this subject may wonder why I used females more often in preference to males. The reasons are these: Female grasshoppers are much larger than the males and consequently easier to handle. Moreover, they seem to be hardier and withstand the alcohol bath and hypodermic needle much better than the males. Finally, the females naturally live longer which is, of course, a decided advantage in any experiment.

Another inconsistency in my experiments seems evident from the fact that at times I used a smaller or a larger number of animals in one experiment than in another. This was found necessary for the reason that large numbers of female grasshoppers of the desired species, sufficiently mature for experimentation, were sometimes difficult to find in the region where my laboratory experiments were performed.

The tables given on pages 38-41 are self-explanatory. The insects were always inoculated with one drop ($\frac{1}{10}$ c. c.) of the particular fluid. The emulsion of the six months old agar culture of *B. poncei* given in Table I was prepared by adding 10 c. c. of sterile water to the old culture and shaking the tube vigorously. The emulsions of the intestinal contents of dead animals were prepared by dissecting out the intestines under aseptic conditions and triturating in sterile test tubes containing 5 c. c. of sterile water. This material, owing to the fact that it contained shreds of tissue was filtered in a sterile filter especially prepared for the experiments and from which unfiltered air was excluded.

Tables II, III and IV represent passage infections modeled after the experiments performed by other workers. By an examination of Tables I-IV it would seem that I had increased the virulence of *B. poncei*, while the deaths represented on Tables I and II extend over a long period of time; at the second and especially at the third passage Tables III and IV, the number of days elapsing between infection and death are considerably shortened.

The optimist would at once proclaim this as evidence for increase in virulence, but such is not the case. The three animals dead in the last experiment were carefully examined

and an earnest attempt was made to recover *B. poncei*, but I utterly failed. I inoculated a variety of media from the blood, from various tissues and from the intestines. I plated from these media and tested all suspicious looking colonies on the required media, (media given in my descriptions of organism) in the sugar tubes and performed the nitrate and indol tests as well but without success. About a half-dozen other organisms were found, but *B. poncei* failed to reveal itself. What killed the grasshoppers? The five deaths represented on Table I were probably due to *B. poncei*, but the deaths in the three passage infections were due to the careless way in which these experiments were carried out. Since this method has been used by practically all workers on this subject, I wish to point out its absolute worthlessness. Grasshopper intestines, as a large number of observations convinced me, are not only often full of gregarines and flagellates, but contain many species of bacteria (intestinal flora). By performing such passage infections as outlined in my tables one simply inoculates the animals with an indefinite quantity of intestinal flora. No wonder the animals succumbed. What then became of *B. poncei*? This bacterium was either destroyed by the countless other introduced bacteria or was killed by the grasshopper blood cells (phagocytosis) or other immunity principles. If the grasshoppers are to be inoculated in the body cavity why should so many investigators choose the intestines for further passages? Why not perform the passages with the blood? Of course, a sufficient number of the organisms introduced should cling to the outside of the intestines when these are removed, but other organisms within the intestines are likewise introduced. I also failed to obtain pure cultures of *B. poncei* by resort to blood passages on the animals I used (*Melanoplus femur-rubrum* and *Encoptolophus sordidus*) for the reason that the blood seems to act antagonistically towards the bacterium in question and destroys it in most cases. Nevertheless, other organisms are carried along since the toxins or other products introduced cause a disturbance of some sort which in turn causes the gut of the grasshopper to rupture liberating the intestinal flora into the body cavity.

Tables V, VI and VII represent another series of experiments performed along the same lines as the preceding. The results were exactly similar. I know of no way in which passage

infections can be performed in this manner. Tables VIII, IX and X represent another series of passages performed on another species of grasshopper, *Encoptolophus sordidus*. Even after the 1st passage I failed to recover *B. poncei*. Strange as it may appear, I recovered *B. poncei* from one animal dead in the 2nd passage.

Table XI represents thirty-five animals (*M. femur-rubrum*) inoculated with a twenty-four hour bouillon culture of *B. poncei*. The organism in question was recovered only three times.

Table XII demonstrates what is meant by the rupture of the gut after a foreign toxin or protein is introduced into the blood. In order to see whether I was rupturing the intestines myself by introducing the hypodermic needle, I injected a large series of grasshoppers with a dead culture of *B. poncei*. After three days I inoculated some bouillon tubes with some of the blood taken from these animals. The tubes remained perfectly sterile.

Tables XIII and XIV represent experiments on infection by feeding. Here the organisms were introduced into the alimentary tract. If *B. poncei* is pathogenic at all, I thought, this would be the most natural method of infection. I failed, however, to recover the organism either from the feces, from the living infected animals, or from the alimentary tract of the dead. From what did these animals die? Possibly from endotoxins liberated from *B. poncei*, which was destroyed within the grasshopper stomach and intestines.

The method of spraying the culture on the food foliage consisted in diluting the culture one-half with sterile water and spraying with a fine atomizer until the leaves were visibly wet.

Conclusions on Experiments with B. poncei.

I conclude from the foregoing experiments that *B. poncei* is pathogenic to *Melanoplus femur-rubrum* and *Encoptolophus sordidus*. In most cases, however, I failed to recover the organism from the blood, the alimentary tract and from the feces. My experiments lead me to believe that insects can develop immunity principles which can more or less successfully cope with certain foreign organisms. The following experiment will further assist in substantiating this view. October 12, 1916, I inoculated six female *M. femur-rubrum* with a twenty-four

hour bouillon culture of *B. poncei*. October 13th the animals were all alive. I pulled out one metathoracic leg from each animal and permitted a drop of blood from each to flow into a nutrient bouillon tube. Three tubes were kept at room temperature and three were incubated, yet all six remained perfectly sterile. Stained smears of some of the blood also failed to reveal any micro-organisms. Sooner or later, I think, the gut would have ruptured liberating the intestinal flora into the body cavity, so I thought it best to make the tests the second day.

I further conclude that passage infections performed by using the alimentary tract are hopeless on account of the extensive flora. Blood passages, with *B. poncei*, were likewise useless, in most cases, for the reason that the gut ruptured after a short time. Passages by means of the blood are possible with other bacteria, however, as I will show later.

*Experiments with Cultures "Souche Cham" and
"Souche Sidi."*

The infection experiments with "Souche Cham" and "Souche Sidi" were much more satisfactory than those with *B. poncei*. In regard to "Souche Cham," I successfully performed two passages, but curiously enough, as can be seen from Tables XV-XVII (1 and 2), obtained no increase in virulence. Perhaps if I had measured the time between inoculation and death in hours instead of in days, I might have noticed something, but many deaths unfortunately occurred during the night. However, measurement of time in days is sufficient and if a marked increase in virulence had manifested itself, I surely would have noticed it.

The gut of *M. atlantis* never ruptured, so the blood or muscle tissue could readily be used as a basis for further inoculations. In no case, however, can extracts from the stomach or the intestines be used for further passages. A series of examinations conclusively proved that these are invariably contaminated even in perfectly normal looking animals.

Tables XVIII and XIX represent experiments dealing with food infections. *M. atlantis* was also the subject for these tests. In general the time between infection and death is somewhat extended which is to be expected in this mode of experiment,

still it seems to me that the organism acts very quickly. These "per os" infections really mean more than the inoculation experiments for the reason that it is the natural way in which the bacterium would invade the insect. Of course, laboratory passages, where pure recoveries are required, are impossible to perform by this method of infection unless one plated between each infection. Since my experiments showed the futility of passages, in so far as increase in virulence is concerned, I did not see any advantage in doing an extra amount of tedious work. It seems to me that the organism is sufficiently virulent even in old cultures, so that if one could succeed in establishing a center of infection in the field an epidemic would soon follow provided certain conditions were favorable.

Tables XX and XXI also represent food infections. *M. bivittatus* was the subject. If it is permissible to judge from two experiments the organism does not seem to be so pathogenic to this insect. A number of insects in the XX experiment succumbed to parasitism by *Mermis ferruginea*, a nematode.

Table XXII represents the same sort of an experiment as the preceding with the exception that *M. femur-rubrum* was the subject. "Souche Cham" also does not seem to be as highly pathogenic to this species as it is to *M. atlanis*.

Table XXIII represents an inoculation experiment with "Souche Sidi." *M. atlanis* was the subject. The period from infection to death extends over a period of six days. This seems to show that "Souche Sidi" is not as pathogenic as "Souche Cham."

Table XXIV represents a food infection experiment with the same culture and the same subject. The period from infection to death is also, in general, prolonged. Two animals died naturally although I am certain they became infected.

In all of the food infection experiments the grasshoppers were given barely enough leaves in order to insure their eating everything in 12-24 hours.

Table XXV represents a food infection experiment with "Souche Sidi." The subject in this case was *M. bivittatus*. The pathogenicity of "Souche Sidi" for this species seems to be the same as for *M. atlanis*.

Suitable checks accompanied all of my experiments. These always died of old age or of *Mermis* parasitism, but seemed not to suffer naturally from any endemic disease. At times I found some checks prematurely dead, but I traced this to CO₂ asphyxiation and on replacing my glass plates, which covered the battery jar containers, with cheese-cloth tops, I overcame this difficulty. The glass plates are splendid, however, unless one confines too many insects in one jar.

As can be seen on examining the tables, I performed a large series of post mortem tests. This means that stained smears were studied and that the material was "plated out," colonies isolated and the species studied on different media, and their bio-chemical characters in carbohydrates, etc., observed. Of course, some of these final tests were finished long after the conclusion of the grasshopper season. It is absolutely impossible to perform in a short time, the huge amount of work which experiments of this sort require.

Conclusions on experiments with cultures "Souche Cham" and "Souche Sidi."

1. "Souche Cham" is pathogenic to *M. atlantis*, *M. bivittatus* and *M. femur-rubrum*.
2. "Souche Cham" is not as pathogenic to *M. bivittatus* and *M. femur-rubrum* as to *M. atlantis*.
3. Passage infections with "Souche Cham" were possible, but no increase in virulence was observed.
4. The gut of *M. atlantis* does not rupture, and for this reason the blood and muscle tissue can be used for passage infections.
5. Extracts from the stomach or intestines can not be used for passage infections.
6. In food infections the time between inoculation and death is somewhat extended.
7. "Souche Cham" and "Souche Sidi" are quite virulent even in old cultures.
8. "Souche Sidi" is not as pathogenic to *M. atlantis* and *M. bivittatus* as "Souche Cham."
9. No passage infections with "Souche Sidi" were attempted.

FIELD EXPERIMENTS.

Melanoplus atlantis is a serious pest in certain regions of the State of Vermont. Since this species occurs in dense swarms and since it acquires cannibalistic habits when natural food becomes scarce, I thought it would be splendid material for field work. Mr. A. M. Wilcox and I have instituted a large series of field experiments with cultures "Souche Cham" and "Souche Sidi" in Vermont, but we wish to await the passage of at least another season before drawing any conclusions. The hurried method of rushing into print field observations dealing with a single season's work is deplorable. The amount of work which is necessary before coming to any conclusions at all is so immense that an army of trained workers co-operating in every possible way could not obtain final results after a single season's work.

Culture sent by Dr. Cicilio Lopez Ponce of Honduras under the name of *Coccobacillus acridiorum*:

Bacillus poncei sp. nov.

Morphology. From 1½% nutrient agar stroke 24 hours old, long rods. From 1½% potato agar stroke 24 hours old, long rods and some short rods. From milk 48 hours old, many short rods. Average length 2.2μ. Average width .9μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth moderate, spreading, flat, glistening, smooth, white, opaque, odor absent, butyrous, medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, arborescent, flat, glistening, smooth, white, opaque, odor absent, butyrous, medium unchanged.

Potato. Growth abundant, spreading, flat, glistening, smooth, white, odor absent, butyrous, medium unchanged.

Gelatin stab. Growth best at top, beaded, no liquifaction, medium unchanged.

Nutrient broth. Neutral. Pellicle, clouding strong, no clearing after 15 days, odor absent, slight sediment.

Milk. Acid. Coagulation in six days. Extrusion of whey in six to ten days, no peptonization, color of medium unchanged.

Litmus milk. Acid, coagulation, prompt reduction.

Gelatin colonies. Growth slow, white, round, slightly raised, edge entire, no liquifaction.

Agar colonies. Growth slow, white, round, smooth, raised slightly, edge entire, amorphous, diameter 4 mm.

Ammonia production. Feeble.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Absent.

Hydrogen sulphide production. Absent.

Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	+
Levulose	+	Mannit	+
Saccharose	0	Adonit	+
Maltose	+	Dulcit	0

Pathogenicity. Pathogenic to *Melanoplus femur-rubrum*, *Encoptolophus sordidus*, and *Gryllus pennsylvanicus*. Pathogenicity not tested out on any other forms.

Culture sent by d'Herelle under the name *Coccobacillus acridiorum*. Culture labeled "Souche Cham":

Morphology. From 1½% nutrient agar stroke 48 hours old, small diplococci. All very uniform. No bacilli. In water of condensation all transition forms between diplococci and bacilli. Highly polymorphous.* From milk 48 hours old, small diplococci, no bacilli. From bouillon 48 hours old, all intermediate stages between true bacilli and coccus forms. Nutrient bouillon is a favorable medium for the development of the bacillus forms. Solid media like nutrient and potato agar are favorable for the development of the diplococcus forms. This can be easily demonstrated by transferring from the liquid to the solid medium and vice versa. Diameter of cocci .6μ. Length of bacilli .7-1.5μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth abundant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato. Growth abundant, whitish.

Gelatin stab. Growth uniform, beaded, gas, liquifaction, medium unchanged.

Nutrient broth. Ring, slight pellicle, clouding strong, sediment abundant, odor absent, no clearing after fifteen days.

Milk. Weak acidity, no coagulation, color of medium unchanged.

Litmus milk. Weak acidity, no coagulation, no reduction.

Gelatin colonies. Growth rapid, round, convex, edge entire, gas, diameter of colony .5-1 mm.

Nutrient agar colonies. Growth rapid, round, smooth, flat, edge entire, amorphous, diameter of colony 2.5-3 mm.

Ammonia production. Positive.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Negative.

*For an interesting article on pleomorphism see: Studies in pleomorphism in Typhus and other diseases by Edward C. Hort. Abstract in Jour. Royal Micros. Soc., December, 1916.

Hydrogen sulphide production. Negative.

Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	+
Levulose	+	Mannit	+
Saccharose	+	Adonit	+
Maltose	+	Dulcitol	O

Pathogenicity. Pathogenic to *Melanoplus allanis*, *Melanoplus bivittatus*, and *Melanoplus femur-rubrum*. Pathogenicity not tested out on any other forms.

Culture sent by d'Herelle under the name *Coccobacillus acridiorum*. Culture labeled "Souche Sidi":

Morphology. From 1½% nutrient agar stroke 48 hours old, short bacilli dominant forms; some coccoid forms. In water of condensation bacillus forms typical. From milk 48 hours old, bacillus forms dominant; some coccoid forms. From bouillon 48 hours old, typical bacillus forms dominant; few coccoid forms. Not as polymorphous as culture "Souche Cham." Length of bacilli .8-1.5μ. Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth abundant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, color of medium unchanged.

Potato. Growth abundant, whitish.

Gelatin stab. Growth uniform, beaded, liquifaction, medium unchanged.

Nutrient broth. Ring, slight pellicle, clouding strong, sediment abundant, odor absent, no clearing after fifteen days.

Milk. Weak acidity, coagulation delayed, extrusion of whey, no peptonization, color of medium unchanged.

Litmus milk. Weak acidity, coagulation, extrusion of whey, reduction complete.

Gelatin colonies. Growth rapid, round, convex, edge entire, no liquifaction, diameter of colony .5-1 mm.

Nutrient agar colonies. Growth rapid, round, smooth, flat, edge entire, coarsely granular, diameter of colony 2.5-3 mm.

Ammonia production. Positive.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Negative.

Hydrogen sulphide production. Negative.

Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	O
Levulose	+	Mannit	+
Saccharose	+	Adonit	O
Maltose	+	Dulcitol	O

Pathogenicity. Pathogenic to *Melanoplus allanis* and *Melanoplus bivittatus*. Pathogenicity not tested out on any other forms.

Culture sent by Messrs. Du Porte and Vanderleek of Canada, who received same from d'Herelle under the name of *Coccobacillus acridiorum*:

Morphology. From 1½% nutrient agar stroke 48 hours old, short bacilli dominant forms; some coccoid forms. In water of condensation bacillus forms typical. From milk 48 hours old, bacillus forms dominant; some coccoid forms. From bouillon 48 hours old, typical bacillus forms abundant; few coccoid forms. Not as polymorphous as culture "Souche Cham." Length of bacilli .8-1.5 μ . Motile. Gram negative. Stains readily.

Nutrient agar stroke. 1½%. Neutral. Growth abundant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, medium unchanged.

Potato agar stroke. 1½%. Neutral. Growth very luxuriant, spreading, flat, glistening, smooth, opaque, odor absent, butyrous, medium unchanged.

Potato. Growth abundant, whitish.

Gelatin stab. Growth uniform, beaded, liquifaction, medium unchanged.

Nutrient broth. Ring, slight pellicle, clouding strong, sediment abundant, odor absent, no clearing after fifteen days.

Milk. Weak acidity, coagulation delayed, extrusion of whey, no peptonization, color of medium unchanged.

Litmus milk. Weak acidity, coagulation, extrusion of whey, reduction complete.

Gelatin colonies. Growth rapid, round, convex, edge entire, no liquifaction, diameter of colony .5-1 mm.

Nutrient agar colonies. Growth rapid, round, smooth, flat, edge entire, coarsely granular, diameter of colony 2.5-3 mm.

Ammonia production. Positive.

Nitrate solution. Nitrates reduced to nitrites.

Indol production. Negative.

Hydrogen sulphide production. Negative.

Fermentation of carbohydrates with gas.

Dextrose	+	Lactose	O
Levulose	+	Mannit	+
Saccharose	+	Dulcit	O
Maltose	+	Adonit	O

Pathogenicity. Pathogenic to *Melanoplus atlans* and *Melanoplus bivittatus*. Pathogenicity not tested out on any other forms.

Original description by d'Herelle of *Coccobacillus acridiorum*:

Morphology. Media from which the morphological observations were made not mentioned. Short bacillus, slightly oval, very polymorphous. Cocci $.6\mu$, bacilli $.4-.6\mu$ by $.9-1.5\mu$. Motile, peripheral flagellæ. Gram negative, stains readily.

Potato. Growth creamy. Water of condensation sirupy, reaction strongly alkaline.

Gelatin. Not liquified.

Nutrient broth. Development rapid at 37° . Clouding from fourth hour on. After several days a very light veil appears. Bouillon clears after three weeks, producing a sediment. A young culture agitated produces silky waves. Odor of Liebig's extract. Rendered strongly alkaline.

Milk. Coagulated and rendered strongly alkaline.

Nutrient agar colonies. Visible after 12 hours. After 18 hours they are 2-3 mm. in diameter. Circular, waxy. Below surface spherical, whitish, opaque.

Fermentation of carbohydrates.

Dextrose	+	Organism renders medium containing one
Levulose	+	of these sugars slightly acid than
Maltose	+	alkaline.
Galactose	+	

Oxygen requirements. Facultative anaerobe.

Pathogenicity. Pathogenic to various Acrididæ, ants and caterpillars.

Description by Du Porte and Vanderleck of culture sent to them from d'Herelle under the name *Coccobacillus acridiorum*:

Morphology. From agar slope 20 hours old, short rods or cocci, some oval, polymorphous. $0.7-1.0\mu$. In milk culture they appear often as diplococci. Motile. Gram negative. Amylgram positive. Stain readily.

Agar stroke. Abundant growth, spreading, flat, glistening, smooth, dirty white to bluish white, opaque, butyrous, medium unchanged. On 1% agar the cultures are arborescent and transparent.

Potato. Abundant growth, spreading, flat, glistening, smooth, butyrous; color from dirty white to yellow.

Gelatin stab. Uniform growth, line of puncture filiform. No liquifaction, medium unchanged. Stab brownish yellow.

Nutrient broth. Pellicle or ring, turbidity, slight sediment, no clearing after 14 days, odor of beef extract.

Milk. At first gas production without coagulation. Delayed coagulation in 2-8 days, acid reaction after 8 days, no peptonization, medium unchanged, no extrusion of whey.

Litmus milk. Gas production, weak acidity, no reduction. After four days partial to complete coagulation, acid.

Gelatin colonies. Growth slow, round, raised, edge entire, yellow. Three weeks, 2 mm. in diameter, yellow white. No liquifaction.

Agar colonies. Rapid growth, irregular, round, smooth, flat, edge entire, amorphous, dirty white to blue, transparent. Growth more restricted on 1½% than on 1% agar.

Aesculin bilesalt agar. Weak field after 24 to 48 hours.

Neutral red bilesalt agar. Strong fluorescence, red spreading.

Indol production. Negative.

Fermentation of carbohydrates.

Dextrose	+	Rafinose	+
Saccharose	+	Arabinose	+
Lactose	+		
Galactose	+	Adonit	O
Muscle sugar	+	Dulcit	O

Pathogenicity. Pathogenic to locusts and grasshoppers. Injection fatal within 24 hours.

TABLE I.

Ten animals injected with an emulsion of a 6 months old agar culture of *B. poncei*. ♀ ♀ *M. femur-rubrum* used.

No. of days...	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of deaths..	1				1			1					1	1

TABLE II.

Eight animals injected with an emulsion of intestinal contents of animal dead on 8th day. ♀ ♀ *M. femur-rubrum* used. 1st passage.

No. of days.....	1	2	3	4	5	6	7	8	9	10
No. of deaths.....		1				2	1	2		1

TABLE III.

Three animals injected with an emulsion of intestinal contents of an animal dead on the 6th day. ♀ ♀ *M. femur-rubrum* used. 2nd passage.

No. of days.....	1	2	3	4	5
No. of deaths.....					1

TABLE IV.

Three animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *M. femur-rubrum* used. 3rd passage.

No. of days.....	1	2	3	4
No. of deaths.....			3	

The three animals dead on 2nd day were "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE V.

Eight animals injected with a 24-hour culture of *B. poncei* in nitrate solution. ♀ ♀ *M. femur-rubrum* used.

No. of days.....	1	2	3	4	5
No. of deaths....			2		2

TABLE VI.

Three animals injected with an emulsion of intestinal contents of last two dead in previous experiment. ♀ ♀ *M. femur-rubrum* used. 1st passage.

No. of days.....	1	2	3	4
No. of deaths.....		2	1	

TABLE VII.

Three animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *M. femur-rubrum* used. 2nd passage.

No. of days.....	1	2	3	4
No. of deaths.....		3		

Three animals dead in last experiment "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE VIII.

Five animals injected with a 24-hour culture of *B. poncei* in nitrate solution. ♀ ♀ *Encoptolophus sordidus* used.

No. of days.....	1	2	3	4	5	6
No. of deaths.....		2	1			1 1 lived

TABLE IX.

Five animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *Encoptolophus sordidus* used. 1st passage.

No. of days....	1	2	3	4	5	6	7
No. of deaths..			1			1	1 2 lived

Animals dead on 6th and 7th days "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE X.

Five animals injected with an emulsion of intestinal contents of last one dead in previous experiment. ♀ ♀ *Encoptolophus sordidus* used. 2nd passage.

No. of days.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
No. of deaths.....								1	1	1							1	1	

Animals dead on 12th, 17th and 19th days "tested." *B. poncei* recovered from animal dead on 12th day. Other organisms recovered from remaining two tests.

TABLE XI.

Thirty-five animals injected with a 24-hour bouillon culture of *B. poncei*. ♀ ♀ *M. femur-rubrum* used.

No. of days....	1	2	3	4	5	6	7	8	9	10	11
No. of deaths..		9	7	12	4	2					1

Three dead animals "tested" on 4th day as well as last seven dead. Recovered *B. poncei* three times. Other organisms recovered in remaining tests.

TABLE XII.

Nineteen animals injected with a 24-hour bouillon culture killed by sterilizing in autoclave. Sterility verified by inoculating various media. ♀ ♀ *M. femur-rubrum* used.

No. of days...1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. of deaths	2	3			9	1	1	1	1				1

Six animals "tested." *B. poncei* not recovered. Two tests showed cultural sterility; four showed presence of other organisms.

TABLE XIII.

Nine animals enclosed in a battery jar and food sprayed with a 48-hour culture of *B. poncei*. Proportions of sexes not noted, but ♂ ♂ and ♀ ♀ of *M. femur-rubrum* used.

No. of days.....	1	2	3	4	5	6	7	8	0	10
No. of deaths.....						2	2			5

Five dead animals "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE XIV.

Eight animals enclosed in a battery jar and food sprayed with a 48-hour culture of *B. poncei* in nitrate solution. Four ♂♂ and four ♀♀ *M. femur-rubrum* used.

No. of days....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
No. of deaths...					1	2	1		1		1						1			1

Three dead animals "tested." *B. poncei* not recovered. Other organisms recovered.

TABLE XV.

Twenty animals injected with a 17-hour bouillon culture of *Coccobacillus acridiorum* "Souche Cham." ♀♀ *M. atlantis* used.

No. of days.....							1		2		3		4
No. of deaths.....									17		3		

Last three dead "tested." Piece of femoral muscle removed aseptically and dropped into culture tube. Pure culture of "Souche Cham" obtained.

TABLE XVI.

Two out of seventeen dead on 2nd day in previous experiment taken and femoral muscle triturated in 10 c. c. sterile H₂O. Eight ♀♀ *M. atlantis* injected. 1st passage.

No. of days....	1	2	3	4	5	6	7	8
No. of deaths..		5	3					

Tests made from blood and femoral muscle of dead animals reacted positively for "Souche Cham." No other organisms found.

TABLE XVII (No. 1 and 2).*

Eight animals injected from one dead on 3rd day in previous experiment and eight injected from another dead the same day. Femoral muscle triturated as above. ♀♀ *M. atlantis* used. 2nd passage.

No. 1.

No. of days.....	1	2	3	4	5
No. of deaths.....		5	3		

No. 2.

No. of days.....	1	2	3	4	5
No. of deaths.....		4	4		

Last three dead in No. 1 and two dead from No. 2 examined. "Souche Cham" recovered. No other organisms found.

TABLE XVIII.

Ten animals infected by spraying corn leaves with 24-hour bouillon culture of "Souche Cham." Five ♂♂ and five ♀♀ *M. atlantis* used.

No. of days.....	1	2	3	4	5	6
No. of deaths.....		4	1	4	1	

Three of dead animals "tested." "Souche Cham" recovered from feces and from alimentary tract. Two other organisms recovered.

TABLE XIX.

Eight animals infected by spraying corn leaves with 24-hour bouillon culture of "Souche Cham." Four ♂♂ and four ♀♀ *M. atlantis* used.

No. of days.....	1	2	3	4
No. of deaths.....		2	6	

Three animals "tested." "Souche Cham" recovered from alimentary tract. One other organism recovered.

*Signifies separate jars in which grasshoppers were kept, so really two separate experiments, otherwise I might have incorporated the two experiments in one table.

TABLE XX.

Nineteen animals infected by spraying corn leaves with 24-hour bouillon culture of "Souche Cham." *M. bivittatus* used. Proportion of sexes not noted.

No. of days....	1	2	3	4	5	6	7
No. of deaths..		3	2	2	2	4	3
		worm parasitism			worm parasitism		

Two dead on 3rd day "tested." "Souche Cham" recovered from alimentary tract. Other organisms recovered.

TABLE XXI.

Eight animals infected by spraying corn leaves with a 24-hour bouillon culture of "Souche Cham." Four ♂♂ and four ♀♀ *M. bivittatus* used.

No. of days.....	1	2	3	4	5	6
No. of deaths.....				4	1	2
						1 lived

One dead on 5th day "tested." "Souche Cham" recovered in pure culture from alimentary tract.

TABLE XXII.

Eight animals infected by spraying corn leaves with a 24-hour bouillon culture of "Souche Cham." Four ♂♂ and four ♀♀ *M. femur-rubrum* used.

No. of days....	1	2	3	4	5	6	7
No. of deaths..				4	2	1	1

Two dead on 5th day "tested." "Souche Cham" recovered from alimentary tract. Other organisms recovered.

TABLE XXIII.

Ten animals injected with a 24-hour culture of "Souche Sidi." ♀♀ *M. atlantis* used.

No. of days....	1	2	3	4	5	6	7
No. of deaths..		1	2	3	2	2	

Two animals dead on 5th day "tested." "Souche Sidi" recovered from blood in pure culture.

TABLE XXIV.

Ten animals infected by spraying corn leaves with a 24-hour culture of "Souche Sidi." Five ♂♂ and five ♀♀ *M. atlantis* used.

No. of days....	1	2	3	4	5	6	7
No. of deaths..		2	1	1	2	1	1
		worm parasitism			2 lived for 10 days and then died naturally after depositing eggs.		

Two dead animals "tested." "Souche Sidi" recovered from alimentary tract. Other organisms recovered.

TABLE XXV.

Eight animals infected by spraying corn leaves with a 24-hour bouillon culture of "Souche Sidi." *M. bivittatus* used. Sexes not noted, but majority females.

No. of days.....	1	2	3	4	5
No. of deaths....			4	1	1
					2 lived for about 10 days and then died after depositing eggs

One animal dead on 4th day "tested." "Souche Sidi" recovered from alimentary tract. Other organisms recovered.

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ADDITIONAL NOTES ON THE LIFE HISTORY OF BOMBUS AURICOMUS ROBT.

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During the summer of 1917 the writer was enabled to make some additional observations on the life-history of *Bombus auricomus* Robt., which resulted in the verification of several statements already published in a preceding article of his ('17), and in the addition of new facts of interest.

I. SPRING FLIGHT OF THE QUEENS.

The queens of *Bombus auricomus* in this vicinity began to fly in the spring of 1917 about the twelfth of May, and continued flying until about the first of July. The queen during the first few days of the spring flight flies rather near the ground, stopping now and then to sip the nectar from some attractive flower. Later this leisurely flight settles into an industrious search for a nesting site, the duration of the search depending entirely upon how soon the queen finds a favorable location. After a nesting site is once selected the queen busies herself mainly with collecting pollen in which to lay the eggs for her future brood.

From this time on, the flights of the queen from the nest gradually decrease in number, until at last there comes a time when sufficient workers have been produced to supply the necessary pollen and honey, and the queen seldom if ever leaves the nest. It is safe to say that nearly all the queens of this species in this vicinity in a normal season have started their nests by the first or second week in June.

II. METHODS USED IN STARTING A COLONY BY CONFINING THE QUEENS.

For several years I have tried confining bumblebee queens in separate artificial nests and feeding them, in the hope of getting the queens to start colonies, but this method has always failed. Sometimes a queen would seem to take an interest in the nest, pat the grass down about the pollen lump, and get very excited when disturbed, but always finally abandoned the nest. This season, however, I decided to try the placing of

two queens of the same species in the same nest, as Sladen ('12) did with the common European bumblebee, *Bombus terrestris* Linn.

On May 14, 1917, I caught one queen of *Bombus auricomus*, which I brought home and confined in an artificial nest. Another queen of the same species was caught a day later, and introduced into the same nest with the first queen. The wings of the latter queen were slightly notched before she was introduced into the nest, in order that I might distinguish her from the queen first introduced. The artificial nest used consisted of a small wooden box with a glass-sectioned top. In the box proper I had placed an old field-mouse nest, in which was a honey-moistened lump of honey-bee pollen. New pollen-lumps had to be placed in the nest from time to time, for the pollen when not worked by the queen soon dried out and became unfit for use. On June 13 a wax-pollen honey-cell was also placed in the nest near the pollen-lump. Liquid food, consisting of a mixture of common honey, rye-flour and water, was supplied to the bumblebees in a small tin container in a far corner of the box. Bright light was excluded from the nest by covering the top of the box with a sheet of dark red glass.

A. THE START OF A COLONY.

Though not showing any interest in the nest, both queens were producing considerable quantities of wax by May 27. This wax was scraped off and carelessly allowed to drop to the floor of the box. On June 13 almost a month since the queens were first confined, both queens suddenly seemed to take an interest in starting a colony. This interest was first manifested by their resting mostly on the pollen-lump, occasionally nibbling at the pollen, and buzzing excitedly when disturbed. For the next few days after this the queens were less active. On June 23, however, they showed renewed vigor, making during the night a honey-pot out of the accumulated and introduced wax, and also an egg-cell in the pollen-lump.

After this second start the activities of the two queens never abated. On June 24 one egg was found in the cell made on June 23, and two more empty cells had been constructed. On June 26 the two cells made on June 24 were closed over and each contained a single egg. Up to this time neither of the

two queens had ever seemed to mind the presence of the other, but from now on whenever the nest was disturbed, they often threatened each other without, however, ever engaging in actual combat. On July 2 larvæ were observed in the pollen-mass. They had probably emerged some days before, but as I did not care to disturb the queens, I had not examined these first few cells critically. It may be mentioned here that both the queens were still occupied with the nest, though the queen that was last introduced seemed to dominate the nest.

By July 10 the nest had progressed so far that I could remove the queens and photograph the nest, without the risk of causing the queens to abandon it. Here I may say that I believe it was the queen with the clipped wings that was the actual mother of the developing colony. As time progressed this latter queen more and more asserted her right over the colony, the other queen remaining listlessly about the honey-pot. Moreover, it seems hardly probable that a queen should start a colony and then calmly submit to its being monopolized by another, when queens under natural conditions usually fight over the nests. Again, from the beginning of the colony, the queen with the clipped wings had been the dominating figure.

On July 14 the larvæ began spinning their cocoons, more eggs were laid by the queen, and the nest promised well for the future. Frequently the queen could be heard making a purring noise, while brooding over the comb. On July 20 the first worker emerged, and by July 25 five more workers had made their appearance. The variation in the rate of emergence of these first few workers was mainly due to the egg-laying habits of the queen.

Of the later life-history of this colony little need be said. It may be mentioned, however, that later in the season the queen was accidentally killed and the colony rapidly declined. The egg-laying habits, nest manipulations, wax-production, and other miscellaneous features were the same in this colony as described in my first article of this species ('17); with one exception.

The honey-pots in this nest, except for the one first constructed, were not so large nor were they so distinctly separated from the comb.

B. GENERAL FACTS OF INTEREST.

Prior to August 1, when the first queen was removed from the nest, neither queen had come to grief through the jealousy of the other. Sladen in his book on the "Humblebee" says that one of the queens, if two shared the same nest, killed the other about the time the first eggs were laid. Again, in this colony started with two queens, the first larvæ were reared to maturity without the addition of introduced workers.

III. OPENING OF A FIELD NEST OF *Bombus auricomus*.

On September 6, 1917, Dr. J. W. Folsom and myself opened and removed a nest of *Bombus auricomus* of natural origin. This nest was found in a hollow cement block, the block being a part of the foundation of a small cabin. In order to remove the block and thus get the nest it was necessary to raise one corner of the cabin with automobile jacks. Upon removing the block we found that the bumblebee nest had been started in a mouse nest within the block. The bumblebees were very docile when the nest was removed, for instead of flying angrily from the nest, the most they did was to run excitedly about on the comb and buzz loudly.

A better protected or situated nest could hardly have been selected by a queen. An examination of this nest was valuable in that it afforded a comparison between a nest of natural origin and one established under more or less controlled conditions. Again, as this nest was taken in fall it was representative of the natural "climax" nest of this species.

A. NEST CONTENTS.

There were ten workers, three new queens and three males alive in the nest at the time of opening. Five dead workers were found in the debris of the nest. A careful search was made for the old queen, but no trace of her could be found. In addition to the above, several bumblebees which were not in the nest when it was opened, returned later and remained about the old nesting site for many days. No trace of the original wax-pollen honey-pot was found, or in fact any wax-pollen cells, except the egg cells. In two of the five dead

bumble-bee workers, I found the puparia of *Zodion obliquefasciatum* Macq. (Malloch det.). The nest was also infested by the phycitid moth, *Vitulas edmansii* Pack., which has been previously reported from the nest of *Bombus perplexus* Cress. by Franklin ('13).

B. LATER HISTORY OF THE COLONY.

After the removal of the nest to an observation box, one or more males emerged almost every day for two weeks, but no additional queens or workers. The males would stay in the nest for several days and then leave, perhaps returning and perhaps not. An attempt was made to secure the fertilization of the three queens by confining them with the males, but this failed. On October 9, two workers were still alive in the nest, but could scarcely move about. On October 12, these two workers succumbed to the increasing cold nights and the colony came to an end.

IV. SUMMARY OF THE LIFE HISTORY.

The following summary of the important facts in the life history of *Bombus auricomus* is based upon a study of the two colonies in this paper, and also upon my previous account ('17).

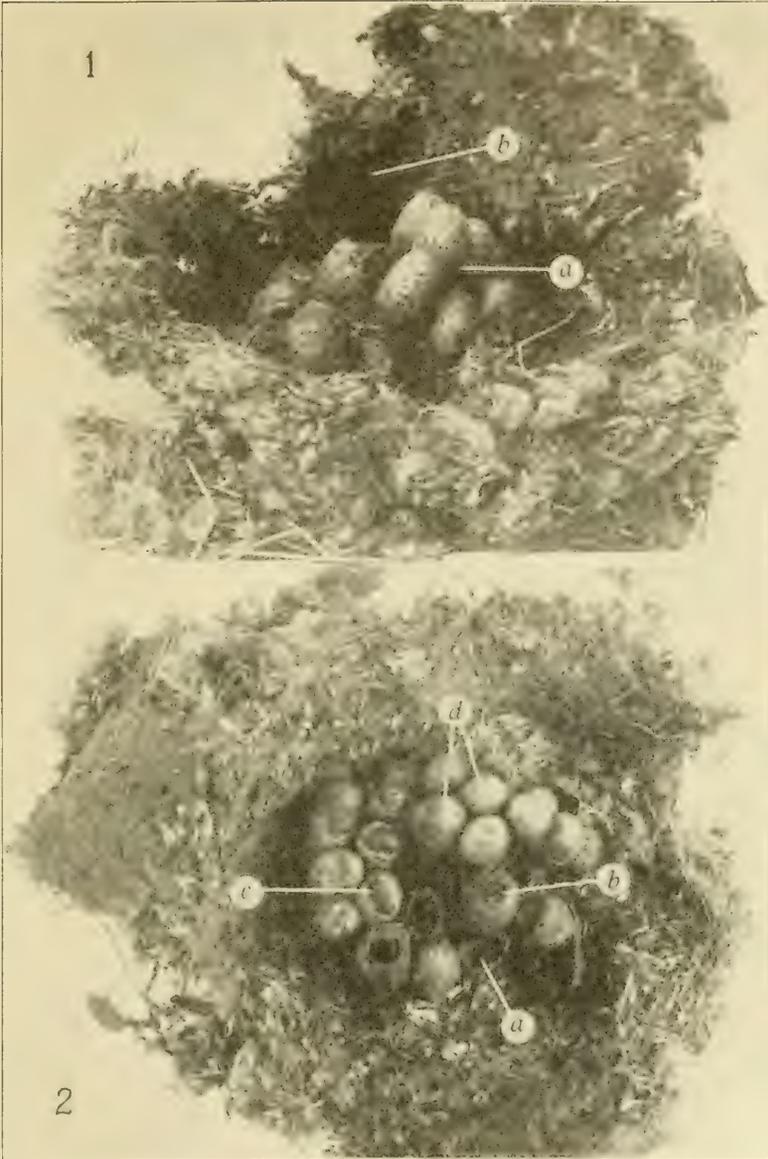
1. The nests are usually established in this vicinity sometime between the middle of May and the middle of June.
2. The bumblebees of this species are of a docile disposition as compared with such a species as *Bombus pennsylvanicus* De Geer.
3. The colonies are of rather small size.
4. The workers sometimes lay eggs, which are capable of hatching.
5. The eggs are laid in separate cells, several of which may be adjoining, but the cell-individuality is never lost.
6. The larvæ continue to remain isolated from other individuals in the same stage of development.
7. The life-cycle varies in individual cases, but may be said to last for all sexes about three and one-half weeks.

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EXPLANATION OF PLATE III.

- Fig. 1. Side view of a nest of *Bombus auricomus* Robt., of natural origin, on September 8, 1917, showing: *a*, perpendicular arrangement of the comb; *b*, usual wax-pollen covering used in forming a protective envelope about the comb. Reduced.
- Fig. 2. Top view of a nest of *Bombus auricomus* Robt., of natural origin, on September 8, 1917, showing: *a*, cocoon partially filled with pollen; *b*, cocoon used for storage of honey; *c*, three egg-cells; *d*, uncapped cocoons. Reduced.



Theo. H. Frison.

CONTRIBUTIONS TO A KNOWLEDGE OF THE CRAMBINÆ OF NORTH AMERICA. I.*

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Since undertaking a study of the Pyralid subfamily Crambinæ it has been found that the little that has been published concerning it is so widely scattered and so fragmentary that it is very difficult of access. In the present series of papers the writer proposes to bring together all the available information concerning each species, both that previously published and that which has resulted from his own work. Both systematic and biological data will be included when available but the papers cannot be exhaustive for our knowledge of many points is too scanty. They are designed to afford a convenient starting point for further work by making it unnecessary for others to go repeatedly over this same ground and to put within reach of economic workers the available facts which may be useful in economic studies of these insects. The bibliographies are intended to be complete and the writer will welcome corrections and additions thereto.

***Crambus hemiochrellus* Zeller.**

SYSTEMATIC HISTORY. Aside from descriptions of the adult little has been published concerning this species. It was originally described by Zeller (1877). Grote (1880) listed it among the American species of the genus *Crambus*. It was reduced to a variety of *mutabilis* by Smith (1891) in which error he was followed by Felt (1894). Hampson (1895) placed it as a synonym of *luteolellus* but Fernald (1896) redescribed and re-established the species as valid and it so appears in Dyar's (1902) catalog.

DISTRIBUTION. Zeller's specimens, all of which were sent him from this country, were collected in Dallas and Bosque Counties, Texas. These are the only localities appearing in the published records. To them the writer can add Chattanooga, Tenn., Wellington, Kan., and Elk Point, S. D., moths having been taken at the first two places by himself and at the last

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by Mr. C. N. Ainslie. The nineteen specimens in the collection of the U. S. National Museum bear locality labels from Devil's River, Dallas, Victoria, Sabinal, Kerrville, Plano and Brownsville, Texas, one simply "Ariz." and one taken at light at Washington, D. C. From these scattered data no definite limits for the distribution of the species can be fixed but in spite of its comparative rarity it appears to be widely diffused. The map below shows the location of the above mentioned localities.



Map of the United States showing points at which *Crambus hemiochrellus* has been collected.

FOOD PLANTS. Nothing is known of the normal food plants. Larvæ were easily reared to maturity on bluegrass (*Poa pratensis*) and doubtless would have accepted any one of a large number of grasses in common with other species of the genus.

SEASONAL HISTORY. Zeller states that the moths fly in Texas during the last half of May. The first moths seen by the writer were those taken at Chattanooga on June 11. Others were taken at Wellington, June 27, and at Elk Point, July 19. All of these were captured alive and sent at once to the Bureau Field Laboratory at Nashville, Tenn., where eggs were obtained and larvæ reared from each lot. The larvæ from the Chattanooga moths pupated as soon as mature and adults emerged on August 5, 7, 11, 14 and 15. Part of the larvæ from the Kansas moths pupated as they reached maturity and moths emerged August 23, 26, 30, and September 2 and 13. The rest of the larvæ in this series did not pupate but continued slowly

to feed until they were supplied with damp sand in which they at once constructed retreats. They lay dormant in these retreats for weeks and the last of them died the following January without further change. The larvæ resulting from the South Dakota moth showed this same habit though in a more pronounced degree for none of them pupated in the fall and all died during the winter. If these overwintering larvæ could have been kept under exactly suitable conditions they would without much doubt have pupated in the spring and formed the first generation of moths. Attempts were made to breed the moths which emerged in the cages but no fertile eggs were obtained.

A consideration of the foregoing data together with the dates of collection of the moths in the National Museum indicate that in the latitude of Tennessee and southward there are two complete generations each year, the moths of the first appearing during the first half of June and of the second about two months later, in August. The collection of other moths at Wellington, August 8 and 15, by Mr. C. L. Scott, lends further support to this hypothesis. Somewhat farther north there is a complete first and a partial second generation, some of the offspring of the first remaining as larvæ until the following spring. As far north as South Dakota it is likely that few if any of the larvæ resulting from moths of the first generation pupate the same year. It appears that even in Texas there are but two generations in a year as no moths are recorded from there later than July 22. It is possible, however, that there is a complete or partial third generation in which case further collections should show moths appearing there in September.

HABITS OF MOTHS. Of the habits of the moths little is known. Those taken at Chattanooga were flying in a dry grassy field in company with *C. caliginosellus* which they so closely resembled in manner of flight and general coloration that the presence of two species was not suspected until they were examined later. At Wellington the moths, perfect unrubbed specimens, were attracted to a light trap. Eight of the nineteen specimens in the National Museum were taken at light. It is an indication of the scarcity of the species that with its positive phototropic tendencies so strongly marked it is not more commonly met with in collections.

EGG LAYING HABITS. The three captured females of which records were kept laid respectively 147, 184 and 303 eggs in confinement. A number of the reared moths of both sexes were confined together but eggs, 92 in number, were obtained from but one female and they were infertile.

REARING METHODS. Larvæ were found to be comparatively easy to rear. Four series were reared from the egg and adults were obtained in three of them. The larvæ were confined in half-ounce tin salve boxes floored with damp blotter to keep the food fresh and absorb excess moisture. They were examined daily, fed, and the boxes cleaned as often as necessary. They were fed only on bluegrass cut in short lengths. Larvæ in each instar were described and preserved. In one series a record was kept of the amount of food consumed. The data given in the rest of this paper are derived from these rearings and while perhaps varying somewhat from actual field conditions give at least a basis for comparison with other species reared by similar methods.

STAGE AND INSTAR RECORDS. The duration of the egg stage is variable, being directly dependent on temperature. The length of the first instar is also variable for some larvæ began at once to feed while others remained inactive for two or three days. Up to the seventh instar the rate of growth is very consistent. Here a complication arises for the instar immediately preceding the change to the pupa is always the longest whether it be VII, VIII or IX. Three larvæ which pupated from VII passed 13 days each in that instar while 15 larvæ which molted to VIII averaged but 4 days in VII. This explains the sudden increase in the maximum length of the seventh and succeeding instars in Table I in which are condensed the data secured as to length of instars and stages.

TABLE I.
LENGTH IN DAYS OF INSTARS AND STAGES.

Stage	Maximum	Minimum	Average	Number Averaged
Egg	9	8	9	...
Larva	47	39	43.6	9
Instar I	8	2	5.09	121
II	5	2	3.33	107
III	5	2	3.25	87
IV	7	2	3.64	79
V	9	2	4.62	67
VI	7	2	4.23	58
VII	17	2	5.18	50
VIII	14	3	7.66	41
IX	22	4	10.60	16
X	8	8	8	1
Pupa	14	9	10.40	10

The normal number of instars for the larvæ of this species is probably seven for the males and eight for the females, though some individuals in each of the reared series exceeded this number. One even reached the twelfth instar. Table II gives the larval measurements for the various instars.

TABLE II.
LARVAL MEASUREMENTS IN MILLIMETERS.

Instar	Head Width		Average	Number Averaged	Body Length
	Maximum	Minimum			
I	.....	.....	.194	..	1.2
II	.....	.....	.264	..	2.0-2.8
III	.424	.318	.362	16	3.0-4.0
IV	.580	.440	.524	14	6.0
V	.880	.635	.750	16	8.0-10.0
VI	1.165	.724	.920	19	10.0-12.0
VII	1.483	1.130	1.318	11	15.0
VIII	1.726	1.119	1.586	21	20.0
IX	1.632	1.213	1.446	21	23.0
X	1.586	1.353	1.469	4	.....

Table III shows the sex and the instar at pupation of nine of the moths reared.

TABLE III.

Number moths reared	Last larval instar	Moths Emerging	
		Male	Female
2	VII	1	1
2	VIII	2	0
4	IX	2	2
1	X	0	1

During the first three instars the larvæ fed mostly by skeletonizing the leaf, leaving only the membrane on one side. Part of those in III and all from that time on consumed the entire leaf. The amount of food consumed progressed in a fairly definite ratio, the amount eaten in any instar being about 100% greater than that eaten in the preceding instar. In this respect a larva about to pupate behaved differently than one still growing for during the last instar its desire and capacity for food seemed almost insatiable until within two or three days of pupation when it ceased entirely to feed, contracted, became sluggish and prepared for the change. It is noteworthy that larvæ of this species did not eat the molted larval skins and head casts as do those of many species of *Crambus*. The larvæ in the series of which the food record was kept were given measured pieces of bluegrass leaves and at the end of each instar the uneaten portion was removed and measured. A skeletonized leaf was considered to be two-thirds consumed. Table IV shows the amounts of food consumed by the larvæ in each instar in linear millimeters of bluegrass leaves which average about 3 mm. in width.

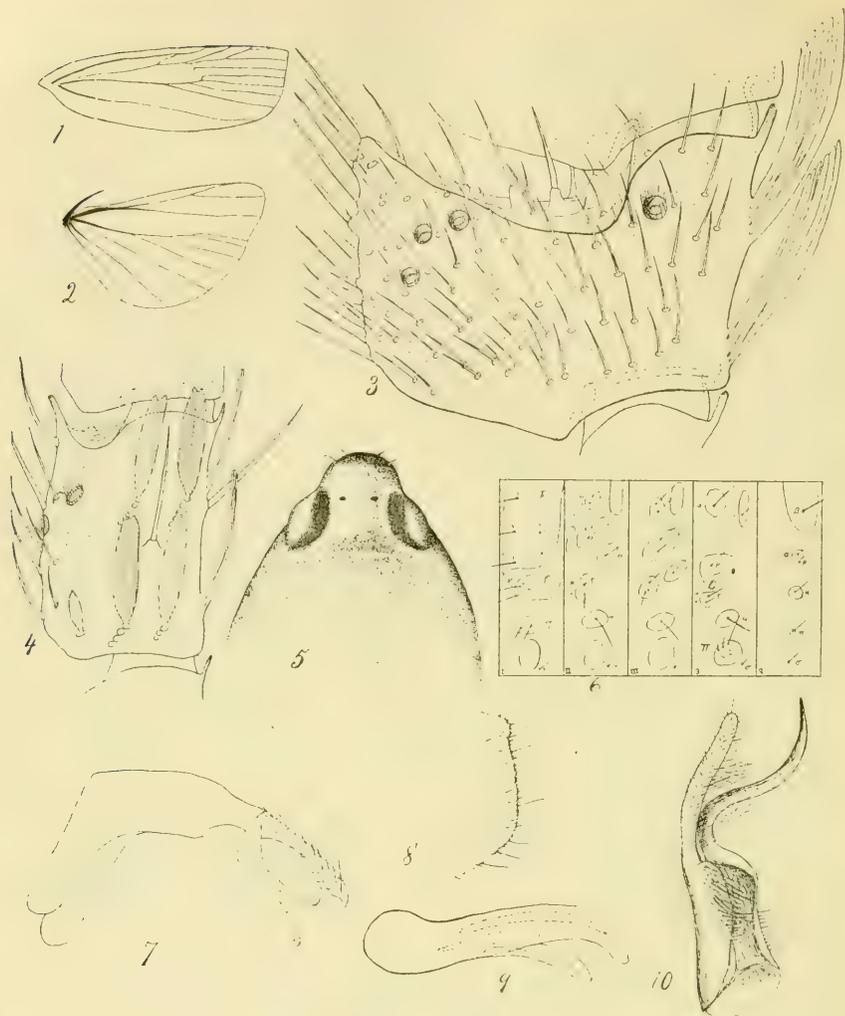
TABLE IV.
BLUEGRASS LEAVES IN LINEAR MILLIMETERS CONSUMED.

Instar	Maximum	Minimum	Average	Number larvae averaged
I	6	2	3	41
II	16	1	7	36
III	20	3	13.7	26
IV	33	5	19.4	25
V	82	19	45.5	23
VI	176	18	101	21
VII	1095	38	336	11
VIII	990	190	474	13
IX	1370	180	832	6
X	420	420	420	1

SYSTEMATIC POSITION. In its relationships this species lies between *C. trisectus* and *C. mutabilis*, more closely allied to the latter. The moth resembles that of *mutabilis* in the dark shading on the costa proximad, the dentate subterminal line and the whitish veins in the middle of the forewing. It is, however, more richly colored than that species and especially do the yellow stripes in the posterior half of the primaries contrast with the much less lively coloration of *mutabilis*. Structurally its close approach to *mutabilis* is shown in the narrow forewing, the broadly pectinate male antennæ, the naked spine-like harpe (Fig. 10) and the hooked uncus (Fig. 6). It differs in that the male antennal processes (Fig. 3) are less abundantly supplied with sensoria, the scaphium is longer, the valve is both longer and somewhat wider and the harpe while spine-like is large, doubly curved and long, exceeding the valve. This latter character in itself is sufficient to define the species for in *mutabilis* the harpe is a slender spine not more than half the length of the valve and in *trisectus*, the nearest form on the other side, the harpe is falcate and setigerous and in length about equals the valve. The relationship to *mutabilis* is shown also by the larvæ for the markings of the two are very similar differing only in shade, brick-red for *hemiochrellus* and dull brown for *mutabilis*. During their incubation period the eggs of the two species assume very nearly the same shade, a pale salmon-yellow.

DESCRIPTIONS. Adult: The description of the adult moth as given by Fernald (1896) is very accurate and complete and is here quoted with the addition of a description of the genitalia by the writer.

Expanse of wings, 22 mm. Head and thorax pale ochre-yellow; palpi thickly sprinkled with grey atoms. Fore wings bright ochre-yellow between the white median vein and hind margin with dusty stripes, and usually with a clear yellow stripe along the fold; costal portion yellowish-gray, darker toward the base; median line fine, rust-brown, forming an acute angle at the end of the cell, and extending in a nearly straight line to the middle of the hind margin; subterminal line fine, dark brown, dentate on the veins and parallel with the outer margin except at the costal end, where it curves sharply inward and terminates at the outer fourth of the costa; terminal space dusty-gray; terminal line rather indistinct, upon which in some specimens, may be seen seven very fine dark gray dots; fringes light gray. Hind wings light gray; fringes lighter.



EXPLANATION OF FIGURES.

- Fig. 1. Venation of fore wing.
 Fig. 2. Venation of hind wing.
 Fig. 3. Antenna, male, 25th segment.
 Fig. 4. Antenna, female, 25th segment.
 Fig. 5. Tip of pupa, dorsal view.
 Fig. 6. Setal map showing arrangement of pinacula and setae on three thoracic segments and the 3rd and 9th abdominal.
 Fig. 7. Male genitalia, scaphium, uncus and lower limb.
 Fig. 8. Female genitalia, edge of anal plate.
 Fig. 9. Male genitalia, penis.
 Fig. 10. Male genitalia, clasp showing harpe and valve.

Genitalia. Female—Anal valve (Fig 8) broad, nearly square in outline, not constricted at the base, dorsal angle rounded and slightly produced. Male—All parts uniformly and moderately chitinized; body of scaphium (Fig. 6) narrow, slightly longer than the limbs, which are narrow and rounded distad; uncus slender, elongate, slightly enlarged distad and ending in a small but distinct sharp hook, hirsute above, lower limb very slender, exceeding the uncus, its branches very short, naked; clasps (Fig. 10) strongly concave at the base, valve slender, elongate, uniformly clothed on the inner surface with fine hair and at its base a heavily spined, rounded lobe; harpe a long, strong, S-shaped, naked spine, exceeding the valve; penis (Fig. 9) moderately chitinized, bulbous at base and tapering to an obliquely truncate, curved tip, hollow, open at the end, with a slender, chitinous internal spine more than half the length of the organ extending nearly to the tip, the whole organ subtended by a weakly chitinized plate attached about the middle.

Our specimens agree exactly with the descriptions of Zeller and Fernald except that in some individuals the terminal line is somewhat more distinct than they indicate and the forewings of our specimens do not have the acute apex with the slight curve beneath that Zeller mentions.

The larva, especially in the later instars is easily distinguished from other Crambin larvæ we have seen by its color, a bright brick-red arranged in longitudinal stripes separated by irregular broken white lines. The head, black in the newly hatched larva, becomes in the larger instars a clear pale yellow, in some individuals faintly clouded with darker yellow. Technical descriptions of the egg, larval and pupal stages follow. Terms as defined and used by Fracker for the larva and Miss Mosher for the pupa are used. Larval measurements are condensed in Table II and are therefore omitted from the descriptions.

Egg. Elongate oval, bluntly rounded at both ends one of which is slightly smaller than the other; chorion with 17 acute longitudinal ribs, 5 or 6 of them running to the pole at each end, the others appearing as the interspaces widen; interspaces faintly transversely striate throughout their length. Measurements (10 eggs):

Length, maximum .529 mm., minimum .460 mm., average .496 mm.

Width, maximum .318 mm., minimum .300 mm., average .307 mm.

The eggs are pure white when laid, when a few hours assume a yellowish tinge and at the end of three or four days become pale salmon-yellow, remaining thus until about twenty-four

hours before hatching, when the black head and dark cervical plate show as a spot and transverse band close to one end of the egg. The hole through which the larva emerges is made at one side of the larger end of the egg, its edge usually just reaching the pole. The empty shell is transparent and iridescent.

Larva. Instar I.—Head black, cervical plate deep fuscous to black; body when first hatched clear pale yellow with minute pinacula, which later become dingy and more conspicuous.

Instar II.—Head uniformly fuscous, mouth-parts paler, ocellar area and latero-caudal margin of head black; Cervical plate fuscous, a little paler than head. Pinacula on meso- and meta-thorax small, dusky, those on abdomen larger and more conspicuous because of a shaded pigmented area just cephalad of each. Abdomen tinged with brick-red and already showing faintly the striped pattern of the larger larvæ.

Instar III.—Head uniformly clear brownish-yellow, cervical plate concolorous with head or a little paler. Pinacula dusky and conspicuous, larger and more deeply pigmented caudad. Spiracles small, dark, not prominent in all specimens.

Instar IV.—Head clear pale yellow without markings except the black ocellar area and latero-caudal margin; mouthparts outlined and the facial sutures marked by very fine dark lines. Cervical plate pale fuscous, darker than head. Pinacula on thorax and abdomen large, mostly surrounded by shaded pigmented areas which make them appear larger. Body plainly longitudinally striped with red, the stripes running one between the dorsal line and alpha and the other between beta and rho on each side, four main stripes separated by narrow whitish more or less broken and irregular lines.

Instar V.—Head uniform clear pale yellow, mouthparts outlined with fine dark lines, ocellar area crescent-shaped, black. On the margin of head caudad of ocellar area is a small black spot from which a heavy dark line runs dorsad margining the head to the vertical triangle. Cervical plate large, pale yellow, darkening laterad and with a small dark spot in the center of each lateral extremity. Spiracles small black, nearly round and with a black cicatrix of the same size but more elongate, caudad and a little dorsad on each of the pedal segments.

Instar VI.—Head clear pale yellow, some faintly clouded with darker yellow, ocellar area black, crescent-shaped, caudal margin of head black beginning at a small black spot caudad of ocellar area. Cervical plate broad, pale, slightly darker than head, with paler median stripe and a faintly dusky spot near the lateral margin.

Instar VII.—Head clear pale yellow, occasionally slightly clouded with darker yellow, black latero-caudal marginal line distinct but becoming faint toward vertical triangle. Facial sutures indistinct, mandibles dark, ocellar area reduced in size, the two terminal ocelli

isolated. Cervical plate large, concolorous with head or somewhat paler, with a pair of medio-lateral spots and dark prominent setæ; cicatrices on pedal segments prominent, black, of the same size as the spiracles.

Instar VIII.—Head clear pale yellow, faintly clouded with dark, ocellar area black, caudal margin of head black beginning at a black spot on margin of genæ; setæ on face pale brown, arising from minute clear, brown-edged circles. Cervical plate large, pale, concolorous with head or paler, with small brownish spot near lateral extremity and a group of dots on each side of median line near caudal margin, median line pale. Kappa almost directly dorsad of eta on the abdominal segments. In live specimens the pinacula have their outlines obscured by the reddish stripes which cross them. These stripes appear first in II and III and become more pronounced until in the older larvæ they give the color to the whole body. They run as follows: a narrow medio-dorsal line, a wider one on each side of this and separated from it by a narrow broken whitish stripe runs through the outer half of pinacula alpha and includes beta, between this and rho runs another white line similar to that dorsad of alpha below which the spots and body are various shades of suffused red, pink and salmon. The larva as a whole appears of a bright brick-red color. In alcohol the red striping disappears.

Pupa (Fig. 5)—Length 9 mm., width 2.7 mm. Of the usual pyralid shape, yellowish brown, the sutures marked by narrow maroon lines. Epicranial suture obsolete; fronto-clypeal suture present only at margin, running a short distance meso-ventrad from the ventral corner of the antennæ; front with a large, dark, flattened and somewhat depressed tubercle mesad on ventral margin and a small dark point mesad near caudal margin of clypeus; maxillæ almost equaling wings; tarsi of prothoracic legs ending about two-thirds of the distance from vertex to caudal margin of wings; antennæ extending about half way from the tips of the mesothoracic tarsi to the caudal margin of the wings; prothorax large, strongly convex cephalad, caudal margin straight and only slightly elevated and wrinkled laterad for the prothoracic spiracles; mesothoracic wings extending to caudal margin of fourth abdominal segment; cremaster short blunt, rounded or feebly angled distad, above sloping with two minute attenuate spines at the angles and with a short deep curved furrow on each side running from the base cephalad, laterad and ventrad finally becoming obsolete on the lateral line, beneath excavated and flattened, the distal angles each bearing a spine like those above, but smaller and closer together.

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SEASONAL AND CLIMATIC VARIATION IN CERODONTA.

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Cerodonta dorsalis is a small fly of the family Agromyzidæ (sens. str.), the larva of which mines in the leaves and leaf-sheaths of wheat, timothy, etc. It is very widespread in the United States and Canada.

It was described by Loew (a) in 1863, the type being a female from the District of Columbia. He referred it to the genus *Odontocera* Macquart (b), a preoccupied name, for which Rondani (c) had proposed to substitute *Cerodonta*, and a year later Schiner (d) had proposed *Ceratomyza*.

In September, 1913, Melander (e) restored Rondani's overlooked generic name[‡] and separated his North American material into two species on color characters; one he called *dorsalis* Loew, represented from Massachusetts, Louisiana, Illinois, and Texas; the other he identified with the European species *femoralis* Meigen, represented from Montana, Wyoming, Idaho, Washington, British Columbia, Oregon, and California. The latter species he compared with European specimens determined by Strobl.

A few days later, about Oct. 1, 1913, Malloch (f) published his large revision of *Agromyza* and also took up this genus *Cerodonta* (he used the original but evidently erroneous spelling *Cerodontha*). He recognized but one North American species, *dorsalis*, not considering the variations in color to be of specific importance. The National Museum material, with which he was working, was from eighteen States, Atlantic and Pacific among them, and also from Mexico and Porto Rico. Neither Melander nor Malloch knew until about the time of publication that the other was working upon the group, and the two conclusions were arrived at independently.

When I began in 1913 to do some biological work on the group, the difference of opinion between two prominent dipterists as to the species limits presented itself as a problem to

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‡Mr. Malloch has called my attention to an earlier use of *Ceradonta* by Collin, *Ent. Mo. Mag.*, Nov. 1911, p. 254.

be solved. I found I had about fifty specimens from the Rocky Mountains and points west of them, all of general dark color and agreeing with *femoralis* as identified by Melander; I also had about an equal number from localities east of the Rockies, all of paler color and undoubtedly *dorsalis*. This led me to conclude provisionally that Malloch had not given sufficient weight to the geographical segregation of the two forms, and that they were probably distinct species.

The color difference is most conspicuous in the pleuræ, which are almost wholly yellow in eastern material, and blackish with paler sutures in the western; the dorsum, tibiæ, frontal orbits, etc., share in varying degrees in the lighter or darker coloration.

My observations in Indiana in 1914 seemed to confirm my opinion that the western dark form is a distinct species, as I found no such coloration in Indiana specimens, of which I examined a large number.

In 1915 I began to make systematic sweepings on grass and grain and tabulate the flies collected. In this I secured the assistance of several entomologists who swept for me in regions that I could not personally visit.* This brought into my hands a large amount of material in Cerodonta (1876 specimens in the season). During most of the season these ran as expected, dark from the Rockies westward, pale from east of that region. Sweepings from Fort Collins, Colo., August 17, showed for the first time in my experience light and dark forms intermingled; but this place is just on the dividing line, where overlapping might be expected. Sweepings from Great Falls, Mont., September 23, showed the dark form some distance east of the mountains for the first time. On October 9th it turn up at Treesbank, Man., where I had had the pale form earlier in the season. On October 19th dark and intermediate forms were swept at Elk Point, S. D., where light specimens had been abundant earlier; and by this time I was noticing that specimens swept at Lafayette were becoming progressively darker. I continued my sweepings here as late as possible, and on Nov. 27th secured two specimens as dark as any from the west. Specimens from Atherton, Mo., Nov. 6th, were in part

*I wish especially to acknowledge important and continued co-operation from Messrs. Norman Criddle, Treesbank, Man.; C. N. Ainslie, then at Elk Point, S. D.; and Dr. C. F. Adams, Atherton, Mo.

dark also. So it seemed completely demonstrated that in late fall the eastern specimens may become as dark as the western—undoubted lineal descendants of the pale midsummer broods, among which dark forms never occur.

In the summer of 1916 I continued sweeping more actively than before, but not very late in the fall. The only additional observations of any significance on this matter were the collection of one somewhat dark specimen at Aberdeen, S. D., on May 29th, and of several dark ones mixed with a much larger number of light ones at Sioux City, Ia., on May 23d and 26th (Ainslie). This showed that the first spring brood is also affected by the tendency of cold to produce dark colors. The total number of specimens examined in the season was 513, although the number of sweepings was much larger than in the preceding year, indicating that the species was much less abundant in 1916. Except as noted already, all Indiana specimens were decidedly of the pale form, except a single one taken May 10, 1915, which was intermediate.

In 1916 I received from T. D. Urbahns, then located at Pasadena, two pale specimens taken at Yuma, Ariz., which were the first of this form that I had ever seen from the region in or beyond the Rockies.

In the summer of 1917 I was enabled to extend my observations into the Southwest in June, making stops for collection at Marfa, Texas; Las Cruces, N. M.; Tucson, Tempe and Yuma, Ariz. Sweepings at all of these places gave the pale form only, and the prevailing temperature seemed an ample explanation of the phenomenon. Continuing my trip, I collected at San Diego, Cal., in late June, and in July at Santa Barbara, Berkeley, Palo Alto, Martinez, and Fallen Leaf, in California; in Utah at Salt Lake City and in Emigration Canyon at an elevation of 7000 feet; and in Colorado at Tennessee Pass, elevation 10,290 feet. At all of these places I collected only the dark form, and it was abundant wherever fresh grass occurred.

Evidently *dorsalis* is no more than a pale variety of *femoralis*; but when we turn to the European literature we find a whole series of names that have been proposed on color characters that are mostly the same as the ones just discussed in our species. Hence there is some doubt as to whether *femoralis* is not itself a variety of *denticornis*, an older name; and also as to

whether *dorsalis* is not antedated by a European name for the same form. These questions will evidently have to be left to European dipterists.

The color variations described fall in the same class as a number that have been studied in Lepidoptera (for instance see a series of articles by Standfuss in *The Entomologist*, XXVIII, 1895, and a translation of Weismann's experiments in the same journal the following year by W. E. Nicholson), in which low temperature during the pupal period causes the colors to be darker. This may normally affect one brood of a double-brooded species, or it may be climatic rather than seasonal, affecting all the individuals living in the colder region. Even the absence of the pale form of *Cerodonta* in the west in mid-summer accords with butterfly experiments, in which the pale form can be made dark by cold, but the dark form cannot be made pale by heat, indicating that the dark is the primitive type, the pale a comparatively recent modification.

While the subject has not been systematically studied except in Lepidoptera, some observations in other orders agree well; for instance, Horn (g) says of the Clerid beetle *Trichodes ornatus*. "As a rule, the hotter the climate in which the specimens were native, the greater the extent of the yellow color. . . . In colder, and especially damper climates, the blue color predominates."

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LIFE-HISTORY OF THE LEAF-EATING CRANE-FLY.

Cylindrotoma splendens, Doane.

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INTRODUCTION.

On April 28, 1917, whilst on a journey undertaken with a view to determining the distribution of the Pear Thrips, *Taeniothrips inconsequens* Uzel on Vancouver Island, the author had the good fortune to discover a curious, Tipulid larva quite unknown to him. The locality of the discovery was in the rural district of Westholme about 40 miles north of the town of Victoria. His attention was first drawn to the insect by his co-worker, Mr. E. W. White, Assistant Horticulturist of the Department of Agriculture, British Columbia, whose interest was first aroused by the feeding activities of the larva. In a rich woodland timbered by lofty cedars and spreading, large-leaved maples, there was growing in great luxuriance the false bugbane, *Trautvetteria grandis*, which affects damp and well-shaded habitats. It was on the leaves of this perennial, ranunculaceous herb that the larvæ in question were feeding in large numbers, eating out large, irregular holes. The insect was successfully reared, and the adults submitted to Mr. Chas. P. Alexander, Department of Entomology, Cornell University, who identified the species as *Cylindrotoma splendens*, Doane, in a letter dated May 25, 1917. In reply to a letter of the author, in which the finding of the larvæ was mentioned and their general appearance outlined, Mr. J. R. Malloch, of the Illinois State Laboratory of Natural History, Urbana, Illinois, under

date of May 20, 1917, suggested with admirable foresight, that the species perhaps belonged to the tribe *Cylindrotomini* of the Tipulidæ; but, as material had not then been forwarded to him, he could not naturally diagnose the species from a brief, written description. Later, however, he was able to corroborate Mr. Alexander's determination from specimens sent from the writer's collection.



Fig. 1. Larvæ of *C. splendens* feeding on a leaf of their food plant (*Trautvetteria grandis*). About natural size. (Original.)

The intrinsic value of the discovery lies in the fact that, according to Mr. Alexander, this represents the first finding of the immature stages of any species of the genus *Cylindrotoma* on the American continent, and it is hoped that the publication of this paper will stimulate other entomologists to search for these very interesting larvæ. A study of their habits will well repay one's efforts by reason of their decided contrast to those of the generality of Tipulid larvæ.

PRESENT KNOWLEDGE OF THE CYLINDROTOMINI.

The literature dealing with this very interesting tribe of the Tipulidæ has not been accessible to me, with the exception of Mr. Alexander's paper, "Biology of the North American Crane-Flies (Tipulidæ Diptera)," published in the Pomona College Journal of Entomology and Zoology, Vol. VI, No. 3, Sept., 1914. Here is presented excellent résumé of the known facts, culled from various workers, regarding this very remarkable group of species, which, according to Osten Sacken, quoted by the author (p. 105), occupies an isolated and intermediate position between the *Tipulidæ brevipalpi* and *longipalpi*. Mr. Alexander goes on to say that "the structure of the adult flies, especially as regards certain details of the venation of the wings, is quite unique, but it is in the immature stages of the different genera that the most interesting distinctions are found. The larvæ, instead of living in the mud along the banks of streams, or in rotten wood, as do the majority of the known crane-fly larvæ, are found on the leaves of various terrestrial and aquatic plants; instead of being brown or grey in color, they are bright green and usually resemble the leaves of their host plants to a very remarkable degree.

The five known larvæ of the *Cylindrotomini* are distributed among four genera as follows: *Phalacroceræ replicata*, L., which is aquatic or nearly so and feeds on *Fontinalis antipyretica*, *Hypnum elodes*, *H. exannulatum*, *Ranunculus fluitans*, etc.; *Cylindrotoma distinctissima*, Meig., terrestrial, feeds on *Viola biflora*, *Stellaria nemoralis*, *Anemone nemorosa*, etc.; *Triogma trisulcata*, Schumm., aquatic, on *Fontinalis antipyretica*; *Liogma glabrata* Meig., terrestrial, on *Hypnum squarrosum*; *Liogma nodicornis* O. S., terrestrial, on *Hypnum cupressiforme* and a related species. All with the exception of the Nearctic *Liogma nodicornis* are Palearctic. For the larvæ of these five species Mr. Alexander (*loc. cit.*, pp. 109-110,) has constructed a key wherein the distinguishing characters are the shape of the body-appendages and the number and position of the teeth on these appendages. He proceeds to state that "the larvæ of the *Cylindrotomini* may be distinguished from those of other crane-flies by the following easily determined points: color green or greenish; the body provided with filiform or leaf-like appendages; larvæ living upon various Bryophytic or Spermatophytic plants."

LIFE-HISTORY AND HABITS.

The adults first appear on the wing about the middle of May, the first specimen in the rearing-boxes emerging from the pupal skin on May 15, the great majority appearing on May 21 and 24. Without food, they do not live longer than five to six days, but in the breeding-cages when they were supplied with food in the shape of sugar solution, they lived as long as 7 to 9 days. In the field, the adults were found on the wing for a period extending over three weeks, May 17–June 7. Soon after emergence the adults begin to copulate, and one male may perform the act of coition with more than one female.

Copulation.—The first individuals were observed to be copulating in the rearing boxes on May 22. The act is undertaken by the sexes apposing their abdomens end to end, the claspers of the genitalia of both interlocking. The head of the female is oriented in the direction diametrically opposed to that of the male which remains suspended with his head towards the ground. When copulation occurs between individuals resting on a vertical surface, such as the walls of the rearing-box, the female is invariably superior in position to the male. In both cases the sexes have all their legs applied to the supporting surface. Sometimes copulation was observed to be taking place among individuals on the inside of the roof of the rearing-cage. Here, only the female at times would be resting on the roof with the male suspended head downwards, its body at an angle of 90° with that of the female and its legs unsupported. The act of copulation is not always interrupted when the sexes are disturbed, but the female may walk off dragging the male after her, or flight may be actually undertaken with the female transporting the male. Pairs in copula were frequently transferred from one rearing cage to another without the union being broken.

In the field, the behavior during copulation was similar to that observed among the sexes in the rearing-cages. Here the act was generally undertaken in the deep shade of the large leaves of the food-plant, *Trautvetteria grandis*, the sexes resting on the under-surfaces of the leaves, or on the stems. When disturbed, the females took to flight, bearing the males with them undisturbed.

No exact records were kept of the time that the sexes remain in copula. It varies considerably, however, and gen-

erally, copulation may continue for two or three hours and even longer. In some cases, the sexes remained in union only a matter of a few minutes.

Oviposition.—Eggs were first observed on the leaves of *Trautvetteria grandis* in the breeding-cages on May 25th when the first female was seen to oviposit. On the following day, a few eggs were found on the leaves in the field at Westholme and on a subsequent visit on May 31, were found to be very numerous.

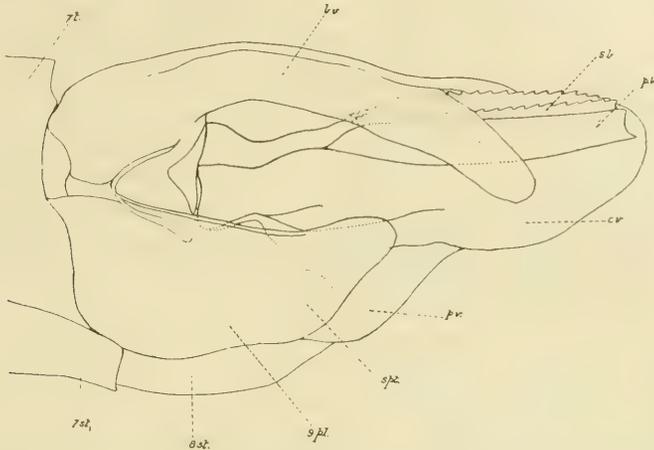


Fig. 1a. Ovipositor: 7 t., seventh tergite; 7 st., seventh sternite; 8 st., eighth sternite; 9 pl., ninth pleurite; spt., spermatheca; b. v., bifurcated valve; p. v., ploughshare valve; c. v., cutting valve bearing serrated blade (s. b.) and plain blade (p. b.). Camera lucida drawing. $\times 40$.

In order to understand the behavior of the female *Cylin-drotoma* in ovipositing, it is necessary that we should recapitulate in brief the structure of the ovipositor (See Figure 1a). It consists of a pair of large double-bladed valves (c. v.), each of which is sparsely clothed with rather elongated, delicate hairs and more closely invested with short ones. The inner blade (s. b.) in each case is serrated along its upper margin which is distinctly recurved externally. The serrations of the proximal half of the blade are directed anteriorly, those of the distal half being directed posteriorly. On each of these cutting valves, external to the saw-edged blade, is a plain blade (p. b.), the upper margin of which is slightly recurved externally and over-topped by the serrated margin of the inner blade. Both blades have their attachment in the dorsal half of the valve. Dorsal to

these cutting valves is an unpaired and unarmed valve, bifurcated in its posterior third (*b. v.*), the two arms of the bifurcation each straddling the cutting valves and being continued at rest beyond the insertion of the blades of these latter valves. It is sparsely invested with long, slender hairs, more thickly disposed on the two bifurcating arms. Along its dorsal median line there runs from the point of bifurcation a narrow depression which terminates at its base. Ventrally, and arising apparently from the eighth sternite and between the paired ninth pleurites, is a ploughshare-shaped valve (*p. v.*), strongly chitinised and invested laterally with short, coarse hairs. It terminates in a position between the cutting valves, the extremities of which extend beyond its apex. The two spermathecae (*sp.*) are dark-brown, strongly chitinised spherical organs in the ninth segment. The spermatheca is tripartite in some Tipulidæ.

The eggs are sub-translucent glistening white, elongate-ovate in shape. Under natural conditions they are almost invariably to be found on the under surface of the leaves of the food-plant, *T. grandis*, inserted beneath the incised epiderm (Figure 7). They are generally deposited in series along the margin of the palmately-lobed, serrate-edged leaf, and just internal to the periphery. They may occur in groups of one or more, all arranged parallel to each other and with their long axes perpendicular to the margin of the leaf, or at least, varying but slightly from the perpendicular. The eggs are only partly hidden beneath the incised epiderm. They are exposed dorsally, the margins of the slit made by the ovipositor overlapping the egg laterally, and to a small degree, both anteriorly and posteriorly. The arrangement of the eggs in series and their partial exposure, lends to the leaf-margin a somewhat beaded appearance. When newly laid, the eggs are not readily observed by the naked eye, unless one examines the leaves closely. Later, owing to a darkening of color of the eggs as well as of the leaf-margin which turns brown, they are more readily detected.

Not only are the eggs deposited along the leaf-margin, but often where a leaf has been eaten earlier in the season by the larva, one will find eggs deposited along the ragged edge of the damaged leaf.

In the breeding-cages, the females laid their eggs indiscriminately on both the upper and lower surfaces of the leaves, but in nature, no eggs were ever found on the upper surface.

The actual method of oviposition was frequently observed. The female rests on the under side of a leaf with the extremity of the abdomen directed towards the leaf-edge. The abdomen is slightly recurved vertically, and the margin of the leaf is grasped between the bifurcated valve of the ovipositor which is applied to the upper surface of the leaf, and the paired, cutting valves the blades of which are apposed to the under surface. These blades are then moved to and fro, and a slit is cut in the epiderm, the recurved margins of the blades serving to widen the aperture of the slit. The ploughshare, ventral valve then comes into play, serving to guide the emerging egg into its position in the slit. By reason of its being excavated internally, after the fashion of a deep-keeled boat, this valve performs its function admirably. The valves are then withdrawn, and the performance may be repeated alongside the first slit, a number of these finally producing the parallel-beaded arrangement of the eggs along the margin. In no instance do the eggs actually touch upon each other as one finds in the case of eggs laid in parallel series by the leaf-mining species of the *Pegomyia* genus of Anthomyiid diptera.*

Duration of Egg-stage.—The period of incubation occupies about two weeks. In the breeding-cages, eggs hatched in from fourteen to eighteen days, and it is not unlikely that under field conditions, the egg-stage endures for two to three weeks. Records show that under experimental conditions, the first eggs were deposited on May 22, and the date of first hatching was June 7. The first, newly-emerged larva was taken at Westholme on a leaf of *T. grandis* on May 31.

The Embryo and Emergence of Larva.—The maturing embryo is at first distinguishable within the egg by the appearance of two dull, red spots, one on each side of the anterior extremity of the egg. Presumably these indicate the position of the eyes. Later, as the embryo develops, the black head-capsule stands out quite markedly within the transparent chorion.

The actual time occupied by the larva in leaving the egg is about three hours. In its efforts to free itself, it is not at all energetic. In one particular case, on June 7, the young larva made slow movements from side to side, erecting its head and

*Cameron, A. E.—A Contribution to a Knowledge of the Belladonna Leaf-Miner, *Pegomyia hyoscyami*, Panz. its Life-History and Biology. Ann. App. Bio. Vol. I, No. 1, May 1914, London, p. 57.

straining forward in an endeavor to liberate itself. As soon as success attended its efforts, it buried its mandibles in the leaf-tissue and commenced feeding.

The anterior extremity of the egg is proximal to the leaf-margin. The chorion splits longitudinally along the mid-dorsal line, the aperture extending almost half the length of the egg. In emerging, the grayish-white larva, almost transparent, avails itself of its tubercles in disengaging itself from the egg-case. In that they are posteriorly directed, their function in assisting the larva to liberate itself from the egg, is at once apparent.

When the larva has succeeded in emerging, the aperture in the chorion has assumed an ellipsoidal shape. The empty egg-case remains in the slit originally made by the ovipositor of the adult, and on no occasion was the larva observed to devour it.

Larval Habits.—The first-stage larvæ (July 7) are semi-translucent, grayish-white, and measure 1.19 mm. long by 0.37 mm. broad. The alimentary canal by reason of its contents, is yellowish-green or sometimes reddish-brown, and the head is black. The larvæ feed on both the upper and lower surfaces of the leaf, embedding their mandibles through the epiderm and eating the parenchyma inside. Whether working on the upper or lower surfaces, the first-stage larvæ rarely disturb the epiderm of the surface other than that on which they are feeding. Their activities are later accentuated by the parts which are eaten, turning a brownish-black, shrivelling and dying.

The young larvæ are very sluggish and not readily disturbed when feeding. The mandibles are very firmly embedded in the leaf-tissue. Gentle exhortation with a camel-hair brush will not serve to induce them to loosen their hold. They assume various attitudes. Usually they lie horizontally on the surface of the leaf, but often the only part of their bodies in contact with the leaf, is the head and mandibles. In the latter case, the rest of the body is elevated at varying angles to the leaf-surface. Sometimes the larva may literally stand on its head with the abdomen erect and vertical. Again, it may assume a looped position where the abdomen is recurved dorsally, and its extremity comes to rest in close proximity with and anterior to the head, like an inverted U, the arms of which are almost closed.

Often they drop voluntarily from the leaves to the ground. It is supposed that many never regain their original positions

but perish either from starvation or are preyed upon by spiders and insect predators.

In nine days (July 16), the larvæ had increased in length to 5.84 mm. long, although a few were only 3.57 mm. Except for the green color of the alimentary canal, they were of a dirty grayish hue. Even in the young stages they display all the characteristic behavior and movements of the full-grown larva, which can be most aptly compared with those of "measuring worms" or "looper" caterpillars (Geometridæ).

The first larval moult occurs after a period of about 18 to 21 days, although in some cases it did not take place for 5 or 6 weeks. Growth is very slow and quite in accord with the sluggishness displayed by the animal. Previous to this first moult, the larvæ, in moving over the leaves, become invested with particles of their excreta which adhere readily to the skin as if it were coated with a sticky substance. The freshly-moulted larvæ are almost translucent white, and the two tracheal trunks with their ramifications are readily distinguishable by the aid of the binocular microscope.

The larvæ have the power, when young, of secreting a silken thread from the mouth, which is probably the product of the salivary glands. They frequently adhered by this thread to the camel-hair, water-color brush used in transferring them from one leaf to another. The power to produce this thread is but limited, and on no occasion was it observed to be of any great length. Usually, it measured not more than half-an-inch.

The second-stage larvæ gradually assume a leaf-green color as they continue to feed, obscured in some by a brownish pigment beneath the cuticle. Laterally, in the more mature first stage larvæ, on each side of the median, dorsal line, there runs an irregularly-defined, brownish-gray band somewhat interrupted intersegmentally. In the larvæ of the second stage, these bands may still persist or give place on each segment to two similarly colored lines representing a V, the arms of which, however, do not meet and fuse posteriorly. On each side, the band on any one segment is parallel with that on the others.

Towards the end of July, more accurately, on the 26th, coincident with the dying off of the food-plant, *T. grandis*, the larvæ which had now assumed a size of 8.32 to 9.00 mm. long, became quiescent and ceased to feed. Previously, in the middle of July, when the larvæ in the breeding-cages were transferred

to fresh food-plants they evinced a decided tendency to creep under the curled-up edges of withered leaves. Feeding and movement gradually ceased completely, and they remained clinging motionless to the leaves. When disturbed, they rolled up, like a watch-spring, moved about a little and then resumed their dormant attitude again. It was also observed that as the leaves withered, the larvæ dropped off and, if possible, attached themselves to the stems. In the breeding-cages, they adhered to the edges of the plant-pot. In the field, they fell to the ground among the dead leaves, and under these they passed the winter in a dormant condition. In color, they match exactly that of their environment of dead leaves, but a large number seemed to retain their original leaf-green tint. In the beginning of September, the larvæ had apparently contracted a little and now measured only 7.00 mm. long by 1.50 mm. broad. This apparent shrinking was probably associated with insufficient moisture under breeding conditions.

The over-wintering larvæ first begin to show signs of activity in March when the *Trautvetteria* sends up its fresh shoots. The growth of the larvæ then proceeds quite rapidly until the larvæ pupate in the middle of May.

In many respects, the details of the larval life-history agree with those of the species *glabrata* of the closely allied genus *Liogma*, as described in the admirable paper of Dr. Mueggenberg published in 1901. Mr. Alexander (*loc. cit.*, p. 106) quotes this author as having found the larva feeding on the moss *Hypnum squarrosum* Brch. and Schp. in the wet, grassy spots of woods in the environs of Berlin. According to Mueggenberg, the larva moults several times, probably at least eight, which Alexander says is the number determined for *Phalacrocera* by Bengtsson. As to the exact number of moults of the larva of *C. splendens*, the author is unable at present to make a definite statement. With tolerable certainty, it can be stated that close observation revealed only one moult as occurring before hibernation and two after, the last being the casting of the larval skin previous to pupation. In the penultimate stage, the larva measures 15.00 mm. and the full-grown larva 17.00 mm. The duration of the various larval stadia, except that of the first, cannot be stated with any degree of accuracy, but it is hoped that it will be possible to decide this, as well as the number of larval moults, later.

The behavior of the full-grown larva (Figure 1), presents much that is interesting. The larva is invariably found on the upper surface of the leaf and in the spring is actively engaged in feeding. On a fresh leaf the larva usually begins by skeletonising it, leaving the lower epiderm intact. Later, however, large holes are eaten completely through the leaf.

Reference has already been made to the extraordinary movements of the first-stage larva. These are much more accentuated in the full-grown animal. The organs used in facilitating its travel, are chiefly the mandibles and the abdominal pro-legs or *pseudopodia*,* which are merely ventral protrusions, of the body-cavity two on each of the last eight segments. They are apparently distensile, and it would appear as if they were capable of secreting some kind of fluid that assist the animals in retaining its hold on a smooth surface, especially so if the surface be inverted. On the three thoracic segments there are no definite pseudopodia, but the function of these is served by the development of a distinct, ventral fold which becomes apparent as the animal contracts. Two pairs of small tubercles or papillæ on the ventral surface of each thoracic segment, are also employed in locomotion.

In moving forward, the last segment is elevated from the leaf-surface. Simultaneously almost with this action, the middle region of the body contracts and arches so that one pair of pseudopodia after another is methodically raised from the leaf in a postero-anterior direction. The last segment comes to rest in a position about half-an-inch anterior to its original one. A series of rhythmical, muscular contractions pass wave-like along the body from segment to segment, pulling the two extremities towards each other with the result that the body assumes the shape of an inverted U involving at first only the abdominal region. The contractions pass along to the thorax and head which also become arched, whilst the pseudopodia of the last five body-segments are applied to the leaf-surface again. The inverted U is then composed of that part of the body anterior

*The author has preferred to apply the name *pseudopodia* to the unsegmented, paired tubercles of the abdominal segments because of their locomotory function as well as their acting as adhering agents. They are charged with body fluid and tracheated. The mechanism which determines their close application to a surface is apparently blood pressure, and this together with the aid of the viscid fluid which they secrete, is capable of maintaining the weight of the larva by surface-tension on an inverted glass-surface.

to the fifth last abdominal segment. All this time the mandibles of the larva have remained fixed, but when the last five segments have renewed contact with the leaf, the head is slowly raised. The anterior region of the body may be moved slowly from side to side, finally extending straight forward, eliminating the arch of the inverted U. The whole body then comes to rest on the leaf. The final result of this methodical series of movements is that the animal has now advanced in its progression just as far as the distance measured by the last body-segment in its original displacement. The whole process is marked by the extreme slowness of an orderly series of individual reflex actions which impart to the observer the notion of an apparent calculation on the part of the organism by reason of their perfect co-ordination. The persistence of the appropriate stimuli determines the continued repetition of the whole series of ambulatory reactions.

In a quiescent condition, the thoracic region of the body has a noticeably humped appearance, apparently produced by the slight ventral retraction of the head-segment.

The full-grown larvæ are very sluggish and inactive. When disturbed, they relax their hold on the leaf-surface and readily fall to the ground. This response to a disturbing factor, together with their marked resemblance to the leaf-color, appears to be their only asset of defense against predaceous species. In all, somewhat more than one hundred adults were reared from larvæ collected in the field, and in not a single instance was one found to be parasitised.

Pupation.—Previous to pupating, the larva attaches itself firmly to the surface of the leaf or leaf-petiole by means of its anal pseudopodia. The skin splits transversely posterior to the head but is only partially sloughed off. The head, thorax and first four abdominal segments of the pupa are exposed, but the remainder of the abdomen remains enclosed in the larval skin, the terminal portion of which, attached to the leaf-surface, is collapsed and wrinkled. The head-capsule of the larva which is moulted with the rest of the exuvium, lies ventrad of the fifth abdominal segment of the pupæ. On the leaf, pupation may take place on both the upper or lower surfaces, but generally on the former. On the petiole, the pupæ generally occur at the axils.

Duration of Pupal Period.—In the breeding-cages, the period of pupation varied from six to ten days. Mueggenberg, quoted by Alexander (*loc. cit.*, p. 106) states that for *Liogma glabrata* the pupal period persists for 11 to 12 days, and it will be probably found that in individual cases the period is as long for our species under natural conditions in the field.

Emergence of Adult.—The pupal skin splits in T-shaped fashion on the dorsal region of the thorax. The adult thorax and head are the first to appear followed by the wings. After a series of efforts, punctuated by periods of quiescence, in which the prevailing movement is a straining forward of the free parts of the body, the legs are unsheathed from their closely-investing cases and the adult emerges. At first, it is of a pale-green color which gradually gives place to the yellow and black of the mature animal.

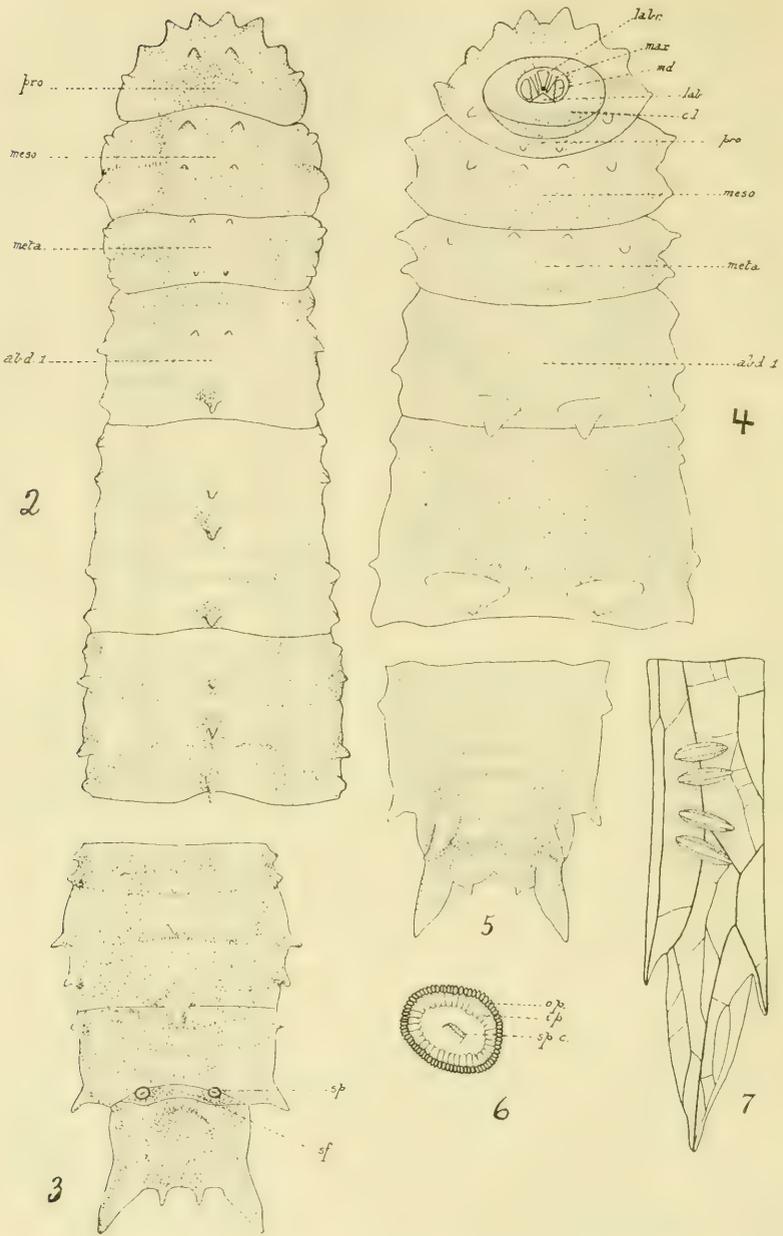
The process of emerging occupies one and a half to two hours, and after it is completed, the adult rests for a short time until the cuticle hardens and the wings expand. A tiny drop of green fluid is voided from the alimentary canal soon after the exit is made.

The pupal skin is never at any time completely uncovered and when sloughed off by the adult, still retains the adhering last larval skin. In some cases where the pupæ had been gently withdrawn from the last larval skin and placed on the floor of the breeding-cages, the adults experienced great difficulty in emerging, and a few, indeed, did not succeed in liberating themselves at all. It is evident, therefore, that the fast adherence of the last larval skin to the leaf-surface and its close investment of the pupa, serves a useful function in facilitating the successful emergence of the adult.

PROPORTION OF SEXES. •

From 108 adults reared from larvæ collected in the field, 91 were females and the remaining 17 males. Thus the percentages of females and males reared were respectively 84.2% and 15.8%.

On June 1, 96 individuals were captured by sweeping the food-plant, *T. grandis*, at Westholme, when the males were found to be in the ascendant in the proportion of 60.2% to 39.8%. On this date many were taken in copulâ.



The marked discrepancy between these two sets of figures appears at first sight to be inexplicable. It is probable, however, that the figures resulting from rearing the adults from the larvæ, represent approximately the actual superiority in total numbers of the females over the males. On the date that the collection was made at Westholme, there were comparatively few adults to be seen. When one adds to this the fact that the females emerge in larger numbers before the males and that they die off soon after laying their eggs, the greater proportion of the later-emerging males towards the end of the adult season on June 1, is readily accounted for. It has already been noted that a single male may copulate with several different females.

DESCRIPTION.

Egg (Fig. 7)—When first deposited, the egg is sub-translucent, grayish-white, spindle-shaped, partly inserted beneath the slit epiderm of the leaf. The chorion is unornamented. It measures, on an average, about 0.840 mm. in length and about 0.303 mm. in breadth at the widest part in the middle.

Just before hatching, two, dull-red spots corresponding to the eyes of the young larvæ are apparent at the anterior end. The black head-capsule of the young larva is also readily distinguishable.

Full-grown Larva (Figs. 2-6).—Length, 17 mm.; maximum breadth, 2.5 mm.; maximum depth, 1.5 mm.

The live larva (Fig. 1) chlorophyll green, closely resembling in color that of the leaves of the food plant, *Trautvetteria grandis*, except for the sclerites of the head-capsule which are black, the less heavily chitinised parts brown. In bright sunlight, the lateral tubercles and margins of the body almost transparent. Dorsally, the middle region of the body darker green because of the contents of the alimentary canal within. The two, main, tracheal trunks apparent as silvery strands, running laterally and posteriorly to their termination in the spiracles of the eighth abdominal segment. Some of the tracheal branches also evident. Two irregular, sub-parallel, fuscous, brown bands on each side of the mid-dorsal line extending from the mesothorax to the spiracles of

EXPLANATION OF FIGURES.

- Fig. 2. Larva, dorsal aspect, thoracic and first three abdominal segments; *pro.*, prothorax; *meso.*, mesothorax; *meta.*, metathorax; *abd. 1*, first abdominal segment. $\times 14$.
- Fig. 3. Larva, dorsal aspect, last two abdominal segments, *sp.*, spiracle. $\times 16$.
- Fig. 4. Larva, ventral aspect, head, thoracic and first two abdominal segments, *labr.*, labrum; *max.*, maxilla; *md.*, mandibles; *lab.*, labium; *c. l.*, circumoral lip. Other lettering as in Fig. 1. $\times 16$.
- Fig. 5. Larva, ventral aspect, last abdominal segment. $\times 20$.
- Fig. 6. Spiracle; *o. p.*, outer periphery; *i. p.*, inner periphery; *sp. c.*, spiracle cleft. Camera lucida drawing. $\times 80$.
- Fig. 7. Eggs deposited in the slit epiderm of leaf of *T. grandis*. The ruptured epiderm partly envelops the egg. $\times 7$.

the ultimate abdominal segment and indicated in Figures 2 and 3, by the darker shading; often faint and indistinct in parts on the anterior segments, but generally well-defined posteriorly. Lateral margins of the body appressed. Skin delicately reticulated and tuberculated, transversely rugose both dorsally and ventrally with the wrinkles either isolated, separate and sub-parallel, or converging and confluent.

Prothorax (Figs. 2 and 4, *pro*) with a broad, circumoral lip (Fig. 4, *c. l.*) on ventral surface, penetrated in the middle by the transverse slit through which the head-capsule may be exerted. Two pairs of ventral tubercles, the members of the inner pair small and merely papillæ. Anterior, marginal tubercles three pairs, the median pair largest. One pair of lateral tubercles. One comparatively large pair of dorsal tubercles.

Mesothorax (Figs. 2 and 4, *meso*), 2 pairs of tubercles ventrally as in the prothorax, small. Two lateral pairs, of which the members of the anterior pair are more pronounced. Two pairs of median, dorsal tubercles the members of the anterior pair the larger.

Metathorax (Figs. 2 and 4, *meta*), with the ventral and lateral tubercles similar to those of the mesothorax. Two pairs of small, median, dorsal tubercles, all of equal size, the members of each pair equally separate but not so widely separate as the median dorsals of the mesothorax.

Abdominal segments, dorsal tubercles: first segment (Figs. 2 and 4, *abd 1*) with an anterior, small pair of tubercles and a larger median, posteriorly-directed, single one behind. Segment II with three, single, posteriorly-directed median tubercles, of which the first is smaller than the second and the second than the third, the first and second not so widely separate as the second and third. Segments III-VII each with three, single, median, posteriorly-directed tubercles as in Segment II, the first equidistant from the second as the second from the third; the third tubercle largest of the median dorsals in each of these segments. *Lateral tubercles:* segments II-VII each with four pairs of tubercles of which the members of the second and third are more prominent than those of the first and fourth. *Ventral tubercles:* first segment with one pair of *pseudopodia** situated posteriorly, broad at the base, bluntly conical in shape. Segments II-VII each with a posteriorly-situated pair of pseudopodia, larger than those of segment I, more widely separate and bases broader.

Eighth segment (Figs. 3 and 5) bearing the stigmal field and the caudal appendages. Posteriorly, two pairs of processes of which the members of the outer pair are directed latero-posteriorly, larger than the members of the faintly-brownish, inner pair which are situated just posterior to the anal orifice. Lateral tubercles two pairs, of which the posterior pair is the larger, posteriorly directed. Ventrally, on each side of the two rounded, anal swellings representing the pseudopodia of other segments, is a pair of large, lateral, anal processes, directed latero-posteriorly. The stigmal field (Fig. 3, *s f.*) somewhat depressed,

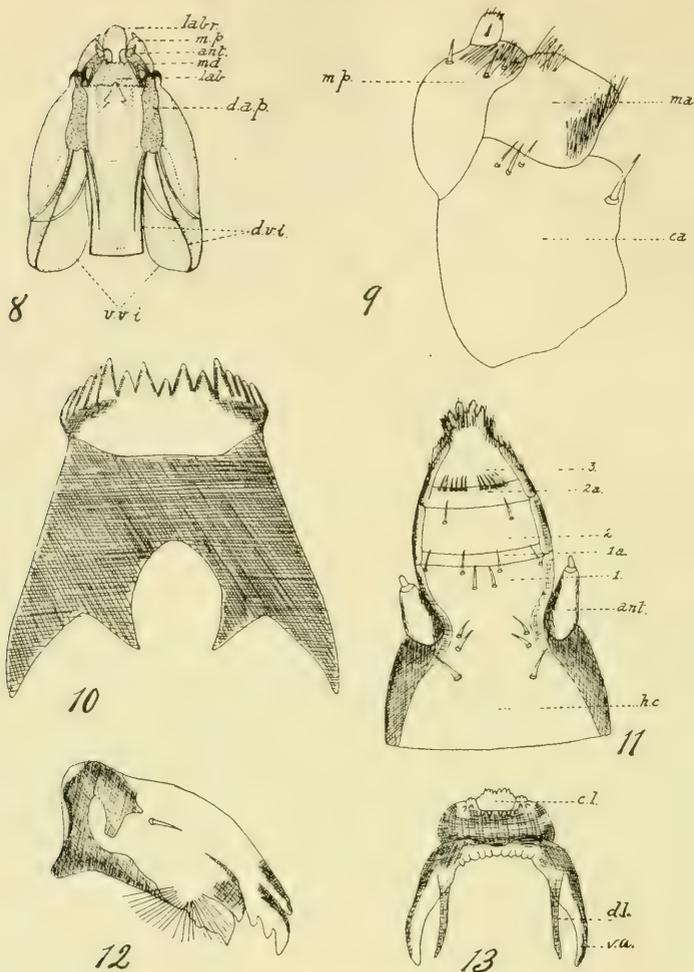
*Explanation has already been made that this term was adopted to signify the paired, ventral, locomotory tubercles of the abdominal segments.

transversely elongate, somewhat overlapped anteriorly by a cuticular fold. The oval-rounded stigma (*sp.*) consists of a transverse slit with scalloped edge, encircled on the outer periphery by two scalloped margins, the outer of which is densely chitinised. The stigmata are somewhat widely separate.

Head-capsule of Larva and Mouth-parts (Figs. 8-13).—Head retracted into the first thoracic segment, mandibles, maxillæ, labium and labrum apparent in ventral view (Fig. 8). Antennæ (Figs. 8 and 11, *ant.*) arising from head-capsule at base of labrum, 2-segmented, the first elongate, pear-shaped, much stouter than the second, thimble-shaped segment, Mandibles (Figs. 8 and 12, *md*) strongly chitinised, many-toothed ventrally, beset with a ventral tuft of hairs posterior to the odontophore extremity. They operate with a latero-vertical movement. Maxillæ very short and broad, consisting of a two-segmented palp (Fig. 9, *m. p.*) and inner lobe (*mala*); second segment of palp thimble-shaped and much smaller than the broad, splint-shaped, first segment; mala (*ma*) beset with a brush of bristles on its inner, lateral margin and a smaller one on its anterior, outer corner. Labrum (Figs. 8-11, *labr.*) tongue-shaped, terminating in four teeth anteriorly, the internal pair larger than the external pair; stoutly chitinised marginally, margin appearing as if involute ventrally, terminally and antero-laterally beset with close-investing hairs; a few, sparse, bristles distributed regularly on its surface; 3-segmented (1, 2, 3), with two paler intersegmental bands (1*a*, 2*a*). The labium (Fig. 10) deeply incised posteriorly to form two broad arms, each of which is again incised posteriorly in fish-tail fashion; more strongly chitinised posteriorly than the anterior odontophore margin which bears seven teeth on each side of the median small one, the first and third of each side being the largest. Hypopharyngeal sclerite (Fig. 13), dorsal to the labium, provided with two rows of tiny denticles; strongly chitinised; excavated anteriorly trough-wise, a weakly chitinised, central lobe (*c. l.*) provided with an anterior, denticulate margin filling the excavation; posteriorly, on each side, a pair of arms, the dorsal member of each pair (*d. a.*) more slender than the ventral (*v. a.*).

Articulating with the external, posterior angle of the mandible is a pair of stoutly chitinised, elongated processes (Fig. 8, *d. a. p.*), broadening considerably posteriorly where they are deeply incised to form two slender arms of which the outer, directed postero-laterally, is apparently continuous with an equally slender process given off ventrally from the labium; the inner tapers off gradually in the dorsal wall of the capsule. Anteriorly, from each dorsal, articulating process, there arises laterally a small process which partly encircles the ocular aperture. The slender, chitinous continuations of the various sclerites serve to support and strengthen the very delicate, transparent walls of the head-capsule.

In the walls of the capsule itself, (Fig. 8) there is dorsally on each side a deep, v-shaped incision (*d. v. i.*) separated by a tongue-process, sharply truncate posteriorly and ventrally, a similar incision situated medially and ventrally (*v. v. i.*).



EXPLANATION OF FIGURES.

- Fig. 8. Head-capsule of larva. *Labr.*, labrum; *m. p.*, maxillary palp; *ant.*, antenna; *md.*, mandible; *lab.*, labrum; *d. a. p.*, dorsal articulating process; *d. v. i.*, dorsal V-shaped incision; *v. v. i.*, ventral V-shaped incision. $\times 30$.
- Fig. 9. Maxilla of larva; *m. p.*, maxillary palp; *ma.*, mala; *ca.*, cardo. Camera lucida drawing. $\times 115$.
- Fig. 10. Labium of larva. Camera lucida drawing. $\times 160$.
- Fig. 11. Labrum of larva; 1, 2, 3, number of segments; 1a, 2a, intersegmental areas; *ant.*, antenna; *h. c.*, head-capsule. Camera lucida drawing. $\times 130$.
- Fig. 12. Mandible of larva. Camera lucida drawing. $\times 160$.
- Fig. 13. Hypopharyngeal sclerite of larva; *c. l.*, central lobe; *d. a.*, dorsal arm; *v. a.*, ventral arm. Camera lucida drawing. $\times 115$.

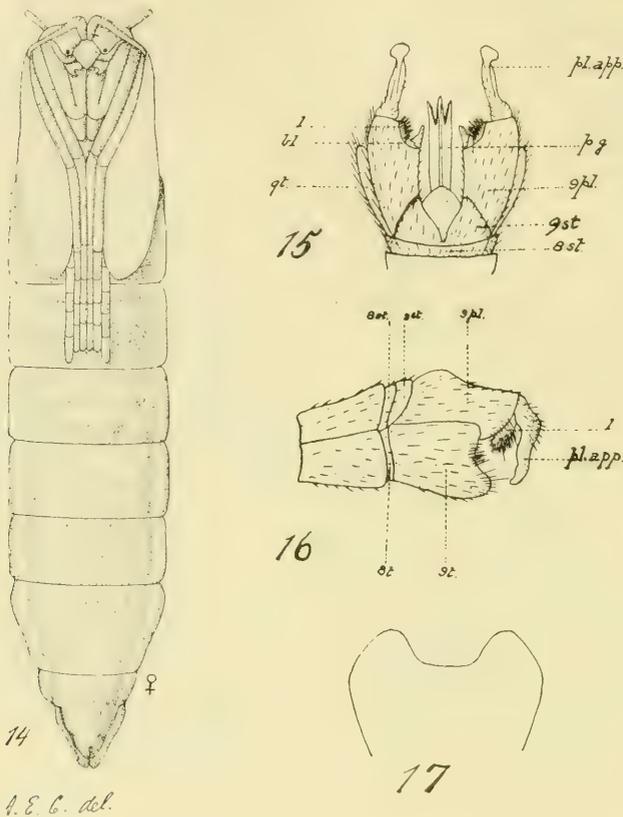
Pupa (Fig. 14).—Length from head to tip of abdomen, ♂, 11.7 mm.; ♀, 13.3 mm. Length from head to tip of tarsi, ♂, 5.9 mm.; ♀, 6 mm. Dextro-sinistral width at the wing-pad, ♂, 2.2 mm.; ♀, 2.8 mm. Dorso-ventral depth at the wing-pad, ♂, 1.4–1.6 mm.; ♀, 2 mm. Color leaf-green, thoracic spiracles grayish-white, margins of abdominal segments sub-translucent, eyes black in mature individuals.

Bases of antennæ arising between the cephalad half of the compound eyes, slightly divergent on either side of the mid-ventral line, more so in the male than in the female. In the *male*, the antennæ rather enlarged, bending round and closely applied to the anterior margin of the compound eye as far as the point where the palpi, reflexed antero-laterally, terminate; then directed postero-medially in the line between the fore femora and tibiæ, the extremity about on a level with the lobes of the labium. In the *female*, the antennal sheaths less stout, continuing around the anterior margin of the eye latero-posteriorly, abruptly bending posteriorly a short distance from their tips to terminate above and just beyond the proximal extremity of the second tibiæ; in mature specimens, the irregular, nodose segments of the adult antennæ apparent through the transparent sheath. Eyes large. Labium elongate, triangular. Head flat and broad dorsally, sloping back to the thorax, devoid of tubercles.

Pronotal breathing horns prominent, somewhat enlarged distally, directed antero-laterally with a distinct, ventral inclination. Mesonotum faintly wrinkled, pronouncedly arched, with two tubercles one on each side of the dorso-median line at the apex of the arch, directed cephalad and laterally; slightly anterior and external to these, a smaller tubercle at the base of wing-sheath. Metanotum devoid of tubercles, slightly wrinkled. The fore femur long, terminating on a level with the middle region of the eye, fore tarsi longest, hind tarsi shortest with a corresponding relationship in the comparative length of the segments of each tarsus. In the *female*, the tip of the hind legs just anterior to the caudal margin of the third abdominal segment, extending slightly beyond those of the first and second pair which are on a level; in the *male*, the tips of all three pairs of legs in alignment just anterior to the caudal margin of the second abdominal segment, the wing-cases completely overlapping the tibia and first tarsal segment of the hind legs.

Abdomen of eight segments, dorsally with the first segment half as long as the second; segments II–VII subequal in length, devoid of tubercles except in so far as small indistinct lateral protrusions may be so considered; segments with transverse wrinkles subparallel or curved, isolated or converging and confluent; lateral margins somewhat appressed. In the *male*, the eighth or terminal segment contains the genitalia of the adult; the ninth tergite a small, well-defined plate with posterior margin slightly concave, lying superior to but only partially covering the valve of the ninth pleurite with its recurved appendages which extend beyond, both laterally and posteriorly; the pleural appendages distinctly evident, recurving dorsally on each side of median line of the valve and terminating at the ninth tergite. From beneath, valve of hypopygium divided by a small, median notch into

two rounded lobes, the notch recurving dorsally to its termination at the posterior margin of the ninth tergite. In the *female*, the eighth segment encloses the ovipositor of the adult, tapering to a blunt, divided extremity; the dorsal valve deeply notched, completely obscuring and overlapping the smaller, ventral valve of which the notch is less than half that of the upper.



- Fig. 14. Pupa (♀). × 8.
 Fig. 15. Hypopygium (adult), ventral aspect; 8st., eighth sternite; 9st., ninth sternite; 9t., ninth tergite; 9 pl., ninth pleurite; l., pleural lobe; pl., pleural blade; pl. app., pleural appendage; p. g., penis guard. Camera lucida drawing. × 20.
 Fig. 16. Hypopygium, lateral aspect, inverted; 8t., eighth tergite; other lettering as in Fig. 2. Camera lucida drawing. × 20.
 Fig. 17. Ninth tergite. Outline of orsal aspect. × 32.

Last larval skin invariably persistent, attached to the pupa which is only partially withdrawn; head, thorax and first four abdominal segments exposed, the remainder enclosed in the exuvium; moulted, larval head-capsule ventral to the fifth abdominal segment of pupa; posteriorly, the exuvium collapsed and wrinkled, its terminal segment adhering to the support by the anal pseudopodia.

Eggs described from numerous specimens collected from host-plant in breeding-cages at Royal Oak, Victoria, V. I., May 25, 1917, and from several found at Westholme, V. I., May 31, 1917.

Larvæ described from numerous specimens collected in rich woodland at Westholme, V. I., May 3, 1917.

Pupæ described from several specimens, ♂ and ♀ reared from larvæ at Royal Oak, Victoria, V. I., killed May 9, 1917, and from several taken at Westholme, V. I., May 15, 1917, killed on same date.

Adult.—The species was first described by Doane* in 1900, who gave it the name of *Cylindrotoma splendens*. His specimens, three males, were obtained from Unalaska. In 1901, Coquillet† redescribed the species under the name of *Cylindrotoma juncta* from a male specimen collected at Virgin Bay, Prince William Sound, Alaska.

The following is Doane's description:

"*Cylindrotoma splendens*, sp. nov. (Pl. VIII, Fig. 21).

Pale yellow and black; head very pale yellow almost whitish; occiput, front, rostrum and palpi brown; first and second segments of antennæ whitish, first with a brown ring, other segments brown, cylindrical, if bent back they would reach to about the middle of the first abdominal segment; thorax very pale yellow or whitish; dorsum with three opaque black stripes, the lateral ones merge anteriorly into broader brown stripes which curve in and meet the median stripe; collar with a black band; a large, black spot on the pleura between the base of the wing and the anterior coxæ, another over the anterior coxæ, and another between the first and second pair of coxæ; a smaller one just in front of the base of the halteres, and a double on the posterior border of the metanotum; scutellum with a median, brown stripe; halteres pale, slightly infuscated above and at the tips; legs brown, base of femora lighter; tarsi and tips of the tibia darker; abdomen black; male forceps large, brownish posteriorly; wings rather narrow, hyaline; stigma pale, veins brown; auxillary vein ends abruptly just before the stigma; the small, cross vein connecting the first longitudinal vein with the costa is very faint and situated a little beyond the middle of the stigma; submarginal cell either longer or shorter than the first posterior cell. (In two of my specimens it is longer in one wing and shorter in the other.) Thus the præfurca may either end in the submarginal cell or in the first posterior cell; five posterior cells, the second sessile; discal cell elongated, somewhat pointed ante-

*Doane, R. W. New North American Tipulidae. Jour. N. Y. Entom. Soc., Vol. VIII, Sept. 1900, p. 197, Pl. VIII, Fig. 21.

†Coquillet, D. W. Diptera Entomological Results. Papers from the Harri-man Alaska Exp. IX. Proc. Wash. Acad. Sci., Vol. II, pp. 389-464, 1900, p. 401.

riorly; posterior cross vein a little before the middle of the discal cell; fifth vein incurved at the tip. Length, male 9 mm.; wing 9 mm."

"*Habitat*: Unalaska, three males. (Kincaid) Type No. 145. Wash. Agric. Coll. and S. of S."

Hypopygium (Figs. 15-17).—Mr. Alexander has very kindly aided in interpreting the relationships and disposition of the various sclerites which compose the hypopygium. In a letter under date of Sept. 26, 1917, he gives a lucid explanation of the whole structure.

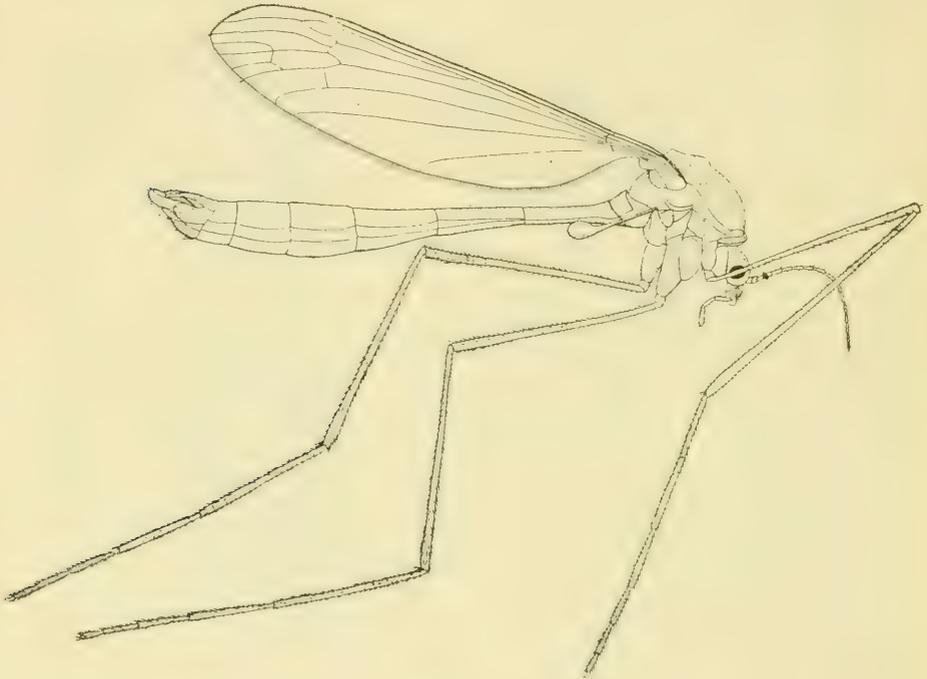


Fig. 18. Adult female. $\times 6.5$.

"The ninth tergite (Fig. 17) large, prominent, the caudal margin with a deep, broad notch, the adjacent lobes rounded at their apices. Ninth pleurite (9 *pl*) (Figs. 15 and 16, *pl*.) prominent, the inner margin at the tip produced caudad into a small flattened blade (*bl*.), a projection of the pleurite; pleural appendage (*pl. app.*) large; fleshy lobe (*l*.), on dorsal face of pleurite densely beset with fine hairs. Ninth sternite (9 *st*.) small, deeply split on the mid-ventral line by a very acute angle. Penis guard (*p. g.*) trifold with numerous appressed teeth on the inner edge of the lateral arms."

This paper would be incomplete were I not to express my gratitude to Mr. C. P. Alexander, of Cornell University, who, as a keen student of the Tipulidæ, showed extreme interest in the progress of the work. To Mr. E. W. White and Mr. W. Downes I am also grateful, the former for first bringing the larvæ to my notice and the latter for carefully attending to the immature larvæ during my absence this summer in Saskatchewan.

SUMMARY.

C. splendens belongs to the sub-family Cylindrotomini of the Tipulidæ. The species, the life-histories of which are known, are peculiar among crane-flies in that the larvæ feed openly on Bryophytic and Spermatophytic plants.

The adults first appear about the end of May on Vancouver Island. Their distribution is apparently determined by their foodplant, *Trautvetteria grandis*, which is confined to moist, rich woodlands.

In ovipositing, the female cuts a slit in the epiderm on the under surface of the leaf by means of its saw-toothed ovipositor. The sub-translucent glistening white eggs are partially concealed. They are generally deposited in series along the margin. A few eggs may be laid on the upper surface also.

The period of incubation occupies about 2 to 3 weeks.

The recently-emerged larvæ feed on both the upper and lower surfaces of the leaves and as they develop, they eat out large holes. There would appear to be at least three moults before pupation, one previous to hibernation and two after. In their movements the larvæ show a marked resemblance to "looper" caterpillars.

About the end of July, the larvæ, now in the second-stage, cease feeding and become quiescent. In this condition they hibernate among the dead leaves. Some remain leaf-green in color, whilst others assume the dirty-brown hue of decayed leaves.

In the spring they resume feeding and grow more rapidly until they pupate in the middle of May. The pupal period lasts for 6 to 10 days. The last larval skin is only partially shed and serves to attach the pupa to the leaves and petioles.

NOTES ON THE GENUS BUPRESTIS LINNE IN CALIFORNIA.

By RICHARD T. GARNETT,
University of California, Berkeley, California.

This genus is represented in California by seven species and three varieties if the numbering of Henshaw's catalogue be taken as gospel. *B. fasciata* var. *langii* LeConte is, however, nothing but the female of the western phase of *B. fasciata* Fabricius. I have before me a specimen of *langii* in which the spots are identical with those of western *fasciata*, although of an ivory color instead of yellow.

Three of our species are quite rare, two of these exceedingly so, while the rest are either common or moderately so.

The majority of the species work upon conifers, while two are known to bore in broad-leaved trees. Variety *langii* is also under suspicion of working on the latter, as it has been taken resting upon the foliage of alders and willows.

Buprestis aurulenta Linn., 14-21 mm. in length, is quite common in the Sierras and works in practically all of the pines as well as Douglas fir, western red cedar, and spruce. It is also found, but less commonly on the Coast belt, a specimen sent to me by Mr. Freeborn of the Medical Parasitology department of the University, having emerged in Berkeley. Specimens in my collection were taken at Yosemite, Donner Lake, Independence Lake, Calistoga, St. Helena, and Siskiyou County, the dates ranging from June 8 to July 30.

Buprestis laeviventris LeConte, 16-22 mm. in length, is taken commonly throughout the Sierras, especially in the north, and works on yellow, lodgepole, digger and sugar pines. Specimens in my collection were taken at Eureka, St. Helena, Mokelumne Hill, Sisson, Donner Lake, and Truckee between June 18 and September 2.

Buprestis maculiventris var. *subornata* LeConte, 17-20 mm. in length is taken in the Sierras, in Northern California particularly, where it bores in Douglas fir, and has been taken on the foliage of western yellow pine. It is moderately common in some localities. Specimens in my collection were taken at Donner Lake and in Oregon between June 10 and July 3.

Buprestis maculiventris var. *rusticorum* Kirby, 16–23 mm. in length, is found commonly in Northern California and breeds in yellow pine, Douglas, alpine, and white fir. Specimens in my collection were taken at Weed, St. Helena, Tahoe Tavern and Donner Lake, between May 25 and July 21.

Buprestis adjecta LeConte, 12–19 mm. in length, is scarce as a rule, and is found in the higher Sierras breeding in yellow and other alpine pines, probably also Jeffrey. Specimens in my collection were taken at Donner and Independence Lakes, July 3–15.

Buprestis fasciata Dejean, 10–19 mm. in length, is taken in the Sierras of northern California and is known to bore in Douglas fir, while the female, usually known as var. *langii* LeConte, has been taken by myself, Dr. E. C. Van Dyke and others resting on the foliage of alder and willow. Specimens in my collection were taken at Donner Lake, Tahoe Tavern, Muir Woods and Willits, between June 10 and July 21.

Buprestis gibbsii LeConte, 12–21 mm. in length, is taken very rarely in California. It has been taken from oak by Mr. E. Leach of Oakland and by Dr. E. C. Van Dyke. This past summer I removed adults from their pupal chambers in cottonwood at Oro Grande, San Bernardino County. Specimens in my collection were taken at Oro Grande and in Trinity County, between May 18 and July 29.

Buprestis confluens Say, 15–16 mm. in length, is taken exceedingly rarely in California, in the Great Basin and Tahoe regions. It works on poplars. Specimens in my collection were taken at Tahoe Tavern and in Colorado, July 1–22.

Buprestis connexa Horn, 14–15 mm. in length, is taken extremely rarely in Washington, Oregon and the eastern base of the Sierras in California. It works on alpine trees, having been taken from western yellow pine. One specimen in my collection taken at Donner Lake, July 7.

I have tried trapping by sawing up fresh pine wood at several localities, but without success, except at Donner Lake in 1915, between July 1 and 15. In three days I collected from a pile of yellow pine chunks 64 specimens of *Buprestis*, as follows: 41 *aurulenta*, var. *rusticorum* 20, *adjecta* 2, *connexa* 1. These three days were separated over several weeks, as I returned to

this pile to collect only occasionally. Several hundred Chrysobothris, mostly *C. caurina*, were also taken at this wood.

Thus California has within her borders over one-third of the species of Buprestis north of Mexico, together with two varieties of an eastern species. One of these species, *B. fasciata* Dej., it is true is common to both east and west, but I think it may be said without fear of contradiction that California has a greater number of species of this genus than any other state in the Union.

OBSERVATIONS ON THE LIFE HISTORY AND HABITS OF PILOPHORUS WALSHII UHLER.

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New York Agricultural Experiment Station, Geneva, New York.

For several summers my attention has been attracted by the large numbers of a species of black bug in a neglected apple orchard near Geneva. Specimens sent to Mr. E. P. Van Duzee were kindly identified as *Pilophorus walshii* Uhler, of the family Miridæ.

One of the most noticeable peculiarities of the insect is its superficial resemblance to a large black species of ant and to the nymphs of a Jassid, *Idiocerus provancheri* Van Duzee, both of which are commonly found on the same trees. The color of the nymphs and adults is a dark reddish brown, almost black. The nymphs have a white transverse band near the base of the abdomen; and in the fourth and fifth instars there is a similar one along the posterior edge of the pronotum. The adults have a white transverse band across the middle of the wings, an incomplete white band at the edge of the wings one-fourth way from the base, and a white spot on each side of the scutellum.

During the summer of 1917 the first specimens were found on July 5 and the oldest of these were in the third instar. By the middle of July all stages of the insect were present, but nymphs of the third and fourth instars were the least plentiful. This circumstance seemed to indicate the existence of two overlapping generations, but a comparison with the life history of related insects makes it appear more probable that this condition was the result of a prolonged hatching period. Early in August adults became more numerous, while there was a corresponding decrease in the earlier nymphal stages. From then on the numbers of the insects began to decline so that on September 4 only a few adults could be found, and by Sept. 15 they were absent from the trees entirely.

EGG.

Early in the summer young nymphs were observed crawling about on some strips of bark which had been cut from small apple branches and kept in the laboratory for a few days. It seems probable that they hatched from eggs contained in the bark, but none could be found, even after a diligent search on branches of various sizes.

Eggs were dissected from mature females for description and drawing. They are 1.2 mm. long by .20 mm. wide and slightly curved. At the micropyle end there are two small projections with a roughened surface. The color is white.

FEEDING HABITS.

A curious habit of the insects in concealing themselves among leaves curled by aphids led to observations on their feeding habits. It was found that aphids constitute one of their chief sources of food. Adults and nymphs of all stages jab their beaks into the aphids and suck out part of the body fluids, often withdrawing the beak several times and inserting it again in other parts of the body. When attacked the aphids secrete droplets of fluid from the cornicles and if these touch the beak of *Pilophorus* the latter will withdraw and remove the substance with the fore tarsi before proceeding further with the meal. The mutilated aphids generally die as the result of their injuries.

The bugs were also seen probing with the proboscis among the cast skins of an aphid colony as if lapping up the refuse honeydew dropped by the aphids. They occasionally vary the diet by sucking from a leaf or stem.

Several nymphs and adults were confined in a gauze bag on a fruit spur free from aphids, and although they lived over a week no injury could be detected on the leaves or the apples, either at that time or later.

In the neglected orchard, which is infested with San Jose scale, the bugs were seen running about over the large branches and this suggested the possibility that they might feed on scale insects also. They can see a moving object so far it is rather difficult to get close enough to observe their feeding

habits under natural conditions. However, one was noted with its beak inserted into a large scale, which it punctured in three other places before moving away. Another nymph, confined in a tube with a scale-infested twig, was observed directing its beak into the scales as if feeding on them.

Without further observation I cannot say whether the bugs commonly feed on scales or whether they were not merely sucking plant juices from the bark beneath the scales.

VALUE AS AN APHID DESTROYER.

In order to test the value of the species as an aphid destroyer an experiment was performed, using two small shoots of *Spiraea* infested by these insects. Fifty aphids were allowed to remain on each shoot and care was taken to have them free from predaceous insects. Three nymphs of *Pilophorus* were placed on one shoot and none on the other, and both were covered with bell-jars. Two days later, six aphids were found alive on the first shoot, but ninety-one were present on the control, many of them being small newly-born individuals.

The experiment was repeated using the same number of aphids, and with two adults of *Pilophorus* in one bell-jar. After twenty-four hours one of these had been on the shoot for some time, but the other was still crawling about the bottom of the jar. This shoot contained forty-one aphids, while the control had sixty-five. Both adults were placed on the shoot and the experiment was allowed to run another day, when the first shoot had twenty-three aphids and the control had eighty.

These experiments show that this species, if present in sufficient numbers, might be an important factor in holding in check the natural rapid increase of aphids.

IN RELATION TO ANTS.

The aphid-infested apple leaves are usually attended by ants, among which a large black species is common. Both nymphs and adults of *Pilophorus* are very rapid runners and carefully avoid meeting the ants. The bugs can see a large moving object, such as the hand, at a distance of one foot or more, and can detect the ants when they are several inches away. They are thus able to keep on the opposite side of a branch or

twig so that the ants pass by them. Ants appear to be unable to detect the presence of the bugs at a greater distance than one centimeter. If one happens to get this close it immediately attacks the bug, but it is doubtful if it ever succeeds in catching one.

In consideration of the poor visual powers of the ants and the helplessness of the aphids, it is hard to imagine how the striking resemblance of *Pilophorus* to the ants, with which they are often associated, can be of any value to the species either for protection or aggression. The only logical conclusion seems to be that the resemblance is purely accidental.

ALGUNOS CASOS TERATOLOGICOS OBSERVADOS EN LOS ARTROPODOS.

PROF. FRANCISCO CAMPOS R.*

1. *Caso de tarso hexámero en el Tetracha suturalis* Horn.
(Coleóptero de la familia Cicindelidæ).

Es esta una espécimen cuyas extremidades son normales á excepción del tarso mesotorácico izquierdo el cual en su tercera articulación parece haber recibido fractura y soldado después. Presenta pues un tarso mesotorácico de 6 artejos lo que hace que la extremidad mesotorácica izquierda sea sensiblemente mas larga que su correspondiente metameral.

Procedencia de esta forma: El Morro.

2. *Caso de anomalia elitral en el Mallodon molarium* Bat.
(Coleóptero de la familia Prionidæ.)

Consiste este caso teratológico en una hipertrofia del élitro derecho y desvío de la línea de sutura media. Los élitros son normales en su base, y ambas piezas se tocan hasta los dos tercios de su longitud. A partir de este punto el borde interno del élitro derecho se separa de la línea de sutura dejando al descubierto parte de las alas membranosas y la margen externa del mismo élitro se expande notablemente no coincidiendo en su terminación con el extremo del élitro izquierdo el cual conserva en todo perfecta regularidad.

Hab.: Duran.

3. *Caso de bifurcacion tibio-femoral en un Calopteron sp.*
(Coleóptero de la familia Lycidæ.)

Representa esta muestra aberrante un tipo heptápodo. Las patas están normalmente desarrolladas á excepción de la metatorácica izquierda la cual en la región media del femur se bifurca constituyendo desde este punto 2 piezas que se articulan después con 2 tibias perfectamente independientes con sus respectivos tarsos. El insecto en referencia ofrece pues, 7 tibias y casi puede decirse 7 fémures, puesto que la bifurcación comprende también la mayor longitud femoral.

Hab.: Chimbo.

* El suscrito catedrático de Ciencias Naturales del Colegio Nacional Vicente Rocafuerte de Guayaquil (Ecuador) y miembro de la Entomolog. Soc. of America, presenta por intermedio del Prof. J. M. Aldrich—a esa Honorable Corporación, las siguientes observaciones recogidas durante su práctica de Entomologista.

4. *Caso de atrofia tibio-femoral en el Alurnus 4-maculatusé*
(Coleóptero de la fam. Hispidæ.)

Trátase de un ejemplar ♂ cuya extremidad mesotorácica derecha ofrece notable anormalidad. El trocanter mesotorácico es normal; femur notablemente reducido á una quinta parte de la longitud natural, tibia fuertemente curva hacia adentro, á modo de *C* y muy corta (un tercio del tamaño natural); tarso normal. El ejemplar observado por el dorso apenas deja ver el tarso de la extremidad aberrante, quedando ocultas las demás regiones de dicha extremidad, á causa de su reducido tamaño.

Hab.: Baños.

5. *Caso de aberración bicaudata en el Centrurus margaritatus*
(Gerv.)—(Arácnido de la familia Scorpionidæ.)

Constituye un caso teratológico interesantísimo. Un alacrán con 2 colas completamente distintas, bien desarrolladas, fenómeno considerado por varios autores como fabuloso. El ejemplar aludido presenta 2 postabdómenes (colas) independientes é igualmente desarrollados, unidos al preabdomen y provistos de sus correspondientes aguijones. Se observa que, cada postabdomen aunque bien desarrollado ofrece sus metámeros algo menos fuertes que en los de un ejemplar normal.

Hab.: Duran.

Localización poco frecuente del Phthirius inguinalis.

El suscrito constata un caso de alojamiento rebelde del parásito arriba indicado, en la base de las pestañas de ambos ojos, en un niño de 5 años, y temporalmente su presencia en el cabello—(Va 1 tubo con alcohol y varios ejemplares).

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

PITTSBURGH MEETING.

The Twelfth Annual Meeting of the Entomological Society of America was called to order by First Vice President, Dr. E. M. Walker, in the Lecture Room of the Carnegie Museum, Pittsburgh, at 2.30 P. M., on December 28, 1917. On account of ill health, President Lawrence Bruner was not present. There was an attendance of sixty-five members at the opening session.

The Chair appointed the following committees:

Nominations—FRANK E. LUTZ, R. C. OSBURN, J. G. SANDERS.

Resolutions—A. G. RUGGLES, V. A. E. DAECKE, VERNON KELLOGG.

Auditing—J. L. KING, SEYMOUR HADWEN.

The following papers were read:

- Studies on the Dryinid Parasites of Leaf-hoppers. F. A. FENTON
Climatic and Seasonal Variation in Cerodonta. J. M. ALDRICH
Observations on the Life History and Habits of *Pilophorus walshii*
Uhler. B. B. FULTON
An Interesting Habit of a Wax Moth Parasite. S. A. GRAHAM
(Presented by A. G. Ruggles).
The Genitalia of *Gryllotalpa* and Related Forms. E. M. WALKER

At 5 o'clock the meeting adjourned until the next morning.

December 29, 10 A. M. The meeting was called to order by First Vice President, E. M. Walker. This being the annual business session, the Executive Committee presented the Reports of the Secretary, Treasurer, the Managing Editor of the ANNALS, and of the Treasurer of the Thomas Say Foundation, as follows:

REPORT OF THE SECRETARY.

The following members have resigned since the last report:

G. A. Akerlind	A. R. Cahn
N. E. Crosby	C. B. Davenport
R. Etheridge	J. B. Garrett
J. L. Hypes	W. D. Kearfott
R. J. Kewley	W. J. Kostir
J. H. Paine	H. A. Preston
Mrs. A. W. Smith	

Total—13.

The following have died: E. J. Goeldi, J. M. Lawford. Total—2.
Dropped for non-payment of dues, 28.

All losses, 43.

Elected to membership, November 1, 1917:

Ellsworth Bethel	Henry L. Bowers
L. L. Buchanan	E. E. Calder
F. S. Carr	W. B. Cartwright
B. R. Coad	H. G. M. Crawford
Philip Dowell	H. S. Fackler
A. J. Flebut	R. T. Garnett
J. W. Green	Fordyce Grinnell, Jr.
L. G. Gwynn	Ralph Hopping
R. H. Howe	Chas. R. Jones
P. B. Lawson	A. W. Lindsey
A. L. Lovett	Georges Maheux
J. W. McCulloch	F. J. A. Morris
A. J. Mutchler	Howard Notman
E. D. Quirsfeld	D. A. Ricker
F. S. Stickney	M. C. Van Duzee
W. R. Walton	Ralph Whittle
Wm. Wild	C. W. Woodworth
Hachiro Yuasa	
Total—35.	

Elected to membership December 28, 1917:

E. A. Chapin	Robt. Dickson
Victor Duran	P. W. Fattig
H. M. Fort	Chas. W. Frost
S. A. Graham	Geo. Hofer
M. J. Elrod	Henry G. Klages
Bernard Krautwurm	M. C. Lane
J. M. Langston	Fred Marloff
R. M. May	C. E. Mickel
Edgar Nelson	J. A. Reis
Franklin Sherman	C. F. Stahl
L. A. Stearns	R. C. Treherne
F. W. Urich	A. O. Weese
Chas. A. Weigel	S. Howard Williams
Howard E. Woodworth	V. J. Zahrobsky
Total—28.	

All additions, 63. Net gain, 20 members.

Frederick Knab, a charter member, was elected a Fellow by the Executive Committee on May 1.

The membership on December 24, 1917, was in the following classes (in which Fellows are not separated from Members):

Honorary Fellows.....	7
Life Members.....	4
Paid for 1918.....	193
Paid for 1917.....	189
Paid for 1916.....	66
Paid for 1915.....	31
Paid-up, foreign.....	20
Other foreign.....	34
Total except new.....	543
New in 1917.....	63
Total membership.....	606

The Secretary has endeavored to make a list of members in war service, but it is very incomplete (hence not printed; the Secretary did not bring up the matter of remitting dues of members in service below commissioned rank, as intended, on account of his inability to get anything like a list of such members at present).

Respectfully submitted,

J. M. ALDRICH, *Secretary*.

REPORT OF THE TREASURER.

RECEIPTS.

Balance December 14, 1916, (Annals, March, 1917, p. 100).....	\$ 38.82
Dues from members.....	1,282.15
From Managing Editor of Annals.....	280.14
Interest on permanent funds, January and July.....	10.58
Interest on current balance.....	11.03
Exchange.....	.15
Total.....	\$1,622.87

DISBURSEMENTS.

Printing five numbers of Annals.....	\$1,161.22
Transferred to Managing Editor, subscriptions.....	3.15
Refund to F. A. Fenton.....	2.00
Printing and stationery, Secretary's office.....	39.48
Stamps, stamped envelopes, postal cards.....	51.60
Clerical assistance, Secretary's office.....	47.00
Interest on permanent funds, re-deposited.....	10.58
Minor office expenses.....	3.85
Balance on hand, December 20, 1917.....	303.99
Total.....	\$1,622.87

The Society owes for the last number of ANNALS, and has a sufficiently large balance to pay this bill on presentation. The total income of the Society (\$1,622.87, minus the second and third items under disbursements, plus Managing Editor's receipts except the transferred item of \$280.14) was \$1,787.88, the largest in its history.

CONDITION OF PERMANENT FUNDS.

Four Life Memberships.....	\$200.00
Samuel Hubbard Scudder Fund.....	50.00
Accumulated interest to last report.....	12.48
	<hr/>
Total last report.....	\$262.48
Interest added January and July, 1917.....	10.58
	<hr/>
Present total.....	\$273.06

Respectfully submitted,

J. M. ALDRICH, *Treasurer.*

REPORT OF THE MANAGING EDITOR.

The Managing Editor is pleased to report a satisfactory year considering the unsettled conditions that have had to be met. The receipts of this office have been \$450.30 and the expenditures \$170.16, leaving a balance of \$280.14, turned over to the Treasurer.

A condensed summary of the items follows:

RECEIPTS.

Subscription account.....	\$243.65
Sale of Back Numbers.....	114.50
Reprints and authors contributions.....	92.15
	<hr/>
	\$450.30

DISBURSEMENTS.

Stamps, Express and Post Office Charges.....	\$ 27.06
Stenographic Help, Office Supplies and Labor.....	34.83
Engraving.....	108.27
Balance to Treasurer.....	280.14
	<hr/>
	\$450.30

The volume issued contains 418 pages, only slightly less than for the preceding year and the expense has been kept approximately the same by the use of a lighter weight paper which, however, is of excellent quality. A number of authors have very kindly contributed toward the preparation of plates which has enabled us to use a larger number of illustrations than would otherwise have been possible.

A number of back volumes have been sold and I am pleased to acknowledge the assistance of various members who have helped in placing such volumes and trust this favor will be continued for the coming year.

We have a number of available papers on hand, in fact the supply has surpassed the available space, but it seems to me that we should for the coming year keep safely within the estimated income of the Society for publication, selecting with care those papers which are most desirable for immediate publication and trusting that authors will appreciate the necessity for delay in some instances.

Respectfully submitted,

HERBERT OSBORN,
Managing Editor.

THE REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION.

As no report was filed by the former treasurer, the entire financial history of the Say Foundation from the beginning is here reported. This does not include the expenditure of the grant from the Entomological Society of America, which has been reported by the Secretary and audited previous to this time.

RECEIPTS.

1 subscriber @ \$25.....	\$ 25.00
34 subscribers @ \$10.....	340.00
94 orders @ \$3.....	282.00
Postage received.....	1.08
	<hr/>
	\$648.08
Less discounts allowed.....	5.30
	<hr/>
Total net receipts.....	\$642.78

EXPENDITURES.

Printing 1000 copies of Sarcophaga & Allies.....	\$406.80
Binding 200 copies.....	49.20
Postage.....	15.04
Advertising.....	15.03
Miscellaneous expenses.....	4.19
	<hr/>
Total expenditures.....	\$490.26
Cash on hand to balance.....	152.52
	<hr/>
Total.....	\$642.78

OBLIGATION.

1 subscriber @ \$25 (balance).....	\$ 22.00
34 subscribers @ \$10 (balance \$7 each).....	238.00
	<hr/>
Total obligation.....	\$260.00
Less cash on hand.....	152.52
	<hr/>
Net obligation.....	\$107.48

This obligation will require the sale of 38 more volumes to liquidate.

Distribution to December 19, 1917.

It will be observed that there are more than enough copies of bound volumes on hand to cover the deficit if sold, so that no further expenditure along that line need be incurred.

Respectfully submitted,

E. D. BALL, *Treasurer.*

REPORT OF THE THOMAS SAY FOUNDATION.

The activities of the Say Foundation have been confined to the distribution of Volume I, "Sarcophaga and Allies."

Owing to the financial condition, as shown by the Treasurer's Report, and the unsettled condition incident to the war, no further publication has been considered.

In addition to the seventeen names, listed on page 111 of the ANNALS for March, 1916, the following persons have subscribed to the Say Foundation:

- | | |
|---------------------------|--------------------------------|
| 18. P. J. Parrott | 27. } Names |
| 19. R. C. William, Jr. | 28. } not |
| 20. Thos. L. Casey (\$25) | 29. } reported |
| 21. William Wheeler | 30. J. H. Comstock |
| 22. R. W. Harned | 31. E. D. Ball |
| 23. American Ent. Soc. | 32. Economic Entomologist, Pa. |
| 24. A. C. Burrill | 33. J. J. DeGryse |
| 25. R. W. Doane | 34. J. F. Illingworth |
| 26. Jas. K. Thibault | 35. Frederic V. Green |

J. M. ALDRICH,
E. D. BALL.

On the Editorial Board of the ANNALS, the Committee has appointed W. S. Marshall, Vernon Kellogg and F. E. Lutz, succeeding P. P. Calvert, J. W. Folsom, and H. C. Fall. On the Thomas Say Foundation, the Committee has reappointed J. M. Aldrich, Editor; E. D. Ball, Treasurer, and E. B. Williamson; and has appointed P. P. Calvert to succeed Morgan Hebard, in war service.

On motion, the report of the Executive Committee was accepted.

The Committee on Nomenclature made the following report:

REPORT OF THE COMMITTEE ON NOMENCLATURE.

Rules of nomenclature have been formulated to facilitate procedure and to prevent, so far as possible, doubt as to the validity of scientific names. There is certainly need of assistance along these lines and if rules are drafted in a conservative spirit and generally followed, we believe that much benefit and little annoyance will result.

The following is respectfully submitted with a recommendation for favorable action:

(1) Generic names should not be considered homonyms unless spelled alike.

(2) Specific names should not be considered homonyms unless originally placed in the same genus, or the earlier name originally referred to the genus to which the later belongs, or the earlier name to be referred to the same genus as the later as a valid species.

Examples: A. b. 1820. A. b. 1840. The latter is a homonym.

A. b. 1820 (now called B. b.). C. b. 1840 (now referred to genus A. as A. b.). The latter is a homonym.

A. b. 1820, now called B. b., a valid species. B. b. 1840. The latter is a homonym.

A. b. 1820 was referred in 1830 to B. as B. b., but is a species of C. B. b. 1840 (the latter is a valid species of B.). Not a homonym.

A. b. 1820 is a species of B., but a synonym of B. c. C. b. 1840 is a valid species of B. (B. b.). The latter is not a homonym.

This interpretation of the rule may be questioned and is here presented for the purpose of stimulating discussion.

(3) A type locality should be cited whenever possible. It can do no harm and may be of material service in establishing the identity of a species.

The advisability of using a single type in taxonomic work was referred to this Committee at the last meeting with instructions to report.

(4) The designation of a holotype is recommended whenever practical and it is advised that the specimen be selected with considerable care in an effort to secure a form typical of the species..

The holotype should, when possible, be accompanied by a series of specimens showing the range of variation and the entire lot might well be designated as a type series.

There are small delicate insects where the designation of a holotype is not customary, such as balsam preparations of Aphididæ, Coccidæ and Itonididæ, especially where it is necessary to examine several specimens in order to ascertain structural details. These are certainly type series and should be so designated on the labels, but it is desirable to mark one specimen (as by a ring on the glass) as a type.

Respectfully submitted,

E. P. FELT,
T. D. A. COCKERELL,
Committee.

The Committee on Entomology in the National Museum made a report, giving a brief summary of progress and suggesting the continuation of the committee.

On motion of Herbert Osborn, the only member of the committee present, the report was referred back to the committee for further consideration.

The Committee on Resolutions made the following report:

The Entomological Society of America greatly appreciate the courtesies shown to us by the local Committee of Arrangements, and particularly by our friend, Dr. W. J. Holland, Director of the Carnegie Museum.

We also appreciate and commend the efforts made to enlarge our membership, resulting in sixty-three additions this year; we should continue this effort, and in these times of stress and hardship, when all our energies are bent upon winning the war, we should look forward more than ever to these annual meetings as times when we get the inspiration to go ahead with renewed zeal, knowing that we are building the foundations of a structure that makes for conservation.

A. G. RUGGLES,
V. A. E. DAECHE,
VERNON KELLOGG.

On motion the report was adopted.

REPORT OF THE AUDITING COMMITTEE.

We, the undersigned, have examined the books of the Entomological Society of America, and find that the accounts are correct as presented by the Secretary-Treasurer, the Managing Editor and the Treasurer of the Thomas Say Foundation.

SEYMOUR HADWEN,
J. L. KING,
Auditing Committee.

On motion the report was accepted.

The nominating committee made the following report:

Your Committee respectfully submits the following nominations for officers in 1918:

President—Nathan Banks.
First Vice-President—T. D. A. Cockerell.
Second Vice-President—E. P. Van Duzee.
Secretary-Treasurer—J. M. Aldrich.
Executive Committee—C. W. Johnson, Wm. Barnes, E.
Walker, W. A. Riley, Henry Skinner.

Respectfully submitted,

(Signed) FRANK E. LUTZ,
RAYMOND C. OSBURN,
Nominating Committee.

On motion, the Secretary was instructed to cast the ballot of the Society for the persons named to fill the various offices. He reported this to be done, and they were duly declared elected.

The members of the retiring Executive Committee asked that the president be authorized to appoint two members for the day to fill the places of absentees, in order that some Fellows might be elected; the President, having been so authorized, appointed Vernon Kellogg and Jas. S. Hine.

No further business appearing, the reading of papers was resumed, as follows:

Notes on the Early Stages and Habits of Botflies (*Gastrophilus*),
SEYMOUR HADWEN and E. A. CAMERON
Notes on the Life History and Habits of the Ox Warble, *Hypo-*
derma lineatum. F. C. BISHOPP and E. W. LAAKE
Session adjourned until 2 P. M.

2 P. M.—On the call to order by Vice President Walker, the Secretary announced for the Executive Committee the election of the following Fellows:

A. F. BURGESS
LAWSON CAESAR
R. V. CHAMBERLIN
GUY C. CRAMPTON
GEO. A. DEAN

WM. T. DAVIS
JOHN J. DAVIS
ARTHUR GIBSON
MORGAN HEBARD
C. W. LENG

FRANK E. LUTZ
W. S. MARSHALL
FREDERICK MUIR
RAYMOND C. OSBURN
E. C. VAN DYKE

The Secretary called attention to two specimens which were passed around, one being *Oroperipains*, from Panama, sent by James Zetek; the other an adult *Cuterebra*, reared from a house mouse in British Columbia by Dr. Hadwen.

The reading of papers was then continued, as follows:

Annotated List of Lachnosterna Enemies.....J. J. DAVIS
Contribution to a Knowledge of the Life History of the Leaf-eating Crane-fly, *Cylindrotoma splendens*.....A. E. CAMERON
Annals and Miscellanies of My Early Work Upon the Diptera...S. W. WILLISTON
Notes on the Genus *Chlorotettix*.....D. M. DELONG
The Alydinae of the United States.....S. B. FRACKER
My Recent Collecting Trip to Alaska.....J. S. HINE

At 5:30 P. M. the afternoon session adjourned.

8:00 P. M.—The Society was called to order by Vice President Walker, who introduced Professor Vernon Kellogg. Professor Kellogg gave the Annual Address, upon the subject "The Entomologist and the War."

At the conclusion of the address, the Chair called upon several present to discuss its subject matter; Dr. Howard and Dr. Holland expressed warm approval, which was evidently shared by all.

The program of the Annual Meeting having been completed, the Society adjourned *sine die*.

J. M. ALDRICH,
Secretary-Treasurer.

NOTICE TO MEMBERS AND CONTRIBUTORS.

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5 x 7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The Managing Editor is provided with the most recent address of all paid-up members on record in the Secretary's office for mailing the numbers of the Annals and members failing to receive their numbers should present their complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate.

The regular annual subscription price for the ANNALS is in the United States, Cuba, Porto Rico, Hawaii and Mexico, \$3.00; Canada, \$3.50; other countries, \$4.00. Checks, drafts or money order should be drawn payable to ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA, and addressed to HERBERT OSBORN, State University, Columbus, Ohio, U. S. A.

Requests for information as to membership and the annual dues of members may be sent to the Secretary-Treasurer, J. M. ALDRICH, West Lafayette, Ind.

Communications relating to the ANNALS, and all orders for separate copies or reprints should be addressed to

HERBERT OSBORN, Managing Editor,
ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA,
State University, Columbus, Ohio.

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Price List of Publications.

Annals, Vols. I, II, III, IV, V, VI, VII, VIII, IX and X complete, each....	\$3.00
Annals, Separate Parts except as below, each.....	1.00
Annals, Vols. I and II, Part 3, each50
Annals, Vol. IV, Part 4, each	1.50

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Of the ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA may be secured from the office of the Managing Editor and new members of the Society who may wish to complete a set are advised to secure the earlier volumes while there is still a supply on hand and the price is kept at the original subscription rate.

Address HERBERT OSBORN, Managing Editor,
ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA,
State University, Columbus, Ohio.

ANNALS
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Number 2

THE COMPARATIVE MORPHOLOGY OF THE
GENITALIA OF INSECTS.*

ANNA GRACE NEWELL, Ph. D.

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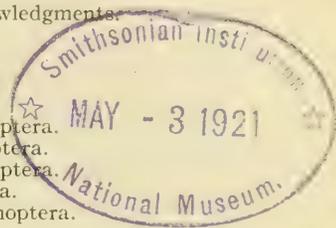
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I. INTRODUCTION.

1. SOMITES.—The third and caudal region of those into which an insect is divided is called the abdomen. Here, for the most part, the segments of which it is composed show a simple and almost primitive structure. In the adult a typical segment, more properly designated a somite, consists of a dorsal chitinized portion or sclerite, called the tergum, and a ventral sclerite, or sternum. These are connected laterally by arthrodial membranes, conjunctiva or pleura, in each one of which is a spiracle. There are exceptions to this arrangement at both cephalic and caudal ends, with the greater complexity at the latter. No

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spiracles are ever present caudad of the eighth somite, and, in most cases, where the somites caudad of the seventh are retracted, spiracles are lacking in the eighth. Therefore it is evident that the adult abdomen always presents, to the eye at least, a far more simple composition than do the head and thorax. In reality, in many larvæ an abdominal somite is an entire ring without differentiation into tergite or sternite, an arrangement often seen in the lower thoracic somites, and a more nearly primitive one than that above mentioned.

The general shape of the abdomen, taken as a whole, also varies considerably. According to the best authorities, one ought to recognize the abdomen, systematically, from the number of its somites and from its appendages. The fact suggested above, that the caudal somites may be more or less, even entirely, concealed by retraction, is responsible for the numbering of abdominal somites which is based only upon the number of visible somites and has no justification in morphology. Disagreement upon this point is found, however, not only among the systematists, who formerly limited themselves to numbering the abdominal somites which were undoubtedly visible, but also among the morphologists. The latter differ in their results for various reasons, as follows: (1) Because of the loss of certain sclerites. (2) Because of differences in the point of view: *e. g.*, some investigators begin to count at the cephalic, while others begin at the caudal end of the abdomen, and still others do not correlate closely dorsal and ventral sclerites. (3) Because, undoubtedly, of failure to observe the sclerites present in the caudal region, due in many cases to the lack of potash or other suitable reagents and methods for exposing chitinized parts.

2. THEORIES AND INVESTIGATORS.—There follows at this point a list of prominent investigators together with the number of abdominal somites which they have believed were present in the adults of certain orders:

ORTHOPTERA.

1872	Chadima.....	11 abdominal somites
1876	Brunner von Wattenwyl.....	9 abdominal somites
1882	Tarzioni-Tozzetti.....	11 abdominal somites

COLEOPTERA.

1894	Peytoureau (in <i>Hydrophilus</i>).....	8 abdominal somites
1894	Peytoureau (in <i>Dytiscus</i>).....	9 abdominal somites
1893	Kölbe (in <i>lamellicornia</i>).....	9 abdominal somites
1893	1894 1896 Verhoeff.....	10 abdominal somites
1903	Berlese (in <i>Coleoptera</i> in general).....	11 abdominal somites

HEMIPTERA.			
1893	1894	1896	Verhoeff.....11 abdominal somites
LEPIDOPTERA.			
1832	Burmeister.....		9 abdominal somites
1893	Kolbe.....		9 abdominal somites
1894	Peytoureau.....		10 abdominal somites
1903	Berlese.....		At least 10 abdominal somites
TRICHOPTERA.			
1849-53	Lacaze-Duthiers, typical number in insects.....		11 abdominal somites
1886	1888	Grassi, typical number in insects.....	10 abdominal somites
1901	Zander.....		13 abdominal somites

From investigations on Thysanura, according to Grassi, there are 10 abdominal somites besides "ein Afterstück, das allerdings nicht mehr als Segment aufzufassen ist;" according to C. Brunner von Wattenwyl, this is a terminal segment, welches aus den drei Afterklappen und den seitlich inserirten "Anhängseln (Cerci) gebildet wird."

Berlese concludes his discussion of the matter by saying that the entire number of abdominal somites varies from nine to eleven, except for the Collembola, which he considered aberrant, this reduction taking place from the lower to the higher orders, and at the caudal as well as at the cephalic end of the abdomen. He states emphatically that eleven is not exceeded, aside from the telson with its rudiments, found only in certain of the Thysanura and immature Orthoptera, and he therefore would consider eleven as the typical number.

Certain other investigators, represented mainly by Heymons, uphold the view that the primitive number of abdominal segments is twelve; the twelfth, just as much as the eleven cephalad of it, containing a cœlomatic cavity. Heymons calls this twelfth somite the telson, and his evidence for it is found mainly in certain Thysanura, where he identifies it with a small sclerite, called by many the supra-anal plate, situated between the eleventh tergite and the anus. He also describes it in immature Acrididæ, Locustidæ, and Gryllidæ as a triangular plate separated from the eleventh tergite, to which it forms the apex, by a suture. In the adults of some Acrididæ this plate becomes totally fused with the eleventh tergite. In this case the terminal segment is commonly called the eleventh only, instead of the eleventh and twelfth, according to Heymons. Berlese gives another example of the twelfth tergite in *Acrida turrata* L., a form not studied by Heymons. (Plate VI, Figs. 1, 10, 13, and 17 t 12.)

According to Haase, the eleventh is not an autonomous somite, and Verhoeff agrees with him. Dewitz states that the eleventh somite is formed only by the doubling of the tenth, and he says that in *Decticus* this only occurs after hatching. Wheeler shows and labels eleven segments in all the figures in his well known embryological investigations.

3. POSTERIOR SOMITES.—The first traces of segmentation are found very early in the germ-band of the insect, which becomes divided by transverse grooves into somites. This process, Heider maintains, even precedes gastrulation in *Hydrophilus*. This is not a primitive condition however. In the completely segmented germ-band, Korschelt and Heider state, there are ten abdominal somites in addition to the telson, and they give the following observations on the germ-bands of various forms, in proof of this statement: Heider, on the germ-band of *Hydrophilus*; Graber, on *Lina*, *Stenobothrus*, various *Lepidoptera* and *Hylotoma*; Wheeler, on *Doryphora* and *Blatta*; Cholodkovsky, on *Blatta*; and Carrière on *Chalicodoma*.

In looking over the plates belonging to all the articles referred to by Korschelt and Heider, in each of the above cases, one sees that in the large number of germ-bands figured the terminal abdominal somite is always numbered eleven, and that in no case is the term telson used, that being the name given by Heymons to the twelfth abdominal somite. Of course, morphologically, what these somites are labeled may seem immaterial, and fundamentally it is. However, there is no doubt that considerable confusion has arisen from Korschelt and Heider's statement in this regard. Many invariably take it that, according to these authors, the insect abdomen is typically composed of ten somites and no more. Others may understand that the telson mentioned is formed of the eleventh and twelfth somites fused. As one can see from the work of the investigators themselves, they agree in giving eleven as the typical number of abdominal somites in the germ-bands of the insects upon which they worked.

One of the difficulties in arriving at any conclusion from the foregoing is that so few investigators have traced structures from embryonic through larval to adult stages, and this same difficulty confronts us when we review the work done on the genital appendages.

A marked deviation from the primitive condition is found in the lack, apparent, at least, of appendages on the adult abdominal somites. If one looks at the germ-band of an insect, however, one can see, soon after the appearance of the appendages of the head and thorax, anlagen of a pair of appendages for each somite of the abdomen also. These rudiments are lateral, sac-like swellings, usually pointing backward, and generally considered as serially homologous with the thoracic legs, as also with the appendages of the head.

The first account of embryonic limb rudiments on the first abdominal somite of *Gryllotalpa*, was written by Rathke in 1844, and, later, on all the abdominal somites, by many others. As we mean by primitive, in insects, that which shows their close relationship to, and probable descent from, a myriapod-like form consisting of several, successive, similar somites, each having a pair of appendages, we are interested to look in the adult for traces of the embryonic condition described above.

4. GENITALIA.—There is, at the caudal end of the abdomen of every insect, a group of appendages having to do, more or less directly, with the function of reproduction. Three pairs of these appendages taken together are called, in a general way, by German authors, "Geschlechtsanhänge"; by English and American ones, "genital appendages," "genitalia," or "gonapophyses," the latter, a term introduced by Huxley in connection with the Crustacea, and used by many others to indicate part or all of these structures, in one or both sexes. They have also been given, individually, names differing from one another in, and characteristic of, each order, so that in some cases only a systematist of the group concerned could follow a description using them. These three pairs of appendages have been attributed to the three somites cephalad of the terminal or anal somite, which, as explained in the foregoing, is considered the eleventh by some and the tenth by others.

It would seem natural to homologize these appendages with the anlagen of legs found respectively on the same somites of the embryonic germ-band, but there are at least two opposed views on this question. Lacaze-Duthiers, who published papers on the subject in 1849-52, did not so consider them, but regarded them as modified ventral sclerites of their respective urites, the latter being the name by which this author, followed in this respect by Berlese and others, called the abdominal somites.

Haase, much later, also stated that the gonapophyses were not true appendages, but, to translate, "integumental structures of a somewhat higher order than styles," meaning those styles which are inserted at the bases of the legs, in the coxæ of some Myriapods and Thysanura. Grassi in 1889 held a similar view. According to Wheeler, all these investigators based their conclusions solely upon comparative anatomical data. The following investigators, however, have regarded these appendages, genitalia or gonapophyses, as homologous with the true, so-called "ambulatory," "segmental," or "pedal" extremities, although they have differed a good deal in the details of their explanations: Weismann in 1866; Kræpelin in 1872; Kowalevsky in 1873; Dewitz in 1875; Huxley in 1877; Cholodkovsky in 1891; and Wheeler in 1893.

Korschelt and Heider state their point of view as follows: "We are here led to ask to what extent the external genital appendages, the so-called gonapophyses, are to be traced back to limb rudiments. The researches of Kræpelin and Dewitz have revealed that the ovipositors of the Hymenoptera and the Locustidæ, and the corresponding genital appendages of the male in these forms, are derived from the imaginal discs of the eighth and ninth abdominal somites, which, when they first appear in the larva, closely resemble the imaginal discs of the larva of *Corethra*, which yield the thoracic limbs." (p. 371.) Bütschli and others have therefore attempted to refer the gonapophyses of these forms to true, abdominal limb-rudiments. "In support of this assumption, we might point out," continue Korschelt and Heider, "that these imaginal discs develop from the abdominal rudiments present in the embryo." "It should, however, be mentioned," they assert, "that Haase, following Uljanin, has recently opposed this view, although, as it appears to us, with insufficient reason, maintaining that the gonapophyses should be regarded merely as secondarily acquired, external appendages."

Heymons is one of the strongest opponents of a homology between the genital appendages and the anlagen of the segmental ambulatory ones of the embryo and the appendages of an ancestral form. He states in a résumé published in 1899 that after embryological investigations on a great number of species of Locustidæ, Gryllidæ, and Hemiptera, he has come to the conclusion that it is a fundamental principle, in the study of

insect embryology, that there is present no genetic relationship between the embryonal anlagen of the ambulatory appendages and the gonapophyses.

The entirely different results obtained by Wheeler, from his embryological work on *Xiphidium*, Heymons attributes to the fact of an unusually early origin of the genitalia in *Xiphidium* and other *Locustidæ*, even as early as the embryonal period before the atrophy of the anlagen of the segmental appendages. Also, in addition to this fact, Heymons lays emphasis upon the very small size of the sternites in *Locustidæ*, which would very easily lead one to confuse the embryonic limb-rudiments and the developing genitalia or gonapophyses; while in other forms, he states, the sternites are much larger. In fact, Heymons asserts, from his investigations on *Lepisma saccharina* and certain Hemiptera, that the sexual appendages do not originate even in the same parts of the sternites where the above-mentioned anlagen of segmental appendages are found. It seems unbelievable that an investigator who has had as much experience as Wheeler in the examination of insect embryos should have made the mistake attributed to him by Heymons.

The anlagen of segmental appendages on the middle and cephalic, as well as on the caudal somites, degenerate during the embryonic stages, and some authors, Goosens and Knatz, for example, have thought that, for this reason, the prolegs of caterpillars first develop during larval life. To quote again from Korschelt and Heider: "We should here have to suppose, as Graber also has pointed out, an embryonic rudiment remaining for a considerable time in a dormant condition. On the whole, the embryonal data seem to support the view of Balfour which Cholodkovsky adopted, and to which Graber was inclined, that the abdominal appendages of the *Lepidoptera* and *Hymenoptera* are to be regarded as true limbs. We have already had several examples, in the *Crustacea*, of the disappearance and redevelopment of a limb out of a rudiment which has meanwhile been latent (Mandibular palp of the *Decapod* larva, Korschelt and Heider, Vol. II, p. 312; maxillipedes of the *Stomatopoda*, Vol. II, p. 300.) A similar example is afforded among the insects by the thoracic limbs of many *Hymenoptera*," and most *Diptera* for that matter. "These appear as rudiments in the embryo, disappear later, and reappear in the imago."

In the above-mentioned résumé of 1899 Heymons takes up, point by point, Verhoeff's work on Coleoptera and Hemiptera, as well as his papers on Tracheates and Myriapods in general, all published between 1892 and 1898. From the results of his review of these investigations Heymons concludes that there is little support for Verhoeff's opinions. The latter include the homology of the styles which are attached to the coxæ of the mesothoracic and metathoracic legs of *Machilis*, as well as to certain abdominal somites of other *Thysanura*. According to Heymons, Verhoeff compares the style-bearing sclerites, which he considers laterad of, and fused with, the true abdominal sternites, with flattened out coxæ, and that rightly, according to Heymons; but, going further caudad, Verhoeff also homologizes the median genital appendages with the distal segments of the legs, and the lateral gonapophyses with the coxæ of these legs, therefore regarding the origin of two pairs of genitalia from one pair of ambulatory appendages belonging to one somite, instead of from two pairs belonging to two successive somites, or, to put it from Heymon's point of view, from at least four isolated evaginations having no connection with the anlagen of the segmental appendages found in the embryo.

One objection which may be made to Heymons's theory, on general morphological grounds, is found in certain of his conclusions which he himself states as follows: "Heymons zufolge, sind die Geschlechtsanhänge männlicher und weiblicher Insekten nur als Hypodermisfortsätze zu betrachten," and "Die Geschlechtsanhänge sind, nach der Ansicht von Haase, Peytoreau, Heymons, u. a. erst innerhalb der Klasse der Insekten erworben." With but few exceptions we find that, in tracing the morphological history of almost any organs we may mention, more or less important and well developed in a group of animals, they have not recently "sprung into being" as it were. Nature is not in the habit, to put it differently, and perhaps in a trite, old-fashioned manner, of building structures out of "etwas Neues." A glance at the history of almost any vertebrate structure will reveal an example of this fundamental principle.

Wheeler realized the necessity of tracing organs not only in the embryonic stages, but also on through later ones. In his paper on *Xiphidium* he says that the embryonic history of the gonapophyses could be "continuously traced," since there is no flexure of the abdomen in that embryo as exists in so many other

forms to obscure the ventral view of the somites. After the time of hatching, Wheeler calls attention to the fact that Dewitz, in 1875, traced the development of the ovipositor in another locustid, *Locusta viridissima*, so that we now have the complete history of that organ, or set of organs. Wheeler concluded that part of his account as follows: "While there can be no doubt about the appendages of the eighth and ninth segments which go to form the two outer sheaths of the ovipositor or sting, the development of the innermost blades is by no means so satisfactory. But whether this pair is only a portion of the ninth pair of appendages as most authors claim, or represents the tenth pair as I maintain, the main question at issue is in no wise affected; for it still remains true that the ovipositor consists of two or three pairs of modified ambulatory limbs." In the male *Xiphidium* embryo, it is claimed by Wheeler that the pair of appendages on the ninth somite persists, to form the definitive styli, those of the eighth and tenth somites disappearing very early. To quote again, "The continuity of the styli"—meaning here male genitalia—"with the embryonic appendages was quite as satisfactorily observed as the continuity of the ovipositor blades." He also says of the investigations of others, "Cholodkovsky has made an exactly similar observation on *Blatta*." The styli, therefore, in the male "are the homologues of the second pair of gonapophyses" in the female. "Haase must, therefore, have gone astray in seeking to homologize the styli" in the male, "with the styloid processes or 'Griffel'" above-mentioned in this paper as those styles attached to the coxæ of certain of the abdominal somites of some *Thysanura*, "for the styli," concludes Wheeler on the male *Xiphidium*, "are modified ambulatory appendages."

5. CERCI.—One more pair of appendages, namely, the cerci, should properly be included under the term genitalia, making the total number four pairs. The cerci, often tactile in function when present, are frequently described as attached to the terminal or anal somite. That different investigators have not meant the same thing, morphologically, by cerci, is undoubtedly true. Some regard them, not as appendages, but as prolongations of pleurites, *i. e.*, of epimerites and episternites. Berlese explains this point of view, which he apparently takes. He says that there may be cerci on the tenth somite, as also on the ninth, the presence of the one generally excluding that of the other,

although he would not lay this down as a fundamental principle. He gives *Notonecta* as an example of a case where he maintains that there is one pair of cerci on the eleventh somite, another pair on the ninth, and on somites cephalad of these he thinks there may be rudiments of others. His classification of cerci is as follows: the ones found on the eleventh somite, he calls acrocerci, or cerci; those on the tenth, mesocerci; and those on the ninth, procerci. The views of other authors are few in number, and have many points in common. Haase considers them as feeler-like appendages of the "Analstück"; Verhoeff, true, segmental appendages of the tenth abdominal somite; Peytoureau, dorsal appendages of the tenth abdominal somite which may be compared, he thinks, with wings in their method of development.

Heymons and Wheeler in Orthoptera, and Heymons in regard to Dermaptera, Ephemera, Odonata, and Thysanura agree that cerci are true appendages of the eleventh abdominal somite.

All of the foregoing opinions except Heymons's may be grouped together in that all their authors agree that the cerci are appendages, of one kind or another, belonging to the terminal abdominal somite. Heymons always regards the terminal anal somite as the telson, or twelfth abdominal somite, so would regard the cerci as appendages of the eleventh, or pre-anal somite. Verhoeff lays great stress on the fact that the cerci must be segmented to be true cerci, comparing their segmentation with that of the thoracic legs. Haase and Heymons maintain that there is no relationship between the segments of these two structures as such, but rather a far-reaching, "weitgehende," according to Heymons—parallel between the cerci and the antennæ, not only in their present form, but in their ontogeny. It is certainly true that the cerci, generally speaking, bear a superficial resemblance to the antennæ, but they may also assume, physiologically, entirely different roles. Thus, for example, they may be purely sensory, but they may also be modified as accessory copulatory organs.

Cholodkovsky was the first, in 1891, to uphold the fact that the cerci were morphologically true pedal extremities, and it is the one place where Heymons can agree with him, as well as with Wheeler and others, that a pair of appendages which may properly be included under the genitalia has its origin in the

anlages of the appendages of an embryonic somite. In fact, Heymons has called the cerci "modifizierte Extremitäten," and he states very emphatically that the cerci are homologues of the above-mentioned styles of some Thysanura, just as those styles themselves are descended from ancestral abdominal appendages.

6. ACKNOWLEDGMENTS.—It is with the foregoing points of theoretical importance in mind that the following investigation is presented. At this point it would seem fitting to state that the investigation was begun at the suggestion of Dr. Alex. D. MacGillivray, of the Department of Entomology, University of Illinois, and I wish to express my gratitude to him for that and for countless timely suggestions and criticisms. I am indebted to Professor S. A. Forbes for many courtesies and for the use of material from the Illinois State Laboratory of Natural History, and also to the staff of that institution. I also desire to thank Dr. Harris H. Wilder, of the Department of Zoology of Smith College, for many important suggestions and criticisms. Dr. H. S. Pratt, of the Department of Zoology of Haverford College, very kindly collected for me specimens of *Mantis* sp. from a colony introduced on nursery stock, near Haverford, and I would at this point express to him my thanks. For considerable mechanical help with the drawings and their arrangement in the plates, I am very grateful to Miss N. B. Lewis, of Smith College.

7. MATERIAL.—The records upon which we must rely in determining the origin of the genitalia are the anatomy of generalized adult forms, a comparison of these with more specialized species and earlier developmental stages. Therefore, this paper consists of a comparative study of the caudal segments and appendages of adults of the following species: *Lepisma saccharina* and *Machilis* sp. of the Thysanura; *Periplaneta orientalis*, *Melanoplus differentialis*, *Dissosteira carolina*, *Xiphidium ensiferum* and *Gryllus pennsylvanicus* of the Orthoptera; *Tibicen septemdecim*, *Notonecta undulata*, *Benacus griseus*, *Corixa* sp., *Anasa tristis* and *Euschistus variolarius* of the Hemiptera; *Corydalis cornuta* of the Neuroptera; *Panorpa lugubris* of the Mecoptera; *Nerophilus californicus* of the Trichoptera; *Harpalus caliginosus*, *Cybister fimbriolatus*, *Hydrophilus triangularis* and *Doryphora decemlineata* of the Coleoptera; *Hepialus humuli*, *Prionoxystus robiniae*, *Agrotis ypsilon*, *Anosia plexippus* and *Phlegethontius sexta* of the Lepidoptera;

Tipula abdominalis, *Tabanus sulcifrons* and *Calliphora viridescens* of the Diptera; and of the Hymenoptera, *Dolerus unicolor* and *Vespa maculata*.

II. INVESTIGATION.

GENERAL PRINCIPLES.—Before taking up any anatomical description or comparison of the foregoing forms, a number of preliminary points should be mentioned.

The distal pair of appendages, as has before been noted, is the cerci, and in the majority of cases in adult insects where these are present they have so changed their position as to be dorso-lateral, or even quite dorsal. As many of the succeeding pairs of appendages as are present are, as a rule, still in a ventral position, and may project beyond the caudal end of the abdomen. Therefore, it will usually seem convenient to begin descriptions of the genitalia by describing the cerci first.

Of the two sexes the female is the more generalized. A good example of this point is seen in the female cockroach where all four pairs of genital appendages are present, almost in their primitive position so far as showing their points of attachment to their respective segments is concerned, and where the total number of segments found in adult insects is also present. The saw-fly is another striking example of the generalized female. These are both examples in primitive families of insects, but on the other hand, in certain specialized groups which do not sting, and which, laying their eggs merely on the flat surfaces of leaves or stems, lack ovipositors, the caudal end of the abdomen presents a most generalized condition, the appendages in such cases being, "specialized by reduction." The genital and anal openings in these insects may be easily seen in a caudal view, the former between the ninth and tenth sternites under the edge of the ninth, and the anus in its usual position between the distal tergite and its corresponding sternite. These openings and whatever rudimentary appendages there may be present are enclosed within a cavity formed by the invagination of the segments beyond and including the eighth. From this sac-like invagination, the appendages may be protruded. When ovipositors and stings are present in specialized forms, these too are often concealed, or at least partially so, in pocket-like cavities similar to the one described above, except that they are usually somewhat longer.

The genital opening of the male is connected with the tenth sternite more closely than with any other, as Berlese states. However, certainly in the adult insect, it is also situated at the distal end of an intromittent organ, which is, in many cases when entirely protruded, nearly as long as the abdomen, and thus the ejaculatory duct is also prolonged to an equally great length, therefore, bringing the external opening itself to a point without any relation to the abdominal sclerites.

Somewhat similar cases occur in such females as possess long ovipositors. However, the distal opening of the vagina itself is seldom situated far beyond the bases of the ovipositors. When the eggs leave this opening, they follow along well-marked grooves on the inner surfaces of the ovipositors into the ground, stem, or other object in which they are to be laid. This same mechanism may exist for the exit of poisonous fluids exuded at the bases of stings, or, as is often the case, through excurrent ducts leading from the glands to an external opening, or paired openings, also situated at the bases of the stings.

In those insects which have their caudal segments and genitalia retracted, the caudal end of the body has a smoothly rounded contour, or it may even be pointed. Excellent examples of such cases are seen in the Diptera and Hymenoptera. In these, one is unable to identify the sex from the genitalia unless they are extruded, but one must instead use other characteristics varying in the two sexes—those commonly called secondary sexual characters. Those abdomens which terminate with most of their distal segments and appendages in view, show projections of a tactile, clasping, or other function, and, although usually bilateral in arrangement, they are very irregular in appearance by contrast with those smooth forms described above. Here, of course, it is very often possible to tell the sex easily from the genitalia alone.

The anus is always surrounded by cuticular membrane divided into folds generally called anal lobes. It is often difficult to decide upon the number of the distal segment in adult insects because it cannot be differentiated from this membrane which may very well be made up, morphologically, of more than one segment.

In numbering the segments of this region it is not necessary to begin with the first abdominal one. The most caudal pair of

abdominal spiracles typically occurs in the eighth abdominal segment of adult insects, but is sometimes concealed if the posterior segments are retracted; otherwise, it is in the seventh, and the arrangement in this particular is quite uniform throughout an order. As, for example, there are always eight pairs of abdominal spiracles in the Orthoptera but only seven pairs in the Lepidoptera, with the possible exception of *Hepialus*. The fact must not be lost sight of that in the larva of this form eight pairs of functional spiracles are present, and that these are rudimentary in the pupa. The caudal appendages of the abdomen, the genitalia, are designated in this paper by the Roman numerals I, II, III and IV, beginning with the cephalic pair. No attempt has been made to apply the names given by systematists to these parts.

With the foregoing general principles in mind, some account of the details of the work may now properly be considered.

METHOD OF PREPARATION.—The method of preparing insects for a study such as the following is very simple. They were softened by leaving the entire insect, the abdomen only, or merely the posterior end, whichever was desired, in a five per cent solution of caustic potash for periods varying from twelve to twenty-four or thirty-six hours, depending upon the hardness and freshness of the specimens used. If pinned specimens were used, they were first boiled in water for a short time. They were then washed in running water, and studied under a binocular dissecting microscope. A compound microscope was also used for studying mounted balsam preparations of the smaller parts.

DISCUSSION AND TABLES.—The arrangement of this section of the paper will be as follows: The Apterygota will be taken up first, and next the Pterygota, beginning in each case with the generalized forms. There are also included tables showing the sclerites and appendages present in the species studied. The presence of a sclerite or a pair of appendages is indicated in the tables by a plus sign, and their absence by a minus sign. When either is rudimentary, an asterisk is added to the plus sign. The abbreviations t and s stand for tergum and sternum respectively.

a. *Thysanura*.—It is obvious from the figures of both *Lepisma* and *Machilis* that the problem is complicated in the *Thysanura* rather than simplified, as would seem natural. It is

here that Heymons makes his best point in regard to the homologies between styles and genitalia, but in these forms both styles and appendages are often attached to the same somites. A careful survey, however, of Figure 12 (Plate IV) of the more generalized female shows that the latter are important outgrowths, which so far as the adults are concerned, may far better be considered genitalia than styles. In the embryos figured by Heymons the buds, anlagen of genitalia and styles, are so near together as to be easily confused and to give ground for the belief that they are one and the same thing, not separate from the very beginning. On the other hand, this separation shows very clearly in his figures, even in those of insects which have entirely degenerate styles; that is, none, in the adult. He, however, does not interpret his figures nor yet his material in that way. He considers that the appendages found in the adult are simply the final specialization of these same above-mentioned styles.

In the male and female *Lepisma* (Plate IV, Figs. 6, 7, 10, and 12), again it is evident that in the adult insect there are appendages corresponding to Appendage I as well as styles, on the same somite, and it seems unnecessary to correlate those appendages found on the terminal somite of *Lepisma* and *Machilis* with styles when they resemble so closely certain appendages, cerci or Appendage IV, of similar form in many groups where styles are not present. It should be said in this connection that the terminal median appendage present in the *Lepisma* and shown in the figures of that insect is the one which, including also the anal lobes, Heymons and Uzel homologize with the eleventh somite.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11,	I,	II,	III,	IV.
<i>Lepisma saccharina</i>									
Female.....	t+	t+	t+	t+	t+	+	+	+?	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+?	+
	s+	s+	s+	s+	s+				
<i>Machilis</i> sp.									
Female.....	t+	t+	t+	t+	t+	+	—	—	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+?	+
	s+	s+	s+	s+	s+				

b. Orthoptera.—In regard to the Orthoptera it may be said that they are of course here, as elsewhere in structure, a very generalized group. To begin with, the tables show the presence of eleven, or at least parts of ten, somites and all four pairs of appendages in all the forms studied. This is particularly remarkable in connection with Appendage II, the commonly called "mesal," or "median" pair of appendages, which are so many times entirely lacking in the female.

In no case is the latter pair so prominent in the above mentioned genera as in Mantis. However, in case of every modification of the genitalia, whether it be for the purpose of digging in the ground, as is true in the grasshopper and the cricket, or whether for holding the spermatophore, the habit of the female *Xiphidium*, it is possible easily, not only to work out and see plainly this appendage, Appendage II, but also to see that it follows immediately upon Appendage I in an extreme ventro-caudal position.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Periplaneta orientalis</i>									
Female.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
<i>Melanoplus differentialis</i>									
Female.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
<i>Dissosteira carolina</i>									
Female.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
<i>Xiphidium</i>									
Female.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
<i>Gryllus</i>									
Female.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	+
	s+	s+	s+	s+	s+				

c. Hemiptera.—In many species of this order we meet the problem presented by Berlese's theory of successive pairs of cerci, which he illustrated by many examples from the Hemiptera. At the posterior end of *Benacus*, *Zaitha* and other species of aquatic Hemiptera, in both the male and female there projects a pair of strap-like appendages, included by some authors among the genitalia. Upon a close examination they are found to be outgrowths of the eighth tergites, and the corresponding pair of spiracles is situated at their bases. From these spiracles two parallel rows of closely set setæ extend to the distal ends of these projecting tergites. Various observers have believed them to be organs used in connection with the respiration of these aquatic species. The seventh tergite of *Benacus* presents a similar modification, and it contains the seventh pair of spiracles, but it is much broader and shorter. The seventh and eighth tergites of *Notonecta* and the eighth tergite of *Corixa* are apparently lengthened in like manner, and, according to some investigators, have also a like function. *Euschistus variolarius* and *Anasa tristis*, among the land forms, show similar projections from the tergites of this region, but lack the arrangements of setæ which have to do with the respiration of the aquatic species. However, in neither case are these parts separated from the sclerite proper, as is always true of the cerci, whether or not they show segmentation. In this connection, it may be noted that these prolongations in the Hemiptera, called by Berlese the cerci, are never segmented. The Hemiptera form a generalized order of insects, yet they are among the most specialized of those having an incomplete metamorphosis.

There are, therefore, few appendages present in certain of the more highly developed species, as is evident from the following table, and they are also specialized by modification in the form of complicated mechanisms. Examples of the latter are seen in the males of both *Euschistus* and *Anasa*.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Tibicen septemdecim</i>									
Female.....	t+	t+	t+	t+	t—	+	+	+	+
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+	+	+	+
<i>Notonecta undulata</i>									
Female.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
<i>Benacus griseus</i>									
Female.....	t+	t+	t+	t+	t—	+	—	+	—
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
<i>Corixa</i> sp.									
Female.....	t+	t+	t+	t+	t—	+*	—	—	—
	s+	s+	s+	s+	s—				
<i>Anasa tristis</i>									
Female.....	t+	t+	t+	t+	t+	+*	+*	+*	—
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
<i>Euschistus variolarius</i>									
Female.....	t+	t+	t+	t+	t—	+*	—	—	—
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				

d. Neuroptera.—Here again, among the first of those forms characterized by a complete metamorphosis, we find a more generalized condition than among the Hemiptera, which, although they have an incomplete metamorphosis, stand at the top of the group. Appendage II is lacking, but this is the above-mentioned "mesal" appendage more often absent than present.

To be sure, somite eleven is apparently entirely wanting, but without embryological evidence one has always a suspicion that parts of this segment may be present in the membrane of the anal lobes. Another point to be noted here, unlike any we found in the Orthoptera, is that the male appendages present almost as primitive a condition as do the female. In fact there is even less specialization in connection with function in the male than in the female.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Corydalid cornuta</i>									
Female.....	t+	t+	t+	t+	t—	+	—	+	+
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+	—	+	+
	s+	s+	s+	s+	s—				

e. Mecoptera.—*Panorpa lugubris*, the example chosen in this case, seems at first glance to be a most specialized insect, particularly so far as genitalia are concerned. This appearance is found to be, with very little and superficial examination, entirely misleading. The real situation at the posterior ends of both the male and female *Panorpa* is that of a generalized form. In the male there is a resemblance to the Lepidoptera in the claspers, which are not, however, the only appendages present as is usually the case in the larger group characterized by such organs.

TABLE OF SCLERITES AND APPENDAGES.

<i>Panorpa lugubris</i>	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
Female.....	t+	t+	t+	t+	t+	+	—	+	+
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t—	+	—	+	+
	s+	s+	s+	s+	s+				

f. Trichoptera.—The male caddis fly is characterized by an apparent specialization, real indeed so far as function is concerned but not fundamentally affecting the relative arrangement of parts. The specialization is in connection with the prolongation merely of the ejaculatory duct, and is formed of Appendage II.

TABLE OF SCLERITES AND APPENDAGES.

<i>Nerophilus californicus</i>	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
Female.....									
Male.....	t+	t+	t+	t+	t+*	+	+	+	+
	s+	s+	s+	s+	s+*				

g. Coleoptera.—The Coleoptera have long presented a great problem to those investigators who wished to be able to make a classification of that group based on genitalia. So far as this paper is concerned they may still present almost unsurmountable difficulties. However, there is very little doubt that ten segments and even traces of eleven are present in the beetles, even if one must depend in large measure upon membrane only and asymmetrically placed sclerites. With relaxation by potash it is very evident that true somites eight, nine, and ten are present, the sutures between them showing plainly by means of evaginated folds or grooves. The eighth somite is always indicated plainly by the position of the eighth spiracle, no

matter how much it is hidden from view at first glance. Appendages are in large measure lacking in the female and the appearance is that of extreme specialization by reduction. The male is modified especially in connection with the external opening of the ejaculatory duct, which is placed at some distance outside of the body-cavity, entirely out of relation to its respective somites 9 and 10.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Harpalus caliginosus</i>									
Female.....	t+	t+	t+	t+	t+	+	—	—	—
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t—	—	+	+	—
	s+	s+	s+	s+	s—				
<i>Cybister fimbriolatus</i>									
Female.....	t+	t+	t+	t+	t+	+*	+	+	—
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
<i>Hydrophilus triangularis</i>									
Female.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+	+	+	—
	s+	s+	s+	s+	s—				
<i>Doryphora decemlineata</i>									
Female.....	t+	t+	t+	t+	t—	+*	—	—	—
	s+	s+	s+	s+	s—				
Male.....	t+	t+	t+	t+	t—	+*	+?	+	—
	s+	s+	s+	s—	s—				

h. Lepidoptera.—The families of Lepidoptera present in the female, beginning with *Hepialus*, most extreme cases of specialization by reduction. The telescoping of segments is here carried to such a degree that we see for the first time the most terminal spiracle in the seventh somite instead of in the eighth, its usual position in a more typical form. It is interesting to note, in this connection, that this spiracle is present in the larva, rudimentary in the pupa, and lost in the adult, with the possible exception of *Hepialus*.

The somites retracted are very long in proportion to their width, and very slightly chitinized. Appendages in the female are largely lacking except perhaps for bud-like outgrowths from the somites at the positions occupied by appendages when present in other forms. The appearance of the female from the caudal point of view presents, particularly in *Hepialus*, because of this relation between somites and the origins of their respec-

tive pairs of genitalia, a most generalized condition. The use of the word generalized may be objected to in a case of such extreme specialization, but certainly the relation between somites and appendages is a primitive characteristic in itself, and one extremely prominent in this group.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Hepialus humuli</i>									
Female.....	t+	t+	t+	t+	t-	+*	-	-	-
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+	-	-	-
	s+	s+	s+	s+	s-				
<i>Pryonoxystus robiniae</i>									
Female.....	t+	t+	t+	t+	t+	-	-	-	-
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	-
	s+	s+	s+	s+	s+				
<i>Agrotis ypsilon</i>									
Female.....	t+	t+	t+	t+	t+	-	-	-	-
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t-	+	+	+	-
	s+	s+	s+	s+	s-				
<i>Anosia plexippus</i>									
Female.....	t+	t+	t+	t+	t-	-	-	-	-
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+	+	+	-
	s+	s+	s+	s+	s-				
<i>Phlegethontius sexta</i>									
Female.....	t+	t+	t+	t+	t+	-	-	-	-
	s+	s+	s+	s+	s+				
Male.....	t+	t+	t+	t+	t+	+	+	+	-
	s+	s+	s+	s+	s+				

i. Diptera.—The Diptera differ among themselves largely in presenting both very generalized and specialized conditions. The specialization, so far as appendages is concerned, is again one of reduction. The best illustration of generalization is seen in the female of *Tipula abdominalis* and specialization is evident in the tabanid. A caudal view (Plate XVI) illustrates extreme specialization by reduction with scarcely any appendages indicated except the cerci, Appendage IV. In this as well as in all cases of this type of specialization both the anal and the genital openings occupy their typical position. The male shows greater specialization both in Appendage IV and in the other appendages, especially in the one forming the case for the ejaculatory duct, Appendage II, but even here, comparatively speaking, specialization by modification and enlargement of parts is fairly slight.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Tipula abdominalis</i>									
Female.....	t+	t+	t+	t+	t-	+?	—	—	+
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+	+	+	+
	s+	s+	s+	s+	s-				
<i>Tabanus sulcifrons</i>									
Female.....	t+	t+	t+	t+	t-	—	—	—	—
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+	+	+	+
	s+	s+	s+	s+	s-				
<i>Calliphora viridescens</i>									
Female.....	t+	t+	t+	t+	t-	—	—	—	—
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+*	+	+	+
	s+	s+	s+	s+	s-				

j. Hymenoptera.—The connections of the 8th and 9th somites with their respective genitalia are very clearly seen, not only in the generalized saw-fly, *Dolerus*, but also in the specialized *Vespa* (Plate XVII). The genitalia, here having the form of saws and stings respectively, are in themselves very naturally greatly modified for their functions, but, except for their length and serrated edges, for example, there is very little about the posterior ends of the females of either of the above mentioned genera which indicates very great specialization. The one point which does strongly suggest such specialization is the complete retraction of parts in this region of the body so that without potash preparations one would see only a perfectly even contour in the caudal region of the abdomen.

The males of this order show numerous small modifications of all the genitalia, Appendages I, II, III, and IV respectively. These modifications are in the form of many irregular points, curved projections, finger-like evaginations, and other small structures hard to describe. The copulatory habits of these forms have been worked on so little that nothing can be said with regard to the meaning of all these structures. Their positions in relation to their respective segments are not difficult to make out, as is evident from the plates showing figures of these forms.

TABLE OF SCLERITES AND APPENDAGES.

	SOMITES					APPENDAGES			
	7,	8,	9,	10,	11	I,	II,	III,	IV.
<i>Dolerus unicolor</i>									
Female.....	t+	t+	t+	t+	t-	+	+	+	+
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+	+	+	-
	s+	s+	s+	s+	s-				
<i>Vespa maculata</i>									
Female.....	t+	t+	t+	t+	t-	+	+	+	-
	s+	s+	s+	s+	s-				
Male.....	t+	t+	t+	t+	t-	+	+	+	-
	s+	s+	s+	s+	s+				

III. SUMMARY.

Comparisons between certain of the somites of the different orders investigated, as well as between some of the appendages studied, may well be taken up as a summary of the above discussions and tables. The homology of the sclerites of the species studied, as well as that of the appendages, has been fully and clearly indicated in the labeling of the figures.

1. SOMITE EIGHT.—This somite, as has already been noted, contains, typically, the terminal pair of spiracles. Except in those species which have well-rounded contours, or are pointed, at the caudal end of the abdomen, this somite approaches very nearly the one figured in the so-called primitive type (Plate IV, Fig. 1). It is simple in outline; broad and blunt in shape; about one-third as long as wide; tapering only very slightly, if at all, and with a tergum and sternum almost equal in size, connected laterally by an appreciable conjunctiva; in the Thysanura, Orthoptera, Hemiptera, and in the generalized orders studied having a complete metamorphosis, such as the Neuroptera, Mecoptera, and Trichoptera. In the Coleoptera and Lepidoptera it is retracted; more or less membranous; long in proportion to its width; and, in the Lepidoptera, except for the possible case of *Hepialus*, it lacks its respective spiracle. It is also small in the higher families of the Diptera, but its extreme specialization occurs in the female Hymenoptera where the sternum consists of two small, sub-triangular sclerites to which is attached its respective pair of appendages, I, saws or sting as the case may be. (Plate XVII, Figs. 10 and 14).

2. SOMITE NINE.—This somite is more specialized than the eighth and markedly shorter in proportion to its width even in the Thysanura and Orthoptera. In these generalized orders of

insects, with incomplete metamorphosis, the ninth somite shows specialization in the sternum, which, early in its history in the female cockroach and grasshopper, is much smaller and far more variable in shape than the tergum. In the Hemiptera it is a larger, less modified somite, in the sternum as well as in the tergum, and this continues to be true in *Corydalis* and *Panorpa*, although it is longer in proportion to its width than before, this latter characteristic following out the general shape of the scorpion fly. In the Coleoptera the entire somite consists of most irregularly shaped chitinous sclerites, and, in large proportion, of cuticular, non-chitinized membrane. Such sclerites may not be bilaterally placed with reference to the shape of the beetle, but in a direct ventral view only a part of the sternum will show, and that, irregular in shape, as in *Hydrophilus* (Plate XIII). In the Lepidoptera the ninth somite is often a homogeneous, membranous cylinder as in the females of *Phlegethontius* and *Pryonoxyatus*; or, as in the male of the same genus there may be a slender, curved sclerite bilaterally placed in a broad area of membrane; or, as is true of *Hepialus* the sclerites may be broad and short, more highly chitinized than the succeeding somites. In the Diptera it varies from the small, crescent-shaped sternum of the female *Tipula abdominalis*, to the broad, well-rounded tergum of the male in the same species.

Between these two extremes, one finds every irregularity, of size and shape, as is well illustrated by the long, sub-cylindrical somite of the male blow-fly and the irregularly chitinized, largely membranous sternum of the female of the tabanid. The corresponding sclerite in the male further accentuates the shape found in the female so that it is almost forked, the points projecting posteriorly and, in the female blow-fly we meet with an almost typical ninth sternum, its only variation being a somewhat curved caudal margin.

The ninth sternum is highly specialized in shape and arrangement in the Hymenoptera, after the same manner already commented upon in connection with the eighth, and it consists of two irregular sclerites again somewhat approaching a triangular shape. However, just as plainly marked as in the case of the eighth, is the primitive connection of this sternite with its respective pair of appendages: a most generalized point in a highly specialized group. It should also be noted that this

generalized condition is almost as clearly seen in *Vespa* as in the saw-fly.

3. SOMITE TEN.—The typical form of this somite holds good, for the tergum in the male and female *Lepisma*, the sternum in these forms having as its main characteristic a deep indentation in the middle of the caudal margin. In the grasshoppers this tergum is narrow and only partly divided from the ninth by an incomplete suture, in both male and female, but the sternum is nearly typical. In the female cockroach it is so deeply indented in the middle of the caudal margin as to seem almost forked, and in the male this sclerite is very short with an entire, caudal margin, while the sternum is very small and retracted in both cases. In the male and female crickets the tergum is a sclerite nearly as long as broad, with a well-rounded caudal margin, but the sternum is smaller, much shorter than broad, and indented on the caudal margin, as is also the tergum of the female *Xiphidium*. The sternum again in this genus, as in all of the Orthoptera studied, shows specialization to a slight degree in its being retracted under the preceding sterna and terga with a consequent reduction in size. In the Hemiptera this small size of somite ten, with its accompanying retraction, is carried to a greater extent, and we have small sclerites, still chitinized, and, for all those studied, very well illustrated by the terminal tergum of *Benacus* which is typical of such sclerites, well developed, considering that they are retracted. The latter point is clear when such a tergum is compared with the tenth tergum or sternum of *Euschistus*. In all the Hemiptera studied there was quite perceptible chitinization of the cuticula forming the tenth somite, but this is lacking in the Neuroptera where membrane only is present. The somite in this case is not only short, but also small in circumference, entirely covered by other somites and appendages, and enclosing the anus without very well-marked sutures between the tergum and sternum. Such a description as this would answer for the tenth somite of almost any form taken through the remaining insect orders considered. Exceptions may be made in the case of *Panorpa* where the whole somite is long in proportion to its width, and firmly chitinized; in forms as reduced and retracted as *Hepialus* and *Tabanus*, where the length is very short in proportion to the width; in the female *Pryonoxystus*, where it is retracted and membranous, yet long and cylindrical.

4. SOMITE ELEVEN.—Somite eleven, as has been shown in the tables, occurs the most infrequently of any of the four caudal somites studied. It is the most characteristic of the Orthoptera of any order, although it also occurs in certain generalized families. When present it is posterior to the tenth, surrounds the anus, and is membranous except in such forms as the female grasshopper, where its tergum is highly chitinized, and clearly separated from the tenth tergum by a well-marked suture. Posterior to it in those cases, in the adult, lies the so-called twelfth somite of Heymons showing in both *Dissosteira* and *Melanoplus* (Plate VI, Figs. 9 and 10; 1, 10, 13, and 17, t12) very distinct in the female. This suture is not, however, present in certain nymphal stages, according to many investigators, even when it appears in the adult, and it would seem, therefore, to be a secondary modification. In other orders than the Orthoptera the eleventh somite is a short, homogeneous, membranous ring surrounding the anus, often distinguishable with difficulty from the anal lobes.

5. GENERAL STATEMENT.—Of the four somites considered above, it is evident that the ninth is the most specialized of all, both by reduction of parts, by modification of form, and by lack of chitinization—all three characteristics following upon retraction of the caudal end of the abdomen. Somite eight changes least from its form in the primitive type, and in the generalized Orthoptera, somites ten and eleven become the simplest in form, structure and substance, by specialization and reduction of parts.

6. APPENDAGE I.—This appendage occupies the most extreme ventro-caudal position, and shows its real connection with somite eight only in the saw-flies and wasps. This pair of appendages usually seems to be placed closely adjoining the ninth sternum, and is often referred to as the ventral pair of appendages. The ventral pair of ovipositors of the grasshopper (Plates V and VI) show this relative position, although the connection would appear at first glance to be with the eighth. This is also true in Appendage I in the female *Lepisma*. This appendage belongs to the eighth somite, but is often crowded out of its typical position by the shape, retraction, and function of the caudal somites. The Hymenoptera present another and one of the clearest cases of the relation between Appendage I

and somite eight, as has already been mentioned in another connection. This is well illustrated by the female saw-flies and *Vespa* (Plate XVII, Figs. 10 and 14) as well as by the generalized genus *Lepisma* in the male. The size of these appendages varies with their function. In the Orthoptera they attain a good size in all the forms studied, in both the male and the female, being more prominent in the latter. They are often apparently small tactile organs in the male when Appendages II and III are highly specialized, as in the case of *Benacus*, *Euschistus* and *Anasa*, Appendage I being even less conspicuous in the females of the two last mentioned genera, and somewhat smaller than in the male. In those groups having a complete metamorphosis it is either rudimentary, as in the female *Hepialus*; absent altogether as is most often the case in both the male and female of the Coleoptera and in female Lepidoptera other than *Hepialus*; or specialized as so-called claspers in most male Neuroptera, Mecoptera, Trichoptera, and Lepidoptera other than *Hepialus*. In the Diptera, it is rudimentary in the female *Tabanus*; of good size in both the male and female *Tipula*, and in the male *Tabanus*; and small in both sexes in *Calliphora*.

7. APPENDAGES II AND III.—These appendages are prominent in those females which have their genitalia specialized to dig holes in which to lay their eggs, to sting, or to perform some other accessory function. Examples of these are common among the Orthoptera and Hymenoptera (Plates V, VI, VII and XVII). Even here Appendage II, referred to above as the "mesal" appendage of certain authors, is small or rudimentary, and it is found to be more often absent altogether in the female than in the male. In the male these appendages are most specialized in connection with the intromittent organ, and Appendage II is more often present in the male than in the female. The best examples of this modification are seen in the Hemiptera and Coleoptera (Plates VIII, IX, X, XI and XII). Similar organs, much smaller in size, are also found in *Corixa*, *Notonecta*, *Corydalis*, *Dolerus*, and *Vespa*, made up, in all these cases of Appendage II, as well as III.

8. APPENDAGE IV.—Appendages included under this head are most often called the cerci. These are more dorsal in position than the others, and seem in many cases in adults, especially in the Orthoptera, to be as well attached to somite ten as

to eleven. (Plates V, VI and VII). Here we have the only instance of the association of one of the genitalia with terga rather than with sterna, so far as the sclerites are concerned, but the membrane forming the tenth and eleventh sterna is also in close contact with the base of this appendage. Wheeler, in his work on the embryo of *Xiphidium*, shows this appendage attached to the eleventh somite. It seems likely that variation in the form of these appendages accompanies a change in function. Evidence of this may be noted in the varied cerci of the Orthoptera, Neuroptera, Mecoptera, Trichoptera, and Diptera.

The main conclusion emphasized is the descent of the male and female genitalia from the anlagen of abdominal, pedal extremities of a myriapod-like ancestor, as seen in the embryos of insects. The stylets upon which so much emphasis has been laid by investigators, mainly represented by Heymons, certainly have little place in the adult insect. That they are present in the Thysanura seems to have little weight after one has worked upon representatives not only of that order but of many other groups, because even where such stylets are present there are also present far more important structures, the above mentioned genitalia. Even in Heymons's figures it is clear that the two descended from entirely separate anlagen, and the interpretation that the genitalia descended from the anlagen of stylets seems entirely unnecessary, and in fact, in one case at least, entirely wrong.

That there are traces in the adult insect of ten, eleven, or possibly twelve somites, would seem but natural considering the probability of a far greater ancestral number, but only somites eight, nine, ten, and eleven bear a direct relation to the genitalia.

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V. EXPLANATION OF PLATES.

ABBREVIATIONS.

The following plates include figures of the posterior somites and appendages of the male and female forms of the insects studied. Other accessory points, such as external openings and their connections with their ducts, are shown wherever possible. Everything has been carefully and clearly labeled according to the following:

I.....	Appendage of Somite Eight.	Cop.....	Bursa Copulatrix.
II.....	Appendage of Somite Nine.	Cp.....	"Copulatory sacs."
III.....	Appendage of Somite Ten.	D.....	Ejaculatory Duct.
IV.....	Appendage of Somite Eleven.	G.....	Gland.
t1-t11.....	Terga One to Eleven.	Ov.....	Oviduct.
t12.....	Terga Twelve of Heymons.	R.....	Rectum.
sl-s11.....	Sterna One to Eleven.	Rp.....	Respiratoria.
A.....	Anus.	S.....	Spermatheca.
Ab.....	Anal Brush.	Sp.....	Spiracle.
Ap.....	Apodeme.	St.....	Stylet.
As.....	Appendages.	Tr.....	Tracheæ.
C.....	Cerci.	V.....	Vagina.
Con.....	Conjunctiva.	Vd.....	Vas deferens.

PLATE IV—PRIMITIVE TYPE AND THYSANURA.

Primitive type, Fig. 1, ventral view.

Machilis sp., 2, ♀, mesal view; 3, ♀, ventral view; 4, ♂, ventral view.

Lepisma saccharina, 5, ♀, dorsal view; 6, ♀, ventral view; 7, ♀, mesal view; 8, ♀, ventral view; 9, ♂, dorsal view; 10, ♂, ventral view; 11, ♂, mesal view; 12, 13, ♂, ventral views.

PLATE V—ORTHOPTERA.

Periplantea orientalis, 1, ♀, lateral view; 2, ♀, dorsal view; 3, 4, 5, 6, 11, ♀, caudal views; 8, ♂, ental and mesal view; 9, ♀, ental view; 10, ♂, ventral view; 13, ♂, mesal view; 16, ♂, dorsal view.

Dissosteira carolina, 7, ♀, dorso-caudal view.

Mantis sp., 12, ♀, lateral view; 14, ♀, ventral view; 15, ♀, ental view.

Melanoplus differentialis, 17, ♂, dorso-caudal view.

PLATE VI—ORTHOPTERA.

Melanoplus differentialis, 1, ♀, lateral view; 2, ♀, mesal view; 4, ♀, mesal view; 5, ♀, lateral view; 6, ♂, lateral view; 7, ♀, ental view; 9, ♂, ventral view; 11, 12, ♂, mesal views; 13, ♂, dorsal view; 16, ♂, dorsal view; 17, ♀, dorsal view; 18, ♂, lateral view; 19, ♀, ventral view.

Dissosteira carolina, 3, ♂, ental view; 8, ♂, caudal view; 10, ♀, lateral view; 14, ♀, ental view; 15, ♀, lateral view; 20, ♀, mesal view.

PLATE VII—ORTHOPTERA.

Gryllus pennsylvanicus, 1, 5, 10, caudal views; 2, lateral view; 3, 6, ventral views; 7, ♀, dorsal view; 8, ♂, lateral and ental views; 9, ♂, ventro-caudal view; 10, ♂, caudal view; 11, ♂, ventral view; 12, ♂, dorsal view; 15, ♀, mesal view.

Dissosteira carolina, 4, ♂, caudal view.

Xiphidium ensiferum, 13, ♂, dorsal view; 14, 17, ♂, caudal view; 16, ♂, ventral view; 18, ♀, dorso-lateral view; 19, ♀, dorsal view.

PLATE VIII—HEMIPTERA.

- Tibicen septemdecim*, 1, 8, ♂, ventral views; 3, 12, ♀, lateral views; 9, ♂, dorsal view; 15, ♂, lateral view; 18, ♀, dorsal view.
Corixa sp., 2, ♀, ventral view; 19, ♀, dorsal view.
Benacus griseus, 4, 13, 14, ♀, lateral views; 7, ♀, ventral view; 6, ♀, dorsal view.
Notonecta undulata, 5, 22, ♂, lateral views; 10, 11, dorsal views; 16, 17, 21, ♂, ventral views; 20, ♀, ventral view.

PLATE IX—HEMIPTERA.

- Anasa tristis*, 1, 3, ♀, dorsal views; 2, 7, 8, ♀ ventral views; 5, ♀, dorsal and mesal views.
Corixa sp., 4, 6, 10, ♀, ventral views; 11, 14, ♀, dorsal views.
Notonecta undulata, 9, ♀, ventral view.
Benacus griseus, 12, 18, ♂, ventral views; 13, ♂, lateral view; 15, ♂, dorsal view; 16, ♂, mesal view; 17, ♂, lateral and ental view.
Notonecta, 19, ♀, ventral view.

PLATE X—HEMIPTERA.

- Euschistus variolarius*, 1, ♀, dorsal view; 2, 6, ♀, ventral view; 3, 8, ♂, dorsal views; 9, ♂, ventral view; 10, ♂, mesal view.
Anasa tristis, 4, 17, ♂, ventral views; 7, ♂, ental view; 14, ♂, caudal view; 15, ♂, lateral view; 18, ♂, dorsal view; 20, ♂, mesal view.
Notonecta undulata, 5, ♀, dorsal view.
Benacus griseus, 11, ♀, caudal view; 12, ♀, mesal view; 13, 16, ventral views; 19, ♂, ventral and ental view.

PLATE XI—NEUROPTERA, MECOPTERA, TRICHOPTERA.

- Corydalis cornuta*, 1, ♂, ventral view; 2, ♂, dorsal view; 4, ♂, ventral-caudal view; 5, ♀, dorsal view; 6, ♀, ventral view; 15, ♀, lateral view; 19, ♀, caudal view.
Panorpa lugubris, 3, 8, 21, ♂, lateral views; 9, ♂, mesal view; 11, ♀, ventral view; 12, 18, dorsal views; 14, ♀, ental and ventral views; 16, ♂, ventral view; 17, ♂, mesal and ventral views;
Nerophilus californicus, 7, ♂, ventral view; 10, ♂, dorsal view; 13, ♂, caudal view.

PLATE XII—COLEOPTERA.

- Harpalus caliginosus*, 1, 2, 7, ♀, dorsal views; 4, 5, 8, ♀, ventral views; 9, ♀, mesal view; 10, ♂, lateral view; 11, 13, ♂, dorsal views; 17, 23, ♂, ventral views.
Cybister fimbriolatus, 3, 18, ♂, ventral views; 12, ♂, mesal view; 14, 21, ♀, dorsal views; 15, ♀, lateral view; 19, ♂, dorsal view; 20, ♀, ventral view.
Doryphora decemlineata, 6, ♂, ventral view; 16, ♀, ventral view.

PLATE XIII—COLEOPTERA.

- Hydrophilus triangularis*, 1, 14, ♂, dorsal views; 6, 15, 16, ♂, ventral views; 7, ♀, ental view; 11, ♀, ventral view; 20, ♀, dorsal view.
Doryphora decemlineata, 2, 13, 18, ♂, ventral views; 4, 5, dorsal views; 10, 22, ♀, dorsal views; 17, ♀, ventral view; 24, ♀, ventral and ental views.
Cybister fimbriolatus, 3, ♀, ental view; 8, ♂, dorsal view; ; ♀, dorsal view; 12, 21, ♂, lateral views; 19, ♀, ventral view.
Harpalus caliginosus, 23, ♀, ental view; 25, ♀, lateral and ental view.

PLATE XIV—LEPIDOPTERA.

- Prionoxystus robinia*, 1, ♂, dorsal view; 2, 11, ♂, ventral views; 3, 9, ♂, lateral views; 4, ♂, mesal view; of genitalia; 5, ♀, dorsal view; 6, ♀, ental view of S. 8; 8, 15, ♀, ventral view; 12, ♀, ventral view of 8th segment; 14, ♀, ental and lateral view; 17, ♀, lateral-ental view.
- Hepialus humuli*, 7, ♀, caudal view; 10, ♂, caudal view; 13, ♀, dorsal view; 16, ♀, ventral view; 19, ♂, lateral view; 22, ♀, lateral view.
- Anosia plexippus*, 18, ♀, lateral view.
- Protoparce carolina*, 20, ♂, lateral view.
- Agrotis ypsilon*, 21, ♀, lateral view.

PLATE XV—LEPIDOPTERA.

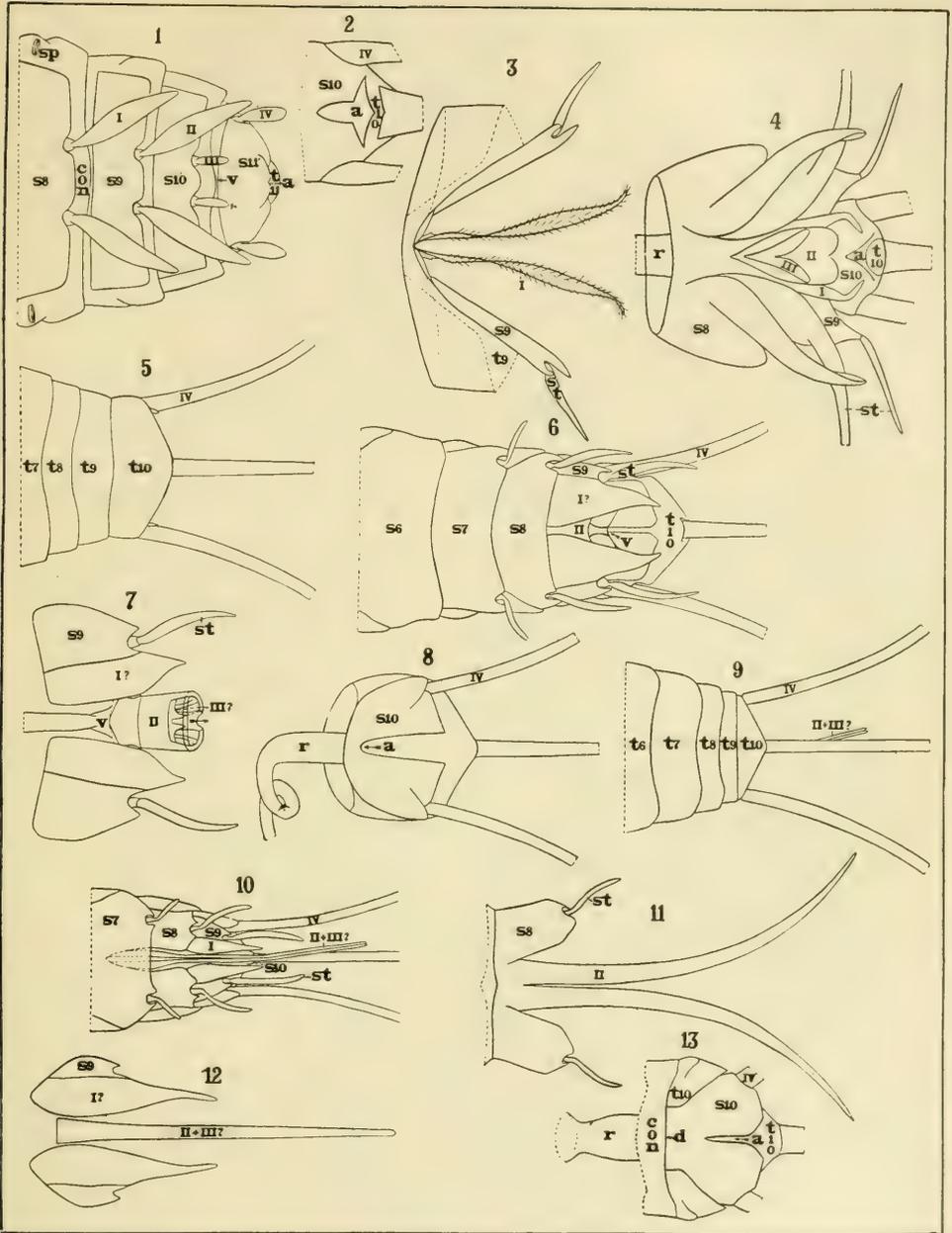
- Agrotis ypsilon*, 1, ♂, dorsal view; 6, ♀, dorsal view; 8, ♂, lateral view of genitalia; 11, ♂, ventral view.
- Protoparce carolina*, 2, ♀, dorsal view; 9, ♂, dorsal view; 12, ♂, ventral view; 14, ♂, lateral view; 15, ♀, ventral view; 16, ♀, lateral view.
- Anosia plexippus*, 3, ♀, dorsal view; 4, ♀, ventral view; 5, 10, ♂, ventral views; 7, ♂, dorsal view; 13, ♂, lateral view.

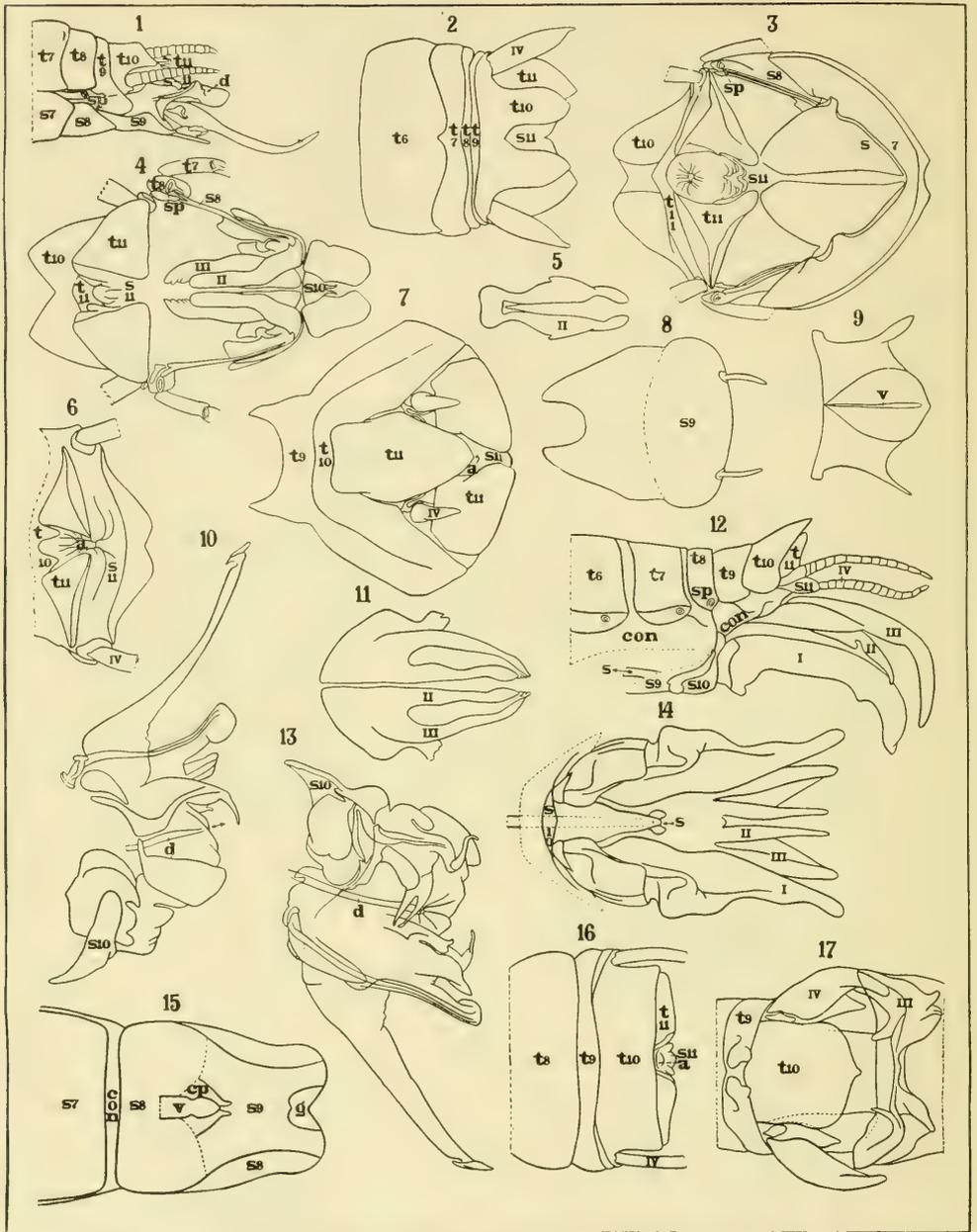
PLATE XVI—DIPTERA.

- Calliphora viridescens*, 1, ♂, dorsal view; 2, ♂, ventral view; 3, 7, ♂, lateral views; 4, ♀, dorsal view; 6, ♀, ventral view.
- Tabanus sulcifrons*, 5, 13, ♂, ventral views; 8, ♂, detail; 9, ♂, dorsal view; 10, ♀, caudal view; 11, 15, ♀, dorsal views; 12, 14, ♀, ventral views.
- Tipula abdominalis*, 16, ♀, ventral view; 17, ♀, dorsal view; 18, 22, ♂, ventral view; 19, ♀, caudal view; 20, 21, ♂, dorsal views.

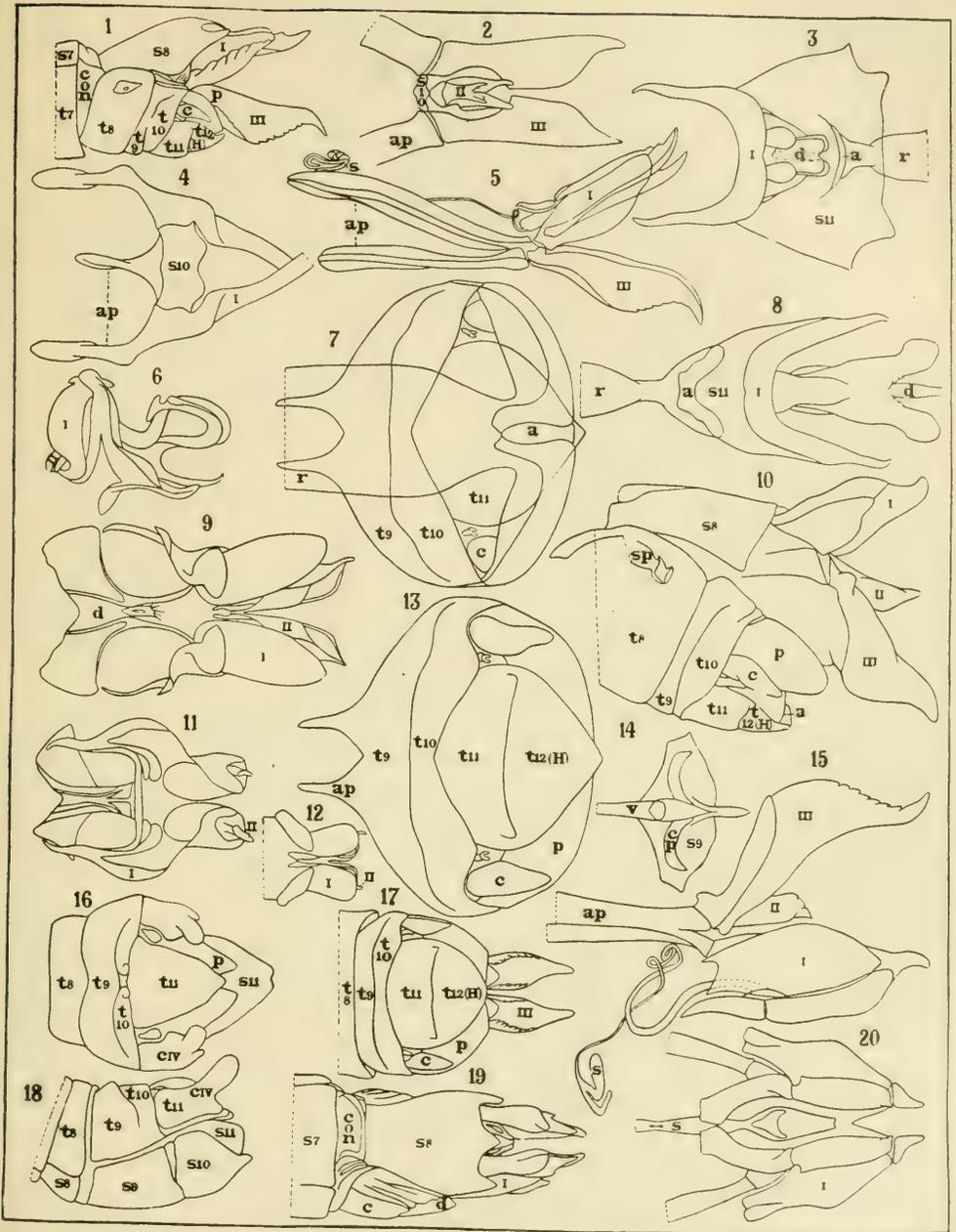
PLATE XVII—HYMENOPTERA.

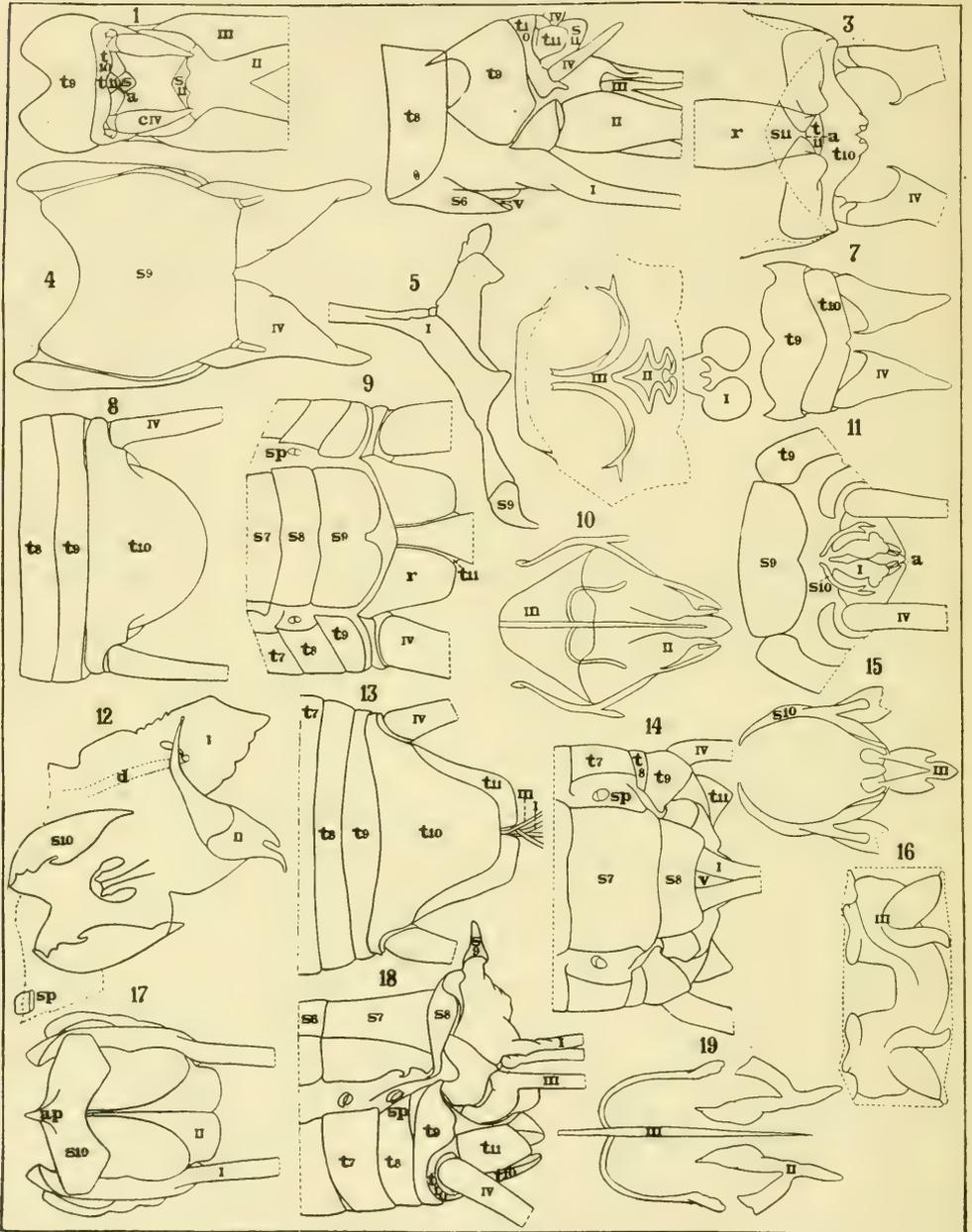
- Dolerus unicolor*, 1, ♀, dorsal view; 5, ♂, mesal view; 9, 19, ♂, dorsal views; 13, 15, ♂, ventral views; 14, 16, 20, ♀, ventral views.
- Vespa maculata*, 2, 11, ♀, lateral views; 3, 4, 8, 18, ♂, ventral views; 6, 17, ♀, dorsal views; 7, ♂, mesal view; 10, 21, ♀, ventral views; 12, 22, ♂, dorsal views.



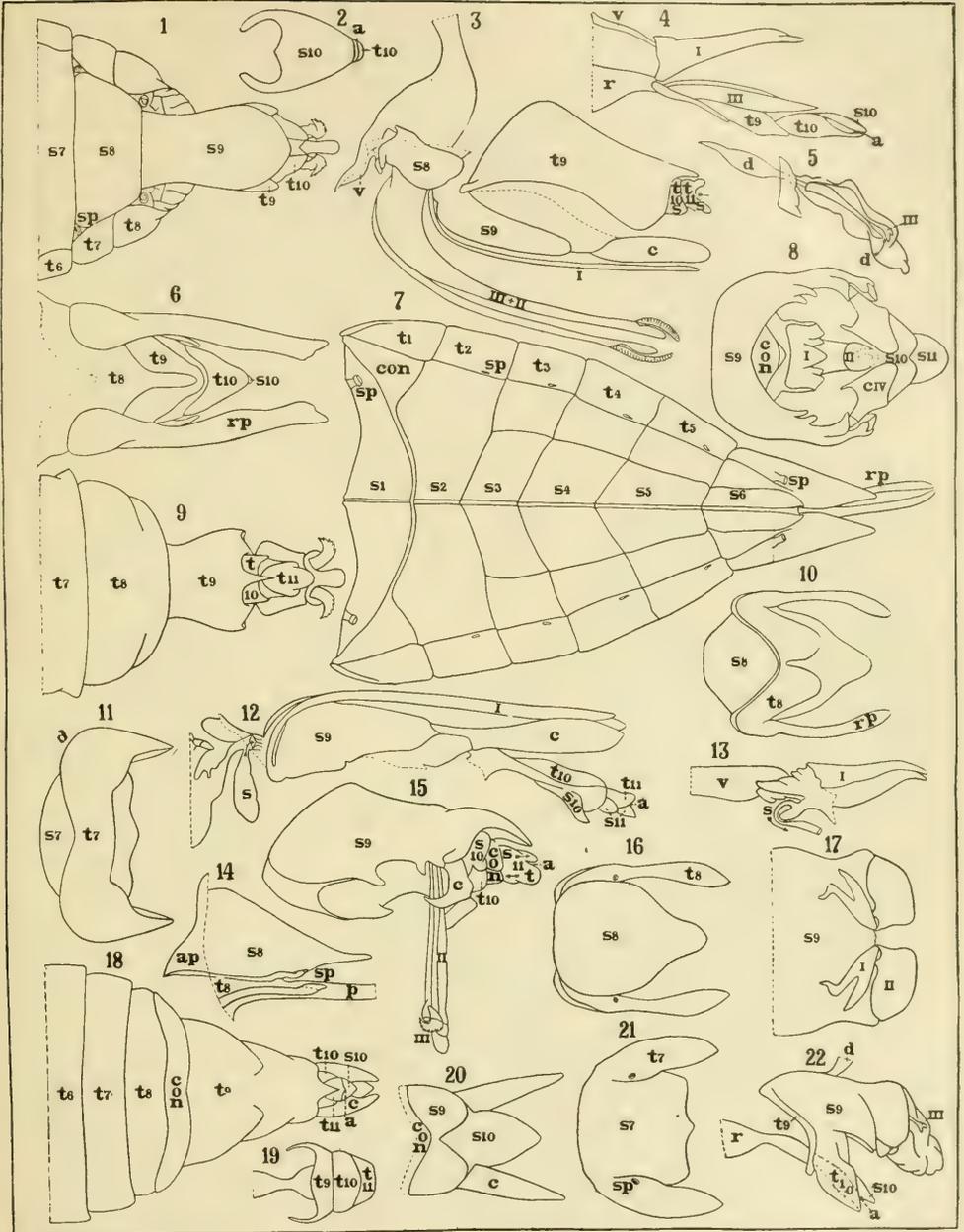


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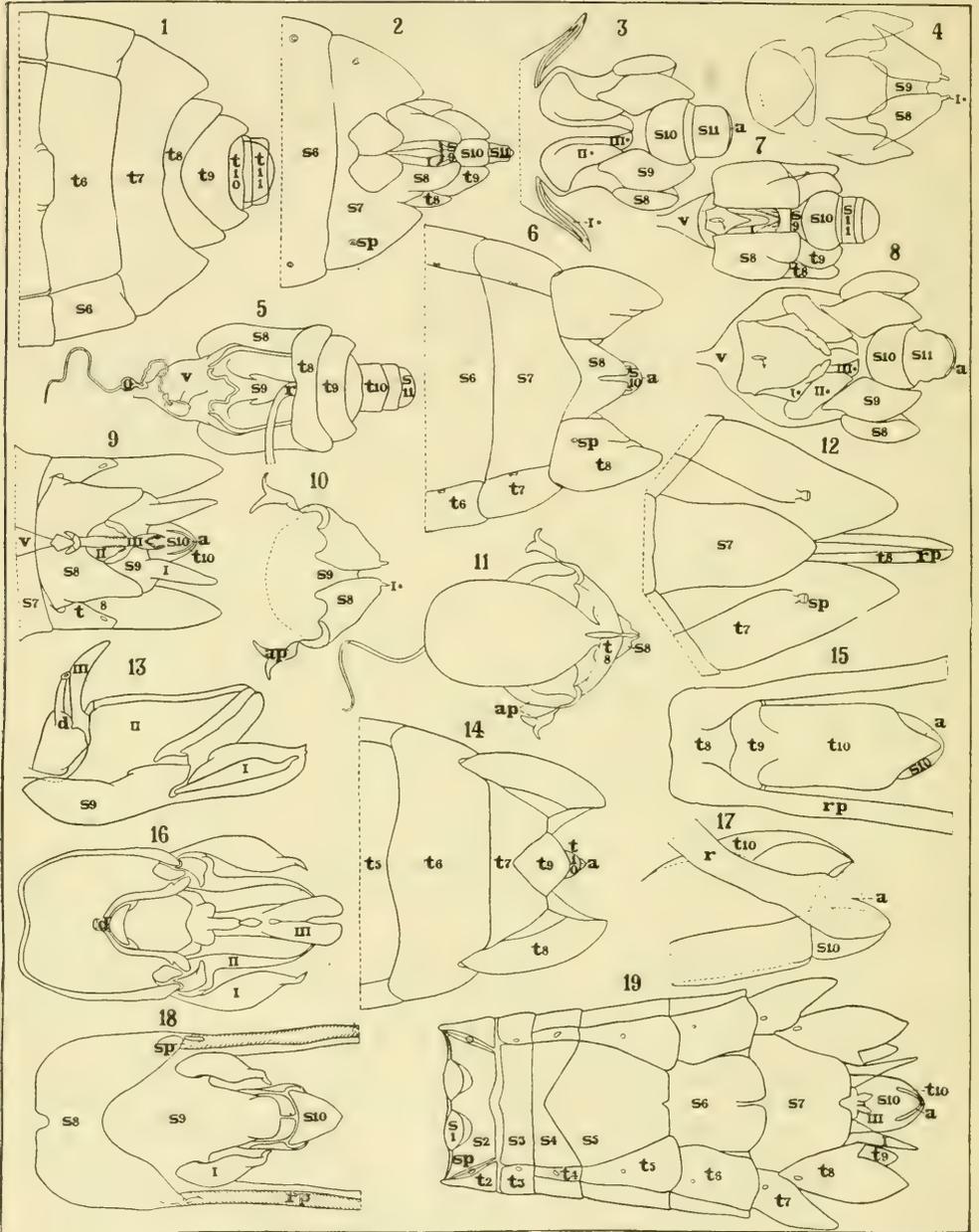


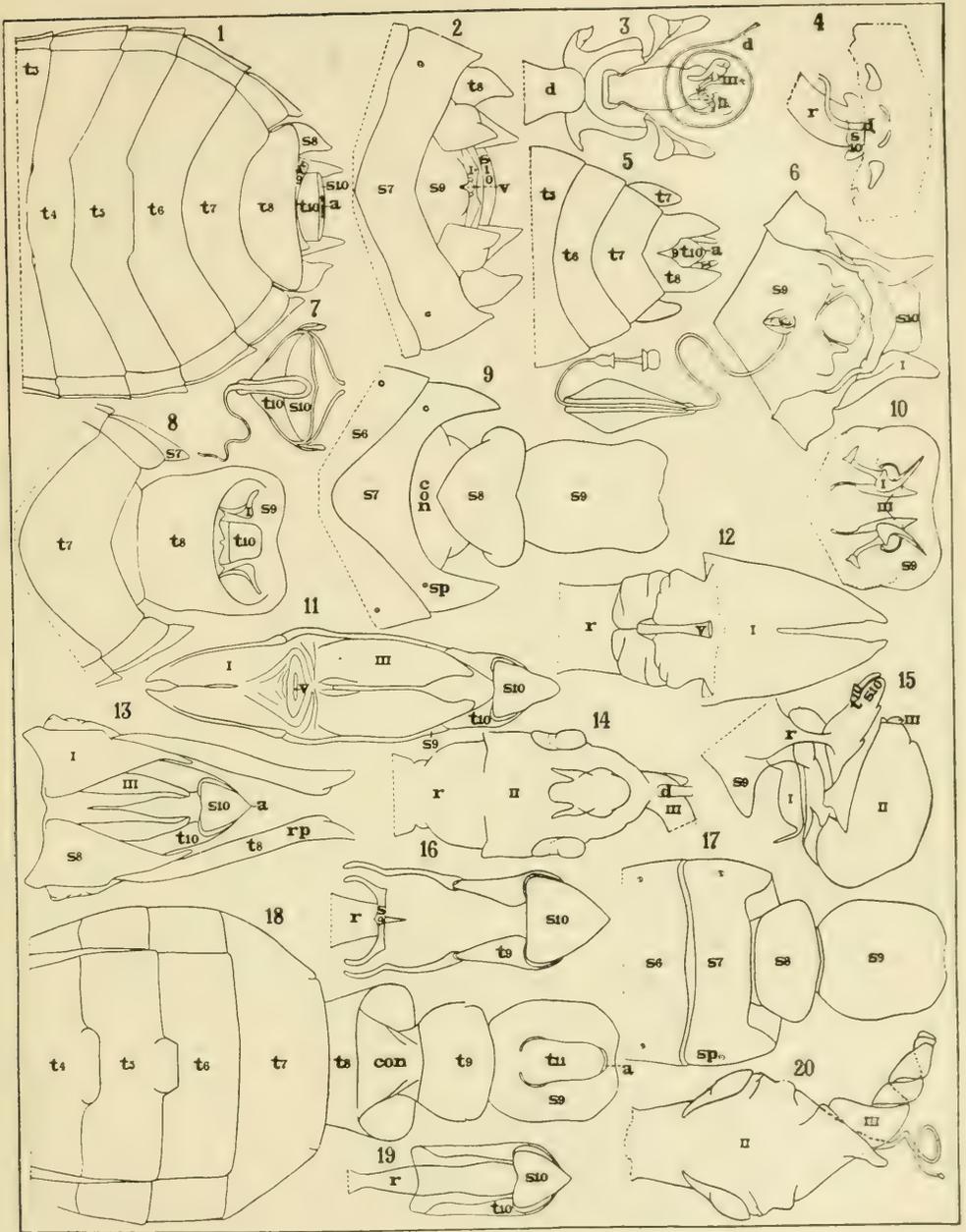


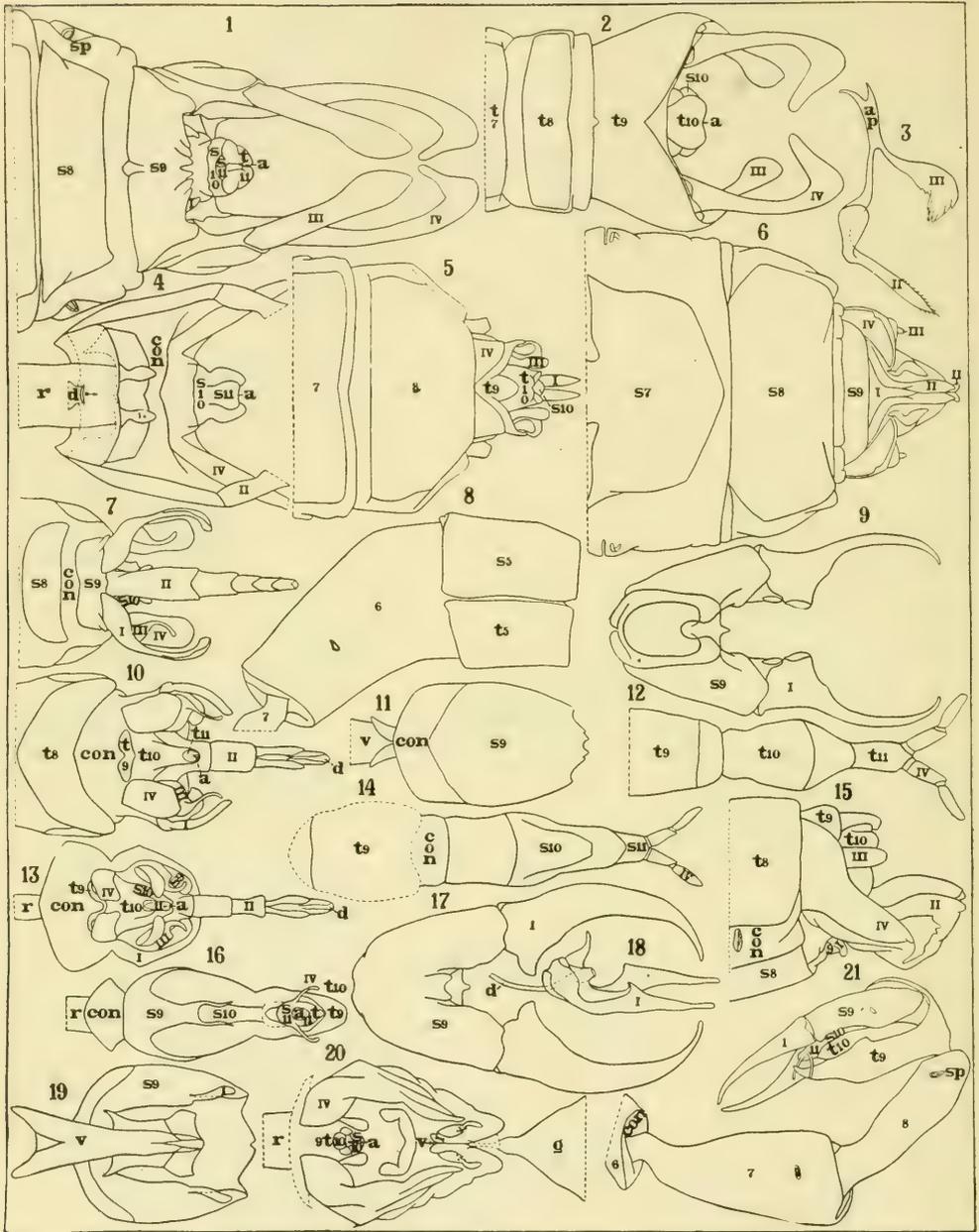
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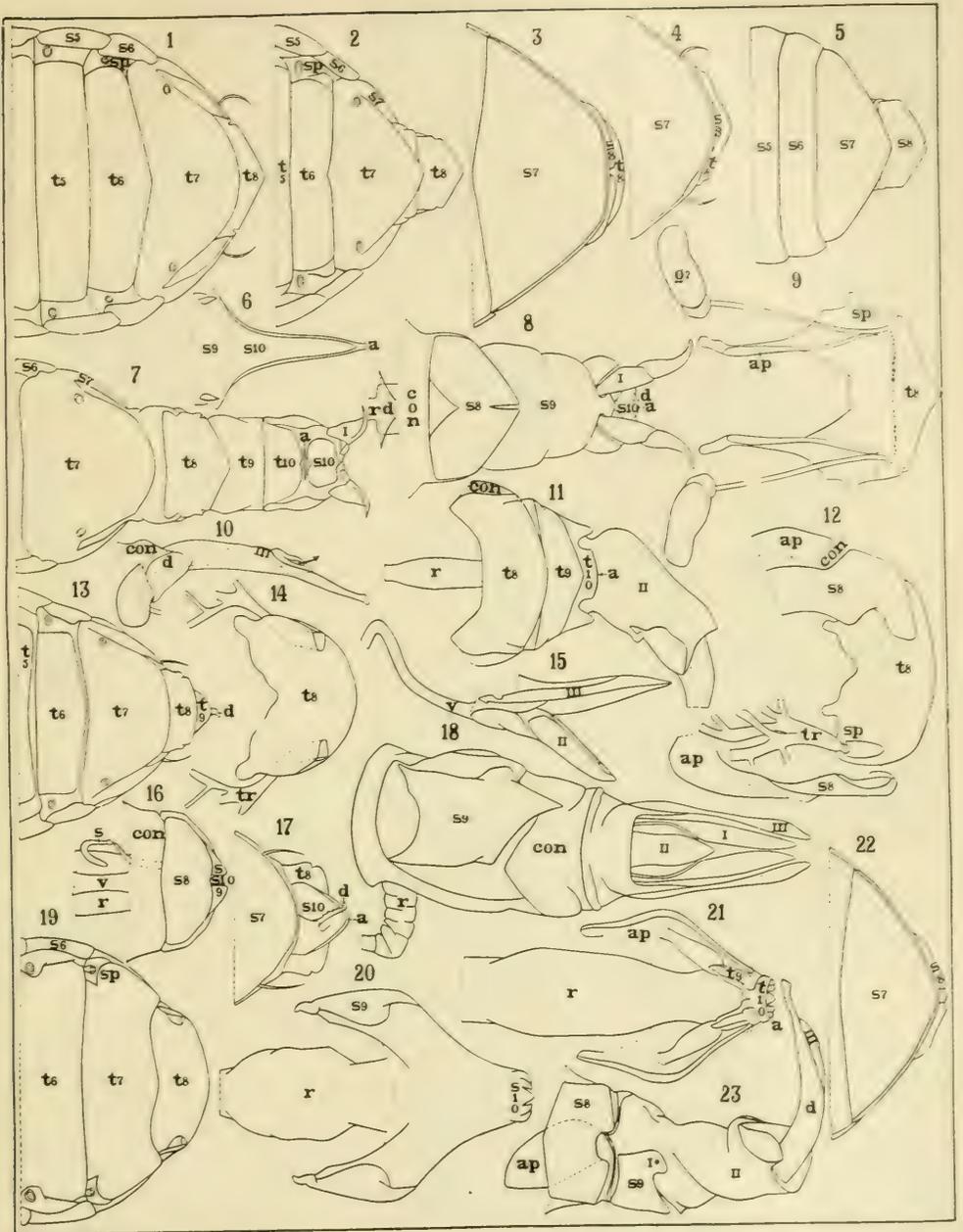


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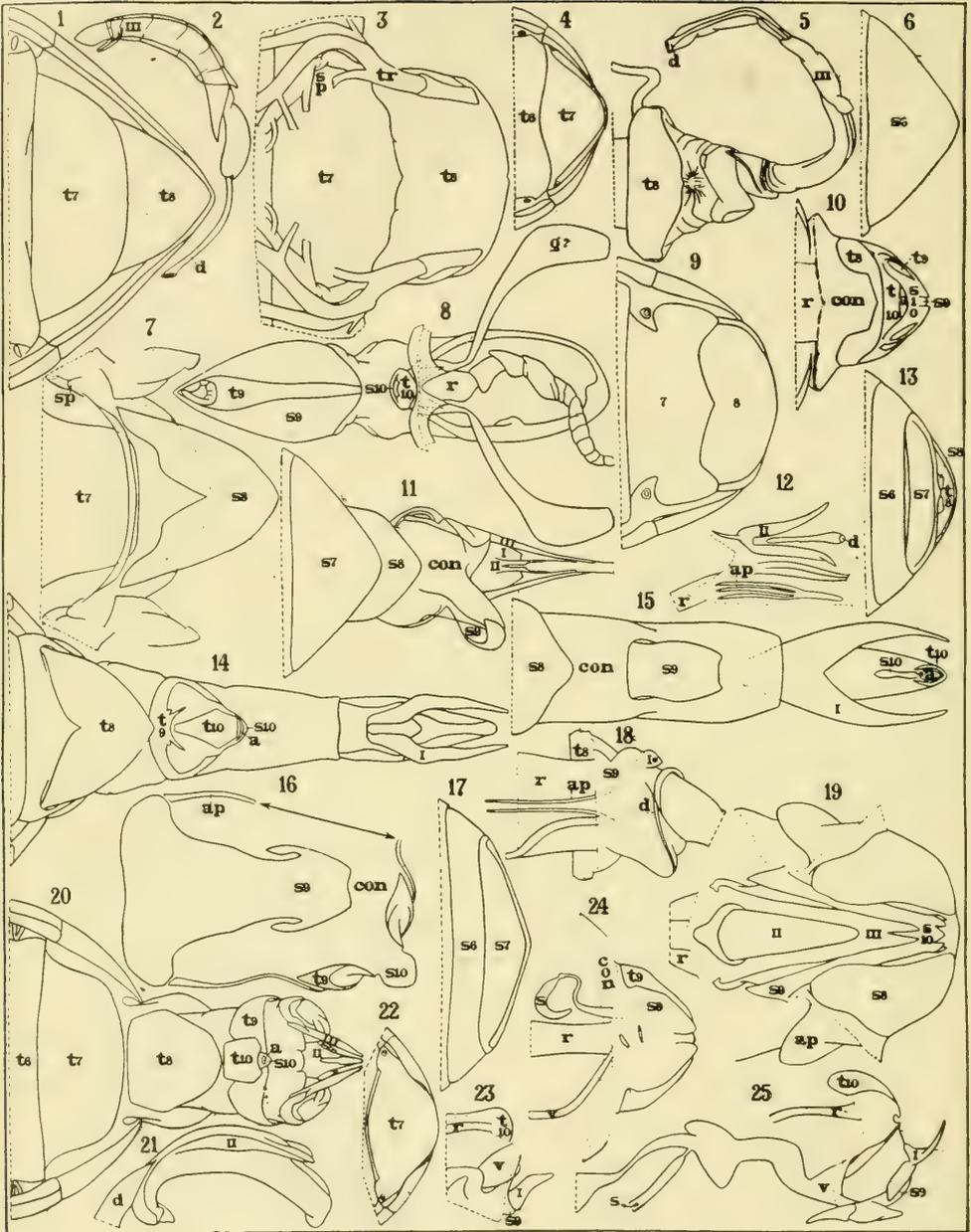


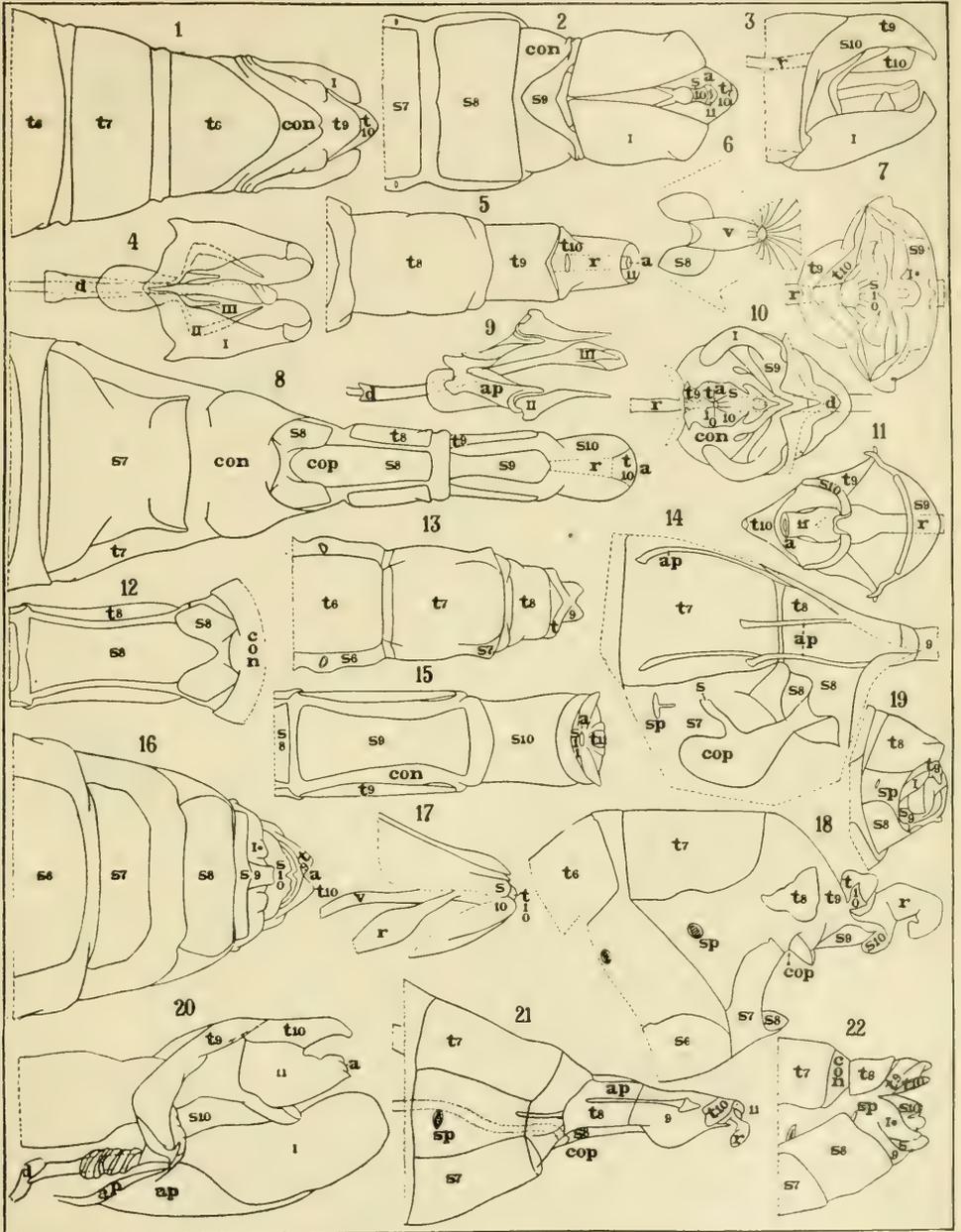




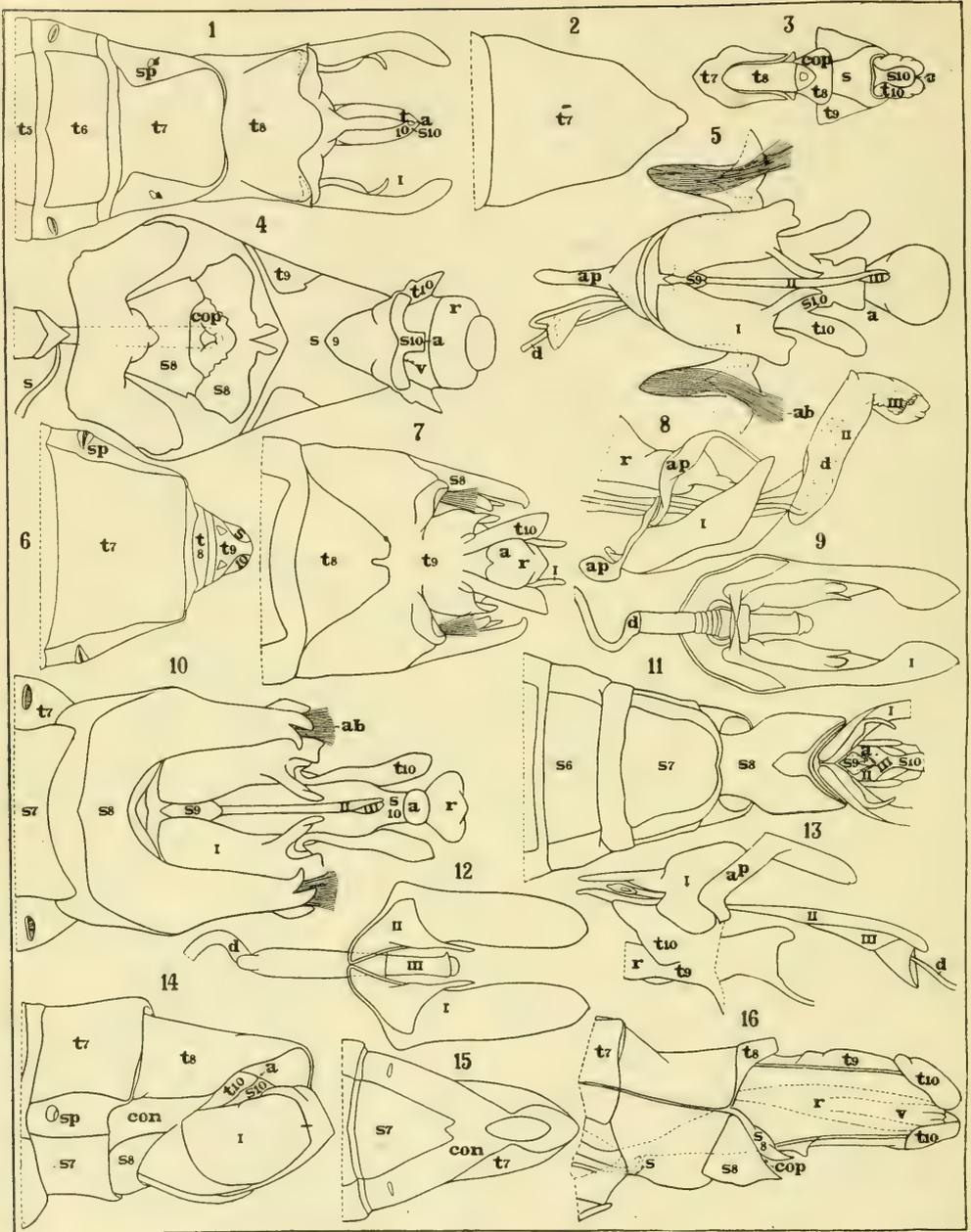


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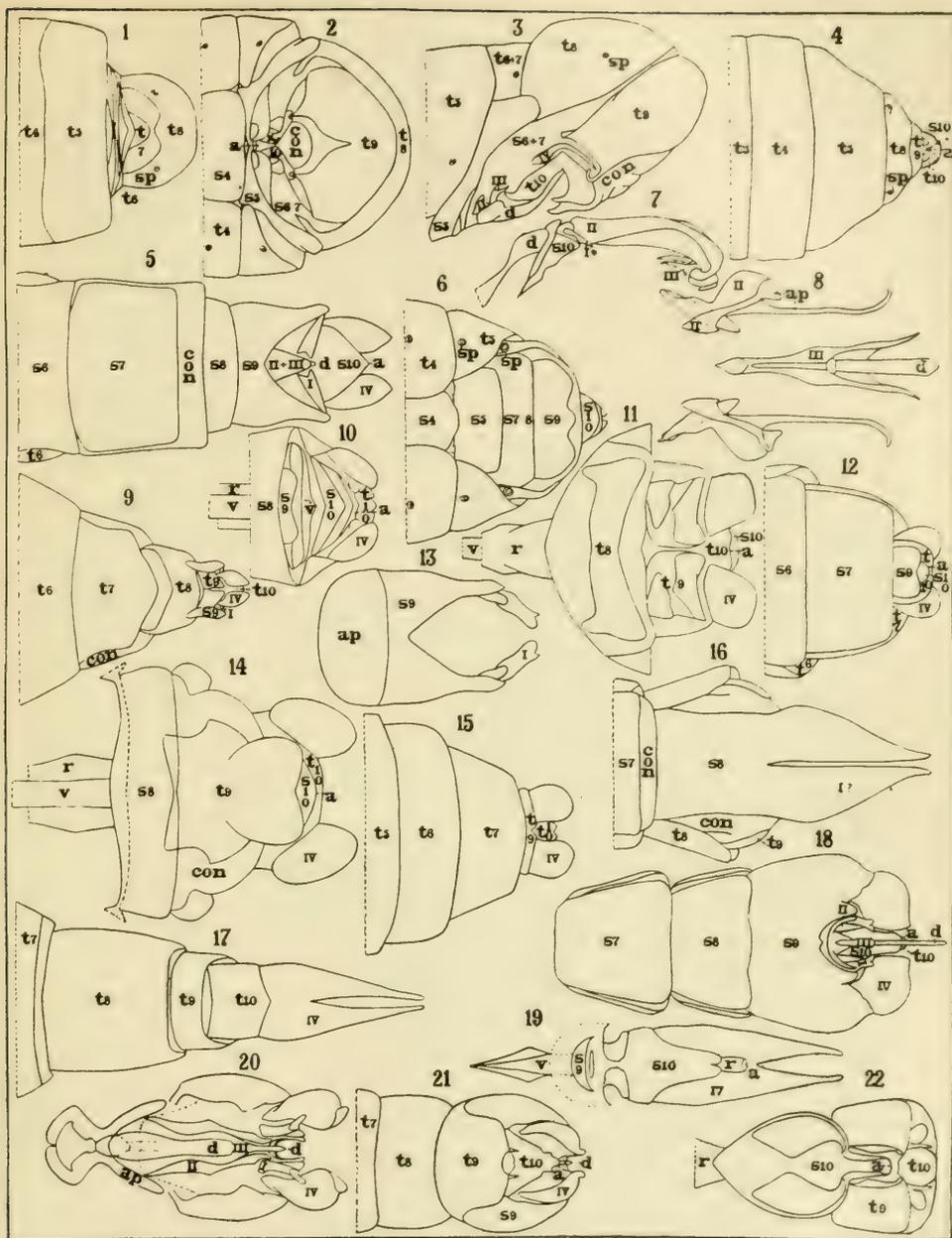




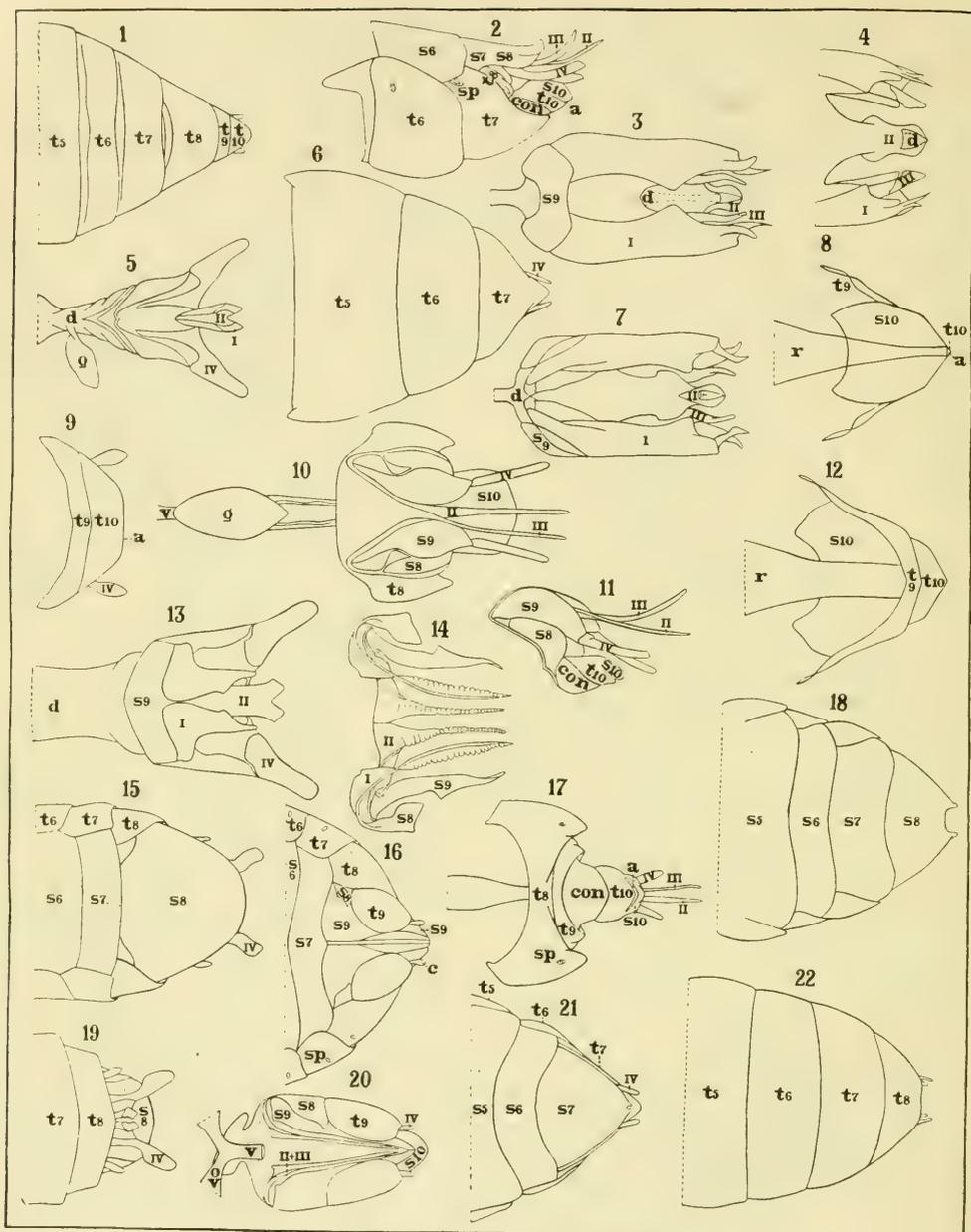
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THE COCCIDÆ OF CUBA.*

J. S. HOUSER,
Ohio Agricultural Experiment Station.

The material upon which this paper is based was procured by the writer during the years 1908 and 1909, while in the employ of the Cuban government as assistant in the Department of Vegetable Pathology of the Central Agricultural Experiment Station. A portion of it consists of duplicates presented him from the collection of the department and the remainder was collected by him personally.

The department collection had been accumulated from specimens sent in for determination and from miscellaneous lots brought in at various times by members of the staff. No careful, systematic collecting had been attempted, except during the time which Mr. Wm. T. Horne, chief of the department, had spent investigating the troubles of Citrus fruits of the Island and during his work on the bud-rot of cocoanuts. Both of these studies extended over a wide range of territory and, as a sharp lookout was maintained constantly for scale insects, the Coccid fauna of the various Citrus plants and of the cocoanut must be fairly well represented in the collection.

The collecting by the writer was done mainly in the vicinity of Santiago de las Vegas and of Havana. The latter locality offered exceptional opportunities because of two botanical gardens which were placed at his disposal—La Jardin Botanica de la Universidad de Habana and La Jardin Botanica del Instituto de la Segunda Ensenada de Cuba. Not only was the work of collecting facilitated by finding in a relatively small area a large number of named host plants, but it seemed little had been done on the part of the gardeners by way of combating the Coccids and, as a result, the field was an unusually rich one.

Two ends were sought in the collecting: To secure as many species as possible and to enlarge the list of known Coccid host-plants. Immediately after it was collected, the material was dried in a slightly warmed oven and treated with flake naphthalene, the former to prevent development of molds and the latter to repel insects. Both operations are important in tropical and semi-tropical Coccid collecting, the former being particularly so if the season of collecting is wet. Moreover,

* Contributions from the Department of Systematic Entomology, Cornell University, 1911.

material collected during the dry season of the year is of better quality than that collected during the rainy season, since in the first case the specimens are much less likely to be filled with entomogeneous fungi. For study, the Diaspine specimens were prepared by two methods. Where possible, at least one slide was prepared by the chloroform method in order to preserve and bring out the pygidial fringe and slow method caustic-potash slides were used in the study of the internal characters.

ACKNOWLEDGMENTS.

This study was conducted under the tutelage of Dr. A. D. MacGillivray. To him the writer expresses his indebtedness. While residing in Cuba, several specimens were sent to Dr. C. L. Marlatt, for identification. These determinations have been of material assistance in checking the identification of others.

SCOPE OF THE WORK.

This paper deals mainly with the subfamilies Conchaspinae and Diaspinae, though a few species from other subfamilies are listed. Much material from the latter is on hand, still undetermined. Altogether, 368 lots of material were examined which yielded 36 species and 3 subspecies. One species and one subspecies are described as new to science. In working the material over, the writer felt some disappointment in the comparatively small number of species which it yielded. He expected at least as many as a collection of similar size from the Temperate Zone would contain. The explanation, however, lies in the fact that in our northern latitude, there is in reality both the Temperate and for the most part the Semi-tropical Zone to draw from; the latter because of the greenhouse and conservatory fauna, while in the South but one zone is available.

The arrangement of the species is in the order of their occurrence in Mrs. Fernald's "Catalogue of the Coccidæ of the World." On the final pages will be found tables for the differentiation of the species of *Conchaspis* and *Pseudischmispis*.

ABBREVIATIONS.

In accrediting the collections the initials of the collector are used. Thus: W. T. H. = Wm. T. Horne, M. T. C. = Dr. Mel T. Cook, C. F. B. = C. F. Baker, W. A. P. = W. A. Page, J. W. S. = J. W. Stakley, S. P. S. = Sebastian Pla y Solarichs, E. W. H. = E. W. Halstead, J. S. H. = J. S. Houser.

Conchaspis angræci Ckll.

Host, *Yucca gloriosa*. *Locality*, Jardin Botanica del Instituto Segunda Ensenda de la Habana (Habana). *Date*, Feb. 2, 1909. *Collector*, J. S. H.

Asterolecanium bambusæ Bdv.

Host, *Bambusa vulgaris*. *Locality*, Rincon. *Date*, June 4, 1908. *Collector*, W. T. H.

Asterolecanium pustulans (Ckll).

Host, Fig. *Locality*, Santiago de las Vegas. *Dates*, May 18, 1905; July 22, 1908. *Collectors*, W. T. H., J. S. H.

Capulinia sallei Sign.

Host, unknown shrub. *Locality*, Lagoona Castellana, Santiago de las Vegas. *Date*, March 25, 1908. *Collector*, J. S. H. *Note*.—The present is the third time this insect has been taken. The first record is that of Signoret, 1874, when the species was described. The type material was taken on "Capulino" in Mexico. The insect was rediscovered May 27, 1897, by C. H. T. Townsend, on "Escobillo" in woods Arroyo San Isidro (near Frontera) Tobasco, Mexico. The material of the present record was taken infesting both leaves and branches of an unknown hardwood shrub, growing near a lagoon situated in the midst of a cattle range of several hundred acres.

So unusual was the appearance of the insect that Prof. W. W. Froggatt, entomologist of Australia, who was with the writer at the time, was not even certain it was a Coccid. Later it was identified by Dr. Marlatt. The most striking characteristic of the insect is the long, white filaments which spring from the dorsum. In time these become wound and matted about the twigs and leaves, at first sight conveying the impression that a bird had been flying with a bit of cotton twine and the latter had become lodged and tangled on the twig.

Pulvinaria psidii Mask.

Host, Unknown wild plant. *Locality*, Calabazar. *Date*, May 3, 1908. *Collector*, W. T. H.

Ceroplastes cerripidiformis Comst.

Host, Wild shrub. *Locality*, Santiago de las Vegas. *Date*, May 18, 1905. *Collector*, W. T. H.

Coccus mangiferæ (Green).

Host, Mango. *Locality*, Santiago de las Vegas. *Date*, April 22, 1908. *Collector*, W. T. H.

Saissetia oleæ (Bern).

Host, Enterolobium cyclocarpum. *Locality*, Santiago de las Vegas. *Date*, December, 1906. *Collector*, W. T. H.

Chionaspis citri Comst.

Host, Citrus sp. Orange, French Lemon, Sweet Orange, Grape Fruit. *Localities*, Santiago de las Vegas, Buenaventura, Ciego d' Avila, Cristo, Ceballos, Herraduria, Bahia Honda, Camaguey. *Dates*, April 13, 1905. Aug. 31, 1906. Sept. 13, 1905. March 6, 1906. Dec. 25, 1907. Feb. 16, 1907. Dec. 11, 1907. *Collectors*, W. T. H., W. A. P., J. W. S. *Notes*.—A survey of all the material at hand shows that this species is variable, the principal differences being in the number and placing of the plates. In Comstock's description (p. 102, Cornell University Report, 1883), he says there is one plate near the penultimate segment (of abdomen). In these specimens there are two and three plates in this position. These specimens sometimes have two plates in one or several of the positions laterad of each lobe as against Comstock's one. In some of the specimens there are bifurcate instead of simple plates. All this material has two large marginal pores laterad of the fourth incision, disagreeing with Comstock's figure in which only one is shown.

Howardia biclavis Comst.

Hosts, *Cestrum diurnum* Lin., *Leucæna glauca* Beuth., *Hæmelia potens* Jaco., *Licuma nervosa* A. C., Sapote, Magon, *Cinnamomicum zeylanicum* Breyn., *Salix Bablionica* L., *Melicocca bijuga* L., "Artea," *Ficus carica* L., *Jatropha hastata*., *Meringa pterigosperma* Gært., Egg plant, Tangarine, Canistel, Camito, *Solanum cellicarpæfolium* Kth., Leguminous liana *Temerind* 834, Malvaceous shrub, *Ficus* sp., *Deheraimia cubensis* Mez., *Solanum verbasafolium* L., *Lantana* sp., *Maclura tinctoria* Don., *Sapindus saponaria* L., Composite shrub, Carbonicella, "Diamela" Avocado, *Malpighia puniceifolia* C., *Mammea americana* L., Jassamine, *Calophyllum calaba* Jacq., *Ficus pertussa*, "Anon," *Guazuma tomentosa* Sw., *Athœa officinalis* L., "Caymito" Fig., *Eucalyptus*, *Psychatria*. *Local-*

ities, Jardín Botánica del Instituto Segundo Ensenado de Cuba (Habana), Jardín Botánica de la Universidad de Habana (Habana), Santiago de las Vegas. *Dates*, Jan. 27, 1909; Feb. 2, 1909; Oct. 11, 1908; Oct. 21, 1908; Feb. 8, 1909; Feb. 16, 1909. *Collectors*, W. T. H., J. S. H., M. T. C. *Note*.—The so-called setæ of Comstock's description are dorsal wax pores.

Howardia biclavis detecta Mask.

Host, Spanish pear. *Locality*, Jardín Botánica de la Universidad de Habana, (Habana). *Date*, Jan. 27, 1909. *Collector*, J. S. H. *Note*.—Although the mounted insects resemble true *biclavis* Comst. in every respect, the specimens are placed under the variety *detecta* Mask. because the scale is not covered with bark. This according to Maskell differentiates the two. The bark of Spanish pear is very hard and smooth, so that it would seem almost impossible for a scale to mine beneath it; hence, it is the belief of the writer that the mining habit of *biclavis* Comst. is regulated by the food plant upon which it occurs and that the variety *detecta* Mask. is not valid. Further evidence on the point is brought out by an examination of a series of infested plants grading from those with soft and corky or flaky bark to those with a hard leathery sort. The insects are almost entirely hidden when they occur on the soft or flaky-barked sorts and that the quantity of covering gradually decreases as the opposite extreme is approached.

Diaspis boisduvalii Sign.

Host, Coconut. *Locality*, Baracoa. *Dates*, March 22, 1907; June 14, 1907. *Collector*, W. T. H. *Note*.—The writer is unable to place these specimens in any other species than *D. boisduvalii* Sign., though the insects at hand differ in several respects from it. The lateral margin of the median lobes is not attached to the body along its entire length, but the tip of the lobe is free. See Comstock (Report of Cornell University 1883, p. 87). In these specimens there is a distinct triangular projection between the median pair of lobes which is not figured by either Comstock or Newstead. The spines vary from Comstock's description; the second pair instead of being mesad of the plate between the first and second lobes is situated upon the median margin of the broad plate bearing the opening of the large dorsal wax pore between the first and second lobes. In his Monograph of the

British Coccids, (p. 154, Vol. I), Newstead states, "A long plate immediately follows the first three pairs of lobes." In my specimens there is a spine between the first and second lobes—not a plate.

***Diaspis pentagona* Targ.**

Hosts, Peach, *Ipomæa antillans*. *Localities*, Tacajo, Calabazar. *Dates*, April 12, 1905; May 3, 1908. *Collectors*, M. T. C., W. T. H. *Note*.—This material does not agree perfectly with Newstead's figure, Monograph of the British Coccidæ, (Vol. I, p. 447). The mesal portion of the second pair of lobes is subequal in Newstead's figure while in these specimens it is much longer. These specimens usually have a trifurcate plate laterad of the second pair of lobes, where Newstead figures an ordinary plate; also these specimens have one to two pectinæ in the fourth position, while Newstead figures three.

***Hemichionaspis aspidistræ* Sign.**

Hosts, Citrus trifoliata, Royal Palm, Wild legume. *Locality*, Santiago de las Vegas. *Collectors*, W. T. H., J. S. H. *Dates*, Nov. 16, 1908; Sept. 24, 1907.

***Hemichionaspis minor* (Mask).**

Hosts, *Lupiter*, "Malba rosa," *Melicocca bijuga* L., *Artea*, *Enterolobium cyclocarpum* (Sw.) Gr., Wild trailing vine, *Hibiscus sabodariffa*, *Sida carpinifolia*, Tree cotton, Hennequin, *Hibiscus*, Citrus trifoliata, Plum, *Bauhinia* sp., *Melina* sp., *Solanum verbasafolium* L., *Yucca gloriosa*, *Thumbergia grandiflora*, "Sterculia," *Mimosa asperata*, *Cajanus inducis* Spr., *Lonchocarpus latifolius*, *Althæa officinalis*, Faberna, and Peach. *Localities*, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana), Jardin Botanica de la Universidad de Habana (Habana), Habana, Santiago de las Vegas, Herraduria. *Dates*, Jan. 27, 1909; Dec., 1906; Dec. 17, 1907; Oct. 16, 1906; Feb. 16, 1907; March 15, 1908; Sept., 1906; Feb. 15, 1907; June 3, 1907; July 22, 1908; Oct. 11, 1908; Feb. 2, 1909; July 20, 1908; Feb. 16, 1909; Feb. 19, 1907. *Collectors*, J. S. H., W. T. H., M. T. C., C. F. B.

***Aspidiotus cocotiphagus* Mar.**

Hosts, *Cycas revoluta*, Coconut, Phoenix Palm, Palm, Citrus trifoliata, Honeysuckle, Anone, Royal Palm. *Localities*, Jardin

Botanica de la Universidad de Habana, (Habana), Santiago de las Vegas, Jardin Botanica del Segundo Ensenanda de Habana, (Habana). Santiago de Cuba. *Dates*, Jan. 27, 1909; June 4, 1908; Aug., 1904; Feb. 2, 1909; July 20, 1908; Sept. 24, 1907; May 13, 1908; Nov. 16, 1908. *Collectors*, J. S. H., W. T. H., S. P. S.

***Aspidiotus subsimilis* var *anonæ* n. vr.**

Hosts, Milliflores verbenacia, Cinnamonicum zeylanicum Breyn, Maclura tinctoria Don., Rose, Spondias purpurea, Lonchocarpus latifolius Kth.; Magnolia grandiflora, Faberna. (Anona sp., Mangifera cambodiana and Loquat—Records of Dr. C. L. Marlatt, Bur. Ent. U. S. D. A. See note following description.) *Localities*, Jardin Botanica de la Universidad de Habana (Habana), Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana). *Dates*, 1907; Jan. 27, 1909; Feb. 21, 1909; 1910. *Collectors*, J. S. H., W. T. H., (E. R. Sasscer. See note following description.)

Description.—Scale of Female: 1 to 1.9 mm. in diameter; irregularly circular; thin; tough; slightly convex; very inconspicuous, due in part to the fact that the insect is partly mining in its habit as particles of thin bark usually extend over the scale; dorsal shed skin conspicuous; located on bark of host; no dot and ring present. Scale of Male: Not known. Adult Female: Length ranges from 0.8 mm. to 1 mm. and width from 0.8 mm. to 1.1 mm., usually wider than long, type specimen 1 mm. wide, 1.12 mm. long, yellow, of usual form, circumgenital pores wanting. Nearest *A. subsimilis* Ckll. and *A. coursetiæ* Mar. Anal Plate: In shape rather sharply triangular, retracted within the scale body, two broad chitinized areas extending from the posterior tip well up into the pygidium where they gradually disperse. One pair of lobes placed close together, broader at base, usually notched on both sides near the tip, tip rounded; chitinized processes equal to two-fifths the length of the lobe extending up into the pygidium from the mesal portion of the base of each lobe and from the opposite of each lobe is a similar process but lacking a little of being half as long as the preceding. Incisions between median lobes shallow, second and third incisions shallow also; lateral margins of second and third incisions bordered by strongly chitinized thickened processes; mesal process of second incision greatly elongated and abruptly terminating in a globular swelling or club; lateral processes about one-third as long and only slightly swollen; chitinous processes of third incision sub-equal, slightly swollen anteriorly and both usually curved laterad. Plates small, simple, inconspicuous, one arising from each side of the mouth of the second incision, two mesad and two laterad of the third incision; of the two last mentioned the outer one is very weak and slender; two or three additional plates on the

pygidial margin. Spines strong, prominent; a single spine laterad of each of the lobes, two laterad of each of the second and third incisions and two about midway of the pygidial margin. Anal opening slightly caudad of the knobs of the chitinous processes of the second incisions, about two-thirds as large as a single knob. Genital opening about nine times the length of the lobes above them. Three rows of dorsal pores of from seven to nine pores each, extending up into the pygidium at an acute angle to the pygidial margin.

Note.—It was the original intention of the writer to describe this as a new species; indeed, this was done in manuscript form as it appears above. In December, 1916, Dr. Marlatt kindly granted him access to the Coccid collection of the Bureau of Entomology, and during this study it developed that an identical species was known under the manuscript name of *A. subsimilis* var. *anonæ* in the Bureau's collection. Upon learning of the writer's material, Dr. Marlatt generously insisted that their material be included with his and published. The collection records of the Bureau's material were:

1. On Anone sp. Lima, Peru, 1909, E. R. Sasser.
2. On *Mangifera acambodiana*, Miami, Fla., 1910, E. R. Sasser.
3. On Loquat, Miami, Fla., 1910, E. R. Sasser.

The following are Dr. Marlatt's manuscript notes:

"*Aspidiotus subsimilis* Ckll. Is very closely allied to *coursetiæ* sp. nov., the latter perhaps not deserving more than varietal rank. It is readily distinguished from the *ancylus* group of species, to which it is closely allied, by the elongated and knobbed character of the inner chitinous thickening or paraphysis of the first incision, resembling in this respect somewhat *Aspidiotus ulmi* Johnson.

"Some material showing a slight divergence from the type was collected in the Department greenhouses by Mr. Sasser on *Anona* sp. imported from Lima, Peru. This form is more chitinized than the type material of *subsimilis*, the knobbed paraphyses are a little longer, and the anal orifice a little more remote from tip. When a larger acquaintance with *subsimilis* is gained by future collections and study, this variety will very probably be found to fall within the variation of the species. For the present, however, it may be designated as *subsimilis* var. *anonæ*."

Type and paratypes in the collection of the Bureau of Entomology U. S., Department of Agriculture, Washington, D. C. Entomology, U. S. Paratypes and cotypes in writer's collection.

Aspidiotus cyanophylli Sign.

Hosts, Rose, Psidium guaiava, Anone. *Locality*, Santiago de las Vegas. *Dates*, Oct. 10, 1906; Oct. 11, 1908; Sept. 18, 1907. *Collectors*, W. T. H., J. S. H.

Aspidiotus destructor Sign.

Host, Coconut. *Locality*, Santiago de las Vegas. *Date*, August, 1904. *Collector*, W. T. H.

Aspidiotus fabernii n. sp.

Host, Faberna. *Locality*, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana). *Date*, Jan. 27, 1909. *Collector*, J. S. H.

Description.—Scale of Female: 1.25 mm. in diameter, strongly convex, usually circular though sometimes slightly elongate; exuviae central, covered, but the granular covering easily rubbed off, leaving exposed the yellow or orange exuviae; ventral scale white, conspicuous; the scales are piled one upon another giving the bark the appearance of bearing scattered nodules. Adult Female: About 1 mm. long and 0.93 mm. wide; pygidium broadly triangular; three pairs of lobes, median broader than long, prominent, lateral margin usually entire though sometimes notched, apices rounded, nearly touching; second pair of lobes slightly less than half as broad and long as median, usually entire though sometimes notched apically; third pair of lobes small, pointed, inconspicuous, usually a rudimentary fourth lobe and if so, low and rounded; second and third incisions with thickened edges; chitinized median portion of each incision longer and stouter than the lateral portion; a very minute plate between the first and second and two between the second and third pairs of lobes; on the pygidial margin laterad of the third pair of lobes are five prominent bifurcate pectinae strongly swollen at the base and usually a simple plate; counting laterad the first three pectinae are similar, equidistant and are between the third and rudimentary fourth lobes; the fourth and fifth pectinae are slightly smaller than the first three and are located laterad of the rudimentary fourth lobes; the bifurcate pectinae are very characteristic, being greatly broadened at the base and the points of the fork usually diverge strongly, but sometimes both curve mesad; the remaining simple plate is located on the pygidial margin at a distance from the fifth pectina a little greater than that between the third and fourth pectinae; it has the same swollen base characteristic of the pectinae but it is not bifurcate at the tip; there is a dorsal and a ventral spine laterad

of each pair of lobes including the rudimentary fourth and one about the middle of the pygidial margin; the spines laterad of the median lobes are weak and subequal in length to the median lobes; the spines of the second, third and fourth positions increase gradually in size until they attain a length equal to twice that of the pectinæ; the spines of the fifth position are about equal to those of the second; the anal opening is four or five times its own width cephalad of the base of the median lobes and the vaginal opening is nearly twice this distance cephalad of the base of the lobes; circumgenital pores are wanting.

Relationship.—This species is nearest *A. diffinis* but differs from it particularly in the number, shape and position of the pectinæ and the number and size of the spines as well as in other characters. Type and paratypes in the collection of the Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C. Paratypes in writer's collection.

***Aspidiotus hederæ* (Vall).**

Hosts, Anone, Magnolia grandiflora, Pandano utes H. de G., Guava, Coconut, Manõca Palm, Citrus trifoliata, Avocado (leaf). *Localities*, Santiago de las Vegas, Jardin Botanica de la Universidad de Habana (Habana), Baracoa. *Dates*, Oct. 23, 1908; Jan. 27, 1909; Feb. 27, 1907; May 14, 1907; March 17, 1907; Sept. 18, 1907; Oct. 16, 1907; Nov. 13, 1906; Oct. 19, 1907; Feb. 19, 1909; Sept. 27, 1907. *Collectors*, J. S. H., W. T. H.

***Aspidiotus lataniæ* Sign.**

Hosts, Peach, Milliflores verbenacia, Lupiter, Cinnamomum zeylanicum Breyn, Salix Bablyonica L., Laurel de Espana, Ficus carica L., Citrus sp., Enterolobium cyclocarpum (Sw) Gr., Antigonum leptopus Hed., Cultivated fig, Cherry, Wild Legume, Clerodendron fragrans L., Wild Guava, Dricina terminalis, Coconut, Hibiscus, Yucca gloriosa, Small honeysuckle, Satlfergia sissoa, Loguat, Avocado, Lonchocarpus latifolius Kth. Spomea purpurea Lam. *Localities*, Santiago de las Vegas, Jardin Botanica de la Universidad de Habana (Habana), Jardin Botanica del Segundo Ensenada de Cuba (Habana), San Cristobal, San Antonio de las Banas. *Dates*, Jan. 31, 1909; Jan. 27, 1909; Feb. 2, 1909; Oct. 10, 1907; Dec., 1906; June 12, 1908; July 22, 1908; May 12, 1906; Oct. 15, 1906; Oct. 11, 1908; July 29, 1908; Oct. 23, 1908; July 29, 1908; Oct. 10, 1906; Sept. 24, 1907; June 13, 1908; Feb. 16, 1909; Feb. 11, 1909; Feb. 8, 1909; June 16, 1906. *Collectors*, J. S. H., W. T. H. E. W. H.

Notes.—It is generally considered that *A. lataniæ* has one pair of lobes, but in the greater part of this material the second and third pairs are developed into sharply pointed, small triangular processes which it seems should be called lobes. According to various descriptions there should be plates between the median pair of lobes, and these specimens agree for the most part in this respect, but some have one pectina and one plate in this position, while others have two pectinæ. The number of circumgenital pores also seems quite variable. Most of this material in this respect runs below the numbers usually attributed to this species.

***Aspidiotus palme* Morg and Ckll.**

Host, *Magnolia grandiflora*. *Locality*, Jardin Botanica de la Universidad de Habana. *Date*, Jan. 27, 1909. *Collector*, J. S. H.

***Aspidiotus sacchari* Ckll.**

Hosts, *Panicum molle*, *Coix lacryma L.* *Localities*, Banes, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana). *Dates*, Aug. 23, 1907; Feb. 2, 1909. *Collectors*, W. T. H., J. S. H.

***Aspidiotus spinosus* Comst.**

Hosts, *Cinnamomum zeylanicum* Breyn. *Locality*, Jardin Botanica del Segundo Ensenada de Cuba. *Date*, Jan. 27, 1909. *Collector*, J. S. H.

***Pseudaonidia tesserata* (de Charm).**

Hosts, "Ciduela," *Leucæna glauca* Beuth. *Localities*, Santiago de las Vegas, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana). *Dates*, Jan. 27, 1909; Feb. 18, 1909. *Collector*, J. S. H. *Note.*—In de Charmoy's description, (Pro. Societie Amicale Scientifique de Mauritius, 1889, p. 23), he states that the second pair of lobes is shorter than the third, while in this material the third is shorter than the second.

***Selenaspidus articulatus* (Morg).**

Hosts, *Phoenix dactylifera* L., Lime, Orange, Small White Honeysuckle, Bergamota, Sweet Orange, French Mandarin, Lemon, Sour Sop, Palm, Laurel nobilis, *Maclura tinctoria* Don., Anone, Satsuma Orange, Tangerine, Grape Fruit, *Muchlenbeckia platyctoda* M., *Calophyllum calaba* Jacq., Laurel de la Yndia, "Sidra" (*Citrus* sp), *Magnolia grandiflora*, Caymito.

Localities, Jardin Botanica de la Habana (Habana), Ciego d'Avila, Santiago de las Vegas, Cristo, Bahia Honda, Sætia, Jardin Botanica del Segunda Ensenada de la Habana (Habana). *Dates*, Jan. 27, 1909; Sept. 7, 1905; Sept. 13, 1905; Sept. 5, 1905; Jan. 13, 1906; Feb. 2, 1908; Jan. 12, 1908; May 5, 1907; July 22, 1908; Sept. 24, 1907. *Collectors*, J. S. H., W. T. H., W. A. P., E. W. H.

Chrysomphalus aonidium Lin.

Hosts, *Cycas revoluta*, Grape fruit, Lime, Rose, Orange, Sour Orange, Sweet Orange, Citrus sp., Lemon, Coconut, Bergamonta, *Zamia pumila*, *Dracina terminalis*, *Martinezia caryotæfolia* Hg. B., Anone, "Hennequin," Citrus trifoliata, *Ficus religiosa*, *Mammea americana*, *Colophyllum coloba* Jacq., Citrus decumana Lin., "Laurel de la Yndia," "Sidra," *Magnolia grandiflora* Lin., Pandano utes H. de G. *Localities*, Jardin Botanica de la Universidad de la Habana (Habana), Santiago de las Vegas, Ciego D' Avila, Alquizar, Guantanamo, Mazorra, Mariel, Consolacion del Sur, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana), Ladd Farm Santiago de las Vegas. *Dates*, Jan. 27, 1909; July 21, 1908; Sept. 7, 1905; Dec. 3, 1905; Oct. 15, 1906; July 27, 1906; Feb. 9, 1905; Dec. 11, 1905; Dec. 3, 1904; Feb. 10, 1905; July 18, 1904; Sept. 7, 1905; Feb. 19, 1905; Sept. 13, 1905; Nov. 3, 1905; Oct. 11, 1908; Feb. 2, 1909; Dec. 1, 1901; July 10, 1908; Feb. 16, 1909. *Collectors*, J. S. H., W. T. H.

Aonidiella calurus (Ckll).

Hosts, *Calapenæ* (Sydney), *Mammea americana*. *Localities*, Santiago de las Vegas, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana). *Dates*, Feb. 16, 1909; Feb. 2, 1909. *Collector*, J. S. H.

Chrysomphalus dictyospermi (Morg).

Hosts, Misparo, Citrus sp., *Cinnamomum zeylanicum* Breyn., *Melicocca bijuga* L., Avocado, Rose, Royal palm, Mango, "Ciduella." *Localities*, Jardin Botanica de la Universidad de Habana (Habana), Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana), Santiago de las Vegas, Santiago de Cuba. *Dates*, Jan. 27, 1909; May 22, 1908; Oct. 17, 1907; July 21, 1908; Sept. 24, 1907; April 22, 1908; July 20, 1908; Nov. 16, 1908; Sept. 24, 1907; Feb. 8, 1909; Feb.

18, 1909. *Collectors*, J. S. H., W. T. H. *Note*.—This is quite a variable species, the principal point of variation being in the so-called "candle-flame" like projections on the pectinæ.

Pseudischnaspis alienus (Newstead).

Hosts, Milliflores verbenacia, *Cassia obtusifolia* L., *Salix Babilonica* L., *Grevillea robusta*, *Yucca gloriosa*, *Clerodendron*, *Muehlenbeckia platyclada* M., Rose. *Localities*, Jardin Botanica de la Universidad de Habana (Habana), Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana), Santiago de las Vegas. *Dates*, Jan. 27, 1909; Oct. 11, 1908; Feb. 2, 1909. *Collector*, J. S. H.

Odonaspis secreta (Ckll).

Host, Paral grass. *Locality*, Aquacati. *Date*, Dec. 16, 1908. *Collector*, J. S. H. *Note*.—These specimens agree well with the description of *O. secreta* excepting as to the arrangement of the circumgenital pores. In these specimens the anterior laterals are joined by a large median group thus forming an almost perfect horseshoe. In this respect they correspond with Maskell's relegated variety *lobulatus*.

Pseudoparlatoria parlatorioides Comst.

Hosts, *Carica papaya*, *Acalyphia tricolor* Hartul, "Sidra" (*Citrus* sp.). *Localities*, Santiago de las Vegas, Jardin Botanica del Instituto Segunda Ensenada de la Habana (Habana), Jardin Botanica de la Universidad de Habana (Habana). *Dates*, Oct. 29, 1906; Feb. 2, 1909; Jan. 27, 1909. *Collectors*, W. T. H., J. S. H. *Note*.—These specimens have three to eight median circumgenital pores, thus disagreeing with Comstock's description. Comstock's types have no pores in this position. The fishtail is a little more pronounced in Comstock's material than in this.

Lepidosaphes beckii (Newm).

Hosts, *Citrus* sp., Grape Fruit, Orange, Lemon, Tangerine, Tangerine Fruit, Passion Vine, *Citrus trifoliata*, *Citrus decumana* L., "Sidra" (*Citrus* sp.), Guava, Avocado. *Localities*, Jardin Botanica de la Universidad de Habana (Habana). Pinar del Rio, Santiago del las Vegas, Artemesia, San Cristobal, Rincon, Ceballos, Sætia, Bahia Hondá, Alquizar, Banes, Mazorra, Mariel, Consolacion del Sur, Jardin Botanica

del Instituto Segundo Ensenada de Cuba (Habana), Taco Taco, Baracoa. *Dates*, Jan. 27, 1909; Dec. 7, 1904; Aug. 26, 1905; Feb. 6, 1906; Nov. 8, 1905; Aug. 4, 1904; Sept. 7, 1905; March 6, 1906; March 5, 1907; July 18, 1904; March 2, 1906; Feb. 14, 1906; Nov. 26, 1905; Sept. 7, 1905; Dec. 3, 1905; Oct. 10, 1907; March, 1906; Feb. 9, 1905; April 14, 1905; Dec. 3, 1904; Feb. 10, 1905; Feb. 19, 1905; Nov. 3, 1905; June 3, 1907; March 22, 1905; Sept. 27, 1907; July 20, 1908; Feb. 2, 1909; July 21, 1908. *Collectors*, J. S. H., M. T. C., W. T. H. *Note*.—Although this species is undoubtedly the true *L. beckii* (Newm), a number of variations have been found which may be worthy of note. In Newstead's description, (Monograph of the British Coccidæ, Vol. I, p. 204), he records from five to seven pores of the median group of the circumgenitals and these are in a single concave series. One specimen, No. 186, has only three median pores grouped—not in a single concave series. One specimen, No. 262, has only six pores of the posterior lateral group, disagreeing with Newstead who reports seven to eleven.

Lepidosaphes flava hawaiiensis (Mask).

Host, Malpighia puniceifolia L. *Locality*, Jardin Botanica de la Universidad de la Habana (Habana). *Date*, Jan. 27, 1909. *Collector*, J. S. H.

Lepidosaphes gloverii (Pack).

Hosts, Tangerine, Grape Fruit, Citrus sp., Lemon, "Lemoncelli." *Localities*, Ceballos, Santiago de las Vegas, San Cristobal, Taco Taco, Jardin de la Universidad de Habana (Habana), Sætia. *Dates*, March 6, 1906; July 18, 1904; March 2, 1906; Feb. 14, 1906; Nov. 8, 1906; Sept. 7, 1905; Nov. 22, 1905; Jan. 27, 1909; March 1, 1909. *Collectors*, W. T. H., J. S. H.

Ischnaspis longirostris (Sign).

Hosts, Royal palm, Honeysuckle. *Locality*, Santiago de las Vegas. *Date*, Sept. 24, 1907. *Collector*, W. T. H.

Parlatoria pergandii Comst.

Hosts, Citrus sp., Grape Fruit, Tangerine Fruit, Orange. *Localities*, Taco Taco, Sætia, Santiago de las Vegas. *Dates*, Nov. 22, 1905; Sept. 7, 1905; Feb. 11, 1909; Feb. 14, 1906. *Collectors*, W. T. H., J. S. H. *Note*.—This material agrees closely

with Comstock's description and figure, (Report of the United States Department of Agriculture, 1880, p. 227), with the exception that the specimens have a seta upon both the ventral and lateral aspects of the median pair of lobes, whereas Comstock gives one on the dorsum only. The material at hand has well-developed pectinæ laterad of the fifth pair of lobes and these are not shown perfectly in Comstock's figure. Newstead (Pl. XXXII, Fig. 2, Monograph of the British Coccidæ), illustrates the fourth lobe as trifurcate. This is believed to be an error. •

SPECIES OF *Conchaspis* Ckll.

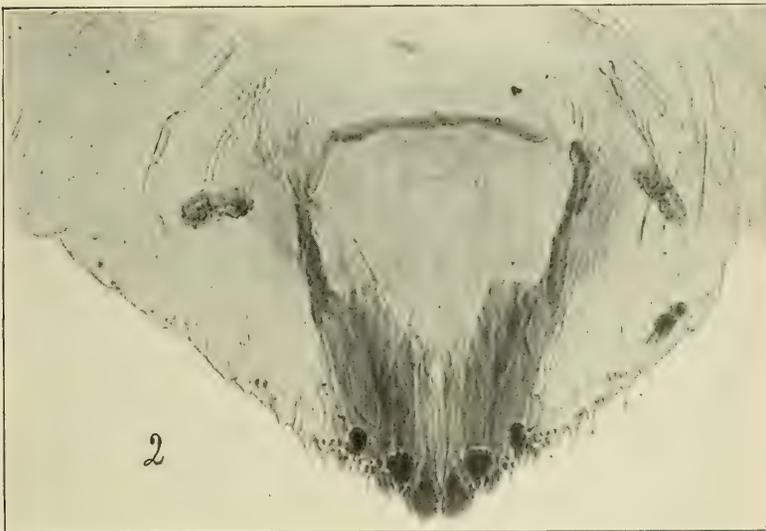
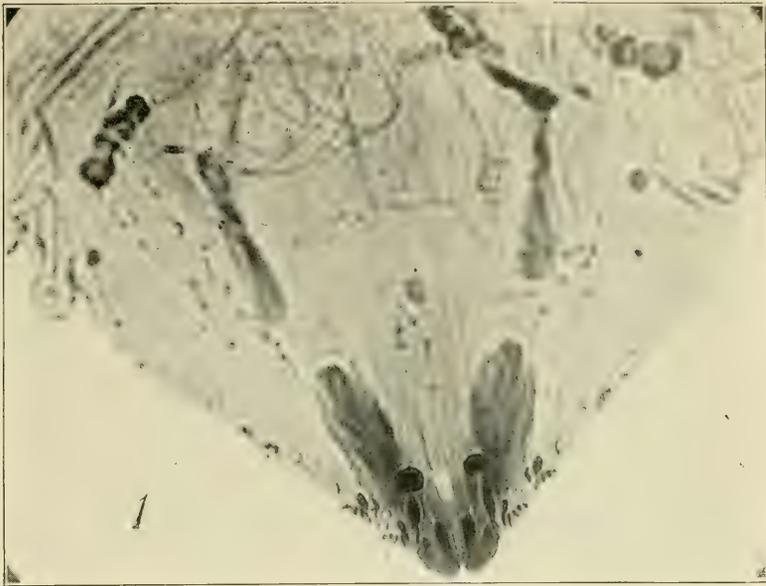
- A. Antennæ of adult female with six segments.....*C. Newsteadi* Ckll.
- AA. Antennæ of adult female with less than six segments.
 - B. Antennæ of adult female with five segments.. *C. fluminensis* Hemp.
 - BB. Antennæ of adult with less than five segments..
 - C. Antennæ of adult female with four segments, body gradually narrowed caudad of thorax.
 - D. Body of adult female purplish red, scale conical with apex normal..... *C. angræci* Ckll.
 - DD. Body of adult female colorless, except the brown pygidium, scale conical, apex to one side.. *C. angræci hibisci* Ckll.
 - CC. Antennæ of adult female with three segments, body abruptly narrowed caudad of the thorax..... *C. socialis* Green.

SPECIES OF *Pseudischnaspis* Hemp.

- A. Large dorsal gland orifices of each side in two rows running parallel with the pygidial margin. Club shaped paraphyses in five pairs, the first pair small, arising from the inner margin of the median pair of lobes, four large ones beyond.
 - B. Circumgenital pores in four groups, anterior laterals of seven each and posterior laterals of eight each. Five distinct serrations and some indistinct ones lateral of the third pair of lobes.. *P. bowreyi* (Ckll).
 - BB. Circumgenital pores in five groups, median two anterior laterals five and posterior laterals three. Three distinct serrations laterad of the third pair of lobes..... *P. longissima* (Ckll).
- AA. Large dorsal gland orifices of each side not arranged in two rows running parallel with the pygidial margin. Paraphyses in six pairs.
 - B. A single bifurcate plate in each of the incisions, one laterad of the third pair of lobes and two simple plates on the pygidial margin. Tips of bifurcate plates recurved and points rounded. Second, fifth and sixth pairs of paraphyses longest. First, third and fourth pairs less than one-half the length of the others..... *P. alienus* (Newst).
 - BB. A single bifurcate plate between the median pairs of lobes, two trifurcate plates in the second and third incisions and a trifurcate plate laterad of the third lobe. No plates on pygidial margin. Bifurcate and trifurcate plates with points triangular and tips acute. Second and fifth pairs of paraphyses longest, fourth and sixth about two-thirds their length, and first and third less than one-half the length of the longest..... *P. linearis* Hemp.

EXPLANATION OF PLATE XVIII.

1. Anal plate of *Aspidiotus subsimilis* var. *anonæ* n. var. Greatly enlarged (original).
2. Anal plate of *Aspidotus farbernii* n. sp. Greatly enlarged (photograph by E. R. Sasser).



AN INTERESTING HABIT OF A WAX MOTH PARASITE.*

By S. A. GRAHAM,

Assistant in Division of Economic Zoology, Minnesota State Experiment Station.

INTRODUCTION.

During the fall of 1916, while rearing the bee moth, *Galleria mellonella* in the insectary for experimental purposes, a Pteromalid parasite *Dibrachys clisiocampæ* Fitch † was observed to be very common about the breeding cages. Further investigation disclosed the fact that these parasites were emerging from the cocoons of the bee moth. They were so abundant that very few of the larvæ of the host were able to pupate and come to maturity. This is interesting inasmuch as previous records of the parasite ‡ give the host as the forest tent caterpillar, *Malacosoma disstria*.

During March these same parasites were emerging in such numbers from nucleus hives stored in the laboratory of the Bee Division that the windows of the room were literally covered with the small black insects.

Insofar as can be ascertained from the literature at hand, this parasite has never been recorded as attacking the bee moth, nor has its complete life history been described. This being the case and considering the possible value of this parasite in checking the ravages of the bee moth in stored combs, it was deemed advisable to keep the insect under observation during the winter and to determine as fully as possible its life history and habits.

LIFE HISTORY.

The host is attacked after spinning the cocoon, usually while still in the larval stage, but occasionally the pupa, while still soft and white, may be attacked. The female parasites walk rapidly over the cocoons feeling the surface with their antennæ. When a suitable place is found the caudal end of the

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† For the identification, I am indebted to Mr. A. J. Girault, formerly of the National Museum, Washington, D. C.

‡ Fitch—2d Report on Noxious, Beneficial and other Insects of the State of New York, page 432.

body is drawn forward until the abdomen is in a vertical position. The ovipositor is then inserted into the cocoon after which the abdomen again assumes its normal position and the ovipositor sheath slips into its place in the groove on the ventral side leaving only the ovipositor proper in a vertical position. At the same time the ventral segments are extended downward and forward, forming a triangular piece below the abdomen from the vertex of which the ovipositor extends. In removing the ovipositor this operation is reversed.

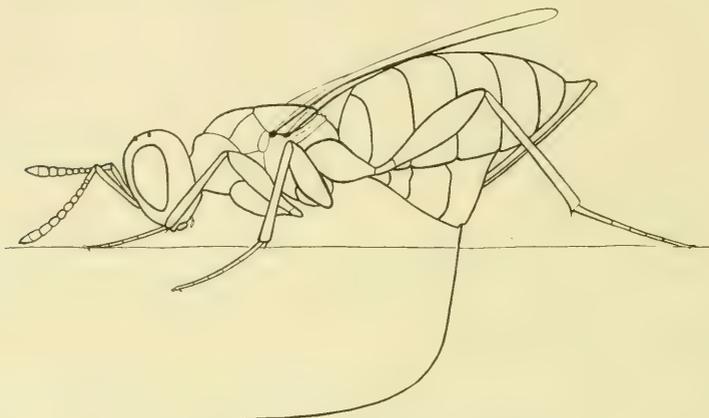


FIG. 1. Female *Dibrachys clisiocampæ* Fitch in position of oviposition.

As soon as the ovipositor is thrust into the cocoon the larva within becomes excited and moves about in an effort to get out of the way. The parasite thrusts its ovipositor into the larva, but does not deposit any eggs. It may stab it several times in different places before removing the ovipositor from the cocoon but no eggs are deposited until the larva within the cocoon is quiescent. This operation is repeated over and over again by the parasite as she walks from cocoon to cocoon, always stabbing the active larva with her ovipositor but never ovipositing in it. In from 6 to 24 hours the larvæ thus stabbed become sluggish and finally die.

When the parasite inserts her ovipositor and the larva remains quiet, she deposits her eggs on the surface of the body, usually in wrinkles in the skin. Usually two or three eggs are deposited in a place but often they are placed singly. The ovipositor can be bent in any direction and the egg after being forced almost entirely out, can be held by the tip and placed in

the proper position, and then released. The eggs are not fastened, but lie loosely in the folds of the skin of the host.

The eggs hatch in from 3 to 7 days and the young parasites immediately fasten themselves to the body of the host and begin to feed. The length of the larval stage was found to be rather variable, lasting from two to four weeks or even longer. Without exception, the moth larva was attacked by bacteria and reduced, before the parasite larvæ completed their growth, to a putrescent semi-liquid state, held together only by the skin of the host.



FIG. 2. Adults of *Dibrachys clisiocampæ* Fitch.

The pupal stage required from 14 to 25 days for its completion. Thus the life cycle from egg to adult varied from 31 to 59 days. The longest period occurred during mid winter when the temperature in the insectary often fell as low as 60° at night.

The adults feed readily upon sweetened water and under natural conditions, honey or nectar probably makes up a large part of their diet. The females were observed to puncture dead larvæ with the ovipositor and carefully draw up parts of the body tissue to the surface of the cocoon and then feed upon it.

HOST KILLED BEFORE OVIPOSITION OF PARASITE.

The one point in this life history which seems to be of unusual interest and perhaps practical importance is the fact that the parasite stings the host before depositing eggs upon it and oviposits only on dead or inactive larvæ.

The question naturally arose as to whether the larvæ were killed by the parasite or died from other causes.

Larvæ which had just died were examined by C. W. Howard of this Division, who was unable to find any indication that the caterpillars were killed by disease. After the larvæ had been dead one or two days, small brown spots appeared on the skin presumably at the points pierced by the ovipositor. These spots rapidly increased in size.

Larvæ, after being stung, but while still alive and active, were injected with a 1% solution of trypan blue and after about an hour were opened and the stain washed out. On examination, the skin and tissues immediately surrounding each puncture made by the ovipositor were found to be stained blue. Larvæ which had never been stung when injected in a similar manner, showed no such stained areas. It was thus possible to determine the number of times a larva had been stung by the parasite. The number of punctures in a single larva ranged from 6 to 38. There seems, therefore, to be no doubt that the parasite actually stings the larva.

In order to prove that this stinging kills the larvæ of the wax moth, forty healthy larvæ were placed in a glass jar containing no parasites. They spun their cocoons and at the end of three days were all perfectly normal. Then twenty of these were removed from their cocoons and placed in another similar jar where they again spun cocoons. Thirty parasites were then introduced into the first jar where the larvæ had been undisturbed, since spinning their cocoons. These parasites were observed to move actively about and sting the larvæ. In less than a week every larva in this jar was dead. The larvæ in the second jar were all alive and eventually eighteen out of the twenty reached maturity. This experiment was repeated three times with similar results in each case. This experiment showed that the larvæ were undoubtedly killed by the sting of the parasite, but whether death was the result of mechanical injury or of a poison injected by the parasite was the subject of further investigation.

A series of healthy larvæ were selected and each was pierced deeply with a minuten pin from one to twenty-five times. In spite of the fact that all stabbed in this way lost considerable blood and many were weak after the operation, every one recovered. Since the minuten pin was longer and thicker than the ovipositor of the parasite, this experiment indicates that the larvæ were not killed by mechanical injury, but that some poisonous material must be injected to cause their death.

Packard* refers to Bordas as authority for the statement that poison glands connected with the ovipositor may be safely said to be of general occurrence in the Hymenoptera. Dissection shows the presence of an organ which may be a poison gland but, as yet, this point has not been definitely determined.

Although apparently not mentioned in literature, this habit of killing the host before oviposition may be common to many of the ectoparasites of the superfamily Chalcidoidea. In support of this supposition it may be stated that the author has observed that the larvæ of the white pine weevil, *Pissodes strobi*, Peck, are always found to be dead when larvæ of the Chalcidid parasite *Eurytoma pissodis* Gir., are found upon them. The oviposition of this species has not as yet been observed. Marcovitch,† while working with parasites of the strawberry weevil, *Anthonomus signatus* Say, never found the eggs of certain Chalcidoid parasites on any but dead weevil larvæ, but on the other hand, found many weevil larvæ dead or dying without any apparent cause. These observations indicate the existence of a similar condition to that found in this parasite of the wax moth. The killing of the host before ovipositing is a decided advantage to such an ectoparasite since it insures the safety of the eggs and larvæ from injury due to movements of the host within the cocoon.

Dibrachys chlisiocampæ and possibly others of the same group apparently form the connecting link between the scavengers and the parasites since the larvæ feed entirely on dead and decaying material killed by the parent.

Since the dead larvæ on which these parasites feed are in a state of decomposition and continually changing chemically and physically during the feeding period, it is possible that under the

* Packard, 1909, A Text Book of Entomology, page 358.

† Marcovitch, 1916, The Strawberry Weevil in Minnesota. Sixteenth Report of the State Entomologist of Minnesota for 1915 and 1916, page 122.

proper conditions, such parasites could be fed upon some animal material other than insect larvæ. This would make it possible to rear parasites on a scale large enough to be of practical importance in the control of some insect pests, inasmuch as one of the greatest difficulties in the raising of parasites, lies in the problem of providing a sufficient amount of suitable food.

SUMMARY.

1. *Dibrachys clisiocampæ* Fitch, is parasitic upon the larvæ and pupæ of the wax moth and should be a valuable parasite in controlling the wax moth in stored combs.

2. The length of life cycle is rather variable requiring from 31 to 59 days for completion.

3. The female parasite stings and kills the host before ovipositing.

4. It may be possible to rear these and other valuable ectoparasites on some food, other than their natural host.

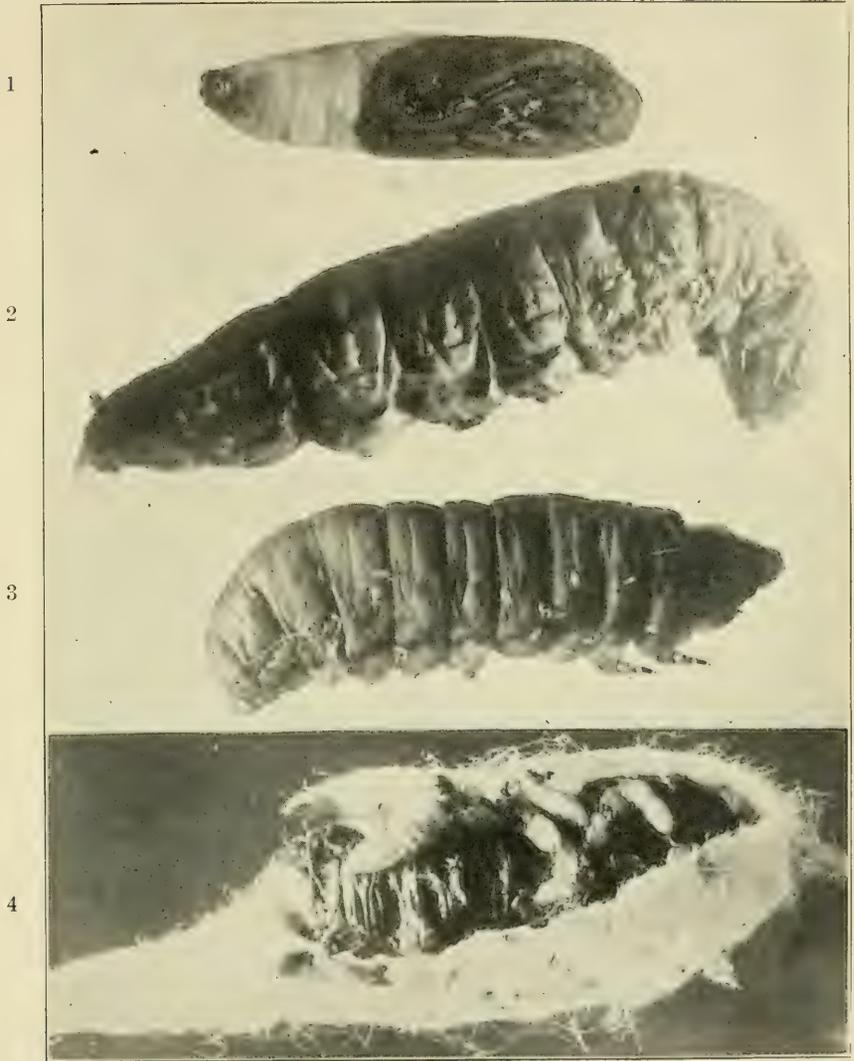
EXPLANATION OF PLATE XIX.

FIG. 1. Eggs of *Dibrachys clisiocampæ* on a pupa of the wax moth.

FIG. 2. Larvæ and eggs of *Dibrachys clisiocampæ* Fitch upon larva of wax moth.

FIG. 3. Young larvæ of *Dibrachys clisiocampæ* Fitch on wax moth larva.

Fig. 4. Pupæ of *Dibrachys clisiocampæ* Fitch upon a wax moth larva.



THE DIPTEROUS GENUS DRAPETIS MEIGEN (Family Empididæ).*

By A. L. MELANDER,
Pullman, Washington.

The species of *Drapetis* are to be distinguished from the remainder of the Empididæ by the following summarized combination of characters. Thorax robust, the humeri not swollen and constricted. Eyes closely approximate on the face, but on the front diverging above; palpi broad, incumbent on the very short proboscis; antennæ three-jointed, with terminal or subterminal arista; one pair each of vertical and ocellar bristles. Legs hairy and often furnished with bristles or setæ, the middle femora however rarely armed and not thicker than the front pair. First basal cell of the wings shorter than the second which is united with the discal cell, anal cell completely wanting, only two posterior cells before the anal area.

The genus *Drapetis* includes very small flies, among the smallest of all the Diptera, which are found during the spring and summer, sometimes swarming about flowers like wild cherry and plum, and sometimes running about singly over grass and low shrubbery. Their early stages are quite unknown. In the tropics slender yellow-colored species predominate but in the Temperate Zone the general species are black and more robust.

In the following pages are given a detailed discussion of the external morphology of the drapetine flies, a synoptic table to

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During the year 1899, while a student at the University of Texas the writer began a study of the Empididæ, a family of predatory dipterous flies. Since that time several papers dealing with the taxonomy of the family have appeared from his pen, notably a review of the North American species known up to 1902, which was published as a thesis for the master's degree. The accumulation of a wealth of material in this family, especially from the rich collecting fields of the Pacific North-west, led to the preparation of an exhaustive review of the group which was accepted by Harvard University in 1914 as the thesis requirement for the degree of Doctor of Science. It was the writer's intention to issue this manuscript of quite one thousand pages in the *Genera Insectorum*, but the outbreak and centralization of the war in Belgium entirely precluded this possibility. Since many of the new species have been distributed among museums and individual collections it seems desirable to have their names published. The following pages, dealing with the single genus *Drapetis*, have been excerpted as the first presentation of the dismembered dissertation.

the fifty-five North American forms, descriptions of forty-two new species and varieties, and a complete bibliography to the genus and to the 133 described species and varieties at present known from the whole world, including four fossil species. The writer's personal collection contains sixty-seven of the named species and varieties, of which forty-six species are represented by type material. In addition he has studied Coquillett's types at the National Museum and Loew's types at the Museum of Comparative Zoology.

Etymologically the name *Drapetis* comes from the Greek word *Drapetis*, meaning a runaway. Since the penult is formed with the short vowel epsilon the accent in English pronunciation falls on the first syllable, *i. e.*, Drap-e-tis.

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GENERAL MORPHOLOGY.

Head globular, sometimes slightly longer than high, the occiput more or less hemispherical; eyes large, bare, at most with scattered microscopic hairs, the facets of uniform size, beneath the antennæ the eyes of both sexes nearly touching, leaving the face linear or very narrow, above the eyes the front is V-shaped, always broader than the face, sometimes the front is quite narrow; three small ocelli present. Excision of the eyes at the level of the antennæ very large; cheeks sometimes entirely obliterated, usually about one-eighth the height of the eye, with the oral margin obliquely descending posteriorly. Proboscis thick, rather sharply pointed, perpendicular or directed backward, averaging one-half the height of the head, its labrum with prominent base and as long as the labium; palpi broadly oval, one-jointed, applied to the proboscis, the inside glabrous and shining, the outside pollinose and with more or less evident recumbent pubescence, generally tipped with a longer seta. Antennæ inserted close together a little above the middle of the head, three-jointed, very rarely the basal joint is wanting, the second joint with a circle of small setulæ, the bottom hair of which is sometimes long, the third joint compressed, varying from short oval, not longer than deep and with subterminal arista to lanceolate or conical, nearly twice as long as deep and with terminal arista; the arista usually slender, nearly bare, two-jointed, its basal joint small, its outer joint two or three times as long as the antennæ, rarely the hairy coating is dense and longer so as to give a thickened appearance

to the arista. Occiput often with a pollinose band on the lower orbits including the cheeks excepting their lower margin, usually with sparse short hairs; typically a pair of ocellar and one of vertical bristles present, rarely two or three pairs of vertical and an additional pair of post-vertical bristles present, sometimes an oral bristle on the back part of the cheeks.

Thorax robust, polished, nearly bare to pubescent, dorso-central bristles usually limited to a pair of prescutellars, humeral and posthumeral bristles present or absent, notopleural bristles present but variable, scutellum with two or four marginal bristles, the lateral ones always shorter; pleuræ bare, rarely with pollinose streaks following the sutures. Abdomen with eight segments, the first segment laterally inflated, the fourth segment usually large and more heavily chitinized than the others, its sides often pollinose and bearing scimiter-shaped, glistening setulæ, the fifth segment short; pygidium varying from small to large, closed to widely open, asymmetrical, the right side usually with a broad, curved, furcate valve. Legs rather stout, the front femora a little the strongest, usually the anterior femora with a basal flexor hair and with a preapical bristle on the outer side, the hind femora with one to three preapical bristles on the anterior face, hind tibiæ with extensor bristles and more or less produced as an apical tooth-like spur, the anterior tibiæ with a pair of apical bristles; sometimes the legs are devoid of all bristles; pulvilli broad; in those species with broad tibial spur the inside of the hind metatarsi and of the end of the hind tibiæ spongy pubescent.

Wings with anal angle more or less developed, except very rarely the first basal cell shorter than the second which is always fused with the discal cell, five simple longitudinal veins, anal cell completely wanting, at most a short trace of the anal vein present toward the hind margin but the anal cross-vein always lacking, usually the entire margin of the wing uniformly short-ciliate, sometimes the hairs of the first section of the costa are longer, no stigma and no definite color pattern.

The species of *Drapetis* are included in the following subgenera:

1. *Drapetis* Meigen, sens. str. Type species, *exilis* Meigen. Rather small, bristleless, black species, with short antennæ directed somewhat upward, the second joint without a conspicuous seta beneath, the third joint oval, with long, subterminal arista; legs without strong bristles,

the hind tibiæ without the terminal spur; notum densely short-pubescent, the hairs appressed, no humeral or discal bristles; wings broad, costa short-pubescent, third vein sometimes curved forward; halteres usually black.

2. *Eudrapetis*, subgen. nov. Type species, *spectabilis* Melander. Robust, larger species, more or less bristly and black; antennæ longer, directed obliquely upward, the second joint with a pronounced seta beneath, the third joint ovate to lanceolate, with a long terminal arista; femora with preapical bristles, anterior tibiæ with apical bristles and the hind ones with a more or less evident terminal spur and usually with extensor or apical bristles; humeral, and sometimes discal bristles (e. g., posthumeral, supraalar and anterior dorsocentrals) present; wings broad, costa short-pubescent, third vein straight or recurved; halteres yellow.

3. *Elaphropeza* Macquart. Type species, *ephippiata* Fallen. Usually yellow, sometimes black species; antennæ elongate, horizontal, the second joint without seta beneath, the third joint lanceolate, two or more times the length of the first two joints together, the terminal arista relatively short, sometimes no longer than the antennæ; abdomen broad, the middle segment with flattened setulæ; legs slender, the hind tibiæ with extensor bristles and with a more or less evident terminal spur; wings narrower, the hairs of the base of the costa longer than elsewhere.

4. *Ctenodrapetis* Bezzi. Type species, *ciliatocosta* Bezzi. Body slender, elongate, usually yellow, the abdomen longer than the thorax; antennæ elongate, horizontal, the second joint without seta, the third joint lanceolate with relatively coarsely pubescent terminal arista; legs slender, with bristles and a long terminal spur on the hind tibiæ; wings long, narrow, cuneate, the costal margin with long cilia.

SYNOPSIS OF THE NORTH AMERICAN SPECIES OF *Drapetis*, S. LAT.

1. Legs mostly black, femora entirely or mostly black.....2.
- Anterior femora more or less yellowish, in addition to the knees.....23.
2. Hind tibiæ without evident bristles, tibiæ without apical spurs; halteres black; no dorsocentrals.....3.
- Hind tibiæ almost always with one or more bristles on the extensor side, tibiæ with apical spurs; halteres whitish.....10.
3. Anterior cross-vein before the middle of the discal cell, last section of the fifth vein much shorter than the preceding; third antennal joint short ovate.....4.
- Anterior cross-vein beyond the middle of the discal cell, sections of the fifth vein subequal.....5.
4. Wings hyaline, third vein uniformly diverging from the fourth; arista terminal.....*assimilis* Fallen.
- Wings infumated, third and fourth veins parallel toward their end; arista subterminal.....*infumata*, n. sp.
5. Third vein uniformly diverging from the straight fourth; pygidium not cleft; head higher than wide, the eyes nearly touching above the antennæ, ocelli minute; mesonotal hairs short.....6.
- Third vein becoming subparallel with the fourth toward the end, the fourth vein with a more or less evident downward bend beyond the discal cell; head globular, the eyes distinctly separated above the antennæ, the ocelli large; mesonotum pubescent.....7.

6. Hind femora with two strong processes above; fourth vein ending before the tip of the wing, first vein ending before the middle of the wing, third section of the costa shorter than either the second or the fourth; pygidium large. *diversa*, n. sp.
 Hind femora unarmed; fourth vein ending beyond the tip of the wing, first vein ending near the middle of the wing, third section of the costa longer than either the second or the fourth; pygidium minute, triangular in outline; front coxæ yellowish. *naica*, n. sp.
7. Pygidium small, not deeply cleft, circular in outline; last abdominal segment not fringed. 8.
 Pygidium large, deeply cleft, the left valve with bristly fringe; last segment of male abdomen fringed with hairs. 9.
8. Hind metatarsi yellowish; notal hairs obliquely outstanding; hypopygium transversely depressed, slightly open on the right side; eastern species. *pilosa*, n. sp.
 Tarsi black; notal hairs decumbent; hypopygium globular and closed; western species. *micropyga*, n. sp.
9. Abdomen and pygidium with fine pale hairs; veins black and thick, the third section of the costa much longer than either the second or the fourth; tarsi and front tibiæ brown. *alaternigra*, n. name
 Pygidium with many coarse black setulæ; veins slender, the third section of the costa subequal to the second and the fourth; legs entirely black. *dividua* Melander
10. Hind tibiæ with long, flattened, scale-like hairs along the inner side and with only preapical bristles, the apical spur large and lappet-like; third antennal joint short ovate, the arista subterminal; third and fourth veins converging apically. *plumipes*, n. sp.
 Hind tibiæ not plumed with long flexor hairs. 11.
11. Hind tibiæ with six short extensor bristles, the terminal spur strong; arista subdorsal, third antennal joint short ovate. *dorsiseta*, n. sp.
 At most three extensor bristles on the hind tibiæ; arista terminal. 12.
12. Hind tibiæ prolonged on the inside as a strong lappet projecting beyond the insertion of the tarsus, hind metatarsi with strong setulæ beneath, middle tibiæ without extensor bristle; four dorsocentrals. 13.
 Hind tibiæ not or scarcely prolonged, certainly not lappet-like, metatarsi setulose only in *medetera*. 19.
13. Front coxæ and femora entirely black; anterior cross-vein beyond middle of cell; only middle pair of scutellar bristles long. 14.
 Front coxæ somewhat yellowish; anterior cross-vein at or before middle of cell. 16.
14. Arista 2.5 times as long as the antenna; hind tibiæ without extensor bristles; upper orbits polished; veins coarse and blackish, the first posterior cell narrowed apically. *nitens*, n. sp.
 Arista 1.5 times as long as the antenna; hind tibiæ with one or two extensor bristles; occiput pollinose; veins pale, the first posterior cell not markedly narrowed at apex (*unipila* Loew). 15.
15. Hind tibiæ with one bristle, located at the basal third. var. *unipila* Loew
 Hind tibiæ with two extensor bristles, one before the middle, the other at the beginning of the apical third of the tibial length.
 var. *nitida* Melander
16. Scutellum with four long equal bristles; hind tibiæ without extensor bristles; hind metatarsi black, darker than the tibia; palpi black.
quadrisetosa, n. sp.
 Scutellum with only the middle pair of bristles long; hind metatarsi rarely contrasting. 17.
17. Occipital orbits heavily white pruinose; sides of the middle segments of the abdomen white pruinose; posterior cross-vein before the middle of the wing, sections of the fourth vein proportioned 1:1:4, of the fifth vein, 1:1. 18.
 Orbits not differentiated; sides of the abdomen not pruinose; posterior cross-vein at the middle of the wing, the sections of the fourth vein, 1:1.2:2.3, of the fifth vein, 1:0.5, the second, third and fourth sections of the costa, 1.5:2:1. *inculta* Coquillett

18. Hind tibiæ without extensor bristles; second, third and fourth sections of the costa, 2.5:1.6:1, middle segments of the abdomen with flat glistening setulæ; base and apex of the front femora, front tibiæ and base of the front tarsi yellow; palpi yellow. *lata* Coquillett
Hind tibiæ with a strong extensor bristle near the middle, legs uniformly brownish; costal sections, 1.6:1.8:1; palpi blackish. *spectabilis* Melander
19. Middle tibiæ with a long extensor bristle at the basal third, hind tibiæ with a bristle above and one below the middle, hind femora with a preapical extensor bristle and with three preapical bristles on the front side; five dorsocentrals; pygidium large; hairs of the mesonotum black, of the legs long and blackish. *medelera* Melander
Middle tibiæ without an extensor bristle, hind femora without extensor bristles, hind metatarsi not setulose; pygidium smaller. 20.
20. Hind tibiæ without extensor bristles; antennæ short, the third joint ovate; veins coarse and brown or black. 21.
Hind tibiæ with two short extensor bristles located at the middle and near the end; antennæ elongate, the third joint lanceolate; veins not coarse and unusually pale. 22.
21. Hind femora ♂ with a strong swelling beyond the middle bulging out the anterior side; vertex broadly polished; basal section of the fifth vein slightly longer than the evanescent outer section; legs brown.
edimera, n. sp.
Hind femora not bearing an abnormal swelling; vertex subshining, the occiput cinereous, the front and lower orbits white pruinose; sections of the fifth vein subequal; legs mostly black. *parvicornis*, n. sp.
22. Front femora ♂ with a bunch of six black setulæ in the middle of the upper side, represented in the ♀ by one or two; no dorsocentrals, dorsum of ♂ nearly glabrous, of ♀ with white hairs; one preapical bristle on the front edge of the hind femora. *armata*, n. sp.
Front femora not setulose, two preapical bristles on the front edge of the hind femora; five dorsocentrals. *scissa*, n. sp.
23. Thorax black. 24.
Yellow or reddish species; second joint of the antennæ without a seta beneath. 41.
24. Under side of hind femora ♂ armed with a pair of long curved black spinous bristles, legs otherwise bristleless; halteres black; third vein curving away from the fourth; pleuræ shining; palpi and base of antennæ yellow. *bispina*, n. sp.
Femora not so armed; species differing from preceding also in two or more other characters. 25.
25. Third vein curving forward, widely diverging from the fourth; pleuræ opaque pollinose except the center of the sternopleura; halteres and fringe of calypteres yellow. *divergens* Loew
Third and fourth veins at least subparallel toward their tip; pleuræ shining except rarely on the sutures. 26.
26. Legs without bristles, at most weak hairs on the base of the front femora beneath and near the apex of the hind ones; no dorsocentrals. 27.
Femora and tibiæ with bristles; halteres yellow. 31.
27. Discal cell long, the ultimate section of the fifth vein much shorter than the preceding, posterior cross-vein opposite the end of the first vein, the anterior cross-vein at or before the middle of the discal cell; mesonotum pubescent. 28.
Discal cell small, sections of the fifth vein nearly equal, the posterior cross-vein before the end of the first vein, the anterior cross-vein beyond the middle of the discal cell, the second section of the costa shorter than the third. 29.
28. Hind tibiæ ciliate along the outer edge; halteres black; veins dark, the second section of the costa equal to the third. *latipennis* Melander
Tibiæ not ciliate; halteres yellow; veins brown, the second section of the costa shorter than the third. *discalis*, n. sp.

29. Antennæ, palpi and proboscis pale yellow; notum not densely pubescent; veins brown, the third vein straight, ♂ with the pedicel of the second and third veins broadened to a black disk and with a stout flexor bristle near the end of the hind tibiæ; halteres yellow. . . . *flavicornis*, n. sp.
 Antennæ and mouthparts black; mesonotum densely pubescent; veins black, the third vein sinuous; ♂ not thus distinguished; halteres black. 30.
30. Pygidium rounded, closed and without long hairs. *setulosa*, n. sp.
 Pygidium open, asymmetrical, the right side projecting as a curled, black setulose lamella, the left side of the pygidium clothed with long, black, hair-like bristles. *trichura*, n. sp.
31. Second antennal joint with a long seta beneath; hind femora with preapical bristles on the front side, hind tibiæ with more or less developed apical spur. 32.
 [Second antennal joint without a long seta; hind femora without preapical bristles, hind tibiæ with extensor bristles. 39.
32. Hind tibiæ with a strong lappet and with a long extensor bristle at its middle but without subapical bristles; three preapical bristles on the outside of the hind femora, hind metatarsi yellow-setulose beneath; pubescence of the mesonotum long and pale, dorsocentrals present; anterior cross-vein just before the middle of the discal cell; eyes nearly touching above the antennæ. *spectabilis* Melander
 Hind tibiæ without extensor bristle but with subapical ones, hind metatarsi darkened and not setulose; mesonotal pubescence short; eyes distinctly separated above the antennæ. 33.
33. Hind tibiæ with a rather strong apical spur. 34.
 Apex of the hind tibiæ simple; pubescence of dorsum blackish; veins dark. *gilvipes* Loew
34. Hairs of the thorax and of the calypteres whitish, some weak erect dorsocentrals on the disk of the mesonotum. 35.
 Hairs of the thorax and calypteres blackish, no erect dorsocentrals on the disk of the thorax; anterior cross-vein beyond the middle of the discal cell. 37.
35. Anterior cross-vein at the middle of the discal cell; scutellum with four bristles; veins strong; one strong preapical extensor bristle on the hind tibiæ, femora largely blackish. *femoralis* Melander
 Anterior cross-vein at three-fifths the length of the discal cell, veins weak; scutellum with two bristles; preapical extensor bristle of the hind tibiæ weak, legs mostly luteous. 36.
36. Hairs of the thorax fine but dense; face broader above and below and opaque gray pollinose, front pollinose; legs luteous. *facialis*, n. sp.
 Hairs of the thorax sparse; face black, narrower below, the front black; abdomen shining, nearly bare, pygidium very large; hind femora blackish. *diversipes*, n. sp.
37. Apical spines of the hind tibiæ stout, hind femora usually not blackened; first posterior cell widest before its end. *xanthopoda* Williston
 Spines at the end of the hind tibiæ not unusually stout, hind femora dark on the distal half; third and fourth veins parallel.
 (*septentrionalis* Melander) 38.
38. Face linear, eyes subcontiguous beneath the antennæ; palpi black.
septentrionalis Melander
 Face narrow, white pollinose, the eyes distinctly separated; palpi yellow var. *mexicana*, n. var.
39. Hind tibiæ with a single extensor bristle near the middle; front very narrowly V-shaped; veins blackish and strong. *inermis*, n. sp.
 Hind tibiæ with two extensor bristles; front narrowly V-shaped; veins slender. 40.
40. Antennæ black, the third joint lanceolate; hairs of the body black and numerous, six acrostichals; sides of the fifth segment of the abdomen with many short scale-like setulæ; tibial spur short. *nigricans*, n. sp.
 Antennæ yellow, the third joint short; hairs of the body pale and very sparse, two acrostichals; tibial spur long. *tenera*, n. sp.

41. Hind tibiæ without long extensor bristles, but instead seriatly bristly, hind metatarsi with an erect comb of seven bristles; halteres blackish; four rows of acrostichals; first posterior cell widest before the end; tibial spur small. *comata*, n. sp.
 Hind tibiæ with two or one long extensor bristles, hind metatarsi not pectinate; halteres yellow. 42.
42. Third and fourth veins converging, the first posterior cell widest before its tip; antennæ dark; scutellum and metanotum yellow, four acrostichals; tibial spur small. *inflexa*, n. sp.
 Third and fourth veins not converging, the first posterior cell widest before its tip; antennæ yellow. 43.
43. Mesonotum and pleuræ largely black, the notopleural suture broadly yellow; dorsal hairs long; tibial spur black; one extensor bristle on hind tibiæ; upper orbits polished. *seminigra*, n. sp.
 Thorax mostly or wholly yellow. 44.
44. Mesonotum with a median brown vitta, upper pleuræ brown; front linear; tibial spur long. *vitata*, n. sp.
 Mesonotum and pleuræ not vittate; front narrow, its sides converging below. 45.
45. Hind tibiæ with a single extensor bristle; posterior half of the mesonotum with a large crescentic black mark. *upsilon*, n. sp.
 Hind tibiæ with two extensor bristles; posterior part of the mesonotum marked at most with a prescutellar spot. 46.
46. Pleuræ with a large round subalar spot, a rounded prescutellar spot fused with the black scutellum; mesonotal hairs sparse; tibial spur strong but blunt. *pleuralis*, n. sp.
 Pleuræ unspotted, mesonotum reddish, sometimes with black metanotum, scutellum and prescutellar spot. 47.
47. Tibial spur blunt; third antennal joint conical, twice as long as broad; abdomen yellow apically; sections of the fourth vein proportioned 1 : 3, of the fifth vein, 2.5 : 1. *rectineura*, n. sp.
 Tibial spur long and sharp; third antennal joint less than twice as long as broad; abdomen often entirely black. 48.
48. Middle tibiæ ♀ not setulose, of ♂ at most microscopically setulose; scutellum reddish, mesonotal hairs sparse; length 1.5-2 mm. 49.
 Middle tibiæ ♂ ♀ setulose with black denticles within; scutellum black; genitalia sometimes yellow; mesonotum hairy; sections of the fourth vein, 1 : 2.2; length 2-3 mm. 50.
49. Sections of the fourth vein proportioned 1 : 4; abdomen black; occiput polished black, without pollen. *luteicollis*, n. sp.
 Sections of the fourth vein proportioned 1 : 2.2; abdomen black on the middle segments only; occiput subshining, coated with fine gray pollen. *simplicipes*, n. sp.
50. Occiput polished black, without pollen; front femora ♂ ♀ without black setulæ below; third antennal joint yellow, arista slender; pygidium without pollen, shining. *calva*, n. sp.
 Occiput pollinose; third antennal joint darker than the basal joints. 51.
51. Arista heavily pubescent, appearing half as thick as the third joint; bristles of the hind tibiæ distant; lower part of the head yellow; second section of the costa longer than the fourth and but little shorter than the third. *plumea*, n. sp.
 Arista not thickly pubescent, less than half as thick as the third antennal joint. 52.
52. Front femora ♂ with black setæ beneath, bristles of the hind tibiæ distant. *flavida* Williston
 Front femora ♂ ♀ with black flexor setæ, the bristles of the hind tibiæ close together. (*lata*, n. sp.) 53.
53. Prescutellar dark spot present; wings three times as long as broad; occiput pollinose to the eyes. *lata*, n. sp. and var.
 Prescutellar spot wanting; wings less than three times as long as broad. 54.
54. Spur of the hind tibiæ forming a long slender curved yellow hook; occiput pollinose to the eyes. var. *ungulifera*, n. var.
 Spur of the hind tibiæ forming a large broad black lappet; upper occipital orbits shining. var. *nigrocalcarata*, n. var.

Drapetis aliternigra, sp. nov.

nigra Melander, Tr. Am., Ent. Soc. xxviii. 208, f. 12, 17, 24 (1902).

Length 1.6 mm. Head round; occiput subshining, bottom of the front one-third to one-half as wide as the second joint; face and cheeks linear; palpi black overlaid with brown; second joint of the antennæ without a seta; one pair of diverging postocellar bristles, two or three verticals. Mesonotum closely pubescent, no discal bristles, the lateral ones confined to three or four in front of the wings, lateral scutellar bristles small; pleuræ shining. Legs simple, without bristles, the front knees more or less brownish.

Washington, British Columbia, Texas, South Dakota, Pennsylvania, New York, Massachusetts.

The species is very close to *naica*, but in that species the third vein has a uniform anterior curve, there are no postocellar bristles, the ocellar and vertical bristles are small and the head is longer than wide, with the front at the bottom less than one-third as wide as the second joint of the antennæ. In *aliter-nigra* the ocellar, postocellar and vertical bristles vary in size.

Drapetis bispina, sp. nov.

♂. Length 1.4 mm. Head, thorax and abdomen black, legs including the coxæ entirely yellow. Head spherical; occiput lightly dusted, orbits not differentiated; front and face very narrow, almost linear, the lowermost sides of the dusted face somewhat diverging; antennæ one-third the head-height, the basal joints yellowish, the second joint without seta, the third joint black, triangularly ovate, as long as the basal joints together, the terminal arista one-half longer than the antennæ, short-pubescent; palpi and a pair of apical setæ yellow, proboscis brown. Mesonotal hairs blackish, rather long and dense, obliquely outstanding, only the posterior dorsocentral bristles evident, no humeral, 3 supraalar, 1 intraalar, 4 scutellar bristles, pleuræ mostly polished. Abdomen shining, the hairs rather evident especially the brown ones margining the last tergite and the pale ones of the underside of the hypopygium; hypopygium oblong, larger than the vertical diameter of the abdomen, nearly erect but somewhat twisted to the right, its left valve with broad rounded end, the penis exerted as a curled filament. Legs relatively stout, covered with yellow hairs which are long but sparse on the underside of the anterior femora, otherwise devoid of bristles except for a pair of contiguous curved black spines located on the inner flexor side of the hind femora at three-fourths the length and extending as far as the knee, inner apical side of the hind tibiæ with a small luteous lappet covering the very base of the metatarsus, no tibial spurs. Halteres black, the roots fuscous; hairs of the calypteres golden. Wings hyaline, veins narrow and light brown, all the veins diverging, costal sections proportioned 1 : 0.6 : 1 : 0.7, first vein ending at basal two-fifths of the wing, fourth vein terminating

conspicuously beyond the tip of the wing, anterior cross-vein located at three-fifths the length of the discal cell, outer sections of the fourth vein proportioned 1 : 6, of the fifth vein, 1 : 0.9, marginal cilia short.

One specimen: Lafayette, Indiana, July 4, 1914. (Melander).

***Drapetis diversa*, sp. nov.**

♂. 1.3 mm. Black, shining, hairs very short and pale, first four longitudinal veins curving forward, the first vein very short, hind femora with two discoid processes above. Head higher than wide, orbits not pollinose, front very narrow, its sides scarcely converging beneath, face linear, black, cheeks very narrow; palpi and proboscis black; antennæ short, the second joint without a seta beneath, the third joint oval, but slightly longer than wide, the bare arista nearly terminal, one and two-thirds times as long as the antennæ. Mesonotum with short close pubescence, the marginal bristles small, two scutellar, about eight rows of fourteen acrostichals; pleuræ not pollinose. Abdomen subshining, laterally subopaque, hypopygium large, the lamellæ with coarse brown hairs. Legs devoid of bristles, the hairs pale, the hind femora greatly swollen above and bearing a strong backward-projecting hook on the proximal fourth of its extensor surface, distal to which near the middle is a prominent disk-shaped protuberance. Halteres yellowish. Wings short, broad, hyaline, veins pale brown, first vein ending before the middle of the wing, the marginal cell broad, the second, third and fourth sections of the costa proportioned 1.2 : 1 : 1, fourth vein ending slightly before the tip of the wing, the first posterior cell much the widest at its end, anterior cross-vein at two-thirds the length of the second basal cell, outer sections of the fourth vein proportioned 1 : 5, of the fifth vein equal, costa bare, cilia of the hind margin short.

One specimen: Alamogorda, New Mexico.

***Drapetis flavicornis*, sp. nov.**

♀. Length 1 mm. Shining black, the appendages yellow. Head globular, black, subshining, sides of the front slightly diverging above, face linear, shining black, the narrow cheeks, palpi, palpal seta, proboscis, antennæ and arista yellow; antennæ three-jointed, the last joint oval, slightly longer than wide, the arista twice the length of the antennæ and microscopically hairy; ocellar and vertical bristles black. Thorax broader than long, its bristles blackish, its hairs moderately sparse, short and brown; pleuræ polished; abdomen opaque blackish, the middle three segments with two transverse rows of converging setulæ; ovipositor yellowish. Legs without bristles, the hind tibiæ with a broad blunt sericeous terminal lappet. Halteres yellow; calypteres brown. Wings narrow, clear hyaline, veins brownish along the middle of the wing, at the base and apex pale yellowish, the second, third and fourth costal sections proportioned 1 : 1.5 : 0.8, third vein straight, nearly parallel with the fourth, posterior cross-vein somewhat oblique, located before the end of the first vein, sections of the fourth vein pro-

portioned 1 : 0.5 : 3.2, of the fifth vein, 1 : 0.7, marginal cilia as long as the anterior cross-vein.

Type; Le Chorrera, Panama, collected by August Busck, May 12, 1912, for the U. S. National Museum. A male from Jamaica differs only in the following characters which are probably sexual and not specific differences. Pedicel of the second and third veins broadened disc-like and black; hind femora with a strong curved yellow bristle underneath at the outer fourth; mesonotal hairs longer; abdominal setulæ less pronounced.

***Drapetis inermis*, sp. nov.**

♂. Length 1.9 mm. Head black, occiput subshining, front very narrow, its sides converging so as almost to touch, eyes separated below the antennæ by a line, ocellar and vertical bristles moderately long; palpi white and with an apical white hair, proboscis short, reddish; antennæ horizontal, without seta beneath, the third joint lanceolate, nearly twice as long as broad, its terminal arista less than two times the length of the antenna. Thorax shining black, the hypopleuræ alone pollinose, its pubescence white, uniformly distributed, six rows of about eight acrostichals, lateral scutellar bristles small. Base of abdomen not chitinized, the middle segment laterally with a few flattened setulæ; hypopygium shining black, with few hairs. Legs largely brownish, the anterior femora and coxæ and the base of the hind femora yellowish, middle femora alone with a preapical bristle, hind tibiæ with a single extensor bristle located just above the middle, its apex merely callous, metatarsi not setulose. Halteres yellow, calypteres with six cilia. Wings narrow, nearly hyaline, the veins strong and dark, marginal cilia minute, the second, third and fourth sections of the costa proportioned 1.6 : 2.4 : 1, the submarginal cell at the end of the first vein one-half as wide as the marginal, and at the end of the second vein equal in width to the first posterior, third and fourth veins subparallel, the first posterior cell widest beyond the end of the second vein, anterior cross-vein just before the middle of the second basal cell, last two sections of the fourth vein proportioned 1 : 2.5, of the fifth vein, 3 : 1.

One specimen, Alhajuelo, Panama, April 11, 1911, collected by August Busck for the U. S. National Museum.

***Drapetis infumata*, sp. nov.**

♀. Length 1.6 mm. Shining black, mesonotum densely black-setulose, wings infumated. Front broadly V-shaped, at the bottom nearly as wide as the second antennal joint; face narrow, its sides parallel; palpi blackish, with a few dusky hairs; antennæ ascending, the lowermost hair of the second joint setiform, the third joint very short, ovate, the subapical nearly bare arista more than three times as long as the antennæ. No humeral, three or four supraalar, four scutellar, two small prescutellar bristles. Abdomen subshining blackish. Legs blackish, the posterior femora with a small preapical bristle, no tibial

bristles, or apical spur. Halteres black. Wings oval, the second, third and fourth sections of the costa proportioned 1.3 : 1.8 : 1, third and fourth veins subparallel, the first posterior cell a little the widest before its tip, anterior cross-vein before the middle of the discal cell, segments of the fourth vein proportioned 1 : 2.3, of the fifth vein, 1.6 : 1, marginal cilia uniformly short.

Type specimen: Nelson, British Columbia, July 17, 1910. Paratype: Priest Lake, Idaho, August 1, 1915 (Melander). In author's collection.

***Drapetis micropyga*, sp. nov.**

♂. Length, 1.5 mm. Black, shining, legs simple without bristles, black, the front coxæ and knees brown, antennæ short, halteres black, third and fourth veins nearly parallel. Head round, orbits shining, bottom of the front one-half as wide as the second joint of the antennæ, face linear, cheeks obliterated, proboscis very short, palpi blackish, brown-hairy and without an apical seta; second antennal joint without seta beneath, the third joint short oval, not longer than wide, the subterminal arista slender, twice as long as the antennæ. Pubescence of the mesonotum short and dense, no discal bristles, the lateral bristles confined to three or four in front of the root of the wings, lateral scutellars small; pleuræ with tomentum in front of the wings and beneath the humeri. Abdomen subshining, nearly bare, hypopygium small, rounded, closed, with uniform short, brown hairs. Wings hyaline, the second, third and fourth sections of the costa proportioned 1 : 1.5 : 1, first posterior cell slightly widening toward the tip, fourth vein ending beyond the apex of the wing, its outer two sections proportioned 1 : 7, sections of the fifth vein equal, anterior cross-vein at two-thirds the length of the second basal cell, marginal cilia uniformly short.

Pullman and Almota, Washington: Moscow Mountain, Idaho. A male from Washington, D. C., does not offer any differences.

***Drapetis naiça*, sp. nov.**

1.2 mm. Black, with simple black legs, third vein curving forward, first vein ending near the middle of the wing, hypopygium small. Head higher than wide, orbits not pollinose, front, face and cheeks very narrow, palpi yellowish, the terminal hair pale, proboscis short, black; antennæ short, ascending, the second joint without a seta beneath, the third joint ovate, one-fourth longer than broad, the slender terminal arista one and three-fourths times the antennal length. Thorax with uniform, short, fine, brown hairs, about eight rows of eighteen acrostichal hairs, no humeral, three supraalar, four scutellar, bristles; pleuræ polished; abdomen shining, the sides of the middle segments subopaque and with brown setulæ; hypopygium small, rather triangular in profile, its valves not open. Front coxæ and knees brownish, posterior femora with a single preapical bristle, spur of the hind tibiæ long but blunt, metatarsi not setulose. Halteres blackish. Wings hyaline, veins

brown and thin, the first four veins curving forward, first vein ending near the middle of the wing, the second, third and fourth sections of the costa proportioned 1 : 1.2 : 1, fourth vein ending beyond the tip of the wing, its outer two sections proportioned 1 : 6, anterior cross-vein at two-thirds the length of the second basal cell, costa and hind margin uniformly short-ciliate.

Various places in Washington, Idaho, New Mexico and Texas.

***Drapetis pilosa*, sp. nov.**

Length 1.25 mm. Black species with halteres and the major portion of the legs black. Head almost spherical, front V-shaped, dusted, ocelli large, face linear; mouthparts black, no long palpal hairs; occiput lightly dusted, orbits not differentiated, cheeks linear; antennæ one-third the head-height, ascending, the second joint not setigerous, the third joint triangularly ovate, scarcely longer than deep, the arista subterminal, three-fourths longer than the antenna. Mesonotum shining, the hairs relatively long, conspicuous and obliquely erect, no humeral, one dorsocentral, one intraalar bristle, only the apical pair of scutellar bristles long; pleuræ polished. Abdomen shining, disc bare, lateral hairs short, stiff and black, last segment without long fringe, fourth segment much longer than any of the others; hypopygium small, transversely depressed, the parts on the right side slightly exposed. Legs entirely bristleless, no tibial lappet or spurs, front tibiæ and all the tarsi yellowish-brown. Hairs of calypteres black. Wings hyaline, veins very thin, brownish, the first vein ending at the middle of the wing, sections of the costa proportioned 1 : 0.4 : 0.7 : 0.3, of fourth vein, 0.3 : 0.2 : 10, third vein sinuate and apically parallel with the fourth, sections of fifth vein subequal.

♀, thoracic pubescence slightly shorter than in ♂.

Type: Lafayette, Indiana., July 4, 1914 (Melander). Four paratypes, Chicago, Illinois, June 28, 1914, on shrubbery in vacant lots near the lake shore (Melander).

***Drapetis setulosa*, sp. nov.**

Length 1.3 mm. Shining black, hairs of the mesonotum numerous and black, legs yellowish. Occipital and ocellar bristles stout, lower part of the front one-third as wide as the second antennal joint; palpi blackish, but covered with white hairs; eyes together higher than broad, obliterating the cheeks; antennæ short, ascending, no seta beneath, the third joint short-ovate, with nearly bare subterminal arista measuring three times the antennal length. Mesonotum shining, densely short-hairy; no humeral, five supraalar bunched together, two small pre-scutellar, two scutellar bristles. Abdomen sub-shining black, hypopygium small, rounded, apically with numerous short yellowish hairs. Legs short, yellowish to brown, the front ones lighter, the hind ones darker, no bristles or terminal spur. Halteres blackish. Wings hyaline, third vein lightly sinuose, parallel with the fourth toward its end, the

fourth vein with a downward curve in the middle of the wing, then straight, the second, third and fourth sections of the costa proportioned 1.2 : 1.8 : 1, submarginal cell as wide as the marginal and the first posterior opposite the ends of the first and second veins respectively, anterior cross-vein near the middle of the second basal cell, outer sections of the fourth vein proportioned 1 : 6, of the fifth vein equal, marginal cilia uniformly short.

Two specimens: Pullman and Almota, Washington, June. A specimen in the U. S. National Museum from South Fork, British Columbia, has the third vein a little closer to the fourth.

***Drapetis trichura*, sp. nov.**

♂. Length 1.4 mm. Black, legs yellowish, hairs black and abundant, the last tergite, apex of hypopygium and of the apical lamella with numerous bristly hairs. Front V-shaped, eyes nearly meeting just above the antennæ and on the middle of the face; cheeks narrow; vertical and ocellar bristles short, upper occiput setulose; antennæ ascending, short, black, no seta beneath, the third joint not longer than broad, ovate, with a subterminal arista nearly bare and measuring two and one-half times the antennal length; palpi white and with straggling white hairs, proboscis very short. Mesonotum shining, densely hairy, about ten rows of setulæ between the dorsocentral rows; no humeral, three notopleural, two dorsocentral, four scutellar bristles; abdomen opaque blackish, hypopygium polished jet black. Legs short, simple, without true bristles on the femora or tibiæ, no apical spur on the hind tibiæ. Halteres blackish. Wings hyaline, the third vein with a strong anterior curve, fourth vein nearly straight but with a slight posterior curve at the middle of the wing, the submarginal cell opposite the end of the first vein two-thirds as wide as the marginal, and at the end of the second vein two-thirds as wide as the first posterior cell, anterior cross-vein at two-thirds the length of the second basal cell, the outer two sections of the fourth vein proportioned 1 : 10, of the fifth vein equal, costa and hind margin uniformly short-ciliate.

One specimen: Austin, Texas.

***Eudrapetis armata*, sp. nov.**

Length 1.8 mm. Black, shining, with black legs, the femora with a single preapical bristle, front femora ♂ above along the middle with a group of about six spines, reduced in the ♀ to one or two, hind tibiæ with two short extensor bristles located at the middle and about half way to the tip, the apical spur small. Front subshining, at the bottom two-thirds as wide as the second antennal joint, face half as broad as this joint, its sides diverging below, subshining black, cheeks broader behind where they are about one-fifth the eye-height; palpi black but the front surface white pruinose, the apical hair black, proboscis black; antennæ elongate, ascending, the second joint with a seta beneath, the third joint lanceolate, about twice as long as broad, its terminal arista rather heavy with close short pubescence, measuring one and two thirds

times the antennal length. Thorax ♂ nearly bare, narrowly tomentose before the scutellum and around the root of the wing and conspicuously so below the humeri; pleuræ shining; one strong humeral, four supraalar, one intraalar almost posthumeral in position, two prescutellar, four scutellar, the lateral ones short; in the ♀ the notal hairs are long, fine, abundant and whitish, the lateral bristles are shorter and the subhumeral region is provided with white hairs instead of tomentum. Abdomen shining, nearly bare, in the ♂ the hairs are blackish and stronger, along the sides of the middle segment slightly flattened, hypopygium short, rather small, its appendages open above. Legs sometimes more or less reddish near the end of the hind tibiae, the hind metatarsi not setulose, apical spines of the anterior tibiae long. Halteres white, calypteres with about eight dusky cilia. Wings yellowish hyaline, veins pale brown, first posterior cell rather broad, its veins parallel outwardly, the second, third and fourth sections of the costa proportioned 1.3 : 1.3 : 1, anterior cross-vein at three-fourths the length of the second basal cell, outer two sections of the fourth vein proportioned 1 : 7, of the fifth vein equal, marginal cilia uniformly short.

Numerous specimens from Washington, Idaho, Massachusetts and Maine. One specimen from Olga, Washington, has three extensor bristles on the hind tibiae.

***Eudrapetis discalis*, sp. nov.**

♂. Length 1.4 mm. Shining black, closely pubescent, legs yellow, posterior cross-vein at the middle of the wing. Occiput with short, brownish hairs and bristles; front V-shaped, at the bottom one-half as wide as the second antennal joint, face and cheeks linear; palpi blackish with a few brown hairs, proboscis short, black; antennæ ascending, the second joint with a seta, the third joint short-ovate, the subterminal arista slender, bare, over three times the antennal length. Hairs of the thorax short, dense, pale, no humeral, three supraalar, four scutellar bristles. Sides of the abdomen subopaque, with white pubescence, disk shining, hypopygium elongate, outwardly with white hairs. Legs slender, the hind femora with short preapical bristles, no tibial bristles or spur. Halteres blackish. Wings hyaline, veins narrow, brownish, third and fourth veins subparallel, the third lightly sinuose, so that the first posterior cell is widest before its apex, second, third and fourth sections of the costa proportioned 1.4 : 1.8 : 1, anterior cross-vein at two-fifths the length of the second basal cell, the outer two sections of the fourth vein proportioned 1 : 1.8, of the fifth vein, 2 : 1, marginal cilia uniformly very short.

Two specimens: Wawawai, Washington, and Palo Alto, California.

***Eudrapetis diversipes*, sp. nov.**

♂. Length 1.9 mm. Black, shining, legs yellowish, the hind femora and metatarsi blackish, hairs of the thorax rather sparse, fine and pale, hypopygium very large. Vertex, front and face grayish black, vertical

and ocellar bristles large, front beneath nearly as wide as the second antennal joint, face very narrow, linear beneath, occipital orbits grayish, cheeks broader behind where they are one-tenth the eye-height; palpi brownish, with apical black hair, proboscis brown; antennæ black, the second joint with a long seta beneath, third joint broken. Four rows of about nine acrostichals, no discal bristles, two scutellars; pleuræ not pollinose. Abdomen shining, nearly bare, hypopygium with very sparse whitish hairs, the right lamella large, broad and deeply cleft. Legs luteous, the hind coxæ, femora and metatarsi blackish, pubescence whitish, anterior femora with a single preapical, the hind femora with two preapical bristles, anterior tibiæ with a pair of apical spines, those of the hind tibiæ small, its apical spur rather strong and pointed, no extensor bristles on the tibiæ, hind metatarsi not setulose. Halteres whitish. Wings hyaline, veins pale brown, the fourth vein very slightly undulate, apically parallel with the third vein, the second, third and fourth sections of the costa proportioned 1.6 : 1.6 : 1, anterior cross-vein at two-thirds the length of the second basal cell, outer sections of the fourth vein proportioned 1 : 6, of the fifth vein equal, marginal cilia uniformly very short.

One specimen: Santa Cruz Mountains, California, received from Professor R. W. Doane.

***Eudrapetis dorsiseta*, sp. nov.**

♀. Length 2 mm. Shining black, the spur of the hind tibiæ and the matted pubescence of the hind metatarsi brown. Second antennal joint with a long seta beneath, third joint ovate, scarcely longer than broad, the arista arising before the end of the third joint, slender, loosely microscopically hairy, measuring three times the antennal length; face linear, white-pollinose, clypeus shining, cheeks narrow in front, broad behind, lower orbits white-pollinose. Dorsum of the thorax loosely hairy, five hairs in the dorsocentral rows a little longer; halteres yellow. All the femora with a single preapical bristle, front tibiæ with one strong preapical flexor bristle, hind tibiæ with five erect extensor bristles which in length are equal to the diameter of the tibiæ but the apical one longer, on the outer side with two short, strong, apical spines and on the inner side with a strongly projecting, broad, blunted spur, hind metatarsi somewhat swollen, not bristly except for one apical setula. Wings narrow, long, hyaline, the veins coarse and black, first vein ending at the middle of the wing, the second, third and fourth sections of the costa proportioned 3.5 : 3.7 : 1, third and fourth veins mutually converging at the tip, anterior cross-vein at three-fifths the length of the second basal cell, the outer two sections of the fourth vein proportioned 1 : 7, of the fifth vein 4 : 3, margin with short cilia.

One specimen: Juan Vinas, Costa Rica, collected by Dr. P. P. Calvert for the Philadelphia Academy of Science.

Eudrapetis facialis, sp. nov.

Length 1.5 mm. Broad, black, shining, mesonotum with dense, white hairs and with erect dorsocentrals on the disk, face white-pruinose, legs yellowish. Posterior orbits white-pruinose, front opaque black, as broad as the second antennal joint, face relatively broad, narrowest in the middle, cheeks obliquely descending in back, one-ninth the eye-height; palpi yellow, proboscis blackish; antennæ black, ascending, the second joint with a seta beneath, the third joint lanceolate, one-half longer than wide, the arista terminal, slender, twice as long as the antennæ. Pleuræ pollinose posteriorly and more or less along the sutures; abdomen shining except along the extreme sides, its hairs sparse, white, hypopygium small, globular. Legs luteous, the hind metatarsi dark, anterior femora with one preapical, hind femora with two, hind tibiæ without extensor bristles but with one pair each of short, stout preapical and apical bristles. Halteres pale yellow; calypteres fringed with six fine white cilia. Wings hyaline, veins pale brown, third and fourth veins converging, the second, third and fourth sections of the costa proportioned 2 : 2 : 1, anterior cross-vein at two-thirds the length of the second basal cell, the outer two sections of the fourth vein proportioned 1 : 4, the outer section of the fifth vein shorter than the preceding, margin uniformly short-ciliate.

Two specimens: Okefenokee Swamp, Georgia, June, received through Professor O. A. Johannsen of Cornell University; and Medicine Hat, Alberta, collected by J. R. Malloch and deposited in the U. S. National Museum.

Eudrapetis nitens, sp. nov.

♀. Length 1.4 mm. Head and body entirely jet black, the legs dark brown, the halteres white. Face linear, front narrowly V-shaped, at the bottom nearly as broad as the width of an antennal joint; lower third of orbits pollinose, occiput, vertex, front and oral margin polished; palpi and proboscis black, the former cinereous pubescent; second antennal joint bisetose below, third joint short oval, the arista slender, microscopically sparsely pubescent, and two and a half times as long as the antenna. Thorax entirely polished, the notal hairs moderate in length and density, the central and distant two scutellar bristles alone long. Hairs of hind tibiæ rather long, four pronounced preapical but no extensor bristles present, the apical lappet strong. Wings lightly infumated, veins strong and blackish, costal sections approximately 1 : 0.6 : 0.8 : 0.3, third and fourth veins converging at apex, sections of fourth vein as 0.5 : 0.4 : 1.8, of fifth vein, 4 : 5.

Type: Panama, March, 1915, received from Dr. A. H. Sturtevant. Paratypes from Havana, Cuba (Sturtevant, and Orizaba, Mexico, (Wm. M. Mann, in Museum of Comparative Zoology) differ in having the legs usually quite black, the posterior occiput slightly pollinose and the mesonotal hairs

sparse. A male from Aquada, Panama (Sturtevant), has brown legs and wing-veins. The hypopygium is globose but not larger than the abdomen.

***Eudrapetis nuda*, sp. nov.**

Length 1.6 mm. Shining black, pubescence pale, short and very fine, legs devoid of bristles, yellow, the hind femora largely black. Occipital orbits white-pollinose; eyes separated above the antennæ nearly as much as the width of the second antennal joint, front subshining black; face gray, linear in the middle, cheeks one-tenth the eye-height, their lower edge horizontal; palpi white and with a terminal white hair, proboscis brown; basal joints of the antennæ yellow, the second joint with a seta beneath, the third joint lanceolate, fuscous, two-thirds longer than broad, with short pubescence, the terminal arista nearly bare, two times the antennal length. Thorax closely covered with short and very fine white hairs, no evident dorso-centrals on the disc, four scutellars, pleuræ with gray tomentum following the notopleural and the meso-sternopleural sutures. Abdomen subopaque black, its short sparse hairs black, hypopygium of moderate size, shining, with white hairs beneath, the left side with a trifurcate process. Legs simple, without spines or bristles, hind tibiæ not spurred, the last tarsal joint a little darker. Halteres yellowish. Wings hyaline, veins thin, brownish, the third and fourth veins rather strongly convergent, the fourth vein curving forward toward its tip, second vein shorter than usual, the second, third and fourth sections of the costa proportioned 1.3 : 4.5 : 1, outer sections of the fourth vein proportioned 1 : 6, of the fifth vein subequal, marginal cilia uniformly short.

Numerous specimens: Kamerun, West Africa, received from Professor Roland Thaxter.

***Eudrapetis œdimera*, sp. nov.**

♂. Length 1 mm. Shining black, with brown legs, black antennæ, blackish palpi, dirty white halteres and strong dark brown veins; hind femora with a pronounced swelling beyond the middle of the anterior face. Second antennal joint with a long inferior seta, third joint short, oval, scarcely longer than wide, its arista long and slender, measuring four times the antennal length, microscopically hairy. Vertex broadly polished, ocellar triangle prominent, occiput slightly dusted, the lower orbits and the lower front only inconspicuously cinereous, face linear, black. Hairs of mesonotum very sparse, brownish, those of the dorso-central rows long, scutellum somewhat dusted; pleuræ entirely polished; abdomen nearly bare, largely shining, pygidium small, elliptical in outline, sparsely hairy. Anterior tibiæ with fine apical bristles, hind femora with two apical bristles on the anterior side, hind tibiæ without extensor bristles but with a group of three at the tip, metatarsi not setulose. Wings hyaline, veins broad, the fifth vein evanescent midway between the posterior cross-vein and the margin, first four veins with a slight anterior curvature, the third and fourth veins nearly parallel,

second, third and fourth sections of the costa proportioned 1 : 1.4 : 0.6, anterior cross-vein at three-fourths the length of the discal cell, the posterior cross-vein a little before the end of the first vein, fourth vein ending at the wing-tip, its sections proportioned 3 : 1 : 9, basal section of the fifth vein slightly longer than the outer, marginal cilia much longer than the anterior cross-vein, nearly as long as the posterior cross-vein.

One specimen, in the U. S. National Museum. Cordoba, Vera Cruz, Mexico, May 13, 1908, collected by Dr. A. Fenyes.

Eudrapetis parvicornis, sp. nov.

♂, ♀. Length 1.2 mm. Black, shining, the hairs fine, sparse and yellowish. Occiput and front opaque black, eyes separated on the face by a narrow line of pollen, antennal incision deep, front at bottom as broad as the base of an antenna; ocellar and vertical bristles strong; palpi black but white pruinose; antennæ short, black, the second joint with a long seta beneath, the third joint rounded oval, no longer than the second joint, its terminal arista nearly bare. No humeral, two small prescutellar dorsocentral, two scutellar bristles; pleuræ polished. Pygidium large, ovate, closed, its hairs short, sparse and pale. Legs black, the under side of the anterior femora reddish brown, hind femora with two preapical bristles, hind tibiæ with three apical bristles and with a strong spur, but without extensor bristles. Halteres fuscous, calypteres margined with six cilia. Wings short and broad, lightly infumated, the veins coarse and dark, margin uniformly short-ciliate, second, third and fourth sections of the costa proportioned 1.7 : 1.8 : 1, third and fourth veins outwardly subparallel, anterior cross-vein at the outer third of the second basal cell, the last two sections of the fourth vein proportioned 1 : 9, of the fifth vein equal.

Three specimens: Pullman, Washington, March 5, (Melander), and Rock Creek, D. C., March 9 (R. C. Shannon). Paratype in U. S. National Museum.

Eudrapetis pennescens, sp. nov.

♀. Length 2.25 mm. Differing from *armipes* Bezzi in the following respects: Legs blacker, the hind femora with only one pronounced knee bristle, the hind tibiæ with five or six long contiguous hair-like bristles forming a feather-like row along the middle of the inner side and with a strong terminal lappet and stout subapical bristles, the hind metatarsi with blackish and not golden pubescence; wings clear hyaline. Differing from *plumipes* in being larger and more robust and in having the mesonotum closely white-pubescent, the hind femora with a single knee bristle and the wings hyaline.

Shining black, pubescence white, bristles black, the narrow front, linear face and lower orbits cinereous pruinose; legs almost black, the hind tibiæ dark brown; halteres white; veins black and strong. Palpi blackish, oral margin polished, seta of the second antennal joint strong.

Second and third sections of the costa subequal, third and fourth veins converging, outer part of the fifth vein abruptly weak, sections of the fourth vein proportioned 3 : 2 : 9, of the fifth vein equal.

One specimen: Matucana, Peru, collected by C. T. Brues, July 1, 1913.

***Eudrapetis plumipes*, sp. nov.**

♀. Length 1.2 mm. Black, legs blackish, the hind tibiæ with long, feathery, flexor hairs and with a strong terminal lappet, halteres yellow, third and fourth veins convergent. Sides of the pollinose front nearly parallel, face linear, whitish, upper occipital orbits polished, lower orbits pruinose, ocellar bristles large and black; palpi brown, without setæ, proboscis black; second antennal joint with a long seta beneath, third joint oval with the arista subterminal, microscopically and closely hairy and more than three times the length of the antennæ. Thorax glistening black, only a narrow pruinose line extending from the middle coxæ to the halteres, pubescence long and very sparse, about five short dorsocentrals visible; hairs of the abdomen rather long. Anterior tibiæ with two terminal bristles, hind femora with two strong preapical bristles, hind tibiæ with three preapical bristles on the exterior side opposite the sharp lappet, hind metatarsi black. Wings somewhat infumated, veins coarse, blackish, basal bristle long, the second, third and fourth sections of the costa proportioned 1 : 1.2 : 0.4, first posterior cell distinctly widest at its outer third, sections of the fourth vein proportioned 1 : 0.3 : 3.2, of the fifth vein, 1 : 0.9.

Type specimen: Austin, Texas. Paratype, Kushla, Alabama, received from Dr. A. H. Sturtevant. Paratype, Orizaba, Mexico, collected by Wm. M. Mann and deposited in the Museum of Comparative Zoology of Harvard University.

***Eudrapetis quadrisetosa*, sp. nov.**

♂. Length 2 mm. Jet black, the halteres whitish. Face linear, pollinose; front V-shaped, nearly shining, at the lowest part nearly as broad as an antennal joint; upper orbits and vertex polished, lowest third of the orbits white pruinose, oral margin broadly shining black; proboscis and palpal ground-color black; second antennal joint with one long bristle beneath, third joint short ovate, the slender subterminal arista nearly three times the antennal length. Notal hairs long, fine, brown and rather abundant, scutellum with an extra pair of long, apical bristles making four long equidistant scutellars in addition to the minor lateral pair. Abdomen with sparse golden hairs; pygidium globose, not swelling the abdomen. Legs sturdy, nearly black, hind tibiæ more brown, hind metatarsi darker than the adjacent joints, front tibiæ with two apical spurs, hind tibiæ without extensor bristles but with two short but stout preapical spurs, the terminal lappet strong, hind metatarsi scarcely visibly setulose. Wings subhyaline, veins dark but narrow, costal sections proportioned 1 : 0.6 : 0.8 : 0.2, third and fourth veins slightly convergent, sections of the fourth vein, 0.6 : 0.5 : 2.1, of fifth vein equal.

Type: San Jose, Costa Rica, Central America, March, 1915, received from Dr. A. H. Sturtevant. Paratypes from same locality and from Orizaba, Mexico (Mann and Skewes), the last in the Museum of Comparative Zoology, Harvard University.

***Drapetis scissa*, sp. nov.**

Drapetis medetera Melander, in part, Tr. Am. Ent. Soc. xxviii. 208 (1902).

Length 1.7 mm. Shining black, thorax with black hairs and discal dorsocentrals; extensor bristles, apical spines and spur of hind tibiae small; antennae elongate; halteres white; third and fourth veins slightly converging toward tip. Head round, occipital orbits grayish black, bottom of the shining black front two-thirds as wide as the second antennal joint, face black narrowed in the middle where it is nearly one-half as wide as the second antennal joint, cheeks scarcely deepened behind, one-tenth the eye-height; palpi black, but overlaid with gray, proboscis black; antennae ascending, second joint with a seta beneath, third joint lanceolate, three-fourths longer than broad, the terminal arista one and three-fourths the antennal length. Pubescence of the thorax fine and rather sparse, six rows of about ten acrostichals, five or six long, slender dorsocentrals, one humeral, one intraalar, two notopleural, three supraalar, four scutellar bristles; a little pollen before the scutellum, pleurae shining. Abdomen shining, its hairs pale and long, hypopygium of moderate size. Legs black, the pubescence pale, anterior femora with one, hind femora with two preapical bristles, extensor bristles of hind tibiae located beyond the middle and near the apex, metatarsi not setulose. Halteres white, calypteres with eight pale cilia. Wings broad, hyaline, veins pale brown, the second, third and fourth sections of the costa proportioned 1.4 : 2 : 1, anterior cross-vein at three-fourths the length of the second basal cell, outer two sections of the fourth vein proportioned 1 : 5, of the fifth vein equal, first posterior cell widest before its end, marginal cilia uniformly small.

Clayton, Washington; Oxford, Idaho; Hunter's Creek and Rock River, Wyoming, the last from the collection of the University of Kansas.

***Eudrapetis septentrionalis*, var. *mexicana*, var. nov.**

♂. A shining black species with yellowish legs, the hind femora blackened apically, especially along the posterior side, hind metatarsi blackish, palpi yellow. Head higher than long, the lower front, the narrow face and the lower orbits silvery pruinose. Pubescence of the body yellowish, about four longer hairs in the dorsocentral rows. Veins pale brown, posterior cross-vein before the end of the first vein, second to the fourth sections of the costa proportioned 1 : 1.2 : 0.6, sections of the fourth vein, 1 : 0.4 : 3.3, of the fifth vein, subequal, marginal cilia a little longer than the anterior cross-vein.

One specimen, in the U. S. National Museum. Collected by F. C. Bishopp, at Tampico, Mexico, December 6.

***Eudrapetis spinipes*, sp. nov.**

Length 1.6 mm. Body polished black, very sparsely hairy, legs luteous, hind tibiæ with several black spinous bristles toward its apex. Front broadly V-shaped, gray pollinose, at the bottom nearly as wide as the second antennal joint, eyes subcontiguous at the middle of the face, lower occiput white-pruinose, cheeks broad, their greatest diameter one-fifth the eye-height; palpi broad, yellowish, with a single apical hair, proboscis nearly as long as the eye-height, brown; antennæ black, the second joint with a long seta beneath, the third joint oval, slightly longer than broad, the slender subterminal arista loosely microscopically pubescent. The very sparse and short hairs of the thorax black, no dorsocentrals, two scutellars; pleuræ entirely polished. Abdomen shining black, its sparse hairs brown; hypopygium small, closed, beneath with white hairs. Legs including the coxæ and ends of the tarsi entirely yellow, anterior femora with a single preapical, hind femora with two preapical bristles, anterior tibiæ tipped with a pair of long, black spines, hind tibiæ at two-thirds their length with a long flexor spine, beyond which on the outside are two preapical and two apical spines, all long, on the inside the short broad apical spur is strong, metatarsi not setulose beneath. Halteres yellow. Wings brownish, veins narrow but firm, the third and fourth veins subparallel, the first posterior cell widest before its apex, the second, third and fourth sections of the costa proportioned 1.6 : 2.4 : 1, anterior cross-vein at two-thirds the length of the second basal cell, outer sections of the fourth vein proportioned 1 : 9, of the fifth vein subequal, marginal cilia uniformly short.

Numerous specimens: Kamerun, West Africa, received from Professor Roland Thaxter.

***Ctenodrapetis aristalis*, sp. nov.**

♂, ♀. Length 1.4 mm. Head glistening black, thorax reddish, abdomen largely or completely black, legs yellow. Front very narrow, eyes contiguous below the antennæ, vertical and ocellar bristles long; basal joints of the antennæ short, yellow, without bristles beneath, the third joint elongate, bluntly oval, thickly black-pubescent, the terminal arista twice as long as the antennæ, with dense black pubescence, so as to appear nearly as thick as the antenna itself. Palpi white; proboscis yellow. Thorax polished reddish yellow, the scutellum and metanotum brown, not pubescent, five pale dorsocentrals, the hindmost long, two scutellars. Abdomen with scattered pale hairs, those of the last segment long, apex of the four basal segments sometimes whitish; hypopygium longer than broad, with few hairs and with asymmetrical appendages visible. Legs slender, including the coxæ pale yellow, the anterior tibiæ and tarsi a little darker, hind tibiæ with only a slight apical swelling and with a single extensor bristle located at the middle, anterior femora with a fine basal hair beneath and all the femora with a preapical bristle on the front side. Halteres white; calypteres white

and with four long, pale hairs. Wings clear hyaline, veins yellowish, the outer half of the fourth and fifth veins darkest, costa provided with long, isolated hairs only on the basal half; in outline the wings are narrow, especially on the proximal portion, the anal angle almost entirely reduced; third section of the costa slightly longer than the second, and two and one-half times as long as the fourth section, third vein lightly sinuose, diverging from the fourth and with an anterior curve at its very apex, the submarginal cell beyond the second vein as wide as the first posterior, the anterior cross-vein short, located at three-fifths the length of the second basal cell, last two sections of the fourth vein proportioned 1 : 5, of the fifth vein, 5 : 3; marginal hairs long.

Thirty-five specimens: Manila, Philippine Islands, Robert Brown, collector, from the U. S. National Museum.

***Ctenodrapetis cuneipennis*, sp. nov.**

♀. Length 1.5 mm. Head globular, occiput glistening black, nearly bare, the vertical and ocellar bristles rather short, front narrow, its sides parallel, eyes contiguous below the antennæ; antennæ yellowish, without bristles beneath, the third joint slightly darker, bluntly lanceolate and densely short-pubescent, two and one-half times as long as wide, the terminal arista one and one-half times the antennal length, bushy with dense black pubescence so as to appear nearly as thick as the antenna itself. Palpi white; proboscis yellow. Thorax flavous, including the scutellum, metanotum and pleuræ, but with a brown spot above the root of each wing. The four basal segments of the abdomen whitish with very narrow, brown sclerites, the tergite of the fifth segment large, corneous and brown. Halteres white; calypteres with two pale hairs. Legs slender, pale yellow, the hind tibiæ with small apical spur and with two extensor bristles near the middle. Wings slender, hyaline, the veins pale, the anal angle very greatly reduced, the third section of the costa twice as long as either the second or the fourth, the third vein lightly sinuous and diverging from the fourth so that the submarginal cell is not nearly so broad as the first posterior, anterior cross-vein short, located before the middle of the second basal cell, the last two sections of the fourth vein proportioned about 1 : 3, of the fifth vein, 5 : 3, marginal hairs long.

One specimen: Manila, Philippine Islands, Robert Brown, collector; in the U. S. National Museum.

***Elaphropeza calva*, sp. nov.**

1.5 mm. long. Shining yellow species with yellow legs, the occiput polished black, the middle segment of the abdomen blackish; middle tibiæ denticulate within, spur of the hind tibiæ short, posterior cross-vein at the middle of the wing. Antennæ entirely yellow, the third joint ovate, one-half longer than broad, the arista microscopically pubescent and three times as long as the antennæ; front narrow, shining, face linear; occiput with a little pollen near the neck, the

yellow hairs and bristles prominent; mouthparts yellow. Hairs of the thorax long but sparse, scutellum and metanotum reddish brown; base and apex of the abdomen testaceous yellow, the pygidial valves rather large, lateral hairs of the middle segment scale-like. Legs hairy and moderately stout, the middle femora a little the strongest, front femora not setose, the distance between the bristles of the hind tibiæ less than one-third the length of the tibiæ, the terminal spur small and yellow. Wings narrow, more than three times as long as broad, veins yellow, second, third and fourth sections of the costa proportioned 1 : 1.8 : 0.8, sections of the fourth vein, 1 : 1 : 2.3, of the fifth vein, 1 : 0.4.

Six specimens: Corazal, Panama, and Motzorongo, Vera Cruz. Type in the U. S. National Museum.

***Elaphropeza comata*, sp. nov.**

♂. Length 1.75 mm. Head black, thorax entirely reddish, middle segments of the abdomen blackish, hairs and bristles pale, hind legs loosely pectinate. Front very narrow, almost linear; antennæ fuscous, without seta beneath, the third joint lanceolate, two times as long as broad, the arista twice as long as the antennæ, with short pubescence; palpi and proboscis yellow. Thorax rather hairy, four rows of about seven acrostichals, two scutellar bristles. Middle segment of the abdomen with many flattened setulæ, last tergite with long hairs, hypopygium elongate, with numerous hairs at apex and below. Legs yellow, the last tarsal joint dark, middle femora alone with preapical bristle, hind tibiæ without long extensor bristles, but instead with a series of about ten shorter, regularly placed, erect bristles, similarly the hind metatarsi provided with seven erect extensor bristles, spur of hind tibiæ very small and blunt. Halteres dusky, calypteres with eight dusky cilia. Wings rather broad, clear hyaline, the veins brown, the second, third and fourth sections of the costa proportioned 1.6 : 2.5 : 1, the third and fourth veins nearly straight, very slightly converging apically so that the widest part of the first posterior cell is just beyond the termination of the second vein, anterior cross-vein before the middle of the second basal cell, last two sections of the fourth vein proportioned 1 : 2, of the fifth vein, 3 : 1.

One specimen: Trinidad Island, West Indies, collected by August Busck, for the U. S. National Museum.

***Elaphropeza inflexa*, sp. nov.**

Length 1.4 mm. Occiput black, front narrowly V-shaped, at the bottom one-third as wide as the second antennal joint; antennæ rather short, blackish, the second joint without seta, the third joint broadly lanceolate, one-half longer than broad, the arista short-pubescent and one and three-fourths times as long as the antennæ; palpi short, whitish, proboscis red. Thorax, including the scutellum and metanotum luteous, unmarked, the hairs noticeable but scattered, four rows of about six acrostichals. Abdomen blackish, the sides of the middle segment with many minute scale-like setulæ, last tergite fringed but the elongate

hypopygium nearly bare. Legs yellow, the front femora with a short preapical bristle, that of the middle femora stronger, hind tibiae with two extensor bristles trisecting its length and with a short blunt terminal spur. Halteres dirty yellow, calypteres fringed with five cilia. Wings clear hyaline, the second, third and fourth sections of the costa proportioned 1.5 : 2.5 : 1, third vein with pronounced anterior curve, the fourth vein nearly straight, submarginal cell at the end of the first vein nearly as wide as the marginal cell, and beyond the end of the second vein narrower than the first posterior cell, which latter is widest at three-fourths its length, the last two sections of the fourth vein proportioned 1 : 2.7, of the fifth vein, 2 : 1, marginal cilia short.

Four specimens, Canal Zone, Panama, collected by August Busck for the U. S. National Museum. The species is near *formosæ* Bezzi, but has a longer arista.

***Elaphropeza læta*, sp. nov.**

♂, ♀. Length 1.7 mm. Shining yellow, with yellow antennæ, mouthparts and legs, the scutellum, metanotum, abdomen and a prescutellar spot blackish; middle tibiae denticulate within, front femora not black setose. Head black except the posterior oral margin, occiput cinereous-pollinose, front very narrow, almost linear, shining, eyes of male contiguous below the antennæ, obliterating the face, in the female the eyes are subcontiguous; vertical bristles brown, palpal setæ yellow; third antennal joint ovate, one-half longer than broad, the arista closely but microscopically pubescent, brown, two and a half times as long as the antennæ. Hairs of the thorax moderately abundant and long, bristles yellow. Middle segment of the abdomen darkest, with lateral flattened setulæ, pygidium sericeous. Legs rather slender, front femora sparsely ciliate below, middle femora with strong preapical bristle, not denticulate below, the antero-flexor edge of the hind femora with stiff yellow setæ, six outstanding extensor hairs toward the base of the hind femora, hind tibiae with a rather strong black terminal lappet, the two extensor bristles separated by less than one-third the length of the tibia. Wings three times as long as broad, veins strong and brown, second, third and fourth sections of the costa proportioned 1 : 1.3 : 0.8, third and fourth veins straight, slightly diverging, sections of the fourth vein proportioned 0.9 : 1 : 2.2, of the fifth vein. 1 : 0.4.

Five specimens: Alhajuelo, Panama; August Busck, collector. Type in U. S. National Museum.

Var. ***ungulifera***, new. A male specimen from Corozal, Panama, differs in having the spur of the hind tibia long, very slender and curved, measuring as long as the third tarsal joint. The scutellum is reddish and the prescutellar spot is lacking. The veins are light yellow and not coarse.

Var. ***nigrocalcarata***, new. A male specimen from Alhajuelo, Panama, differs in having the spur of the hind tibia very large and broad and black, so it contrasts markedly with the remainder of the legs. The

prescutellar spot is lacking but the scutellum is blackish like the metanotum and abdomen. The upper occipital orbits are polished and the veins are only moderately brown. The wings of both variations are less than three times as long as broad. Possibly these specimens represent distinct species. They are deposited in the U. S. National Museum.

***Elaphropeza luteicollis*, sp. nov.**

Length 1.5 mm. Slender, the head and abdomen black, thorax reddish, legs yellow, apex of the tibiæ black, hairs and bristles yellow. Front narrow, its sides slightly converging below, at the bottom one-fourth as wide as the second antennal joint, eyes separated by a line beneath the antennæ; palpi white, proboscis short, brown; antennæ horizontal, yellow, no seta beneath, the third joint lanceolate, one-half longer than wide, the arista two and six-tenths times as long as the antennæ, its pubescence close and short. Thorax reddish yellow, the metanotum and rarely the scutellum brown, hairs very sparse, two rows of two acrostichals, only four hairs in the dorsocentral rows. Sides of middle abdominal segment with flattened setulæ; hypopygium black, nearly bare. Hind tibiæ with two extensor bristles trisecting its length, the terminal spur long and sharp. Halteres yellow. Wings clear hyaline, veins narrow, light brown, marginal cell moderately long, the second, third and fourth sections of the costa proportioned 1 : 1.8 : 1, the third and fourth veins straight, uniformly and slightly diverging, the first posterior cell widest at the apex, the anterior cross-vein at the middle of the second basal cell, last two sections of the fourth vein proportioned 1 : 3, of the fifth vein, 1.8 : 1.

Forty specimens, collected by August Busck for the U. S. National Museum in various places in the Canal Zone of Panama.

***Elaphropeza nigricans* sp. nov.**

♂. Length 1.7 mm. Near *tenera* but with longer antennæ, shorter arista and more hairy body. Front narrowly V-shaped, at the bottom one-third as wide as the second antennal joint; ocellar and vertical bristles long and blackish; antennæ black, the second joint without long seta, the third joint lanceolate, twice as long as wide, the terminal arista scarcely longer than the antennæ, short-pubescent; eyes nearly contiguous below the antennæ; palpi white, and with a few white hairs; proboscis short and brown. Thorax polished black, but uniformly covered with long, black hairs, forming four rows of acrostichals with about eight hairs to each row, prescutellar and scutellar pairs of bristles long and black. Abdomen shining black, the sides of the middle segment with many scale-like setulæ; hypopygium minute. Legs yellow, the outer third of hind femora brown, hind tibiæ with two extensor bristles and with a very short and blunt apical spur. Halteres whitish; calypteres with five dusky hairs. Wings clear hyaline, veins narrow but dark, the second, third and fourth sections of the costa proportioned

1.5 : 2 : 1, the third and fourth veins straight, very slightly divergent, the last two sections of the fourth vein proportioned 1 : 2.7, of the fifth vein, 2.5 : 1, hairs of hind margin short.

One specimen: Corazal, Canal Zone, Panama, March. Collected by August Busck for the U. S. National Museum.

***Elaphropeza pleuralis*, sp. nov.**

Length 2 mm. Robust, yellow species marked with black, hairs and bristles yellow. Occiput polished black, the occipital bristles longer than the ocellar; front very narrow, its sides converging below, at the bottom one-fourth as wide as the second antennal joint, eyes almost contiguous below the antennæ; palpi pale yellow and with a few yellow hairs, proboscis luteous; antennæ horizontal, pale yellow, the second joint with a circle of setulæ but without seta beneath, third joint short-lanceolate, one and one-half times as long as wide, the terminal arista pubescent, two and one-half times as long as the antenna. Thorax luteous, marked with a black, prescutellar spot, which is round in front and includes the scutellum and metanotum behind, a round prealar spot on the mesopleuræ, encroaching on the sternopleura; mesonotal hairs sparse, two rows of four acrostichals, a pair each of prescutellar and scutellar bristles. Abdomen yellow, not chitinized except the black middle segment and the narrow one following, sides of these segments with many flattened black setulæ; last tergite fringed with hairs, hypopygium small, elongate, rather hairy. Legs yellow, the last tarsal joint black, only the middle femora with preapical bristle, spur of the hind tibiæ long, blunt, brown, two extensor bristles on the hind tibiæ, one at the middle and one half-way to the knee. Halteres whitish, calypteres dark, with seven brown cilia. Wings clear hyaline, veins thin and brown, the second, third and fourth sections of the costa proportioned 1.5 : 2.5 : 1, the third and fourth veins parallel, the submarginal cell at the end of the first vein one-half as wide as the marginal and at the end of the second vein equal to the first posterior, last two segments of the fourth vein proportioned 1 : 2.7, of the fifth vein, 2.5 : 1, marginal cilia short.

Four specimens: Alhajuelo, Panama, and Orizaba, Vera Cruz; from the U. S. National Museum.

***Elaphropeza plumea*, sp. nov.**

♀. Length 2.2 mm. Robust shining yellow species with black occiput and heavily pubescent arista, discal cell large. Front very narrow, almost linear, shining black, face linear and black, occiput finely gray pollinose, cheeks and proboscis yellow, palpi large and white, epistome white pollinose; vertical bristles black; antennæ yellow, the second joint with uniform setulæ, the third joint ovate, one-half longer than broad, the blackish arista including its dense hairs appearing as thick as one-half the diameter of the third joint. Thoracic hairs moderately dense, the bristles yellowish; tip of the scutellum, center of the metanotum and a prescutellar spot brown. Middle segment of the

abdomen brown and with flattened lateral setulæ. Legs slender, flexor hairs of the front femora long and yellow, middle tibiæ armed within with two rows of minute hook-like black setulæ, the apex angulate and black, hind tibiæ with two extensor bristles located before the basal third and beyond the apical third, the apical lappet sharp and rather strong. Halteres yellow. Wings narrow, more than three times as long as wide, veins yellow, second, third and fourth sections of the costa proportioned 1 : 1.3 : 0.6, third and fourth veins nearly straight and parallel, sections of the fourth vein proportioned 1 : 1 : 2.2, of the fifth vein, 2.5 : 1.

One specimen: Orizaba, Mexico (H. H. Smith); in author's collection.

***Elaphropeza rectineura*, sp. nov.**

Length 1.6 mm. Robust, yellow species, with pale hairs and bristles, last tarsal joint blackish. Head black, front narrow, the sides slightly converging below, at the bottom one-third as wide as the second antennal joint, ocellar bristles long, eyes contiguous beneath the antennæ; palpi white, proboscis short, yellow; antennæ yellow, the second joint without seta, the third joint broadly lanceolate, scarcely twice as long as broad. Thorax loosely hairy, two rows of six acrostichals, scutellum yellow, with lateral bristle one-fourth as long as the apical pair, metathorax yellow. Abdomen brownish yellow in the middle segments, where laterally there are many minute flattened setulæ. Middle femora alone with preapical setulæ, hind tibiæ with two long extensor bristles trisecting its length, the apical spur short and blunt. Halteres yellow, calypteres with five cilia. Wings clear hyaline, rather broad and rounded, marginal cilia short, the second, third and fourth sections of the costa proportioned 1 : 2 : 1, the third and fourth veins nearly straight, uniformly but slightly diverging, the first posterior cell widest at its apex, anterior cross-vein before the middle of the second basal cell, the outer two sections of the fourth vein proportioned 1 : 2.7, of the fifth vein, 2 : 1.

Two specimens: Tabogal and Corazal, Panama, collected by August Busck for the U. S. National Museum.

***Elaphropeza seminigra*, sp. nov.**

♂. Length 2.5 mm. Partly testaceous yellow and partly black. Occiput black, the upper orbits largely shining, the remainder pollinose, ocellar bristles brown, reaching to the antennæ, vertical bristles long and black; front very narrowly triangular; antennæ yellow, the third joint but slightly longer than deep, its blackish arista three times the length of the antenna proper, closely and evidently pubescent; palpi yellow, proboscis tipped with black. Thorax shining, the mesonotum broadly yellow about the shoulders, medially black, the dark coloring extending from side to side at the wings, bristles and hairs long and yellow, four rows of scattered acrostichals; scutellum and metanotum black, the apical pair of scutellar bristles approximate, long and cruciate;

pleuræ irregularly marked with black and reddish yellow, the mesopleuræ blackened except toward the coxæ. Abdomen yellowish, the middle and apical segments black, scales of the middle segment prominent on a gray velvety setting, abdominal hairs yellow. Legs yellow, the tarsi becoming dusky at the apex, front legs devoid of setulæ, middle femora and tibiæ with close-set rows of black setulæ, anterior femora with a long basal, yellow bristle underneath, hind tibiæ with a single black extensor bristle at two-fifths its length, the apical spur blackened, curved and pointed. Halteres pale yellow. Wings yellowish hyaline, their roots yellow, veins brown, costal sections proportioned 4 : 1.5 : 2.5 : 1, third and fourth veins parallel toward the end, anterior cross-vein at middle of the second basal cell, posterior cross-vein at the middle of the wing, sections of the fifth vein 2 : 1, costal hairs conspicuous.

Two specimens: San Jose, Costa Rica, March, 1915, received from Dr. A. H. Sturtevant.

***Elaphropeza simplicipes*, sp. nov.**

Length 1.5 mm. Yellow, head cinereous black, scutellum, metanotum, middle segment of the abdomen and a vague prescutellar spot blackish, antennæ, mouthparts and legs yellow, middle tibiæ of the male with microscopic denticles within, of the female without denticles. Front narrow, shining, its sides nearly parallel, face linear, white-pollinose, vertical bristles brownish, third antennal joint conical, one-half longer than broad, the arista microscopically pubescent, about two and one-third times the antennal length. Mesonotum with sparse hairs, its bristles yellow; lateral setulæ of the middle segment of the abdomen flattened; upper valve of the brownish pygidium rounded and sericeous, the apical fringes short. Legs rather slender and short, front femora without black setæ, the two extensor bristles of the hind tibiæ close together, the apical spur moderate, yellowish, velvety and rather acute, last tarsal joint not dark. Wings less than three times as long as broad, veins yellow and thin, second, third and fourth sections of the costa proportioned 1 : 1.7 : 1, third and fourth veins straight and slightly diverging, sections of the fourth vein proportioned 1 : 1 : 2.2, of the fifth vein, 1 : 0.4.

Montego Bay and Balaklava, Jamaica. Type in the Boston Society of Natural History.

A male specimen from Victoria, Texas, in the U. S. National Museum, is associated here. It is larger, measuring two millimeters, has the outer antennal joint dark, the metanotum reddish and the last tarsal joint dusky. Although phyletically it probably represents a distinct species the visible differences are too slight to utilize.

***Elaphropeza tenera*, sp. nov.**

Length 1.5 mm. Polished black of a brownish tinge, hairs very sparse and pale. Front narrow, the sides nearly parallel, at the bottom less than one-half the width of the second antennal joint; ocelli minute,

the ocellar bristles long; eyes nearly touching below the antennæ; palpi broad, white, with a couple of white bristles, proboscis yellow; antennæ short, yellow, the last joint short-lanceolate, one and one-half times as long as wide, the arista three times the antennal length, microscopically pubescent. Hairs of middle abdominal segment strong, but not scale-like in the Trinidad specimen; hypopygium small. Legs including the coxæ pale yellow, slender, the front trochanters with a black dot, apex of hind tibiæ blackish in the Trinidad specimen, middle femora alone with preapical bristle, hind tibiæ with two extensor bristles, the outer one small, the apical spur long and thumb-like. Halteres whitish; calypteres with four pale cilia. Wings clear hyaline, veins pale, the third section of the costa one and one-half times either the second or fourth section, the third and fourth veins straight, slightly diverging, the last two sections of the fourth vein proportioned 1 : 4, of the fifth vein, 2 : 1, wing margin ciliate.

Two specimens. Porto Bello, Panama, March 13, 1911, in the collection of the U. S. National Museum, and Montserrat, Trinidad Island, June 29, both collected by August Busck.

***Elaphropeza uniseta*, sp. nov.**

♀. Occiput black, lightly pollinose, a spot on each side of the vertex shining, ocellar and vertical bristles short and black; front very narrow, linear, eyes subcontiguous beneath the antennæ; palpi and proboscis yellow, the palpi with scattered blackish hairs; antennæ horizontal, brown, the third joint triangular, twice as long as deep, the blackish arista slender, microscopically and closely pubescent, twice as long as the antennæ. Thorax shining reddish yellow, mesonotum with a median vitta abbreviated behind, and with a spot above the notopleural suture dark brown, center of the scutellum and the inflated sides of the first abdominal segment also brown; abdomen weakly chitinized except the middle segment whose sides are thickly studded with black scale-like setulæ; hairs of the thorax fine, dark, confined to the anterior region, comprising a few posthumeral and four definite rows of acrostichals with about five hairs to each row; presutural dorsocentral long, scutellum with two long cruciate bristles. Legs including the coxæ yellow, a little dusky distally, anterior femora with basal hair below, middle femora with a strong preapical bristle, hind tibiæ with a single strong extensor bristle located below the middle and with a broad blunt apical spur. Knob of halteres blackish; calypteres small but with a fan-like fringe of dark cilia. Wings hyaline, veins yellow, first vein ending beyond the middle, third section of the costa about three times either the second or the fourth section, marginal cell at the end of the first vein nearly twice as wide as the submarginal, the latter at the end of the second vein as wide as the first posterior cell, third vein lightly sinuous, converging with the fourth on its outer portion, anterior cross-vein before the middle of the second basal cell, the outer two sections of the fourth vein proportioned 1 : 2, of the fifth vein, 3 : 1, costa with a basal hair, but not long ciliate, hairs of the posterior margin of the wings very short.

One specimen: Manila, Philippine Islands, Robert Brown, collector, in the U. S. National Museum.

Elaphropeza upsilon, sp. nov.

♂. Length 1.5 mm. Largely yellow with yellow legs and antennæ, the posterior part of the mesonotum marked with a broad U-shaped mark, hind tibiæ with a single extensor bristle located just before its middle, middle tibiæ microscopically denticulate along the flexor side. Head black, occiput pollinose up to the eyes, face linear, white-pollinose; mouthparts yellow; third antennal joint short-ovate, the arista less than three times as long as the antennæ and microscopically pubescent; vertical and ocellar bristles yellow. Hairs of the mesonotum rather sparse and long, bristles yellow; the black mark fills the posterior half of the mesonotum except in the middle and except the postalar callus; scutellum, metanotum and middle segment of the abdomen black, the middle segment of the abdomen with scale-like setulæ along the sides; pygidium brown, glabrous except the marginal fringe. Hind tibiæ with a moderate, acute, yellow, velvety, terminal lappet. Veins brown, second and third sections of the costa nearly equal, third and fourth veins nearly parallel, sections of the fourth vein proportioned 1 : 1 : 2.2, of the fifth vein, 1 : 0.4.

Jamaica (Brues). In author's collection.

Elaphropeza vittata, sp. nov.

♀. Length 1.8 mm. Robust, yellow marked with black. Occiput black, lightly pollinose, its bristles and the ocellars pronounced; front linear, its sides parallel, eyes separated below the antennæ by a dense row of microscopic white hairs; palpi white and with white hairs, proboscis yellow; antennæ destroyed. Thorax polished reddish yellow, marked with a black vitta which is broadest behind and there includes the scutellum and metanotum and meets a black pleural vitta. The median vitta is not sharply bounded, the pleural vittæ fill the meso- and meta-pleuræ. The thoracic hairs are rather long and isolated, two rows of six acrostichal hairs, a pair each of prescutellar and scutellar bristles. Abdomen pale yellow, only the middle segment fully chitinized, the basal segments with only small lateral sclerites, the sides of the middle segment with many glistening scale-like setulæ. Legs yellow, the anterior tibiæ and all of the tarsi a little brownish, anterior femora with a moderate preapical bristle, hind tibiæ with two strong extensor bristles trisecting their length, their terminal spur long and sharpened, pale brown. Halteres white; calypteres ciliate with five brown hairs. Wings clear hyaline, veins yellow, third section of the costa nearly twice as long as the second or fourth, third and fourth veins parallel at the end, anterior cross-vein before the middle of the second basal cell, outer sections of the fourth vein proportioned 1 : 2.5, of the fifth vein, 3 : 1, hind margin with short cilia.

Type specimen from the U. S. National Museum, labeled "on pineapple," Lemon City, Florida, April 12, 1899. A defective specimen from Havana, Cuba, (Dr. A. H. Sturtevant), is apparently the same, differing in that the pleural blackening is less pronounced.

BIBLIOGRAPHIC LIST OF THE SPECIES OF *Drapetis*.A. Subgenus *Drapetis* Meigen, sens. str.

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nigra MELANDER, not MEIGEN, Tr. Am. Ent. Soc. xxviii. 208, f. 12, 17, 24 (1902).
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nigra MEIGEN, S. B. vi. 344 (1830); CURTIS, Brit. Ent. viii. 397 (1832); MACQUART, Suit. a Buff. i. 358 (1834); WALKER, List, iii. 511 (1849) occ. in Canada; WALKER, Ins. Brit. i. 136 (1851).
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- dividua** MELANDER.....W. North America
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fascipes ROSER, Württemb. Correspbl. i. 54 (1840).
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- latipennis** MELANDER.....Kansas, Wisconsin
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- xanthopyga** BEZZI.....N. Guinea
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B. Subgenus *Eudrapetis*, new subgenus.

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- diversipes*, new species..... California
- dorsiseta*, new species..... Costa Rica
- facialis*, new species..... Georgia, Alberta
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curvinervis ZETTERSTEDT, Dipt. Sc. i. 301 (1842) *Tachydromia*.
flexuosa LOEW, Progr. Posen, 1840, 23; Isis vii. 552 (1840); SCHOLZ, Zts. Ent. Bresl. v. (19) 60 (1851); LOEW Neue Beitr. vi. 39 (1859); SCHINER, F. A. Dipt. i. 96 (1862).
geniculata FALLEN, Empid. 7, part (1815) *Tachydromia*.
nigra ZETTERSTEDT, Dipt. Sc. i. 297 (1842) *Tachydromia*; BONSDORF, Finl. tv. Ins. i. 150 (1861) *Tachydromia*.
picipes ZETTERSTEDT, Dipt. Sc. i. 298 (1842) *Tachydromia*.
 var. **setigera** LOEW
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nuda, new species.....Africa
obscuripennis PHILIPPI, not BEZZI.....Chile
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parvicornis, new species.....Washington
pennescens, new species.....Peru
phæoptera BEZZI.....N. Guinea
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pubicornis BEZZI.....Formosa
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quadrissetosa, new species.....Mexico, Central America
scissa, new species.....W. United States
medetera MELANDER, part, Tr. Am. Ent. Soc. xxviii. 208, pl. 5, f. 22 (1902); COQUILLET Proc. Ent. Soc. Wash. v. 265 (1903) *Elaphropeza*; MELANDER, Ent. News, 372 (1906); BEZZI, Ann. Mus. Hung. v. 567 (1907) *Elaphropeza*.
septentrionalis MELANDER.....Michigan
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 var. **mexicana**, new variety.....Tampico
spectabilis MELANDER.....United States
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spinipes, new species.....Africa
unipila LOEW.....W. United States
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 var. **nitida** MELANDER.....W. United States
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- xanthopoda** WILLISTON part.....West Indies
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discoidalis BEZZI..... E. Indies
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gracilis BEZZI..... N. Guinea
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monochæta BEZZI..... Peru
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valdiviana PHILIPPI..... Chile
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D. Subgenus *Elaphropeza* Macquart.

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 Hung. ii. 359, note (1904) *Tachydromia*; MELANDER, Psyche, xvii. 52 (1910)
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basalis BEZZI..... Ceylon
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bicolor BEZZI..... N. S. Wales
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bicoloripes BRUNETTI..... E. Himalayas
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bihamata BEZZI..... N. Guinea
 BEZZI, Ann. Mus. Nat. Hung. ii. 353 (1904) *Drapetis*.
binotata MEIJERE..... Java
 MEIJERE, Tijdschr. Ent. Liv. 333 (1911) *Drapetis*; lvi. suppl. 75 (1914).
calcarifera BEZZI..... Formosa
 BEZZI, Ann. Mus. Hung. v. 267 and 268 (1907); x. 481 and 488 (1912).
callositibia BEZZI..... N. Guinea
 BEZZI, Ann. Mus. Nat. Hung. ii. 354 (1904) *Drapetis*; x. 480 (1912) *Drapetis*.
calva, new species..... Panama
comata, new species..... Trinidad

- dispar** ADAMS Rhodesia
ADAMS, Kans. Univ. Sci. Bul. iii. 157 (1905); BEZZI, Ann. Mus. Hung. v. 567 (1907); x. 480 (1912).
- ephippiata** FALLEN Europe
FALLEN, Empid. 11 (1815) *Tachydromia*; MEIGEN, Syst. Bes. iii. 65, pl. 23, f. 10 (1822) *Hemerodromia*; MACQUART, Dipt. Nord. Fr. iii. 87, pl. 2, f. 1 (1827); Hist. Nat. i. 359, pl. 8, f. 14a (1834); ZETTERSTEDT, Dipt. Sc. i. 326 (1842); BOITARD, Nouv. Man. iii. 325 (1843); WALKER, List. iii. 505 (1849); Ins. Saunders. i. 134, pl. 5, f. 4 (1851); SCHOLZ, Zts. Ent. Bresl. v. 60 (1851) (*ephippium*); SCHINER, F. A. Dipt. i. 95 (1862); STROBL, Mitth. Steierm. xxix. 127 (1892); MELANDER, Ent. News, xvii. 372 (1906) *Drapetis*; BEZZI, Ann. Mus. Hung. v. 567 (1907); LUNDBECK, Dipt. Dan. iii. 273, f. 123, 124 (1910); WAHLGREN, Ent. Tidskr. xxxi. 89 (1910); BEZZI, Ann. Mus. Hung. x. 482 (1912); FREY, Acta Soc. Fenn. xxxvii. (3) 75 (1913).
? *maculata* MACQUART, Mem. Soc. Sci. Lille, 153 (1823) *Tachydromia*.
- exul** OSTEN SACKEN Philippine Islands
OSTEN SACKEN, Berl. Zts. xxvi. 113 (1882); BEZZI, Ann. Mus. Hung. ii. 347; (1904); v. 567 (1907); x. 480 (1912) *Drapetis*.
- ferruginea** BRUNETTI India
BRUNETTI, Rec. Ind. Mus. ix. 43 (1913).
- flavicollis** BECKER E. Africa
BECKER, Bull. Mus. Paris 116 (1909) *Drapetis*; Ann. Soc. Ent. Fr. lxxix. 24 (1910) *Drapetis*; BEZZI, Ann. Mus. Hung. x. 482 (1913).
- flavida** WILLISTON W. Indies, C. and S. America
WILLISTON, Trans. Ent. Soc. Lond. iii. 308, pl. 11, f. 86 (1896) *Drapetis*; COQUILLET, Proc. U. S. N. Mus. xxii. 251 (1900) *Tachydromia*; WHEELER & MELANDER, Biol. C. Am. Dipt. i. 376 (1901) *Drapetis*; MELANDER, Mon. Empid. 213 (1902) *Drapetis*; COQUILLET, Proc. Ent. Soc. Wash. v. 265 (1903) *Tachydromia*; BEZZI, N. Act. Kais. Akad. xci. 397 and 398 (1909) *Drapetis*; MELANDER, Psyche, xvii. 52 (1910) *Ctenodrapetis*; 1910; BEZZI, Ann. Mus. Hung. x. 481 (1912).
fulvida BEZZI, Wien. Ent. Ztg. xxxiii. 144 (1904) *Tachista*.
xanthopoda WILLISTON part, Tr. Ent. Soc. Lond. iii. Appendix, 441, table (1896) *Drapetis*.
- formosæ** BEZZI Formosa
BEZZI, Ann. Mus. Hung. v. 566 (1907); x. 480 and 487 (1912).
- fulvithorax** v. D. WULP Ceylon
WULP, Termes, Fuzet. xx. 138 (1897); Tijdschr. Ent. xlii. 49 (1899); BEZZI, Ann. Mus. Hung. ii. 347 (1904); v. 567 (1907); x. 480 (1912); MEIJERE, Tijd. Ent. lvi. suppl. 73 (1914).
- hirsutitibia** MEIJERE Java
MEIJERE, Tijd. Ent. lvi. suppl. 73 (1914).
bihamata MEIJERE, not BEZZI, Tijd. Ent. liv. 332 (1911) *Drapetis*.
- inflexa**, new species Panama
- Kerteszi** BEZZI Formosa
BEZZI, Ann. Mus. Hung. x. 481 and 486 (1912); MEIJERE, Tijd. Ent. lvi. suppl. 74 (1914).
- læta**, new species Panama
var. **nigrocalcarata**, new var. Panama
var. **ungulifera**, new var. Panama
- lanuginosa** BEZZI Formosa
BEZZI, Suppl. Entom. iii. 75 (1914).
- lineola** MEIJERE Java
MEIJERE, Tijdschr. Ent. liv. 331 (1911); lvi. suppl. 75 (1914).
- lutea** MEIJERE Java
MEIJERE, Tijdschr. Ent. liv. 332 (1911); lvi. 76 (1914).
- luteicollis**, new species Panama

- marginalis** BEZZI Formosa
 BEZZI, Ann. Mus. Hung. x. 481 and 489 (1912).
- melanura** BEZZI Formosa
 BEZZI, Ann. Mus. Hung. x. 481 and 489 (1912).
- metatarsata** BEZZI Ceylon
 BEZZI, Ann. Mus. Hung. ii. 348 (1904); v. 567 (1907); x. 482 (1912).
- nigricans**, new species Panama
- obliquinervis** MEIJERE Java
 MEIJERE, Tijdschr. Ent. suppl. 73, pl. 2, f. 9 (1914).
- palpata** MEIJERE Java
 MEIJERE, Tijdschr. Ent. liv. 330 (1911); lvi. suppl. 76 (1914).
- pictithorax** BEZZI Formosa
 BEZZI, Ann. Mus. Hung. x. 482 and 486 (1912).
- pleuralis**, new species Vera Cruz, Panama
- plumea**, new species Mexico
- rectineura**, new species Panama
- scutellaris** BEZZI Formosa
 BEZZI, Ann. Mus. Hung. x. 481, 482, 487 (1912).
- seminigra**, new species Costa Rica
- simplicipes**, new species W. Indies
- spuria** BEZZI N. Guinea
 BEZZI, Ann. Mus. Hung. ii. 347 (1904); v. 567 (1907); x. 480 (1912).
- tenera**, new species Trinidad, Panama
- uniseta**, new species Philippine Islands
- upsilon**, new species W. Indies
- variata**, new name India
variegata BRUNETTI (bis) Rec. Ind. Mus. ix. 42 (1913).
- variegata** BRUNETTI Burma
 BRUNETTI, Rec. Ind. Mus. ix. 39 (1913) *Drapetis*.
- vittata**, new species Florida
- xanthocephala** BEZZI Formosa
 BEZZI, Ann. Mus. Hung. x. 481 and 488 (1912).

NYMPHS, NAIADS, AND LARVÆ.

By J. H. COMSTOCK.

"*Yon nymphs, called naiads, of the wand'ring brooks.*"
—*Shakespeare.*

The object of this note is to propose an addition to the terminology of the metamorphoses of insects, which I believe will tend to make more clear certain fundamental distinctions now generally recognized.

The older entomologists recognized two types of postembryonic development of insects. These types were distinguished by various terms, but were most commonly described as *incomplete metamorphosis* and *complete metamorphosis*. The term *larva* was applied by these writers to the early stages of all insects, those undergoing an incomplete metamorphosis as well as those in which the metamorphosis is complete.

At a later period, during the last quarter of the last century, it was found desirable to distinguish the early stages of insects with a complete metamorphosis from those of insects with an incomplete metamorphosis; hence the term *larva* was restricted to the young of insects with a complete metamorphosis and the term *nymph*, which had been formerly used as a synonym of pupa, was applied to the young of insects with an incomplete metamorphosis.

In the earlier descriptions of these two types of metamorphosis account was taken only of the difference in degree of the change in the form of the body that distinguishes the two types; in one the change is partial or incomplete, in the other it is complete. The fundamental reason for this difference was not generally appreciated although it was understood by some writers.

Fritz Muller in his "Für Darwin" (1864) points out clearly the essential difference between incomplete metamorphosis and complete metamorphosis and in discussing the latter makes the aphorism, "There were, I believe, perfect insects before larvæ and pupæ." The significance of this aphorism should be clearly understood by every student of entomology, which is far from being the case. This is shown by the fact that frequently writers refer to larval characteristics as being more generalized than the corresponding characteristics of the adult.

The fundamental fact that should be understood is that larvæ, *i. e.*, the young of insects with a complete metamorphosis, exhibit a cenogenetic or sidewise development. Here the form of the body bears but little relation to the form to be assumed by the adult, the nature of the larval life being the controlling factor. While the ontogeny of an orthopterous insect can be taken as an indication of the course of the phylogeny of the race to which it belongs, this obviously is not the case with representatives of the Diptera or the Lepidoptera. In these orders, and in others with a complete metamorphosis, the larvæ have been sidewise developed while the adults have continued their specialization in a direct line. This is an illustration of the fact pointed out by Darwin in his "Origin of Species," that at whatever age a variation first appeared in the parent it tends to reappear at a corresponding age in the offspring.

The more striking of the adaptive characteristics of larvæ are: the form of the body; the internal development of wings; and the retarding of the development of the compound eyes. It is obvious that the restriction of the application of the term larva to the designating of this type of immature insect is a useful one.

Let us now study those immature insects to which the term nymph has been applied, those that were formerly classed as having an incomplete metamorphosis.

It is now quite generally recognized that this group of insects included those exhibiting two quite distinct types of metamorphosis: first, those, as the Orthoptera and Hemiptera for example, in which the development is direct; and second, those in which there is a cenogenetic development. The second group includes the Plecoptera, the Odonata, and the Ephemera.

In this second group the ontogeny of the individual does not represent the phylogeny of its race. The recognition of this fact has led to the introduction of a term indicating a third type of metamorphosis. We have, therefore, in the more recent textbooks the following categories, in addition to development without metamorphosis, which is characteristic of the Thysanura and Collembola.

First, *gradual metamorphosis* or paurometabolous development. This is characteristic of the Orthoptera, Hemiptera, *et al.*

Second, *incomplete metamorphosis* or hemimetabolous development. This is characteristic of the Plecoptera, Odonata, and Ephemera.

Third, *complete metamorphosis* or homometabolous development. This is characteristic of the Diptera, Lepidoptera, *et al.*

The features of the cenogenetic development of insects with an incomplete metamorphosis, as the term is now restricted, are very different from those of the cenogenetic development of insects with a complete metamorphosis. In insects with an incomplete metamorphosis the immature stages are modified so as to fit them for aquatic life; the more striking features of larvæ, the elongate form of the body, the internal development of wings, and the retarding of the development of the compound eyes are not exhibited by them.

From this it can be seen that the immature stages of the Plecoptera, the Odonata, and the Ephemera differ fundamentally from those of insects with a gradual metamorphosis on the one hand and from those of insects with a complete metamorphosis on the other; and that the reasons that make desirable the restriction of the use of the term larva to designate the young of insects with a complete metamorphosis make desirable a distinctive term for the sidewise developed young of those with an incomplete metamorphosis.

I, therefore, propose the restriction of the term *nymph* to the designating of the early stages of insects with a gradual metamorphosis and the use of the term *naiad* for designating the immature stages of the Plecoptera, Odonata, and Ephemera.

If this proposal is adopted the three terms, nymph, naiad, and larva will each indicate a distinct type of immature insect; and their use will tend to emphasize the distinctive characteristics of the three types of metamorphosis.

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THE THORACIC SCLERITES OF HEMIPTERA
AND HETEROPTERA.*

With Notes on the Relationships Indicated.

BY LELAND H. TAYLOR.

INTRODUCTION.

This paper is intended primarily as a contribution to the morphology of the thoracic sclerites of "Hemiptera" (*sensu lato*). Incidentally it may offer some suggestions as to the relationships of the families of the order, but these can be only suggestions, since the morphology of the thorax alone can contribute but a share toward the determination of phylogeny or relationships.

But little has been written on the morphology of the Hemipterous thorax. A number of articles were found dealing with a certain family, genus, or species, but in most instances the thorax was not studied in detail and generally no attempt was made to harmonize the results with the present day conception of the thorax, or to use a terminology applicable to all insects.

Thanks are due Doctor G. C. Crampton for his assistance in interpreting the homologies of the sclerites and for the loan of valuable material to work with. His papers (Crampton, 1908-09, 1914A, 1914B, 1914C) have been indispensable in the preparation of this paper, and the nomenclature employed by him has been generally adopted here. The writer would also express his thanks to Doctor H. T. Fernald for his interest and helpful criticism.

* Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass. This paper is presented as part of a thesis for the degree of Master of Science.

It has seemed advisable in this study to make drawings of at least one thoracic segment of a member of each available family of the Hemiptera. It is not necessary to present all of these, for many families resemble each other closely in the thoracic structure and separate drawings of these would be largely repetitions. One or two families, on the other hand, are omitted owing to an unfortunate lack of suitable specimens for study. The observations on the Psyllidæ as well as Figures 10 and 11 have been derived from the excellent monograph of Crawford, 1914, on that family, the present writer having been unable to secure specimens for study. Only drawings of such forms as show marked deviation from the simpler type, and of such individuals as offer features of particular interest are presented.

A slight attempt has been made at the end of the paper to group those families which from their thoracic sclerites appear to be more closely related. The grouping is made without regard to other morphological features and thus may not be entirely correct. It is hoped, however, that it may suggest, in combination with other morphological characters, some idea of the evolutionary development of the Hemiptera.

Having studied only a limited number of species representing a family, the writer does not care to state that the characters of these species obtain throughout the family. For convenience, however, family names have been largely used in this paper where specific names would have been more correct, it being understood that, so used, they imply only those species studied by the writer. Nevertheless, there is apparently not much variation in a family, and one species may be considered as more or less typical of the entire family.

LIST OF FORMS STUDIED.

In the preparation of this paper the following families and their representatives were studied. The writer has not attempted to arrange these in any logical order, but has followed the sequence of families in Comstock's "Manual" for the Homoptera and that of Banks' "Catalogue of the Nearctic Hemiptera-Heteroptera" for the Heteroptera.

SUBORDER HOMOPTERA.

FAMILY	EXAMPLES STUDIED	FIGURES
Cicadidæ.....	<i>Cicada tibicen</i>	1, 2, 3, 4, 5
	<i>Cryptotympana epithesia</i> .	
Fulgoridæ.....	<i>Fulgora</i> sp.....	9
	<i>Ormenis</i> sp.....	8
	<i>Amphiscepa bivittata</i> .	
Cercopidæ.....	<i>Aphrophora</i> sp.....	6
Jassidæ.....	<i>Draculacephala</i> sp.....	7
Membracidæ.....	<i>Ceresa</i> sp.....	
Psyllidæ.....	<i>Apsylla cistellata</i>	10
	<i>Arytaina robusta</i>	11
Aphididæ.....	<i>Pemphigus acerifolia</i>	12
Aleyrodidæ.....	<i>Aleyrodes vaporariorum</i>	13

SUBORDER HETEROPTERA.

FAMILY.	EXAMPLES STUDIED.	FIGURES.
Corixidæ.....	<i>Corixa</i> sp.....	19
Notonectidæ.....	<i>Notonecta</i> sp.....	15, 16
Nepidæ.....	<i>Ranatra</i> sp.....	17
	<i>Nepa cinerea</i> .	
Belostomatidæ.....	<i>Belostoma americana</i>	18, 20
	<i>Zaitha</i> sp.	
Reduviidæ.....	<i>Sinea</i> sp.	
Emesidæ.....	<i>Emesa</i> sp.....	14
Nabidæ.....	<i>Corsicus</i> sp.....	24
Cimicidæ.....	<i>Cimex lectularius</i> .	
Gerridæ.....	<i>Gerris</i> sp.....	21
Capsidæ.....	<i>Poecilocapsus</i> sp.	
Phymatidæ.....	<i>Phymata</i> sp.	
Tingitidæ.....	<i>Corythuca</i> sp.	
Lygaeidæ.....	<i>Lygaeus</i> sp.	
Berytidæ.....	<i>Neides</i> sp.....	22
Coreidæ.....	<i>Anasa tristis</i>	23
	<i>Metapodius</i> sp.	
Pentatomidæ.....	<i>Brochymena</i> sp.	
	<i>Podisus</i> sp.	
Thyreocoridae.....	<i>Thyreocoris</i> sp.....	25

GENERAL CONSIDERATIONS.

The Hemipterous thorax, while peculiarly developed in its higher forms, is in the more generalized individuals easily comparable to that of other insects. Indeed, the points of similarity between the thorax of *Cicada* and that of certain Neuroptera (*Mantispa* or *Corydalis*, for example) are very marked. In each of these forms the notum is similarly divided. Homologous plates occur at the base of the wings of each. The pleura, particularly, of these forms resemble each other, the episterna and epimera being in all cases divided into upper and lower portions by sutures. In certain Neuroptera, also, we find a third, median sclerite in the episternum homologous with a similar piece in certain Cicadidæ. The coxæ and sterna are also much alike in both Neuroptera and Cicadidæ.

DESCRIPTION OF A GENERALIZED HOMOPTEROUS THORAX.

Suborder Homoptera, Family Cicadidæ; *Cicada tibicen*, *Cryptotympana epithesia*. Figures 1, 2, 3, 4, 5.

These insects have been selected for detailed description as being probably rather primitive Hemiptera. They have the additional advantage of being comparatively large and therefore easy to study.

Between the thorax and the head are three pairs of small, free plates, the cervical intersegmentalia (Figures 2 and 3, is). These probably belong, partly to the head, partly to the prothorax. They may all be included under the term veracervix of Crampton, 1914B.

Prothorax. Figure 3.

This segment, as compared with the prothorax of the more specialized forms, is small, overlapping only a slight portion of the mesothorax.

Notum. Figure 3. The notum or tergum occupies the larger part of this segment, extending downward laterally for a considerable distance. There is a narrow pretergite (prt) marked off on the anterior margin and connected with the pleuron by a lateral extension which is homologous with the prealare (pra) in the wing bearing segments. There are no distinct sutures in the pronotum, but there are several grooves or furrows which mark off a triangular prescutum (psc), a scutum (sc), which is narrow mesally and widens as it approaches the pleuron, and a scutellum (sl), a rectangular band along the rear margin of the segment. The postscutellum is probably not represented in this segment.

Pleuron. Figures 2 and 3. The pleuron of the prothorax is much reduced and is closely joined to the notum. It is divided into an anterior portion, the episternum (es), and a posterior portion, the epimeron (em), by a short pleural suture (p). The episternum is small and is connected with the sternum by a narrow precoxal bridge, the precoxale (pcx), from which it is not distinctly separated. The epimeron is larger, overlapping the mesopleuron to some extent. It likewise is joined to the sternum, by a postcoxal bridge, the postcoxale (poc). The trochantin (tn) is rather broad, and when in position partly overlaps the base of the coxa (cx).

Sternum. Figures 2 and 3. The sternum (st) of the prothorax is narrow from front to rear and apparently consists of but one sclerite, which bears the furca, an interior projecting fork for muscle attachment. The coxa is divided into a front portion, the veracoxa (vcx), and a rear portion, the meron (me).

Mesothorax. Figures 1, 2 and 4.

The mesothorax is by far the largest and most typical segment.

Notum. Figures 1 and 4. The mesonotum, as in most insects, is divided primarily into two distinct plates. The first, which is that part of the notum visible externally, is roughly pentagonal in shape and is called the scuto-scutellum by Crampton, 1914A, 1914B. This portion has often been called notum, but this term should be applied only to the whole dorsal region of the segment. The second primary division of the notum is the postscutellum, which is concealed behind and somewhat beneath the scuto-scutellum, and hence is not shown in the figures.

The scuto-scutellum is in turn subdivided by various infoldings of chitin into several parts. The foremost of these is the anterior phragma (aph), which projects under the pronotum and is connected with it by membrane. Immediately behind this is the pretergite (prt), which is narrow and is fused with the rather large, bilobed prealare (pra) on either side. The latter, as is usual in the Hemiptera, connects the notum with the pleuron, anterior to the wing. Two distinct, nearly longitudinal sutures, which approach each other posterior to the middle of the tergum, mark off the prescutum (psc). The scutum (sc) is an ill-defined region just posterior to the prescutum, extending downward on either side and forming the major part of the whole scuto-scutellum. Where the scutum articulates with the wing base a small piece, the suralare or supralare (sr), is partly marked off by a cleft extending forward. (In some insects this piece is entirely separated from the scutum by a suture.) Another cleft extending backward partly defines a similar piece. These two pieces articulate with a free plate, the notopterale (npt), which forms one of the principal connections with the wing. The tegula (tg) in the Cicada is poorly chitinized, but its homologue is clearly seen in the membrane anterior to the base of the fore wing (Figure 1). A broken suture nearly parallel with the posterior margin of the

scuto-scutellum demarks the scutellum (sl). The posterior edge of the scutellum is produced on either side to a point which connects with the anal margin of the wing. Just anterior to this point, imbedded in the membrane, occurs a small triangular plate, the adanal pterale (apt), articulating with the bases of the anal veins. The postscutellum is a narrow piece entirely concealed beneath the edge of the scutellum and fused with the anterior phragma of the metathorax. It is connected with the mesoepimeron by a narrow postalar bridge (Figure 4, poa). This has been termed pleurophragmite, pleurotergite, and postalare by various authors. The term postalare appeals to the present writer, as there is a corresponding prealare in front of the wing.

Pleuron. Figures 2 and 4. The mesopleuron of the *Cicada* is decidedly primitive and resembles the condition found in certain Neuroptera. The pleural suture (p) is particularly distinct, extending from the wing base to the articulation of the coxa. The episternum (es) is divided by a suture (a) into an upper and a lower region, called respectively the anepisternum (aes) and the katepisternum (kes). The upper portion has often been wrongly designated as the whole episternum, but, as Crampton, 1914A, 1914B, has shown, the episternum always extends the entire length of the pleural suture. The anepisternum (aes) is partly divided vertically by a cleft running about parallel to and near the pleural suture. In *Cryptotympana epithesia*, a large Sumatran Cicadid, and probably in other forms, a median portion (mes), in addition to the upper and lower parts, is marked off on the episternum by sutures. A similar condition is to be observed in certain Neuroptera.

The katepisternum (kes), the precoxale, or precoxal bridge (pcx), and the sternum are indefinitely fused. Above the episternum at the base of the wing is a free sclerite, the posterior basalare (pba). Another plate a little in front of and below this sclerite is the anterior basalare (aba), which is only partly separated by a cleft from the episternum. The spiracle of the mesothorax is located anterior to the prealare and is surrounded by a chitinous plate, the peritreme (pt).

The epimeron (em), like the episternum, is divided into an upper region (aem) and a lower region (kem) by a prolongation (b) of the suture which divides the episternum. These regions have been designated variously as hyperepimeron or anepimeron

(the upper) and hypoepimeron or katepimeron (the lower) by Crampton, 1908, 1909. The same writer (Crampton, 1914B) has used the term pteropleurite for the upper part, this being a modification of Osten-Sacken's, 1884, term pteropleura of the Diptera. It seems reasonable, if we decide on the prefixes ana- and kata- for the two divisions of the episternum, to employ the corresponding terms anepimeron and katepimeron in this instance. These terms are both self-descriptive and logical, while pteropleurite might be taken to mean a part of the episternum.

The connection of the epimeron with the postscutellum (i. e., the postalare) has already been mentioned. This is always strongly fused with the epimeron and usually no suture is to be seen between the two. A postcoxal bridge, the postcoxale (poc), connects the katepimeron with the sternum. Above the epimeron at the wing base two plates, the anterior (asa) and the posterior subalares (psa), occur, supporting the anal region of the wing. The trochantin (tn) of the mesothorax is semi-circular and rather broad. A continuation of the pleural suture in the coxa partly marks off the meron (me) from the veracoxa (vcx).

Sternum. Figures 2 and 4. The mesosternum consists of but two well defined sclerites, the basisternite (bs) and the furcasternite (fs).

Smith and Grossbeck, 1907, in figuring the ventral view of *Cicada tibicen*, have apparently misinterpreted the parts of the prothorax and the mesothorax. In a figure similar to the writer's Figure 2 they have called the mesothoracic anepisternum (aes_2) the proepimeron; they have designated the metathoracic katepisternum (kes_2) as the entire mesosternum; the mesothoracic anepimeron (aem_2) has been called mesoepisternum; and the mesothoracic katepimeron (kem_2) has been termed the entire mesoepimeron. The median sclerite (mes_2) of the mesothoracic episternum is labelled proepisternum. A comparison of the ventral view with the lateral aspect of the thorax of this insect will instantly establish the true relation of these parts, though it may not be apparent from the ventral view alone.

Metathorax.

The metathorax is similar in general make-up to the mesothorax.

Notum. Figure 5. The notum of the metathorax is narrow from front to rear. The prescutum (psc) is but a narrow band. The scutum (sc) is narrow at the summit and broadens as it reaches the wings. The scutellum (sl) is ill defined at the summit. It is produced laterally into a narrow band bearing the axillary cord, which is continuous with the anal margin of the wing. The postscutellum (psl) is also narrow and is joined by the postalare (poa) to the epimeron (em).

Pleuron. Figure 5. The metathoracic pleuron is divided by a distinct pleural suture (p). The episternum (es) is undivided and is fused ventrally with the precoxale (pcx). The posterior basalare (pba) rests on the anterior basalare (aba), while the latter rests on the episternum (es); all are closely united, but the sutures demarking them are distinct. A wide peritreme (pt) joined to the episternum surrounds the spiracle. The epimeron (em) of the female is large and rectangular. In the male a broad lobe (op), called sometimes the operculum, extends backward from the epimeron and sternum, forming a cover for the tympanum or sound producing organ. In either case the postcoxale is indistinct. An anterior (asa) and a posterior subalare (psa) support the anal part of the wing as in the mesothorax. The trochantin (tn) is long and narrow in this segment.

Sternum. Figures 2 and 5. The sternum of the metathorax consists of basisternite (bs_3 , Figure 2; bs , Figure 5) and furcasternite (fs_3 , Figure 2). The latter region together with the episternum is prolonged posteriorly to cover the tympanum in the male. The meral region (me) of the coxa bears on its posterior side a flattened spine or spur (mc), called by Fieber, 1875, the meracanthus.

MODIFICATIONS IN OTHER HOMOPTERA.

It is difficult to trace the development of the Homoptera along definite directions toward the various modifications which characterize the higher forms. All the families show close relation to each other, but most of them possess striking features not comparable or traceable to features in others. The following are among the more striking modifications occurring throughout the Homoptera.

Prothorax. Figures 10 and 11.

The prothorax of Membracids is developed to extreme proportions. It covers a good part of the mesothorax and extends

dorsad nearly to the tip of the abdomen, terminating in a point. In the other families the prothorax is similar to that of *Cicada* (Figure 3), except that in the Psyllidæ (Figures 10 and 11), Aphididæ, Coccidæ and Aleyrodidæ it is even more collar like, scarcely overlapping the mesothorax.

Between the prothorax and the mesothorax of Psyllidæ (Figures 10 and 11) there are, according to Crawford, 1914, three small sclerites. One of these, the lower, is the peritrema (pt) surrounding the spiracle. Above this and often separated from it only by a line is a second sclerite (pt) which is probably part of the peritrema. The third of these sclerites (it) occurs behind the above mentioned two, and its origin is not easily traceable. Crawford, 1914, calls it an accessory sclerite. It would, however, probably come under the term intersegmentalia used by Crampton, 1914A, 1914B, and would thus be termed intertergite. Its homologue was not found in any of the forms treated in this paper.

Mesothorax. Figures 7, 10, 11 and 12.

Notum. The mesonotum in the other Homoptera differs only in detail from that of *Cicada*. The primary divisions—prescutum (psc), scutum (sc), scutellum (sl) and postscutellum (psl)—are always present. A well chitinized and fairly large tegula occurs in the mesothorax of Fulgorids (*Fulgora* sp.), but is not present in other families of Homoptera.

Pleuron. In the pleuron of the mesothorax several differences are noticeable. The basales (aba, pba) disappear or become fused to the episternum in some families. The beginning of this is observable in *Cicada*, where the anterior basale (aba) is only partly separated from the episternum by a cleft or notch. In the Fulgoridæ, Jassidæ (Figure 7) and Membracidæ no free basales are to be seen, though one at least is probably present, fused with the episternum. On the other hand, there are usually two basales (aba, pba) in Psyllids, (Figures 10 and 11), in the Aphids there is at least one (pba), and though they could not be detected by the writer on account of poor material, it is not improbable that one or two occur in the Coccids and Aleyrodids. The pleural suture (p) of the mesothorax is usually distinct among the Homoptera. In some Psyllids, however, it extends but halfway up the pleuron from the coxal attachment. The cleft or notch mentioned as running parallel to the pleural suture in the mesoepisternum

of the Cicadidæ persists in the Fulgoridæ, the Jassidæ (Figure 7) and the Membracidæ, greatly reduced. In the Aphididæ (Figure 12) it is even deeper and in the Psyllidæ (Figures 10 and 11) a probable trace of it remains.

The episternum in the Jassidæ (Figure 7) is subdivided into three parts (aes, mes, kes) as in the Cicadidæ, but in most of the other Homoptera all trace of these divisions is lost. In the Aphididæ (Figure 12) the episternum (es) of the mesothorax is divided into an upper and a lower portion, the anepisternum (aes) and the katepisternum (kes),* as in Cicadidæ, Jassidæ and Neuroptera, but the median plate is not present. In the Jassidæ (Figure 7) a narrow band (hyp) is marked off in front of the episternum and is produced into the sternum. This has been shown by Crampton, 1914C, to be the hypopteron of Audouin, 1820, termed the pre-episternum by Snodgrass, 1909. As in the Cicadidæ, the episternum is not separated from the sternum in the Fulgoridæ, Cercopidæ, Jassidæ, Membracidæ and Aphididæ. The mesothoracic trochantin (tn) is readily seen in all the families studied except the Psyllidæ, Aphididæ and Aleyrodidæ.

The epimeron does not present many differences among the Homoptera. The homologue of the suture dividing the epimeron of *Cicada* into upper and lower parts, however, has not been found in other families.

Sternum. The sternum of the mesothorax is considerably lengthened in all forms except the Membracidæ, where both mesothorax and metathorax are much condensed from front to rear. The coxa of this segment in the Fulgoridæ and the Cercopidæ bears sometimes a spur or meracanthus.

Metathorax. Figures 6, 8, 9, 10, 11, 12 and 13.

Notum. The notum of the metathorax in other Homoptera is usually longer than that of Cicadidæ. It is often shortest along the mid-dorsal line and longest as it approaches the wings. In the Aphididæ and the Psyllidæ this is not generally true, the median length of the notum being usually greater than the length of the lateral margin. In the Jassidæ the metanotum is nearly as long as the mesonotum.

* Attention is called to an error in labelling in Figure 12. The abbreviation kes₂ should refer to that part of the plate marked pex₂ which is just anterior to the pleural suture (p₂). The abbreviation pex₂ would then refer to an indefinite portion of this plate between kes₂ and the posterior part of st₂.

Pleuron. The metathoracic pleuron exhibits several points of difference from the primitive type. In the lower part of the episternum of the Cercopidæ (Figure 6) will be noticed a short suture running parallel to the pleural suture. In the Fulgoridæ (Figures 8 and 9) this suture is possibly represented by a membranous cleft, to be described later. The metapleuron, metasternum and metacoxa of the Fulgoridæ (Figures 8 and 9) present a very remarkable and puzzling condition. Hansen, 1890, figured and described the coxa and its surrounding parts, but was mistaken in his interpretation of the boundary of the coxa. He did not consider the upper portion of the part labelled meron (me) in Figures 8 and 9 as a part of the coxa. Since this plate bears muscles extending to the subalar region and such muscles characteristically connect the meron with that region in other insects, it is unquestionably a part of the coxa. The coxa is, indeed, so fused with the pleuron and sternum as to make these parts extremely difficult of interpretation. Added to this confusing state is the substitution of a considerable amount of membrane for chitin in these parts. On comparing Figures 8 and 9 it will be seen that there is a marked variation in the two forms. Essentially, however, they are very similar. In *Ormenis* sp. (Figure 8) the parts can be more easily identified. It will be noticed that in this form the coxa (cx) extends dorsally to a point not far from the wing base and that a lobe of the episternum covers the anterior part of the coxa to some extent. This lobe being transparent, the true limits of the coxa can be distinguished through it. That the coxa extends posteriorly to the point indicated in the figures is shown—as mentioned above—by the presence of characteristic muscles running from the subalar region to the meral region (me) of the coxa.

The coxa, then, in Fulgoridæ is rather extensive; it is divided into a true coxa, or veracoxa (vcx), and a large meron (me), which in turn is divided into two parts. The coxa is, moreover, immovable as a result of its close fusion with the other parts. The large non-chitinous areas in the pleural and sternal regions, however, probably impart a certain elasticity to the coxa, which doubtless compensates for its immobility to some extent. These membranous areas are to be found in the episternum, the epimeron and the sternum. In the episternum the membranous portion forms a cleft, nearly bisecting the

plate. In the epimeron a similar cleft is found, but this is nearly surrounded by chitin and does not open broadly as does that of the episternum. The sternum, save a small anterior plate and a piece between and behind the coxæ, is almost entirely membranous.

In the Cercopidæ (Figure 6) there occurs in the lower epimeron, partly covering the meron of the coxa, a flap-like process, which may be the homologue of a similar process on the lower epimeron of Fulgoridæ (Figure 9).

Also meriting particular mention are the pleuron, sternum and coxa of the Psyllid metathorax (Figures 10 and 11). In the generalized forms, *Apsylla* (Figure 10) for example, the pleuron and coxa are not radically different from those of other Homoptera, but in certain higher forms like *Arytaina robusta* (Figure 11) some remarkable conditions obtain. The pleuron, particularly the epimeron (em), is greatly reduced, while the coxa (cx) has become enormous. The pleural suture (p) no longer extends from the wing articulation to the coxal condyle, but seems to end arbitrarily on the lower margin of the pleuron. The coxal articulation (x) occurs at the center of the lower margin of the greatly reduced epimeron (em). The pleuron and coxa thus present the appearance of the latter having become extended far up the side of the body, replacing the former to a great extent. In this shifting the coxa seems to have carried with it along the lower margin of the pleuron its articulatory process (x), which in other forms, is almost universally found at the end of the pleural suture. In the Psyllids there is no distinct precoxale in the metathorax, but the narrow postcoxale (poc) is remarkably long and distinct. It is possible that the large trochantin (tn₃) figured by Crawford, 1914, may be a region homologous with the precoxale found in other forms. The coxa bears on its lower posterior side an articulated meracanthus (mc).

In the metathorax of Aleyrodidæ (Figure 13) the pleural suture (p) is only partly distinct, the upper part being wanting. A continuation of the pleural suture extends the entire length of the coxa, which is apparently fused with the pleuron.

Sternum. The sternum of Psyllidæ is represented by a very narrow sclerite between the coxæ, hardly visible from the side. Aside from this and the modifications noted above in the Fulgoridæ, the metathoracic sternum is fairly normal.

DESCRIPTION OF A GENERALIZED HETEROPTEROUS THORAX.

Suborder Heteroptera, Family Belostomatidæ; *Belostoma americana*, *Zaittha* sp. Figures 18 and 20.

The giant water bug (*Belostoma americana*) is described rather fully here, since it is a somewhat generalized Heteropteron. It is also of a convenient size to study and it is widely distributed.

Prothorax.

This segment, as in most Heteroptera, is somewhat collar like, fitting tightly to the head and closely overlapping the anterior part of the mesothorax. The notum is trapezoidal in outline and is rather large. The pleural region is somewhat broad above, narrowing to meet the narrow sternum. Rarely is the prothorax distinctly marked off into sclerites, and it is fundamentally so similar in all Heteroptera, that it will require but little mention.

Mesothorax. Figure 18.

Notum. The notum of the mesothorax does not show a distinct pretergite, this sclerite being probably represented by part of the anterior phragma (aph). The prescutum (psc), a semi-circular piece, is marked off clearly. Extending in front of the wing from the lateral margin of the prescutum is a bilobed prealare (pra), the anterior lobe of which joins an upward projection of the sternal region. No separating suture occurs between scutum (sc) and scutellum (sl). The latter is produced backward to a point over the metanotum. A postscutellum (psl) is concealed under the scutellum and is connected by the postalare (poa) with the epimeron. Snodgrass, 1909, at first stated that no postscutellum was present in the mesothorax of *Belostoma*. Later (Snodgrass, 1910), however, he noted the presence of this sclerite.

Pleuron. The mesopleuron in this and in other Heteroptera has the appearance of having been distorted from its normal form, i. e., the upper part seems to have been pushed forward, or the lower part backward. This brings about two remarkable conditions: first, the pleural suture (p) becomes almost horizontal, and second, the coxa (cx) extends outward from the rear of the segment instead of from beneath. Another peculiarity of this and other members of the suborder is the overlapping of the base of the coxa by the lower parts of the two pleural

plates. The episternum (es) is long and somewhat narrow. Its lower portion lies virtually below the coxa (cx) and hence has been called the subcoxal plate by some authors. It is evident, however, that it is really but a part of the episternum. Fused to the anterior (or to what is normally the dorsal) end of the episternum, the homologue of at least one of the two basalar plates (aba) occurs. The posterior basalar may also be present. The epimeron (em) is triangular in shape and lies above the episternum. It is produced posteriorly to a sharp point, which overlaps the metapleuron and bears dorsally a knob-like projection. This projection fits into a socket in the closed forewing to hold it fast.

Sternum. Owing to the aforementioned shifting of the pleural plates, the sternum lies along what would naturally be the anterior margin (but actually is the lower margin) of the episternum. The coxa (cx), as has been stated, proceeds from the rear of the segment, the attachment being concealed beneath the pleuron at a point marked (x). The trochantin is hidden beneath the episternum.

Metathorax. Figure 20.

Notum. The notum is not long mesally, but it lengthens as it reaches the wing. It is largely composed of the prescutum (psc) and the scutellum (sl), the other plates not being clearly defined, though the scutum (sc) is probably represented. The postscutellum (psl) is concealed and is fused with the narrow first abdominal tergite. The postalare (poa) is unusually broad where it joins the epimeron.

Pleuron. The pleuron of the metathorax overlaps the coxa to some degree. Like the mesopleuron, it is turned or twisted so that the pleural suture (p) is nearly horizontal. The episternum (es) is divided into an upper (aes) and a lower section (kes), but these may not be homologous with similar divisions in the mesopleuron of *Cicada* and related forms. The lower portion (kes), often designated as the subcoxal plate, is produced backward in a pointed flap, which reaches two-thirds the length of the coxa. The epimeron (em) is small, triangular and pointed posteriorly.

Sternum. The metasternum (st) is not clearly separated from the episternum. It is very similar to the sternum of the mesothorax. The hind coxa (cx) is very large.

MODIFICATIONS IN OTHER HETEROPTERA.

As in the Homoptera, it is difficult to trace the modifications of the higher Heteroptera along definite lines of development. Unlike the Homoptera, however, the higher families of Heteroptera show considerable departure from the primitive type, and resemble only slightly the Belostomatidæ and their near relatives. Of the forms studied only the Corixidæ (Figure 19), Notonectidæ (Figures 15 and 16), and Nepidæ (Figure 17) show characters very similar to *Belostoma*. The Nepidæ seem in a number of ways to be a connecting link between these and the more modified forms.

Before commencing the discussion of the modifications of the thorax in the Heteroptera, it may be well to mention Heymons', 1899, interpretation of the thorax of *Nepa cinerea*, since this work is frequently referred to by other writers. In the later larval stages, which he studied and figured, the body is much flattened dorso-ventrally. The pleural plates are thus apparently ventral. Heymons has hence called the episternum of the various segments the "lamina subcoxalis" or subcoxal plate (Subcoxalplatte), since its true position is beneath the coxa. The mesothoracic epimeron is a sickle-shaped flap, which extends beyond the hind coxa. This sclerite was considered by Heymons to be the metathoracic "pleurite," but that it is most certainly the mesothoracic epimeron is clearly seen by lifting the flap and observing its attachment. A sclerite which Heymons designates as paratergite, the writer believes from its location to be the metathoracic epimeron.

Prothorax.

This segment is fairly constant throughout the group. It may vary in size and shape, but in its ground plan it is essentially the same in all the families studied. It is of minor importance in the study of the sclerites, and is not figured in this paper. One notable exception obtains in the Gerridæ, where the scutellar region of the pronotum extends so far back as to entirely cover the mesonotum.

Mesothorax. Figures 14, 15, 17, 18, 19, 21, 22, 23, 24 and 25.

Notum. The notum of the mesothorax in the suborder Heteroptera is usually divided by sutures into pretergite (prt), prescutum (psc), scutum (sc), scutellum (sl) and postscutellum

(psl). In most families the scutellum (sl) is very prominent, and is always to be seen between the closed forewings, extending backward over the succeeding segment and terminating usually in a point. In some forms the scutellum (sl) becomes unusually extensive. In the Pentatomidæ it reaches beyond the metathorax and projects over the abdomen, in the Scutelleridæ it extends still farther, while in the Thyreocoridæ (Figure 25) it almost conceals the abdomen. The postscutellum (psl) is always closely attached to the anterior part of the next segment so that it is frequently difficult to ascertain its posterior limit. A prealare (pra) is almost invariably found in the mesothorax throughout the Heteroptera, and together with the anterolateral margin of the mesonotum and the upper anterior margin of the mesopleuron, it forms the boundary of an irregular, often more or less triangular, membranous region (i. e., the region posterior to pra, ventral to psc and dorsal to aba and es). In front of the prealare (pra) the spiracle, surrounded by its peritreme (pt), is usually to be seen. The postalare (poa) is usually narrow and often almost indistinguishably fused with the prescutum (psc) of the metathorax.

Pleuron. The mesopleuron exhibits a considerable degree of diversity in the suborder. Along the upper margin of the episternum (es) there is usually marked off a narrow plate (aba), probably the anterior basalare, which has become fused to the episternum. This fusion occurs in most Heteroptera. Often the posterior basalare (pba) is also distinguishable, usually above the anterior basalare; this, too, is often fused to the episternum. This plate (pba) occurs in the Emesidæ (Figure 14), Berytidæ (Figure 22) and Coreidæ (Figure 23).

In nearly all the Heteropterous families studied (except in the Notonectidæ, Nabidæ, Cimicidæ and Capsidæ) the pleural plates extend down over the upper part of the coxa (cx). In such cases the lower part of the pleuron is divided by a cleft (c) extending lateral to the coxa and terminating in the coxal articulation (x). From this coxal process, as the articulatory projection of the pleuron is called, the pleural suture, when present, extends dorsad. In the Heteroptera it is more often absent, being entirely visible only in the Corixidæ (Figure 19), Notonectidæ (Figures 15 and 16) and Belostomatidæ (Figure 18). In the Nepidæ (Figure 17), Capsidæ, Reduviidæ, and Thyreocoridæ (Figure 25) it is visible in part, extending dorsal-

ward from the coxal articulation (x) to a point about midway up the pleuron. The division of the pleuron is usually indicated on the inner side of the plate by a ridge, the internal representative of the pleural suture, even when the pleural suture itself is entirely absent. It must be mentioned here that the coxal cleft in the metathorax does not occupy a position homologous with that in the mesothorax and hence cannot be taken as a "landmark" for the separation of episternum and epimeron in that segment.

In the Nepidæ (Figure 17) and the Thyreocoridæ (Figure 25) the episternum of the mesothorax is divided into anepisternum (aes) and katepisternum (kes), a condition not general with the Heteroptera, but met with in Cicadidæ, Jassidæ and Aphididæ, among the Homoptera.

The distorted condition remarked above in connection with *Belostoma* is noticed also in the Corixidæ (Figure 19) and Notonectidæ (Figure 15). The backward projecting flap of the epimeron of *Belostoma* finds its homologue only in the Nepidæ (Figure 17), though in most forms the posterior margin of the epimeron overlaps more or less the anterior part of the next segment. In the higher Heteroptera, among them the Reduviidæ, Emesidæ (Figure 14), Nabidæ (Figure 24), Gerridæ (Figure 21), Capsidæ, Phymatidæ, Lygæidæ, Berytidæ (Figure 22), Coreidæ (Figure 23) and Pentatomidæ, the shape of the mesopleuron, and usually of the metapleuron is rectangular. The coxa (cx) retains its position at the rear of the segment even in the elongated forms, *Emesa* (Figure 14), *Gerris* (Figure 21) and *Neides* (Figure 22), for example. In the Gerridæ (Figure 21), where the body is very nearly cylindrical, the mesocoxa (cx₂) is partially encased by a cylindrical, bulging socket. The coxal cleft (c₂) runs the length of this socket. A trochantin (tn, Figure 15) is very probably present in most of the Heteroptera, though its position beneath the episternum prevents it from being easily detected.

Sternum. The mesothoracic sternum is usually indistinguishably fused with the pleuron, and consists apparently of a single sclerite. In some instances, namely in the Notonectidæ (Figure 15), Reduviidæ, Emesidæ (Figure 14), Cimicidæ, Phymatidæ and Tingitidæ, a faint line more or less distinctly marks off the sternum from the pleuron.

Metathorax. Figures 14, 16, 19, 20, 21, 22, 23, 24 and 25.

Notum. The metanotum varies in the Heteroptera from a size nearly equal to that of the mesonotum to a small section almost entirely concealed under the scutellum of the mesothorax. The pretergite (prt), if present, is indistinguishably fused with the posterior phragma of the mesothorax. A narrow prescutum (psc) is often visible, but it is closely united with the mesothoracic postscutellum (psl₂) often adhering to it when the mesothorax and metathorax are pulled apart. Prescutum (psc), scutum (sc) and scutellum (sl) are sometimes, as in the Corixidæ (Figure 19), Notonectidæ (Figure 16), Nabidæ (Figure 24), Cimicidæ and Berytidæ (Figure 22), inseparably fused together. In some cases, on the other hand, one, two, or all three of these sclerites are definitely marked off by sutures. The postscutellum (psl) is found in all gradations, from a brief, partially hidden plate, as in *Belostoma* (Figure 20), to a large, extensive sclerite, as in the Berytidæ (Figure 22).

In the Gerridæ (Figure 21) the homologies of the parts of the metanotum are not easily determined. There is apparently a short plate composing the scutoscutellum (ssl₂), rather long mesally and coming forward to a point on either side to reach the narrow wing bases, which are set somewhat forward. Behind this is the rather extensive postscutellum (psl₃), likewise extending forward in a point on each side, and very broadly joined to the epimeron (em₃).

In the Coreidæ (Figure 23) and similar forms a narrow, raised portion (ce₃), the cenchrus of Hemipterologists, extends along the upper margin of the epimeron (em₃) where the postalare (poa₃) joins it. This is possibly homologous with the parapleuron of Coleopterologists.

Pleuron. The pleuron of the metathorax is in general similar to that of the preceding segment. The distorted condition mentioned above is most noticeable in the Corixidæ (Figure 19), Notonectidæ (Figure 16) and Belostomatidæ (Figure 20). In *Corixa* (Figure 19) the coxa (cx₃) is very large and its base is covered by flaps of both episternum (es₃) and epimeron (em₃). The pleural suture (p₃) is nearly horizontal and lies very near the upper margin of the pleuron. The epimeron (em₃) is thus very narrow. Only in *Belostoma* (Figure 20) is the metathoracic episternum divided into anepisternum (aes) and katepisternum (kes). In *Notonecta* (Figure 16) and in *Belostoma* (Figure 20) the epimeron (em) does not overlap the coxa, but the episternum

(es) projects backward over it for some distance. With few exceptions, notably in the Nabidæ (Figure 24) and Cimicidæ, and possibly in some others, the coxæ (cx) of all Heteroptera are partially overlapped by the metapleural plates, the coxal attachment (x) being concealed and its position not usually recognizable externally. In *Gerris* (Figure 21), an elongate, cylindrical form, the base of the coxa is set in a bulging socket, as in the mesothorax, except that there is no cleft in this socket. In *Emesa* (Figure 14), another elongate form, the base of the hind coxa (cx₃) is partly covered by a pointed flap, while another pointed flap lies behind it.

The pleural suture (p₃), except in *Corixa* (Figure 19), *Noto-necta* (Figure 16) and *Belostoma* (Figure 20) is absent in the metathorax of all forms studied. A coxal cleft (c₃) is often present, as in the Nepidæ, Berytidæ (Figure 22), Coreidæ (Figure 23) and many other forms, but it is not to be homologized with the coxal cleft (c₂) of the mesothorax, since it does not terminate at the coxal process (x), but is usually located in front of and below the coxa. Hence it is incorrect to use the metathoracic coxal cleft (c₃), as some writers, (Tower, 1914, for example) have done, as a "landmark" for separating episternum (es₃) and epimeron (em₃). The episternum (es₃) and epimeron (em₃) are always to be separated by the pleural suture (p₃), and when this is absent, as it is in these forms, we must take as a basis for the division of the pleuron, the two points which are the constant limits of this suture when it is present. Thus the episternum and epimeron can be exteriorly separated only by an imaginary line, representing the pleural suture, extending from the wing fulcrum to the articulation of the coxa (x). This conclusion is strengthened by the fact that on examination of the interior surface of the pleuron in certain forms where no pleural suture exists, one will find a more or less distinct ridge, extending in an irregular, but fairly definite line between the wing fulcrum and the coxal process. Now in all forms possessing a pleural suture there is to be found on the inner surface of the pleuron a corresponding pleural ridge, this ridge being the internal manifestation of the external pleural suture. Hence it is not incorrect to use this ridge, which is as constant as the suture, as a "landmark" in naming the pleural plates. The ridge has been represented by a dotted line in the figure of the squash bug (Figure 23). It would probably be

found in other forms where the pleural suture is absent, extending in a similar direction.

The general shape of the metapleuron in those forms where the pleural suture is absent is rectangular. In many forms the upper forward margin of the metathoracic pleuron extends slightly beneath, or at least anterior to the rear margin of the mesothoracic pleuron. This is true of the Nabidæ (Figure 24), Gerridæ (Figure 21) and Berytidæ (Figure 22) and of other forms not figured. It is particularly well shown in *Gerris* (Figure 21), where the rear wing lies very far forward, and the pleuron extends beyond it to support it.

In one of the elongate forms, *Emesa* (Figure 14), the epimera (em_3) of each side present the appearance of meeting dorsally and bridging the region behind the postscutellum (psl_3). Though this may seem an improbable conception, it may not be an impossible one, since it will be recalled that in the mesothorax of Odonata the two episterna meet in front of the notum in much the same fashion.

Openings of scent glands (sg) occur in a number of families. These are represented in the figure of the squash bug (Figure 23). The opening is located at the end of the coxal cleft (c_3) in the lower anterior corner of the episternum (es_3).

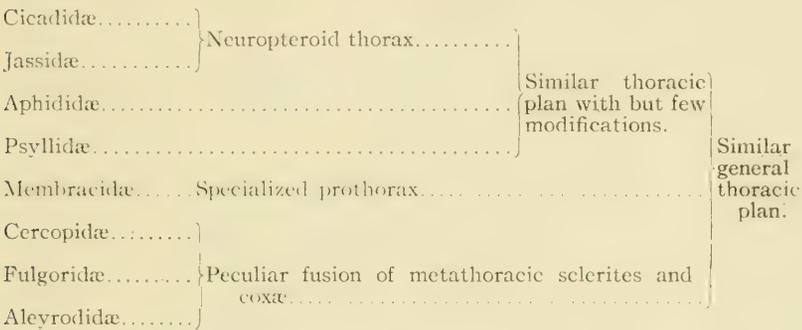
Sternum. The metasternum is quite like the mesosternum in the Heteroptera. It consists of one plate (st_3) usually and is not often separated from the episternum. A narrow postcoxale (poc_3), usually concealed, passes behind the coxa (cx_3) from epimeron (em_3) to sternum (st_3). This postcoxale is externally visible in *Coriscus* (Figure 24, poc_3).

RELATIONSHIPS OF THE HEMIPTERA INDICATED BY THE THORACIC SCLERITES.

On account of the diversity in the thoracic structure of Hemiptera, it is difficult to interpret the relationships of the families. Moreover, there are in the sclerites of some forms modifications, the origin of which is uncertain, there being apparently no intermediate or ancestral conditions leading up to these modifications in the forms studied. Hence it has been possible only to group together certain families whose thoracic sclerites most resemble each other.

Among the Homoptera the Cicadidæ exhibit certain features in common with the Jassidæ, of which the most striking is the

Neuropteroid mesothoracic episternum. The general plan of the Cicadid thorax is followed in the Aphididæ, Membracidæ, Psyllidæ, Cercopidæ and Fulgoridæ. Of these, however, all but the Aphididæ and perhaps the Psyllidæ present striking modifications, such as the extreme specialization of the Membracid prothorax, and the remarkable fusion of the coxæ and the metathoracic pleura of the Fulgoridæ, the latter of which seems to have originated in a similar condition (less marked) in the Cercopidæ. The Membracidæ and Fulgoridæ, therefore, seem to be nearly related with respect to the thorax. The thorax of the Aleyrodidæ, being extremely small and lacking in pigment, cannot be carefully compared with that of the other families. Its large metathoracic coxa, immovably fused with the pleuron, may connect it with the Fulgoridæ. The following diagram illustrates to some extent the relationships shown by the thorax, without regard to primitiveness.



In the Heteroptera the thoracic structures of all the families are similar in their general composition. The relation of the coxæ to the pleural plates differs to some extent and may in a way serve to indicate some of the more general relationships. The Notonectidæ, Corixidæ, Belostomatidæ and Nepidæ are apparently related, both because of the distorted condition of the thorax, mentioned above, and from the large size of the metacoxa, which is overlapped more or less by the pleural plates. The remaining families studied in this paper seem very similar in the construction of the thorax. In the Capsidæ, Nabidæ and Cimicidæ the mesothoracic and metathoracic coxæ are entirely exposed, or nearly so, not being overlapped by the pleural plates. The relation of the Cimicidæ to the other two is

somewhat problematic, the flattening of the thorax and consequent contraction of the thoracic plates giving these insects a unique place in the order. The Reduviidæ and Phymatidæ, unlike any others of the families studied, have a true coxal cleft in the metathorax, homologous with that in the mesothorax. The Pentatomidæ, Scutelleridæ and Corymelænidæ may be grouped on account of the extremely developed mesothoracic scutellum, which projects far over the abdomen. The chief reasons for uniting the Berytidæ and Gerridæ in the diagram below are the horizontal lengthening of the mesopleura, and the metathoracic scutellum, which in both joins broadly with the epimeron ventrad. The Emesidæ also resemble these two families, though their relation to them may be questioned. The following diagram is an attempt at grouping those Heteropterous families, which appear from their thoracic sclerites to be related.

Notonectidæ.....	} Large metathoracic coxæ, overlapped by episterna; mesothoracic and metathoracic pleura distorted.	} Similarity in general structure; pleura of meso- and metathorax usually rectangular in shape.
Corixidæ.....		
Belostomatidæ....		
Nepidæ.....		
Capsidæ.....	} Coxæ of both mesothorax and metathorax entirely exposed, or nearly so.....	
Nabidæ.....		
(Cimicidæ).....		
Reduviidæ.....	} True coxal cleft in metathorax; mesothoracic sternum and pleuron separated by a suture.....	
Phymatidæ.....		
Coreidæ.....		
Lygaeidæ.....		
Tingitidæ.....		
Pentatomidæ.....	} Mesothoracic scutellum prolonged over abdomen.	
Scutelleridæ.....		
Corymelaenidæ....		
Berytidæ.....	} Pleura of mesothorax lengthened horizontally; metathoracic epimeron broadly joined to postscutellum.....	
Gerridæ.....		
Emesidæ.....		

It will be seen that these results are not entirely in harmony with the conclusions of certain writers (Osborn, 1896; Kirkaldy, 1908, 1909; Handlirsch, 1906-'08; Reuter, 1910), concerning the phylogeny of the Hemiptera. This, of course, is to be expected, since the grouping above is based entirely on the morphology of the thorax. Handlirsch, 1906-'08, places the Aleyrodidæ near the Fulgoridæ, and though superficially the two families do not seem related, the thoracic sclerites support this grouping. The arrangement of other Homopterous families followed by writers on phylogeny is not generally borne out by the morphology of the thorax.

The Notonectidæ, Corixidæ, Belostomatidæ and Nepidæ are placed together by Osborn, 1896, Handlirsch, 1906-'08, and Reuter, 1910, but Kirkaldy, 1908, 1909, separates the Nepidæ from the others. Both Handlirsch, 1906-'08, and Reuter, 1910, place the Capsidæ, Cimicidæ and Nabisidæ fairly near each other, and this arrangement agrees with their thoracic structure. The close connection of the Reduviidæ and Phymatidæ is shown by Kirkaldy, 1908, 1909, Handlirsch, 1906-'08, and Reuter, 1910. The Pentatomidæ, Scutelleridæ and Corymelænidæ are usually placed together by writers on phylogeny.

It will thus be seen that relationships shown by the thoracic sclerites are supported in part by the conclusions of writers on phylogeny, especially Handlirsch and Reuter. In the relationships of the Homopterous families, of the Coreidæ, Lygæidæ and Tingitidæ, and of the Berytidæ, Gerridæ and Emesidæ the results obtained in this study do not agree with those of the writers mentioned. More extensive and thorough study of other morphological features as well as of the thorax will be necessary to show the true relationships of these groups.

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EXPLANATION OF PLATES.

(NOTE: All are lateral views unless otherwise indicated).

PLATE XX.

- Fig. 1. *Cicada tibicen* Cicadidæ). Mesonotum and wing articulation. Dorsal view.
 Fig. 2. Same. Pro-, meso- and metathorax. Ventral view.
 Fig. 3. Same. Prothorax.
 Fig. 4. Same. Mesothorax. (A combination of conditions in *C. tibicen* and in *Cryptotympana epithesia*).
 Fig. 5. Same. Metathorax.
 Fig. 6. *Aphrophora* sp. (Cercopidæ). Metathoracic pleuron and sternum.

PLATE XXI.

- Fig. 7. *Draeculacephala* sp. (Jassidæ). Mesothorax.
 Fig. 8. *Ormenis* sp. (Fulgoridæ). Metathoracic pleuron and sternum.
 Fig. 9. *Fulgora* sp. (Fulgoridæ). Metathorax.
 Fig. 10. *Apsylla cistella* (Psyllidæ). Pro-, meso- and metathorax. From CRAWFORD, 1914.
 Fig. 11. *Arytaina robusta* (Psyllidæ). Pro-, meso- and metathorax. From CRAWFORD, 1914.
 Fig. 12. *Pemphigus acerifolia* (Aphididæ). Meso- and metathorax. See footnote page 234.
 Fig. 13. *Aleyrodes vaporariorum*. (Aleyrodidæ). Metathoracic pleuron and coxa.

PLATE XXII.

- Fig. 14. *Emesa* sp. (Emesidæ). Meso- and metathorax.
 Fig. 15. *Notonecta* sp. (Notonectidæ). Mesothorax.
 Fig. 16. Same. Metathorax.
 Fig. 17. *Ranatra* sp. (Nepidæ). Mesothorax.
 Fig. 18. *Belostoma americana* (Belostomatidæ). Mesothorax.
 Fig. 19. *Corixa* sp. (Corixidæ). Meso- and metathorax.
 Fig. 20. *Belostoma americana* (Belostomatidæ). Metathorax.
 Fig. 21. *Gerris* sp. (Gerridæ). Meso- and metathorax.

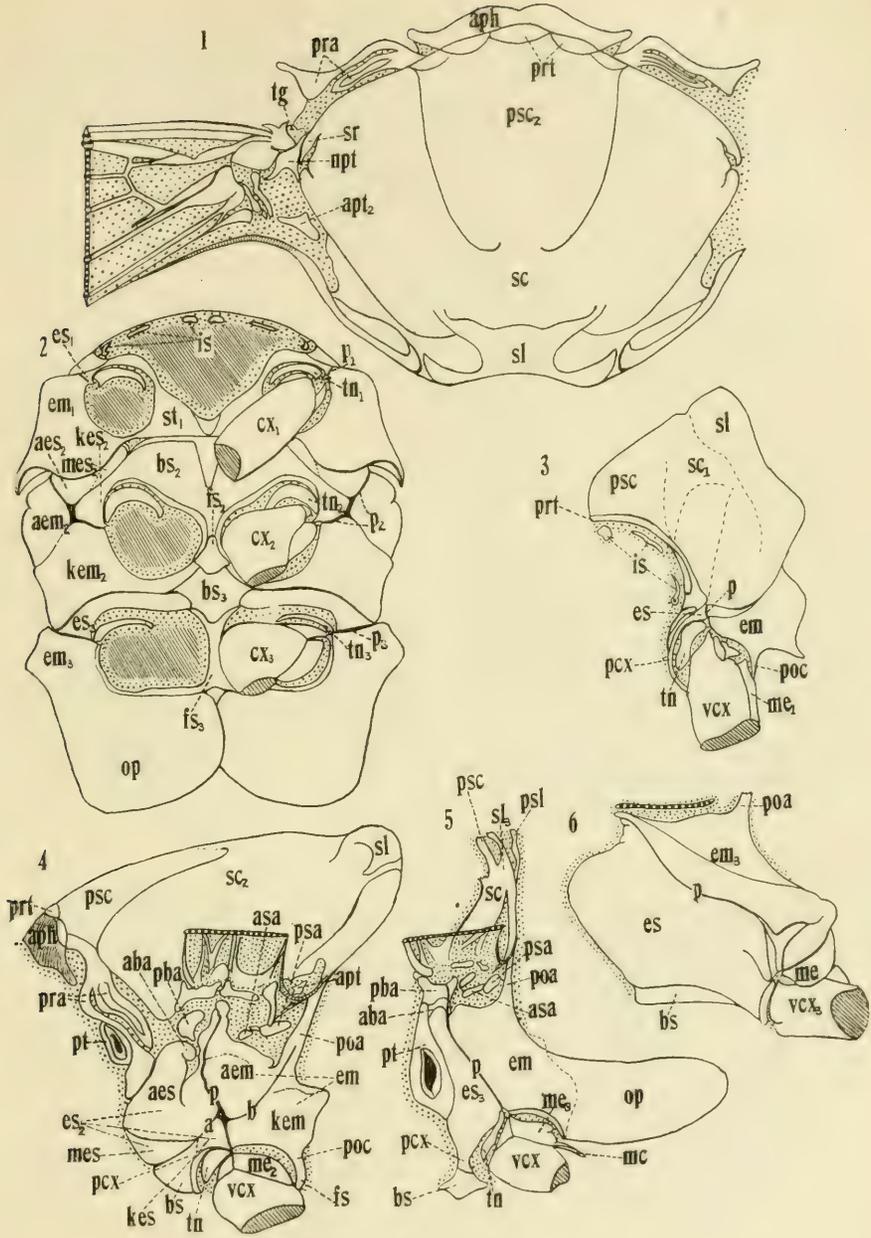
PLATE XXIII.

- Fig. 22. *Neides* sp. (Berytidæ). Meso- and metathorax.
 Fig. 23. *Anasa tristis* (Coreidæ). Meso- and metathorax.
 Fig. 24. *Coriscus* sp. (Nabidæ). Meso- and metathorax.
 Fig. 25. *Thyreocoris* sp. (Thyreocoridæ). Meso- and metathorax.

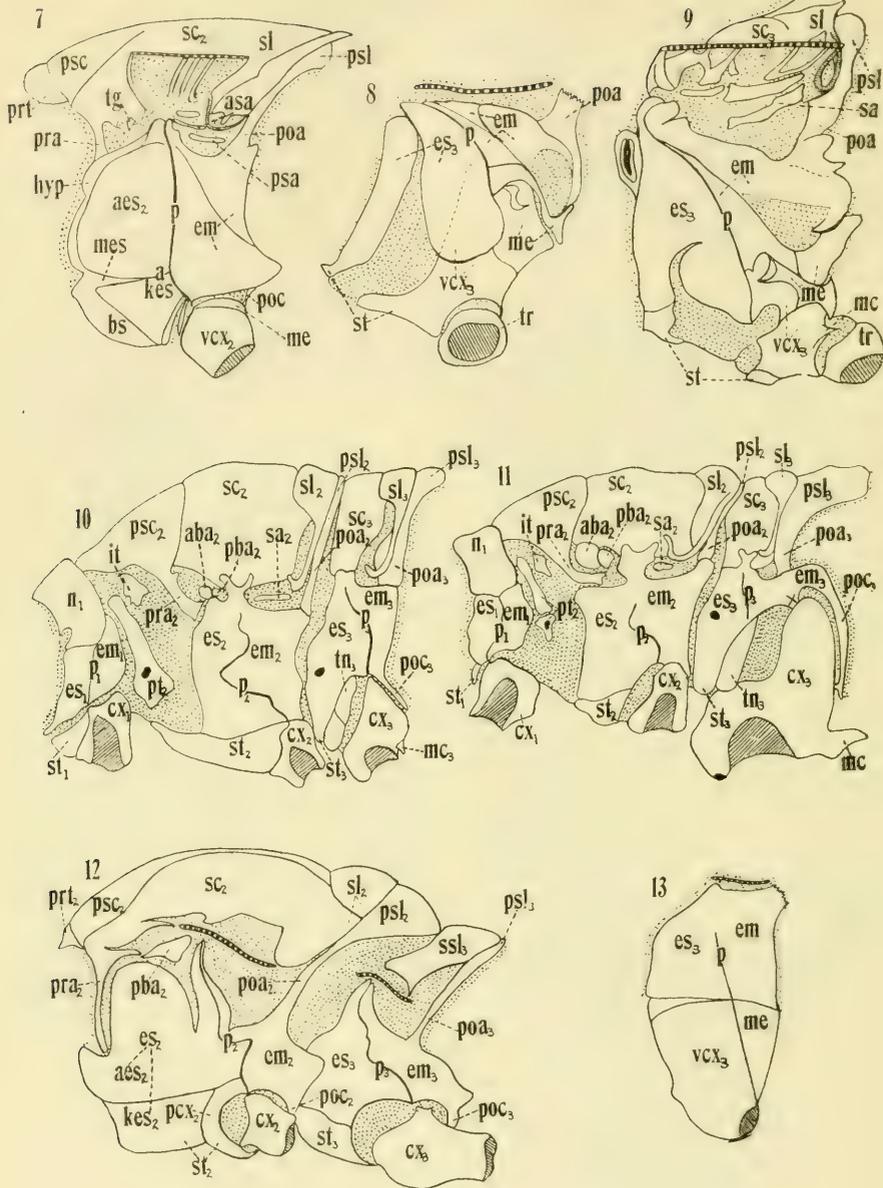
ABBREVIATIONS USED IN THE PLATES.

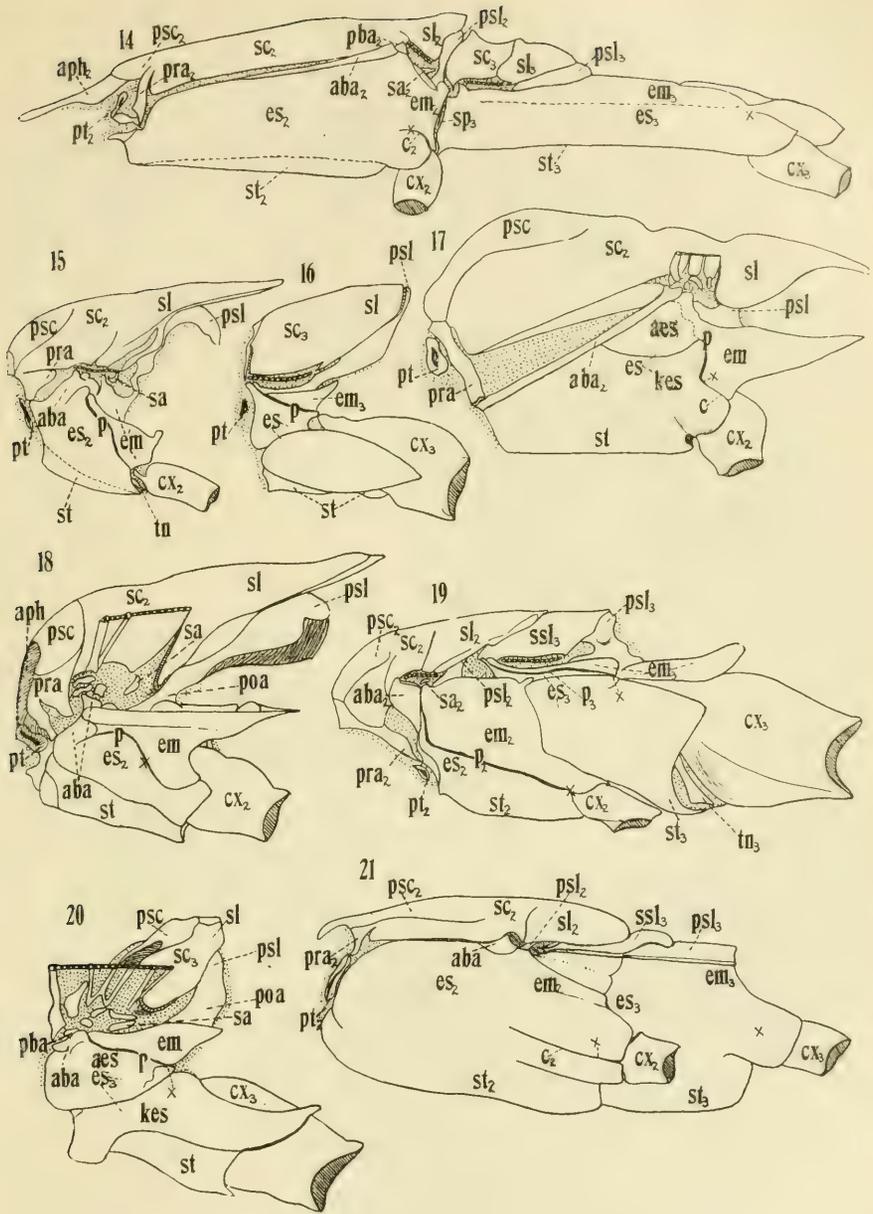
a, suture dividing episternum.	op, operculum.
aba, anterior basalare.	p, pleural suture.
aem, anepimeron.	pba, posterior basalare.
aes, anepisternum.	pcx, precoxale.
aph, anterior phragma.	poa, postalare.
apt, adanal pterale.	poc, postcoxale.
asa, anterior subalare.	pra, prealare.
b, suture dividing epimeron.	prt, pretergite.
bs, basisternite.	psa, posterior subalare.
c, coxal cleft.	pse, prescutum.
ce, cenchrus.	psl, postscutellum.
cx, coxa.	pt, peritreme, surrounding spiracle.
em, epimeron.	sa, subalare.
es, episternum.	sc, scutum.
fs, furcasternite.	sg, opening of scent glands.
hyp, hypopteron.	sl, scutellum.
is, intersegmentalia.	sp, spiracle.
it, intertergite	sr, supraalare or suralare.
kem, katepimeron.	ssl, scuto-scutellum (prt—psc—sc—sl).
kes, katepisternum.	tg, tegula.
mc, meracanthus.	tn, trochantin.
me, meron.	tr, trochanter.
mes, median portion of episternum.	vcx, veracoxa.
n, notum.	x, coxal articulation. (Location so
npt, notopterale.	indicated when concealed).

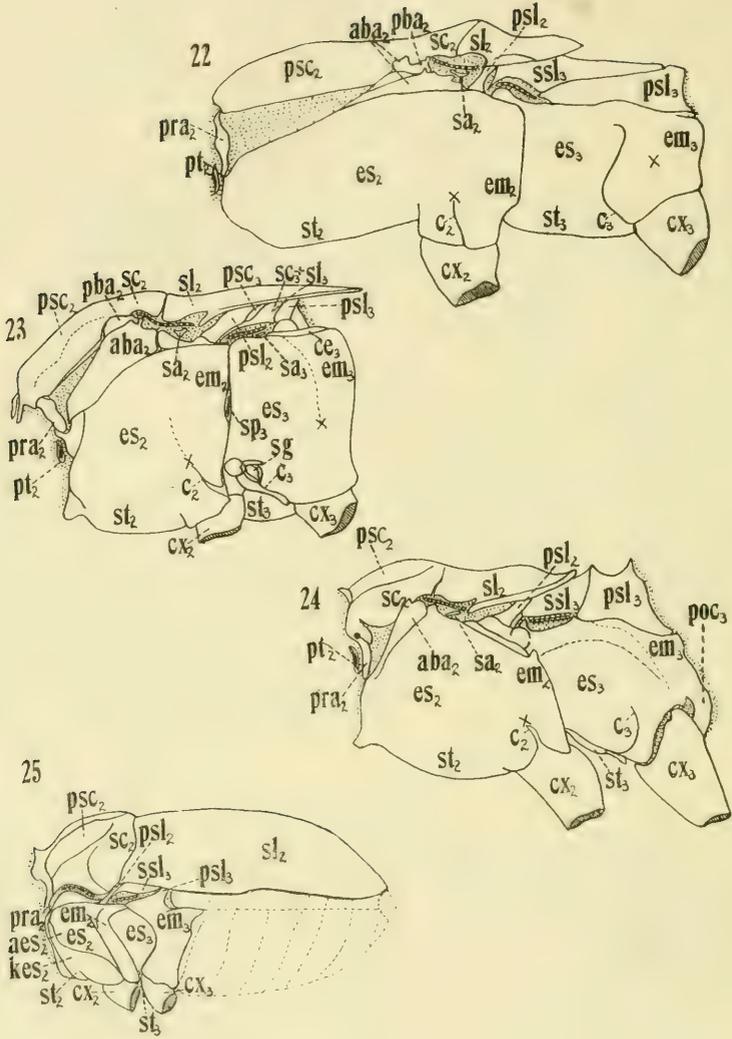
The subscripts 1, 2 and 3 indicate respectively the pro-, meso- and metathorax.



L. H. Taylor







THE ALYDINÆ OF THE UNITED STATES.

By S. B. FRACKER, Madison, Wisconsin.

The family Coreidæ consists of five subfamilies, two of which, the Merocorinæ and Pseudophlœinæ, are very small. The larger divisions, often ranked as families themselves, are: Corizinæ, characterized by a mesal constriction of the fourth dorsal abdominal segment and the obsolescence of the scent-gland orifices; Alydinæ, distinguished by the wide head and unusually small bucculæ; and Coreinæ, which, together with the smaller groups named above, includes the rather diverse remaining members of the family.

The Alydinæ form a compact and easily recognizable group found in all parts of the world and include several cosmopolitan genera. Those occurring in the United States all possess a head at least three-fourths as wide as the pronotum and all except the last two genera have well developed and conspicuous scent gland orifices in front of the posterior coxæ. The bucculæ are short, not surpassing the insertion of the antennæ and the scutellum is narrower than the intraocular part of the head.

In this paper eleven genera, nineteen species and seven varieties are recognized, of which one species and three varieties are new. Material was available in all except three subtropical species (numbers 3, 4 and 8) each of which has been reported from the United States only once. The discussions of these three are based on the descriptions.

Eight of the species found in the United States, and six of the genera, are subtropical, and are confined to the southern tier of States. Four are probably limited to the Rocky Mountains and Pacific coast, and three almost entirely to the States north of the Ohio River. The remaining four have been collected in nearly every part of the United States. *Protenor belfragei*, *Megalotomus 5-spinosus*, *Alydus eurinus*, and *A. conspersus* are among the most common Heteroptera of the temperate zone.

No members of the subfamily are known to be of economic importance. The common species are found in meadows or

about flowers and along roadsides. So far as observed, they are single brooded, the adults appearing in July and August and, in some species, hibernating.

In considering the distribution the published papers are indicated by numerals, and the available collections by letters used in the same way as follows: the collection of Dr. E. D. Ball, ^b; that of the Milwaukee public museum, ^m; that of Prof. W. S. Marshall, University of Wisconsin, ^u; that of the Wisconsin Agricultural Experiment Station, ^a; of Mr. Wm. J. Gerhard, of Chicago, ^g; and of the State Entomologist's office, including the author's collections, ^s. These letters thus indicate for each species the place of collection and the present ownership of the material with which the author has been working. The state names printed in *Italics* are now added to the distribution as given by Van Duzee (1917), and localities are credited to his catalogue when the present writer could find no other published records for them.

The writer is indebted to Mr. Wm. J. Gerhard, Curator of Insects in the Field Museum, Chicago; to Mr. T. E. B. Pope, Curator of Insects in the Milwaukee Museum; to Prof. H. F. Wilson of the Agricultural Experiment Station; and to Prof. W. S. Marshall of the University of Wisconsin, for their courtesy in allowing material in their private collections or under their charge to be freely used. Mr. H. G. Barber and Mr. E. P. VanDuzee have also kindly loaned some valuable specimens. Special acknowledgments are due to Dr. E. D. Ball with whose library and collections most of the work reported herein was done and who has kindly aided with valuable suggestions. Many of the biological notes are on his authority, in particular those from Colorado.

KEY TO TRIBES OF ALYDINÆ.

- a. Posterior femora not armed with spines; lateral plates of female hypopygium (in species examined) contiguous from base to apex, mesal plates concealed or wanting.
 - b. Apical segment of rostrum twice as long as third, second longer than two apical segments together.....*Micrellytrini*
 - bb. Apical segment of rostrum subequal to third, second not longer than third and fourth together; body and legs greatly elongated.....*Leptocorisini*
- aa. Posterior femora armed beneath with a row of spines; lateral plates of female hypopygium distant, at least at base, exposing mesal plates, (except in *Stachyocnemus*).....*Alydini*

Tribe **Micrelytrini** Stal (1867).

One northern, three subtropical and several tropical species are united in this tribe. They resemble each other closely, are more elongate and slender than an *Alydus*, and present a trim appearance. In the first two genera the union of the juga above and in front of the tylus gives the head a very peculiar aspect.

KEY TO GENERA OF MICRELYTRINI.

- a. Juga contiguous above apex of tylus; posterior angles of metapleura acute, more or less produced; lateral angles of pronotum and apex of scutellum unarmed.
 - b. Juga, as seen from the side, split at apex and much longer than tylus; antennæ with first two segments subequal.....*Protenor*
 - bb. Juga as seen from the side, entire at apex, not longer than tylus; antennæ with second segment nearly twice as long as first.....*Darmistus*
- aa. Juga not contiguous at apex, never exceeding tylus.
 - b. Pronotum with lateral angles each armed with spine; scutellum with spine at apex; posterior angles of metapleura more or less acute.....*Cydamus*
 - bb. Pronotum with lateral angles unarmed; lateral and posterior margins of metapleura forming a right angle.....*Esperanza*

Protenor Haglund.Haplotype *belfragei* Haglund.

Protenor Haglund (1868); Stal (1867) 543, nom. nud., (1870) 217, (1873) 87; Distant (1881) 160.

Tetrarhinus Provancher (1872) 75, (1885) 57.

The produced juga, adjacent in front of the tylus and split vertically and horizontally, and the elongated body, separate this genus at a glance from all other Heteroptera. The following species is the only member of the genus.

1. **Protenor belfragei** Haglund.

Protenor belfragei Haglund (1868)¹; Stal (1870) 217²; Uhler (1872) 402³, (1876) 295⁴; Van Duzee (1889)⁵, (1894)⁶, (1905)⁷, (1908)⁸, (1912)⁹; Osborn (1892)¹⁰, (1900)¹¹; Gillette and Baker (1895)¹²; Montgomery (1902)¹³; Bueno (1908b)¹⁴, (1910b)¹⁵; Smith (1910)¹⁶; Parshley (1914)¹⁷; Barber (1914)¹⁸.

Tetrarhinus quebecensis Provancher (1872) 76¹⁹, (1885) 57²⁰.

Description.—Color flavescent, closely and regularly punctate with piceous dots above, more sparsely punctate with pale fuscous or rufescent dots beneath; body, legs, and antennæ elongate, slender.

Head bearing a short mediodorsal groove between antenniferous tubercles; juga contiguous above, surpassing tylus, and split at tip vertically and horizontally so that head terminates in four short processes. Antennæ red, about as long as body.

Venter of abdomen pale, marked with a median black line continued between hind coxæ, and about a dozen black dots on each side. Hypopygium of male produced below into a caudomesal sharp spine directed posteriorly. Sixth ventral segment of female slightly split at tip and with a medioventral tubercle near the posterior margin.

Size 12-15 x 1.2-1.8 mm., males slightly smaller than females.

This widespread and rather common species in the northern States is rare in the habitat of the three other species of the tribe. With the exception of single references to Texas⁴ and Florida¹⁸ respectively, it appears to be limited to the territory north of Maryland and the Ohio River and east of the Rocky Mountains. In the north it is reported in Canada⁵⁻⁸⁻¹⁹⁻²⁰, Maine¹⁷, Massachusetts¹³, New York⁶⁻⁷⁻¹⁴⁻¹⁵, New Jersey¹⁶, Maryland³⁻⁴, Ohio¹¹, Michigan³⁻⁴, Wisconsin^{4-5-m}, Illinois^{4-g}, Iowa^{10-b}, Colorado³⁻⁴⁻¹². The available collections show that it has been found in all parts of Wisconsin including the northern tier of counties.

The immature feed on sedges, and the adults are especially common in low meadows after the first of August and until frost, probably hibernating.

Darmistus Stal.

Haplotype *subvittatus* Stal.

Darmistus Stal (1859a) 469, (1867) 543, (1870) 217, (1873) 88; Distant (1881) 160.

One comparatively uncommon species from the southwestern states and Mexico constitutes this genus. The body, legs and antennæ are not as elongate as in *Protenor* and the shape of the jugs is entirely different.

2. *Darmistus subvittatus* Stal.

Darmistus subvittatus Stal (1859a) 469¹, (1870) 217; Distant (1881) 160²; Gillette and Baker (1895)³; Snow (1906a)⁴; Van Duzee (1914)⁵.

Description.—Flavescent, more or less suffused with dark fuscous above, deeply and regularly punctate, black punctures arranged in a pair of dorsal and a pair of lateral vittæ on head and pronotum, the lateral continued on basal segments of antennæ. Antennæ with second and fourth segments subequal, each nearly twice as long as first. Sixth ventral segment of female entire at apex.

Size 10-11 x 1.5-1.7 mm.

This low-ground western species was described from Mexico and has been collected in Colorado^{3-b}, Brownsville, Texas⁴, California⁵ and *New Mexico*^b. As the mature insects are found in Colorado in late August and September and again from March to June, they must hibernate as adults. The young reach maturity during August, breeding on *Spartina* and probably other low ground grasses.

Cydamus Stal.Haplotype *adpersipes* Stal.*Cydamus* Stal (1860) 33, (1867) 542, (1870) 216, (1873) 88; Distant (1881) 159.

The only member of this South American genus found north of Mexico is the species listed below. In form and general appearance there is a close resemblance to *Darmistus*, although the antennal lengths indicate a similarity to *Protenor*. The armed scutellum distinguishes from all other Alydinæ.

3. **Cydamus borealis** Distant.*Cydamus borealis* Distant (1881) 159; Snow (1906a) 151.

Description.—Pale ochraceous, punctured with fuscous, dark punctures in longitudinal rows. Antennæ with first and fourth segments subequal in length, each as long as second and third together. Pronotum with a slender spine at each lateral angle and scutellum with an acute spine at apex.

Size 8–9 x 1.5 mm.

Snow has reported the collection of this Central American form in Texas. No material is at hand.

Esperanza Barber.Haplotype *texana* Barber.*Esperanza* Barber (1906) 269.*Cydamus*, subgenus *Esperanza*, Bergroth (1913).

A genus erected for *E. texana* on the basis of the following characters: Jugal not attaining the tip of the broad tylus; rostrum as in other Microlytrini; pronotal angles rounded, unarmed; posterior angles of metapleura not acute, but forming a right angle as in *Alydus*; femora unarmed.

4. **Esperanza texana** Barber.*Esperanza texana* Barber (1906) 270.

Description.—Head mottled with fuscous; antennæ yellow, first segment short, spotted with fuscous, second and third subequal, longer than first and more faintly marked, fourth fuscous except at base and apex; rostrum with first segment thickened, yellow, spotted. Pronotum with mediodorsal raised smooth line. Membrane fuscous. Legs long and slender, yellow, spotted with fuscous.

This description is an abstract of Barber's, as the species, based on one male from Brownsville, Texas, has not been seen by the writer.

Tribe **Leptocorisini** Stal (1872).

Gerrida Stal (1867) 543, (in error), (1870) 217.

Leptocorisaria Stal (1872) 54, (1873) 85.

Leptocorisimi Van Duzee (1917).

Only one subtropical species represents this large cosmopolitan tribe in the United States and but two genera are known in the western hemisphere. The remainder are Asiatic and African. The comparatively long third rostral segment and the unusually small size of the head for Alydinae are the diagnostic characters of the group.

Leptocorisa Latreille.

Orthotype *varicornis* Fabricius.

Leptocorisa Latreille (1829) 197; Stal (1873) 86, 87; Distant (1881) 161; and many other authors.

Gerris Fabricius (1803, not 1794); Stal (1865) 87, (1867) 543, (1868) 66, (1870) 217.

Myodocha Latreille (1807) 126, nom. nud.; et al. auct.

Myodochus Leach (1815) (1832) (not *Myodocha* Latreille (1810), a valid name in Lygaeidae); Burmeister (1835) 325; Herrich-Schaeffer (1848) 91.

Leptocorise Latreille (1825) 421, not Latin.

Leptocorixa Berthold (1827) 418, nom. nud.; et al. auct.

Stenocoris Burmeister (1838) 1010; Herrich-Schaeffer (1853); Stal (1873) 87, as subgenus.

Leptocoris Westwood (1840) 483, in error.

Rhabdocoris Kolenati (1845) 67; Stal (1873) 86, as subgenus.

Erbula Stal (1873) 86, as subgenus.

Leptocorisa, as indicated by the many references* and synonyms, is a widespread genus with species in all parts of the world. Three of them belong to the western hemisphere, and one has been collected in the United States. The long juga, which exceed the tylus separate it from the neotropical *Lyrnessus*.

5. **Leptocorisa tipuloides** De Geer.

Cimex tipuloides De Geer (1773) 354; Goeze (1778); Retzius (1783); Gmelin (1788).

Myodocha tipuloides Latreille (1807); Lamarck (1816); Laporte (1832).

Myodochus tipuloides Olivier (1811); Burmeister (1835).

Leptocorisa tipuloides Brulle (1835); Amyot et Serville (1843); Dallas (1852) 484;

Guerin (1857) 391; Mayr (1866) 113; Stal (1870) 218, (1873) 87; Uhler (1876)

291; Distant (1881) 162, (1901) 331; Van Duzee (1909)²; Barber (1914)³.

Leptocorisa crudelis Westwood (1842) 18.

Description.—Color pale flavescent, marked with olivaceous and rufescent. Head much shorter than pronotum, juga united to tip above tylus, which they slightly surpass. Antennae nearly as long as body, reddish except dark apices of second and third segments. Rostrum with second segment subequal to two apical segments together; third about as long as fourth, which is black at tip.

* A much longer list of references is given by Van Duzee (1917); the ones omitted above are European papers in which American species are not especially considered and in which the terms *Leptocorisa* and *Myodocha* are used. The history of the genus name is given by Van Duzee in Can. Ent. 46:378, 379. 1914.

Pronotum with lateral angles rounded, unarmed. Posterior angles of metapleura acutely produced. Posterior femora reaching only half way to tip of abdomen, pale at base, rufescent at apex.

Venter pale, immaculate, darker toward apex. Sixth ventral segment of female entire, produced posteriorly into a large flat mesal lobe. Male with the hypopygium truncate unarmed at tip, completely covering the genitalia except above.

This Central and South American species has been recorded from Texas¹ and Florida²⁻³. It is the only member of subgenus *Stenocoris* Burmeister and may be distinguished from the other species from neighboring territory by the rufescent tips of the femora and the produced, entire, sixth ventral segment of the female. The body and legs are more elongate than those of any other Coreid.

Tribe **Alydini** Stal (1867).

With one exception all the common North American members of the Alydinae belong to this tribe and nearly every species is widely distributed in the northern states. Owing to great uniformity in appearance among the fifteen nearctic species of the group, more or less confusion has existed in their determination in the past, and the distribution of some species is therefore in doubt.

KEY TO GENERA OF ALYDINI.

- a. Posterior tibiae strongly curved and produced into a distinct tooth near the apex; lateral angles of pronotum acute, armed with a spine; openings of ventral scent glands distinct, with long sulci. *Hyalymenus*
- aa. Posterior tibiae straight, not produced into a tooth at apex (except obsoletely in *Burtinus*).
 - b. Openings of scent glands distinct, continued laterad as a sulcus with a callous margin; antennae with first segment surpassing apex of head, fourth subequal to second and third segments together.
 - c. Antennae with first segment longer than second; sixth ventral segment of female split on the medioventral line.
 - d. Posterior femora without tooth near base, tibiae unarmed; posterior metatarsus twice as long as two apical segments together. *Megalotomus*
 - dd. Posterior femora with an obtuse tooth near base; apex of posterior tibiae armed with a small acute tooth; posterior metatarsus about one and one-half times as long as two apical segments together. *Burtinus*
 - cc. Antennae with first segment shorter than second; sixth ventral segment of female entire. *Alydus*
 - bb. Openings of scent glands obscure or obsolescent, without a callous-margined sulcus; antennae with first segment short, not surpassing apex of head, fourth segment much shorter than second and third together.
 - c. Posterior tibiae unarmed; posterior margin of pronotum armed with an obsolete tooth or none. *Tollius*
 - cc. Posterior tibiae armed with two rows of strong spines; posterior margin of pronotum with a mesal tooth. *Stachyocnemus*

Hyalymenus Amyot et Serville.Logotype *dentatus* Fabricius.*Hyalymenus* Amyot et Serville (1843) 223; Dallas (1852) 467; Herrich-Schaeffer (1853) 243; Stal (1867) 542, (1870) 210, (1873) 90; Distant (1881) 156.*Tivarbus* Stal (1859a) 459.*Galeottus* Distant (1893) 459.

The genus *Hyalymenus* as now limited includes all American species of Alydini in which the posterior coxæ are subcontiguous and the posterior tibiæ, compressed, curved, and armed with a strong tooth at the apex. The former character separates it from *Apidaurus*, of which the species *conspersus* is to be found in Mexico and South America.

No representatives of subgenus *Hyalymenus* in which the corium is transparent like the membrane, are known north of Central America and the Antilles. Our species all belong to subgenus *Tivarbus* Stal.

KEY TO SPECIES OF HYALYMENUS.

- a. Male with posterior tibiæ serrate on the anterior margin near the middle; pleura with two to three large shining flavous spots; antennæ refuscent.
 b. Humeral spines not very long, width between apices not over one and one-third times as great as width of head; posterior femora gradually darker toward tip.....*tarsatus* Fabr.
 bb. Humeral spines very long, width between their apices over one and one-half times width of head; posterior femora flavescent, suddenly dark ferruginous at tip.....*longispinus* Stal
 aa. Male with posterior tibiæ entire; pleura without shining flavous spots; antennæ black.....*pulcher* Stal

6. *Hyalymenus tarsatus* Fabricius.*Alydus tarsatus* Fabricius (1803) 250.*Alydus atratus* Fabricius (1803) 257.*Alydus diversipes* Westwood (1842) 19; Dallas (1852) 477.*Alydus affinis* Westwood (1842) 19; Dallas (1852) 477.*Alydus obscurus* Westwood (1842) 19.*Alydus sinuatus* Herrich-Schaeffer (1846) 98; nec Fabricius.*Alydus recurvatus* Herrich-Schaeffer (1846) 98.*Alydus pallens* Dallas (1852) 476.*Tivarbus tarsatus* Stal (1859) 460.*Camptopus pectoralis* Stal (1860) 34.*Hyalymenus tarsatus* Stal (1868) 62, (1870) 212; Uhler (1876) 294¹; Distant (1881) 156; Barber (1906)²; Snow (1907)³.*Camptopus tarsatus* Walker (1871) 162.*Galeottus formicarius* Distant (1893) 459.*Tivarbus diversipes* Uhler (1894) 236.

Description.—Color varying from pale flavescent to dark fuscous or nigricant; thorax with a small white spot near posterior margin of sides of pronotum and two or three large lateral white spots on the pleura near coxæ; abdomen with a row of medioventral white spots.

Abdomen depressed, third to sixth segments in the male each armed with a lateral spine, those of fourth and sixth longer than others. Male with the posterior femora armed at middle with a prominent spine and

near tip with a serrate and dentate ridge; posterior tibiae expanded, crenulate on the anterior margin at the curve. Female with the posterior femora armed with four large spines and two small teeth; posterior tibiae less expanded, not crenulate.

Size 14-17 x 2.5-3 mm.

This variable tropical species is well known from Mexico to Brazil and has been captured in Texas², Arizona³, and California.¹

7. *Hyalymenus longispinus* Stal.

Hyalymenus longispinus Stal (1870) 213; Banks (1910)¹; Barber (1914)².

Alydus (*Campitopus*) *sinuatus* Guerin (1857) 390, 391; (nec H. S., nec Fabr.)

Stal introduces *longispinus* as a new name for the Cuban species which Guerin identified and described as "*sinuatus* H. S.," with the only added information that it differs from *tarsatus* in the fact that the spines of the lateral angles of the pronotum are twice as long and directed more nearly dorsad. The characters given in the key are taken from a female kindly loaned by Mr. H. G. Barber, who records the species from Florida.¹⁻² It is slightly smaller than *H. tarsatus*.

8. *Hyalymenus pulcher* Stal.

Alydus pulcher Stal (1854) 235.

Hyalymenus pulcher Stal (1870) 211; Distant (1881) 156, (1893) 372; Banks (1910)¹.

Banks lists this Central American species as occurring in Texas.¹ It differs from *H. tarsatus* in the black color of the antennae and in the absence of the pleural white spots. The anterior margin of the posterior tibiae of the male is entire and the posterior femora are provided with a series of small teeth throughout their length. Distant's statement that it can be distinguished from "all varieties of *H. tarsatus* by the marginal ventral spines" is apparently incorrect, as this is a secondary sexual character in both species. The armature of the femora is distinctive, however, and the tibiae and apices of the posterior femora are nearly always black. Size 17 x 3.5 mm.

Megalotomus Fieber.

Logotype *limbatus* Herrich-Schaeffer = *junceus* Scopoli.

Megalotomus Fieber (1861) 58, 226; Stal (1872) 54, (1873) 90, 92; Montandon (1893) 50.

Alydus Stal (1867) 542; (1870) 214, (in part).

Huphus Mulsant and Rey (1870) 158, (a palearctic subgenus of *Megalotomus*).

The lateral angles of the pronotum are more acute and the body and legs are more elongated and slender in this cosmopoli-

tan genus than in *Alydus*, there being a close resemblance in many respects to *Burtinus*. Only one species occurs in the United States, although another, somewhat smaller one (*pallescens*) is found in the West Indies.

9. *Megalotomus quinquespinosus* Say.

Lygaeus quinquespinosus Say (1825) 323¹; [(1859) 247²].

Alydus cruentus Herrich-Schaeffer (1848) 100²; Dallas (1852) 477.

Alydus quinquespinosus Uhler (1861) 23, (1875) 832³.

Alydus (Megalotomus) quinquespinosus Stal (1870) 214⁴.

Megalotomus (or *Alydus*) *quinquespinosus* Uhler (1876) 294⁵, (1877a) 406⁶, (1878b) 383⁷; Provancher (1885) 56⁸; Osborn (1892)⁹, (1904)¹⁰; Montandon (1893)¹¹; Van Duzee (1894)¹²; Gillette and Baker (1895)¹³; Snow (1904)¹⁴, (1906b)¹⁴; Crevecoeur (1905)¹⁵; Bueno (1905)¹⁶, (1908)¹⁷, (1913a)¹⁸; Bueno and Brimley (1907)¹⁹; Van Duzee (1908)²⁰, (1917)²¹; Bueno and Englehardt (1910)²²; Smith (1910)²³; Parshley (1914)²⁴.

Description.—Color dusky flavescent to rufous. Head black beneath and with a transverse semilunar black spot above; sternum of thoracic and sometimes basal abdominal segments black. Antennæ with first three segments flavescent, sometimes darker at apex, subequal in length, fourth segment much longer and with apical two-thirds fuscous.

Pronotum with lateral angles acute, and with a transverse, elongate concavity along posterior margin of the disc. Legs pale flavous, except apical half of posterior femora which is red; the latter armed with five or six spines and surpassing apex of abdomen.

Claspers of male with a large tooth-like mesal expansion near base and a long attenuated apex. Sixth ventral of female split at tip, lateral plates of hypopygium widely separated at base, convergent, broadly rounded at apex, and with mesal margins entire.

This is one of the most widely distributed Coreidæ of the northern states and appears in nearly every faunal list of Heteroptera in the temperate zone. In addition to Montandon's record of its occurrence in Florida¹¹, which has not been confirmed by later collectors, it has been found in Canada⁸⁻¹¹⁻²⁰, Maine²⁴, Massachusetts¹¹, New York¹¹⁻¹²⁻¹⁶⁻¹⁷, New Jersey¹⁶⁻²³, Pennsylvania⁷, North Carolina¹⁸⁻¹⁹⁻²², Ohio¹⁰, Illinois^{4-g}, Wisconsin^{11-s-m-u}, Iowa^{9-b}, Kansas¹⁵, Colorado^{5-13-b}, Utah⁶, Arizona¹⁴, California³, Washington²¹, and Vancouver Island²¹. Collected in Wisconsin in Milwaukee^m, Dane^{s-a-m-u}, Sauk^c, Vernon^m, Pierce^m, Polk^s, and St. Croix^m counties, but not so common as *Protenor belfragei* and *Alydus conspersus* and not extending so far north. After the first of August the adults may be found along the edges of woods where they are active flyers. The nymphs feed on *Oxytropis* in Colorado, according to Dr. Ball, and probably on Lupine, reaching maturity in July.

Burtinus Stal.Haplotype *notatipennis* Stal.*Burtinus* Stal (1859a) 458, (1873) 90.*Alydus* Stal (1867) 542, (1870) 214; in part.

Although closely related to the preceding genus which is typically boreal, the species of *Burtinus* are tropical in distribution and only one has been found in our fauna. The generic characters are sufficiently described in the synopsis.

10. **Burtinus notatipennis** Stal.*Burtinus notatipennis* Stal (1859a) 459¹, (1862) 305; Barber (1910) 5², Van Duzee (1917)³.*Alydus notatipennis* Stal (1870) 214; Walker (1871) 160; Distant (1893) 373⁴; Barber (1914)⁵.*Alydus (Megalotomus) femoralis* Distant (1881) 158⁶.*Alydus (Burtinus) femoralis* Distant (1893) 373⁷.*Burtinus femoralis* Uhler (1894)⁸.

Description.—Color varying from pale flavescent to dusky ochraceous mottled and punctured with brown, more or less marked with black on head and venter. Antennæ, rostrum, and legs similar to those of *M. 5-spinosus*, but posterior femora with apical half usually marked with fuscous, sometimes flavo-annulate, not rufescent, not attaining apex of abdomen, and usually with an obsolete little tooth near base; tibiæ armed at the apex with a small spine.

Male with lateral and mesal margins of claspers subparallel to near the obliquely truncate tip. Female with mesal plates of hypopygium armed near base with a blunt lateral tooth, which engages a notch in the mesal margin of the convergent lateral plates.

Described from Central America¹⁻⁴⁻⁶⁻⁷, Mexico¹⁻⁷, and South America¹ and collected since in Lower California⁸, Arizona², Florida⁵ and Texas³. The relationship with Distant's species was proposed by Uhler⁸ and this position has been supported by Barber⁵. *B. femoralis* should possibly, however, be listed as a variety for it is larger and paler than the form which Stal described. No other differences have been found. The specimens at hand are from Arizona (kindly loaned by Mr. Barber) and Linares and Cuernavaca, Mexico, from the Ball collection.

Alydus Fabricius:Orthotype *calcaratus* Linnæus.*Alydus* Fabricius (1803) 248; Stal (1859a) 458, (1867) 542, (1870) 213, (1872) 54, (1873) 90; Fieber (1861) 58, 225; Distant (1881) 157; Provancher (1885) 55; Montandon (1893); Barber (1911).**Alyde* Latreille (1825) 421.

The type genus of the Alydinæ is one of nearctic origin with two palearctic and seven nearctic species. It is a compact group of closely similar forms united by the possession of

* A more complete list of early references is given by Van Duzee (1917). Only those works on which the modern conception of the genus is based are named above, all except two of those before 1860 being omitted.

armed posterior femora, unarmed pronotum and tibiae and well developed scent gland orifices.

The species have been described singly with only meager comparative notes, with the result that superficial instead of fundamental characters have usually been employed to distinguish them. A synopsis of the genus based on coloration and wing characters has been published by Barber (1911). Owing to numerous variations, especially in *A. eurinus* and *A. conspersus*, the present writer has been compelled to rely on genitalia for the separation of these two species and their relatives. Fortunately, this method is easy to apply as *Alydus* has the claspers of the male exposed instead of covered. They are described in the Key as seen from the caudal aspect; no dissection is necessary.

KEY TO SPECIES OF ALYDUS.

- a. Venation of the membrane simple, veins not irregular and only slightly anastomosing; claspers of male when arcuate not toothed near apex; posterior femora not with pale annulus.
- b. Pronotum with lateral angles blunt, and sides and lateral margins not distinctly paler than the disc.
- c. Claspers of male with caudomesal margins subparallel, caudal aspect narrow (Fig. 2); female of *pluto* with lateral plates of hypopygium terminating in a tumid finger-like process (Fig. 1); sixth ventral segment with a distinct median carina; mainly mountain species.
- d. Antennae with fourth segment shorter than second and third together, third subequal to second; body black, not densely pilose; (genitalia, figs. 1, 2)..... *pluto* Uhl.
- dd. Antennae with fourth segment more than one-third longer than second and third together, third shorter than second; body variegated with fuscous, densely pilose; (♂ claspers, fig. 3)..... *tomentosus* n. sp.
- cc. Claspers of male not with caudo-mesal margins parallel; lateral plates of female hypopygium flat, not tumid at tip, sixth ventral segment with carina short, indistinct or wanting; widely distributed species.
- d. Claspers of male twisted, not arcuate (Fig. 5); lateral plates of female hypopygium acute at apex (Fig. 4); pronotum usually black; membrane infuscate..... *eurinus* Say.
- dd. Claspers of male arcuate, divaricate at base and convergent at tip (Fig. 8); lateral plates of female hypopygium broadly rounded at apex (Fig. 7); pronotum usually with posterior two-thirds fulvous; membrane often spotted..... *conspersus* Montd.
- bb. Pronotum with lateral angles acute and lateral margins pale; claspers of male with lateral expansion and acuminate tip (Fig. 10); lateral plates of female hypopygium bluntly rounded, approximate at apex (Fig. 9)..... *pilosulus* H.-S.
- aa. Venation of membrane, or at least costal third, irregular with anastomosing veins; posterior femora with pale annulus near apex; claspers of male elongate, arcuate, with an enlarged stout mesal tooth near apex (Fig. 6)..... *scutellatus* Van D.

11. *Alydus pluto* Uhler.

Alydus pluto Uhler (1872) 401, 402¹, (1876) 294², (1877a) 406³, (1904)⁴; Gillette and Baker (1895)⁵; Snow (1906b)⁶; Van Duzee (1916)⁷, (1917)⁸; [Heideman (1902); Barber (1911)].

Description.—Color piceous black throughout entire head, body and appendages except as follows: Head with fulvous brown spot between ocelli, two behind each eye, and sometimes a minute one in front of eye; antennæ castaneous on base of first three segments, fourth fuscous; pronotum rarely with obscure fuscous areas on the disc; tibiæ castaneous except at tip, metatarsi flavous at base; corium infusate. Abdominal margins rarely spotted. Form robust, moderately hairy, rather sparsely punctate. Antennæ with second and third segments together subequal to fourth.

Claspers of the male (Fig. 2) with only their narrow subparallel posterior edges showing in a caudal view, and with slight mesal expansions, near base; unlike those of any other species, except *tomentosus*. Female with lateral plates of the hypopygium (Fig. 1) terminating in a long, finger-like tumid lobe. These genitalic characters separate them at a glance from the robust specimens of *eurinus* from which they are almost indistinguishable by other means.

Size, ♂, 10.5–11 x 3; ♀, 12–13 x 3 mm.

A great deal of confusion has existed in regard to this species, owing to its similarity to robust forms of *eurinus*. This is evidenced by Heidemann's reference to its "very hairy" character; Barber's indefiniteness as to its identity, and Osborn's recording it from Iowa (1892) and Ohio (1900), each time with a query "(?)." After a careful study of all accessible material in the genus, the writer is convinced that the species defined above by the peculiar genitalia is the one Uhler described. The great similarity, however, in all other respects to *A. eurinus* var. *obesus* casts a doubt on the distribution records east of the Rocky Mountains. Uhler reports its presence in Colorado¹⁻²⁻³⁻⁵, Idaho¹⁻², Texas², New Mexico⁴, Kansas¹⁻², and Louisiana¹⁻², while *Arizona*⁶, California⁷, Utah⁸, Washington⁸, and Vancouver Id.⁸ have since been added. The only specimens at hand are from Fort Collins, Sterling, and Dutch Gorge, Colorado, (Ball collection), and Dilley, Oregon, (from Mr. Barber).

12. *Alydus tomentosus* n. sp.

Description.—Color black, mottled with dark brown; body and legs densely covered with long, fine, black and white setæ intermixed; form more robust than in *eurinus* and not so large as in *pluto*. Head black, marked on each side with a longitudinal flavescent ante-ocular line, slightly broken at tip of antenniferous tubercle and extending nearly

to apex of jugum; also a short, pale fuscous vitta caudo-ventrad of each eye. (One specimen in addition shows a small fuscous spot behind the ocelli). Antennæ fuscous, first, second and third segments black toward apex; fourth segment more than one-third longer than two preceding together, first shorter than second, subequal to third, and attaining apex of head. Rostrum picous, paler at incisions, first segment longest, slightly longer than second and subequal to two apical ones together; fourth one-half longer than third.

Pronotum densely punctate, black, mottled with fuscous on posterior half of the disc and on the sides, sometimes with an indication of short mediodorsal and lateral marginal fulvous lines near anterior margin. Scutellum black, flavescens at tip. Corium castaneous, mottled with flavescens; membrane infuscate. Thorax and abdomen black beneath, densely hairy, sides of thorax rugose and deeply punctate. Scent gland orifices well developed. Margins of abdomen minutely flavo-maculate. Legs with the coxæ, trochanters, and tibiæ castaneous, the latter black at tip; femora black, armed with three or four long spines. Claspers of the male with mesal margins subparallel, caudal surfaces slightly expanded laterally near tip. (Fig. 3).

Size ♂, 10 x 2.6 mm.

Holotype: ♂, from Ft. Collins, Colorado.

Paratype: ♂, from La Animas, Colorado; both in the Ball collection.

This western form might easily be mistaken for *eurinus*. The male genitalia are somewhat similar to those of *pluto*, from which, however, the species is distinguished by the length of the last antennal segment, the brownish mottling of the pronotum, the fuscous corium, the smaller size, and the dense covering of long, soft, pale hairs which give the insect a greyish cast. It is possible that Heidemann had it in mind when he stated (1902) that *A. pluto* is "very hairy." None of the specimens of *pluto* at hand are as hairy as *eurinus* and Uhler's description does not indicate such a condition, his only reference to setæ being the statements that the head is pubescent, the pronotum "a little pubescent" and with bald callosities, and venter, "pubescent at tip." The species here described is more densely hairy than any other *Alydus* and the second and third antennal segments are relatively much shorter. The types are from Colorado, where they were collected at comparatively low altitudes.

13. *Alydus eurinus* Say.

Lygaeus eurinus Say (1825) 324¹, (1859) 247.

Alydus eurinus Uhler (1872) 401², (1875) 832³, (1876) 293⁴, (1877a) 406⁵, (1878a) 504⁶, (1878b) 384⁷; Distant (1881) 157; Provancher (1885) 53⁸; Van Duzee (1889)⁹, (1894)¹⁰, (1903)¹¹, (1908)¹², (1917)¹³; Osborn (1892)¹⁴, (1900)¹⁵; Montandon (1893)¹⁶; Gillette and Baker (1895)¹⁷; Montgomery (1902)¹⁸; Wirtner (1904)¹⁹; Snow (1904)²⁰, (1906b)²⁰; Bueno (1905)²¹, (1908)²², (1910a)²³, (1910b)²⁴, (1912)²⁵; Bueno and Brimley (1907)²⁶; Tucker (1907a) (1907b)²⁷; Bueno and Engelhardt (1910)²⁸; Smith (1910)²⁹; Barber (1911); Parshley (1914)³⁰.

Alydus ater Dallas (1852) 478; Stal (1870) 213³¹.

Alydus pluto Prov. (1885) 56; (?) Osborn (1892), (1894), (1900).

Coriscus vicarius Prov. (1887) 175, in error.

Description.—Head, thorax, venter, and femora piceous black, verging at times to dark castaneous and sometimes apparently griseus in pilose individuals. Flavescent spots at base of head (as in *pluto*) and along margins of abdomen. Antennæ castaneous marked at the tip of each segment with piceous; apical segment fuscous; first shorter than second or third, which together are subequal to or a little longer than fourth.

Caudal aspect of clasper of male (Fig. 5) with a tumid hemispherical area at base from which arises a propeller-shaped lobe, showing a broad caudo-mesal face; claspers approximate except along caudal margin. Female with lateral plates of hypopygium (Fig. 4) flat, acute at tip, convergent; mesal plates obliquely truncate; sixth ventral segment with carina very short, indistinct, or wanting.

The only *Alydus* reported from every section of the United States is *A. eurinus*, although in Wisconsin it is not as widespread as the following species and is rare north of Madison. Throughout its range the adults are numerous in late summer along road sides and the edges of woods on goldenrod and other fall flowers. The young have been bred on *Astragalus* in Colorado, appearing the middle of May.

The recorded distribution is as follows: Quebec 8-12, Ontario⁹, Maine⁷⁻³⁰, New Hampshire⁷⁻²³, Massachusetts⁷⁻¹⁶⁻¹⁸, Connecticut¹⁶, New York 10-21-22-24-25, New Jersey²¹⁻²⁹, Pennsylvania¹⁹, Virginia²⁸, North Carolina²⁶⁻²⁸, Georgia¹³, Florida¹⁶, Ohio^{7-15-b}, Illinois^{31-g}, Wisconsin^{31-s-m-a}, Iowa^{14-16-b}, Missouri¹, Arkansas¹, Nebraska², Kansas^{27-b}, Texas⁴, Dakota⁶, Montana⁶, Colorado⁵⁻¹⁷, Arizona³⁻²⁰, Utah¹³, California¹³.

The characters appearing in the literature do not serve to differentiate this species from *A. pluto* on one hand and *A. conspersus* on the other. In fact it is necessary to examine the genitalia in order to distinguish them. Some of the *eurinus* of the upper Mississippi valley are densely black and very robust, closely resembling *A. pluto*. These may be known as:

13a. *Alydus eurinus* var. *obesus* n. var. (= *A. pluto* auct. in part). Black, punctate, moderately pilose; pronotum tumid, about 3 mm. wide; corium black or nearly so; posterior tibiæ usually black. Length 12 to 13 mm.

Holotype: ♂ from Urbana, Ill. Author's collection.

Allotype: Topotypic. Author's collection.

Paratype: ♀ from Columbus, O. Ball collection.

13b. *Alydus eurinus* var. *eurinus* Say, the typical form of the species, is marked with fulvous brown on the corium, often mottled with flavescent, the pronotum is flatter on the disc and not over $2\frac{1}{2}$ or $2\frac{3}{4}$ mm. wide, and the posterior tibiæ are fulvous brown to fuscous. Length 10 to 12 mm. At the same time there is sufficient intergrading to make it certain that only one species possesses the distinctive genitalia.

14. *Alydus conspersus* Montandon.

Alydus conspersus Montandon (1893)¹; Osborn (1894)², (1900)³; Van Duzee (1894)⁴, (1908)⁵; Heideman (1902)⁶; Wirtner (1904)⁷; Bueno (1905)⁸, (1910b)⁹; Snow (1907)¹⁰; Smith (1910)¹¹; Barber (1911); Parshley (1914)¹².

Alydus calcaratus Uhl. (1861); in error.

Alydus rufescens, Barber (1911); ss below.

Description.—Head and anterior third of pronotum shining black, finely punctate; pronotum with posterior two-thirds usually fulvous to castaneous, occasionally darker, rarely black. Corium varying from mottled fuscous and flavescent to nearly black. Membrane spotted (var. *conspersus*) or infusate (var. *infuscatus*). Segments of antennæ varying in color and length, but fourth not exceeding second and third together by more than one-eighth of their length; abdominal margins and connexivum with pale segmental maculæ or continuous rufescent border.

Male with claspers (Fig. 8) divaricate at base, arcuate as seen from the caudal aspect, convergent at tip, leaving an oval or pyriform opening. Female with lateral plates of hypopygium (Fig. 7) with mesal margins parallel and apices broadly rounded, mesal plates apparently squarely truncate at tip.

In Wisconsin and neighboring states *A. conspersus* is much more common than *eurinus*. It was originally separated from the latter on the basis of the spotted membrane and greyish to castaneous posterior two-thirds of the pronotum and these characters hold for a majority of the specimens seen. The strongly arcuate male claspers, surrounding an oval opening, and the character of the lateral plates of the female hypopygium which have their mesal margins subparallel and are broadly rounded at the apex are, however, the only characters on which complete reliance may be placed.

From August 1st until late fall, the adults are found in every section of Wisconsin, including the most northern counties. They copulate in September and October, and the winter is apparently passed in the egg stage.

Three varieties of this species, differing considerably from each other in color, may be distinguished as follows:

- a. Membrane pale with many fuscous dots; abdomen and margins of connexivum with flavescens maculae.....var. *conspersus* Mont.
- aa. Membrane infuscate, not dotted.
 - b. Connexivum and margin of venter, black with flavescens maculae.
var. *infuscatus* n. var.
 - bb. Connexivum and margin of venter broadly rufescent, latter to beyond spiracles; rufescent band sometimes slightly broken by the encroaching black coloration.....var. *rufescens* Barber

14a. *Alydus conspersus* var. *conspersus* Montandon is the typical form and the only one which has been recognized heretofore as belonging to the species. In addition to the spotted membrane, it is characterized by fulvous pronotum (except cephalic third) and castaneous corium. The distribution is strictly boreal, including Canada⁵, *Maine*¹², Massachusetts¹, New York⁴⁻⁹, New Jersey⁸⁻¹¹, Pennsylvania⁷, *Ohio*,³ Michigan¹, *Illinois*⁶, *Indiana*⁶, *Wisconsin*^{s-m-a-u}, Iowa^{1-2-b}, Dakota¹, Colorado^{1-6-b}, and *Arizona*¹⁰. The Arizona reference may concern var. *rufescens*.

14b. *Alydus conspersus* var. *infuscatus* n. var. is the melanic form of the species, closely resembling and usually identified as *eurinus*. The pronotum and corium are fuscous, sometimes even piceous, and the membrane is dark, entirely without spots. This variety and the typical *conspersus* have been captured copulating on flowers. In the available material a large number of males belong to the variety, but few females, and all the high mountain and extreme northern specimens are of this type. The distribution may possibly be limited to the northern boundaries of the spread of the species.

Holotype: ♂, from Madison, Wisconsin. State collection.

Allotype: topotypic. State collection.

Paratypes: 2 ♂s from Dutch Gorge and Palmer Lake, Colorado, respectively. Ball collection.

14c. *Alydus conspersus* var. *rufescens* Barber (*Alydus rufescens* Barber (1911) 29, 30) has been considered a distinct species heretofore but the genitalia prove it to be a southern variety of *A. conspersus*. The head, pronotum, and corium

resemble those of var. *conspersus* but the membrane is infuscate and unspotted. The venter is dull bronzy black and the margins, to beyond the spiracles, rufescent, sometimes also with rufous spots on the disc; lateral rufescent band is sometimes broken into segmental maculæ.

Described from Huachuca Mountains, Arizona. A pair of topotypes was kindly loaned the author by Mr. Barber.

15. *Alydus scutellatus* Van Duzee.

Alydus scutellatus Van Duzee (1903) 108¹, (1917)²; Cockerell (1910)³; Barber (1911).

Description.—Color variegated brown and black. Head above black with mesal and lateral rufous or flavous lines and about four spots of the same color, two behind the ocelli and two between antennæ. Antennæ as in *curinus*, fourth segment shorter than second and third together. Pronotum with anterior margin dull black and mediodorsal line depressed; posterior two-thirds, and corium, fulvous brown, spotted with black. Membrane varying from pale between veins to fuscous throughout, venation varied, but always irregular and reticulated. Venter of head and thorax black, that of abdomen black with flavescent or fuscous markings varying from a small area on the fifth ventral to the entire abdomen. Femora fuscous to piceous, posterior with a broad subapical pale annulus.

Male with claspers (Fig. 6) more elongate than in other species, armed inside near apex with an expanded triangular tooth, and curved sharply cephalo-laterad at tip. Female unknown.

Described from New Mexico¹ and reported since from Colorado^{2-b}, Montana^{2-g}, and British Columbia². A specimen is also in the Milwaukee Museum labeled "Rauterberg col., Dubuque, Iowa." It is possible that this is a boreal and alpine form which will be found along the upper Mississippi. In the Rocky Mountains it has been collected from 8000 feet up to the timber line.

The species is well marked and comparatively constant. The peculiar genitalia, annulate femora, and black scutellum cause it to be unmistakable. Cockerell's material differed from the type in the pale but spotted venter and comparatively pale membrane.

16. *Alydus pilosulus* Herrich-Schaeffer.

Alydus pilosulus H.-Sch. (1848) 101; Uhler (1876) 294¹, (1878b) 384²; Montandon (1893) 50³; Montgomery (1902)⁴; Bueno (1905)⁵, (1908b)⁶, (1910b)⁷, (1913a)⁸; Hine (1907?)⁹; Tucker (1907a)¹⁰, (1907b)¹¹; Bueno and Brimley (1907)¹²; Van Duzee (1909)¹³, (1914)¹⁴, (1917)¹⁵; Smith (1910)¹⁶; Bueno and Englehardt (1910)¹⁷; Barber (1911)¹⁸, (1914)¹⁹; Parshley (1914)²⁰.

Alydus eurinus Stal (1870) 213, nec Say.

[*Alydus villinosus* Harris, (Cata. Ins. Mass. 1833) according to Uhler (1878) 384].

Description.—Color varying from black marked with fuscous to pale flavescent, with a few black maculae. Head black, with a longitudinal flavescent line on dorso-meson, a pair through eyes, and another below eyes, these lines sometimes widened until only narrow black vittae remain between them. Disc of pronotum varying from fulvous brown to fuscous, anterior third black, except at middle; margins and sides of pronotum flavescent (except near anterior margin), covered with a dense mat of white soft setae. Sternum black, pleura fuscous to black. Venter varying from black to rufescent.

Male with claspers (Fig. 10) parallel on mesal margin, narrow at base, suddenly expanded laterally below middle, acuminate at tip. Lateral plates of female hypopygium (Fig. 9) convergent, contiguous at tip, causing mesal plates to appear triangular in shape. Size: ♀, 11–12 x 2.2–2.5 mm.; ♂ distinctly shorter and much more slender.

Less confusion has existed in regard to the identity of this species than that of the other common members of the genus as its characteristics are marked. The pronotum with its acute angles and pale margins and sides, as well as the unusual form of the genitalia are distinctive.

The distribution extends from Maine and Florida to Kansas and Texas with a single California record. The list of States is as follows: *Maine*²⁰, *Massachusetts*²⁻³⁻⁴, *New York*⁵⁻⁶⁻⁷, *New Jersey*⁵⁻¹⁶, *Pennsylvania*^{15-g}, *Delaware*¹⁵, *Maryland*¹, *Virginia*⁴⁷, *North Carolina*⁸⁻¹², *Florida*³⁻¹³⁻¹⁹, *Indiana*^g, *Illinois*^{1-g}, *Wisconsin*^m, *Iowa*^b, *Missouri*^{3-m}, *Nebraska*^m, *Kansas*^{10-11-b}, *Louisiana*⁹, *Texas*^{1-m}, *Oklahoma*¹⁻¹⁵, *California*¹⁴.

Tollius Stal.

Haplotype *curtulus* Stal.

Tollius Stal (1870) 213 (as subgenus), (1873) 89 (as genus).

Although closely similar in appearance, the structural differences between *Alydus* and *Tollius* are marked. In the latter the scent gland orifices are obsolescent, the first antennal segment does not attain the apex of the head, the posterior femora surpass the tip of the abdomen and the claspers of the male are flat and approximate. Two species have been described.

KEY TO THE SPECIES OF TOLLIUS.

- a. Claspers of male elongate, nearly four times as long as wide, gradually twisted near truncate apex; corium with lateral margin and often entire disc dotted with fuscous, apical margin not paler; median line of pronotum and scutellum obscure, at least posteriorly. *curtulus* Stal
- aa. Claspers of male short, not over three times as long as wide, suddenly obliquely truncate, acute at apex; corium with lateral half pale, immaculate, apical margin conspicuously so, unspotted; median pale line of pronotum and scutellum conspicuous; lateral margins of pronotum pale.

setosus Van D.

17. *Tollius curtulus* Stal.

Alydus curtulus Stal (1859b) 234¹.

Alydus (Tollius) curtulus Stal (1870) 213.

Tollius curtulus Uhler (1876) 294², (1894) 236³; Gillette and Baker (1895)⁴; Barber (1911)⁵; Van Duzee (1916)⁶, (1917)⁷.

Description.—Color varying from grayish testaceous to fuscous; pubescent. Head grey above, marked with pale longitudinal stripes through eyes, beneath eyes and obscurely along dorso-meson; ventral surface black. Antennæ pale, first and fourth segments darker.

Pronotum griseous, disc marked with a pair of fuscous, slightly divergent vittæ, more obscure than in *setosus*. Scutellum with median line obscure. Corium always marked along costal margin with fuscous dots, which sometimes cover entire surface. Femora mottled, sometimes flavo-annulate.

Claspers of male (Fig. 11) slender, one-fourth as wide as long, with basal half flattened, apical half gradually twisted; apex subtruncate, especially as seen from the side; caudo-lateral portion of pygofer tumid, distinctly marked off from the ventral surface of the segment by a deep notch ventrad of their apex. Female with lateral plates of hypopygium contiguous at tip; mesal plates elongate, triangular, resembling those of *Alydus pilosulus*.

Length, 9.5 to 11 mm.; width 2.2 to 2.7 mm.

The widespread distribution of this comparatively uncommon insect has not been appreciated until recently. It is now known from New York⁵, Illinois^m, Colorado⁴, Utah⁷, Oregon, California¹⁻²⁻⁶, and Lower California³. The Illinois record is from a Chicago specimen in the Milwaukee museum and the Oregon one from ten specimens kindly loaned by Mr. H. G. Barber.

The shape of the male claspers at the apex, and of the pygofer are distinctive, though the twisted shape of the claspers makes the truncate apex difficult to see. The color markings of the insect are not nearly as attractive as in *setosus*, the sharp contrasts of the latter being wholly wanting. Twenty-six specimens from New York, Illinois, Colorado, Oregon and California have been examined by the writer and the description is based on them.

18. *Tollius setosus* Van Duzee.

Alydus setosus Van Duzee (1906)¹; Snow (1907)²; Barber (1911)³; Bueno (1913b)⁴.

Tollius setosus Van Duzee (1914)⁵; (1917)⁶.

Description.—Color flavescent to castaneous, marked attractively with fuscous. Dorso-mesal pale line continuous from tylus to tip of scutellum, conspicuous. Ventral surface of head black, often narrowly. Divergent vittæ of pronotum conspicuous. Corium with the anal

area much darker than the costal and apical margins which are unspotted. Femora various in color.

Claspers of male (Fig. 12) short, flat, quadrangular, suddenly obliquely truncate at tip, dorso-lateral apex acute; caudo-lateral portion of pygofers scarcely tumid, apex rectangular, not distinctly marked off from ventro-caudal margin of segment by a notch. Female with lateral plates of hypopygium slightly wider at base than in *curtulus*.

Size 10 x 2.4 mm.

Originally described as an *Alydus* and compared with *A. eurinus*, *Tollius setosus* has never been satisfactorily distinguished from Stal's species. The variability in coloration in each of them and their similarity in distribution has caused some confusion. The characters used above are derived from a pair collected by Mr. Van Duzee, in California, compared by him with the type, a male, and kindly loaned the author. Two other specimens are at hand, a female from Mt. View, California, in the Ball collection, and a male sent from Mr. H. G. Barber, as having been collected in Kingsbridge, N. Y. These are identical with those from Mr. Van Duzee.

The distribution of *T. setosus* includes Arizona¹⁻², Utah⁶, California^{4-5-b} and Montana⁶, in addition to the *New York* record.

Stachyocnemus Stal.

Haplotype *apicalis* Dallas.

Stachyocnemus Stal (1870) 215, (1873) 91.

Many characters make this genus the most aberrant one of the tribe. The complete obsolescence of the scent-gland orifices, the spinose posterior tibiae, the shape of the male hypopygium which conceals the claspers, and the absence or concealment of the mesal plates of the female hypopygium are unique. The affinities are clearly with *Tollius*.

19. *Stachyocnemus apicalis* Dallas.

Alydus apicalis Dallas (1852) 479¹.

Stachyocnemus apicalis Stal (1870) 215; Uhler (1872) 402², (1876) 294³, (1877b) 1325⁴; Heidemann (1902) 81⁵; Snow (1906a)⁶, (1906b)⁷; Van Duzee (1909)⁸; Smith (1910)⁹; Bueno (1913a)¹⁰; Barber (1914)¹¹.

Description.—Body covered with short stiff black setae and more or less gray pubescence. For color, see varieties below. Antennae with first segment widened to tip, second and third slender, subequal; fourth longer and thicker than others.

Pronotum with posterior margin bearing a mesal tooth. Hemelytra variable in length, usually slightly surpassing apex of abdomen. Anterior and intermediate femora and tibiae slender and unarmed; posterior

femora thickened, attaining apex of abdomen and armed beneath with two rows of acute teeth; posterior tibiae armed with two rows of strong spines, those of inner row longer than the others.

Size 7.5-8 x 2-2.5 mm.

Taking the two varieties together, the species is known from Florida¹⁻²⁻³⁻⁸⁻¹¹, North Carolina¹⁰, District of Columbia⁵, New Jersey⁹, New York, Indiana⁶, Colorado^{5-b-g}, Dakota², Montana⁶, Texas²⁻³⁻⁶, Arizona⁷, New Mexico⁴ and California³. In the east, according to Mr. Barber, it is "well established, but rarely taken by collectors, possibly because they do not know just where to look for it—in sandy spots."

Two varieties are found in the United States, so different in appearance that they may possibly prove to be distinct species. They may be separated as follows:

- a. Juga projecting cephalo-laterad from tylus so that head appears to be three-pointed; body with little or no gray pubescence, general color black, marked with dark ferruginous; head strongly depressed; caudo-mesal tooth of pronotum minute. var. *apicalis*
- aa. Juga scarcely projecting, indistinct as seen from above; body covered with fine grey pubescence; general color gray-flavescent; head not depressed; caudo-mesal tooth of pronotum prominent. var. *cinereus*

The typical variety (*apicalis*, Fig's 13, 13a) is piceous black, slightly marked with dark reddish brown. It is eastern in distribution, ranging from Florida, the type locality, to New York. Specimens from Florida, New Jersey and New York have been examined.

Stachyocnemus apicalis var. *cinereus* n. var. (Fig's 14, 14a) does not answer Dallas' description of the species in any particular. It is flavescent in color, covered with dense fine white pubescence, marked above with a large fuscous triangle on the pronotum. The femora and venter are mottled, yellow and brown with numerous small dots.

Holotype: male from Fort Collins, Colorado.

Allotype: from Gunnison, Colorado.

Paratypes: male from LaSalle, Colorado; female from Fort Collins, Colorado. All in the Ball collection.

In addition to the type material the writer has examined a considerable number of specimens of the latter variety from Colorado; Hessville, Indiana; and Helena, Montana, in the Gerhard collection, and one from the Huachuca Mountains of Arizona from Mr. Barber. The types were taken at comparatively low altitudes in Colorado (5000 to 7000 feet) and were found running about the surface of the ground. Dates of capture include June, July, August, and September.

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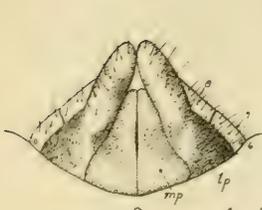
EXPLANATION OF PLATES.

PLATE XXIV.

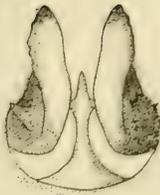
- Fig. 1. *Alydus pluto*. Caudo-ventral aspect of female genitalia. *mp*, mesal plates; *lp*, lateral plates of hypopygium; *6*, sixth abdominal segment. The lateral plates apparently represent the seventh, and the mesal plates the eighth ventral segment.
- Fig. 2. *Alydus pluto*. Male genitalia, showing the caudal aspect of the claspers.
- Fig. 3. *Alydus tomentosus*. Claspers of male.
- Fig. 4. *Alydus eurinus*. Female hypopygium.
- Fig. 5. *Alydus eurinus*. Claspers of male.
- Fig. 6. *Alydus scutellatus*. Claspers of male.
- Fig. 7. *Alydus conspersus*. Female hypopygium.
- Fig. 8. *Alydus conspersus*. Claspers of male.
- Fig. 9. *Alydus pilosulus*. Female hypopygium.
- Fig. 10. *Alydus pilosulus*. Claspers of male.
- Fig. 11. *Tollius curtulus*. Claspers of male. *pf*, caudo-lateral portion of pygofer.
- Fig. 12. *Tollius setosus*. Claspers of male.

PLATE XXV.

- Fig. 13. *Stachyocnemus apicalis* var. *apicalis*.
- Fig. 14. *Stachyocnemus apicalis* var. *cinereus*.



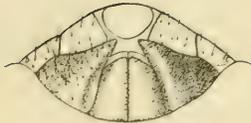
♀ *A. pluto*
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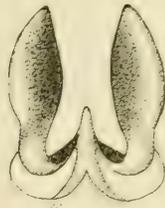
♂
2



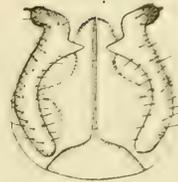
A. tomentosus
3



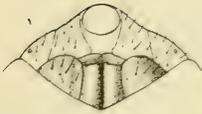
♀
4
A. eurinus



♂
5



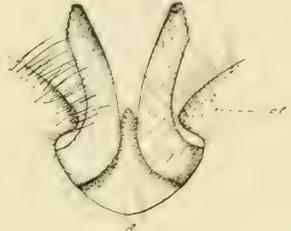
♂
6
A. scutellatus



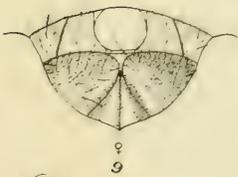
♀
7
A. conspersus



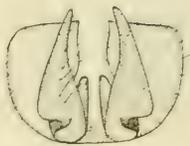
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8



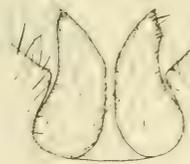
♂
9
Tollius curtulus
11



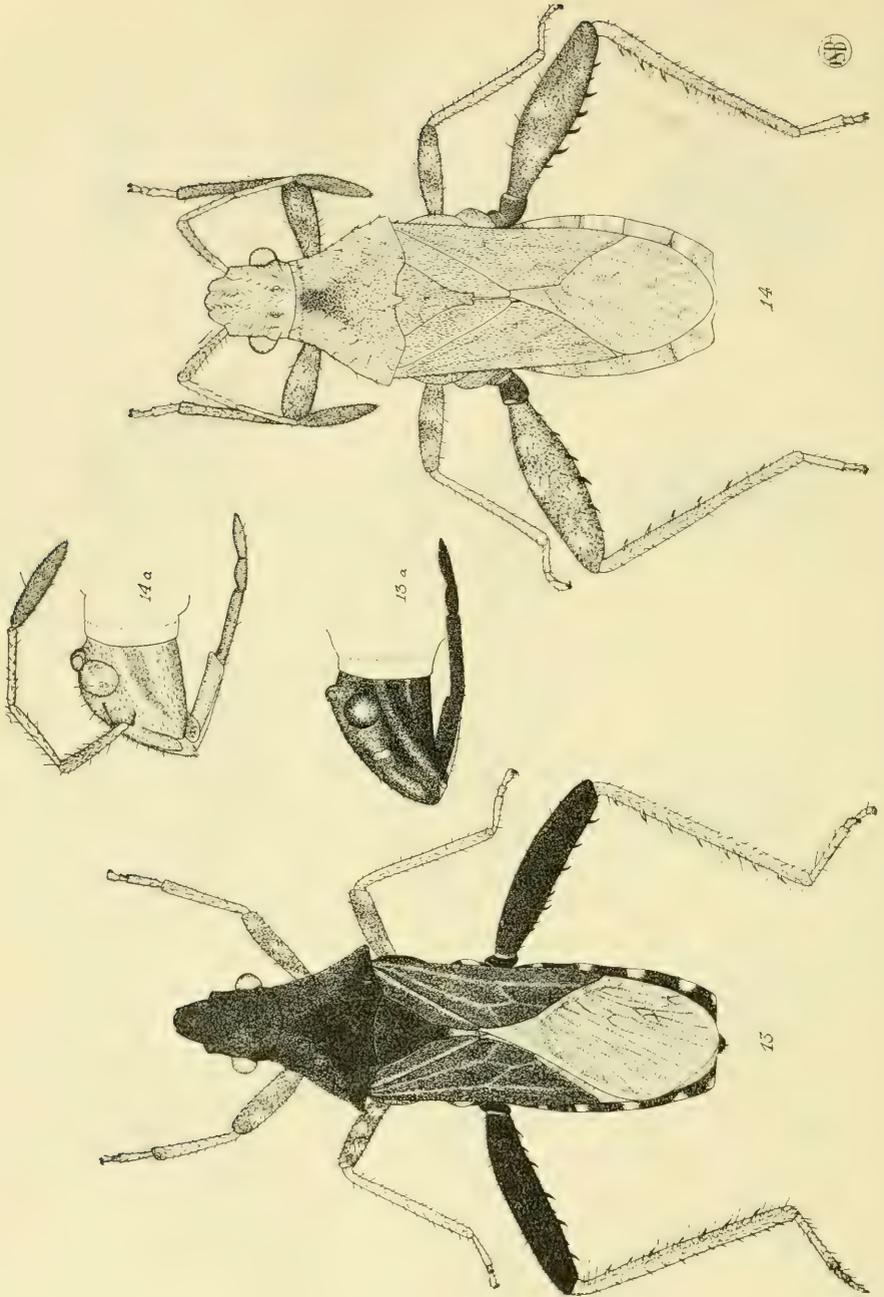
♀
10
A. pilosulus



♂
12



♂
13
Tollius setosus
12



S. B. Fracker

THE ALIMENTARY CANAL OF THE LARVA OF *ALTICA BIMARGINATA* SAY (Coleoptera).*

By WILLIAM COLCORD WOODS.

1. The gross anatomy.
2. The histological structure of the alimentary canal.
3. The Malpighian vessels.
4. The salivary glands.

1. THE GROSS ANATOMY OF THE LARVAL CANAL.

In the alimentary canal of the alder flea-beetle, *Altica bimarginata* Say, (Chrysomelidæ) as in insects generally, three primary divisions of the digestive tract are at once evident; the fore-intestine (stomodæum), the mid-intestine (mesenteron or ventriculus), and the hind-intestine (proctodæum). In this larva, the comparatively short alimentary canal, which is a nearly straight tube with few convolutions, is somewhat less than half again as long as the body. The writer has already published a figure showing the general structure (Woods 1916, Fig. 1).

The alder flea-beetle is entirely a plant feeder, living usually on the leaves of the alder (*Alnus incana* Moench), or more rarely on the willow (*Salix* spp.), or the balsam poplar (*Populus balsamifera* L.). Among adult insects the carnivorous species as a rule have rather short, straight intestines, whereas the phytophagous species tend to have longer and more convoluted digestive tracts. The larva of the alder flea-beetle does not really form an exception to this generalization, although at first sight it may appear to; for the alimentary canal, though short, is of considerable diameter throughout, so that what it may lack in length is made up in volume. Gastric coeca such as are developed in the Acridiidae or in *Corydalis* are entirely wanting.

The fore-intestine is short, extending back only as far as the beginning of the second thoracic segment. Two divisions only are recognizable in it upon dissection, but histologically four regions can be distinguished, the first three appearing to constitute a single region macroscopically. These parts are first

* Contribution from the Entomological Laboratory of Cornell University.

the buccal cavity, then the pharynx (the limits of which are determined by the attachment of the muscles which run from the alimentary canal to the body wall), and third, a short, narrow, muscular oesophagus which extends as far as the prothorax, where it gradually broadens out into a thin-walled distensible crop, the fourth division, the diameter of which is half as great as that of the mesenteron. A constriction, as well as a conspicuous difference in the thickness of the walls, marks externally the separation between the fore-intestine and the mid-intestine.

The mid-intestine composes by far the largest part of the digestive tract of this species. The ventriculus runs through the body as a straight tube of nearly uniform diameter, from a point near the beginning of the mesothorax to the end of the fourth abdominal segment, where a slight constriction is apparent; from here on it is somewhat convoluted and of less diameter, extending nearly or quite to the end of the seventh abdominal segment. Correlated with this macroscopic division into the two sections, is a differentiation of the lining epithelium.

The hind-intestine, which is composed of three regions, begins in the posterior portion of the seventh abdominal segment, where it joins the mid-intestine at a sharp angle. The six Malpighian vessels arise at the point of union. Their origin and distribution has already been discussed (Woods 1916). They are divisible into two series, the first (i. e., posterior) consisting of four vessels, and the second (i. e., anterior), of two. The vessels of the second series arise as separate evaginations from the intestine at the point where the mid-intestinal epithelium passes into that of the hind-intestine. The vessels of the first series unite into a bladder, which opens directly (i. e., without a stalk or urethra) into the lumen of the ileum (first division of the hind-intestine), slightly posterior to the evagination of the tubes of the second series. After a greater or less course through the body-cavity, the vessels of the first series unite into two pairs, and to each pair is joined one of the vessels of the second series, so that two common trunks of three vessels each are formed. These trunks pass into the wall of the colon (second division), where they end blindly in irregular ramifications.

At the junction of the mid-intestine with the hind-intestine, there is a sharp turn in the alimentary canal, so that, between

the mesenteron which runs caudad and the ileum which runs cephalad, is formed a U-shaped bend, on the inner side of which the bladder opens. Having bent forward, the hind intestine extends as far cephalad as the posterior edge of the fifth abdominal segment, where it turns back on itself; this bend marks externally the separation between the ileum and colon. The colon, which is nearly straight, runs caudad as far as the anterior edge of the ninth abdominal segment, ventrad of the ileum. The colon passes directly into the rectum (third division), which is only one segment long. The anal opening is in the center of the anal proleg, and is shaped like an inverted Y. Macroscopically no difference is apparent between the ileum and the colon. The colon is smaller than the second division of the ventriculus; anteriorly, the colon is of the same diameter as the ileum, but it gradually increases in size posteriorly. The rectum is surrounded by powerful circular muscles, which show up clearly in a dissected specimen, and clearly differentiate it from the rest of the alimentary canal.

The structure of the different regions of the alimentary canal is discussed in the remainder of this paper. The parts are considered in order, beginning at the anterior end.

2. THE HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL.

THE FORE INTESTINE.

THE MOUTH-PARTS AND THEIR MUSCLES.

Mouth parts. The mouth parts of the larva of the alder flea beetle consist of the typical biting pieces; a labrum, two mandibles, two maxillæ, and a labium. The writer has already published figures of these structures (Woods 1917, Fig. 19).

Cuticular invaginations. There are four cuticular invaginations in the head of this larva, one unpaired and three paired, which serve for the attachment of muscles. The unpaired cuticular invagination extends along the mid-dorsal line of the head from the caudal margin of the epicranium as far cephalad as the clypeus. Both primary and secondary cuticulæ are equally involved. The paired invaginations arise from the labrum, the mandibles and the maxillæ.

The first is a very slight cuticular invagination on each side of the labrum. Both cuticular layers take part in its formation. The mandibular tendon is a long chitinous invagination extending caudo-mesad from the posterior edge of the inner face of the mandible. It is formed almost entirely of the secondary cuticula. The maxillary tendon arises at the end of the chitinized portion of the stipes, and extends mesad in a curved line, so as to form a semi-circle. Both layers of chitin contribute equally to its formation.

Muscles. Two sets of muscle fibres are connected with the labrum. A large muscle fibre runs on each side from the labral invagination to the median dorsal invagination. Their contraction closes the labrum firmly against the mandibles. The second set consists of five or six fibres which run between the labral invaginations. Their contraction tends to pucker the labrum. There does not seem to be a set of fibres to open the labrum. All of these muscles are cephalad of the oral invagination, and of the supra-oesophageal ganglion.

The muscles connected with the mandibles occupy the greater part of the head cavity. There are two principal sets. Both are attached to the mandibular tendon; the flexor muscles extend to the median dorsal invagination, or to the body wall entad of the tendon, while the retractor muscles extend to the cuticula ectad of the tendon. The most cephalic fibres are anterior to the labral muscles, while others extend caudad as far as the oesophageal connectives. There is also a third set of mandibular muscles which are but slightly developed. They are inserted at one end on the cuticula of the outer face of the mandible, and at the other on the cuticula of the body wall at the base of the mandibles. Their contraction would serve to close the mandibles very tightly.

The maxillary muscles arise on the maxillary tendon and extend to the gula. There are about twenty fibres connected with each maxilla.

The labial muscles arise on the thickened cuticula at the distal end of the mentum, and are inserted on the gula. There are about five fibres on each side of the labium.

Attachment. The muscles are attached through the hypodermis to the secondary cuticula (or through the epithelium to the secondary intima) both here and elsewhere in the body.

The hypodermal cells through which the attachments are made become fibrillar, and their fibrils interlace with those of the muscles. (See figure 1, A). In some sections of just molted larvæ, these tendons are quite long, but usually the cells are not drawn out at all. (See figure 1, B). The basement membrane of the hypodermis or epithelium appears to be continuous with the sarcolemma of the muscles.

THE BUCCAL CAVITY.

As is to be expected, longitudinal sections show clearly that the cuticula of the body wall is directly continuous with the intima of the fore-intestine, the hypodermis with the epithelium, and the basement membrane of one with the basement membrane of the other. The primary cuticula is of about the same thickness as the primary intima, but it becomes deeply pigmented and beset with many cuticular nodules as soon as it is outside of the oral invagination. The secondary cuticula is also of about the same width as the secondary intima, and both stain pink with eosin. The intima of the buccal cavity is armed with small backward directed spines.

The epithelial cells are considerably larger than those of the hypodermis, but the transition is gradual and there is no abrupt change of type, the cells first becoming higher than the flat hypodermis, and then gradually broadening out into the cuboidal form characteristic of the pharyngeal and œsophageal epithelium.

THE PHARYNX.

In this species, the limits of the pharynx can be determined only by the attachment of the muscle fibres which run to the body wall. Dorsally there are two sets of these, one of four fibres running perpendicularly, and the other of three extending at an angle, to the body wall. Ventrally there is a single set which consists of two large fibres running nearly vertically to the body wall. These muscles are all paired. They are attached to the intima in the usual way, and their sarcolemmata appear continuous with the basement membrane.

The oral invagination is shown in figure 2. The location of the pharyngeal muscles is shown in figure 3.

The histological features of the pharynx and œsophagus are identical as regards the type of intima and epithelium, which

are discussed under the latter region. In the pharynx the epithelium is simple and is not thrown into the folds so characteristic of the œsophagus, and this character helps to distinguish between the two regions.

THE OESOPHAGUS.

Intima. In this region the intima, which is comparatively well developed, appears, in cross sections, to be thrown into a series of strong longitudinal folds, usually six in number. The primary intima is well developed; the secondary intima is thicker, and stains with eosin. The primary intima bears sharp backward directed spines. The apparent teeth which the folds make almost close the lumen at the anterior end, but become weaker and weaker posteriorly.

Epithelium. The epithelium of the œsophagus is composed of large cuboidal cells; the cell divisions are not always clear, but this is doubtless due to the fixative, and does not represent any tendency toward a syncytium. There is a great variation in the size of the cells. The cytoplasm, which stains a violet-pink with eosin, appears almost homogeneous; it is non-granular and non-vacuolar. The nuclei are round-oval both in cross and longitudinal sections; they are comparatively small, and are densely filled with coarse deep-staining chromatin granules.

There is no indication of salivary cells in the œsophagus as were reported for *Hydrophilus* by Plateau (1874), and have since been recorded for several other insects.

Just after a molt, and throughout each instar, the epithelial cells lie close against the intima, and the above description has reference to such a condition. But several days before the insect is ready to cast its skin, a very characteristic premolting condition develops. The cells, which seem to be glandular in their nature, appear to secrete a fluid beneath the intima. They become fibrillar entad, and the spaces between the narrow cytoplasmic strands are probably filled with a secretion. As this process continues, in a characteristic section, the epithelium seems separated from the intima by a fibrillar vacuolar portion, which stains light blue with Delafield's hæmatoxylin. Toward the end of each instar the fibrillar portion constitutes the bulk of the apparent teeth which the folds of the intima make, and the

epithelium does not pass out into these projections at all, as it does earlier in the instar. At all times, the true cytoplasmic area of the cells is sharply marked off from the fibrillar portion.

This fluid doubtless functions in connection with the molting of the intima of the fore-intestine, for this is of course shed at each molt, with the rest of the chitinous structures derived from the ectoderm.

The epithelium in the newly hatched larva, and after each of the two molts, lies directly against the intima. This fibrillar secretion is developed in all three of the larval instars. Eventually it also extends out more or less into the undifferentiated hypodermis of the body wall, with which the epithelium is continuous, but this premolting condition is always apparent in the alimentary canal before any of the hypodermal cells are affected. In the full grown larva, this area is apparent at least three or four days before it ceases feeding. The new intima appears on the last day before the larva enters the ground, and the secondary intima becomes apparent on the fourth day of prepupal life.

The œsophagus is shown in cross-section in figure 4; a few epithelial cells, in the typical state, in figure 5; a few epithelial cells in the premolt condition, in figure 6; and a few epithelial cells after the new intima has been formed, in figure 7.

Basement membrane. A structureless limiting membrane is clearly distinguishable in all of the sections which were examined. Neither here nor elsewhere in the canal has the writer found nuclei in the basement membrane, and he believes that it is formed by the hypodermal cells themselves, and is not of connective tissue.

Longitudinal muscles. From twenty to twenty-five longitudinal muscle fibres occur inside of the circular muscle layer. They are inserted proximally on the intima at the very beginning of the pharynx; they continue not only throughout the fore-intestine, but through the mid-intestine, and a part of the hind-intestine; distally they are inserted on the intima at the end of the ileum. In a general way, the arrangement of these muscles is like that described by Balbiani (1890) for *Cryptops*.

Circular muscles. The circular muscles are strongly developed. There is but a single layer of them. The most cephalic muscle is inserted on the intima at the very beginning of the pharynx, but they are lodged in a connective tissue envelope which is continuous throughout the whole alimentary canal as

far as the rectum, and forms a complete membranous cylinder around the digestive tube. As is the case with all of the muscles of the alimentary canal of this insect (and probably of all others), they are clearly striated.

THE CROP.

Transition. The transition from the œsophagus to the crop is gradual. The lumen grows gradually wider, the epithelium becomes thinner and more stretched, and the chitinous folds become less and less pronounced as one traces the œsophagus posteriorly.

Intima. The intima is very much thinner than in the œsophagus, and while it is thrown into many minute wavy folds, the six large primary folds have disappeared entirely. Both primary and secondary intima may be recognized; they are of the same nature as the corresponding structures in the œsophagus, but are much more delicate.

Epithelium. In both cross and longitudinal sections, the cells appear as if they were stretched; their bases are long, and their altitude low, so that instead of being cuboidal, they present the aspect of long, narrow rectangles. The oval, granular nuclei stain quite deeply, but are not as chromatic as those in the pharyngo-œsophageal epithelium. The cytoplasm is homogeneous, non-granular and non-vacuolar.

As in the rest of the fore-intestine, a fibrillar area is developed between the epithelium and the intima previous to each molt. It is much less extensive than in the pharynx and œsophagus, probably because the thin, little folded intima is shed much more easily than the thick, strongly folded intima which lines the other regions.

A cross-section through the crop is illustrated in figure 8.

Basement membrane. A well developed basement membrane is present.

Longitudinal muscles. The longitudinal muscles are represented by isolated striated fibres, which continue anteriorly into the pharyngo-œsophageal region, and posteriorly into the ventriculus.

Circular muscles. The circular muscles are much stronger than the longitudinal fibres. They appear to be continuous with the muscles of the œsophagus anteriorly and with those of the ventriculus posteriorly, since they all lie in the same connective tissue sheath.

THE ŒSOPHAGEAL VALVE.

In typical cases among insects, such as *Pieris* or *Simulium*, the œsophageal valve is a large fold of the fore-intestine, which projects down into the mid-intestine, almost closing the aperture between them. The function assigned to it is that of preventing the regurgitation of food, due to the peristaltic movements of the intestine.

In *Altica bimarginata* there is a fold of the fore-intestine which projects slightly down into the mid-intestine, and marks the point of transition between these two regions. It is by no means large enough to close the lumen and can be of but little if any use as a means of preventing the repassing of food into the fore-intestine. However, there is a strong constriction between the crop and the ventriculus, and the opening between the two is much less than the diameter of the alimentary canal at this point, so an œsophageal valve is little needed, and this fold is probably all that is necessary. In its structure the œsophageal valve is much like the rest of the crop. Intima, epithelium and basement membrane are clearly distinguishable. The primary intima becomes very thin, but distinction between primary and secondary intima continues to the end. This condition is very similar to that described by Poyarkoff (1910) in the elm leaf beetle.

The œsophageal valve of *Altica bimarginata* is shown in figure 9.

THE TRANSITION BETWEEN THE FORE-INTESTINE AND THE MID-INTESTINE.

Intima. The intima disappears at the end of the fore-intestine.

Striated border. A striated border is developed on the inner face of the cells in place of an intima throughout the mid-intestine.

Epithelium. There is a well marked transition between the type of epithelium characteristic of the fore-intestine and that characteristic of the mid-intestine, even though there is no sudden change. The cells of the fore-intestine at the posterior face of the œsophageal valve become first cuboidal, and then nar-

rower and more elongate, passing almost imperceptibly into the type characteristic of the mid-intestine.

The transition area is shown in figure 9.

Basement membrane. The basement membrane is continuous from the crop to the ventriculus.

Imaginal ring. There is no clearly defined imaginal ring. The cells on the extreme posterior face of the oesophageal valve are very small and close together, and probably constitute the imaginal ring of the fore-intestine. This is very comparable to the conditions described by Poyarkoff (1909, 1910) in the elm leaf beetle, where the imaginal mid-intestine is derived from the cells of the posterior face of the larval oesophageal valve, although these cells are not sharply separated off as a distinct imaginal ring in the larva. The cells are never crowded together in *Altica* so as to form an apparently several layered imaginal ring, as in the case in *Cybister* (Deegener 1904), where the ring lies above the oesophageal valve.

Longitudinal muscles. The longitudinal muscle fibres are continuous from the fore-intestine into the mid-intestine. With respect to the connective tissue sheath in which the circular muscles lie, they are internal in the fore-intestine, but at the point of junction between the crop and the ventriculus, each fibre divides into two or three smaller ones which penetrate this sheath, so that the longitudinal muscles lie outermost in the mid-intestine. There are about twenty of these fibres in the fore-intestine, and about forty at the anterior end of the mid-intestine.

The passage of these muscles from the crop to the ventriculus is shown in figure 10.

Circular muscles. The circular muscles of the fore-intestine and the mid-intestine appear to be continuous, since they both lie in the same connective tissue tube around the intestine, but doubtless here, as in all insects in which the conditions have been studied, embryologically they have very different origins, and are not homologous. The muscles immediately at the junction form a strong sphincter.

THE MID-INTESTINE.

THE FIRST DIVISION OF THE VENTRICULUS.

Striated border. The epithelium of the mid-intestine never supports an intima in insects, but instead is clothed with a striated border, which is very characteristic of this region. This striated border is usually considered as a vestige of a formerly ciliated condition. In this species, the striated border is always conspicuous and well developed. The striæ are close together, and are not always sharply separated from the cytoplasm interiorly.

Epithelium. The epithelium is of the columnar type, and the cells are very clearly defined. They vary greatly in size and shape; they may be almost cuboidal, or more than twice as high as wide, probably depending upon their physiological condition. In general, the more anterior cells are the higher. The nuclei are large, median, and almost round; they are quite densely filled with coarse chromatin granules, and there are from one to three larger granules, probably nucleoli. The cytoplasm is non-granular, but is usually more or less vacuolar.

The secretion is merocrine. In the resting state the cytoplasm becomes charged with vacuoles, which pass to the outer margin of the cell, beneath the striated border, where they merge into larger drops. At the time of the secretion these cytoplasmic balls pass out of the cell through the striated border, apparently pushing away the striæ on either side. In the process of being discharged, they remain more or less attenuated on the inner end, but they become spherical as soon as they are free in the lumen of the canal. They stain with eosin, and appear homogeneous.

The first division of the mid-intestine is shown in figure 11.

Replacement cells. During the pupal and prepupal period of most, if not all, insects, the epithelium of the mid-intestine breaks down completely, and a new epithelium is built up from little cells or groups of cells, which lie at the base of the ordinary epithelial cells. In *Altica bimarginata* at least, they seem to remain quiescent during larval life, but begin to proliferate actively during the prepupal period, in which the old larval epithelium breaks down, and a new epithelium is developed, apparently out of these replacement cells. They are apparent in sections through larvæ which have just hatched from the egg.

The replacement cells are more or less triangular cells, which lie at the bases of the functional cells, at irregular intervals, wedged in between two of the cells. The nucleus is large in proportion (it is almost as large as that of the active cells), and there is but relatively little cytoplasm, which is non-granular and non-vacuolar. The nuclei stain a little more deeply, and the particles of chromatin are a little coarser than is the case with the nuclei of the functional cells. Three replacement cells are shown in figure 11.

Basement membrane. A very delicate basement membrane, on which both the functional and the replacement cells rest, can be detected in well fixed preparations and is doubtless present in all cases.

Circular muscles. Striated circular muscle fibres surround the mid-intestine, lodged in a continuous sheath of connective tissue, which forms a complete tube around the canal. The fibres are branched, and often interlace.

Longitudinal muscles. The longitudinal muscle fibres lie outside the circular muscle layer. There are about forty of these fibres, which branch and interlace to some extent.

THE SECOND DIVISION OF THE VENTRICULUS.

Striated border. The striated border is not well developed in this region, but is doubtless always at least feebly developed, even when it is not apparent in sections. It is not even as sharply separated from the cytoplasm as in the preceding region.

Epithelium. The columnar epithelium is composed of cells which are comparatively much longer and more slender than those of the preceding region. On the free end the cell outlines are less even and very irregular, instead of about equal and straight. The nuclei are of about the same size, but are oval rather than round; they are median, or slightly basal if the secretion be abundant.

The second division of the ventriculus is shown in figure 12.

The secretion takes place in the same manner as before, but much more actively and abundantly. It is of quite a different chemical nature, for the cytoplasmic balls stain a light pink with eosin, and are very granular.

Replacement cells. The replacement cells are of the same type and arrangement as in the preceding region.

Basement membrane. The basement membrane is of the same character as in the preceding region.

Circular muscles. The condition of the circular muscle fibres is the same as in the preceding region.

Longitudinal muscles. The longitudinal muscle fibres are continuous with those of the preceding region. They are more numerous, as the fibres split up more or less at the point of junction between the two regions.

The musculature of the two regions of the ventriculus is shown in figure 13.

THE HIND INTESTINE.

THE TRANSITION BETWEEN THE MID-INTESTINE AND THE HIND-INTESTINE.

Striated border. The striated border stops with the end of the mid-intestinal epithelium. It is very faint and feebly developed, as is characteristic of the whole posterior portion of the second division of the ventriculus.

Intima. A chitinous intima originates with the epithelium of the hind-intestine. The primary intima is very thin, the secondary somewhat broader. Neither layer is stained by eosin nor by Delafield's hæmatoxylin.

Epithelium. There is a sharp break between the epithelium of the mid-intestine and that of the hind-intestine. The epithelial cells of the mid-intestine do not differ markedly from the normal as the transition area is approached, save that the replacement cells become very numerous, and tend to form small nests or nidi, instead of occurring singly. At the extreme end of the mid-intestine, the cells lose their columnar character, the cell divisions become very indistinct, and the replacement cells are abundant. The epithelium of the hind-intestine is clearly separated from that of the mid-intestine. The cells, at first narrow, become higher and wider, and shortly merge into an epithelium perfectly typical of the proximal division of the ileum. The cytoplasm is vacuolar and very fibrillar.

The transition area is shown in figure 14.

Pyloric valve. There is no pyloric valve.

Imaginal ring. The cells at the extreme anterior end of the hind-intestine are very small, narrow, and pressed closely together; they probably constitute the imaginal ring of the hind-intestine, although they never present a several layered appearance. This is much the same condition which Poyarkoff (1910) described for *Galerucella*.

Basement membrane. The basement membrane of one region is continuous with that of the other.

Circular muscles. The connective tissue sheet, in which the circular muscle fibres lie, is continuous from the mid-intestine into the hind-intestine, so that the circular muscles of the two regions appear to be homologous and continuous but doubtless embryological researches would show that, as is the case with insects generally, they have entirely different origins. There is a sphincter at the point of junction.

Longitudinal muscles. The longitudinal muscle fibres are continuous from the mid-intestine into the hind-intestine. As the transition area is neared, the numerous longitudinal muscles of the mid-intestine (fifty or sixty in number) come together so as to form eighteen or twenty larger fibres, which again penetrate through the connective tissue sheath of the circular muscles, so as to lie outside of them, as is the case in the fore-intestine.

This condition is illustrated in figure 15.

THE EVAGINATION OF THE SECOND SERIES OF MALPIGHIAN VESSELS.

(It seems illogical to speak of the more anterior set of Malpighian tubes as the second series, but the writer prefers this usage, because he believes that the close association of this series with the mid-intestinal epithelium is entirely secondary, and that the opening of the bladder formed by the vessels of the first series represents more nearly the primitive insertion of the tubes).

The two Malpighian vessels of the second series arise at the extreme posterior end of the ventriculus, appearing abruptly, before there is any change in the mid-intestinal epithelium. Their cells are, however, very distinct from the ventricular epithelium. They are lined by a very faint striated border. The lumen of the vessels is continuous with that of the intestine. The two vessels arise very close together. As soon as they penetrate the connective tissue layer in which the muscles are

imbedded, it continues around them as a nucleated peritoneum. Their basement membrane is continuous with that of the alimentary epithelium.

The evagination of these vessels is shown in figure 16.

Their structure and relations make it perfectly clear that any connection which they have with the mid-intestine is entirely secondary. Although there may be two or three cells of the mesenteron which lie between them and the hind-intestine, their complete fusion distally with the vessels of the first series, makes it clear that they are appendages of the hind-intestine; and their present point of origin from the ventriculus is due to secondary migration.

THE PROXIMAL PORTION OF THE ILEUM.

Proximal and distal ileum. The first division of the hind-intestine, the ileum, may be divided histologically into a proximal and a distal portion. The proximal portion extends from the beginning of the hind-intestine as far as the opening of the bladder. The distal region includes all of the ileum beyond this point.

The proximal ileum corresponds to the first region of the hind-intestine, and the distal ileum to the second region, as Poyarkoff (1910) considered them in *Galerucella*.

Intima. The primary intima is very thin, but the secondary intima is fairly thick. Neither layer is stained with eosin nor Delafield's haematoxylin, but the primary layer contains brown pigment.

Epithelium. The epithelium is composed of wide, flat cells, very much smaller than those of the distal region, as are also the round chromatic nuclei, full of densely-packed coarse granules. The cytoplasm is homogeneous, and usually non-vascular. The epithelium is thrown into small, wavy, pointed folds.

Basement membrane. The basement membrane is well developed.

Longitudinal muscles. There are about twenty longitudinal muscle fibres, which lie in a continuous connective tissue sheath. Anteriorly they are continuous with the muscles of the ventriculus, and posteriorly they are inserted on the intima at the end of the distal portion of the ileum.

Circular muscles. The circular muscle fibres are well developed and lie in the connective tissue sheath outside that of the longitudinal fibres, this sheath being continuous with that of the mid-intestine. There are thus in the ileum two connective tissue sheaths around the canal outside the basement membrane of the epithelium.

FORMATION AND ATTACHMENT OF THE BLADDER.

The four Malpighian vessels (those of the first series) whose fusion at their proximal ends is to form the bladder, run closely parallel to one another between the ventriculus and the ileum, for some little distance before they unite. At the point of fusion there is at first no change in the character of the cells, and an ovoid swelling is formed without any interruption of the separate lumen of each tube. The two outer vessels (i. e., the two nearest the ileum) unite first, and their combined lumen is lined with very small epithelial cells, with a faint striated border. The other two vessels are arranged at right angles to them, with their lumina still distinct, and their cells of the usual size. Here as elsewhere the whole enlargement is invested with a basement membrane and a nucleated peritoneum distinct from the former. The cells of the two inner vessels become smaller abruptly, and in a few sections of six micra each, an uniform bladder results, with a common lumen (made up of the fused lumina of the four vessels) lined by a single layer of epithelial cells. The striated border, faint everywhere in the fusing vessels, has now disappeared and is replaced by a thin intima. In some cases the epithelium seems to consist of more than a single layer, but this is only apparent, not real, and is due to folding. The cell divisions are never clearly distinct. The nuclei of the bladder cells are of the same essential structure throughout, although they vary greatly in size, according to the size of the cells. They are round in the larger cells, and ovoid or oval in the smaller. They are densely chromatic and stain intensely; the chromatin is in the form of coarse granules with a few larger periferal granules in each nucleus.

As the bladder approaches the ventriculo-iliac bend, the circular muscles of the intestine grow out and surround it, and the lumen of the bladder soon opens directly into that of the proximal portion of the ileum. The intima of the bladder, both primary and secondary, is directly continuous with that of

the ileum and, like the latter, it does not stain either with eosin or Delafield's hæmatoxylin; the intima in the bladder is somewhat thinner, and the primary intima is not pigmented. The epithelium of the two portions is continuous; the cells of the ileum are more elongate than those of the bladder, but the nuclei are of about the same size. The basement membrane is continuous. The peritoneum, which ends when the circular muscles grow out and surround the bladder, is continuous with the connective tissue sheath in which they are lodged.

There is no suggestion of an urethra, or stalk, leading from the bladder to the intestine, such as is often present, except that two of the undulatory folds of the iliac epithelium are larger where the bladder empties, and make a sort of passage-way between the two lumina. Since such a stalk is present at least in *A. nemorum* (Schindler 1878; p. 631), this may represent the first step in the development of one.

The fusion of the four vessels is shown in figure 17; the fusion of the lumina of the two outer vessels, in figure 18; the complete bladder, in figure 19; and the junction of the bladder and ileum, in figure 20.

THE DISTAL PORTION OF THE ILEUM.

Transition. As soon as the bladder has emptied into the canal, the intima is gradually reduced in thickness, and the epithelial cells become thicker, with the folds larger and less acute; the nuclei also become larger, and the cytoplasm tends to become differentiated into two regions, as is explained below. This transition is gradual, not abrupt. All of the layers of the proximal portion of the ileum are continuous with those of the distal.

Intima. The intima is divided into a primary and a secondary intima, but the latter is much thinner than in the proximal portion. It becomes progressively narrower throughout this region.

Epithelium. The epithelium is composed of large, irregularly cuboidal cells, whose boundaries are frequently so indistinct that they form an apparent syncytium. In most cases there are two areas of cytoplasm clearly distinguishable: an inner (toward the basement membrane) layer, denser and darker, staining violet-pink with eosin, and an outer, more or less

fibrillar, staining light pink. These areas are of about equal width. This condition (which is doubtless related to the absorption of food, since such a differentiation is not apparent unless there is food in the intestine) is most prominent proximally, but becomes less and less distinct, although it is still plainly discernible through the whole course of the ileum. The nuclei, which are quite large, may be either round or oval; they are densely chromatic, especially around the periphery and in the center. The chromatin is present in the form of coarse granules.

In some sections the epithelium appears only slightly, if at all, folded, but usually it is conspicuously and strongly thrown into tooth-like projections, typically six in number.

The distal portion of the ileum is shown in figure 21.

Basement membrane. The basement membrane is thin, but clearly distinguishable.

Longitudinal muscles. The longitudinal muscle fibres are continuous anteriorly with those of the proximal portion of the ileum, and are inserted posteriorly on the intima at the extreme end of this region. The longitudinal muscles are continuous nearly the whole length of the alimentary canal; they arise at the extreme anterior end of the pharynx and lie inside of the circular muscle sheath in the fore-intestine; they pass outside this sheath, and are external in the mid-intestine; they pass inside again at the beginning of the hind-intestine, so that they are internal, and are finally inserted on intima at the posterior end of the ileum.

Circular muscles. The striated circular muscle fibres are well developed. They lie in a connective tissue sheath continuous anteriorly with that of the proximal portion of the ileum, and posteriorly with that of the colon.

THE COLON.

Transition. The epithelium changes gradually in type between this region and the preceding. The intima, basement membrane, and circular muscles are also continuous. The longitudinal muscles of the ileum disappear, as they are inserted on the intima at the end of the ileum, and a new layer of much larger longitudinal muscle fibres, external and not internal, appears, inserted on the intima at the beginning of this region.

Intima. The intima is slightly thicker than it was in the ileum; like the latter, it is differentiated into a primary and a secondary intima, the former being very thin.

Epithelium. At the point of union between the colon and the ileum, the epithelial cells of one region closely resemble those of the other. The intestine bends again caudad at the junction, and a section through this region shows at one side typical ileum cells and at the other typical colon cells, while between them are transition cells which might be assigned to either region. The cells of the ileum nearly always show a differentiation into two areas of cytoplasm, while the cytoplasm of the colon cells is only rarely so differentiated, this differentiation usually disappearing in the intervening transitional cells. There is at this point no difference in the size of the cells.

As one traces the course of the colon toward the rectum, the cells of the epithelium become flatter and flatter, this tendency beginning with the association of the Malpighian vessels with the wall of the canal. Typically, the epithelium of the colon is only about one-half as high as that of the ileum, though the cells are nearly if not quite as wide. The cytoplasm is usually of the same structure throughout, resembling the inner layer of the ileum, but rarely it is feebly differentiated into two layers as is the case in the ileum.

The nuclei are of about the same size and shape as in the preceding region, but the chromatin granules are slightly larger. Here, too, the cell divisions are obscure, probably in part at least due to the fixation. The epithelium may be unfolded, or may be thrown into six or more prominent tooth-like folds, which project into the lumen.

A typical cross-section through the colon is shown in figure 25.

Basement membrane. The basement membrane is always clearly defined.

Circular muscles. The layer of circular muscles, which is continuous with that of the ileum, is strongly developed in the anterior portion of the colon, but the fibres become weaker and weaker as one traces them caudad, although they do not disappear completely until the end of this region. The most posterior muscle is inserted on the intima of the colon, on an

apodeme-like projection between the colon and rectum. Like the other circular muscle fibres, they lie in a connective tissue sheath. This sheath forms a continuous tube around the alimentary canal from the anterior end of the pharynx through the posterior end of the colon.

Longitudinal muscles. New and very strong longitudinal muscle fibres appear with the colon. They lie outside the circular muscles, not inside like the longitudinal muscles of the ileum. They begin at the point where sections through the ileo-colonic bend first show signs of the approaching constriction and separation. At their origin, they are inserted on the intima of this region. There are six of these longitudinal muscle fibres, arranged quite regularly in a typical cross section. Three of these muscles appear on the outer (left) side as soon as there is any sign of the constriction referred to above, and three are developed on the inner (right) as soon as the colon and ileum have separated. These muscles grow gradually smaller and are inserted on the intima slightly anterior to the end of the colon.

Peritoneum and Malpighian vessels. The distal ends of the Malpighian vessels are closely associated with the walls of the colon. The fusion of the Malpighian vessels into two common trunks at the end of their "coelomic" course has been pointed out already (page 298). Each trunk applies itself closely to the wall of the colon, one dorsally and one ventrally, each lying between two of the longitudinal fibres; they join the canal as soon as these fibres have been developed. As soon as the vessels have become appressed to the wall of the colon, their peritoneal sheaths grow out and join, so that a continuous peritoneal coat is formed, which completely surrounds the colon, and encloses the six muscle fibres and the two Malpighian trunks.

As soon as this tunic is complete, or even before, each trunk (which is not larger than an ordinary Malpighian tube) redivides into three vessels, which almost immediately begin to "migrate" outside the muscle fibres, so as to lie alternately with them. This "slipping" or "migration" extends through about twenty sections of six micra each before it is completed. The condition which results characterizes the greater part of the colon, and in a typical cross-section, one will find lying outside the circular muscles, a layer composed of the six longitudinal muscle fibres,

alternating with the six Malpighian vessels, the whole surrounded by a nucleated peritoneum, which is a double layer, since it represents the investing sheath of the vessels. The two sheets separate at the vessels, one layer passing inside and the other outside of the tubes, but both sheets pass outside of the longitudinal muscles.

Normally the two trunks do not join the colon opposite one another as would be expected; at least, this is the case in every series which the writer has examined. The ventral trunk occupies what may be termed the normal position, and when it redivides into three vessels, the central vessel remains in position and each of the two lateral ones migrates around the adjacent muscle fibre. The dorsal trunk, however, does not enter exactly opposite (i. e., with three muscles intervening), but slightly to one side of the canal (i. e., with two muscles intervening). Therefore when it redivides, it is the innermost vessel which remains in place; the outermost not only must slip outside the adjacent muscle fibre, but must also pass the next one beyond, so that in its migration it slips outside of two muscles before it is in position; the middle vessel slips outside a single fibre, the one originally adjacent to the outermost vessel, and then it is in place. Thus is brought about the regular alternation of muscle fibre and Malpighian vessels, which obtained in every instance which the writer has observed.

In the anterior part of the colon the cross-sections of the Malpighian vessels and of the longitudinal muscles are about equal in diameter. But as they pass caudad, the Malpighian vessels gradually increase in size, while the longitudinal muscles become weaker, and two-thirds caudad the Malpighian tubes are twice as large as the muscles. At this point the longitudinal muscles begin to diminish in size rapidly, and become very small, although they persist faintly to the end of the region. The circular muscles also decrease so markedly in size as to be almost negligible. The Malpighian vessels, which have been almost circular in cross-sections, now become elongated along the diameter perpendicular to the axis of the canal, and tend to crowd the longitudinal muscles inside. This tendency becomes more and more pronounced, and a little distance before the end of the colon the intestine is surrounded by a practically continuous layer of Malpighian tubes, with the

small longitudinal muscles intercalated between them. The vessels do not extend along the wall of the rectum, but terminate blindly at the extreme posterior end of the colon.

It is very difficult to make out the exact course of the vessels in the wall of the colon. They seem to extend posteriorly as six parallel tubes, at first of slight diameter and almost straight, but as the diameter increases, they become more and more wavy, with larger and larger folds. It is this character which makes the tubes appear so elongate in cross-section. Toward the end of the colon, these undulatory folds are so large that those of one series almost touch those of the adjacent series, and thus they almost completely surround the wall of the colon. The vessels seem to branch irregularly, the tubes terminating blindly and separately in irregular ramifications, just anterior to the strong circular muscles which appear abruptly, and mark externally the beginning of the rectum.

The writer has already figured the course of the vessels in the wall of the colon (Woods, 1916, figure 4); and a series of cross-sections of the colon showing the different conditions described above is illustrated in figures 22-27.

THE RECTUM.

Transition. The transition between the colon and the rectum is the most abrupt in the whole course of the alimentary canal. The Malpighian vessels and the peritoneal sheath disappear abruptly, and new circular muscles make their appearance suddenly. The epithelial cells of the colon become flatter and flatter, and the cell boundaries more and more distinct near the rectum, but the type changes quite abruptly to the glandular and eosinophile cells characteristic of the rectum.

Intima. At first there are only minute wavy folds in the intima and epithelium, but posteriorly these folds become gradually more and more pronounced, and more and more tooth-like in appearance, while the lumen becomes smaller and smaller. The typical number of these "teeth" is probably six, but they are far from regular, and there may be from five to eight. As is to be expected, the primary and secondary intima are continuous with the primary and secondary cuticula respectively, of the body wall. There is no pigment in the primary cuticula for a considerable distance beyond the rectal invagination.

At the proximal end of the rectum there is a pronounced outpushing of the intima into the body-cavity; this serves as a place for the attachment of the circular muscles of the colon, and the origin of the circular muscles of the rectum.

Epithelium. The cells of the epithelium are much smaller than those in the two sections immediately preceding the rectum, and the cell divisions are much clearer. At the bases of the chitinous folds referred to above, the epithelial cells are thin and stretched out, but at the apices they are broadened out and glandular in appearance. Because the cells are so thin at their bases, they might readily be overlooked, and this probably accounts for the fact that some writers have described the epithelium as wanting in the case of similar structures. It is, of course, evident that where there is an intima there must be underlying cells to secrete it. The cytoplasm of these cells stains deep pink with eosin, and is smooth, non-granular. The nuclei are smaller than those of the ileum and colon, and are not so chromatic. Posteriorly, the epithelium becomes more and more glandular in appearance, and these gland-like cells persist out into the otherwise unmodified hypodermis of the body-wall, with which this layer is of course continuous.

The epithelial cells elaborate a "molting-fluid" exactly as was described in the case of the fore-intestine. In larvæ fixed just after a molt, or at the time of hatching, the cells of the epithelium lie close against the intima; but they begin to secrete a fluid very soon, and in a few days there is a fibrillar-vacuolar area, which stains blue with Delafield's hæmatoxylin, separating the intima and epithelium. This fibrillar area is always clearly marked off from the true cytoplasmic cellular portion. The presence of this fibrillar portion is characteristic of the rectum, and is developed in all of the instars. The new cuticula is formed ectad of this area just before each molt. The new intima is formed not more than a day before the larva enters the ground, and the secondary intima becomes apparent on the fourth day of prepupal life. The fibrillar area extends out beyond the proctodeal invagination between the hypodermis and the cuticula in the body-wall, about to the point where pigment appears in the primary cuticula, and glandular cells of a type continuous with those of the rectum do not appear in the hypodermis beyond this point.

This fluid secreted doubtless serves as an aid in molting, as was suggested under the discussion of the œsophagus, for the intima of the whole hind-intestine, like that of the fore-intestine, is shed at each molt. This fluid is developed along the whole course of the fore-intestine, but is present only in the last division of the hind-intestine. This may be due to the fact that the rest of the hind-intestine is the principal seat of absorption; the intima is much thinner, and probably slips off more easily.

A cross-section through the rectum is shown in figure 28; the rectal epithelium after a molt, in figure 29; the rectal epithelium with the fibrillar area developing, in figure 30; the rectal epithelium after the formation of the pupal intima, in figure 31; and the rectal invagination, in figure 32.

Basement membrane. The basement membrane, which is clear and well developed throughout this region, is continuous with that of the body wall.

Circular muscles. There are three distinct layers of very strong circular muscles in the rectum, each layer forming a complete ring around the alimentary canal. They have their origin on the posterior face of the apodeme-like projection from the intima at the anterior end of the rectum, and are inserted on the cuticula around the proctodeal invagination. Each layer originates and is inserted independently.

Longitudinal muscles. Longitudinal muscles are entirely lacking in the rectum.

3. THE MALPIGHIAN VESSELS.

THE GENERAL COURSE OF THE VESSELS.

From a morphological point of view, the Malpighian vessels of an insect are ectodermal structures which arise during embryonic life as evaginations of the distal end of the hind-intestine. In the larva of the alder flea-beetle, they are six in number, constituting two series of four vessels and two vessels respectively. The details of their course in the body cavity has already been pointed out (Woods, 1916), and their relation to the colon is discussed elsewhere in this paper (pages 298-302). It should be clearly understood that they do not open into the colon, and that their only connection with the lumen of the alimentary canal is at the point of their evagination.

We may summarize the distribution of the tubes in the larva as follows (beginning at the distal end): Six Malpighian vessels extend parallel to one another, running cephalad in the wall of the colon; they unite at the anterior end of this region to form two common trunks, which, leaving the wall of the intestine, split up into a single tube, and a common stem representing a pair of tubes; the single tube, which is very short and delicate, runs directly to the ventriculus, where it is inserted isolated into the wall of the intestine, just at the point where the mid-intestine joins the hind-intestine; each common stem soon splits up into two vessels, which have a long course through the body-cavity, but eventually all four unite to form a single common urinary bladder, which empties directly into the ileum, at a point a little posterior to the insertion of the two shorter tubes.

For convenience in discussing the histological structure of the tubes, the writer has spoken of that portion of the Malpighian vessels enclosed in the walls of the colon, as the "included" portion, and the part which lies free in the body cavity as the "coelomic" portion. This is of course a very free use of the term, for the coelome, or true body-cavity, is very much reduced in insects, and the apparent body-cavity is in reality only a greatly enlarged haemocoel, or blood sinus.

THE HISTOLOGICAL STRUCTURE OF THE VESSELS OF THE FIRST SERIES.

THE "COELOMIC" PORTION.

Proximal. Interiorly, the epithelial cells of the proximal portion of the Malpighian tubes of the larva are covered by a wide, lightly staining striated border, composed of many very fine and closely appressed striæ, beneath which is a narrow band of dense deeply-staining cytoplasm. The cell cytoplasm, which stains deep violet-pink with eosin, is very granular, and presents a more or less fibrillar aspect. The nucleus, which is proportionately large, varies in shape from elliptical to circular, and is typically basal in position. The chromatin granules are larger than those of the distal nuclei and are not so densely compacted. They occur especially around the periphery.

Vacuoles in these cells indicate a secretory activity, but the writer has not followed the secretion cycle. From the

sections studied it would appear that tiny secretion vacuoles are formed between the nucleus and the basement membrane, which then migrate around the nucleus so as to lie between it and the striated border, where they fuse to form a large secretion vacuole at the tip, which causes the cell to bulge out, papilla-like, into the lumen of the tube.

The epithelial cells have a very delicate but distinct basement membrane, besides a nucleated peritoneal sheath which completely surrounds the vessels.

There is no indication of a lightly staining fibrillar area just inside of the basement membrane, as is the case in the cells of the distal portion.

Distal. The epithelial cells of the distal region of the vessels are larger than those of the proximal region and the striated border is extremely delicate. The cytoplasm stains deeply with eosin, usually a little more intensely than in the cells of the proximal portion. There is a narrow area of light fibrillar cytoplasm (which even under an oil-immersion lens looks not unlike the striated border) just within the basement membrane which here too, though delicate, is clearly distinct from the nucleated peritoneum. The rest of the cytoplasm is homogeneous, and stains intensely. There may be few or several vacuolated areas in the cells, just interior to the narrow band of dense cytoplasm, lying just inside the fibrillar area referred to above.

The nucleoplasm stains a light violet with Delafield's haematoxylin, while the coarse irregularly scattered, but densely compacted chromatin granules stain deep violet. One or two chromatic granules are usually larger than the others. The oval nuclei are of about the same size as those in the proximal portion.

Typical. In a typical cross section through one of the vessels of the first series of larval tubes there are four cells, usually not more than one or two of which will be cut through the nuclei. The nuclei are oval, large and central in position. The chromatin granules are large, rather sparse and mostly periferal.

The lumen is lined by a very narrow lightly stained striated border of very closely set striæ. Between this border and the basement membrane, four areas of cytoplasm may be distinguished, the last two very narrow and the first two of about

equal width. The first area is composed of more or less reticular cytoplasm which stains deeply with eosin. The second area is made up of lighter staining, homogeneous cytoplasm, surrounding secretion vacuoles. The third area is a very narrow band of dense, intensely-stained cytoplasm. The fourth area stains lightly, and is fibrillar, seemingly composed of very fine and closely apposed striations. Outside of this area is the very delicate basement membrane and the whole tube is surrounded by a nucleated peritoneum.

The aspect of the tubes varies greatly according to the fixing fluid used, and according to the stage of secretion. The differences between the proximal and distal portions of the tubes may be exaggerated in the above account, for they do not always seem to be so well marked, but in all cases which the writer has observed, the cells of the two regions present a different microscopical aspect, and the striated border seems always to be well developed in one and almost wanting in the other. This character agrees with the description of the tubes of *Scaurus* (Tenebrionidæ), by Leger and Hagenmuller (1899), where the proximal end of the vessels is lined with conspicuous cilia, but no cilia can be detected in the distal end.

All of the cells of the "coelomic" portion agree in that they undergo cyclic changes, denoting secretory activity. The cycle is probably the same in all of the cells. While the writer has not made a careful study of the process, it seems to be approximately as follows: The nuclei of the cells at first lie nearer the lumen than the basement membrane; vacuoles are formed between the nucleus and the basement membrane, which pass around the nucleus and lie between it and the striated border; the cell then bulges out, papilla-like, into the lumen as these small vacuoles fuse into one large one, which finally discharges its contents into the lumen of the vessel.

THE COMMON STEM.

The cells of the common stem formed after the vessels have fused in pairs, as well as those of the common trunk formed by the union of the three vessels, do not differ in appearance from those of the distal region of the vessels, as described above, except that the writer has not been able to detect any trace of the striated border.

THE HISTOLOGICAL STRUCTURE OF THE VESSELS OF THE SECOND SERIES.

The cells of the second series of tubes are considerably smaller than those of the first series, and the nuclei, which are round or oval, are much smaller. The nuclei are densely chromatic; the chromatin granules are of the same color and size as those in the nuclei of the first series. The cytoplasm stains less intensely with eosin and is pinkish rather than purple-pink. The lumen is very slight. There is a distinct basement membrane and a nucleated peritoneum.

THE VESSELS IN THE WALL OF THE COLON.

Both cells and nuclei of the vessels in the wall of the colon are very much smaller even than those of the second series. The nuclei, which are proportionately large, are round or oval, and densely chromatic, with small dark-stained chromatin granules. The cytoplasm is homogeneous, and is not divided into areas; it stains less intensely with eosin than that of the free portion of the tubes. The writer has not been able to find any trace of a striated border lining the lumen. There is a very delicate but distinct basement membrane, and a nucleated peritoneum.

4. THE SALIVARY GLANDS OF THE LARVA.

The salivary glands of insects are not appendages of the alimentary canal, but are independent ectodermal invaginations, which open secondarily, if at all, into the mouth cavity. In the larva of the alder flea-beetle there is a single pair of these glands, more properly in this case to be called maxillary glands, which open at the inner base of the maxillæ. They are simple tubular glands, short, lying entirely within the head, usually extending along the ventral side nearly to the thoracic border, and then bending up at a sharp angle, running nearly to the dorsal body wall.

Sections through the invagination of these tubes (see figure 33) show that the chitin of the central duct (which is differentiated into a primary and a secondary layer) is continuous with the cuticula of the body wall. There is no transition between the hypodermis and the gland cells, but the glandular epithelium

is developed abruptly, as soon as the invagination takes place; it is of course continuous with the perfectly unmodified hypodermis just outside.

In cross and longitudinal sections alike, it is clearly to be seen that the glands are composed of a single layer of cells around a common central duct. This chitinous duct is always clear in all of the sections which the writer has examined. The cells are large, and of the cuboidal epithelium type. The nuclei are proportionately large, round or oval, and densely chromatic; the chromatin is in the form of fine granules, except for four or five coarser granules in each nucleus. The position of the nuclei is variable, but usually they are median, or nearer the duct. The cytoplasm is reticular, and seems to consist of a fine net-work. Large vacuoles may appear in the cells, depending on the state of secretory activity.

There is a delicate limiting membrane outside, which is continuous with the basement membrane of the hypodermis.

The labial glands, which constitute the prominent salivary glands, or cephalic silk glands, of the Lepidoptera and Trichoptera, for example, are entirely absent in the larva of the alder flea-beetle, as in insects of this order generally, both larvæ and adults.

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1917. The Biology of the Alder Flea-Beetle. Me. Agr. Exp. Sta. Bul. 265.

Since so many good bibliographies of the papers dealing with the alimentary canals of insects are available the writer has included here only those papers to which actual reference has been made in the preceding discussion.

EXPLANATION OF PLATES.

PLATE XXVI.

- Fig. 1. Diagrams to show the attachment of muscles to the cuticula; A, the normal condition; B, after a molt, showing the tendons.
 Fig. 2. The oral invagination, longitudinal section.
 Fig. 3. The musculature of the pharynx (longitudinal section).
 Fig. 4. The oesophagus, cross-section.
 Fig. 5. The oesophageal epithelium, normal condition.
 Fig. 6. The oesophageal epithelium, premolt condition.
 Fig. 7. The oesophageal epithelium, after the formation of the new intima.
 Fig. 8. A portion of the crop, cross-section.
 Fig. 9. The oesophageal valve, and the transition from the fore-intestine to the mid-intestine (longitudinal section).
 Fig. 10. The transition in the musculature from the fore-intestine to the mid-intestine.
 Fig. 11. A portion of the first division of the ventriculus, cross-section.
 Fig. 12. A portion of the second division of the ventriculus, cross-section.

PLATE XXVII.

- Fig. 13. The musculature of the mid-intestine, showing the transition from the first division of the ventriculus to the second. (The constriction marks the point of separation between the two divisions).
 Fig. 14. The transition from the mid-intestine to the hind-intestine (longitudinal section).
 Fig. 15. The transition in the musculature from the mid-intestine to the hind-intestine.
 Fig. 16. The evagination of the second series of Malpighian vessels.
 Fig. 17. The first stage in the formation of the bladder; the fusion of the four Malpighian vessels of the first series.
 Fig. 18. The second stage in the formation of the bladder; the fusion of the lumina of the two outer vessels.
 Fig. 19. The completed bladder.
 Fig. 20. The entrance of the bladder into the ileum.

PLATE XXVIII.

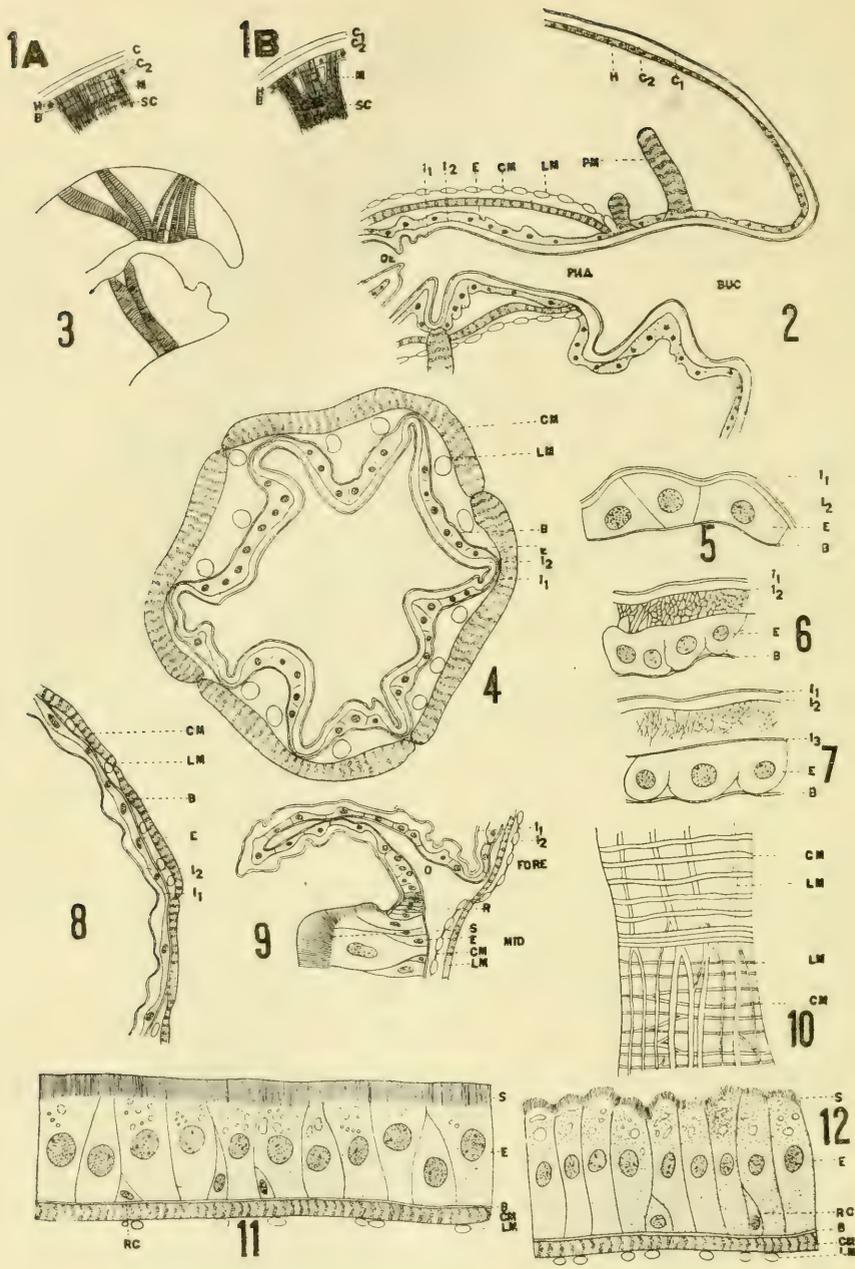
- Fig. 21. The distal portion of the ileum, cross-section.
 Fig. 22. Cross-section of the colon; association of the Malpighian vessels with its walls. The ventral vessel is just coming in contact with the colon; the two vessels of the first series, with the common stem formed by their fusion, and the one vessel of the second series, with the common trunk formed by the fusion of all three, can still be seen. (A nerve separates the two vessels of the first series). The dorsal vessel is already joined to the colon, and the peritoneal sheath is beginning to extend out on each side.
 Fig. 23. Cross-section of the colon; redivision of the trunks. The ventral vessel-trunk has just redivided into three vessels; the dorsal vessel-trunk has already redivided, and the vessels are beginning to migrate around the muscle fibres.
 Fig. 24. Cross-section of colon: the migration of the vessels almost completed.
 Fig. 25. Cross-section of colon: typical. Note the alternate arrangement of Malpighian vessels and longitudinal muscle fibres. (The upper "E" in this figure should be "C. M.")
 Fig. 26. Cross-section of colon: the Malpighian vessels are increasing in size and tending to crowd the longitudinal muscles inside.

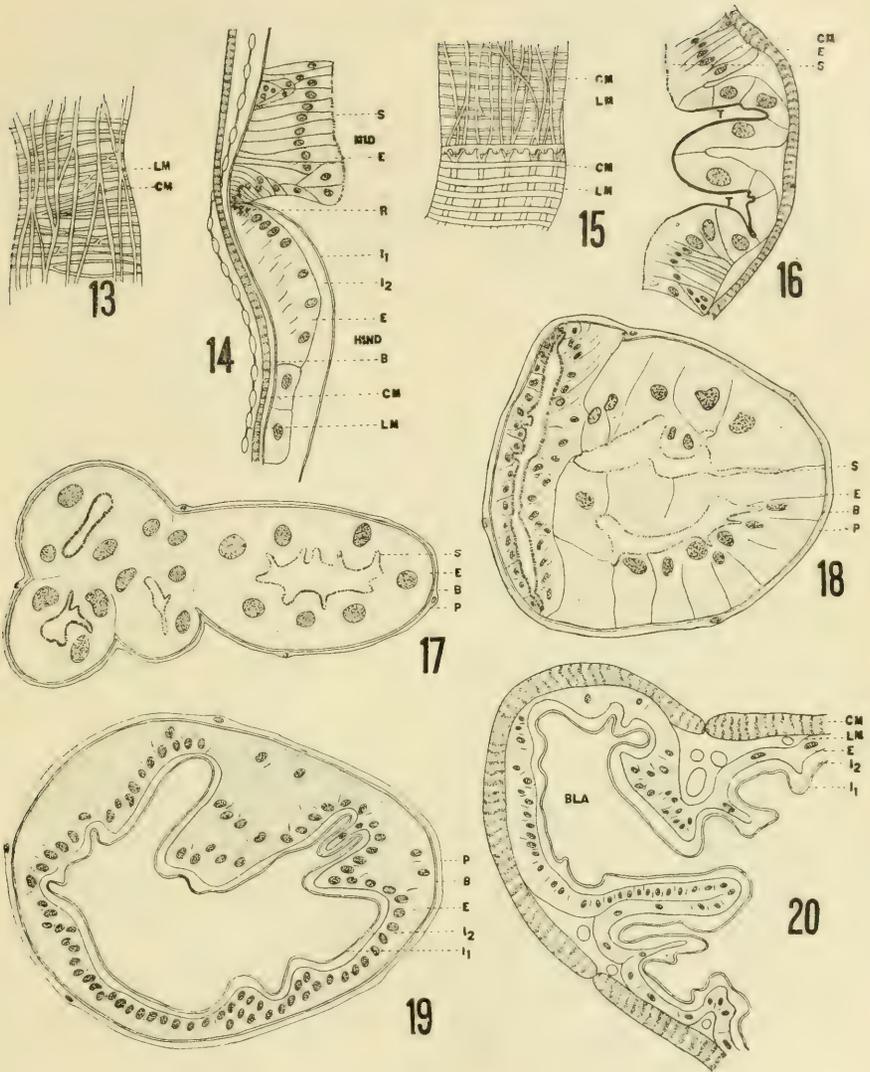
PLATE XXIX.

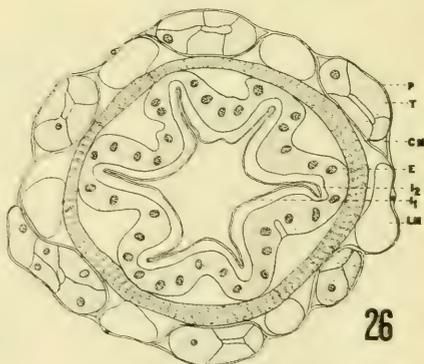
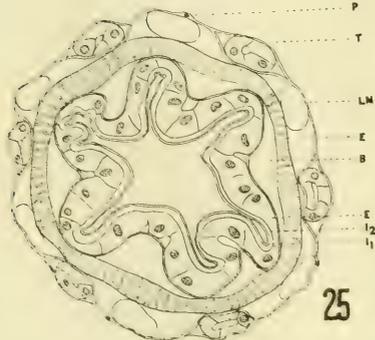
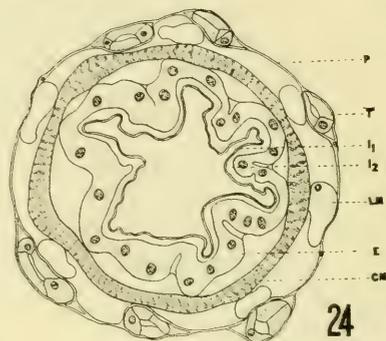
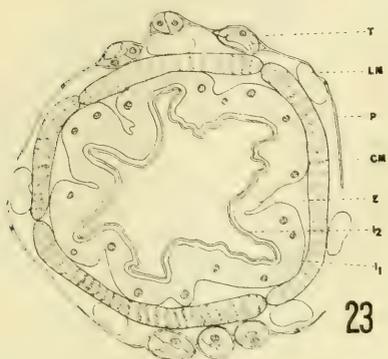
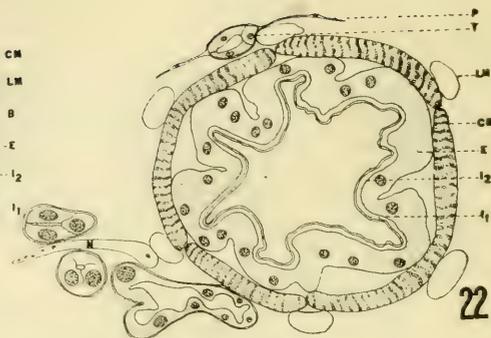
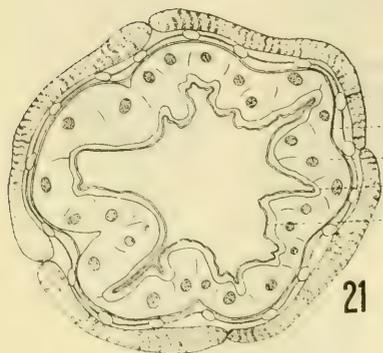
- Fig. 27. Cross-section of colon: the Malpighian vessels have so increased in size as practically to surround the region; both longitudinal and circular muscles are much reduced.
- Fig. 28. Cross-section of the rectum.
- Fig. 29. A portion of the rectal epithelium, typical condition.
- Fig. 30. A portion of the rectal epithelium, in the premolt condition.
- Fig. 31. A portion of the rectal epithelium, just before a molt, the new intima forming.
- Fig. 32. A cross-section through the rectal invagination.
- Fig. 33. A cross-section through the invagination of the salivary gland.

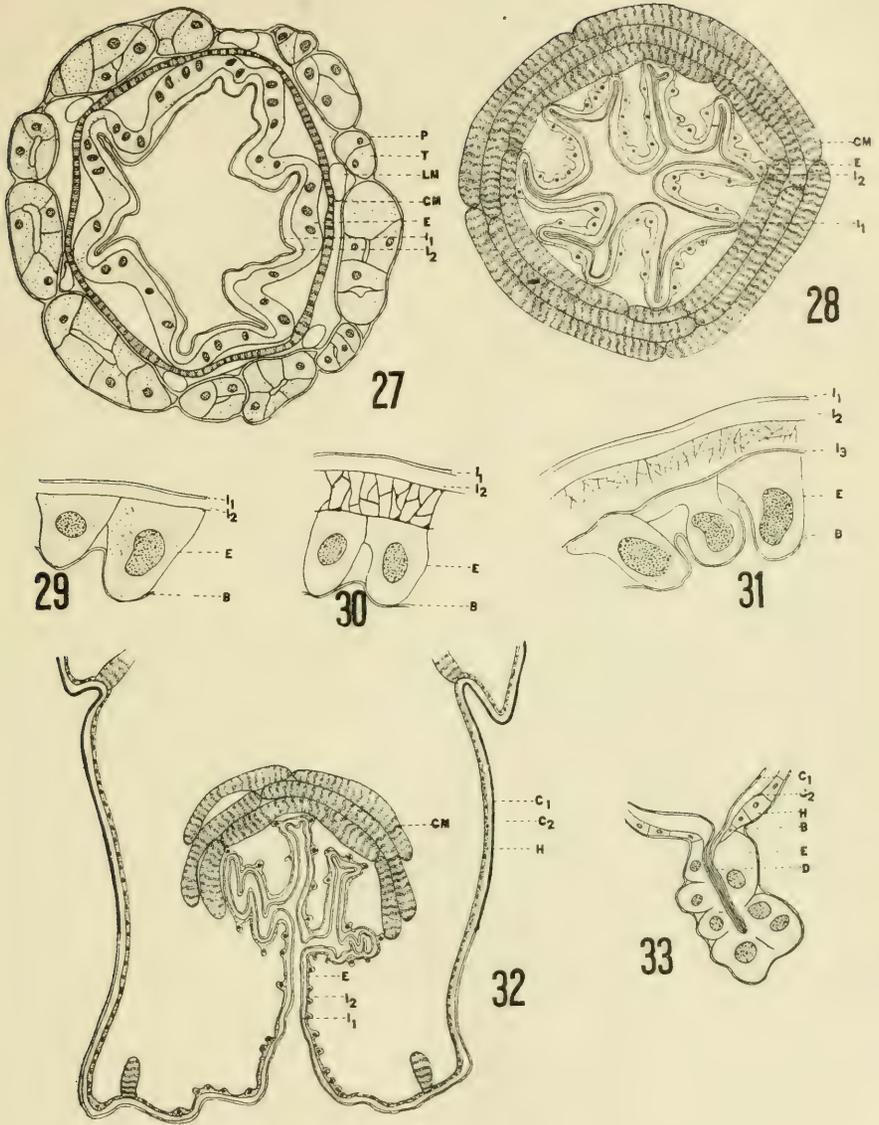
ABBREVIATIONS USED IN THE FIGURES.

B.....	Basement membrane.	LM.....	Longitudinal muscles.
BLA....	Bladder.	M.....	Muscle.
BUC...	Buccal cavity.	MID...	Mid-intestine.
C ¹	Primary cuticula.	N.....	Nerve.
C ²	Secondary cuticula.	O.....	Oesophageal valve.
CM....	Circular muscles	OE.....	Oesophagus.
D.....	Duct of salivary gland.	P.....	Peritoneum.
E.....	Epithelium.	PHA...	Pharynx.
FORE..	Fore-intestine.	PM....	Pharyngeal muscle.
H.....	Hypodermis.	R.....	Imaginal ring.
HIND..	Hind-intestine.	RC....	Replacement cell.
I ¹	Primary intima.	S.....	Striated border.
I ²	Secondary intima.	SC....	Sarcolemma.
I ³	New intima, forming.	T.....	Malpighian tube.









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A REVISION OF THE GENUS *SCIARA* OF THE FAMILY
MYCETOPHILIDÆ (Diptera)

By F. W. PETTEY, Cornell University.

In working over the Cornell University collection of specimens of *Sciara*, family *Mycetophilidæ*, thirty-one new species collected in the United States were discovered. Consequently it was thought advisable to revise Dr. Johannsen's *Sciara* key, found in the Maine Agricultural Exp. Sta. Bull. No. 200, Part IV, pp. 117-123. The work was done under Dr. Johannsen's direction.

Dr. Johannsen, in his classification of the species of the genus *Sciara*, has divided them into two main groups, those whose wings have setose media and cubitus and those whose wings have no setæ on these veins. Other scientists, in their description of new species of *Sciara*, have frequently overlooked this important structural character. In an effort to call more particular attention to this feature and to avoid the possibility of neglecting it in the future descriptions, a new genus is proposed for those species having no setæ on the media and cubitus. Since the type species of the genus *Sciara*, *thomæ* L. (*Syst. Nat.* Ed. XII, II. 976.39 (*Tipula*) 1767), has subsequently been found to have setose media and cubitus, those species having this character are left in the genus *Sciara*.

About half of those species of the male sex under the new genus have a hypopygium with one or two clusters of setæ at the base on the median ventral line. No males of the genus *Sciara* as above restricted exhibit this character. Although this structure should not be overlooked in the description of a species, it would be inadvisable to make use of it as a generic character, since it cannot be designated in females.

The larvæ of all those species observed, under the genus *Sciara* as above restricted, *i. e.*, those species possessing setose media and cubitus, have the habit of migrating in a chain-like line. None of the observed larvæ of the *Neosciara* species exhibit this feature.

Neosciara new genus.

This genus includes species which would formerly have been placed under the genus *Sciara*, but which are now placed under the above genus because they lack setæ on the cubitus and media.

Face short; palpi 4-jointed, the first very short and not always differentiated from the second; antennæ 2 plus 14 jointed; 3 ocelli, the laterals remote from the eye margin. Thorax moderately arched. Legs slender, tarsal claws not toothed. Wings microscopically setulose, not hairy; cubitus and media with no setæ.

Type: *Sciara coprophila* Lintner.

TABLE OF NORTH AMERICAN SPECIES OF THE REVISED GENUS *Sciara*
AND OF *Neosciara*.

- a. Genus *SCIARA*. Costa, radius, media except sometimes the petiole, and cubitus of the wings distinctly though sparsely setose.
- *b. Large southern species, 6 mm. or more in length; males undescribed,
cingulata Rùbsaamen
- bb. Medium or small species.
- c. R_1 ends noticeably proximad of the fork of M.
- *d. Petiole of cubitus one-eighth as long as the basal section of M. (Fig. 219);
clasper (Fig. 100); N. Y. *vicina* Joh.
- dd. Petiole of cubitus scant half or more than half as long as the basal section of M.
- e. Clasper with at least one stout apical spine.
- f. Clasper with a single stout spine; costa produced two-thirds the distance from the tip of R_8 to M_1 (Fig. 220); clasper (Fig. 101); Cal. *dives* Joh.
- ff. Clasper (Fig. 1) with several stout apical spines and one more prominent subapical spine; costa produced less than two-thirds the distance from the tip of R_8 to M_1 , (Fig. 32) . . . 1. *forceps* n. sp.
- ee. Clasper with no stout apical spines.
- f. The perpendicular distance from the crest of the arc of M_1 to that of R_8 greater than the perpendicular distance from the tip of R_8 to M_1 (Fig. 33). Petiole of cubitus longer than the base of M. Clasper (Fig. 2) 2. *multisetifera* n. sp.

* This table is based largely on male characters, only a few well defined species represented by females alone are included; *cingulata* is placed under both genera since it is not certain whether the cubitus and media have setæ or not. By wing length is meant the distance from the humeral cross vein to the tip of the wing, measured parallel to the longitudinal axis.

The figures and descriptions of those species not designated as new may be found in the Maine Agr. Exp. Sta. Bull. 200, part IV.

All the types and some paratypes of the new species are to be found in the Cornell University collection.

- ff. The perpendicular distance from the crest of the arc of M_1 to that of R_s less than the perpendicular distance from the tip of R_s to M_1 .
- g. Petiole of cubitus less than three-fourths the length of the base of media; costa produced at least two-thirds the distance between the tips of R_s and M_1 (Fig. 34). Clasper (Fig. 3),
3. *cylindrica* n. sp.
- gg. Petiole of cubitus more than three-fourths the length of the base of media; costa not produced two-thirds the distance between the tips of R_s and M_1 .
- h. Wing wide at base, subcosta exceptionally long and almost reaching the costa, base of R_s evanescent; setæ or slender spines at tip of clasper larger than the setæ along the inner margin; tip of R_s ends proximad of tip of M_2 (Fig. 35). Clasper (Fig. 4). (See figures in this paper).....4. *congregata* Joh.
- hh. Wing normal at base; subcosta normal; base of R_s distinct; setæ at apex of clasper not larger than those along its inner margin; tip of R_s ends slightly distad of tip of M_2 (Fig. 36). Clasper (Fig. 5).....5. *psittacus* n. sp.
- cc. R_1 ends about opposite or distad of the base of the fork of M ; species 2.5 mm or more in length.
- d. Petiole of cubitus over one-half as long as the basal section of M .
- e. R_1 ends about opposite the forking of M . (Fig. 221).....*futilis* Joh.
- ee. R_1 ends distad of the forking of M . (Fig. 266).....*abdita* Joh.
- dd. Petiole of cubitus less than one-fourth as long as the basal section of M .
- e. Humeri, pleura in part and hypopygium (Fig. 103) more or less yellow; knob of halteres dark.....*ochrolabis* Loew.
- ee. Thorax and abdomen black.
- f. Clasper with two distinct clusters of stout spines, one apical, the other subapical (Fig. 104).....*sciophila* Loew.
- ff. Clasper of different structure.
- g. Halteres and coxæ yellow.
- h. Clasper with a few, about 5 subequal stout spines along the inner margin (Fig. 139).....*habilis* Joh.
- hh. Clasper (Fig. 6) with many, over 12 subequal, rather slender spines along the inner margin. Wing (Fig. 37),
6. *habilis* var.
- gg. Knobs of halteres and coxæ fuscous. Wing (Fig. 38). Clasper (Fig. 7).....7. *globosa* n. sp.
- aa. Genus NEOSCIARA. Media and cubitus without setæ.
- b. Large southern species, 6 mm. or more in length; males undescribed.
- c. R_1 ends distad of the base of the fork of M ; wings blackish (Fig. 218),
picea Rübсаamen
- *cc. R_1 ends about opposite the base of the fork of M ...*cingulata* Rübсаamen
- bb. Medium or small species.
- c. R_1 ends distad, or opposite (not more than one-tenth of wing length proximad) of the base of the fork of M , and base of R_s at or proximad of a point midway between the humeral crossvein and the tip of R_1 .
- d. Thorax yellowish to rufous, coxæ and femora dull yellow.
- e. Claspers large, triangular, no terminal stout spine. Petiole of cubitus less than one-half as long as the basal section of media (Fig. 111),
fulvicauda Felt
- ee. Clasper (Fig. 8) cylindrical, with one stout apical spine. Petiole of cubitus more than one-half as long as the basal section of media. Wing (Fig. 39).....8. *falcata* n. sp.
- dd. Thorax dusky.
- e. R_s ends proximad of the tip of M_2 ; halteres dark.
- f. Clasper with 2 median lobes (Fig. 109); costa produced about one-half way from tip of R_s to M_1*tridentata* Rübсаamen
- ff. Clasper without median lobes; costa produced distinctly over half way from tip of R_s to M_1 .
- g. Clasper with 2 or 3 stout apical spines.

- h. Hypopygium with 2 clusters of setæ, 1 on each side of the mid-ventral line, no long slender seta on the inner margin of the clasper (Fig. 9). Costa produced not over two-thirds the way from the tip of R_s to the tip of M_1 (Fig. 40)... 9. *fochi* n. sp.
- hh. Hypopygium with no cluster of setæ on each side of the mid-ventral line, at least one long slender seta on the inner margin of the clasper (Fig. 10). Costa produced over two-thirds the distance from the tip of R_s to the tip of M_1 (Fig. 41).... 10. *joffrei* n. sp.
- gg. Clasper with no stout apical spines..... *munda* Joh.
- ee. R_s ends opposite or distad of the tip of M_2 .
- f. R_1 ends distad of the forking of M; halteres dark.
- g. Clasper with a mesal process. R_s ends noticeably distad of the tip of M_2 .
- h. Mesal process of claspers robust (Fig. 106 m); wing (Fig. 225), *dux* Joh.
- hh. Mesal process of claspers slender (Fig. 107 m); wing (Fig. 226), *imitans* Joh.
- gg. Clasper (Fig. 11) with no mesal process. R_s ends about opposite the tip of M_2 (Fig. 42)..... 11. *quadrispinosa* n. sp.
- ff. R_1 ends about opposite the forking of M.
- g. Apical tooth of clasper placed near the mesal margin of the apex (Fig. 115); Species under 2.5 mm. Halteres dusky yellow, *varians* Joh.
- gg. Apical tooth of clasper placed at apex (Fig. 108) or tooth wanting (Fig. 123).
- h. Halteres blackish; hind coxæ and legs brownish; claspers without apical tooth (Fig. 123); wing (Fig. 232), *jucunda* Joh.
- hh. Halteres and coxæ yellowish; clasper with distinct apical tooth (Fig. 108).
- i. Halteres and coxæ yellowish. Clasper with no subapical spines.
- j. Petiole of cubitus about .6 as long as the basal section of M. (Fig. 227)..... *prolifera* Felt.
- jj. Petiole of cubitus over .8 as long as the basal section of M.
- k. Wing veins heavily shaded (Fig. 228).... *prolifera* var. a.
- kk. Wing veins not shaded..... *prolifera* var. b.
- ii. Halteres fuscous. Coxæ dull brown. Clasper (Fig. 18 a, b) with several subapical stout spines. Wing (Fig. 49), 18. *conglomerata* n. sp.
- cc. R_1 ends at least one-sixteenth of the wing length proximad of the forking of M; the base of R_s is distad of the mid point between the humeral cross vein and the tips of R_1 .
- d. Fulvous mesonotum, abdomen more dusky; or reddish species.
- e. Dusky red species, female 4 mm. long, halteres white; male not described..... *sylvestrii* Kieffer
- ee. Fulvous mesonotum, abdomen more dusky, length 2 mm. or less.
- f. Clasper without strong spines at apex.
- g. Tip of R_s ends far remote from apex of wing at a point on the costa about opposite the mid point of branch M_1 (Fig. 229). Clasper with several rather slender spines on the inner margin proximad of the mid point (Fig. 110)..... *mellea* Joh.
- gg. Tip of R_s ends rather remote from apex of wing, but at a point on the costa distad of the mid point of the branch of M_1 . Clasper (Fig. 12) with about 5 stout spines and one longer, more slender spine at the middle of the inner margin. Wing (Fig. 43), 12. *luteola* n. sp.
- ff. Clasper with one or more apical spines.
- g. M_1 less than .8 as long as the petiole of the media. *tritici* Coquillett
- gg. M_1 at least .9 as long as the petiole of the media.

- h. Hypopygium with a median ventral lobe at base finely setose, clasper with single stout apical spine. (Fig. 13, a, b). Wing (Fig. 44).....13. *lobosa* n. sp.
- hh. Hypopygium with no median ventral lobe at base, clasper with more than one apical spine (Fig. 265).
ocellaris Comstock
- dd. Black or fuscous species.
- e. Clasper with a mesal articulated process (Fig. 112); R_s ends far remote from apex of wing. (Fig. 230).....*hastata* Joh.
- ee. Clasper without mesal articulated process.
- f. Hypopygium near its base with one or two patches of setæ on or by the side of the median ventral line.
- g. Hypopygium with one patch of setæ on the median ventral line near its base.
- h. Clasper (Fig. 14, a, b) concave at apex, with at least two stout long spines, and over eight smaller spines on the margin of the concavity. Wing (Fig. 45).....14. *petaini* n. sp.
- hh. Clasper of different form and structure.
- i. Clasper with a terminal tooth.
- j. Clasper blunt at apex. (Fig. 15, a, b). Wing (Fig. 46).
15. *grandis* n. sp.
- jj. Clasper tapering at apex and with several prominent sub-apical spines.
- k. Hypopygium with no more than 10 setæ on the basal median ventral line.
- l. Costa extends about half the distance between the tips of R_s and M_1 .
- m. Wing of normal proportions (Fig. 47). Median ventral lobe of hypopygium distinct (Fig. 16, a, b).
16. *trifolii* n. sp.
- mm. Wing narrow (Fig. 240). Median ventral lobe of hypopygium indistinct. Clasper (Fig. 120).
sativæ Joh.
- ll. Costa extends about two-thirds the distance between the tips of R_s and M_1 . (Fig. 117a)..*pauciseta* Felt.
- kk. Hypopygium with more than 25 setæ on the basal median ventral line.
- l. Abdomen variable dark ochreous, palpi yellow, anterior veins dark ochreous.....*multiseta* Felt.
- ll. Abdomen variable dark brown, palpi brown, anterior veins nearly black.....*agraria* Felt.
- ii. Clasper without a terminal tooth (Fig. 123); the hypopygium with the setæ of the ventral median patch arranged in a transverse line (Fig. 123a). Halteres black. *jucunda* Joh.
- gg. Hypopygium with 2 patches of setæ, one on each side of the median ventral line.
- h. Clasper with subapical stout spines, the proximal one longest.
- i. Clasper (Fig. 17 a, b) with 6 or more subapical stout spines, the most proximal one being longer than the others. Costa produced less than one-half the distance between the tips of R_s and M_1 (Fig. 48).....17. *polychaeta* n. sp.
- ii. Claspers (Fig. 18, a, b) with 3 or 4 subapical stout spines. Costa produced at least one-half the distance between the tips of R_s and M_1 (Fig. 49).....18. *conglomerata* n. sp.
- hh. Clasper (Fig. 128) with no subapical stout spines. Costa produced over one-half the distance between the tips of R_s and M_1 . Cu petiole at least half length of base of M (Fig. 247).....*scita* Joh.
- ff. Hypopygium without a tuft of setæ on the median ventral line near the base, or if feeble tuft is present then petiole of cubitus is not under .6 as long as the basal section of media.

- g. Claspers with 4 or 5 large subequal teeth or spines.
- h. Distance from point on the costa opposite the base of R_s to the tip of R_1 less than the distance from the tip of R_1 to a point on the costa opposite the forking of the media.
- i. Costa extends at least one-half the distance between the tips of R_s and M_1 .
- j. Clasper (Fig. 119) with one stout spine separate from the other 4 stout spines (Fig. 239). *spinata* n. sp. (sp. 24 Joh.)
- jj. Clasper with spines equidistant (Fig. 114). Wing (Fig. 234).
nacta Joh.
- ii. Costa extends less than one-half the distance between the tips of R_s and M_1 (Fig. 50). Clasper has no separate stout spine (Fig. 19) 19. *ovata* n. sp.
- hh. Distance from point on the costa opposite the base of R_s to the tip of R_1 greater than the distance from the tip of R_1 to a point on the costa opposite the forking of the media. Wing (Fig. 233). Clasper (Fig. 113) *mutua* Joh.
- gg. Claspers of different structure.
- h. Petiole of cubitus short, less than one-half as long as basal section of M.
- i. R_s ends distad of M_2 ; costa produced about one-half of distance from R_s to M_1 . Mesonotum highly polished.
- j. Halteres and coxæ bright yellow. (= *nigricans* Joh).
johannseni End.
- jj. Halteres fuscous, (Figs. 217, 260) *actuosa* Joh.
- ii. Costa produced over one-half distance from R_s to M_1 ; if not, then R_s ends proximad of tip of M_2 .
- j. Clasper with 3 stout or several not stout apical teeth or spines.
- k. Clasper with about 3 stout apical spines.
- l. Distance from a point on the costa opposite the base of R_s to the tip of R_1 much less than the distance from the tip of R_1 to a point on the costa opposite the forking of media.
- m. R_s ends on the costa opposite a point on M_1 proximad of the midpoint of M_1 .
- n. Costa extends less than one-half the distance between the tips of R_s and M_1 (Fig. 267).
cucumeris Joh.
- nn. Costa extends a little more than one-half the distance between the tips of R_s and M_1 (Fig. 241).
fatigans Joh.
- mm. R_s ends on the costa opposite a point on M_1 slightly distad of the midpoint of M_1 . Costa extends less than one-half the distance between the tips of R_s and M_1 (Fig. 51). Clasper (Fig. 20).
20. *trifurca* n. sp.
- ll. Distance from a point on the costa opposite the base of R_s to the tip of R_1 slightly greater than the distance from the tip of R_1 to a point on the costa opposite the forking of media (Fig. 52). Clasper (Fig. 21).
21. *pilata* n. sp.
- kk. Clasper with more than three spines all of which are slender and not conspicuously distinguished from the setæ of the clasper. *coprophila* Lint.
- jj. Clasper without any or with only a single prominent apical or subapical tooth.
- k. R_1 ends about opposite or only slightly proximad of the forking of M. (Fig. 255). Knob of halteres and coxæ brownish. Clasper (Fig. 115) *varians* Joh. var. c.
- kk. R_1 ends considerably proximad of the forking of M.

1. Clasper globular or subglobular.
- m. Thorax subopaque, not very shiny.
- n. Clasper with a single stout spine, subapical in position. *longispina* n. sp. (Fig. 116).
(Sp. 27 Joh.)
- nn. Clasper with no stout spines (Fig. 22). Wing (Fig. 53).....22. *ericia* n. sp.
- mm. Thorax very shiny. Clasper subglobular. (Fig. 123).....*lugens* Joh.
11. Clasper not globular or subglobular.
- m. Clasper with a stout apical or stout subapical spine.
- n. Clasper with several subapical, slender, rather long spines (Fig. 131). R_s ends about opposite the tip of M_2 (Fig. 250). Mesonotum highly polished.....*acuta* Joh.
- nn. Clasper with no subapical, slender, long spines. R_s ends considerably proximad of the tip of M_2 (Fig. 54).
- o. Stout spine subapical (Fig. 67). (See plate, this key). Media forks distad of tip of Cu_2 ; R_s almost straight, only slightly curved at tip and usually distant from M_1 ...*hartii* Joh.
- oo. Stout spine apical (Fig. 23).
- p. Cu petiole less than half the length of the base of M . Distance from point on costa opposite the base of R_s to the tip of R_1 greater than the distance from the tip of R_1 to a point on costa opposite the forking of M . Branches of M considerably diverging. Wing (Fig. 54). Clasper (Fig. 23).
23. *penna*. n. sp.
- pp. Cu petiole at least half the length of base of M . Distance from point on costa opposite the base of R_s to the tip of R_1 not greater than distance from tip of R_1 to a point on costa opposite the forking of M . Branches of M only slightly diverging. Wing (Fig. 56). Clasper (Fig. 25)...25. *hamata* n. sp.
- mm. Clasper with no stout apical or subapical spine. Halteres luteous. Wing (Fig. 61). Clasper (Fig. 30).
30. *perfecta* n. sp.
- hh. Petiole of cubitus at least half as long as the basal section of M .
- i. R_s ends proximad of .85 of the length of the wing.
- j. Clasper with 2 strong apical spines (Fig. 118). Wing veins strongly defined (Fig. 238). Thorax shining black.
parilis Joh.
- jj. Clasper and wing of different structure.
- k. Costa produced less than two-thirds of distance from R_s to M_1 .
- l. Clasper with one or more stout apical spines.
- m. Wing narrow (Fig. 240). Clasper with one stout apical spine; hypopygium with an indistinct basal cluster of setae on the mid-ventral line (Fig. 120).
sativae Joh.
- mm. Wing wider (Fig. 267). Clasper with 3 apical spines; hypopygium with no trace of basal cluster of setae on the mid-ventral line (Fig. 261).
cucumeris Joh.
11. Clasper with no stout apical spines, with one long slender subapical seta. (Fig. 24). Wing (Fig. 55).
24. *pollicis* n. sp.

- kk. Costa produced over two-thirds from R_8 to M_1 .
1. Clasper with two apical teeth (Fig. 121). Petiole of cubitus about three-fourths as long as basal section of M. Hind tarsus shorter than the tibia. *sp.-33* Joh.
 11. Clasper with a median process (Fig. 122). Petiole of the cubitus about half as long as the basal section of M. (Fig. 242). Hind tarsus and tibia subequal. *neglecta* Joh.
- ii. R_8 ends distad of .85 of wing length.
- j. Clasper with one prominent terminal or subterminal spine or tooth, or if several teeth are present, one is conspicuously larger than the others.
 - k. Costa produced about one-half way from R_8 to M_1 .
 1. Halteres bright yellow. Claspers (Fig. 125). Wing (Fig. 243). R_8 ends distad of the tip of M_2 . (= *nigricans* Joh.) *johannseni* End.
 11. Halteres fuscous. R_8 ends opposite or proximad of the tip of M_2 .
 - m. R_8 ends about opposite the tip of M_2 ; Wing (Fig. 217). Mesonotum highly polished. *actuosa* Joh.
 - mm. R_8 ends considerably proximad of the tip of M_2 (Fig. 56). Mesonotum shiny. Clasper (Fig. 25). *25. hamata* n. sp.
 - kk. Costa produced over half way from R_8 to M_1 .
 1. Costa produced over three-fourths way from R_8 to M_1 (Fig. 244). Halteres yellow. Claspers (Fig. 126). *S. sp. 37* Joh.
 11. Costa produced less than .7 from R_8 to M_1 .
 - m. R_1 ends over one-fifth of wing length proximad of the forking of the media (Fig. 245). Halteres dark. Clasper (Fig. 127). *dolens* Joh.
 - mm. R_1 ends considerably less than one-fifth of wing length proximad of the forking of M.
 - n. Apex or near the apex of clasper with a number of spines of which one is somewhat larger or stouter than the others.
 - o. Halteres yellow. Clasper (Fig. 132). *diluta* Joh.
 - oo. Halteres dark. Clasper (Fig. 140). *diluta* Joh. var. a.
 - nn. Spine of apex of clasper distinctly differentiated from the apical setæ or from those near the apex.
 - o. Halteres yellow. Clasper with no subapical spines differentiated from the setæ of the clasper.
 - p. Costa produced less than five-eighths of the distance from R_8 to M_1 .
 - q. Hind tibia a little shorter than the tarsus. Wing (Fig. 246). *varians* Joh.
 - qq. Hind tibia and tarsus subequal in length. *varians*, var. a.
 - pp. Costa produced over two-thirds of distance from R_8 to M_1 *varians*, var. b.
 - oo. Knobs of halteres fuscous.
 - p. Clasper (Fig. 26) with several long slender subapical spines, a little longer than the stout apical spine. The distance from the tip of R_1 to the point on the costa opposite the forking of M is greater than the distance between the tips of M_1 and M_2 (Fig. 57). *26. felli* n. sp.

- pp. Clasper (Fig. 27) with no long subapical spines. The distance between the tip of R_1 and the point on the costa opposite the forking of M is not greater than the distance between the tips of M_1 and M_2 .
Wing. (Fig. 58)...27. *macroptera* n. sp.
- jj. Clasper with two or more prominent apical teeth, spines, or with strong setæ.
- k. Clasper with two or three apical or subapical spines.
Knobs of halteres black or brown.
1. Black species 3 mm. in length, with blackish legs.
Clasper subglobose (Fig. 128)...*scita* Joh.
- ll. Smaller species with fuscous yellowish legs. Claspers more slender.
- m. Spines of clasper unusually short (Fig. 129). The distance from the tip of R_1 to the point on the costa opposite the forking of M is greater than the distance between the tips of M_1 and M_2 .
fumida Joh.
- mm. Spines of clasper not unusually short. The distance from the tip of R_1 to the point on the costa opposite the forking of M is less than the distance between the tips of M_1 and M_2 .
- n. Clasper (Fig. 130) with three or four slender subequal spines, two or three near the apex, the other near the apical third, all on the inner margin. Petiole of cubitus about as long as or longer than the base of media (Fig. 249).
trivialis Joh.
- mn. Clasper (Fig. 28) with three rather stout subequal spines, all clustered at the apex. Petiole of cubitus much shorter than the base of media (Fig. 59)...28. *subtrivialis* n. sp.
- kk. Clasper with five or more apical and subapical setæ or spines.
1. Apex of clasper with six or eight spines, one of which is set at an angle to the others. (Fig. 137). Halteres yellow. Wing (Fig. 252)...*impatiens* Joh.
- ll. Apex of clasper with spines or setæ subequal in size and distance from each other.
- m. Clasper with about six stout conspicuous subequal spines (Fig. 29). Wing (Fig. 60).
29. *sexdentata* n. sp.
- mm. Clasper with no conspicuous or stout spines.
- n. M_2 distinctly shorter than length of petiole of media. Coxæ yellowish. (Fig. 133).
coprophila Lint.
- nn. M_2 about equal in length to the petiole of media. Coxæ brown or black. Wing (Fig. 62). Clasper (Fig. 31). (Compare *caldaria* Lint.)
caldaria var.

SCIARA.

1. *Sciara forceps* n. sp.

Male: Length, 1.6 mm. Head black, shiny; palpi and scape of antennæ luteous, antennæ broken. Thorax; mesonotum shiny, black; humeri and pleura of prothorax luteous; metanotum and pleuræ of meso and metathorax fuscous. Abdomen dark fuscous with posterior third of the abdominal segments and venter luteous; hypopygium light brown; clasper (Fig. 1) with several stout apical spines, one slightly stouter than the rest, and one very prominent large, subapical spine, giving the clasper a bifurcated appearance. Coxæ and femora luteous, trochanters black, tibiæ and tarsi fuscous. Wings (Fig. 32) hyaline; media and cubitus setose; base of R_s noticeably distad of the midpoint between the humeral cross vein and the tip of R_1 ; R_1 ends noticeably proximad of the forking of media; petiole of cubitus distinctly longer than the base of media; costa extends over half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and slightly proximad of the tip of M_2 . Halteres; pedicel luteous, knobs darker.

This species is closely related to *dives*, but may be distinguished from the latter by the characters of the clasper, the color of the body and the fact that the petiole of the media is setose.

Described from 1 male collected May 3, 4, 1916, at Palatka, Florida, by J. C. Bradley. Type No. 207.

2. *Sciara multisetifera* n. sp.

Male: Length, 2.8 mm. Head piceous to black; antennæ of dried specimen half as long as body, piceous to black. Thorax, abdomen piceous to black, the posterior margins of the second, third and fourth abdominal segments grayish. Angles of humeri dull luteous. Appendages, including palpi, halteres, legs and hypopygium fuscous. Hypopygium; clasper (Fig. 2) with many setæ shorter than the numerous slender spines along the inner margin. Wings (Fig. 33) smoky brown; media branches setose; base of R_s noticeably distad of the midpoint between the humeral cross vein and the tip of R_1 ; R_1 ends proximad of the forking of media; petiole of cubitus distinctly longer than the base of media; costa extends about half the distance between the tips of R_s and M_1 ; R_s ends far distad of .85 the length of the wing and distad of the tip of M_2 .

This species differs from *cylindrica*, its near relative, by having many more setæ on the clasper, all of which are shorter than those on the inner margin.

Described from 3 males, collected in South Arizona, Aug., 1902, by F. H. Snow. Type No. 208. Two allotypes.

3. *Sciara cylindrica* n. sp.

Male: Length, 1.5 mm. Head shiny black; antennæ almost black; palpi almost black. Thorax shiny black. Abdomen and hypopygium almost black. Hypopygium; clasper (Fig. 3) as wide at the apex as at the middle, setæ longer than the about 8 rather slender spines of the inner margin. Coxæ dull luteous, femora, tibiæ and tarsi fuscous. Wings (Fig. 34) hyaline, media and cubitus setose; base of R_s slightly distad of the midpoint between the humeral cross vein and the tip of R_1 ; R_1 ends proximad of the forking of media; petiole of cubitus evanescent, apparently less than half the length of the base of media; costa extends about two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing, and slightly proximad of the tip of M_2 . Halteres luteous with dark knob.

This species may be distinguished from its near relatives, *congregata*, *psittacus*, and *cylindrica* by the form of the clasper and by the petiole of cubitus being shorter than the base of media.

Described from 1 male, collected May 15-19, 1907, at Felton, St. Cruz Mts., Cal., by J. C. Bradley, Type No. 209.

4. *Sciara congregata* Joh.

Psyche. Vol. XXI. June 1914, No. 3, pp. 93, 95.

Male: Length, 2 mm. Head black; antennæ fuscous, short (about two-thirds as long as wing from humeral cross vein), joints not twice as long as wide; palpi fuscous. Mesonotum subshining blackish; scutellum, metanotum and pleura subopaque, brownish black. Abdomen subopaque, brownish black. Hypopygium brownish black; no median ventral setiferous lobe; claspers resemble those of *jucunda*, but apical setæ are stouter. Legs brown, the tarsi darker; hind tibia about as long as the petiole of the media of the wing; apical third of tibiæ slightly broadened; hind tarsus about .8 as long as the tibia, hind metatarsus slightly over .7 as long as the following 4 joints. Wings (Fig. 35) smoky; veins dark brown, forks of media and apical part of forks of cubitus setose; R_1 ends one-third as far proximad of the forking of media as the tip of R_s is distad of this point; basal section of R_s very faint but is evidently distad of the midpoint between the humeral cross vein and the tip of R_1 ; petiole of cubitus slightly longer than the basal section of M ; media petiole is indistinct; costa produced half of the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and slightly proximad of the tip of M_2 . Halteres dark.

Female: Length, 2.5 mm. Like the male in coloring and structure, differing in having slightly shorter antennæ, these being less than one-half as long as the wing, with intermediate joints but little longer than wide; the basal section of R_s and the petiole of media a little more distinct. The lamellæ of the ovipositor are only slightly longer than wide.

Type in Dr. Johannsen's collection, Cornell University. Paratypes in the collection of the Arkansas Exp. Station.

5. *Sciara psittacus* n. sp.

Male: Length, 1.9 mm. Head fuscous; antennæ fuscous, scape luteous; palpi fuscous. Thorax fulvous. Abdomen fuscous with posterior margin of each segment and the whole of the venter luteous. Hypopygium fulvous, clasper (Fig. 5) distinctly narrower at apex than the middle, with the comparatively few setæ on the surface longer than the numerous slender spines along the inner margin. Coxæ and femora luteous, trochanters black; tibiæ and tarsi fuscous. Wings (Fig. 36) hyaline; media and cubitus setose; the petiole of media evanescent or very faint; base of R_s considerably distad of the midpoint between the humeral cross vein and the tip of R_1 ; R_1 ends considerably proximad of the forking of media; petiole of cubitus about as long as the base of media, costa extends about half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres luteous.

Described from 1 male collected in Maine, Aug. 21, 1913, by C. P. Alexander. Type No. 210.

6. *Sciara habilis* var.

Male: Length, 2.4 mm. Head black; antennæ fuscous with dull fulvous scape; palpi fuscous. Thorax subshining, black, covered with a fine, whitish powder. Abdomen and hypopygium almost black. Hypopygium; clasper (Fig. 6) narrower at apex than middle, the setæ as long or longer than the numerous rather short spines along the inner margin. Coxæ and femora luteous; trochanters black, tibiæ and tarsi fuscous. Wings (Fig. 37) hyaline; media and cubitus setose; base of R_s about at the midpoint between the humeral cross vein and the tip of R_1 ; R_1 ends slightly distad of the forking of media; petiole of cubitus less than one-fourth the length of the base of media; costa extends two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and very slightly proximad of the tip of M_2 . Halteres luteous.

This variety differs from *Sciara habilis*, by having more subequal spines along the inner margin, and by the fact that *habilis* is larger.

Described from one male, collected at Clayton, Ga., May 18-26, 1911. Type No. 211.

7. *Sciara globosa* n. sp.

Male: Length, 3.2 mm. Head black, shiny; antennæ fuscous with the two basal segments fulvous; palpi fuscous. Thorax shiny, dark fuscous with angles of humeri fulvous. Abdomen dark fuscous, with posterior third of each segment black. Hypopygium dark fuscous; clasper (Fig. 7) subglobose, with about 6 stout subapical spines surrounded by short setæ. Coxæ, femora, tibiæ and tarsi fuscous, trochanters black. Wings (Fig. 38) smoky brown; media and cubitus

setose; base of R_s about at the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends distad of the forking of media; petiole of cubitus less than one-fourth the length of the base of media; costa extends about two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and slightly proximad of the tip of M_2 . Halteres fuscous.

This species is similar to both *habilis* and *serrosa*, but differs from both by having a subglobose clasper, and by having dark coxæ and halteres.

Described from 1 male, collected at Muir Woods, Cal., Aug. 30, 1908, by J. C. Bradley, Type No. 212.

NEOSCIARA.

(New genus.)

8. *Neosciara falcata* n. sp.

Male: Length, 2.3 mm. Head black; antennæ: flaggelum black, scape luteous; palpi luteous. Thorax; mesonotum and metanotum fulvous, not shiny, pleura fuscous. Abdomen fuscous. Hypopygium brown, with a basal median ventral lobe (Fig. 8, b) on which are about 14 prominent spines arranged in 2 rather indistinct rows; clasper (Fig. 8, a) with an apical spine and no subapical spines. Legs: coxæ and femora luteous; trochanters, tibiæ and tarsi fuscous. Wings (Fig. 39) hyaline; media and cubitus without setæ; base of R_s at the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends slightly (not more than one-tenth the wing length) proximad of the base of the fork of M; petiole of cubitus over half the length of the base of media; costa extends over half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres luteous.

This species is related to *fulvicauda* but is easily separated from the latter by the structure of the clasper and the longer petiole of cubitus.

Described from one male, collected at Auburndale, Mass., April, 1916. Type No. 213.

9. *Neosciara fochi* n. sp.

Male: Length, 2.5 mm. Head black; antennæ missing; palpi missing. Thorax shiny, black. Abdomen fuscous to black. Hypopygium fuscous, with 2 clusters of prominent spines at the base, one on each side of the mid ventral line (Fig. 9b); clasper (Fig. 9a) with 2 apical stout spines and no subapical spines. Legs fuscous to black. Wings (Fig. 40) smoky; media and cubitus without setæ; base of R_s at the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends slightly (not more than one-tenth of the wing length) proximad of the forking of M; petiole of cubitus a little longer than the base of media;

costa extends a little over half the distance between the tips of R_s and M_1 ; R_s ends slightly distad of .85 the length of the wing, and noticeably proximad of the tip of M_2 . Halteres fuscous.

Described from 1 male, collected near Leander, Wyoming, August, by Roy Moodie, at an elevation of 5,000 to 8,000 feet. Type No. 214.

10. *Neosciara joffrei* n. sp.

Male: Length, 2.5 mm. Head dull, black; antennæ fuscous, over half the length of the body; palpi fuscous. Thorax shining, dark fuscous. Hypopygium with no median ventral lobe at base, fuscous; clasper (Fig. 10) conical, with 2 apical subequal stout spines and 1 sub-apical longer more slender spine. Legs fuscous. Wings (Fig. 41) hyaline; media and cubitus without setæ; base of R_s at the midpoint between humerus and the tip of R_1 ; R_1 ends about opposite the forking of media; petiole of cubitus over half the length of the base of media; costa extends over two-thirds the distance between the tips of R_s and M_1 ; R_s ends slightly distad of .85 the length of the wing and proximad of the tip of M_2 . Halteres fuscous.

This species is similar to *fochi*, but differs in structure and shape of the clasper, the shorter petiole of cubitus, and the longer costa.

Described from one male, collected at North Mt., Pa., June 7. Type No. 215.

11. *Neosciara quadrispinosa* n. sp.

Male: Length, 2.6 mm. Head shiny, black; antennæ piceous, over half the length of the body; palpi piceous. Thorax shiny, piceous to black. Abdomen piceous, the anterior half of the intermediate segments brown. Hypopygium brown, with no median ventral lobe at the base; clasper (Fig. 11) circular, with 4 long conspicuous stout spines at the apex, no subapical spines. Coxæ, femora and tibiæ luteous, tarsi fuscous. Wings (Fig. 42) smoky; media and cubitus without setæ; base of R_s at the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends distad of the forking of media; petiole of cubitus less than half the length of the base of media; costa extends at least two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres; knobs fuscous, pedicels luteous.

This species differs from *dux* and *imitans*, by having no mesal process on the clasper and by having R_s end opposite the tip of M_2 .

Described from one male collected at North Adams, Mass., March 20. Type No. 216.

12. *Neosciara luteola* n. sp.

Male: Length, 1.5 mm. Head luteous; antennæ about as long as body, fuscous with scape luteous; segments at least twice as long as wide; palpi luteous. Thorax luteous, shining. Abdomen; dorsum brownish with posterior margin of each segment luteous; venter luteous. Hypopygium luteous, with no median ventral lobe at base; clasper (Fig. 12) with 5 or 6 subapical stout spines and one more slender slightly longer spine, one or two of the most proximad spines points more cephalad than the rest, several very small setæ proximad of the stout spines. Legs luteous, trochanters black. Wings (Fig. 43) hyaline; media and cubitus without setæ; base of R_s slightly distad of the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends proximad of the forking of media; petiole of cubitus less than half the length of the base of the media; costa extends a little over half the distance between the tips of R_s and M_1 ; R_s ends slightly proximad of .85 the length of the wing and proximad of M_2 . Halteres luteous.

This species is closely related to *mellea*, but differs in the structure of the clasper and the color of the body.

Described from 2 males collected at Black Rock, Rabun Co., Ga., May 20-23, 1911. Type No. 217, and one paratype.

13. *Neosciara lobosa* n. sp.

Male: Length, 1.5 mm. Head fuscous, not shiny; antennæ with fuscous flagellum and fulvous scape; palpi fulvous. Thorax subshining, fulvous, with a broad median dorsal indistinct fuscous line on the mesonotum. Abdomen fuscous. Hypopygium fuscous, at base with a median ventral lobe covered with minute setæ (Fig. 13b); clasper (Fig. 13a) with a large apical spine and no subapical spines. Legs: coxæ luteous, trochanters fuscous, tibiæ fulvous, tarsi fuscous. Wings (Fig. 44) hyaline; media and cubitus without setæ; base of R_s distad of the mid-point between the humerus and the tip of R_1 ; R_1 ends distinctly proximad of the forking of media; petiole of cubitus over half the length of the base of media; costa extends a little over half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres; knobs fuscous, pedicels luteous.

This species differs from *ocellaris* by having a median ventral lobe on the hypopygium, and a clasper with only one apical spine.

Described from one male, collected at Carbonate, Columbia River, British Columbia, July 7-12, 1908, by J. C. Bradley, at an altitude of 2,600 feet. Type No. 218.

14. *Neosciara petaini* n. sp.

Male: Length, 1.6 mm. Head black, somewhat shining; antennæ fuscous, about two-thirds the length of the body, segments of flagellum at least twice as long as wide, distal segments more than twice as long as wide; palpi fulvous. Thorax fuscous, somewhat shining. Abdomen fuscous. Hypopygium fuscous, with a cluster of about 10 broad setæ much larger than the surrounding setæ (Fig. 14b) at base on the mid ventral line; clasper (Fig. 14a) concave, at apex, with about 2 very stout spines and at least 10 smaller spines on the margin of the concavity. Legs fulvous, tibiæ and tarsi darker. Wings (Fig. 45) hyaline; media and cubitus with no setæ; base of R_s distad of the mid-point between the humeral cross vein and the tip of R_1 ; R_1 proximad of the forking of M; petiole of cubitus about as long as the basal section of M; costa extends a little over half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres fuscous.

Described from one male collected in Maryland, May 14, 1909. Type No. 219.

15. *Neosciara grandis* n. sp.

Male: Length, 2 mm. Head black; antennæ and palpi fuscous; antennæ as long as head and thorax. Thorax black, shining; humeri angles fuscous. Abdomen dark fuscous, posterior margins of segments black. Hypopygium (Fig. 15b) dark fuscous, with a patch of about 6 setæ at the base on the median ventral line; clasper (Fig. 15a) blunt at apex with one stout apical spine and no distinct subapical spines. Coxæ and femora fulvous, trochanters black, tibiæ brown, tarsi fuscous. Wings (Fig. 46) hyaline; media and cubitus without setæ; base of R_s at about the midpoint between the humeral cross vein and the tip of R_1 ; R_1 ends proximad of the forking of M; petiole of cubitus not quite half as long as the base of media; costa produced more than half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres fulvous.

This species differs from *trifolii* and *pauciseta* by having no prominent subapical spines on the clasper.

Described from one male, collected July 13, 1913, on Lost Mount, Cobb Co., Georgia. Type No. 220.

16. *Neosciara trifolii* n. sp.

Male: Length, 1.2 mm. Head black; antennæ fuscous, over two-thirds the length of the body. Thorax; mesonotum piceous, shiny, pleuræ fuscous. Abdomen black, intermediate segments with anterior two-thirds fuscous, hairs pale yellow; hypopygium brown, near its base with a small median ventral lobe (Fig. 16b) margined with about 8 setæ; clasper (Fig. 16a) with an apical tooth, and with about 4 stout,

subequal, scattered spines, and with one proximad, longer, more slender spine along the inner margin. Coxæ and palpi luteous; trochanters black; tibiæ dull yellowish-brown; tarsi fuscous to black; hind tibia and tarsus about equal in length. Wings (Fig. 47) hyaline; veins brown, rather strongly marked; media and cubitus without setæ; petiole of cubitus slightly less than half the length of the base of media; R_1 ends at least one-sixteenth of the wing length proximad of the forking of M; the base of R_s distad of the mid-point between the humeral cross vein and the tip of R_1 ; M_2 ends distad of the termination of R_s . Twin Falls, Moscow, Idaho.

Female: Length, 1.5 mm. Colored like the male. Moscow, Idaho.

This species is closely related to *pauciseta* Felt., from which it may be distinguished by the characters of the hypopygium and the more retracted position of the tip of R_s .

Described from 2 males reared by Professor Burrill, Oct. 27, 1916, and Oct. 3, 1917, and 10 females reared Oct. 27, 1916, from the heads of red clover, Moscow, Idaho. Type No. 221.

17. *Neosciara polychæta* n. sp.

Male: Length, 1.2 mm. Head black; antennæ dark fuscous, over two-thirds the length of the body, scape fulvous, palpi luteous. Thorax black shining. Abdomen fuscous to black; hypopygium fuscous, with 2 patches of setæ at base (Fig. 17b), one on each side of the median ventral line; clasper (Fig. 17) with one large apical spine and about 6 subapical smaller but stout spines, the most proximal one being longer and more slender than the others. Coxæ luteous, trochanters black, femora dull luteous, tibiæ brown, tarsi fuscous. Wings (Fig. 48) hyaline; media and cubitus without setæ; base of R_s far distad of the mid-point between the tip of R_1 and the humeral cross vein; R_1 ends noticeably proximad of the forking of media; petiole of cubitus over half as long as the base of media; costa produced less than half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the wing length, and about opposite the tip of M_2 . Halteres luteous.

Female: Length, 1.4 mm. Same as male, except the antennæ which have a black scape and are no more than half the length of the body.

Described from 5 males and 1 female collected at Clayton, Georgia, May 18-26, 1911. Type No. 222. Four paratypes and one allotype.

18. *Neosciara conglomerata* n. sp.

Male: Length, 1.8 mm. Head black; antennæ black, not quite one-half the length of the body. Thorax black, dull, covered with a fine white powder. Abdomen fuscous, the posterior margin of each segment luteous. Hypopygium fuscous, with 2 patches of setæ at the

base, one on each side of the median ventral line (Fig. 18b); clasper (Fig. 18a) with one large apical spine and about 3 subapical, subequal spines and one subapical long, slender spine proximal to the others. Coxæ dull brown, trochanters fuscous, femora and tibiæ dull fulvous, tarsi almost black. Wing (Fig. 49) hyaline; media and cubitus without setæ; base of R_s distad of the mid-point between the tip of R_1 and the humeral cross vein; R_1 ends proximad of the forking of media; petiole of cubitus is a little over one-half as long as the base of media; costa produced more than one-half the distance between the tips of R_s and M_1 ; R_s is about parallel with costa and ends distad of .85 of the wing length and about opposite the termination of M_2 . Halteres fuscous.

Female: Length, 2.2 mm. Same as male except that in one specimen the venter is dull luteous in color.

Described from 4 males and 4 females collected June 20–27, 1907, at Blue Lake, Humboldt Co., Cal., by J. C. Bradley. Type No. 223. Three paratypes and 4 allotypes.

19. *Neosciara ovata* n. sp.

Male: Length, 1.1 mm. Head black, somewhat shining; antennæ fuscous, at least half the length of the body; palpi fuscous. Thorax fuscous to black, subshining. Abdomen fuscous, intermediate segments dull luteous along the posterior margin. Hypopygium fuscous, no cluster of setæ at base on median ventral line; clasper (Fig. 19) oval with 4 or 5 stout subequal spines near or at the apex. Legs dull fulvous. Wings (Fig. 50) hyaline; media and cubitus without setæ; base of R_s distad of the mid-point between the humerus and the tip of R_1 ; R_1 ends considerably proximad of the forking of M ; petiole of cubitus shorter than half the length of the base of M ; costa extends less than half the distance between the tips of R_s and M_1 ; R_s ends slightly proximad of .85 the length of the wing and distinctly proximad of the tip of M_2 . Halteres fuscous.

This species is closely related to *spinata*, but differs in the structure of the clasper and the shorter petiole of cubitus.

Described from one male collected at Howser, Selkirk Mts., British Columbia, June 22, 1905, by J. C. Bradley. Type No. 224.

20. *Neosciara trifurca* n. sp.

Male: Length, 1 mm. Head somewhat shining, black; antennæ fuscous, about as long as the body; palpi fuscous. Thorax somewhat shining, fuscous. Abdomen almost black. Hypopygium fuscous with no cluster of setæ at base on the mid-ventral line; clasper (Fig. 20) oval, with about 3 subequal, apical stout spines and no subapical spines, several small setæ along the inner margin. Legs: coxæ, femora and tibiæ dull fulvous, trochanters black, tarsi fuscous. Wings (Fig. 51) hyaline, media and cubitus without setæ; base of R_s distad of the mid-point between humerus and the tip of R_1 ; R_1 ends far proximad of the

forking of M; petiole of cubitus shorter than half the length of the base of M; costa extends less than half the distance between the tips of R_s and M_1 ; R_s ends slightly proximad of .85 the length of the wing and considerably proximad of the tip of M_2 . Halteres fuscous.

This species is near *fatigans* in the key, but differs by having fuscous halteres, a shorter costa and a shorter cubitus petiole.

Described from one male, collected at Felton, St. Cruz Mts., Cal., May 15-19, 1907, by J. C. Bradley. Type No. 225.

21. *Neosciara pilata* n. sp.

Male: Length, 1.4 mm. Head somewhat shining, black; antennæ fuscous; palpi luteous. Thorax somewhat shining, almost black. Abdomen dark fuscous. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 21) conical, with 3 apical stout spines, no subapical spines, and several small setæ on the inner margin. Legs: coxæ and femora luteous, trochanters black, tibiæ fulvous; tarsi fuscous. Wings (Fig. 52) hyaline; media and cubitus without setæ; base of R_s distad of the mid-point between humerus and the tip of R_1 ; R_1 ends far proximad of the forking of M; petiole of cubitus a little less than half the length of the base of M; costa extends more than half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and slightly proximad of the tip of M_2 . Halteres; knobs fuscous, pedicels luteous.

This species is very similar to *trifurca*, but differs in size, in the longer costa and cubitus petiole, and in the position of R_2 in relation to that of M_2 .

Described from one male, collected at Felton, St. Cruz Mts., Cal., May 15-19, '07, by J. C. Bradley. Type No. 226.

22. *Neosciara ericia* n. sp.

Male: Length, 2.9 mm. Head black, somewhat shiny; antennæ fuscous, about two-thirds the length of the body; palpi fuscous. Thorax fuscous, somewhat shiny. Abdomen almost black. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 22) globose, with no stout spines. Legs: coxæ fulvous, femora and tibiæ brown, tarsi fuscous. Wings (Fig. 53) hyaline; cubitus and media with no setæ; base of R_s distad of the mid-point between the humerus and the tip of R_1 ; R_1 proximad of the forking of media; petiole of cubitus much less than half the length of the basal section of M; costa extends over two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing, and about opposite the tip of M_2 . Halteres fuscous.

This species is near *longispina* in the key, but differs by having no stout spine on the clasper, and by having a shorter cubitus petiole.

Described from one male collected at Brookline, Mass., by C. W. Johnson. Type No. 227.

23. *Neosciara penna* n. sp.

Male: Length, 1.1 mm. Head black, somewhat shiny; antennæ fuscous, over half the length of the body; palpi luteous. Thorax somewhat shining, almost black. Abdomen dark fuscous with posterior margin of the intermediate segments dull luteous. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at the base; clasper (Fig. 23) narrowly oval, with one apical stout spine and no subapical spines. Legs; coxæ and femora luteous, trochanters black, tibiæ and tarsi fuscous. Wings (Fig. 54) hyaline; media and cubitus without setæ; base of R_s distad of the mid-point between the humerus and the tip of R_1 ; R_1 ends considerably proximad of the forking of M ; petiole of cubitus shorter than half the length of the base of M ; costa extends more than half the distance between the tips of R_s and M_1 ; R_s ends slightly proximad of .85 the length of the wing and considerably proximad of M_2 . Halteres, knob fuscous, pedicel luteous.

This species is near *acuta* in the key but differs from the latter by having no subapical spines on the clasper and by having R_s end proximad of the tip of M_2 . Type No. 228.

Described from one male, collected at Blue Lake, Humboldt Co., Cal., June 20-27, by J. C. Bradley.

24. *Neosciara pollicis* n. sp.

Male: Length, 1.4 mm. Head somewhat shiny, black; antennæ fuscous, about half the length of the body; palpi fuscous. Thorax somewhat shining, fuscous. Abdomen almost black. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 24) longer than wide, with no stout spines, but with a subapical long seta. Legs; coxæ and femora fulvous, trochanters black; tibiæ and tarsi dull brown. Wings (Fig. 55) brownish; cubitus and media without setæ; base of R_s distad of the mid-point between the humerus and the tip of R_1 ; R_1 ends proximad of the forking of M ; petiole of cubitus almost as long as the base of media; costa extends a little over half the distance between the tips of R_s and M_1 . R_s ends proximad of .85 the length of the wing and noticeably proximad of the tip of M_2 . Halteres dark fuscous.

This species is near *sativa* and may be distinguished from the latter especially by having a wider wing and by the clasper lacking spines.

Described from one male collected in Arizona, August. Type No. 229.

25. *Neosciara hamata* n. sp.

Male: Length, 1.2 mm. Head shining, black; antennæ fuscous; palpi fuscous. Thorax shiny, almost black. Abdomen almost black. Hypopygium almost black, with no cluster of setæ on the mid-ventral

line at base; clasper (Fig. 25) at least twice as long as wide, with one large apical spine, and no subapical spines. Legs fuscous; the front coxæ fulvous. Wings (Fig. 56) hyaline; cubitus and media with no setæ; base of R_s considerably distad of the mid-point between humerus and the tip of R_1 ; R_1 ends far proximad of the forking of M ; petiole of cubitus a little longer than half the length of the base of media; costa extends about half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing, and noticeably proximad of the tip of M_2 . Halteres fuscous.

This species is near *actuosa* in the key, but differs especially in the form of the clasper, which is longer, narrower and more blunt at the tip.

Described from one male, collected by J. C. Bradley at Black Rock Mt., Georgia, at an altitude of 3,500 feet, May 20–25, 1911. Type No. 230.

26. *Neosciara felti* n. sp.

Male: Length, 1 mm. Head shiny black; antennæ dark fuscous; palpi fuscous. Thorax shiny black. Abdomen dark fuscous. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 26) about twice as long as wide, with one very stout apical spine, and about 5 more slender subapical spines, the most proximad of which is longer and more slender than the others. Legs: coxæ and femora fulvous to luteous, trochanters black, tibiæ and tarsi fuscous. Wings (Fig. 57) hyaline; media and cubitus without setæ; base of R_s far distad of the mid-point between humerus and the tip of R_1 ; R_1 ends far proximad of the forking of M ; petiole of cubitus over half as long as the basal section of media; costa extends about two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and about opposite the tip of M_2 . Halteres fuscous.

Described from one male collected at Ithaca, N. Y., July 9, 1904. Type No. 231.

27. *Neosciara macroptera* n. sp.

Male: Length, 1.5 mm. Head somewhat shining, black, antennæ fuscous; palpi fuscous. Thorax somewhat shiny, fuscous. Abdomen almost black. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 27) at least twice as long as wide, with one stout apical spine and about 8 subequal much smaller subapical spines on the inner margin. Legs; coxæ fulvous, trochanters black, femora, tibiæ and tarsi fuscous. Wings (Fig. 58) hyaline, with no setæ on the media and cubitus; base of R_s considerably distad of the mid-point between humerus and the tip of R_1 ; R_1 ends proximad of the forking of M ; petiole of cubitus a little over half the length of the base

of media; costa extends a little over half the distance between the tips of R_s and M_1 ; R_s ends slightly distad of .85 the length of the wing and distinctly proximad of the tip of M_2 . Halteres; knobs fuscous, pedicels luteous.

This species differs from *felti* by having a clasper with no long subapical spines.

Described from one male collected by J. C. Bradley at Felton, St. Cruz Mts., Cal., May 15-19, at an elevation of 300-500 feet. Type No. 232.

28. *Neosciara subtrivialis* n. sp.

Male: Length, 1.5 mm. Head somewhat shining, black; antennæ fuscous, a little over half the length of the body; palpi fulvous. Thorax somewhat shiny, fuscous. Abdomen fuscous. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 28) at least twice as long as wide, with about 3 stout apical spines, no subapical spines, and several minute subapical setæ along the inner margin. Legs: coxæ and femora dull fulvous, trochanters black, tibiæ and tarsi fuscous. Wings (Fig. 59) hyaline, media and cubitus without setæ; base of R_s distad of the mid-point between humerus and the tip of R_1 ; R_1 ends far proximad of the forking of M; petiole of cubitus about half as long as the basal section of M; costa extends about two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing and slightly proximad of the tip of M_2 . Halteres; knobs fuscous, pedicels luteous.

This species is near *trivialis* in the key, differing from the latter by having 3 stout apical spines on the clasper and a shorter cubitus petiole.

Described from 2 males, collected at Berkeley, Cal., Oct. 31, 1906, by J. C. Bradley. Type No. 233. One holotype and one paratype.

29. *Neosciara sexdentata* n. sp.

Male: Length, 2 mm. Head black, not shining; antennæ fuscous, half the length of the body; palpi luteous. Thorax not shiny, almost black. Abdomen dark fuscous. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 29) about twice as long as wide at widest part, about 6 apical stout spines and no subapical spines, several minute subapical setæ. Legs: coxæ fulvous; femora, tibiæ and tarsi fuscous; trochanters black. Wings (Fig. 60) hyaline; cubitus and media with no setæ; base of R_s distad of the mid-point between the humerus and the tip of R_1 ; R_1 proximad of the forking of M; petiole of cubitus almost as long as the basal section of media; costa extends about half the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing, and slightly proximad of the tip of M_2 . Halteres; knobs fuscous, pedicels luteous.

This species is near *impatiens* in the key, and differs from the latter by having no spine separated from the rest on the clasper, and a more retracted costa.

Described from one male collected at Santa Paula, Cal. Type No. 234.

30. *Neosciara perfecta* n. sp.

Male: Length, 1.8 mm. Head black, somewhat shiny; antennæ fuscous, about half the length of the body, segments of flagellum not twice as long as wide except at tip; palpi fulvous. Thorax somewhat shining, fuscous. Abdomen fuscous. Hypopygium fuscous, with no cluster of setæ on the mid-ventral line at the base; clasper (Fig. 30) with numerous comparatively short setæ at the apex, and with no stout spines. Legs fulvous, tibiæ and tarsi fuscous. Wings (Fig. 61) hyaline; cubitus and media without setæ; base of R_s distad of the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends proximad of the forking of M ; petiole of cubitus a little less than half the length of the basal section of M ; costa extends about two-thirds the distance between the tips of R_s and M_1 ; R_s ends distad of .85 the length of the wing, and proximad of the tip of M_2 . Halteres luteous.

This species is near *coprophila* in the key, but differs from the latter especially by having a shorter cubitus petiole, yellow halteres, and shorter apical setæ on the clasper.

Described from one male specimen collected in Maryland, April 12, 1914. Type No. 235.

NEW SPECIES OF SCIARIDS FROM SOUTH AMERICA.

By F. W. PETTEY, Cornell University, Ithaca, N. Y.

Sciara paradoxa n. sp.

Male: Length, 2.8 mm. Head black; antennæ and palpi black. Thorax black, somewhat shining, with whitish powdery covering. Abdomen black. Hypopygium black, with no cluster of setæ on the mid-ventral line at base; clasper (Fig. 65) at least twice as long as wide, with one large and about 4 smaller but stout apical spines, and one larger subapical spine. Legs: coxæ black, femora and tibiæ dark fuscous; tarsi black. Wings (Fig. 64) smoky brown, with cubitus and media setose and second anal vein indicated by a row of setæ; base of R_s at about the mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends opposite or slightly distad of the forking of M ; petiole of cubitus one-third of its length longer than the basal section of M ; costa extends about one-third the distance between R_s and M_1 ; R_s ends considerably distad of .85 the length of the wing, and slightly proximad of the tip of M_2 . Halteres black.

This species possesses a structural character unknown to the writer in any other species of *Sciara*, *i. e.*, a row of setæ forming apparently a second anal vein.

Described from 3 males collected at Valle de Papas, Coqueta, Columbia, South America, March, 1912. Type No. 237. Two paratypes. Cornell University collection.

***Neosciara columbia* n. sp.**

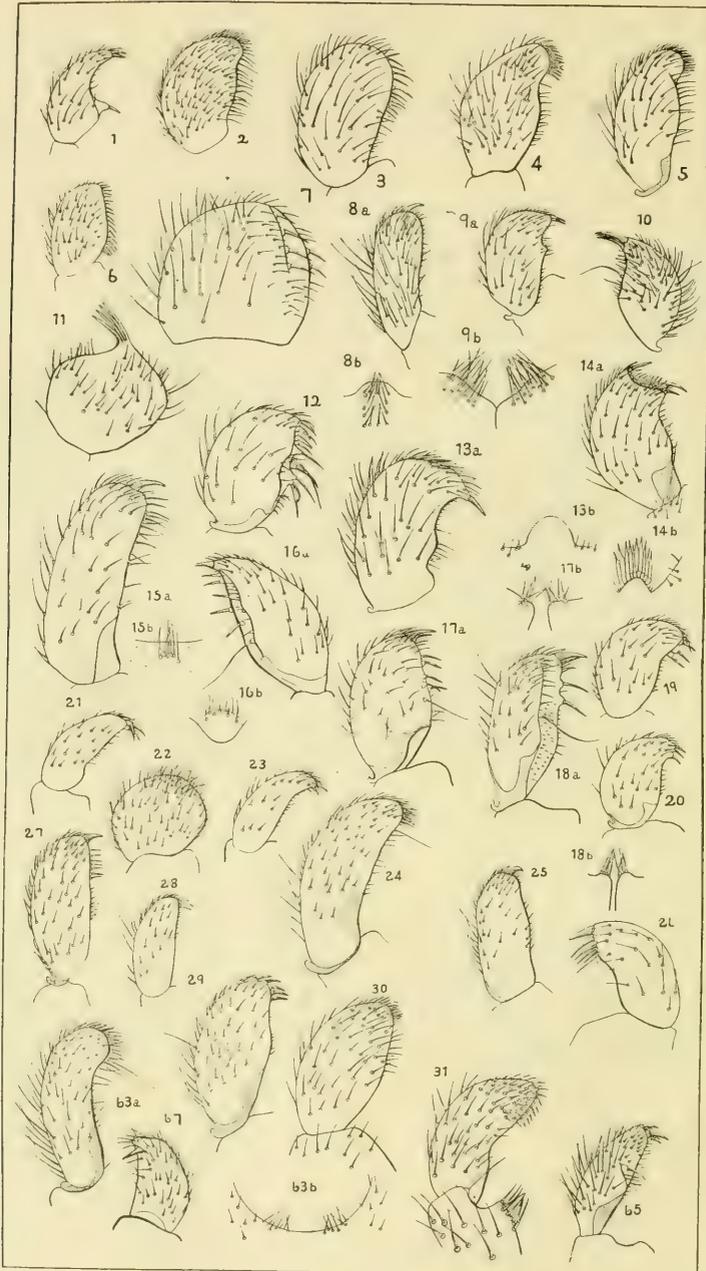
Male: Length, 1.2 mm. Head black, dull; antennæ fuscous, over half the length of the body, segments of flagellum twice as long as wide; palpi fuscous. Thorax dull, fuscous. Abdomen fuscous to black. Hypopygium fuscous, with 2 clusters of setæ no larger than the surrounding setæ, one cluster on each side of the mid-ventral line at the base (Fig. 63b); clasper (Fig. 63a) over twice as long as wide, with no stout spines, and with about 2 subapical long setæ on the inner margin. Legs fuscous; tibiæ and tarsi darker than coxæ and femora. Wings (Fig. 66) smoky brown; cubitus and media with no setæ; base of R_s distad of mid-point between the humeral cross vein and the tip of R_1 ; R_1 ends proximad of the forking of M ; petiole of cubitus as long as the basal section of M ; costa extends at least two-thirds the distance between R_s and M_1 ; R_s ends proximad of .85 the length of the wing and far proximad of the tip of M_2 . Halteres; knobs fuscous, pedicels fulvous.

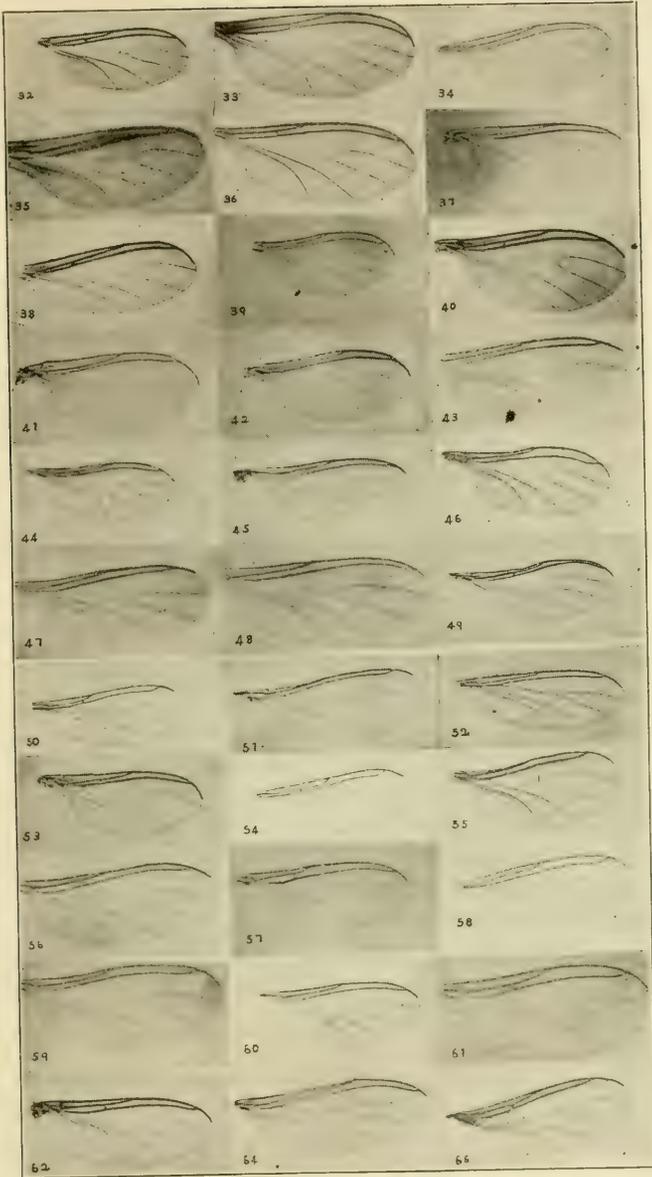
Described from 4 males collected at La Sierra, Columbia, South America, March 1, 1912. Type No. 238. Three paratypes. Cornell University collection.

EXPLANATION OF PLATES XXX AND XXXI.

Figures 1 to 31, inclusive, and Figures 63, 65 and 67 are from camera lucida drawings, much enlarged, each figure representing a clasper of the genitalia of a male. Figures 32 to 62 inclusive and Figures 64 and 66 are photomicrographs of the right wing of each species of male.

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| Fig. 1. | <i>Sciara forceps</i> n. sp. | Fig. 33. | <i>Sciara multisetifera</i> n. sp. |
| Fig. 2. | <i>Sciara multisetifera</i> n. sp. | Fig. 34. | <i>Sciara cylindrica</i> n. sp. |
| Fig. 3. | <i>Sciara cylindrica</i> n. sp. | Fig. 35. | <i>Sciara congregata</i> n. sp. |
| Fig. 4. | <i>Sciara congregata</i> Joh. | Fig. 36. | <i>Sciara psittacus</i> n. sp. |
| Fig. 5. | <i>Sciara psittacus</i> n. sp. | Fig. 37. | <i>Sciara habilis</i> var. |
| Fig. 6. | <i>Sciara habilis</i> var. | Fig. 38. | <i>Sciara globosa</i> n. sp. |
| Fig. 7. | <i>Sciara globosa</i> n. sp. | Fig. 39. | <i>Neosciara falcata</i> n. sp. |
| Fig. 8. | <i>Neosciara falcata</i> n. sp. | Fig. 40. | <i>Neosciara fochi</i> n. sp. |
| Fig. 9. | <i>Neosciara fochi</i> n. sp. | Fig. 41. | <i>Neosciara joffrei</i> n. sp. |
| Fig. 10. | <i>Neosciara joffrei</i> n. sp. | Fig. 42. | <i>Neosciara quadrispinosa</i> n. sp. |
| Fig. 11. | <i>Neosciara quadrispinosa</i> n. sp. | Fig. 43. | <i>Neosciara luteola</i> n. sp. |
| Fig. 12. | <i>Neosciara luteola</i> n. sp. | Fig. 44. | <i>Neosciara lobosa</i> n. sp. |
| Fig. 13. | a, b, <i>Neosciara lobosa</i> n. sp. | Fig. 45. | <i>Neosciara petaini</i> n. sp. |
| Fig. 14. | a, b, <i>Neosciara petaini</i> n. sp. | Fig. 46. | <i>Neosciara grandis</i> n. sp. |
| Fig. 15. | a, b, <i>Neosciara grandis</i> n. sp. | Fig. 47. | <i>Neosciara trifolii</i> n. sp. |
| Fig. 16. | a, b, <i>Neosciara trifolii</i> n. sp. | Fig. 48. | <i>Neosciara polychaeta</i> n. sp. |
| Fig. 17. | a, b, <i>Neosciara polychaeta</i> n. sp. | Fig. 49. | <i>Neosciara conglomerata</i> n. sp. |
| Fig. 18. | a, b, <i>Neosciara conglomerata</i>
n. sp. | Fig. 50. | <i>Neosciara ovata</i> n. sp. |
| Fig. 19. | <i>Neosciara ovata</i> n. sp. | Fig. 51. | <i>Neosciara trifurca</i> n. sp. |
| Fig. 20. | <i>Neosciara trifurca</i> n. sp. | Fig. 52. | <i>Neosciara pilata</i> n. sp. |
| Fig. 21. | <i>Neosciara pilata</i> n. sp. | Fig. 53. | <i>Neosciara ericia</i> n. sp. |
| Fig. 22. | <i>Neosciara ericia</i> n. sp. | Fig. 54. | <i>Neosciara penna</i> n. sp. |
| Fig. 23. | <i>Neosciara penna</i> n. sp. | Fig. 55. | <i>Neosciara pollicis</i> n. sp. |
| Fig. 24. | <i>Neosciara pollicis</i> n. sp. | Fig. 56. | <i>Neosciara hamata</i> n. sp. |
| Fig. 25. | <i>Neosciara hamata</i> n. sp. | Fig. 57. | <i>Neosciara feli</i> n. sp. |
| Fig. 26. | <i>Neosciara feli</i> n. sp. | Fig. 58. | <i>Neosciara macroptera</i> n. sp. |
| Fig. 27. | <i>Neosciara macroptera</i> n. sp. | Fig. 59. | <i>Neosciara subtrivialis</i> n. sp. |
| Fig. 28. | <i>Neosciara subtrivialis</i> n. sp. | Fig. 60. | <i>Neosciara sexdentata</i> n. sp. |
| Fig. 29. | <i>Neosciara sexdentata</i> n. sp. | Fig. 61. | <i>Neosciara perfecta</i> n. sp. |
| Fig. 30. | <i>Neosciara perfecta</i> n. sp. | Fig. 62. | <i>Neosciara caldaria</i> var. |
| Fig. 31. | <i>Neosciara caldaria</i> var. | Fig. 63. | a, b, and Fig. 66, <i>Neosciara</i>
<i>columbia</i> n. sp. |
| Fig. 32. | <i>Sciara forceps</i> n. sp. | Fig. 64, 65. | <i>Sciara paradoxa</i> n. sp. |





THE THORACIC SCLERITES OF THE GRASSHOPPER *DISSOSTEIRA CAROLINA**

By G. C. CRAMPTON, Ph. D.

There is perhaps no insect which is studied more frequently than the grasshopper, since the drawing of its structural details has served as an introduction to entomology for "generations" of students; yet the parts of its thorax have been surprisingly misinterpreted in practically all text-books and other publications in which it has been described.

Since the incorrect figures and descriptions of the grasshopper's anatomy have been so widely copied in various text-books, (the figures by Packard, 1898, having received the widest acceptance) and other publications, it has seemed advisable to make a further study of the structural details of this insect, with a view to determining what interpretation of the parts is the correct one. For this purpose, the thoracic structures of *Dissosteira carolina*, L., have been selected to illustrate the points to be considered in the following discussion, since this insect is as little modified as any of our common grasshoppers, and is among the largest (and hence the most easily examined) of the forms whose wide distribution makes them available to everyone for study.

In order to avoid the distortion due to the shrinking of dried material, only such specimens as have been preserved in alcohol, or similar preserving fluids, have been used, and in examining them, it has proved more satisfactory to keep the specimens immersed in a liquid medium (alcohol or water) and to illuminate the field of the binocular (which is the most satisfactory microscope for dissection work) by means of a nitrogen-bulb lamp provided with a condenser.

PROTHORAX.

The prothorax is the only thoracic segment which has remained freely mobile, the meso- and metathorax being rather closely united, although the line of demarcation between them

* This paper is one of a series of contributions from the Entomological Laboratory of the Massachusetts Agricultural College, dealing with the anatomy of the grasshopper *Dissosteira carolina* L.

is clearly evident. The grasshopper group thus differs from the crickets and katydids, in which the union of the mesothorax and metathorax is much less close, especially in the sternal region.

The Neck Region.

In front of the prothorax, of which it is a part, is a membranous neck region (Plate XXXII, Fig. 1, "vc"), called the *eucervix* or *veracervix*, by means of which the head is attached to the prothorax; and the membranous character of its integument permits a greater freedom of movement to the head. Since this membranous region might offer a more vulnerable point of attack than the more heavily chitinized segments, it is protected by the forward-projecting, anterior margin of the pronotum, into which the head fits, as in a collar.

Embedded in the more membranous walls of the neck region are several small plates called *jugular sclerites*, *cervical sclerites*, or *cervicalia*, which serve to strengthen the walls of the neck and to furnish points of articulation for the head. Some of them were also formed as points of attachment for certain muscles, since they offer a firmer support for muscle attachment than the more yielding membranous walls of the neck region. These sclerites are homologous with the intersegmental sclerites occurring between the different thoracic segments in certain lower insects, and therefore are not to be interpreted as representing the labial segment, or the remains of a rudimentary segment between the head and prothorax (see Crampton, 1917). In the grasshoppers only the *lateral* and *ventral cervical* sclerites are preserved. The anteriormost lateral cervical sclerite (Figs. 2 and 1, "lc") supports the head. The ventral one, Fig. 2, "ps" is homologous with the so-called *presternum* of lower insects.

The Pronotum.

The *pronotum* is a large saddle-shaped or "sunbonnet-shaped" structure which extends over the greater portion of the dorsal and lateral regions of the prothorax, and projects backward over the anterior portion of the segment behind it. The projecting posterior region of the pronotum is called the "*hind process of the pronotum*" by systematists (Text figure 2, "x"). The two postero-lateral margins of the pronotum form an angle

(in which the letters "x" are contained in Text figure 2). Whether the angle containing the two letters "x" (Text figure 2) is a right angle, or an acute angle, is a feature used in classification. If the sides of the posterior region of the pronotum instead of making an angle, extend approximately straight across, the pronotum is spoken of as *truncate posteriorly*. Similarly, if the anterior margin is approximately straight, it is spoken of as *truncate anteriorly*. Whether the surface of the pronotum is *smooth*, *granulated* (powdery appearing), *wrinkled*, *rugose* or roughened with numerous tubercles, are other features of value in classification.

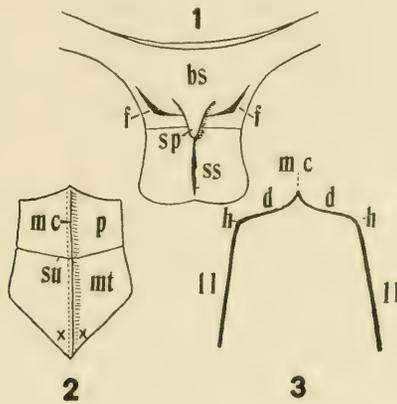


Fig. 1. Ventral view of prosternum of *Rhomalea*.

Fig. 2. Dorsal view of upper portion of pronotum of *Dissosteira*.

Fig. 3. Vertical transverse section through wall of pronotum of *Dissosteira*.

In the grasshopper *Dissosteira*, the pronotum is divided by a *notch* "n" (Fig. 1) and an impressed line "su" extending downward from it, into a *front* and *hind lobe*. The dorsal ridge "mc" (Fig. 1 and Text Figs. 1 and 2) extending longitudinally along the median line of the pronotum is called the *median carina*, and in *Dissosteira* it is broken by a single notch "n" (Fig. 1), while in other grasshoppers there may be two such notches. The median carina "mc" of Fig. 1 is high and arched on the hind lobe of the pronotum of *Dissosteira*, but in other grasshoppers it may be nearly obsolete on the hind lobe. This, and other features, such as whether the median carina is irregular (as in *Dissosteria*) or whether it is even in contour, are features used in classification.

A downward-bending of the pronotum along the shoulder-like ridge labeled "h" in Fig. 1 and Text Fig. 3 divides the pronotum into an upper surface or *disc* (*i. e.*, the region bearing the labels "p" and "mt" in Fig. 1, or that designated as "d" in Text Fig. 3) and two *lateral lobes*, one on either side of the body, labeled "ll" in Fig. 1 and Text Fig. 3. The shoulder-like ridge "h" of Fig. 1 and Text Fig. 3, demarking the disk of the pronotum from the lateral lobe "ll," is called the *lateral carina*, or better, the *humeral carina*, (since the term lateral carina is also applied to certain ridges of the head region). A lack of ability in shading, has made it difficult to show that the regions labeled "p" and "mt" in Fig. 1, represent a dorsal disc, while the sides, labeled, "ll" are bent downward at an angle with it, and thereby produce the shoulder-like ridge "h." Text Fig. 3, however, represents a vertical cross-section of the pronotum, in which each half of the disc labeled "d," corresponds to the regions designated as "p" and "mt" in Fig. 1. The other labelings are the same in both Text Fig. 3 and Fig. 1, so that by comparing the vertical cross section of the pronotum shown in Text Fig. 3, with the view of the pronotum shown in Fig. 1, the same parts may be readily identified in each.

As was mentioned above, the two lateral or humeral carinae (Text Fig. 3, "h," and Fig. 1, "h") divide the pronotum into an upper disc and two lateral lobes. The notch "n" and the impressed line "su" extending downward from it (Fig. 1) divide the disc of the pronotum into an anterior region called the "*prozona*" and a posterior one called the "*metazona*" (Fig. 1, "p" and "mt"). It would be preferable to refer to these as the *prezona* and *postzona*, however, since the prefix "meta" is reserved for structures belonging to the meta-thorax alone. The fore and hind margins of the disc of the pronotum may be *truncate*, *rounded*, *angled*, *notched*, etc., and its surface may be smooth, wrinkled, etc., these features being used in classification.

Three approximately vertical sutures or impressed lines called *sulci* (Fig. 1, "su") divide the pronotum into *intralobes* or areas which, beginning with the anteriormost, have been incorrectly designated as the "prescutum," "scutum," "scutellum" and "postscutellum," although they are purely secondary structures having no connection with the four typical subdivisions of the notal region of the wing-bearing segments; and in some grasshoppers there are more than four of these "intralobes."

The Propleuron.

Contrary to the statement that the pronotum has "crowded out" the pleural region of the prothorax (Snodgrass, 1909, pp. 534, 555 and 556), the lateral portions of the pronotum "11" of Fig. 1 have merely grown down *over* the pleural region which lies beneath the overlapping pronotum, the surfaces of the two regions being closely applied to each other. If one of the larger grasshoppers such as *Rhomalea* be boiled in caustic potash to soften the sclerites, it will be found very easy to separate the pleural sclerites from the overlapping pronotum by inserting a knife blade between the two, and gently forcing them apart. It will then be seen that the *episternum* and *epimerum* (Fig. 2, "es₁" and "em₁") are the principal sclerites of the pleural region, as in the other segments, and that both extend far upward under the overlying pronotum. The lower portion of the episternum and epimerum project below the lower margin of the pronotum in *Dissosteira* (Fig. 2, "es₁" and "em₁"), and if a specimen be boiled in caustic potash, the pleuron can be separated from the overlying pronotum, in this insect also, but this is much more easily accomplished in the larger forms such as *Rhomalea*. The middle one of the three sulci labeled "su" in Fig. 1, is superimposed upon the pleural suture (separating the episternal from the epimeral region) of the prothoracic pleural region which is overlapped by the sides of the pronotum, and, since the surfaces of the pleural region and the pronotum are so closely applied together, it is possible that the presence of the pleural suture is responsible for the formation of the middle sulcus "su" which is directly over it and coincides with it exactly. The posterior sulcus "su" is closely associated with the margin of the inflexed portion of the posterior region of the pronotum which is folded in under the remainder of the pronotum, and the surface of the fold is closely applied to the surface of the pronotum. It is possible that the attachment of this margin on the inner surface of the pronotum has given rise to the posterior sulcus "su," and it is thus clearly evident that the sulci "su" of Fig. 1 owe their origin to mechanical causes, rather than to the assumed fact of their representing the four tergal subdivisions of the notum of a wing-bearing segment. Since the pleural region is present, although closely applied to the inner surface of the pronotum

which overlaps it, it thus is incorrect to state that the pronotum has crowded out the propleural region and has assumed its functions.

At the base of the leg is a small articular plate "tn" of Figs. 1 and 2. This represents a portion of the *trochantin*, which is much reduced in the Orthoptera.

The Leg.

Only the basal segments of the leg are shown in the accompanying figures, the femur being shortened in each case. As shown in Fig. 2, the prothoracic *coxa*, "cx₁," is divided into several subdivisions, but these have no especial significance. One of these subdivisions bears a *coxal spine* "cs." The coxa is broader than long. The *trochanter* "tr", is small and is quite closely united with the femur.

The Prosternum.

The pleural region of the thorax is connected with the prosternal region by a *pre-coxal bridge* extending in front of the sclerite "tn" (Fig. 2). This pre-coxal bridge is largely made up of a lateral wing of the sternal region, although a small portion of the pleural region is also involved in its make-up.

The anteriormost sclerite of the prosternal region is the small plate "ps" (Fig. 2), which is homologous with the so-called *presternum* of lower insects. Immediately back of the presternum "ps" is a narrow anterior marginal region "pr₁," homologous with a similar anterior marginal region "pr₂" in the mesosternal region. The term *prepectus* has been very appropriately applied to this region in the Hymenoptera by Snodgrass, 1910, although Snodgrass does not think that the sclerite of the Hymenoptera is homologous with this sclerite in the Orthoptera. Just behind the region "pr" is the *basisternum* "bs₁," whose lateral wings form the precoxal bridges connecting it with the pleural region on either side. In some grasshoppers, this region (the basisternum) bears a prominent spine, the *prosternal spine* (Text Fig. 1, "sp") projecting backward between the front coxæ. The presence or absence of this spine is a feature used in classification. Behind the region "bs₁" (Fig. 2) is an area largely composed of the *spinasternum*, or fourth chief sternal subdivision which has united with the third to form a region sometimes called the *sternellum*. In this

region are situated the two *furcal pits* "f," and the median *spinal pit* "ss₁." The furcal pits "f" are the outward indications of a pair of invaginations or hollow "in-pushings" of the integument serving as structures for muscle attachment. These paired invaginations are called *apophyses*, and when their basal portions unite, while their distal portions remain free to form the two arms of a "Y," the structure is called the *furca* or forked internal structure for muscle attachment. The spinal pit "ss" is the outward manifestation of an internal unpaired median process called the *spina*, which also serves as a point for muscle attachment.

MESOTHORAX.

Despite the fact that the fore wings are reduced to form the so-called *tegmina* which are not as important as the hind wings for flight, and despite the greater development of the hind legs for leaping, and the consequent greater development of the muscles of the metathorax, the mesothorax is subequal to the metathorax in size, being but slightly smaller than the latter.

The Mesonotum.

In the anterior region of the mesonotum is a narrow marginal region "pt₂" (Fig. 3) known as the *pretergite*. In some insects it bears an internal transverse fold called the *phragma*, to which are attached certain dorsal longitudinal muscles serving to arch the notal region in the movements of flight. Immediately behind the region "pt" is an area "psc₂" corresponding to the *prescutum* of other insects, but the prescutum is not demarked from the remainder of the tergal plate in the grasshopper under consideration. The greater portion of the tergal plate is composed of the *scutum* "sc₂," although its limits are not clearly defined in the notum of *Dissosteira*. The region labeled "sl₂" is the *scutellum*, and the area on either side of it is known as the *parascutellum* or *juxtascutellum*, "js₂." The posterior marginal area "po" is the *postergite*, which is a fold-like region projecting backward over the front portion of the segment behind it for a considerable distance in lower insects such as the Mantids, Termites, etc. With the region labeled "js₂," the fold "po" is sometimes incorrectly referred to as the "postscutellum," but the true mesothoracic *postscutellum* is greatly reduced, and projects vertically downward below the

fold which overlaps it, and the postscutellum also bears a *phragma* or internal transverse process for the attachment of the longitudinal muscles arching the notum in the movements of flight.

Along the sides of the *notum*, or tergal region of the segment, are several projections, some of which are involved in the movements of flight. The anterior projection "pa₂" or *prealare*, sometimes forms a complete pre-alar bridge extending in front of the wing from the tergal region to the pleural region, and in some insects it extends down to, or slightly beyond, the pleural plate "ba" of Fig. 3, (*i. e.*, the anterior one of the two plates labeled "ba₂" in Fig. 1). The projecting region "sur₂" (Fig. 3) or *suralare* is frequently demarked by a complete suture, and it serves as an anterior pivot for the wing, in the movements of flight. Certain of the other projections also serve as pivots for the wing in the movements of flight, but are of no great morphological importance.

The Wing-Ossicles.

At the bases of the wing veins are several small articulatory plates called *alar ossicles*, which assist in the articulation of the wings to the tergal region. There are also some small plates below the wing near its attachment to the body, and these are also included under the designation *alar* or *wing ossicles*. The alar ossicles by means of which the wing articulates with the tergal region or notum, are called *pteralia*.

A small plate called the *tegula* "tg" (Fig. 3) occurs near the anterior margin of the wing, at its base, and might be included with the alar ossicles. The principal alar ossicle, however, is the *notopterale* "np₂," which seems to be a detached portion of the tergal region which doubtless originally projected from its lateral margin somewhat after the fashion of the sclerite "sur." In its typical form, this ossicle bears an anterior neck-like narrow region articulating with the base of the vein called the subcosta in Comstock's terminology. Beside the ossicle "np" is a more or less distinct ossicle "m," which is formed at the bases of certain of the wing veins. The radius, media and cubitus of Comstock's terminology may extend to it, although a chitinized area may intervene between it and the bases of certain of these veins. The sclerite "m" has been termed the *medipterale*, or the middle one of the pteralia. The ossicle "b"

or *basanale* is situated at the base of the anal veins, and articulates with a posterior process of the notum which may become detached to form an intermediate plate "a" called the *adanal ossicle*.

The Mesopleuron.

Beneath the wing, at its base, are several alar ossicles which are apparently of a pleural origin, or were formed in the region largely belonging to the pleuron. These have been called the *alaria*, in contradistinction to the pteralia which are tergal ossicles. The two anteriormost of these ossicles "ba₂," called the *basalar ossicles*, are situated at the base of the wing, immediately in front of the dorsal neck-like prolongation of the pleural region serving as a ventral pivot for the wing in the movements of flight. Immediately above this pivot, is the *intralare* "ia₂," and just behind it is the *subalar* ossicle "sa₂."

The greater part of the mesopleural region is composed of the *epimerum* "em₂" and the *episternum* "es₂," which are separated by the *pleural suture* extending in an approximately vertical line from the wing base to the coxal region. Extending along the anterior margin of the region "es₂" is a narrow sclerite "pr₂" called the *prepectus*, and in the upper portion of the episternal region "es₂" a small area labeled "ae" is marked off by a faint suture. Ventral to the episternum and epimerum a *pericoxal* sclerite "pc" extends around the base of the coxa, and encloses the small sclerite "tn," which is all that remains of the much reduced *trochantin*.

In the membranous "intersegmental region" between the prothorax and mesothorax is the first thoracic spiracle "s." This spiracle has been attributed to the prothorax, but from the standpoint of embryology, it is mesothoracic, since it has its embryonic origin in the anterior region of the mesothorax and later migrates into the "intersegmental" region (which is also largely mesothoracic).

The Leg.

As in most Orthoptera, the bases of the legs are widely separated. The pericoxal sclerite "pc₂" encircling the base of the coxa (Figs. 1 and 2) seems to be peculiar to the grasshopper group, since I have been unable to find it in any of the crickets, mole-crickets, or katydids which I have examined. The pleural

suture between the epimerum "em₂" and episternum "es₂" (Fig. 1) is continued downward into the coxal region "cx₂" as the *coxal suture* which divides the coxa into an anterior region (*veracoxa*) and a posterior region (*meron*) in higher insects. The mesothoracic coxæ are broader than long, and tend to assume a ring-like outline.

The Mesosternum.

The mesosternum is connected with the pleural region by a *pre-coxal bridge* "ls₂" (Figs. 1 and 2) extending in front of the coxa on either side of the sternum. In the crickets and katydids, this region ("ls") forms a distinct plate, the *laterosternite*, but in the grasshoppers, it is fused with the episternal region, although a faint line marks it off from the sternal region ventrally. This region originates as a lateral wing of the sternal region, although its true nature is sometimes masked by its secondary union with the pleural region.

A ventral extension of the *prepectus* "pr₂" (Fig. 1) is continued around into the sternal region (Fig. 2, "pr₂") and up the surface of the other flank, thus making an anterior marginal sclerite bordering the pleural and sternal regions. The large sternal sclerite immediately behind it is the *basissternite* "bs₂," and posterior to this is the narrow transverse region containing the *furcal* and *spinal pits* ("f₂" and "ss₂") which mark the location of the internal *furca* and *spina*, or processes for muscle attachment. This region corresponds to the united third and fourth principal sternal subdivisions (the *furca-* and *spinaster-nite*) to which the designation "*sternellum*" is sometimes applied in the prothoracic region.

In the posterior region of the mesosternum, a suture extending backward in a broad sweep from each of the furcal pits "f₂" marks off a lobe "l₂" and "l₂" on either side of the sternal region. These two lobes are referred to as the *mesosternal lobes* by systematists, while the similar lobes "l₃" and "l₃" marked off in the metasternal region are termed the *metasternal lobes*, and the relative width between these mesosternal lobes (measured transversely between the points labeled "x" and "x" in the mesothorax) as compared with the distance between the metasternal lobes (measured transversely between the points labeled "x" and "x" in the metathorax) is a feature used in classification. Thus in the grasshopper shown in Fig. 2, the mesosternal

lobes are only "slightly more distant than the metasternal lobes"; in other words, the distance from "x" to "x" in the mesosternum is subequal to that from "x" to "x" in the metasternum. In the males, however, the mesosternal lobes may be nearly twice as distant as the metasternal lobes, so that this feature holds good only for females.

METATHORAX.

In the crickets, mole-crickets and most katydids, the metathorax is markedly larger than the mesothorax, especially in the tergal region (as is also true of a few other insects, such as the earwigs, beetles, Strepsiptera, etc.) and one would naturally expect the same to be true of the grasshopper group also, since the hind wings and hind legs are much larger than the others and consequently require larger muscles for operating them. The meso- and metathorax are subequal in size, however, in *Dissosteira*, and the two wing-bearing segments are more or less closely united to furnish a firmer support for the wing muscles, since the grasshoppers are better fliers than the crickets and katydids.

The Metanotum.

An anterior region "psc₃" which corresponds to the *prescutum* is indistinctly marked off in the tergal region of the metathorax (Fig. 3), and behind it is the scutum "sc₃" which is of a somewhat indefinite extent. The *parascutellar* regions "js₃" of the metanotum are not strictly homologous with the regions labeled "js₂" in the mesonotum, since they extend over a greater area in the metanotum; but it is inadvisable to attempt to distinguish between the two in the different segments, since they are practically the same in position, etc., in both meso- and metathorax. The metathoracic *scutellum* "sl₃" is not very different from the mesothoracic scutellum "sl₂"; but the *postergite* "po₃" or region behind the scutellum is of greater extent in the metathorax than in the mesothorax ("po"). The mesothoracic postscutellum is greatly reduced, and is overlapped by the region "po," but in the metathorax, the *postscutellum* "psl₃" is large and well-developed, although it is more or less closely united with the first abdominal tergum. Along its posterior margin, it bears an internal transverse ridge or *phragma*, to which certain longitudinal dorsal muscles are

attached (and which serve to arch the tergal region in the movements of flight). The *prealar region* "pa₃" of the metanotum is essentially like that of the mesonotum "pa₂," but the *suralar process* "sur₃" of the metathorax is slightly different from that of the mesothorax "sur₂."

The Wing-Ossicles.

The *tegula* "tg₃" (Fig. 3) is present in the metathorax as well as in the mesothorax of the grasshopper, unlike many other forms in which it is retained in the mesothorax alone. The *median ossicle* "m₃" of the metanotum is not very different from its homolog in the mesonotum; but the *notopterale* "np₃" has lost its slender neck-like prolongation present in the homologous plate "np₂" of the mesonotum; although the small plate just in front of the projection "sur₃" of the metanotum, doubtless represents the remains of this anterior neck-like prolongation of the notopterale. The *basanal region* "b₃" at the base of the anal veins is much larger in the metathorax than in the mesothorax, but the plate "a" of the metanotum is smaller than its homolog in the mesonotum.

The Metapleuron.

The ossicles "ba₃," "ia₃" and "sa" (Fig. 1) of the metathoracic region are essentially like those of the mesothorax. The postscutellum "psl₃" extends downward behind the wing, making a postalar bridge connecting the tergal region with the *epimerum* "em₃," whose shape is somewhat different from that of the mesothoracic epimerum "em₂." The metathoracic *episternum* "es₃" is demarked from the region "ls₃" by a faint line which is absent in the mesothorax, while on the other hand, the faint line demarking the region "ae" which is present in the mesothoracic episternum is lacking in the metathoracic episternal region. The region "ls₃" is largely composed of the *laterosternite*, or lateral wing of the sternal region. Behind it, a narrow *antecoxal region* "ac₃" is marked off in front of the metathoracic coxa "cx₃," and appears to be homologous with a portion of the pericoxal ring "pc₂" extending around the mesothoracic coxa. The metathoracic trochantin is reduced to the small plate "tn" at the base of the coxa. The metathoracic spiracle "s" is actually situated in the intersegmental region, but appears to be located in the posterior portion of the mesothoracic pleuron.

*The Leg.**

The metathoracic coxa "cx₃" is much larger than the coxæ of the other segments due to the greater development of the hind legs for leaping, and tends to become longer than the other coxæ. The trochanter "tr₃" (Fig. 2) is greatly reduced, and is more readily seen from the ventral (or mesal) surface. The femur is greatly thickened for leaping, and is provided with prominent longitudinal ridges on its inner surface.

The Metasternum.

The principal region of the metasternum is the *basisternum* "bs₃" (Fig. 2) which interlocks with the mesosternum in front of it, the narrow anterior region of the metasternum being "dovetailed" between the mesosternal lobes "l₂" and "l₂." The lateral wings of the basisternum largely make up the sclerite "ls₃" forming a pre-coxal bridge on either side of the body, connecting the sternal with the pleural regions. The *antecoxal region* "ac₃" is largely sternal in origin, and, with the sternal sclerite "st," it forms an incomplete ring extending around the base of the coxa anteriorly, so that these two sclerites may represent a portion of the ring "pc" which completely encircles the base of the mesothoracic coxa. The *furcal pits* "f₃" are retained in the metasternum, but the spinal pit "ss₂" of the mesosternal region has disappeared in the metasternum. The *metasternal lobes* "l₃" and "l₃" are somewhat smaller than the mesosternal lobes. In certain grasshoppers the transverse distance between the two points "x" and "x" of the metasternum is only half the distance between the points "x" and "x" of the mesothorax (*i. e.*, the mesosternal lobes are "twice as distant" as the metasternal lobes)—a feature frequently used in classification. The greater part of the region between the metasternal lobes "l₃" and "l₃" is thought to be an anterior "neck" of the first abdominal sternum which has become wedged in between the metasternal lobes, although it is rather difficult to understand how such a dovetailing process

* Since the coxa of the metathorax is called the metacoxa, the tibia of this segment is called the metatibia, etc., the tarsus of the metathorax should be designated as the metatarsus; but since the designation metatarsus is sometimes incorrectly applied to the basal tarsal segment of the prothoracic or mesothoracic regions, it is preferable to designate the basal segment of the tarsus as the praetarsus, or basitarsus, in all cases, if we are to avoid ambiguity.

could be brought about. At any rate, the mesosternum *appears* to be dovetailed into the metasternum and the first abdominal sternum appears to be dovetailed into the metasternum, which is a condition peculiar to the grasshopper group (so far as I am aware). None of the crickets or katydids which I have examined has a mesothoracic ring "pc₂" about the base of the coxa (Figs. 1 and 2), or a metathoracic sclerite like those shown in Fig. 2, "ac₃" and "st," so that these structures, together with the "dovetailed" condition of the sternal regions, may be characteristic of the grasshoppers alone, and serves to further separate them from the crickets and katydids.

OTHER INTERPRETATIONS.

The Tergal Region.

Brooks, 1882, page 247 (also Fig. 130 of "*Acridium*") is apparently responsible for the frequently repeated statement that the pronotum of the grasshopper is divided into four regions homologous with the prescutum, scutum, scutellum, and postscutellum of the other segments of the thorax, and this view has been adopted by Comstock and Kellogg, 1902 (p. 21) and many other writers. The fact that this view cannot be the correct one, however, is demonstrated by the occurrence of five or even six such areas in the pronota of some grasshoppers, as well as by the fact that the four principal tergal subdivisions never occur as transverse bands in the other segments. The line of division between the true scutum and scutellum never lies directly over the pleural suture (as is supposed to be the case in the pronotum), since the true scutellum is usually triangular in outline. Furthermore, the true postscutellum is always formed as a plate distinct from the plate in which the prescutum, scutum, and scutellum are demarked, and, in connection with many other facts such as the nature of the musculature attached to the regions in question, etc., the pronotal subdivisions cannot possibly be interpreted as representing the four typical tergal subdivisions, but evidently owe their origin to mechanical causes as pointed out in the preceding discussion.

Brooks, 1882, (p. 250, and Fig. 133) would interpret the narrow transverse marginal region of the mesonotum ("pt₂" of Fig. 3 of this paper) as the "prescutum," but it is clearly not the entire prescutum, being merely the narrow anterior mar-

ginal region of the prescutum called the pretergite. Brooks (p. 250) apparently interprets the alar ossicle "np₂" as the "patagium" (which is really an erectile lobe on the pronotum of Lepidoptera, having nothing to do with the sclerite "np₂," although Brooks may have had the tegulæ in mind, since the tegulæ are sometimes incorrectly homologized with the sclerite "np₂") and he homologizes the regions "js₂" and "po" (of Fig. 3 of the present paper) with the "postscutellum." (See also Fig. 32 of *Melanoplus* by Lugger, 1898). The true postscutellum of the mesothorax, however, is situated below the region "po" and bears the characteristic longitudinal dorsal muscles attached to the postscutellum of other insects, so that the representative of a mesothoracic postscutellum is present in grasshoppers, despite Snodgrass' statement to the contrary.

Berlese, 1909, has discussed the tergal region of *Acridium*, but, since I have no specimens of the species which he figures, I am not sure that the regions into which he subdivides the tergum correspond to those here given, especially since Berlese doesn't homologize the sclerites correctly in different insects, and as Snodgrass, 1909 (p. 535) very truly remarks "in order to carry out his scheme, Berlese has in many cases drawn purely arbitrary lines across the notum." Furthermore, Berlese employs the prefixes "pro," "meso," and "meta" for subdivisions of one and the same segment instead of limiting the prefix "pro" to prothoracic structure, "meso" to mesothoracic structures, and "meta" to metathoracic structures. Thus "metatergite" to any one else would mean the tergite of the metathorax, but Berlese applies this term to a subdivision of the pronotum, mesonotum or metanotum indiscriminately, as is also true of his terms "mesotergite" and "protergite." As nearly as I can determine, the tergal subdivisions which he describes in *Acridium* correspond to the following tergal sclerites of the grasshopper here discussed.

In his Fig. 1, Plate IV, Berlese applies the term "acrotergite" to the *anteriormost* tergite "pt₂" of the mesothorax of the grasshopper (Fig. 3 of this paper) while he applies this same term to the *posteriormost* tergite "psl₃" (Fig. 3) in the metathorax of the grasshopper. In the mesonotum, he terms only the region "sur₂" the "protergite," and homologizes it with the entire prescutum "psc₃" in the metathorax. The scutum "sc" and scutellum "sl" comprise his "mesotergite" and the region

which he calls the "metatergite" is apparently the sclerite "js" and "po" together. In his Fig. 274 of the metanotum of *Acridium*, Berlese terms the tegula "tg₃" the "acroptero," and designates the ossicles "np₃" and "m₃" together as the "proptero." The sclerite "a" he terms the "mesoptero," and designates the region "b₃" as one of the "capi delle nervature delle interala."

The Pleural Region.

The lateral cervical sclerites "lc" (Figs. 1 and 2) are interpreted as the episternum and epimerum of the labial segment of the head by Comstock and Kochi 1902 in their Fig. 20 of the lateral neck plates of *Melanoplus* (see also Fig. 26 of *Melanoplus* by Hosford, 1913); but, in a paper dealing with the nature of the neck sclerites (Crampton, 1917) it was shown that these plates are merely detached portions of the prothorax, and therefore cannot represent the episternum and epimeron of the labial or any other segment.

In his Fig. 7 of the mesopleuron of *Acridium*, Jordan, 1902, calls the region "ae" of Fig. 1 (of this paper) the "parasternum" (a term previously applied to a different region by Heymons and others); but in other instances, Jordan applies the term "parasternum" to the basalar plates "ba." He terms the sclerite "pr₂" (Fig. 1) the "peristernum" in the pleural region, and designates its median ventral portion "pr₂" of Fig. 2, as the "mesoclidium," although it is not homologous with the sclerites which he designates as the "mesoclidium" in his other figures (e. g., his Figs. 17, 19, etc., in which the "mesoclidium" appears to represent the region "ss" of Fig. 2 of this paper). Comstock and Kellogg, 1902, call the region "pr₂" the "sternellum."

Berlese, 1909, designates the basalar plates "ba" (Fig. 1) as the "due meta dell' acrosterno o prefulcro," while he terms the sclerites "ia" the "endoptero," and "sa" the "paraptero." Snodgrass, 1909, also appears to think that these plates at the base of the wing are the "paraptera," since he calls the anterior ones "ba" the "episternal paraptera" and the posterior one "sa" the "epimeral parapteron," but, as was pointed out in a paper dealing with the application of the terms parapteron, hypopteron, etc. (Crampton, 1914b) the designation parapteron is a synonym of tegula alone, and is so used in practically all textbooks of Entomology.

In his Fig. 89 of the locust *Melanoplus*, which has been copied in many textbooks and other publications, Packard, 1898, restricts the term coxa to the anterior region of the coxa ("cx₂" of Fig. 1 of this paper) and terms its posterior portion the "trochantine," in the pro- and mesothorax of the grasshopper, although the true trochantin "tn" (or what is left of it) is present. In the metathorax of his figure of *Melanoplus* Packard interprets the anterior region of the membranous area above the coxa "cx₃" (Fig. 1) as the "coxa" and the posterior region of this membranous area he designates as the "trochantine." The true metathoracic coxa "cx₃," he calls the trochanter.

The Sternal Region.

Jordan, 1902, in his Fig. 7 of *Acridium* terms the ventral portion of the anterior marginal region "pr₂" (Fig. 2 of this paper) the "mesoclidium" in the mesothorax of the grasshopper, and designates the lateral portion of this marginal region as the "peristernum." The term "sternum" is restricted to the portion of the sternum behind the region "pr₂" by Jordan, who applies the term "sternite" to the ventral and entire lateral region of the segment.

Snodgrass, 1909, in his Fig. 70, of the mesopleuron of *Dissosteira*, terms the region "pr₂" (Figs. 1 and 2 of this paper) the "pre-episternum," but the "pre-episternum" of his Fig. 56 of *Melanoplus*, and Fig. 57 of *Hippiscus* is an entirely different sclerite, namely the region "ls₃" of Fig. 1 (of this paper). Snodgrass, 1910, designates a region which for all practical purposes corresponds to the region "pr₂" (Figs. 1 and 2) as the "prepectus" in the Hymenoptera, but he claims that the "pre-episternum" is not present in the Hymenoptera. This is apparently due to the fact that he has applied the term "pre-episternum" to so many different sclerites in his earlier paper; but since the region which he calls the prepectus in the Hymenoptera is located in the same position as the sclerite which he designates as the "pre-episternum" in the grasshopper *Dissosteira*, and extends into the sternal region in the same way (*i. e.*, sclerite "pr₂" of Fig. 1), it would appear that Snodgrass is mistaken in concluding that the "prepectus" of Hymenoptera is not to all intents and purposes homologous with the sclerite "pr₂" (Figs. 1 and 2) which he terms the "pre-epister-

num" in *Dissosteira*. The term "prepectus" is much preferable to "pre-episternum" however, since "pectus" is the term for the united pleural and sternal regions; and "pre-pectus" is therefore a very appropriate designation for the anterior marginal region of the pleural and sternal regions, so that the designation prepectus has been retained in the present paper rather than the designation "pre-episternum" or the designation "hypopteron" which was originally applied to this region in the Coleoptera by Audouin (see Crampton, 1914b).

Comstock and Kellogg, 1902, (p. 22) have proposed the surprising view that the sclerite "pr₂" of Figs. 1 and 2 (which represents the anterior marginal prepectus of the *mesothorax* is the "sternellum of the *prothorax*," and they would homologize it with the mesothoracic lobes "l₂" and "l₂" of Fig. 2, which they regard as the "widely separated halves of the sternellum of the mesothorax" (p. 24). These in turn, they homologize with the metathoracic sclerites "st" of Fig. 2, which they refer to on page 24 as "the two halves of the sternellum of the metathorax . . . widely separated, each being situated near the base of the leg." If one takes into consideration such "landmarks" as the furcal pits "f" however, it will be seen that it is impossible to homologize the regions "pr₂" or "l₂" with "st" in Fig. 2. Comstock and Kellogg restrict the term "sternum" to the region in front of the lobes.

In his Figs. 197 and 198 of the sternal region of *Acridium*, Berlese 1909 gives some very astonishing interpretation of the sclerites. Thus in the mesothorax, he restricts the term "sterno" (*i. e.*, sternum) to the marginal region "pr₂" (Fig. 2) alone, and designates all the remainder of the mesosternum (*i. e.*, "bs₂" and "l₂" of Fig. 2) as the "sternello" (*i. e.*, sternellum). In the metathorax, however, he calls practically the entire metasternum the "sterno" and designates the first abdominal sternum as the "sternello" of the metathorax. In fact, Berlese's interpretations of many of the sclerites in his figures of the thorax of different insects are so incorrect as to greatly detract from the value of his book as a basis for research, although its monumental size and wide scope have placed it among the most important of the reference works in Entomology.

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EXPLANATION OF PLATE XXXII.

In all Figures the legs have been shortened, and the head has been removed. Only the first abdominal segment shown.

Fig. 1. Lateral view of the neck, thorax and first abdominal segment.

Fig. 2. Ventral view of same.

Fig. 3. Dorsal view of mesonotum, metanotum, and a portion of the first abdominal tergum.

ABBREVIATIONS.

The subscripts 1, 2 or 3, denote that the structure in question belongs to the pro-, meso-, or metathorax respectively. 1 ab denotes the first abdominal segment.

a, Adanale, or adanal ossicle.	mt, Postzona, or "metazona" of pronotum.
ab, Abdominal segment.	n, Notch in median carina.
ac, Antecoxale, or antecoxal piece.	np, Notopterales, or notopteral ossicle.
ae, Anepisternum, or upper region of episternum.	p, Prezona, or "prozona" of pronotum.
b, Basanale, or basanal ossicle.	pa, Prealare, or prealar region.
ba, Basalar sclerite.s	pc, Pericoxale, or pericoxal ring.
bs, Basisternum.	po, Postergite.
cs, Coxal spine.	pr, Prepectus, or hypopteron.
cx, Coxa.	ps, Presternum.
d, Disc of pronotum.	psl, Postscutellum.
em, Epimerum.	pt, Pretergite.
es, Episternum.	s, Spiracle.
f, Furcal pits.	sa, Subalare, or subalar plate.
h, Lateral or humeral carina of pronotum.	sc, Scutum.
ia, Intralare, or intralar ossicle.	sl, Scutellum.
js, Parascutellum, or juxtascutellum.	sp, Prosternal spine.
l ₂ , Mesosternal lobes (lobisternite).	ss, Spinal pit.
l ₃ , Metasternal lobes (lobisternite).	st, Sternocoxale, or sternocoxal sclerite.
lc, Lateral cervicals.	su, Sulci, or pronotal sutures.
ll, Lateral lobes of pronotum.	sur, Suralare, or suralar region.
ls, Laterosternite, or wing of sternal region.	tg, Tegula, or parapteron.
m, Medipterale, or median ossicle.	tn, Trochantin, or trochantinus.
mc, Median carina of pronotum.	tr, Trochanter.
	vc, Neck region, eucervix, or veracervix.

MYRIOPODS FROM OKEFENOKEE SWAMP, GA., AND FROM NATCHITOCHE PARISH, LOUISIANA.

By RALPH V. CHAMBERLIN.

The myriopods noted in the present paper compose a collection made in the Okefenokee Swamp by the Cornell University Expedition of 1912 and 1913 and one made by Mr. Karl P. Schmidt in Louisiana in 1915. The specimens of the second collection were all taken near the town of Creston in Natchitoches Parish. The species secured in the two localities are shown in the two separate lists below. Type specimens are placed in the Museum of Comparative Zoology, Cambridge, Massachusetts.

OKEFENOKEE SWAMP.

<i>Scutigera immaculata</i> (Newport).	<i>Cryptops hyalinus</i> Say.
<i>Cleidogona</i> sp.	<i>Theatops posticus</i> (Say).
<i>Leptodesmus okefenokensis</i> sp. nov.	<i>Hemiscolopendra punctiventris</i> (Newport).
<i>Polydesmus</i> sp.	<i>Helembius nannus</i> gen. et sp. nov.
<i>Spirobolus marginatus</i> (Say).	
<i>Spirobolus paludis</i> sp. nov.	

LOUISIANA.

<i>Callipus lactarius</i> (Say).	<i>Theatops posticus</i> (Say).
<i>Leptodesmus hispidipes</i> (Wood).	<i>Scolopendra viridis</i> Say.
<i>Euryurus erythropygus</i> (Brandt).	<i>Scolopendra heros</i> Girard.
<i>Euryurus louisianus</i> sp. nov.	<i>Hemiscolopendra punctiventris</i> (Newport).
<i>Fontaria lampra</i> sp. nov.	<i>Linotaenia fulva</i> (Sager).
<i>Fontaria clara</i> sp. nov.	<i>Arenophilus bipuncticeps</i> (Wood).
<i>Polydesmus serratus</i> Say.	<i>Arenophilus watsignus</i> Chamberlin.
<i>Nemasoma pium</i> sp. nov.	<i>Geophilus mordax</i> Meinert.
<i>Parajulus robustior</i> sp. nov.	<i>Nannocrix porethus</i> gen. et sp. nov.
<i>Cambala annulata</i> (Say).	<i>Neolithobius mordax</i> (L. Koch).
<i>Spirobolus marginatus</i> (Say).	<i>Neolithobius transmarinus</i> (L. Koch).
<i>Cryptops hyalinus</i> Say.	<i>Neolithobius helius</i> sp. nov.
<i>Otocryptops sexspinosus</i> (Say).	

SYMPHYLA.

Scutigera immaculata (Newport).

One specimen taken on Billy's Id., Okefenokee Swamp, in June, 1912.

DIPLOPODA.

Cleidogona sp.

A number of specimens not yet adult. All are in the stage possessing twenty-three segments and are not at this time determinable as to species with certainty. They were taken on Billy's Id., Okefenokee Swamp, in June, 1912.

Leptodesmus hispidipes (Wood).

Numerous specimens taken near Creston, La., in February, March and May, 1915.

Leptodesmus okefenokensis sp. nov.

This is a smaller species than *hispidipes*, which it in general resembles. There is no trace of a median dorsal dark line, the dorsum being clear testaceous with no distinct markings excepting the carinae which are lighter, yellow, though there is a rather vaguely lighter border caudally on some of the somites.

Somites in general smooth and shining, not at all tuberculate or roughened.

Vertigial sulcus of head deep, extending ventrad to a little above level of antennae, with two setae on each side. Antennae long, the ultimate article and the distal end of the penult blackened.

Each end of first dorsal plate subacute, narrowly rounded. Posterior margin of second and third plates straight, the keels not at all produced caudad. Posterior corners of other plates produced caudad, more strongly so in posterior region. Pores opening laterally or slightly above the thickened border of keels which are slightly incurved at level of pores.

Anal tergite of usual form, distally truncate and a little decurved, with three long setae on each side. Anal scale semicircular in outline. Anal valves mesally margined, the borders being strongly though narrowly elevated.

Ventral plates without processes in male. Plates smooth and most glabrous or nearly so.

In the gonopods of the male the proximal division is rounded. It bears two completely separated branches of which the smaller proximal one meets and crosses the one of opposite gonopod in the middle line. The principal branch of each gonopod is curved caudad and then dorsad, crossing the other one at its tip; distally it is bifurcate, the outer blade being much the more slender and bending first away and then again towards the principal process; the branch as a whole is densely setose on its mesal surface proximad of its middle, being elsewhere glabrous in striking contrast to the conditions in *hispidipes*, from which the bifurcate tip and other structural features also remove it.

Length, cir. 21 mm. Width, 3.7 mm.

Locality.—Okefenokee Swamp: Billy's Id., Dec., 1913. One male.

Euryurus louisiana sp. nov.

In general appearance much like *Euryurus erythropygus* (Brandt) but appearing somewhat more slender and with the red carinae more elevated. The carinae have the tooth at the anterior corner proportionately larger and caudad of this less bulging ectad, the swollen border narrowing cephalad as in *erythropygus*; the caudal margin of the anterior somites is wholly smooth, not so irregularly crenulate or bluntly denticulate as usual in the latter species. The vertigial sulcus of the head ends in a rather deep depression at the level of the upper edges of the antennal sockets.

The gonopods of the male are strikingly different from those of *erythropygus*. The proximal division of each is very short, subcylindrical and glabrous. The distal division about its stouter proximal end extends at an angle ventrocaudad as a stout subcylindrical body which is subtruncate at the free end, which is darker and more highly chitinized; distal end concavely depressed or grooved, with a short, blade-like branch arising from the dorsomesal corner and curving a little dorsad of ectad above the main branch, the outer edge of which it does not reach. The enlarged base of the distal division is concavely depressed on its mesal surface, the depression densely clothed with long bristles. Midway between this basal depression and the distal end is a smaller depression similarly setose. The division is also less densely setose over the remaining surface excepting the chitinous distal end.

Length about 25 mm.

Locality.—La.: Creston. Feb. 27, 1915. One male. Also two broken females taken March 5, 1915.

Euryurus erythropygus (Brandt).

Several specimens taken near Creston, March 5, 1915.

Fontaria lampra sp. nov.

This species seems nearest to *F. bimaculata* (McNeil), described from Pensacola, Fla. The male gonopods are in general similar but the proximal common stalk of the principal, bifurcate spine, is relatively much longer, being as long as or longer than the branches; the shorter or inner branch is much broader, being as broad as the other, is slightly clavately expanded and at tip narrowed to a straight acute process, which does not curve toward the other branch. The process as a whole is bent upon itself almost at right angles at the level of bifurcation. The anterior or basal spine which in *bimaculata* is nearly as long as the principal one, in the present species is very much shorter, less than half as long, slender, acute, moderately curved.

The color is a very dull brown, the carinae somewhat lighter, though not much contrasting in the types. In some the color is deep, almost black, with the carinae not paler. A mid-dorsal dark stripe shows in some.

The processes of the second coxæ in the male, slender, cylindrical, moderately long. Coxæ and ventral plates unarmed.

Vertex with two setigerous foveolæ on each side.

Length of male type, 38 mm.; width, 7.3 mm. Length of a female, 50 mm.; width, 9.2 mm.

Locality.—La.: Creston. Type and three other specimens taken March 26, 1915. Several other specimens taken on other dates in March.

***Fontaria clara* sp. nov.**

This form is characterized in having the gonopods of the male of a very distinct type. The proximal end of the second or principal division of each gonopod is densely hirsute; the blade is in two branches, which are smooth and strongly chitinous; of these the ectal one curves first proximad (dorsad) on the ectal side of base and then bends in a semi-circle and extends ventro-caudad subparallel with its basal portion, and is distally acutely acuminate; the mesal branch is larger and extends ventrad or ventrocaudad in general, with a slight double or sigmoid curve, the tip, which is flattened from side to side and is acute, weakly hooked or recurved. The basal process springs from the dorsomesal side of the base of the principal process; proximally it is flattened and narrows to an acute tip distad, somewhat twisted and crossing over the process from the other side, much shorter than the other processes.

When in full color the dorsum is very dark, black or nearly so, with the carinæ sharply contrasting by their lighter, in preserved specimens yellowish color. First tergite lighter along anterior border, but not along the posterior. Under surface and legs yellowish.

Vertigial foveolæ two on each side. Vestigial sulcus ending below at the angle of an inversely v-shaped transverse sulcus between the antennæ.

Sternites unarmed. Processes of coxæ of second legs in the male stout, clavate, distally truncate.

Locality.—La.: Creston. Type, a male, taken March 5, 1915. Other specimens taken Feb. 25, 27 and 28, and March 21, 1915.

***Polydesmus serratus* Say.**

Several specimens taken in February, March and May, 1915, near Creston, La.

***Polydesmus* sp.**

One broken specimen, not fully mature and of uncertain species, taken in Mixon's Hammock, Okefenokee Swamp in June, 1912.

Nemasoma pium sp. nov.

This is a much larger species than the *minutum* of Brandt, so common in the northeastern states, the type being near 25 mm. in length, with a diameter of 1.6 mm.

The general color is brown, with a distinct middorsal longitudinal black line and a series of black dots along each side over the repugnatorial glands. The posterior region of each segment is darker than the anterior and a line along the suture is blackish. No light areas, such as occur in *sayanum*.

Repugnatorial pores large, each contiguous with the suture, which is moderately curved about it.

The lower end of the first tergite on each side narrows to an acute angle just above which the anterior edge is moderately incurved.

The last tergite exceeds the anal valves. It narrows subtriangularly but is distally truncate, or very obtusely rounded, differing in this conspicuously from that of *minutum* and approaching that of *sayanum*.

Locality.—La.: Creston. March 21, 1915. One female.

Parajulus robustior sp. nov.

This is an exceptionally robust species. The general color is brown, each somite showing near its middle a solid annulus of a deeper, somewhat chestnut, color, and in front of this above and separated from it by a narrow pale stripe, a blackish band enclosing a series of light dots, while the anterior border above the level of the pores is bluish. There is a broad black band connecting the eyes. There is a median dorsal longitudinal black line and a series of small black dots along each side (the repugnatorial glands).

The cardo of the mandibles in the male strongly produced ventrad, attaining to near lower level of labrum.

Each segmental suture is strongly angularly at the level of the pore. A characteristic feature is presented in the last tergite, which exceeds the anal valves, being produced into an acute spine, which is strongly, evenly decurved in the male, less so in the female; this spine proportionately much shorter than in *canadensis*.

The first tergite in the female is angular below, but in the male the lower border is long, the edge horizontal. Strongly margined below. Without distinct striæ. Other segments strongly striate below. The second tergite in the female much extended below level of the first. In the male the second and third tergites are strongly angularly extended into a ridge along the lower level of each side.

The first legs of the male are strongly crassate, unusually long and strongly hooked.

Promentum of gnathochilarium in male much enlarged; oblong elliptic in form.

The species seems to be strongly distinct in the structure of the male gonopods. The sixth and seventh segments are moderately extended below. Of the anterior gonopods the anterior process on each side is strongly clavate, the distal portion above its base subconical, apically

narrowly rounded, bearing distally numerous long hairs. The posterior division is a stout, thicker and longer process; it is furrowed across the apex and down the caudal side and is bent moderately cephalad at the tip; the process is glabrous. The principal process of each posterior gonopod is a blade flattened from side to side and curving back caudad below the groove in the posterior piece of the anterior gonopod; it is not distally acute and is without branches or processes; it bears the seminal duct, which opens above a little proximad of the tip. A much smaller, straight, distally pointed process extends ventrad on the ectal side of the base of the principal process, its tip not attaining the lower level of the latter.

Length of a female near 53 mm.; width, 3.5 mm.

Locality.—La.: Creston. One specimen each on February 22, February 28 and March 5 (male, type) and two without date.

***Cambala annulata* (Say).**

Numerous specimens taken near Creston, La., in February, March and May, 1915.

***Spirobolus marginatus* (Say).**

One small specimen taken on Spring Creek, Ga., Aug. 27, 1913. Also three specimens taken near Creston, La., in March and April, 1915.

***Spirobolus paludis* sp. nov.**

This species in comparison with *S. marginatus* is distinguished in general appearance by its coloration, the sides contrasting through their paler brownish color with the mainly blackish dorsum, the black band across each somite covering the entire width dorsally, but narrowing down each side along the anterior margin and ending in a very acute point ventrally. The first dorsal plate is narrowly margined with a lighter color, both anteriorly and posteriorly and the other somites of the anterior region are margined caudally with lighter color, the marginal stripe obscure or absent dorsally in middle and posterior regions.

The antennal furrow on head below eye and across cardo of mandibles much shallower and less sharply limited than in *marginatus*, with no trace of the ridge bordering the furrow on the cardo ventrally though the ridge on the caudal side is present. Cardo lacking the small, very acute ventrodiscal process seen in the male *marginatus*.

Second segment much less produced below the first plate than in *marginatus*, not at all extending below level of general ventral surface of the segment and not much lower anteriorly than posteriorly.

The modifications of the anterior legs in the male are very obviously different from those in *marginatus*. The first two pairs of legs are smaller in size than the others. The third pair of legs show ventrally a pair of rounded processes contiguous at the middle line, and bearing distally two or three long setæ. The coxal processes of the fourth legs

are higher and more narrowed distad, each bearing at apex a much narrower and paler mammiliform process. The coxal processes of the fifth pair are much longer, above base subcylindric, a concave depression on each side in an oblique anter-distal face. The processes of the sixth legs are somewhat shorter and each is cupped or concavely depressed on its distal end. The coxal processes of the seventh legs are much the largest; each broadly and deeply concave on its anterior face.

Repugnatorial pore in front of suture which it does not touch; the suture angularly bent cephalad just above the level of the pore.

Number of somites 49-50. Length of the male (type) 45 mm.; diameter, 5.2 mm. A female paratype much larger with the dorsal transverse bands blacker and more sharply defined; length about 95 mm., with the width 8 mm.

Locality.—Ga.: Okefenokee Swamp: Mixon's Hammock (male type), June, 1912. The female was labeled simply "Okefenokee Swamp."

CHILOPODA.

Cryptops hyalinus Say.

Seven specimens taken in the Okefenokee Swamp, one in Mixon's Hammock, June, and six on Billy's Id., July, 1912. Also four specimens taken near Creston, La., in February and March, 1915.

Otocryptops sexspinosus (Say).

Numerous specimens taken near Creston, La., in February and March, 1915.

Theatops posticus (Say).

Several specimens taken in the Okefenokee Swamp: Minnie Lake Run, June 14, one specimen; Billy's Id., June, six specimens; and four in Mixon's Hammock, June 5, 1912. Also five specimens taken near Creston, La., in February and March, 1915.

Scolopendra viridis Say.

One specimen taken near Creston, April 20, 1915.

Scolopendra heros Girard.

Two specimens taken near Creston, May 1, 1915.

Hemiscolopendra punctiventris (Newport).

Five specimens taken on Billy's Id., Okefenokee Swamp, in June, 1912, and Dec., 1913. Also fourteen specimens taken near Creston, La., in March and April, 1915.

Linotaenia fulva (Sager).

One specimen taken at Creston, March 9, 1915.

Arenophilus bipuncticeps (Wood).

One specimen from near Creston, La.

Arenophilus watsingus Chamberlin.

One specimen from near Creston taken May 5, 1915.

Geophilus mardax Meinert.

One specimen from near Creston, April 2, 1915.

Nannocrix gen. nov.

Frontal suture not present. Prebasal plate developed and exposed. Basal plate trapeziform, narrowed cephalad.

Labrum free, tripartite. Lateral pieces armed with long spinous processes.

First maxillæ with coxæ completely fused at middle and separated by suture from the distal divisions. Palpi biarticulate, the coxæ and femora with long membranous lappets at distal external angles.

Coxæ of second maxillæ completely fused. No trace of pleurosternal sutures. Palpus triarticulate; femur without distal process; claw simple.

Coxosternum of prehensors with strongly developed and complete chitinous lines. Prehensors short, not attaining front margin of head; articles wholly unarmed within.

Dorsal plates strongly bisulcate.

Ventral pores on anterior plates in a transverse band in front of caudal margin and in two small anterior areas, one in each anterolateral corner. Anterior areas may disappear in caudal region, where pores of posterior band are also fewer and may be divided into two areas.

Last ventral plate very wide. Coxopleural pores few, obscure, covered by plate.

Anal pores absent.

Anal legs unarmed, the claw being replaced by a minute, transparent terminal article.

Type.—*Nannocrix porethus* sp. nov.

Nannocrix porethus sp. nov.

Body moderately attenuated cephalad of middle, more strongly so caudad.

General color yellow, becoming dilute ferruginous in the anterior region and sometimes in the extreme posterior, the head deeper ferruginous. Antennæ and legs yellow.

Cephalic plates short, equal in length and breadth. Greatest width near junction of posterior and middle thirds of length. Sides convexly rounded; caudal margin incurved; anterior margin in the form of a very obtuse angle. Sparsely and uniformly hirsute.

Basal plate trapeziform, the anterior margin widely evenly concave. About one-third as long on median line as the cephalic plate; three and a half times as wide as length at middle.

Antennæ moderately short, three times as long as the cephalic plate. Attenuated distad. The ultimate article equal in length to the two preceding taken together. Proximally sparsely hirsute, becoming densely so distad with the hairs shorter.

Prosternum much wider than long (21:13). Anterior margin forming a very obtuse re-entrant angle with the edge smooth and strongly chitinized except at middle. Joints of prehensors very short, the distal end of the first one on the mesal side scarcely cephalad of the anterior edge of the prosternum. Claws when closed, falling much short of attaining the front margin of head. All joints wholly unarmed.

Prescuta in middle region a half or a little more as long as scuta, becoming very short cephalad and in the extreme posterior region.

First four spiracles broadly vertically elliptic, the others circular; decreasing in size gradually from the first, which is large, caudad.

First legs much reduced in size, the second ones being abruptly longer and stouter. Posterior pairs proportionately more slender than the anterior and much longer.

None of the ventral plates at all sulcate. Ventral pores in anterior region distinct and numerous, forming a continuous transverse band posteriorly, which may extend slightly forward at the middle and a small subcircular area in each anterior corner. Posteriorly the anterior areas disappear and the pores of the posterior band become few and less distinct.

Last ventral plate very wide, wider than the preceding sternite. Sides strongly convex, converging caudad. Caudal margin straight. Coxopleural pores obscure, covered by the ventral plate.

Anal legs much longer and stouter than the penult in both sexes. The sixth article abruptly much more slender than the fifth, the appendage replacing the claw minute.

Pairs of legs, 61-63.

Length up to 45 mm.

Locality.—La.: Creston, March 5, March 9, and March 20, one specimen being secured on each of these dates.

Helembius gen. nov.

Of the genera of smaller lithobiids previously known to occur in the southeastern United States this genus is like *Nampabius* and *Garibius* in having the number of articles in the antennæ definitely fixed at twenty. It differs from those genera in having the anal and penult legs of the male simply inflated and wholly without special lobes on either pair. In the sparse development of spines on the legs and their complete absence from the coxæ, the type species suggests *Nampabius*, which differs, aside from the possession of the highly characteristic lobe on the penult legs of the males, in the characteristic U-form of the median incision of the prosternum and in the small, not enlarged, single ocellus.

In the general character of the spining of the legs the new form almost fully agrees with *Sigibius* occurring in the New England States; but the latter genus has the number of articles of the antennæ twenty-five. The body is slender and only slightly narrowed cephalad. First tergite narrower than head and than the third tergite.

Antennæ short; articles twenty.

Ocelli few, in two, or irregularly in three, series; the single ocellus enlarged.

Prosternal teeth 2+2, the line of apices distinctly recurved. Median incision acute at bottom, V-shaped.

None of the dorsal plates at all produced. The posterior corners of the ninth, eleventh and thirteenth plates moderately oblique or excised.

Coxal pores small, circular, few, uniserrate.

Claw of female gonopods tripartite; lobes small, the lateral subequal. Basal spines 2+2, moderately stout, though less so than in *Tidabius*, the sides from base to apical division parallel, the apical acuminate part very short.

Coxæ of legs all wholly unarmed. Claws of anal and penult legs two. Ventral spines of anal legs, 0, 1, 1, 1, 0; dorsal, 0, 0, 2, 0, 0, (female) or 0, 0, 1, 0, 0, (male). Ventral spines of penult legs, 0, 1, 1, 1, 0; dorsal, 0, 0, 1, 0, 0.

Anal legs of male short, strongly and uniformly inflated; the penult legs more moderately inflated, the tarsal joints slender; both pairs wholly lacking special furrows or processes.

Very small, the type species near 6 mm. (female) or less (male) in length.

Type.—*Helembius nannus* sp. nov.

Helembius nannus sp. nov.

General color brown of slight chestnut tinge, the head more deeply colored. Antennæ paler, yellowish at tips. Legs yellow, but the posterior pairs darker, excepting the tarsi, which are bright orange or yellow.

Head much wider than long (about 34:25). Hairs sparse, of moderate length. On caudal portion two sublongitudinal impressions diverging cephalad.

Antennæ very short; articles, excepting second and ultimate, very short, the ultimate equalling the two preceding taken together. Hairs, excepting the proximal articles, dense, of moderate length, setose.

Ocelli in female type six or seven in number, thus, 1+2, 3 or 1+2, 3, 1. The single ocellus greatly exceeding the others in size, subvertically elongate, and the ocelli of the upper series exceeding those of the lower.

Prosternum 1.5 times wider than long. Distance between chitinous spots near 3.57 times the dental line. Outer prosternal tooth on each side extending farther forward than the mesal one, making the line of the apices decidedly recurved. Sides slanting directly from the ectal tooth, a little incurved.

First dorsal plate 1.7 times wider than long, widest anteriorly; sides converging caudad, evenly convex. Posterior corners of ninth and eleventh dorsal plates distinctly obliquely excised more on caudal side, those of the thirteenth plate less distinctly so.

Coxal pores: small and circular; 2, 3, 3, 2.

Spines of anal legs, $\frac{0, 0, 2, 0, 0}{0, 1, 1, 1, 0}$ or $\frac{0, 0, 1, 0, 0}{0, 1, 1, 1, 0}$ (male), claws 2; of penult, $\frac{0, 0, 1, 0, 0}{0, 1, 1, 1, 0}$, claws 2; of thirteenth, $\frac{0, 0, 1, 0, 0}{0, 0, 1, 1, 0}$; of the twelfth $\frac{0, 0, 0, 0, 1}{0, 0, 1, 1, 0}$; of the tenth, $\frac{0, 0, 0, 1, 1}{0, 0, 1, 1, 0}$.

Claw of female gonopods of uniform width, tripartite, the lobes very short, the lateral equal and the median one but little exceeding these. Inner and outer basal spines equal or very nearly so; acuminate distal division very short, subobtusate.

Length of female, 6 mm.; of male only 4 mm.

Locality.—Ga.: Okefenokee Swamp; Billy's Id., June, 1912. One female and one male.

***Neolithobius helius* sp. nov.**

General color of dorsum brown, the head chestnut. Antennæ chestnut, paler, yellowish, distally. Legs yellowish, the posterior pairs darker, brown to chestnut, but with the distal joints bright orange or yellowish.

Head subcordate, but anteriorly truncate between the antennæ and the caudal margin excepting at ends straight or nearly so. Wider than long in the ratio 7.5:6.

Antennæ moderately long, reaching to the seventh pediferous segment. Articles typically from thirty to thirty-three in number, short and very short, the ultimate variable in proportionate length, sometimes equalling the two preceding ones and sometimes much shorter. Subdensely setose distally, more sparsely setose proximally.

Prosternum with distance between chitinous spots three times the length of the dental line. Lateral sloping margins conspicuously incurved. Prosternal teeth mostly rather small, mostly 5+5, but also 5+6, 6+6, 6+7, and 7+7, the most mesal teeth on each side often much reduced and lower in position. Mesal incision very narrow.

Ocelli forming a compact oblong area. Ocelli arranged mostly in four to six longitudinal series with the single ocellus much larger, pale: e. g., one 6, 5, 5, 4, and one 6, 7, 6, 5, 3.

First dorsal plate across its anterior end only a little narrower than the head and equal in width to the third plate.

Coxal pores very small, circular. Examples of arrangement and number: 4, 5, 5, 4; 5, 6, 6, 4.

Spines of the anal legs $\frac{1, 0, 3, 1, 0}{0, 1, 3, 3, 2}$, claw single; penult, $\frac{1, 0, 3, 3, 1}{0, 1, 3, 3, 2}$,
 claw single; thirteenth, $\frac{1, 0, 3, 2, 1}{0, 1, 3, 3, 2} - \frac{1, 0, 3, 2, 2}{0, 1, 3, 3, 2}$; twelfth, $\frac{1, 0, 3, 2, 2}{0, 0, 2, 3, 2}$
 second to eleventh, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$; first, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 1}$. Last three pairs
 of coxæ laterally armed.

Claw of female gonopods rather small, tripartite, the lobes acute, the median obviously longer and stouter than the others. Basal spines 2, 2; moderately slender, in ventral view with sides parallel to acute distal portion.

In the male the anal legs have the third article strongly clavately enlarged distad of the base, the thickening chiefly represented by a high ridge situated dorsomesally and bearing distally a stout spine bifid serrate at the apex somewhat as in *xenopus*, and a patch of long bristles. This rounded, ridge-like lobe extends mesad well beyond inner side of the succeeding or fourth article. Fourth article conspicuously excavated and longitudinally furrowed along the dorsomesal surface as usual, but the joint as a whole not bowed; at ends and along sides of furrow are long setæ.

Length 14 to 18 mm.

Locality.—Okefenokee Swamp: Billy's Id., nine specimens taken in June; and Honey Id., three specimens taken May 31 and June 1, 1912.

***Neolithobius mordax* (L. Koch).**

One specimen, with head missing, referable to this species taken at Creston.

***Neolithobius transmarinus* (L. Koch).**

Numerous specimens taken in February and March, 1915, near Creston, La.

THE PHLEPSIDS OF MEXICO AND CENTRAL AMERICA.*
(HOMOPTERA CICADELLINÆ)

By E. D. BALL.

Genus Phepsius Fieb.

This genus was erected by Fieber for a small number of European leaf hoppers with vermiculate brown or dark lines inscribed on the elytra and usually with similar markings throughout.

This group reaches its highest development in the temperate region of North America. Only a small number of species extend into the more tropical regions and most of these are found in the mountains of central and southern Mexico, while no species is known from Central or South American regions.

The vermiculate lines will serve to separate nearly all of the species of the group, while the remainder show such evident relationship that they are easily placed. A few have lost these vermiculations by reduction in number, while others have lost them by the gradual substitution of dots in their place.

The following subgenera are represented in the North American fauna:

KEY TO THE SUBGENERA OF PHLEPSIUS.

- a. Head distinctly narrower than the pronotum; the lateral margin of pronotum strongly carinate, long, nearly equaling the short diameter of the eye.
 - b. Head much narrower than pronotum, which is produced between the eyes; vertex and front long and narrow; large active species with long narrow elytra..... *Iowanus* nov.
 - bb. Head slightly narrower than pronotum which is regularly rounding in front; front broader above; shorter and stouter species..... *Texanus* nov.
- aa. Head conical, about equaling pronotum; lateral margin of pronotum almost obsolete, never more than one-fourth the short diameter of the eye; elytra usually with an angular pattern on inner part; outer margin pale, often with four definite spots..... *Dixianus* nov.
- aaa. Head as wide or wider than pronotum; lateral margin of pronotum carinate, one-third the short diameter of the eye or longer; elytra with pattern transverse or wanting.
 - b. Front margin of head not produced or foliaceous.
 - c. Vertex long and flat; front flat in profile, meeting vertex in acute angle; margin blunt..... *Zioninus* nov.
 - c. Vertex short; front sloping, convex, thin; margin rounding or acute, but not produced..... *Phlepsius* Fieb.
 - bb. Front margin of head produced, foliaceous..... *Paraphlepsius* Baker

* The writer was asked to undertake the Jassidæ of the Biologia Centrali-Americana in 1902. The material arrived in very poor shape, but the work was taken up and more than half completed in the course of the next three years, including the figuring of many species by Mrs. Ball. A change to executive work at that time reduced the time possible to give to this material and so the work was not completed at the date the editors set for the close of the Homoptera volume. The writer then decided to publish his studies of the groups from time to time, as opportunity offered, after which the material will be returned to the Biologia collection.

Described from a single female from Amula Guerrero, Mex. (H. H. Smith). This is a strikingly distinct species in many characters and unique in the genus in the elongate female segment.

Phlepsius (*Iowanus*) **hebraeus** *n. sp.* (Fig. 2a and b).

Resembling *handlirschi* in general form and appearance, slightly smaller; color and marking similar but slightly paler. Length 8.5–9 mm.; width, 3 mm. Vertex transversely convex, one-fourth longer on middle than against eye, twice wider than long, the anterior margin bluntly rounding to front; front long and narrow, the margin straight to just before the apex. Pronotum broad, the outer angle sharp. Elytra long and narrow; the antepical cells parallel margined, a number of extra cells on the costa opposite the antepicals.

Color. Vertex and face marked as in *handlirschi* and *majestus*. Pronotum pale, irrorate with brown and with a few black spots along the anterior sub-margin. Elytra as in *handlirschi* but lacking the rufous cast and usually with a few definite light spots in the apical cells.

Genitalia. Female segment moderately long, posterior margin slightly concave with a small semi-circular median notch.

Described from eight females, one from Vienna Museum, labeled "Mexico, Coll. Sign. *Jassus hebraeus* Stal (*hebraeus* det. Sign)," and seven from Amula Guerrero Mex. (H. H. Smith).

Phlepsius (*Iowanus*) **handlirschi** *n. sp.* (Fig. 3b, c, and d).

Form and general appearance of *majestus* Osborn and Ball. Slightly smaller and with a narrower vertex. General color, fulvous brown. Vertex pale yellow with a broad band and two sub-apical spots black. Length 9–10 mm.; width 3–3.5 mm. Vertex and face as in *hebraeus*. Elytra slightly broader and less flaring, second and third apical cells long and curved.

Color. Vertex pale yellow, a transverse band behind the ocelli widening on the disc and interrupted in the middle, and a pair of spots in front of this, black; this band incloses a yellow dot against each eye. Face pale sordid yellow. Short brown arcs on front and a dark ocellate spot on clypeus. Pronotum pale, coarsely irrorate with fulvous brown, the anterior sub-margin with coarse ocellate dark spots. Elytra pale, rather sparsely inscribed with fulvous; three dark spots along the suture.

Genitalia. Female segment short, transverse; posterior margin, nearly straight, the median third produced on each side of a narrow median notch extending over half way to the base; angles next this notch acute. Male valve semi-circular, plates long, acutely triangular, the extreme tips rounding, three times as long as the valve.

Described from three females and one male from Omilteme and Xucumanatlan in Guerrero (H. H. Smith) and Ciudad Mex. (Forrer). One female from Vienna Museum, labeled "Mexico Coll. Sign. (*hebraeus* det. Sign.) (114)," which is slightly darker than the rest but does not differ otherwise.

***Phlepsius (Iowanus) spatulatus* V. D.** (Fig. 4b and c).

This is a smaller, paler, and less definitely marked species, occurring commonly from Colorado south to Central Mexico. Specimens are at hand from Mexicali, June; Ti-Juana, August (Ball); El Taste and Presidio Mex. (Forrer). The short teeth on the female segment separated by an acute notch will readily separate this species from any other.

Subgenus Texananus nov.

Resembling *Phlepsius* but with head narrower than the pronotum, front rather broad, convex, widening above the antennæ and approaching the eyes. Vertex bluntly conical, the margin to the front rounding. Pronotum large, broadly and evenly rounding in front; the lateral margin long, oblique, and definitely carinate. Elytra broader and shorter than in *Iowanus*, whole surface inscribed with vermiculate lines. Type of the subgenus *Phlepsius (Texananus) mexicanus* n. sp.

KEY TO THE SPECIES OF TEXANANUS.

- a. Sutural margin of elytra not definitely marked with light.
 - b. Elytra uniformly irrorate.
 - c. Length 7 mm., female segment excavated to base.5. *eugeneus* n. sp.
 - cc. Shorter, female segment excavated half way to base.6. *superbus* V. D.
 - bb. Elytra with irregular areas of dark and light.7. *mexicanus* n. sp.
 - aa. Sutural margin of elytra definitely light marked.
 - b. Vertex, pronotum and scutellum each with a pair of black dots.
 - 8. *excultus* Uhl.
 - bb. Without definite black dots.
 - c. Vertex dark brown, nearly flat.9. *hosanus* n. sp.
 - cc. Vertex cinereous, convex; species small.10. *ovatus* V. D.

***Phlepsius (Texananus) eugeneus* n. sp.** (Fig. 5b and c).

Nearly of the form of *excultus* but larger, paler, and lacking the definite markings of that species. Pale grayish or slightly fulvous brown. Length 7 mm., width 3 mm. Vertex convex, one-fourth longer on middle than against eye, twice wider than long. Anterior margin bluntly rounding except at apex, front broader than in *hebraeus*, almost parallel margined until just before the apex. Pronotum but little wider than across eyes. Elytra longer than in *excultus*, flaring behind, the inner anteapical cell very long, the outer one broadest in front.

Color. Pale yellow, two pairs of approximate dots on suture between vertex and pronotum as in *excultus*, two indistinct brown spots at apex of vertex, and front brown with pale dots. Elytra milky, inscribed with brown, faintly washed with rufous in most specimens, the tips of the claval nervures fuscous.

Genitalia. Female segment long, angularly narrowing posteriorly, middle half roundly emarginate clear to the base where there is a slight median tooth. Male valve very short and obtuse; plates large, triangular, with nearly straight margins, white with black spots at the base of the short marginal hairs; the stout spines of the pygofers exceeding those of the plates.

Described from twelve specimens from Acuguizotla, Guerrero, 3,500 ft. Oct. (H. H. Smith); Amula, Guerrero, 6,000 ft. Sept. (H. H. Smith); Das Arroyos, Guerrero, 1,000 ft. Sept. (H. H. Smith); Tierra, Colorado, Guerrero, 2,000 ft. Oct. (H. H. Smith); Cuernavaca, May; and Iguala, Mex.

This species may be separated from *excultus* by the absence of definite fulvous and wavy markings along the dorsum, as well as by the much longer notch in the female segment, and from *spatulatus* which it resembles by the distinct genitalia.

Phlepsius (*Texananus*) *superbus* V. D. (Fig. 6b and c).

This compact, dark brown species much resembles *mexicanus* but is slightly smaller and more elongate. The very dark face and distinct genitalia will readily distinguish it.

It occurs from Colorado and Oregon south to Central Mexico. Specimens are at hand from Ti. Juana, June (Ball) and Mescala, Guerrero Mex. (H. H. Smith).

Phlepsius (*Texananus*) *mexicanus* n. sp. (Fig. 7a, b, c, d and e).

Closely resembling *P. areolatus* but quite distinct in shape of vertex and genitalia. A stout species with the brownish fuscous irrorations irregularly distributed, leaving patches of milk white. Length 6.75 mm., width 3 mm.

Vertex convex, with the front almost conical, nearly half longer on middle than against eye, almost three times wider than long, front broad wedge-shaped but little longer than its basal width. Elytra broad and short, the apices appressed; apical cells short.

Color. Vertex testaceous brown, three irregular blotches on the anterior margin and numerous dots on the disc pale; pronotum testaceous brown, with irregular hieroglyphic light markings on anterior half and light pustulate spots on the remainder. Scutellum with the apex and two marginal spots light. Elytra milky white, the nervures fuscous brown, the vermiculation mostly coalesced into fuscous dots which are larger toward the margins.

Genitalia. Female segment reduced, less than two-thirds as wide as the penultimate, consisting of an obtusely triangular plate with the apex produced into a strap-like tooth as long as the segment. A pair of broad plates arising under this segment cover the base of the pygofer and a pair of heavy folds occupy the corners. Male valve rounding, plates narrow, scarcely as wide as the valve, concavely narrowing to the blunt points, two and one-half times as long as the valve, not quite as long as the compressed pygofer.

Described from seven specimens from Orizaba, December (H. S. and F. D. G.); Chilpancingo, Mex., June, (H. H. S.); and one female from Vienna Museum labeled *mexicana* det. Sign.

Phlepsius (*Texananus*) **excultus** Uhl. (Fig. 8a, b and c).

This strikingly marked species resembles *eugeneus* in structure and *decorus* in markings but the fulvous dorsum and commisural line will at once distinguish it. It ranges through the southern United States and a single specimen is at hand from Puentad, Ixtla, Mexico, July (C. C. Deam).

Phlepsius (*Texananus*) **hosanus** *n. sp.* (Fig. 9a and b).

Form and general appearance of *decorus* O. & B. slightly smaller and with a definite concave light line between the ocelli. Length 6 mm., width $2\frac{1}{2}$ mm.

Vertex transversely convex, slightly sloping to the narrow margin, one-fifth longer on middle than against eye, twice wider than long. Front moderately broad above, wedge shaped, distinctly longer than wide. Pronotum but little wider than across the eyes. Elytra longer and more flaring than in *decorus*.

Color. Vertex brownish fuscous; a spot at apex, the line between ocelli and the base ivory white. Pronotum with tawny markings on the anterior third. Scutellum tawny with light and black spots. Elytra ivory white, with fuscous irrorations coalescing into irregular spots omitting the inner margin back to apex of clavus. This ivory margin is narrow next the scutellum and is crossed by the inner claval nervure. It widens out on middle of clavus and again before apex and usually bears one or more black spots in each expansion.

Genitalia. Female segment short, posterior margin nearly truncate with four triangular teeth on the middle third, the outer pair the larger.

Described from two females, from Orizaba, Dec., (H. S. and F. D. G.); and Tepetlapa Guerrero, Mex., Oct. (H. H. S.). The broad, stout form and the dark color within the median ivory spots render this an easily recognized form.

Phlepsius (*Texananus*) **ovatus** V. D. (Fig. 10a, b and c).

This is the smallest species of the group in Mexico and its small size, oval shape, and pale commissural line will at once distinguish it.

It ranges from Oregon and Colorado south to southern Mexico. Specimens are at hand from Cuernavaca, Morelos (H. H. S.); Jalapa, Vera Cruz, June; Aumlema, 535 ft., (Barrett); and Ti Juana, August, (Ball).

Subgenus Dixianus nov.

Resembling *Phlepsius* but with the head about equaling the pronotum in width; the lateral margin of pronotum very short, sub-obsolete, scarcely carinate; vertex flat or sub-conical, rather narrow, the width of head made up by the long diameter of eye which is nearly as great as the width of vertex; front long, convex margin, forming a regular curve to ocelli which are large and touch the eye; eyes wider than genæ; clypeus long, narrow, and very slightly constricted. Elytra long and narrow, venation obscured by the pattern, the central apical cell long and narrow, slightly curved, the outer anteapical broad at base, often acuminate with several supernumerary cells at apex, the costal margin often broadly light with four black spots; usually an angulate euttetix-like pattern on the disc.

Type of the subgenus *Phlepsius* (*Texananus*) *utahnus* Ball.

This is a very distinct little group, intermediate in character, between *Euttetix* and *Phlepsius* proper, and it will probably receive generic rank later. Its members can be recognized at once by the sub-obsolete lateral margin of the pronotum; the unusual width of the eyes, the costal spots, and the pattern of the elytra. *P. costomaculatus* is the most common Mexican form and has been figured but *utahnus* is more representative of the group, which includes a number of species from the southwestern United States, such as *pulchripennis* Bak., *loculatus* Ball, *stellaris* Ball, and *floridanus* Ball.

KEY TO THE SPECIES OF DIXIANUS.

- a. Vertex short, convex, almost parallel margined; elytra pale, costal spots large.....*costomaculatus* V. D.
 aa. Vertex definitely angulate, flat; elytra with a heavy pattern and small costal spots.....*utahnus* Ball

Phlepsius (*Dixianus*) **costomaculatus** V. D. (Fig. 11a, b, c, d and e).

This pale species is the largest one of the group. It occurs in most of the Gulf States region of the United States and is the only one so far known to occur far south of the Mexican border. Specimens are at hand from Teapa in Tabasco, Mexico, February, (H. H. S.).

Phlepsius (*Dixianus*) **utahnus** Ball.

Of this beautiful little species which occurs in the southwestern United States a single example has been examined from Comondu, Lower California, Mexico (Haines).

Subgenus Zioninus nov.

Resembling *Paraphlepsius* in general form but without the foliaceous margin to the vertex. Vertex long, flat, rounding or subangulate in front; face almost straight in profile, meeting vertex at an acute angle; the margin blunt and not inclined to be foliaceous; front broad, wedge-shaped, the ocelli distant more than their width from eyes. Pronotum with the lateral margin almost as long as the short diameter of the eye, strongly carinate. Elytra broad, short, apical cells almost quadrangular, venation of disc much obscured by heavy reticulations.

Type of the subgenus *Phlepsius* (*Zioninus*) **extremus** Ball,

The broad, short form of this small species renders it quite distinct in the broad-headed groups, while the large; flat vertex and reticulate venation set it off structurally from all others.

Phlepsius (*Zioninus*) **extremus** Ball (Fig. 13a, b, c, d and e).

This species has been found in the United States from Utah to California and south to Mexico. Mexican examples are at hand from Ti Juana, June and August, (Ball).

EXPLANATION OF PLATES.

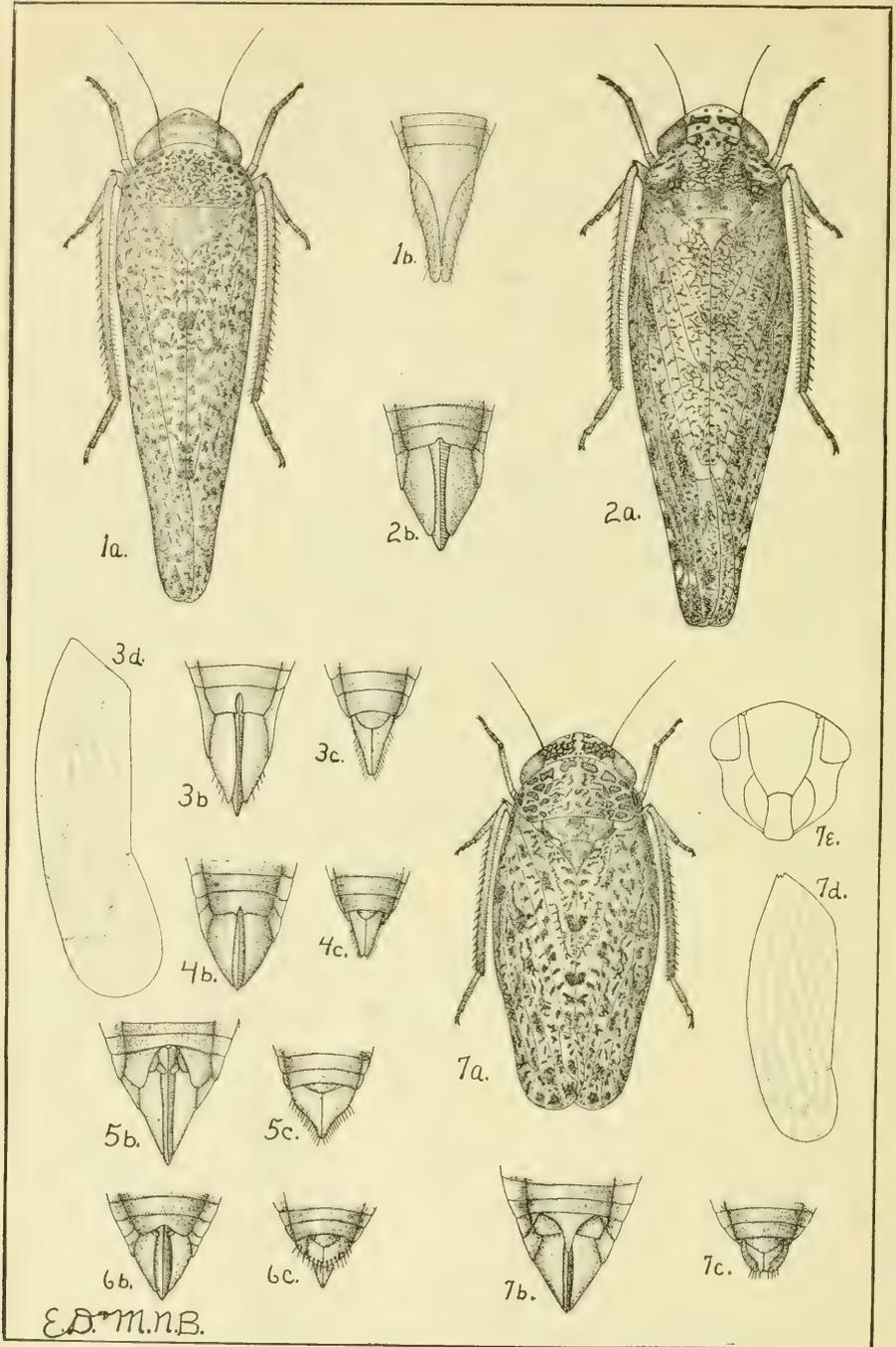
PLATE XXXIII.

- Fig. 1. **Phlepsius* (*Iowanus*) *elongatus* n. sp.
Fig. 2. *Phlepsius* (*Iowanus*) *hebraeus* n. sp.
Fig. 3. *Phlepsius* (*Iowanus*) *handlirschi* n. sp.
Fig. 4. *Phlepsius* (*Iowanus*) *spatulatus* V. D.
Fig. 5. *Phlepsius* (*Texananus*) *eugeneus* n. sp.
Fig. 6. *Phlepsius* (*Texananus*) *superbus* V. D.
Fig. 7. *Phlepsius* (*Texananus*) *mexicanus* n. sp.

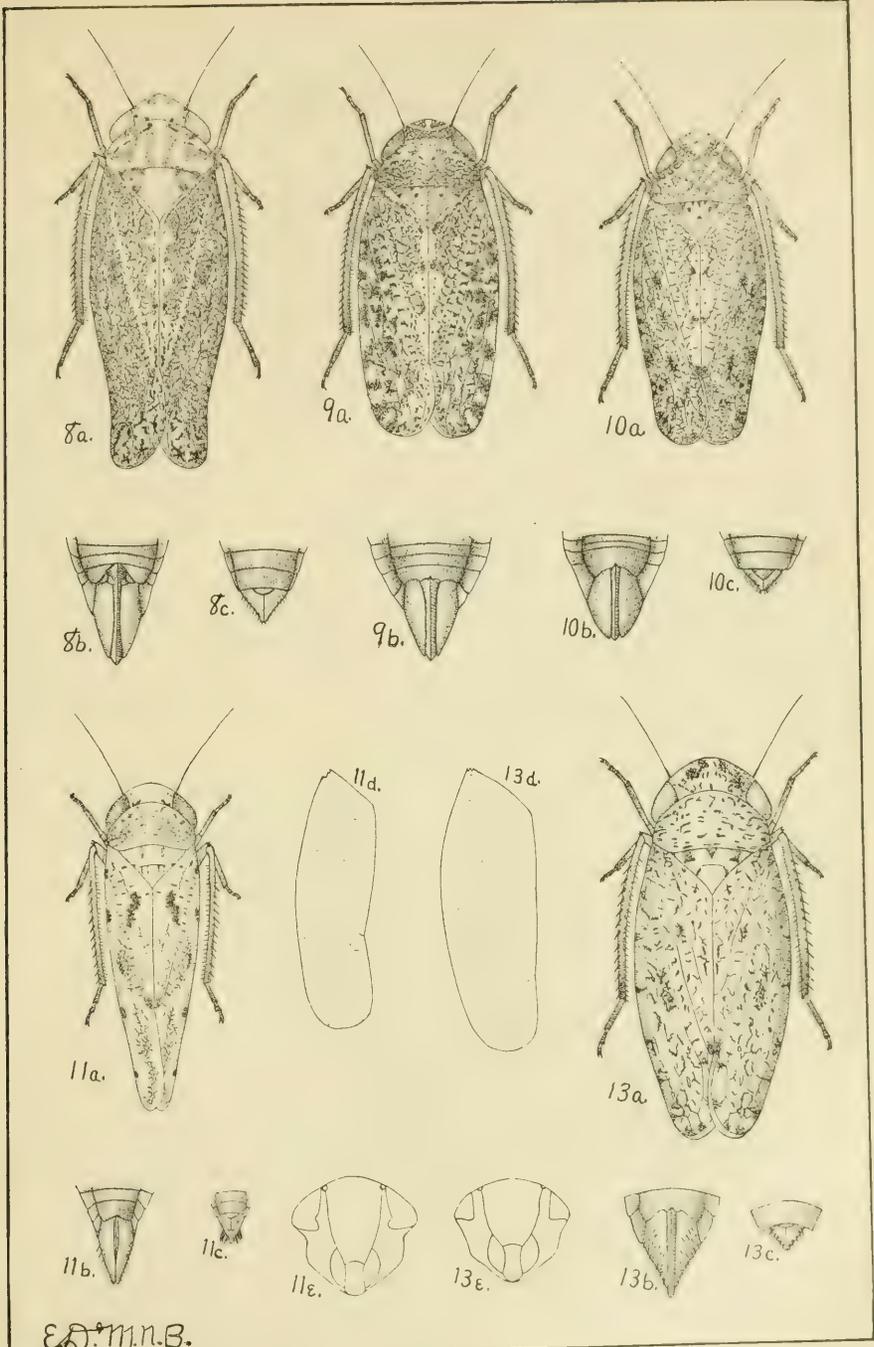
PLATE XXXIV.

- Fig. 8. *Phlepsius* (*Texananus*) *excultus* Uhl.
Fig. 9. *Phlepsius* (*Texananus*) *hosanus* n. sp.
Fig. 10. *Phlepsius* (*Texananus*) *ovatus* V. D.
Fig. 11. *Phlepsius* (*Dixianus*) *costomaculatus* V. D.
Fig. 13. *Phlepsius* (*Zioninus*) *extremus* Ball.

* In all figures *a* refers to adult; *b*, ♀ genitalia; *c*, ♂ genitalia; *d*, elytra; *e*, face.



E. D. Ball



E. D. M. N. B.

E. D. Ball

SCIRTES TIBIALIS, GUER., (Coleoptera-Dascyllidæ),
With Observations on its Life History.*

WALTER C. KRAATZ.

Scirtes tibialis, Guer., belongs to the *Dascyllidæ*, a comparatively little known family of small, inconspicuous beetles which have not been extensively studied. The adults are technically described, but few of the life histories have been worked out, despite some very interesting larval forms represented in the family. Of these beetles, some (grouped together as the *Cyphonides*, (13), from the name of the genus *Cyphon*) have aquatic larvæ, and these are remarkable in possessing long, many-jointed antennæ. *Scirtes* is of this type.

A search into the literature revealed nothing on *Scirtes tibialis*, except the description of the adult (4), (5), (1), and only a few scattered notes on the genus, with but one paper dealing with the larva (9), and that the species *Scirtes championi*. Both *Helodes* and *Cyphon* have been the subject of a number of studies, mainly in Europe, and most of the aid relative to the larvæ of *Scirtes* was obtained from the papers (2, 3, 9, 10, 11, 12) on these related genera.

OCCURRENCE AND DISTRIBUTION.

Although aquatic, the larva is not an open-water swimmer. It has a distribution restricted to that of the duckweed, *Lemna minor*, its one food plant, which grows commonly in solid areas often of some considerable extent, throughout the summer, in quiet shallow waters of bays along the shores of small lakes, and in suitable permanent ponds, large or small. The material used in this study was obtained principally from a pond northwest of Madison, Wisconsin, and also from such bays along the shores of Lake Mendota and Monona. The larvæ are usually found resting or feeding on the lower surfaces of *Lemna* leaves.

When crossing small spaces of open water, the larva moves (never more than a few inches at a time) usually with ventral side uppermost, just beneath the surface film. It may also be dorsal side uppermost, especially when swimming down away from the surface. Its motion is a characteristic wriggling one,

* Contribution from the Zoological Laboratory of the University of Wisconsin.

which is a combination of very rapid leg movements and rapid jerky bendings of the body from side to side. The body movement is the effective factor in the locomotion. Sometimes it suddenly stops in its movement and rests just beneath the surface film apparently as well as beneath leaves. The locomotion of the younger instars differs somewhat, but this is one of the phases that can not be elaborated here.

The beetle itself is never aquatic, but is commonly found on grasses and other plants along shores and on the exposed portions of aquatic vegetation, of waters suitable for the larva. The imago is perfectly capable of flying, but is also a remarkably powerful jumper, possessing enormously swollen hind femora. Most of its motion, within its usual habitat, is by jumping.

LIFE HISTORY.

Egg.

The eggs were not found in nature, but many were laid under laboratory conditions by both reared and captured beetles. Whether eggs are normally laid submerged could unfortunately not be determined. I never saw a beetle enter the water to lay eggs, nor deposit them into water, although some dishes were favorably constructed for such procedure. Judging from the immediate water requirements of the young larva, however, it seems an entirely artificial and abnormal condition that all eggs secured were laid by beetles on dry objects, directly on the glass surface or on bits of leaves in small vials (without water) in which many of the beetles were isolated for observation.

Eggs are laid in small, irregular masses, which are stuck to the surface. Of the eggs studied, the first mass was laid during the night of July 5 and hatched July 16, making an egg period of 11 days. The time of oviposition of six other masses was known, but in three of these all the eggs died because of mold. The periods of the remaining ones were $9\frac{1}{2}$, $10\frac{1}{2}$ and 11 days. The eggs of a single mass all hatch within a space of several hours. The egg period is hence $9\frac{1}{2}$ to 11 days.

Larva.

The only young larvæ obtained were from the above mentioned egg masses in the laboratory, and were numbered in groups correspondingly. Records of all of their ecdyses were

made and the stadia lengths were noted (in a series of tables) in days, but also in half days and shorter intervals where possible. The average length of the stadia for all the individuals in a group are given in the following table:

GROUP	No. of individuals in group at begin'ng	LENGTH OF STADIA IN NUMBER OF DAYS						
		1st Stadium	2nd Stadium	3rd Stadium	4th Stadium	5th Stadium	6th Stadium	7th Stadium
No. 1.....	23	3	4	4	8	9	3	8
No. 4.....	19	2.56	6	6.2	6	6.16	.....	.....
No. 5.....	15	2.5	6	5.34	6.7	7.7	7	.....
No. 7.....	12	2.25	.....	.....	.....	.....	.....	.....

There is some apparent regularity in these stadia lengths, but not enough for drawing exact conclusions. Especially is this true of the latter ones because of the many fatalities caused largely by molds, that occurred in an increasing rate. As a result these latter stadia are represented by only a few individuals. In group 1 unfortunately all the larvæ except one were killed by mold early in the second stadium, sharing the fate of groups 2 and 3; but this one survivor lived through its seventh stadium and died in its eighth. Thus of group 7, all the larvæ died before they had completed the second stadium, and of group 4, before they had completed the 6th stadium. Observations terminated in the middle of September. Since work could not be continued during fall and winter, further data of ecdyses and growth and the exact manner of over-wintering, could not be ascertained. An unsuccessful effort was made to determine the winter condition of the larvæ when I resumed work in March.

The first larva found in Spring (1918) was on May 4 at which time just a few new Lemna leaves had come to the surface, (having developed from bulblets, which overwinter at the bottom). Though the food supply was just as meagre May 11, twelve larvæ were secured, and they were becoming increasingly more abundant in the upper water. This represents then the time of resumption of growth and activity. The seventh instar, the last reared the preceding August, was only three-tenths as long as the average full grown larva. Some of the larvæ obtained in May were no larger, but they varied from

2 to 3 mm. in length. The disparity in size is accounted for by earlier or later hatching the previous summer, and because of this fact, and since no individual life history could be traced, no significant comparisons as to size between these larvæ, or with that of the preceding autumn, can be made.

It can be stated that the larvæ have a comparatively slow growth, a large number of ecdyses, that they overwinter at the bottom of the water, and must pass through considerable of their growth in late spring.

Old larvæ were obtained (in 1917) from June 17, when this work was begun, to July 22. The distribution over this period and relative abundance of maximum size old larvæ shows that in this locality the mean date for their full growth is during the first week in July.

Pupa.

The pupa is short-lived. It was not found in nature, but many old larvæ pupated in the laboratory, and, although there was a rather high death rate, due to molds, a number completed their life history. Out of 25 pupæ, the time of pupation of 4 was not secured, and 12 died before emerging as imagoes. The records of the other 9 show an average pupal period of about 3 days.

Adult.

The beetle was first caught on July 4, but only three were then secured. This date corresponds pretty well with that of the first emergence of the beetle in the laboratory, July 6. In nature the beetles became increasingly more abundant up to the latter part of the month, after which there was a rapid decline until the last week in August when no more were captured.

The life stages obviously overlap during early and middle summer, when at some favorable time old larvæ, pupæ, adults, eggs, and even young, new larvæ may exist simultaneously. The period for each life stage is pretty well marked off though with a maximum point of abundance for each.

A summary of the life history (which seems reasonable even from the incomplete results) shows an egg period of about ten days, a larval life of about eleven months, a pupal period of three days, and an imaginal existence of possibly a week or two,

although the last is a mere estimate from a few laboratory cases, and it must be said that the laboratory conditions for the adult were unavoidably very artificial. There is one generation a year.

DESCRIPTION OF STAGES.

The Egg (Fig. 1).

The eggs are ellipsoidal in shape, smooth, of cream-white color, and uniform size, measuring .37 mm. in length and .25 mm. in greatest thickness. Eggs are laid in irregular masses. The embryo in the latter part of the stage is clearly visible.

The Larva, First Instar (Fig. 2).

The first instar is very small, the specimen figured being .69 mm. in length (exclusive of antennæ) and .19 mm. in greatest width. Body elongate, tapering distinctly and continuously caudad, widest at pro- and meso-thorax. Translucent whitish color. Head narrower than thorax, slightly broader than long, widest at eyes. Prothorax longest segment of the body. Eighth abdominal segment longer than others, as long as broad, tapering caudad, and complete (as are preceding seven), but its sternum only half as long as its tergum; ninth segment, represented by sternum only, equal in length to sternum of eighth. Each eye consists of a larger mass of ocelli, with a smaller mass just behind it and nearly confluent with it. Antennæ setaceous, half as long as body, and of 7 segments. Legs similar; coxa short; trochanter triangular; femur and tibia of nearly equal length; tarsus of one segment, and in form of a long single claw. Of the setæ, distributed as shown in Fig. 1, only the very long ones extending posteriorly from the eighth abdominal segment, need be noted here, as a distinguishing character for the instar.

Subsequent Instars.

Succeeding instars do not differ markedly from the first. There is more difference in general appearance between the first and second instars (compare Figs. 2 and 3) than between any two subsequent, successive ones. The long caudal setæ of the first instar are replaced by short setæ after the first molt. Growth in size is very slow. After the second molt the body begins to taper somewhat more cephalad, the greatest width being in the metathorax. A slight yellow-tan color is apparent as early as the third instar; it becomes darker in succeeding ones, and ultimately brown. The two adjacent masses of ocelli soon fuse into one rounded eye. The coxa, even in the second instar is longer than in the first, and in later instars is comparatively much longer.

The most marked change is that of the number and proportionate size of the antennal segments, which increase in a graduated way at successive ecdyses. Examination of available specimens showed a constant number of segments (barring obvious abnormalities) as follows: first instar, 7 segments; second instar, 13 segments; third instar, 21 segments; fourth instar, 29 segments; fifth instar, 35 or 37 segments.

Determination of what stage a larva was in depended upon counts of antennal segments. Lack of sufficient material precluded study of instars directly following the above. Whether there is a similarly graduated increase and constancy for all instars cannot consequently be stated. A continued increase in number (without corresponding large increase in comparative length of the antennæ) seems certain though, for in the full grown larva, a big total of 120 to 125 segments exist. This is a striking feature, and one which does not correspond with the condition in larvæ of *Helodes* and *Cyphon*, (11).

Last Instar (Fig. 4).

The average full grown larva has a length of 7 mm. The specimen figured, with a length of 7.33 mm., was of maximum size. The body generally is as described for earlier instars, but is more flattened dorso-ventrally. Its shape can be characterized in short as that of the silver fish, *Lepisma* sp., a similarity that is true also of the antennæ. Color a dark, uniform brown. Head normally deflexed. Antennæ setaceous, very long and slender, three-fourths as long as body, of 120-125 segments; segments 1 and 2 much longer than any of those following. Leg has long, heavy coxa.

Pupa (Fig. 5).

The pupa is elongate-rounded, about 4.5 mm. in length, and of cream white color. It is attached by its anterior end to the lower surface of a *Lemna* leaf, and hangs freely. The last larval skin may or may not remain attached to the pupa; if it remains it may be for either a short period or even beyond the emergence of the imago.

Adult (Fig. 6).

The adult (length 3 to 3.5 mm.) was originally described by Guerin (4). Although his work was not available, the descriptions of Horn (5), and Blatchley (1), obviate the need of technical description here. The most characteristic features which are easily noted in this beetle are its very broadly oval shape, its short, much deflexed head, and its greatly swollen hind femora.

Although the color of very many of the specimens of beetles is, as described, "uniform piceous or nearly black, moderately shining," (1), of a considerable number of others it is a uniform dull, dark brown. The beetle is "sparsely pubescent," but the brown ones are relatively more pubescent than the black. The brown ones as a group are also larger, having all about the maximum length of 3.5 mm., while the black are on the whole 3 mm. in length. While Horn (5), says that the claw on the tarsus is simple, in all beetles examined in this study, the tarsal claw was double.

ACKNOWLEDGMENT.

The writer wishes to express his indebtedness to Professor Wm. S. Marshall, who gave aid and suggestions throughout the progress of the work.

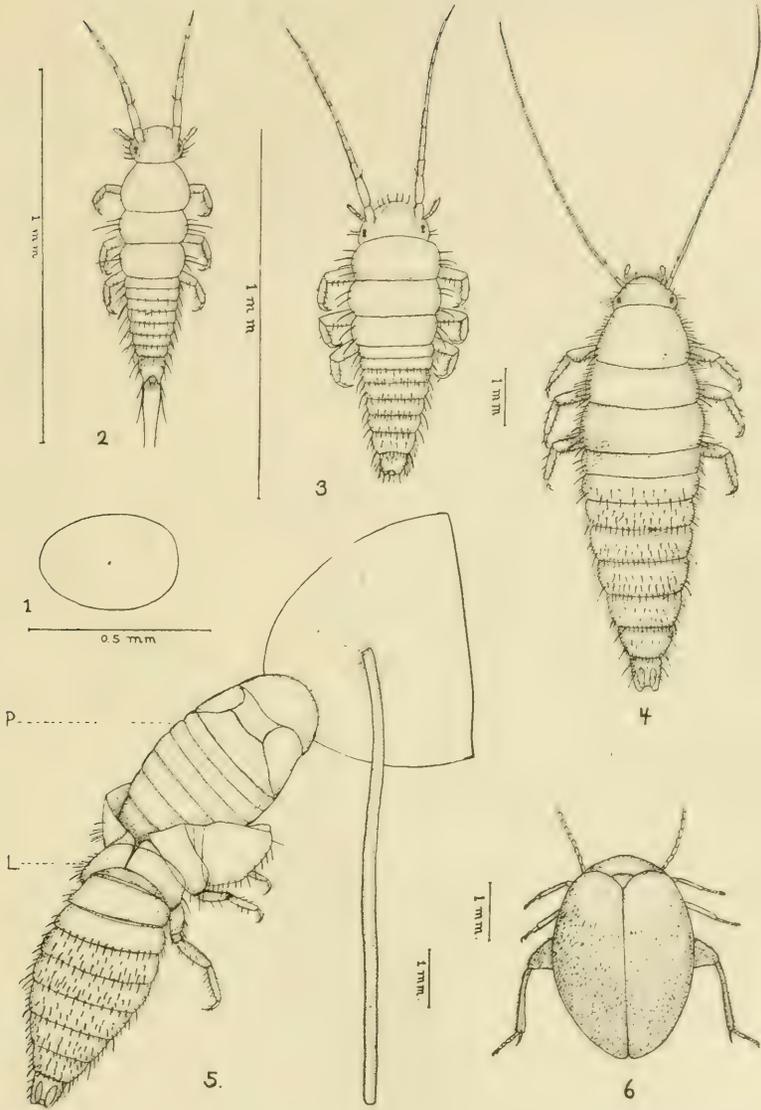
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EXPLANATION OF PLATE XXXV.

(Figures outlined with camera lucida).

- Fig. 1. Egg, length .37 mm.
- Fig. 2. Larva, first instar, dorsal view, length .69 mm.
- Fig. 3. Larva, second instar, dorsal view, length .74 mm.
- Fig. 4. Larva, final instar, dorsal view, length 7.33 mm.
- Fig. 5. Pupa (P), attached to Lemna leaf. Last larval skin (L) still attached to pupa. Leaf tilted upward to show under surface completely.
- Fig. 6. Adult beetle, dorsal view, length 3.6 mm. Head much deflexed so that it is not seen from this aspect. Pubescence indicated by short hair lines.



PUPÆ OF COMMON SPHINGIDÆ OF EASTERN NORTH AMERICA.*

By EDNA MOSHER.

Since beginning the study of pupæ it has been necessary many times to try to prove that a classification based on pupal characters should indicate natural relationships just as well as a study of the adults. There are still too few persons who believe that anything can be gained from a study of the biology of a species, or that a classification based on the immature stages of a group offers any aid in the solution of problems relating to the adults. It seemed to me, therefore, that a study of so compact a group as the Sphingidæ, upon which such a careful study of the adults of the world species has been made by Rothschild and Jordan in their masterly revision of the family, would offer some evidence on this vexed question. The study has confirmed in practically every detail the classification of Rothschild and Jordan. It has shown the same relationships, and practically the same degree of relationship existing between the various species. In some cases it was not possible to separate satisfactorily very closely related genera and species, which serves to illustrate another idea about pupæ which seems to me to be an absolute fact, namely, that the pupa is slower to change than either larva or adult and therefore indicates the ancestry and relationships of a species or genus better than any of the other stages.

Since the Sphingidæ contain the largest, as well as some of the most interesting lepidopterous pupæ, it also seemed worth while to make it possible for any one to identify the commoner forms. It has not been possible to rear all of the species to verify identifications, but practically all of the material not reared by the author was reared by Mr. William Beutenmueller, a well-known authority on the subject.

Except where especially mentioned the materials used in this study are in the collection of the University of Illinois or in the author's private collection.

* Contributions from the Entomological Laboratories of the University of Illinois, No. 58.

CHARACTERISTICS OF THE PUPÆ.

The pupæ belonging to this family are, in the main, very easy to distinguish from other lepidopterous pupæ. They are seldom found in cocoons, and these, when present, are formed of a few threads, or at most a thin layer of silk which fastens together a few leaves or twigs found on the surface of the ground. The cocoons are never suspended from twigs as in the case of many saturnian pupæ, but are always found free. The majority of the sphinx moths, however, spend their pupal life in a cell in the ground, which is formed by the mature larva. When ready to pupate the larvæ burrow into the soil to the depth of a few inches and push the soil on all sides with their heads until the space is large enough to turn in, and then the change from larva to pupa takes place.

Sphingid pupæ are usually of considerable size, only one or two species measuring less than an inch in length. The majority average one and one-half inches in length, although some are much longer. As a general rule the body is somewhat fusiform, being narrowed at the cephalic end with the mesothorax considerably wider. The remainder have the ordinary type of pupa found in the noctuids and many others. The fifth and sixth abdominal segments are "free" or movable as in the saturnians.

The body surface is generally punctate, with indeterminate transverse striations between the punctures, and the sides of the abdomen in the spiracular region are usually more strongly sculptured than the rest of the body. The cephalic margins of abdominal segments 5-7 are strongly furrowed or carinate in most sphingid pupæ. These furrows are cephalad of the spiracles and usually extend for a considerable distance dorsad. The furrows are so deep in some instances as to form a sort of pocket-like cavity. They have been referred to as spiracular furrows.

So far as observed no setæ have been found on the body. In those species in which the caudal horn is present in the larva, the scar may usually be easily identified on the dorsum of the eighth abdominal segment. The scars of the larval prolegs are also easily distinguished on the ventral surface of the fifth and sixth abdominal segments, but the scars of the anal prolegs are usually indistinct. The cremaster is usually triangular, sharply

pointed at the distal end and in many instances slightly bifurcate. It never bears hooks or spines, excepting in the genus *Hæmorrhagia* where the larvæ spin cocoons. Then a few slender hooks along the lateral margin and at the distal end of the cremaster hold the pupa in position in its cocoon.

The metathorax often bears some distinguishing character, such as prominent furrows, or roughened areas of various shapes, which seem to be characteristic in the different groups. The antennæ are slender and pointed at the distal end, the length usually at least ten times the breadth. In the subfamily *Ambulicinæ* the antennæ are considerably broader and differ markedly in the sexes, approaching somewhat the condition found in the *Saturniidæ*. They generally bear rows of minute tubercles arranged in various ways. The suture between the antenna and the epicranial area is always clearly defined. Owing to the fact that the antennæ are so slender, both eye-pieces are always to be clearly distinguished. The glazed eye-piece does not always form a smooth band around the entire mesal margin of the sculptured eye-piece, but on the contrary, in many species forms an arc or crescent-shaped piece which reaches neither the antennæ nor the caudal margin of the head. The invaginations for the anterior arms of the tentorium are hard to determine.

The maxillæ reach the greatest development in the *Lepidoptera* in certain of the species of this family. Here the length of the maxillæ in the pupæ often greatly exceeds the length of the wings, in some instances being twice their length. This elongation of the maxillary tube is used by the adults in reaching the nectaries at the bottom of long tubular flowers. In most lepidopterous forms in which the maxillæ are longer than the wings of the pupa, the remainder can not be soldered down to the body surface on account of the movable abdominal segments, so this part usually extends free along the meson of the ventral surface of the body. In a number of species the maxillæ extend for some distance beyond the caudal end of the body. This would probably result in serious injury to the sphingid pupa, as all of the forms in which the maxillæ are longer than the wings pupate in the soil. The *Sphingidæ* have provided for the extra length of the maxillæ in three different ways, and as far as my knowledge goes, two of these are peculiar to the pupæ of this family. In some of the genera, as *Deidamia*

(Fig. 8), or *Darapsa* the maxillæ are too long to occupy the space between the labrum and the caudal margin of the wings if they extended straight caudad, so the proximal part of the maxillæ arches away from the body and forms a prominent curve near the cephalic end. In other genera as *Pholus*, (Fig. 7), *Celerio*, *Xylophanes*, etc., the head has been tipped back so the labrum appears on the dorsal surface. This gives some additional length, and, as the wings extend about three-fifths the length of the body, and the segments are lengthened ventrally to accommodate these, it usually is sufficient for the length of the maxilla. In cases where it is not, the proximal part arches out from the surface of the body as previously described. This is true of *Xylophanes tersa*. There are still some pupæ, however, with considerably longer maxillæ, and the method of taking care of this extra length seems to me to have developed from those previously described. It would be rather difficult for the maxillæ to be arched very far from the surface, so the extra length is taken up in a loop at the proximal end. This loop is, in most instances, closely appressed to the ventral surface of the body. In others, as in the common tomato worm pupa (Fig. 3), it is strongly arched, while in *Herse cingulata* the loop is equal in length to the remainder and is recurved (Fig. 2). When one considers that the maxilla is double in the maxillary loop (Fig. 1) it will be seen that in such genera as *Herse*, the maxillæ must be at least one and one-half times the length of the body. The maxillary loop has been referred to by some authors as the raised tongue case, or the jug-handle tongue case, as contrasted to the ordinary type of maxilla (Fig. 5) which was said to be "sunken." Other authors referred to it simply as the tongue case, ignoring the remainder of the maxillæ. In all measurements involving the maxillæ, or the length of wings when comparison is made, the length is always measured from the suture separating the labrum and maxillæ.

CLASSIFICATION.

Strange as it may seem, the spiracular furrows and the maxillæ have proven to be the best characters for separating the pupæ into the various divisions of Rothschild and Jordan. In their "Revision of the Lepidopterous Family Sphingidæ" in 1903 they divide the family into two groups, the *Asemanaphoræ*

and the *Semanaphoræ*. These groups may be distinguished in the pupæ by a very easy character—the presence of spiracular furrows on three abdominal segments, that is 5–7, in the former; and the absence of the furrows from one, two, or all of the segments in the latter. These divisions are further subdivided into subfamilies, and of these we have representatives of five; the Acherontiinæ and Ambulicinæ belonging to the *Asemanaphoræ*; the Sesiinæ, Philampelinæ, and Chærocampinæ belonging to the *Semanaphoræ*. It was found possible to separate the first two subfamilies and the last by well-defined characters; the Sesiinæ and Philampelinæ were more difficult. All of our genera of Sesiinæ except Pseudosphinx seem to fall into a natural group but any character which could be used to separate it from the Philampelinæ is shared by Pholus, and in a less degree by Proserpinus, of that subfamily. The remaining genera of Philampelinæ form a very compact group. Rothschild and Jordan found the same condition in their study of the adults. On page 349 we find “Of all these issues from the ancestral *Semanaphoræ* only one group of genera is sharply circumscribed; it claims the rank of a subfamily. This group, * * * is termed by us the Chærocampinæ. The remaining groups of *Semanaphoræ* are not so obviously distinguished from one another in all their members, owing to the preservation of generalized forms linking the groups together, and to the differences becoming obscured by the recurrence of similar structures in phylogenetically widely different genera.” Owing to this difficulty it seems best not to attempt keys to the subfamilies, but to furnish a key to the genera of the family and then discuss the genera under the different subfamilies of Rothschild and Jordan. The synonymy follows, in the main, Barnes and McDunnough’s Check List which differs slightly from that of Rothschild and Jordan, but is more easily accessible for American students. Some slight changes have been made necessary where it was impossible to separate, or to connect, genera and species in this study.

KEY TO THE GENERA OF SPHINGIDÆ.

- a. Spiracular furrows present on three segments, that is, on abdominal segments 5-7.....(*Asemanaphoræ*)
- b. Abdominal segments 5-7 with either one or two (occasionally a trace of three) spiracular furrows, always with one deep pocket-like furrow (Fig. 2) and a shallower outer one; body always without spines and with a triangular cremaster.....(*Acherontiinae*)
- c. Maxillary loop present.
- d. Maxillary loop with its distal half recurved and touching the proximal portion (Fig. 2).....*Herse* Oken.
- dd. Maxillary loop with its distal half never recurved, its distal end touching the body.
- e. Maxillary loop strongly arched from the surface of the body, the height of the arch always greater than the width of the loop in that region.
- f. Dorsum of abdominal segments 2-8 with a strongly rugose band on the cephalic third, similar to the triangular area on each side of the metathorax.....*Cocytius* Hbn.
- ff. Dorsum of abdominal segments 2-8 punctate; metathorax with a strongly elevated smooth transverse ridge on each side.
Protoparce Burm.
- ee. Maxillary loop never strongly arched from the surface of the body, the space between it and the surface never as great as the width of the loop, usually closely applied to the ventral surface.
- f. Two spiracular furrows present (Fig. 3).
- g. Spiracular furrows 5 mm. or more in transverse length, and extending ventrad of the spiracle for a distance equal to the length of the spiracle; maxillary loop never over 5 mm. in length.
Chlenogramma Sm.
- gg. Spiracular furrows always less than 5 mm. in transverse length, seldom extending ventrad of the spiracle, if so, then for a distance less than the length of the spiracle; maxillary loop in most species over 5 mm. in length.....*Sphinx* L.
- ff. One spiracular furrow present—the deep inner one.
- g. Maxillary loop extending as far caudad as the distal ends of the prothoracic legs, and occasionally beyond them...*Atreus* Grt.
- gg. Maxillary loop never extending as far caudad as the distal ends of the prothoracic legs.....*Dolba* Wlk.
- cc. No maxillary loop present.
- d. With two spiracular furrows.....*Ceratomia* Harr.
- dd. With one spiracular furrow, the deep inner one.
- e. Maxillæ never more than five-sevenths the length of the wings; body surface polished, the punctures on the abdomen distinct.
Daremma Grt.
- ee. Maxillæ normally more than five-sevenths the length of the wings; body surface dull, the punctures on the abdomen usually obscured by the sculpturing.....*Lapara* Wlk.
- bb. Abdominal segments 5-7 either with three or four more or less interrupted furrows over each spiracle, the surface of the furrows often punctate like the remainder of the cephalic margin (Fig. 5) or with one deep furrow, in which case the body is spinose and the cremaster truncate.
Ambulicinæ
- c. Surface of body spinose; cremaster broad and truncate; one spiracular furrow present.....*Cressonia* G. & R.
- cc. Surface of body smooth; cremaster triangular and pointed; more than one spiracular furrow present.
- d. Maxillæ never half the length of the wings, their length 5-7 mm.; length of pupa usually less than 40 mm., usually slender...*Smerinthus* Latr.
- dd. Maxillæ half the length of the wings, their average length 10 mm., sometimes longer; length of pupa normally over 45 mm., very stout.
Pachysphinx R. & J.

- aa. Spiracular furrows usually present on one or two segments, never on three, often absent. (*Semanophora*)
- b. Spiracular furrows present.
- c. Spiracular furrows usually three or four, separated by carinate ridges, which are never broken and wavy as in Fig. 9, and present on the fifth or on the fifth and sixth abdominal segments. (*Sesiina* in part)
- d. Cremaster sparsely covered with short curved spines on the dorsal and lateral aspects; spiracular furrows present on segments 5 and 6.
Hæmorragia Grt.
- dd. Cremaster never spinose; spiracular furrows only present on segment 5.
Erinyis Hbn.
- cc. Spiracular furrows usually five or six, separated by interrupted, wavy, carinate ridges (Fig. 9) usually present only on the fifth segment, but sometimes on the sixth. (*Charocampina*)
- d. A small portion of the prothoracic femur always exposed; color light brown or coffee color, never with a prominent median dorsal stripe.
Celerio Oken.
- dd. Prothoracic femur never exposed; color grayish or grayish brown with a prominent median dorsal stripe. *Xylophanes* Hbn.
- bb. Spiracular furrows never present. (*Sesiina* in part; *Philampelina* in part)
- c. Body always more than two inches long, labrum either at the cephalic end or on the dorsal surface of the body.
- d. No mandibular tubercles present; body surface highly polished with only a few small punctures; color black, usually marked with red.
Pseudosphinx Burm.
- dd. Mandibular tubercles present; body surface roughened and rather coarsely punctate; color uniform dark brown. *Pholus* Hbn.
- cc. Body always much less than two inches long; labrum usually on the ventral surface, sometimes at the cephalic end of the body.
- d. Body with three prominent projections at the cephalic end, consisting of a very rugose tubercle on the labrum and one mesad of each glazed eye-piece; proximal part of maxillæ excurved and carinate.
Deidamia Clem.
- dd. Body without three prominent projections at the cephalic end, the only prominent tubercles are mandibular.
- e. Abdominal segments 5-7 with one or more interrupted rows of spines along the cephalic margin, more prominent on the dorsal surface.
Darapsa Wlk.
- ee. Abdominal segments without spines.
- f. Mandibular area usually with distinct tubercles, if not distinct, then the appendages roughened with deep sculpturing.
- g. Body surface rough, deeply punctate over the entire surface of the abdominal segments, especially segments 8-10; prothoracic femur never visible. *Amphion* Hbn.
- gg. Body surface smooth and polished, the cephalic portion of the segment with punctures of medium size, the caudal portion finely, sparsely punctate; prothoracic femur always visible.
Proserpinus Hbn.
- ff. Mandibular area without distinct tubercles; surface of appendages not very rough, usually silky or polished in appearance.
- g. Dorsum of eighth abdominal segment with a row of large deep punctures or pits along the cephalic margin; color always light brown with darker markings *Ampelaca* R. & J.
- gg. Dorsum of eighth abdominal segment never with a row of deep punctures or pits along the cephalic margin; color uniform dark brown. *Sphæcodina* Blanch.

Subfamily ACHERONTIINÆ.

This subfamily consists of pupæ which have either one or two spiracular furrows on each of the abdominal segments 5-7. This is the only subfamily in which the maxillary loop is found, although all members of the subfamily do not possess it. The length of maxillæ varies greatly, being longest in the genus *Herse* and shortest in *Ceratomia*. The glazed eye-piece is usually almost hemispherical, bounded along its mesal margin by a smooth impressed line, which usually touches neither the antenna nor the maxilla. The antennæ are filiform, of the same width throughout, except at the pointed tip. Rothschild and Jordan have divided this subfamily into two tribes, the first of which, *Acherontiicæ*, has only one American representative, *Herse*, while all the other genera belong to the *Sphingicæ*. It will be seen from a study of the pupa that *Herse* differs considerably from the other genera. The remaining genera form a remarkably compact group excepting *Ceratomia*, *Daremma*, and *Lapara*, which, however, show very close relationships. They differ principally in the absence of the maxillary loop.

Genus *Herse* Oken.

The species of this genus are characterized by having the maxillary loop doubled back upon itself as shown in Fig. 2. The body is broader at the cephalic end than is customary in this family and the head is bent slightly ventrad, but not so that the labrum is visible. The maxillary loop extends about half way to the distal end of the maxillæ. The prothoracic femur has always a considerable portion exposed. There are always two prominent spiracular furrows on the movable abdominal segments, a deep, pocket-like, mesal one and a longer, shallower, lateral one, with a slight ridge and furrow often visible between the two. The first eight abdominal segments are thickly punctate on the cephalic half. The cremaster is triangular, with the length and breadth about equal; sometimes slightly bifurcate.

But one species of this genus is found in North America. This is a tropical or subtropical species occurring rarely in the temperate regions along the Atlantic coast. The moths sometimes stray as far north as Canada.

Herse cingulata Fabr. (Fig. 2).

Color chestnut brown; body surface smooth and polished, excepting the ninth abdominal segment and the cephalic half of the first eight which are densely punctate; head nearly as broad as long; antennæ transversely striated, a few tubercles along the margin and the elevated flagellum, not extending as far as the prothoracic leg in the female; labrum only visible on the cephalic aspect of the head; mandibular tubercles smooth, scarcely elevated; prothoracic legs with a prominent swelling opposite the exposed portion of the femur; mesothoracic wings extending about three-fifths the length of the body; mesothoracic spiracle with an elevated, black caudal margin which almost conceals the opening; mesothorax prominently excurved along the lateral margin; metathorax with a very rugose triangular, or somewhat cordate area on each side the meson; scar of caudal horn a distinct, slightly depressed smooth area, a longitudinal furrow on the meson and a small tubercle on each side; cremaster deeply rugose. Length 52-62 mm., greatest width 16-18 mm.; length of cremaster 2.5 mm.

Genus Cocytius Hbn.

One species of this genus, *C. antæus*, ranges as far north as Florida and occasionally farther. The pupa is the largest which has ever been examined by the writer and differs from all others examined in having a prominent rugose band on the dorsocephalic portion of the first eight abdominal segments, which is like the rugose areas on the metathorax. These areas on the metathorax are almost identical in shape and sculpturing with those of *Herse cingulata*. Similar sculpturing occurs on the ridge caudad of the mesothoracic spiracle. The maxillary loop is strongly arched from the surface of the body, almost forming a semi-circle, and its distal end is swollen into a prominent bulb. Rothschild and Jordan describe one species of this genus as having a prominently recurved loop of "two and one-half windings." This seems rather peculiar as this loop appears to have generic value in all other cases. In *C. antæus* the lateral margins of the loop are closely set with tubercles, seemingly formed by the transverse constrictions over its surface. According to Rothschild and Jordan the other known species with a similar loop has these prominent markings. The body is fusiform, the labrum visible from the dorsal surface.

Cocytius antæus Dru.

Color chestnut to mahogany brown, with the sculptured areas on the dorsum much darker, and occasional blotches and lines of a darker color; surface smooth and highly polished, except for the bands of sculpturing; maxillary loop extends nearly half the distance to the cau-

dal margin of the wings and touches only at the prominent bulbous tip, prominently arched—the height of the arch about 10 mm.; antennæ extend slightly farther caudad than the prothoracic legs; portion of prothoracic femur exposed, 6–7 mm. long, 1.5 mm. wide; prothoracic leg usually with a prominent elevation on the tibia; inner spiracular furrow about 2 mm. from the outer which is bounded by two carinate ridges making it appear to be three furrows on some of the segments; rugose band of the eighth segment interrupted by the scar of the caudal horn which is smooth and polished; cremaster very rugose, about 4 mm. long, ending in a sharp point. Length of pupa described, 101 mm., greatest width 20 mm.

Genus *Protoparce* Burm.

The species of this genus are the only common pupæ belonging to the so-called "jug-handled" type, thought by many persons to be typical for the family Sphingidæ. The maxillary loop is strongly arched from the surface of the body, usually touching only at the tip, and extending about half the length of the wings. Some of the species of *Sphinx* occasionally have the maxillary loop arched considerably, and when this happens *S. chersis* and *P. sexta* look very much alike. The body is fusiform with the cephalic end rather blunt. The prothoracic femur always has a narrow portion exposed. The movable abdominal segments have two spiracular furrows, a deep pocket-like mesal one and an outer less prominent lateral one.

These pupæ are found in earthen cells in the ground where they winter in the pupal stage. There are two species of this genus found in the temperate zone, *P. quinquemaculatus* and *P. sexta*. The pupæ of these two species vary greatly with regard to the most obvious characters, such as length of maxillary loop, legs, antennæ, etc. The maxillary loop, in the great majority of individuals of *P. quinquemaculatus* is longer and far more strongly arched than in *P. sexta*, but it is not a character which can be used in separating the species, as it varies markedly with the individuals. Such a character was not found until over a hundred specimens had been bred and examined. Then it was discovered that the spiracular furrows provided a constant character. The species, therefore, may be separated as follows:

- a. Spiracular furrows of the fifth abdominal segment always extending ventrad of the spiracle for at least 3 mm.; maxillary loop usually reaching about three-fourths of the distance between the cephalic end of the body and the caudal margin of the wings, strongly arched from the surface, (generally about 5 mm.) and touching only at the tip.....*P. quinquemaculatus*
- aa. Spiracular furrows of the fifth abdominal segment very seldom extending ventrad of the spiracle and then only the lateral furrow, which may extend for about 1 mm. or less; maxillary loop usually reaching for half, or less, the distance between the cephalic end of the body and the caudal margin of the wings, not strongly arched (seldom over 2 mm.), and touching more than at the tip.....*P. sexta*

Protoparce sexta Johan. (Fig. 3).

Color chestnut brown; head, thorax and appendages with very shallow impressed lines, appearing smooth and polished on most of the surface, abdomen punctate, the annulets fairly distinct on all segments; metathorax with a prominent rounded ridge on each side the meson, usually darker than the remainder of the segment; maxillary loop averages 17 mm. in length and extends about half the distance to the caudal margin of the wings; antennæ extend considerably beyond the distal ends of the prothoracic legs, sometimes almost to the mesothoracic pair; spiracular furrows seldom extending ventrad of the spiracles; scar of caudal horn usually elevated and smooth; cremaster 1.5–2.5 mm. long, bifurcate at tip. Length of pupa 45–60 mm., greatest breadth 10–12 mm.

Protoparce quinquemaculatus Haw.

This species differs from the preceding only in the characters given in the key.

Genus **Chlænogramma** Sm.

A single species of this genus is found in eastern North America. It is characterized by the very short maxillary loop, which averages 3 mm., and by two very long spiracular furrows. The body is typically sphingiform, with the labrum visible on the ventral surface. The maxillary loop extends for about one-sixth the length of the maxilla, and is closely applied to its surface. A distinct swelling is always visible on each prothoracic tibia and a small portion of the femur is always exposed. The spiracular furrows are about equal in transverse length, or the inner one is longer. The body is quite strongly sculptured on the head and thorax and less strongly on the appendages, while the abdomen is distinctly punctate with traces of annulets on the dorsal surface. The cremaster is triangular, somewhat longer than broad, deeply rugose and occasionally bifid at tip. The only species is apparently not common and very little has been published regarding its life history.

Chlænogramma jasminearum Bdv.

Color chestnut brown; labrum with an indistinct tubercle in each ventral angle; mandibular area slightly elevated and very rugose; maxillary loop deeply transversely striate, slightly bulbous at distal end, never over 5 mm. in length, usually less; antennæ transversely striate with indications of tubercles along the lateral margins, extending farther caudad than the prothoracic legs; mesothoracic spiracles with slightly elevated black margins; abdominal segments usually showing four indistinct dorsal annulets; scar of caudal horn very small, usually smooth, on an elevated transverse ridge in the middle of the segment; cremaster about 3 mm. long, or less, strongly rugose and usually almost black; length of pupa, 45–48 mm., greatest width 10 mm.

Genus **Dolba** Wlk.

This monotypic genus is also very closely related to *Protoparce*, but more so to *Atreus*. In each of these genera there is only one spiracular furrow present, a very distinct, deep, pocket-like furrow. The body is typically sphingiform, with the labrum mostly on the cephalic aspect of the head. There is a distinct ridge along each lateral margin of the clypeus and labrum, which shows as two small projections at the caudal end in both dorsal and ventral views. This ridge sometimes breaks up into tubercles. The maxillary loop varies considerably in length, from 4 mm. in small specimens, to 8 mm. in the large ones, but is always less than half the length of the maxillæ. The impressed line along the mesal margin of the glazed eye-piece touches the antenna in this genus. The antennæ are slightly elevated, transversely striate, with two rows of tiny tubercles extending for the entire length. The tibia of the prothoracic leg is slightly swollen, but the femur is not exposed. The cremaster is triangular, ending in a smooth cylindrical point, which may be slightly bifurcate at tip.

The species of this genus *Dolba hylæus* is only found in eastern North America so far as known. The larvæ are fairly common on pawpaw in the region around Urbana, Ill., and probably wherever its food plants occur.

Dolba hylæus Dru.

Color yellowish to chestnut brown; head, thorax and appendages with indeterminate wavy striations; abdomen with shallow indistinct punctures on the first seven segments, the remainder distinctly punctate, the dorsal surface showing about three annulets on each segment; maxillary loop deeply transversely striate, the end very slightly bulbous and usually closely applied to the surface, but occasionally slightly elevated at the proximal end, the length between one-third and one-half of the maxillæ; antennæ extending about midway between the proximal ends of the first two pairs of legs; mesothoracic spiracles with black, elevated margins; spiracular furrows as in Fig. 4; scar of caudal horn normally prominent, elevated, usually smoother and darker than the remainder of the segment; cremaster 2 to 2.5 mm. long, rugose, with a smooth spine at the end. Length of pupa 29-37 mm., greatest width 7-8 mm.

Genus **Ceratomia** Harr.

This is one of the genera in which a study of the pupæ does not support the classification based on either the larvæ or adults. The larvæ of the three species usually placed in this

genus differ remarkably from each other. The adults have very much in common and, if separated, Rothschild and Jordan remark that it would necessitate a genus for each species. The pupæ of two of these species, which fall in the same division of the key by Rothschild and Jordan, are remarkably alike, while the third species differs markedly in the spiracular furrows. Since these furrows have proved such valuable aids in the classification, the species have been separated on this basis—*amyntor* and *undulosa* remaining in the genus *Ceratomia*, *catalpæ* being placed under the genus *Daremma*. These are the only two genera known in this region with bodies of normal shape, having a deep spiracular furrow on each of the movable segments and without a maxillary loop. The body is typically sphingiform with the labrum visible in ventral view. The color is chestnut brown. The maxillæ are slightly swollen at the proximal end, and extend at least two-thirds of the distance to the caudal margin of the wings. The tibia of the prothoracic leg is slightly swollen and the femur is not exposed. The antennæ are indistinctly transversely striate and slightly roughened by minute tubercles which are more numerous at the proximal end. The abdominal segments are punctate, and often show distinct annulets. There are two spiracular furrows present, the inner one much deeper. The cremaster is somewhat triangular, longer than broad and sometimes ends in a sharp spine, although it is usually slightly bifurcate.

The two species of this genus resemble each other very closely in size and general appearance. They may be separated as follows:

- a. Maxillæ normally reaching the caudal margin of the wings, occasionally overlaid by the wings at the distal end; mesothorax with the scar of a larval horn on each side of the meson near the middle of the segment. . . . *C. amyntor*
- aa. Maxillæ never reaching the caudal margin of the wings, usually two-thirds of their length; mesothorax never with scars of larval horns. . . . *C. undulosa*

Ceratomia undulosa Wlk.

Appendages mostly transversely striate; all except the wings appearing polished; head and thorax with coarser, irregular sculpturing, appearing dull; abdominal segments thickly, usually finely punctate, the punctures confluent on the first seven segments, larger and distinct on the remainder; annulets showing plainly in some individuals, but scarcely visible in others; maxillæ slightly swollen and deeply striate at the proximal end, extending for about two-thirds the length of the wings; spiracular furrows equal in length; scar of caudal horn smooth,

usually elevated, often with a few radiating lines; cremaster 2.5 mm., in length, very rugose, narrowing to a bifid spine at tip. Length of pupa 45-52 mm.; greatest width 13 mm.

This species is more variable than *amyntor*. Although the abdomen is usually finely punctate, certain individuals show very coarse punctures like *amyntor*. As far as my experience goes the scars on the mesothorax may be relied on to separate the two species, if no other characters were available.

Ceratomia amyntor Hbn.

Body usually dull; the head and thorax with rather deep indeterminate striations and finer striations on the appendages which sometimes appear polished; abdomen with medium or coarse punctures on the first seven segments, these sometimes confluent and interrupted by transverse striations, the remaining segments always coarsely punctate, annulets usually distinct on the dorsum of the segments; maxillæ slightly swollen and striate at proximal end, sometimes for the whole length, and reaching the caudal margin of the wings, though sometimes partially overlaid by the wings at the distal end; mesothorax with a scar of a larval horn prominent on each side the meson about two-fifths of the distance from the cephalic to the caudal margin, each represented by a more or less interrupted series of concentric circles, another pair of scars usually visible near the cephalic margin and a little farther apart than the former, usually elevated; metathorax with a slightly elevated crescentic ridge on each side the meson only distinct in fresh specimens; scar of caudal horn very seldom elevated, smooth and polished; cremaster 3 mm. long, very rugose and slightly bifid at tip. Length of pupa 45-50 mm., greatest width 13 mm.

Genus Daremma Grt.

The pupæ of this genus are normally very much smaller and more slender than those of *Ceratomia* and the entire surface appears polished. The segments are not so deeply punctate and the punctures are smaller and less numerous on the caudal half. There are few, if any, of the transverse striations which were present in the species of *Ceratomia*. There is no maxillary loop and the maxillæ do not reach the caudal margin of the wings. The antennæ are indistinctly transversely striate and have a single row of minute tubercles along the middle line. The prothoracic legs usually show slight swellings and occasionally a very narrow portion of the femur is exposed on one side. There is but one deep spiracular furrow present, the outer, shallow one present in *Ceratomia* is lacking here. The cremaster is triangular, narrowed to the tip, which is sometimes slightly bifurcate.

This genus, as defined here, consists of a single species, *D. catalpæ*, the catalpa sphinx, which is a common pest wherever these trees are found. The larvæ enter the soil to pupate.

Daremma catalpæ Grt. (Fig. 4).

Color yellowish to chestnut brown; head and thorax with fine indeterminate transverse striations, these practically absent from the abdomen which shows fine scattered punctures on the first seven segments, more numerous on the cephalic half and on the remaining segments; annulets usually distinct on the first three abdominal segments; each abdominal segment usually shows some fine longitudinal furrows on the dorso-meson at the cephalic margin; maxillæ five-sevenths of the length of the wings, ending just beyond the mesothoracic legs; proleg scars very prominent on the venter, usually depressed rounded areas; metathorax with a slightly curved transverse furrow in the middle of the segment on each side of the slightly elevated median line; scar of caudal horn slightly elevated and punctate like the remainder of the segment, usually having a prominent depressed area just caudad of the elevation; cremaster about 2 mm. long, finely rugose, usually bluntly pointed at tip, sometimes bifurcate. Length 30-35 mm.; greatest width 8-9 mm.

This species seems to be fairly constant in its characters and not so variable as either of the species of *Ceratomia*.

Genus **Atreus** Grt.

This genus is said by Rothschild and Jordan to be "an offshoot from *Protoparce*, or rather from a form (not yet discovered, or extinct) connecting *Protoparce* with *Hyloicus* (*Sphinx*)."
A study of the pupa shows it to be indeed closely connected with the two genera above mentioned. It is separated from *Protoparce* by the flat maxillary loop, which never arches from the surface of the body, and from *Sphinx* by the presence of a single spiracular furrow. The characters separating it from *Sphinx* are practically the same as those separating *Daremma* from *Ceratomia*. The body is typically sphingiform with the labrum at the cephalic end. The labrum is very rugose and has a row of four small tubercles adjacent to the maxillæ, the two mesal ones being more prominent and easily visible at the end of the body in cephalic and lateral views. The maxillary loop is closely appressed to the ventral surface of the body, and reaches slightly more than half way to the caudal margin of the wings. The movable segments have one deep pocket-like spiracular furrow. The cremaster is somewhat triangular, longer than broad and ends in a sharp point.

The genus includes a single species, *A. plebeja*.

Atreus plebeja Fabr.

Color chestnut brown, often marked with black or darker brown blotches in various places; body surface polished except the head, prothorax and parts of the mesothorax which are irregularly sculptured; abdominal segments finely, but rather sparsely punctate excepting along the cephalic portions of the segments; median pair of tubercles on labrum longer than broad, rounded at the tip, the lateral ones shorter and somewhat pointed; maxillary loop about 12 mm. long, not extending as far caudad as the antennæ of either sex, usually as far as the prothoracic legs; scar of caudal horn very distinct, smooth and polished, usually with shallow radiating furrows; cremaster with the proximal half rugose, the remainder smooth and polished, its length about 2.5 mm., ending in a pointed tip, with occasional indications of bifurcation. Length of pupa 40–45 mm.; greatest width 10 mm.

Genus **Sphinx** L.

This genus is very closely related to *Protoparce*, the main difference in the pupæ being in the maxillary loop, which is never strongly arched in *Sphinx*, but closely applied to the ventral surface of the body in most species, or slightly elevated in others. The body is typically sphingiform, with the labrum at the cephalic end of the body and partially visible in ventral view. The antennæ have the surface more or less roughened with minute rounded tubercles, and are transversely ridged, to correspond with the segmentation of the adult. There is a noticeable difference in the length of antennæ in most species. Nearly all of the species show annulets on the dorsum, although only on the cephalic segments in some species. The movable segments have two spiracular furrows, the inner one deep and pocket-like, the outer shallow, both with carinate edges, less than 5 mm. long, and never extending ventrad of the spiracle. The scar of the caudal horn is always present, usually easily distinguished by a smooth area, while the remaining surface of the segment is punctate. Many species have a prominent depression just caudad of the scar. The cremaster is always triangular, longer than broad and bifurcate at the tip in most species. According to Rothschild and Jordan this genus includes thirty species and twenty of these occur in North America. Some of these species are confined to the region west of the Mississippi. Of the eastern species, it has only been possible to obtain pupæ of six. Three of these I have reared many times: *S. chersis*, *S. kalmiæ*, and *S. drupiferarum*. Of the other species live pupæ were purchased and one or two allowed to emerge.

Two other species were reared to the pupal stage but adults were not obtained. These may be *S. ligustri* and *S. canadensis*, but it seems better not to describe them at this time from a single pupa, without being sure of the identification.

The six common species described here may be separated as follows:

- a. Maxillary loop less than 6 mm. long and extending one-fourth or less the distance to the caudal margin of the wings; surface of antennæ roughened with four or five rows of minute tubercles.
 - b. Maxillary loop 3-4 mm. long, averaging 3 mm., extending less than one-fourth, usually one-fifth, the distance to the caudal margin of the wings.
 - bb. Maxillary loop 5-6 mm. long, averaging 5 mm., extending one-fourth (or perhaps slightly more) of the distance to the caudal margin of the wings.
 - S. luscitiosa*
 - S. gordius*
 - aa. Maxillary loop always more than 6 mm. long and extending for more than one-fourth the distance to the caudal margin of the wings; surface of antennæ with less than four distinct rows of tubercles.
 - b. Maxillary loop closely applied to the ventral surface of the body; large, stout pupæ normally over 45 mm. long.
 - c. Transverse carinate ridge of metathorax prominent, extending at least half way across the segment; maxillary loop 13-15 mm. long, usually extending half the distance to the caudal margin of the wings; antennæ extending at least half way between the tips of the prothoracic and mesothoracic legs.....*S. chersis*
 - cc. Transverse carinate ridge of metathorax inconspicuous, extending less than half way across the segment; maxillary loop 9-11 mm. long, usually extending two-fifths of the distance to the caudal margin of the wings; antennæ seldom extending beyond the tips of the prothoracic legs.
 - S. drupiferarum*
 - bb. Maxillary loop touching the surface of the body only at the bulbous tip; smaller, slenderer pupæ, generally less than 40 mm. long.
 - c. Maxillary loop 7.5-8 mm. long, extending about one-third of the distance to the caudal margin of the wings; antennæ extending to, or slightly beyond, the tips of the prothoracic legs.....*S. kalmia*
 - cc. Maxillary loop 9.5-10 mm. long, extending nearly half the distance to the caudal margin of the wings; antennæ extending at least half-way between the tips of the prothoracic and mesothoracic legs.....*S. eremitus*

Sphinx luscitiosa Clem.

This species differs so little from *S. gordius* that a detailed description is scarcely necessary. Its color differs somewhat, being a bright brown and occasionally is marked with black blotches. The maxillary loop is 3-4 mm. long, usually 3 mm., and usually strongly curved. It seldom extends as much as one-fourth the length of the wings, usually one-fifth, sometimes less. It appears slightly flattened, without any enlargement at the end, and is seldom so deeply striate as *S. gordius*. The circular area of sculpturing on the proximal part of the maxillæ has not yet been observed. The scar of the caudal horn is usually made prominent by a deep concavity behind it, but this varies somewhat. The cremaster is not as rugose as *S. gordius* and seldom shows lateral projections. The length of pupa is 33-38 mm., the greatest width 9 mm.

***Sphinx gordius* Cram.**

Color very dark brown; head, thorax and appendages roughened with sculpturing, mostly transverse striations; abdominal segments finely punctate with wavy impressed lines between the punctures; maxillary loop 5-6 mm. long, usually 5 mm., extending for at least one-fourth the distance to the caudal margin of the wings, with deep irregular, transverse striations, usually excurved and slightly bulbous at tip; proximal portion of maxillæ more deeply sculptured, usually a circular area outlined on either side the maxillary loop; antennæ with four or five irregular rows of tubercles which cover the entire surface, those of the female extending about as far caudad as the prothoracic legs, while those of the male extend half way between the distal ends of the prothoracic and mesothoracic legs; prothoracic legs slightly swollen opposite the distal end of the maxillary loop; scar of caudal horn slightly elevated and punctate like the remainder of the segment; cremaster 3.5 mm. long, slender, the proximal part rugose, usually with sharp points on the lateral margins, the distal part smooth and ending in a sharp point. Length of pupa 38-42 mm., breadth 9 mm.

***Sphinx chersis* Hbn.**

Color bright yellowish brown or chestnut brown, rarely with black blotches; head, thorax, and appendages roughened with deep wavy impressed lines, mostly transverse striations, and indistinct flattened tubercles; abdominal segments thickly punctate with wavy impressed lines between the punctures; lateral margins of the labrum very clearly defined and the clypeo-labral suture sometimes distinct, with two distinct, flattened tubercles on the clypeus adjacent to it; maxillary loop 13-15 mm. long, averaging 14 mm., and usually extending half the distance to the caudal margin of the wings, usually closely applied to the ventral surface of the body, sometimes very slightly elevated; antennæ variable as to markings, but oftenest showing one row of minute tubercles along the median line for at least part of the distance and never having more than two rows, and never having the lateral margins elevated; antennæ of female extending half-way between the distal ends of the prothoracic and mesothoracic legs, those of the male considerably farther, often to the distal end of the mesothoracic legs or beyond; sometimes a small portion of prothoracic femur exposed; metathorax seldom with a median ridge, but with a prominent carinate ridge on each side the meson extending at least half way across to the margin of the wing, usually darker in color than the remainder of the segment; scar of caudal horn smooth and polished, usually more distinct than in the preceding species, with a prominent concave area just caudad of it; cremaster about 2.5 mm. long, slightly longer than broad, rugose and bifurcate at tip. Length of pupa 50-58 mm., greatest width 13 mm.

Some authors have reported pupæ less than 50 mm. I have reared a great many of these from the egg and have never had them smaller, but have no doubt that the observation was correct as many factors influence the size of the pupa.

Sphinx drupiferarum A. & S.

Color dark purplish brown, the purple tinge more apparent in fresh pupæ; head, thorax and appendages roughened with deep, wavy impressed lines and indistinct tubercles, the latter most evident in the region of the clypeus and labrum; abdomen punctate, with the punctures larger on the cephalic third of segments 1-6 which is slightly elevated, and on the remaining segments, the punctures extending on the ventral surface; maxillary loop 9 or 10, rarely 11 mm. long, extending about two-fifths the distance to the caudal margin of the wings; surface of antennæ almost covered near the proximal end with indistinct tubercles which are scarcely visible on the distal half, the lateral margins very slightly elevated and often bearing a distinct row of minute tubercles; antennæ of male usually extend as far caudad as the prothoracic legs, those of the female shorter; mesothorax with an elevated median ridge, and an inconspicuous transverse ridge on either side of it near the cephalic margin of the segment, which never extends half-way across; scar of caudal horn smooth, with a concavity just caudad; cremaster 3-3.5 mm. long, longer than broad and slightly bifurcate at tip. Length of pupa 47-53 mm., greatest width 11 mm.

Alcoholic specimens of *S. drupiferarum* are rather hard to separate easily from *S. chersis*, because both become very dark brown or nearly black if the latter are placed in alcohol when nearly mature. The easiest way, if one has seen both species, is to examine the metathoracic ridges. The length and sculpturing of the antennæ usually will furnish a reliable means of separation, although the length does vary somewhat.

Sphinx kalmiæ A. & S.

Color bright reddish brown, sometimes marked with black; body appearing polished, the sculpturing shallow; head and thoracic segments slightly roughened with impressed lines; abdominal segments punctate with wavy impressed lines between, the punctures larger on the cephalic part of segments 1-8 and interrupted by short longitudinal depressions; maxillary loop 7.5-8 mm. long, extending one-third of the distance to the caudal margin of the wings, slightly raised from the surface and touching only at the bulbous tip; antennæ with a distinct row of small tubercles extending along the median line for about two-thirds of the length, the lateral rows very indistinct or wanting; antennæ in both sexes nearly of equal length extending to, or very slightly beyond, the prothoracic legs; scar of caudal horn not very distinct, identified by a smooth polished area; cremaster 2-2.5 mm. long, very rugose, shallowly bifurcate at tip. Length of pupa 35-45 mm., greatest width 9 mm.

Sphinx eremitus Hbn.

Color chestnut brown, often marked with black; body surface polished, the sculpturing as in *S. kalmia*; maxillary loop 9.5–10 mm. long, extending nearly half the distance to the caudal margin of the wings, slightly elevated from the body and touching only at its bulbous tip; antennæ with two indistinct rows of small tubercles along the median line, these often confluent so as to form an elongate tubercle; antennæ of female extending half way between the distal ends of the prothoracic and mesothoracic legs, those of the male a little longer; metathorax with a low but distinct, carinate ridge on each side the meson which extends nearly half way across the segment; scar of caudal horn slightly elevated, smooth and polished, usually without a concave area caudad; cremaster 3 mm. long, slender, slightly rugose and ending in a smooth sharp point. Length of pupa 35–38 mm., greatest width 9 mm.

Genus **Lapara** Wlk.

This genus is very closely related to *Daremma* as far as pupal characters are concerned. It has no maxillary loop and but one spiracular furrow. Normally the species of *Lapara* are smaller than *Daremma*, but the individuals of approximately the same size are rather hard to distinguish. The scar of the caudal horn is not very distinct in *Daremma*, being punctate as the remainder of the segment, so this very important character in the larva is not very helpful in the pupa, except that in *Daremma* the characteristic depression caudad of the scar is practically always present. The entire surface of the pupa appears polished in *Daremma* with fine scattered punctures on the abdominal segments. In *Lapara* the surface appears dull and the punctures on the abdominal segments are almost obscured by the impressed lines. The wings, too, are deeply sculptured in *Lapara*, but almost smooth in *Daremma*. The body in *Lapara* is typically sphingiform with the labrum always on the ventral surface. There is no maxillary loop and the maxillæ extend nearly to the caudal margin of the wings. The glazed eye-pieces are a little larger than in the members of the subfamily previously studied, and the impressed line on the mesal margin touches both antenna and maxilla. The antennæ are roughened with irregular rows of minute tubercles. The swelling of the prothoracic legs, which is so noticeable in most members of the subfamily, is very slight in both species of this genus. The cremaster is always longer than broad and ends in a sharp point. This genus includes two North American species

which resemble each other very closely. Indeed they are so closely related as to make one doubt that there are two species here. Unfortunately it has been impossible to breed these species so that all data is obtained from purchased specimens. The individuals vary almost as much from each other as the species do. For example, the maxillæ in some individuals of *L. coniferarum* instead of extending to the caudal margin of the wing, as they appear to do normally, are overlaid by the wings so that they are apparently shorter and like a typical *bombycoides*. The following are the characteristics which seem best to separate the two species:

- a. Annulets distinct on the first three abdominal segments; punctures larger on the dorsum of the cephalic half of abdominal segments 1-7; spiracles with width more than twice the length.....*L. coniferarum*
- aa. Annulets not distinct on the first three abdominal segments; punctures scarcely larger on the dorsum of the cephalic half of abdominal segments 1-7; spiracles with width about twice length.....*L. bombycoides*

Lapara coniferarum A. & S.

Color chestnut brown, usually with black blotches; surface of body dull; head, thorax and appendages with rather deep impressed lines making the surface rough; abdomen punctate, the punctures considerably larger near the cephalic margin of the first six segments and obscured by impressed lines, the remaining segments distinctly punctate, with the punctures more nearly of uniform size; labrum elevated, usually rugose; mandibular area elevated forming irregular tubercles; maxillæ normally reaching the caudal margin of the wings, but sometimes overlaid by the wings near the distal end; antennæ of male extending as far caudad as the prothoracic legs, those of the female a little shorter; median line distinct on the thorax, generally carinate on the prothorax; abdominal segments 1-3 with very distinct annulets; scar of caudal horn never present; cremaster slightly rugose, 2 mm. long, ending in a minutely bifurcate spine. Length of pupa 25-32 mm., greatest width 6-7 mm.

This species is exceedingly variable, especially in regard to the sculpturing of the body.

Lapara bombycoides Wlk.

This species varies but slightly from the preceding. It is usually a little larger so far as observed. The body seems to be a little smoother especially on the wings, which are not sculptured so deeply, and on the abdominal segments where the punctures are not much larger on the cephalic margins of the segments 1-7, nor on the remaining segments. The annulets are not distinct on any of the segments. The spiracles are a little smaller and more circular than in the preceding species. Length of pupa 30-35 mm., greatest width 6 mm.

Subfamily SMERINTHINÆ.

There are but three American genera belonging here, *Smerinthus* (including *Paonias*), *Pachysphinx* and *Cressonia*. These differ from all other sphingid pupæ in the possession of short maxillæ and broader antennæ than is usual. They approach more nearly to the saturnian type of pupa, and many of them have been reported as spinning cocoons. The labrum is in the position normal to all lepidopterous pupæ. They show no trace of the prothoracic femur and are in that respect more specialized than most of the *Archerontiina*æ. The eye-pieces are very like the preceding subfamily except that they usually touch at one point. The antennæ vary in the sexes being longer and wider in the males. The spiracular furrows which are three or four in number, punctate, and separated by interrupted ridges, are almost identical in all of these pupæ except *Cressonia*, which has only one deep spiracular furrow, thus showing kinship with the *Acherontiina*æ. *Cressonia* is not very closely related in many respects to this group, and seems to be a rather aberrant form. Its maxillæ and antennæ, however, show that it belongs here.

Genus *Smerinthus* Latr.

It has been impossible for me to find any characters which will serve to separate the genus *Smerinthus* from *Paonias*, so all species have been included under one generic name. The species are so extremely variable that it is impossible to give a species description which will fit all the individuals, and makes it exceedingly difficult to separate them. The head, thorax and appendages are somewhat roughened with impressed lines, and the abdomen has both punctures and impressed lines, yet in most cases the body presents a polished appearance. The labrum is always on the ventral surface. The maxillæ are short, only about one-third the length of the wings and there is no maxillary loop. The antennæ are fairly constant in length in most of the species. They are a little shorter and narrower in the female than in the male. In the female their greatest width is about equal to that of the prothoracic legs. Both prothoracic and mesothoracic legs as well as the metathoracic wings meet on the meson caudad of the maxillæ. The thorax usually has a slightly elevated median line, most prominent on the meta-

thorax. The spiracular furrows are very shallow. The outer furrows are sparsely punctate, while the inner ones are practically obscured by large deep punctures, very close together so as to appear honeycombed, an extension of the punctate area on the dorsal cephalic margin of each movable segment. The cremaster is triangular, scarcely longer than broad and usually very rugose.

The following key may help to separate these species:

- a. Pupæ 35-43 mm. in length; greatest width, 11 mm.....*S. excæcata*
- aa. Pupæ of smaller size.
 - b. Greatest width, 8 mm. or less; body of nearly uniform sculpturing; smooth band along cephalic margin of abdominal segments 5-7, usually sparsely punctate or wrinkled.....*S. astylus*
 - bb. Greatest width at least 9 mm.
 - c. Spiracles about 1 mm. across.....*S. myops*
 - cc. Spiracles less than 1 mm. across, usually .5 or .6 mm.
 - d. Antennæ varying in the sexes, those of the female shorter and not extending as far caudad as the prothoracic legs; surface of antenna elevated and either smooth or with one row of minute tubercles.
 - S. jamaicensis*
 - dd. Antennæ not varying in the sexes, in neither sex extending much farther caudad than the maxilla; surface of antennæ roughened with three or four interrupted rows of minute tubercles.....*S. cerisyi*

***Smerinthus jamaicensis* Dru.**

Color chestnut brown or darker, occasionally marked with black; surface polished and glossy; head, thorax and appendages with shallow impressed lines, mostly transverse, the abdomen with rather coarse punctures more distinct on segments 1-3 and 8-10, an irregular row or two of larger punctures along the cephalic margins of segments 1-7, these so close together on the movable segments as to give it a honeycombed appearance; segments 4-7 with the punctures connected and obscured by irregular impressed lines; segments 5-7 with a slightly elevated smooth, polished area on the dorsum just caudad of the larger punctures along the cephalic margin; maxillæ short, extending a trifle over one-third the distance to the caudal margin of the wings; antennæ of male longer and broader than those of the female, in the male extending almost as far caudad as the mesothoracic legs, in the female not as far as the prothoracic pair; surface of antennæ either smooth or with one row of minute tubercles on the median line; scar of caudal horn slightly elevated, with a slight concavity just caudad of it; cremaster very rugose with short projections along the lateral margins, ending in a blunt point, and frequently curved slightly dorsad. Length of pupa 30-35 mm., greatest width 9 mm.

***Smerinthus cerisyi* Kirby.**

The only constant difference found between this species and the preceding one is that the antennæ do not show sexual variation and in neither sex do they extend as far caudad as the prothoracic legs. The surface is roughened with about three rows of minute tubercles in

addition to the transverse striations found in both species. This species is apparently a little larger, being from 32–37 mm. long and about 9 mm. wide. I have never bred this species and have only a few pupæ, but these characters were constant for the individuals examined.

Smerinthus excæcata A. & S.

This species is so variable that it is impossible to write a detailed description that would fit better than the description of *S. jamaicensis* which it strongly resembles. The sculpturing varies very much. The color is usually a bright brown, but varies from chestnut to a very dark brown. The antennæ vary in the sexes, those of the male extending about half way between the distal ends of the prothoracic and mesothoracic legs, while those of the female are considerably shorter and do not nearly reach the tips of the prothoracic legs. The species may always be distinguished by its large size, being both longer and stouter than any of the closely related species. The length is from 35–43 mm., greatest width 11 mm.

Smerinthus myops A. & S.

This is normally easily distinguished from the other species included in the genus *Paonias*, on account of its size but it is exceedingly difficult to separate from *S. jamaicensis* and *S. cerisyi*. The only constant character found so far is the size of the spiracles, those of *myops* being a millimeter across, but in the other two species scarcely more than half of this. The color of *myops* varies greatly, but is often a deep purplish brown, which color has not been noticed in other species of the genus. The antennæ vary with the sex, as in *S. jamaicensis*, extending slightly farther caudad than the maxillæ in the female, and as far or farther than the prothoracic legs in the male. The sculpturing of the antenna varies greatly in this species. The length is from 30–36 mm., greatest width, 9 mm.

Smerinthus astylus Dru.

This species is more slender than *myops*, so far as observed, never being over 8 mm. in greatest width. The sculpturing is usually not so deep as on the other species and does not obscure the punctures on any of the abdominal segments. The smooth area along the cephalic margin of segments 5–7 is usually wrinkled or sparsely punctate, and never as distinct as in other species. The punctures on the abdominal segments are never as close together, and the body is more uniformly sculptured throughout. Length of pupa 30–35 mm., greatest width 7.5–8 mm.

Genus **Pachysphinx** R. & J.

The pupæ of this genus very strongly resemble some of the Saturniidae. The body is broad in proportion to its length and of practically the same width throughout, being narrowed but very little at the cephalic end. The surface is rather coarsely sculptured and shows distinct annulets on the dorsum of the abdominal segments. The labrum is on the ventral surface.

The shallow spiracular furrows are almost obscured by coarse punctures. The scar of the caudal horn is never prominent, and sometimes not distinguishable. The cremaster is short and somewhat quadrangular, usually ending in a very short, sharp point.

There is a single species of this genus in North America, *P. modesta*, which ranges from Atlantic to Pacific, mostly in the northern half of the United States.

***Pachysphinx modesta* Harr. (Fig. 5).**

Color varies from chestnut brown to almost black; surface of head, thorax and appendages roughened by very deep, interrupted, transverse impressions and fine granulations making it dull, the abdomen coarsely punctate, with annulets on the dorsum, but appearing polished, the cephalic margins of the segments always more densely punctate; clypeo-labral suture always distinct; antennæ of female with a single row of tubercles, extending as far caudad as the prothoracic legs, those of the male without tubercles and extending as far as the mesothoracic legs; maxillæ extend about two-fifths of the distance to the caudal margin of the wings. The cremaster is very rugose, occasionally triangular, and 2 mm. or less in length. Length of pupa 40-50 mm., usually about 50, greatest width 13-15 mm.

A pupa of *P. modesta imperator*, bred by Mr. H. H. Brehme, of the New Jersey Entomological Co., showed no perceptible difference from the species.

Genus ***Cressonia*** G. & R.

The pupæ of this genus differ markedly from all other sphingids and should always be very easily distinguished. The body is somewhat of the saturnian type, but flattened ventrally on abdominal segments 7-10. The surface of the body is rough and spiny, and always appears dull. The clypeo-labral suture is distinct. The antennæ have a row of spiny tubercles along the median line and do not differ in the sexes. There is but one deep spiracular furrow which extends both dorsad and ventrad of the spiracles. The cremaster is short, broader than long, truncate at the tip.

This genus consists of a single species, *C. juglandis*, which is found almost everywhere in the United States east of the Mississippi and extends into Canada. As far as pupal characters go, it seems intermediate between *Smerinthus* and *Pachysphinx* of the *Ambulicinae* and *Lapara* and *Daremma* of the *Acherontiinae*.

***Cressonia juglandis* A. & S.**

Color varies from reddish brown to nearly black, always dull and opaque; surface of body roughened with spines which are larger along the caudal margin of abdominal segments 4-7 and on the antennæ; head with six spiny tubercles, two between the bases of the antennæ, two on the clypeus and one on either side between the clypeus and glazed eye, almost in line with the clypeal tubercles; clypeo-labral suture distinct; antennæ in both sexes extending as far caudad as the prothoracic legs; maxillæ extending for a little more than one-third of the distance to the caudal margin of the wings; abdominal segments showing annulets on the dorsum, segments 4-7 with a prominent lateral ridge covered with curved spines which project cephalad; segments 9-10 with longitudinal wrinkles on the dorsum; scar of caudal horn very prominent with a rounded spiny elevation just laterad on each side; cremaster 1 mm. or less long, the caudo-lateral angles usually produced into sharp points. Length of pupa 28-38 mm., greatest width 9 mm.

Subfamily SESIINÆ.

The members of this subfamily in America belong to the genera *Pseudosphinx*, *Hæmorrhagia*, and *Erinnyis*. *Pseudosphinx* does not have any spiracular furrows, whereas the other genera have them extending for a considerable distance dorsad and ventrad of the spiracle. The members of this subfamily, in common with *Pholus* and *Proserpinus*, have a very peculiar type of ridge on the mesothorax, caused mostly by the deep furrows which surround it. The general type of body is the same in these genera, differing markedly from the remaining genera of *Philampelinæ*. The labrum is sometimes on the cephalic end of the body, but oftener pushed back on the dorsal surface. The antennæ are filiform and may vary slightly in length in the sexes, but not otherwise. The eye-pieces are much like the *Acherontiinæ*, except that they come nearer to touching the maxillæ. The *Sesiinæ*, and the two genera of *Philampelinæ* which resemble them, all have another character in common, a portion of the prothoracic femur exposed, showing them to be more generalized than the remainder of the *Philampelinæ*. This is only present in some individuals in *Hæmorrhagia*, which is in other respects by far the most specialized of the group.

Genus *Pseudosphinx* Burm.

The pupæ of this genus are typically sphingiform. The head is visible mostly on the dorsal surface. The labrum is only visible in cephalic view, and the clypeo-labral suture is never wanting. The maxillæ extend from the cephalic end of the body to the caudal margin of the wings and are slightly swollen and excurved at the proximal end. Each mandibular region is slightly elevated into a low tubercle, and these are visible at the end of the body in ventral view. The antennæ are slightly elevated along the flagellum. The metathorax has a prominent ridge and the median line is also elevated. There are no spiracular furrows present. The cremaster is triangular, ending in a slightly bifurcate tip.

Pseudosphinx tetrico L.

Color black in alcoholic specimens, living ones marked with red, occasionally with red predominating, but usually marked with red on the transverse conjunctiva and on the head, thorax and appendages, particularly on the ventral surface; body surface smooth and glossy, with very faint impressed lines, but scarcely punctate except along the cephalic margin of the movable segments; abdominal segments showing annulets and somewhat wrinkled dorsally; antennæ smooth, slightly longer in the male, those of the female extending just beyond the prothoracic legs; exposed portion of prothoracic femur 3-4 mm. long, the greatest width, .5 mm.; cremaster finely rugose, 4 mm. in length, slightly broader than long with a distinctly bifurcate point at tip. Length of pupa 65-75 mm., greatest width 15 mm.

Genus *Erinnyis* Hbn.

In this genus the body is typically sphingiform and the females are very much larger than the males. The labrum is only visible at the cephalic end of the body. The maxillæ extend to the caudal margin of the wings. The antennæ are slightly longer in the male and extend beyond the prothoracic legs, while those of the female seldom do. There are four or five shallow spiracular furrows on the fifth segment, separated by carinate ridges, but there are none present on the other movable segments. The abdominal segments are thickly punctate along the cephalic margin, and this area is slightly elevated. The scar of the caudal horn is small and variously indicated, usually by a slight elevation and radiating furrows. The cremaster is triangular but not bifurcate at tip.

This genus consists of a number of species which may be found in Florida and two of these at least are found farther north, *E. alope* and *E. ello*. These species may be separated as follows:

- a. Predominating color usually red; cephalic portion of abdominal segments with the punctures mostly confluent; cremaster longer than broad. . . . *E. alope*
- aa. Predominating color usually black; cephalic portion of abdominal segments not usually confluent; cremaster with length and breadth equal. . . . *E. ello*

***Erinnyis alope* Dru.**

Color orange red or vermilion, marked with black, the proportion of color varying; head, thorax and particularly the appendages marked with longitudinal stripes; abdomen with two transverse rows of black dashes more or less united on the ventral surface, a black stripe along the caudal margin and a black dot on either side the meson between the rows of dashes, these dots occasionally modified into dashes; spiracles ringed with black; body smooth and polished; surface of head and thorax with fine transverse striations, these scarcely visible on the appendages; abdominal segments with an elevated punctate band along the cephalic margin of segments 2-7, the punctures denser and confluent on 5-7, the remainder of the surface almost smooth except near the spiracles where it is transversely striate; maxillæ extending over the curve of the head at their proximal end and to the caudal margin of the wings; antennæ extending to the distal end of the prothoracic legs in the male, a little shorter in the female; exposed portion of prothoracic femur about 5 mm. long and .5 mm. broad; metathorax with ridges as in *Pseudosphinx*; spiracular furrows about 6 mm., long, extending both dorsad and ventrad of the spiracle; annulets faintly indicated on the first three abdominal segments; scar of caudal horn usually a smooth, circular, polished area with finely radiating furrows; cremaster very finely rugose, 2 mm. long, not quite as broad. Length of pupa 50-60 mm., greatest width 13 mm.

***Erinnyis ello* L. (Fig. 6).**

This species differs but little from the preceding species except that it usually has less red and this is a darker red, so that the black markings do not show so plainly. In fact the pupa appears to be black, rather than red. There is a distinct black dash instead of a dot normally present between the two rows of black dashes on the abdominal segments. The annulets are much more distinct in this species, being visible on all the segments. The punctures along the cephalic margins of the segments are not usually confluent as in *alope*. The cremaster has the length and breadth equal, about 2 mm. Length of pupa 43-53 mm., greatest breadth 11-13 mm.

Genus *Hæmorrhagia* Grt.

In this genus the body is typically sphingiform, considerably narrowed at the cephalic end, and the labrum is visible only in

dorsal and cephalic views. The maxillæ extend to the caudal margin of the wings. The antennæ are slightly elevated along the flagellum, and length and breadth appear equal in both sexes. There is often a small portion of the prothoracic femur exposed, but this is usually so narrow as to scarcely be noticed. The pupæ of this genus differ from all the others examined, except *Celerio gallii*, in having spiracular furrows on two abdominal segments, five and six, while the others have them on either one or three segments or not at all. *Celerio gallii* has short, interrupted ridges separating the furrows. There are four or five long furrows which extend for an almost equal distance dorsad and ventrad of the spiracles. The body is sculptured practically all over the surface, except the scar of the caudal horn which appears polished. The cremaster is triangular, longer than broad, coarsely punctured and bears numerous hooks curved caudad with a larger double hook at the distal end. The pupæ of this genus are among the few which are found in cocoons. The larvæ drop to the ground to pupate and fasten bits of leaves or other debris together with silk to form the cocoon. The larvæ of *H. diffinis* have been so abundant on snowberry and various bush honeysuckles in Urbana as to be a serious pest.

It is extremely difficult to separate the pupæ of this genus. *H. thysbe* and *H. diffinis* are both common species and after rearing hundreds of them I hesitate to attempt a key to separate these two common species. The larvæ are very variable as to coloring and often difficult to distinguish on this account. The pupæ of *H. diffinis* are slightly smaller, averaging 25 mm., but are so variable in size that this factor counts for little. They are not so much excurved ventrally, but this difference is hard to put into exact measurements. The greatest width of *H. diffinis* averages 7 mm., of *H. thysbe* 8 mm. The description of *H. diffinis* will be given, as more specimens have been reared of that species.

Hæmorrhagia diffinis Bdv.

Color varying from dark reddish brown to brownish black, with a lighter conjunctiva on the movable segments, this difference nearly always visible in alcoholic specimens; body surface dull, somewhat shagreened, the head, thorax and abdominal segments roughened with impressed lines, mostly transverse, the abdominal segments finely, thickly punctate, with the punctures mostly confluent, conjunctivæ

smooth and silky in appearance; prothoracic femur sometimes showing a narrow portion about 1.5 mm. long; antennæ roughened, with transverse striations, scarcely tuberculate, extending half way between the distal ends of the prothoracic and mesothoracic legs; metathorax with a prominent transverse ridge set off by a distinct furrow on each side; abdomen sometimes showing traces of annulets on the first three segments; cremaster 1.5-2 mm. long, rugose and punctate. Length of pupa 20-27 mm., greatest width 6-7 mm.

Subfamily PHILAMPELINÆ.

Of the genera comprising this subfamily, *Pholus* and *Proserpinus* have been discussed in connection with the *Sesiinæ*. The remaining genera, *Ampelœca*, *Darapsa*, *Sphecodina*, *Deidamia*, and *Amphion*, together with *Proserpinus* are included in one tribe by Rothschild and Jordan while *Pholus* is in another. I can scarcely understand the position of *Proserpinus*, but as so few of these forms have been available for study, hesitate to express an opinion. With this exception the group consists of rather short, somewhat "stumpy" pupæ, with the labrum usually near the cephalic end of the head, but not carried over on the dorsal surface. The maxillæ always reach the caudal margin of the wings, but are often excurved at the proximal end. The antennæ are normal. There is never any portion of the prothoracic femur visible, except in *Darapsa* and *Pholus*. The glazed eye-piece usually touches both antenna and maxilla. There are no spiracular furrows present.

Genus *Pholus* Hbn.

The pupæ of this genus are among the largest of our common species, normally two inches or more in length. The body is typically sphingiform with a distinct "shouldered" appearance, and always bright chestnut brown. The labrum is on the dorsal surface a short distance from the cephalic end of the body, so that the maxillæ rise on the dorsal aspect of the head and extend to the caudal margin of the wings. The mandibular region usually shows a prominent tubercle on each side the labrum and these are prominent in dorsal view. The antennæ are filiform and slightly longer in the male. A small portion of the prothoracic femur is always exposed. The metathorax has a prominent transverse ridge on each side the meson. The scar of the caudal horn is always smooth and polished. The cremaster is triangular and usually ends in a sharp point.

There are seven species of *Pholus* in North America but only two of these are common in the east. These species may be separated as follows:

- a. Head longer than broad as seen in lateral view, the distance from the cephalic margin of the glazed eye to the anterior end of the body three times or more the length of the eye-pieces.....*P. achemon*
 aa. Head broader than long as seen in lateral view, the distance from the cephalic margin of the glazed eye-piece to the anterior end of the body twice the length of the eye-pieces.....*P. satellitia pandorus*

***Pholus achemon* Dru. (Fig. 7).**

Proximal part of maxillæ, head and thorax roughened with indeterminate transverse striations, or often somewhat granular, the appendages usually smooth and polished, abdominal segments coarsely densely punctate on the cephalic margin, but more sparsely punctate on the remainder; head noticeably narrowed as seen in ventral view; in lateral view the distance between the cephalic margin of the glazed eye-piece and the cephalic end of the body is at least three times the length of both eye-pieces; antennæ scarcely tuberculate, sometimes with a minute, mesal row on the proximal half, a little longer in the male, extending to, or slightly beyond, the distal ends of the prothoracic legs; portion of prothoracic femur exposed about 4 mm. long and 1 mm. wide; annulets seldom distinct on the abdominal segments; scar of caudal horn smooth and polished; cremaster rugose 2-3 mm. long, longer than broad, but variable as to breadth. Length of pupa 50-65 mm., greatest width 12-13 mm.

***Pholus satellitia pandorus* Hbn.**

Body stouter than in *P. achemon*, head not so much narrowed as seen in ventral view, in lateral view the distance from the cephalic margin of the glazed eye-piece to the end of the head is about twice the length of the eye-pieces; head, thorax and usually the appendages roughened with striations and impressed lines, sometimes finely granular, abdominal segments coarsely punctate, more densely punctate along the cephalic margin; antennæ usually smooth, sometimes with minute tubercles mesad of the median line, longer in the male extending to, or in some male specimens one-third of the distance between the distal ends of the prothoracic and mesothoracic legs; annulets usually distinct on the dorsum of the abdominal segments; cremaster triangular, variable as to width, ending in a sharp point which is somewhat bifurcate. Length of pupa 52-65 mm., greatest width 14-15 mm.

Genus *Ampelœca* R. & J.

The pupæ of this genus belong to the small number among lepidopterous pupæ which are not dark brown or black, but instead a very light brown or coffee color with darker markings. They are not of the typical sphingid shape but rather blunt at the cephalic end, and the labrum is always on the ventral

surface. The maxillæ reach the caudal margin of the wings. There is never any portion of the prothoracic femur exposed. The antennæ are slightly broader on the cephalic half. There is a conspicuous row of large punctures extending along the dorsal cephalic margin of the eighth segment, which has not been noted in any of the other sphingid pupæ studied. The scar of the caudal horn is smooth and polished, occasionally showing a small tubercle on each side the meson.

This genus includes two species in North America which may be separated as follows:

- a. Abdominal segments 7-10 tapering gradually to a point, somewhat triangular in outline; cremaster triangular, bifid at tip.....*A. myron*
- aa. Abdominal segments 8-10 rounded abruptly at end of body, almost semi-circular in outline; cremaster a sharp spine scarcely broader at the proximal end.....*A. versicolor*

Ampelœca versicolor Harris.

Color grayish or coffee color often with a pinkish tinge, sometimes darker in mature pupæ, dotted with black, the eye-pieces and spiracles conspicuously black; body rather stout and more cylindrical than is typical in sphingid pupæ, rounded abruptly at the caudal end; surface of body dull and roughened with wavy impressed lines, with fine punctures on the cephalic margin of each movable segment and around the spiracles; abdominal segments 8-10 coarsely punctate; antennæ extending as far caudad as the prothoracic legs; distinct spiracular furrows not present, the region cephalad of the spiracles finely punctate with no indication of ridges; cremaster 2-3 mm. long, a slender sharp spine, not noticeably wider at the proximal end. Length of pupa 35-40 mm., greatest width 10 mm.

Ampelœca myron Cram.

Color usually light brown finely dotted with black, the eye-pieces, spiracles and conjunctiva of the movable segments black or dark brown; surface of body dull, roughened with wavy impressed lines, abdominal segments 1-7 distinctly, finely punctate with much coarser punctures on the remaining segments; antennæ extending as far caudad as the prothoracic legs; distinct spiracular furrows not present, but a series of low interrupted ridges are distinctly visible over the spiracles of the fifth segment; cremaster about 2 mm. long, triangular, much longer than broad and slightly bifurcate at tip. Length of pupa 30-38 mm., greatest width 9-10 mm.

Genus *Darapsa* Walk.

The pupæ of this genus differ markedly from those of the genus *Ampelœca*. They are the only sphingid pupa examined in this study excepting *Cressonia* which have rows of spines on

the segments. As far as other characters are concerned, it resembles *Deidamia* most closely, as it has a low tubercle mesad of each eye-piece and the proximal part of the maxilla prominently excurved, but scarcely carinate. Each mandibular area has a low, indistinct tubercle which is visible in ventral view. The maxillæ extend to the caudal margin of the wings. A small portion of the prothoracic femur is exposed. The antennæ are similar in the sexes. The scar of the caudal horn is more rugose than the remainder of the segment. The cremaster is triangular and sharply pointed. This genus includes a single species *D. pholus*. The species has been commonly known in this country as *Ampelophaga chærilus*.

Darapsa pholus Cram.

Color light brown to darker brown, mottled with darker brown or black, somewhat resembling the coloring of *Ampelocæa* species, spiracles and conjunctiva black; entire surface of body dull and roughened with wavy impressed lines, the sculpturing deeper on the head, thorax and appendages; abdominal segments 5-6 with two or three interrupted rows of spines on the dorsum, becoming a single row near the spiracles, segment 7 with one row on the dorsum, but more near the spiracles; the spines very small on the ventral surface; annulets faintly indicated on the dorsum of segments 1-3; segments 8-9 punctate, the ninth segment almost smooth; antennæ almost smooth, without prominent tubercles, extending a little farther caudad than the prothoracic legs; portion of prothoracic femur exposed about 1.5 mm. long and .5 mm. wide; cremaster rugose, about 3 mm. long, triangular, longer than broad, usually slightly curved and ending in a sharp point. Length of pupa 35-37 mm., greatest width 9 mm.

Genus **Sphecodina** Blanch.

The pupæ of this genus have a longer cremaster in proportion to their size than most other pupæ of the family except *Amphion*, where it is twice as long as broad. The body is sphingiform but stout, with the labrum visible in ventral view. The maxillæ extend to the caudal margin of the wings. The antennæ are similar in the sexes and are a little wider on the cephalic half. The metathorax has a transverse furrow extending about half-way across the segment. The scar of the caudal horn is always easily distinguished. The cremaster is triangular, and pointed at the distal end, with length and breadth approximately equal.

***Sphecodina abbotti* Swains.**

Color chestnut brown or darker, usually darker on the dorsum, and somewhat mottled, especially on the appendages; surface dull, the head, thorax and appendages with fine impressed lines, the abdomen punctate, the punctures of medium size and connected on the first six segments with impressed lines; annulets indicated on the first five abdominal segments, the ninth usually quite smooth and polished; scar of caudal horn usually elevated, smooth and polished; cremaster rugose, 3 mm. long, ending in a sharp point. Length of pupa 35–40 mm., greatest width, 9 mm.

Genus *Deidamia* Clemens.

The pupæ of this genus are very easily distinguished by the three prominent projections on the head, the excurved, carinate proximal portion of the maxillæ and the very coarse punctures on the caudal abdominal segments. The body is somewhat fusiform with the labrum at the cephalic end. The labrum bears the median projection of the head, a very rugose, usually blunt tubercle. The lateral tubercles are also rugose, pointed and situated just mesad of the eye-pieces. The maxillæ are of the usual type, distinctly carinate on the proximal third and extend to the caudal margin of the wings. The antennæ are similar in the sexes and bear a prominent row of tubercles along the median line. The scar of the caudal horn is prominent. The cremaster is triangular and pointed. On all the pupæ examined there were prominent projections on the ventral surface of the tenth abdominal segment, apparently the remains of the anal prolegs.

***Deidamia inscriptum* Harr. (Fig. 8).**

Color variable, fresh pupæ often light brown with darker brown on the appendages and dorsum, others very dark brown all over; surface of head and prothorax with deeper, broader sculpturing than is usual on pupæ; mesothorax and metathorax and appendages almost smooth with shallow sculpturing; abdominal segments punctate, the punctures very deep and coarse on the cephalic margins of the first seven segments and on segments 8–10, punctures finer and sparser on the remaining parts; antennæ extend as far caudad as the mesothoracic legs; spiracles prominent with smooth elevated rings; scar of caudal horn usually smooth, often with prominent radiating furrows; cremaster scarcely 2 mm. long, very rugose with a smooth tip. Length of pupa 30–33 mm., greatest width 9 mm.

Genus **Amphion** Hbn.

In this genus the caudal half of the body is much narrower and more tapering than the typical sphingid, indeed more than any of the other sphingid pupæ examined. This, together with the long pointed cremaster and the small tubercles at the cephalic end, are quite distinctive. The labrum is at the cephalic end of the body and the maxillæ extend to the caudal margin of the wings. The scar of the caudal horn is easily recognized. The cremaster is about twice as long as broad and ends in a sharp point, which is occasionally bifid at tip.

Amphion nesus Cram.

Color uniform dark brown; surface of head, thorax and appendages dull, considerable roughened, with deep, wavy transverse furrows near the cephalic end, abdomen punctate, the punctures large and confluent on segments 1-4, lunate on 5-8, and deeper circular punctures on 8-10; mandibular tubercles nearly always prominent; antennæ of female extending half way between the tips of the prothoracic and mesothoracic legs, those of the male slightly longer; prothoracic femur never visible; maxillæ very rugose at cephalic end; cremaster rugose, usually 4 mm. long. Length of pupa 32-37 mm., greatest width 8-9 mm.

Genus **Proserpinus** G. & R.

The pupæ of this genus are small and slender, averaging about an inch in length. They are typically sphingiform, with the labrum at the cephalic end of the body, not visible in ventral view. There are prominent mandibular tubercles visible in ventral view at the end of the body. The maxillæ are of the usual type and extend to the caudal margin of the wings. The antennæ are filiform and apparently do not differ in the sexes. There is always a small portion of the prothoracic femur exposed. There are no spiracular furrows present, the cephalic margin of each movable segment is punctate like the adjacent portion. The scar of the caudal horn may usually be identified but is not very distinct. The cremaster is narrow and triangular, ending in a sharp point.

There are probably only three species of *Proserpinus*, two occurring in this region, and it has only been possible to obtain pupæ of *P. juanita* and *P. gauræ*. These are found in the southern part of the United States. As only one specimen of *P. gauræ* was obtained its variations could not be noted. It seemed to differ from *P. juanita* in one important particular which I

should hesitate to use were it not for the fact that the figure in Smith and Abbott's "Lepidopterous Insects of Georgia" shows the same characteristic.

- a. Head bent forward ventrally, the proximal part of the maxilla considerable swollen so that the ventral margin of the body as seen in lateral view is prominently excurved at the cephalic end.....*P. gauræ*
 aa. Head never bent forward ventrally, the proximal part of maxilla only slightly swollen and the ventral margin of the body as seen in lateral view is practically straight.....*P. juanita*

So far as it is possible to observe from a single specimen, the only differences in the two species are listed above. It is therefore necessary to give but the description of *P. juanita*. The specimen of *P. gauræ* Strecker examined was 28 mm. in length and the greatest width was 6 mm.

Proserpinus juanita Stkr.

Color chestnut brown sparsely dotted with black; surface of head and thorax with very shallow impressed lines, fainter on the appendages, appearing polished, abdominal segments punctate, 2-7 more densely punctate along the cephalic margin and over nearly the cephalic half of the segment, 8-10 over the entire segment; mandibular areas each with a distinct tubercle, prominent in ventral view; maxillæ slightly swollen near the proximal end; antennæ vary in length somewhat though this is not a sexual difference apparently, in some they extend as far caudad as the prothoracic legs, in others half way between the prothoracic and mesothoracic legs; portion of prothoracic femur exposed about 2 mm. long, less than .5 mm. broad; metathoracic ridge black, often wrinkled; scar of caudal horn often a distinct tubercle, at other times scarcely apparent; cremaster 2-3 mm. long, often slightly bifurcate. Length of pupa 27-33 mm., greatest width 6-7 mm.

Subfamily CHEROCAMPINÆ.

The only common American genera belonging here are *Xylophanes* and *Celerio*. They have a number of spiracular furrows, separated by wavy interrupted ridges. They are long, slender pupæ with the wings extending for about three-fifths the length of the body. The prothoracic femur is exposed in *Celerio*. The antennæ vary but little in the sexes, and only in length. The maxillæ extend to the caudal margin of the wings and are sometimes excurved at the proximal end. The eye-pieces are very much like those of the *Acherontiinae* and usually do not extend nearly to the maxillæ.

Genus *Xylophanes* Hbn.

The pupæ of this species are of very much the same shape as those of the genus *Pholus*, but are very different in their coloring, those of *Xylophanes* being a dirty grayish or clay color with darker markings while the pupæ of *Pholus* are uniform dark brown. The pupæ of *Xylophanes* also lack the prominent "shoulders" of *Pholus*, and are generally typically sphingiform. The labrum is on the dorsal surface of the body. The maxillæ are of the usual type, and extend to the caudal margin of the wings. The antennæ of the male are longer than those of the female. There is no portion of the prothoracic femur exposed. There are spiracular furrows on the fifth segment. These are very shallow and separated by low, interrupted carinate ridges. The scar of the caudal horn may usually be identified. The cremaster is narrow and triangular, ending in a sharp point.

There are four species of this genus which may occur in this region but only one is common. The larva of one of these species is described, but according to Rothschild and Jordan the early stages of the other two are unknown. *Xylophanes tersa* is found in the southern part of the United States and has been collected in Illinois.

Xylophanes tersa L.

Color grayish or grayish brown, with an interrupted black median line on both dorsal and ventral surfaces, broad and more distinct on the dorsal surface, spiracles deeply ringed with black so that they form a row of large round spots, remainder of surface variously marked with black; entire surface of body with very fine, mostly transverse striations giving it a silky appearance, the abdominal segments also showing fine punctures; maxillæ prominently excurved at the proximal end; antennæ of male extending as far caudad as the prothoracic legs, those of the female always considerably shorter; spiracular furrows very shallow, extending over the whole cephalic margin of the segment down to the spiracles and separated by fine, more or less wavy, interrupted carinate ridges making the surface appear very rough, the furrows extending farther dorsal than ventral of the spiracle; cremaster 2-3 mm. long, about half as wide at base and ending in a sharp point. Length of pupa 40-50 mm., greatest breadth 10 mm.

Genus *Celerio* Oken.

The pupæ of this genus also strongly resemble those of the genus *Pholus*, perhaps more so than those of the preceding genus, as *Celerio* has very prominent mandibular tubercles in

one species and lacks the excurved proximal portion of the maxilla. It may always be distinguished when fresh by its very light brown color, and the darker alcoholic specimens are readily separated by the spiracular furrows of the fifth abdominal segment. In this genus there is one inner, deeper furrow with four or five shallower interrupted furrows between it and the spiracle. The body is typically spingiform. The eye-pieces differ somewhat from most of the nearly related pupæ as the glazed eye-piece with its median impressed line extends only about two-thirds of the distance between the antenna and the maxilla. The maxillæ are of the usual type and extend to the caudal margin of the wings. The femur of the prothoracic leg is visible. The antennæ are slightly longer in the male. The scar of the caudal horn is usually elevated. The cremaster is triangular, longer than broad, and ends in a sharp point, which may be slightly bifurcate.

There are two species of this genus found in Eastern North America, *C. lineata* and *C. gallii*. According to Rothschild and Jordan, we have the subspecies *C. gallii intermedia* in this country. The only specimen of the latter which I have seen was bred by Dr. Edith M. Patch, of the Maine Agricultural Experiment Station, and kindly loaned by her for this study. The larva was found feeding on Galium in that state.

The species may be separated as follows:

- a. Mandibular tubercles very prominent on the dorsal aspect of the head; head pointed, the length and breadth approximately equal.....*C. lineata*
- aa. Mandibular tubercles scarcely elevated, never prominent; head blunt, the breadth much greater than the length.....*C. gallii intermedia*

Celerio lineata Fabr. (Fig. 9).

Color usually very light brown or coffee color, often marked with irregular blotches of darker brown; head, thorax and appendages roughened with indeterminate transverse striations very much deeper at the proximal end of the maxillæ, abdominal segments deeply punctate, the punctures larger along the cephalic margin and usually confluent over the entire segment; labrum on the dorsal surface of the head, slightly elevated adjoining the maxillæ; mandibular tubercles very prominent; antennæ of female extending as far caudad as the prothoracic legs, those of the male extending half way between the tips of the prothoracic and mesothoracic legs; exposed portion of prothoracic femur about 2 mm. long and .5 mm. broad, the tibia prominently elevated adjacent to it; spiracular furrows present only on the fifth segment, the ridges between carinate, wavy and broken, extending from the inner furrow to the spiracle; scar of caudal horn usually a slight elevation with

radiating furrows; cremaster 2 mm. long, rugose at base, the distal half smooth, bifurcate at tip. Length of pupa 40-50 mm., greatest breadth 10-11 mm. The pupæ of this species have been reared a number of times from larvæ found feeding on the common purslane. They enter the soil to pupate.

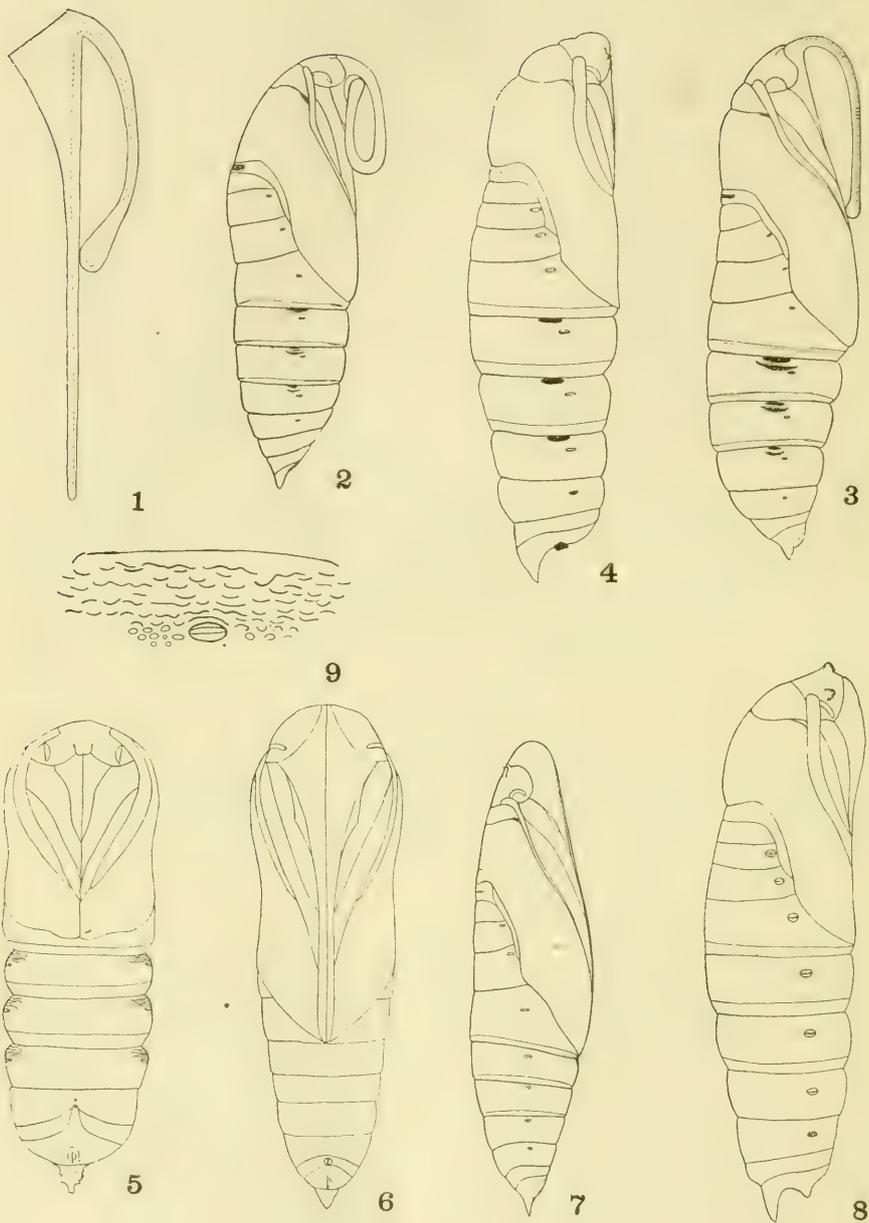
This is said to be the only cosmopolitan species of Sphingidæ.

Celerio gallii intermedia Kirby.

Color light brown, with darker brown appendages and darker punctures and blotches on the abdomen; head, thorax and appendages sculptured with indeterminate transverse striations, rather coarser than in *lineata*, abdomen punctate, the punctures somewhat confluent, and partly obscured by the sculpturing; labrum at the cephalic end of the body, not at all elevated; mandibular area scarcely elevated and not forming distinct tubercles; antennæ of female not extending as far caudad as the prothoracic legs; exposed portion of prothoracic femur 1-5 mm. long and less than .5 mm. broad, the tibia not elevated adjacent to it; spiracular furrows present and distinct on segments 5-6, with a trace of them on 7, the ridges separating them wavy, broken and carinate, extending from the inner furrow to the spiracle; scar of caudal horn indistinct; cremaster 2-5 mm. long, about half as broad, rugose nearly to the pointed tip. Length of pupa 48 mm., greatest width 10 mm.

EXPLANATION OF PLATE XXXVI.

- Fig. 1. Maxilla of *Sphinx* sp., showing its doubling and the extreme length.
Fig. 2. *Herse cingulata*, lateral view.
Fig. 3. *Protoparce sexta*, lateral view.
Fig. 4. *Daremma catalpæ*, lateral view.
Fig. 5. *Pachysphinx modesta*, ventral view.
Fig. 6. *Erinnyis ello*, ventral view.
Fig. 7. *Pholus achemon*, lateral view.
Fig. 8. *Deidamia inscriptum*, lateral view.
Fig. 9. *Celerio lineata*, spiracular furrows.



RECORDS OF JAPANESE CRANE-FLIES (DIPTERA).

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The crane-fly fauna of Japan is a very interesting one but much remains to be ascertained before we can possess a clear conception of the actual faunal constituents of the islands. The published records are grievously incomplete and comparatively few extensive collections have been made. Some years ago (Canadian Entomologist, July, 1913,—July, 1914) the writer published a series of six papers on this subject. Since that time additional material has come to hand principally through the kindness of Dr. Akio Nohira and Dr. T. Miyake and the more interesting records included in this material are given herewith to supplement our knowledge of distribution. A few *Limnobiinæ* are redescribed in order to make their descriptions more available to American students, the original descriptions having been published in Japan in a publication not readily accessible to all students.

As is to be expected a large proportion of the known Japanese crane-flies are referable to genera that are characteristically Holarctic (*Limnobia*, *Tricyphona*, *Eutonia*, *Crypteria*, *Liogma*, etc.). Others are referable to groups with a wide or cosmopolitan distribution (*Dicranomyia*, *Geranomyia*, *Discobola*, *Erioptera*, *Gonomyia*, *Eriocera*, *Nephrotoma*, *Tipulæ*, etc.). A considerable element is clearly derived from the Oriental fauna through migrations from the south (*Libnotes*, *Conosia*, *Nesopeza*, *Ctenacroscelis*, etc.). The very interesting relationship of the fauna and flora of Japan and the Eastern United States, strikingly shown in many widely-separated groups of plants and animals is indicated in the Tipulidæ by the genus *Oropeza* Needham, at present known only from the eastern States and Japan. The subgenus *Iloplolabis* (*Erioptera*) indicates a somewhat similar condition although representatives also occur in the western States.

Ptychoptera japonica Alex.

Mt. Takao, Musashi, May 15, 1913 (T. Miyake).

Kioto, April 12, 1914 (Nohira).

Dicranomyia depauperata Alex.

Kioto, April 18, 1914 (Nohira).

Male.—Length, 5 mm.; wing, 6.6 mm.

Female.—Length, 6.2 mm.; wing, 7.8 mm.

Rostrum and palpi pale yellowish-brown. Antennæ with the scape yellow, the flagellum pale yellowish-brown. Head yellow.

Thorax dull yellow, with distinct greenish reflections, especially on the dorso-pleural membrane and near the coxæ. Halteres with the stem greenish, the knobs darker. Legs pale with the femora slightly greenish, the terminal tarsal segments brown. Wings with the veins and membrane pale, subhyaline. Venation: *Sc* short, ending before the origin of the arcuated sector; cell 1st *M*₂ closed; basal deflection of *Cu*₁ at the fork of *M*.

Abdomen brownish-yellow, tinged with greenish, the apices of the segments more yellowish.

In life it is probable that the insect is quite greenish.

Limnobia avis Alex.

Takuhara, Province Shinano, September 4, 1915 (Nohira).

Male.—Length, 12.5–15 mm.; wing, 13.5–18.5 mm.

Rostrum and palpi dark brownish-black. Antennæ pale brownish-yellow. Head dark brown, the genæ paler brown.

Mesonotal præscutum obscure yellow, with three dark brown stripes, the median one broadest, indistinctly bisected by a reddish line; lateral stripes very short, not reaching the suture; scutum dull yellow, the lobes brown; scutellum and postnotum largely brown. Pleura dark brown and pale whitish-yellow. Halteres pale. Legs with the fore coxæ brown basally, yellow apically; remaining coxæ and the trochanters yellowish; femora yellowish, the tips broadly brown; tibiæ brownish yellow, narrowly tipped with brown; tarsi light brown. Wings yellowish, deepest on the costal region; veins and cross-veins narrowly seamed with brown, especially at the origin of the sector and along the cord; stigma largely pale. Venation: *Rs* angulated or spurred at origin; *r* at the tip *R*₁. Tip of the wing obtuse.

Abdomen with the four basal tergites yellow, with broad median and narrower lateral stripes; terminal tergites dark brownish; sternites similar, the four basal segments yellow, brownish laterally; terminal segments dark brown; hypopygium largely yellowish. The dorso-pleural appendage produced cephalad in a sharp point, the entire sclerite suggesting the head and beak of a bird.

Limnobia avis flavo-abdominalis Alex.

No specific locality, labeled March, No. 32.

Female.—Length, 13 mm.; wing, 13.4 mm.

Similar to the typical *avis*, differing as follows; Smaller. The head yellow with two, linear, brown, subparallel marks on the vertex; stripes on the præscutum represented only by two median black marks at the anterior end and four similar marks near the suture; scutal lobes black in the centers; legs yellow except the tips of the femora, which are very narrowly brown; abdomen clear yellow throughout.

Libnotes nohirai Alex.

Iwate, June, 1916.

Female.—Length, 10.5–13 mm.; wing, 15–17.4 mm.

Rostrum and palpi dark brown. Antennæ with the scape brown, the flagellum clear light yellow throughout. Head brownish-gray, clearer gray along the inner margin of the eyes.

Pronotum elongate, dark brown above. Mesonotal præscutum light brownish-yellow, whitish pollinose with four brown stripes, the median one extending the length of the sclerite, the lateral pair very short; scutum brown, lobes darker; scutellum and postnotum dark brown, sparsely gray pruinose. Pleura yellowish, the mesopleura slightly gray pruinose, darkest on the mesosternum. Halteres elongate, yellow, the knobs a little darker. Legs yellow, tips of the femora broadly black, tips of the tibiæ narrowly darkened; the last three tarsal segments and tips of the other two dark brown. Wings with a yellow tinge basally, more grayish distally. Veins, especially costa, bright yellow, except where they traverse dark spots, where they are brown; cross veins and deflections of veins, the radial sector and second anal vein narrowly seamed with dark brown. Venation: basal deflection of *Cu*₁ short, about as long as *r-m*.

Abdomen yellowish, the tergites more or less distinctly trivittate with dark brown.

Limnophila (Eutonia) satsuma (Westw.)

Kioto, May 10, 1914 (Nohira).

Limnophila japonica Alex.

Mount Tateyama, July 28, 1914 (Nohira).

Limnophila inconcussa Alex.

Kioto, April to June, 1916 (Nohira).

Limnophila (Prionolabis) submunda Alex.

Kioto, May 4 to 18, 1914 (Nohira).

Male.—Length, 6–6.5 mm.; wing, 7.8–8 mm.

Female.—Length, 7.2 mm.; wing, 8 mm.

Rostrum, palpi, head and antennæ black.

Thorax black, sub-shining. Halteres yellow. Legs with the coxæ and trochanters blackish; femora dull brownish-yellow basally, the tips broadly blackened, these dark tips broadest on the fore femora, where they include the outer two-thirds, narrowest on the hind femora where they include the apical third; remainder of the legs black. In the female the black apices are more extensive on all the legs and the femora are stouter, more clavate. Wings grayish-yellow, brighter yellow basally, and on the costa; stigma distinct, elongate-oval, dark brown; cross veins and deflections of veins seamed with pale brown. Venation as in *L. munda* O. S. (Eastern United States).

Abdomen black; valves of the female ovipositor rusty.

Limnophila (Prionolabis) auribasis Alex.

Osaka, April 26, 1914 (Nohira).

Female.—Length, 11.7 mm.; wing, 11.2 mm.

Similar to *L. submunda*, but much larger and more brightly colored. The legs are long and slender, the femora not incrassated as in the female of *submunda*. The basal portions of the femora are bright yellow, the wings are much brighter colored, suffused basally with deep orange.

Eriocera nipponensis Alex.

Kioto, May 28, 1914 (Nohira).

Male.—Length, 12 mm.; wing, 13.3 mm.

Rostrum dull yellow above, the palpi dark brown. Antennæ with the scapal segments conspicuously bright brownish-orange

beneath, darker brown above; flagellum black. Head blackish, with a sparse brownish-gray pruinosity; genæ dull yellowish. Frontal tubercle prominent.

Mesonotal præscutum brownish-gray, with four distinct shiny black stripes, the median pair elongated, narrowed behind, becoming obliterated just before the suture; the remainder of the thorax black, sparsely silvery-gray pruinose, especially on the pleurites. Halteres short, light brown, the knobs darker. Legs with the coxæ blackish-gray; trochanters rusty yellow; femora rusty yellow, the tips blackened, these broadest on the fore femora, narrowest on the hind femora; remainder of the legs dark brown. Wings slightly infumed, the costal cell brownish; stigma small, rounded; indistinct brownish seams along the veins and deflections; an indistinct yellowish spot before the stigma. Venation: *Rs* elongate; cell *M*₁ lacking.

Abdomen black, sub-shiny.

Tricyphona vetusta Alex.

Osaka, April 27, 1917 (Nohira).

Erioptera (Acyphona) asymmetrica Alex.

Kioto, April to June, 1916 (Nohira).

Erioptera (Hoplolabis) asiatica Alex.

Kioto, April to June, 1916 (Nohira).

Female.—Length, 5 mm.; wing, 4.4 mm.

Rostrum and palpi brown. Antennæ dull yellow; apical segments a little more brownish; flagellar segments short-oval. Head yellowish-brown.

Thorax brownish-yellow; if any bloom is present, it is destroyed by emersion in alcohol; the usual brownish stripes present on the præscutum; pseudosutural foveæ distinct, dark brown. Pleura dull yellow, the mesopleura more brownish. Halteres yellow. Legs with the coxæ brown, the posterior coxæ darkest; trochanters dull yellow; femora yellowish, brownish at the tips; tibiæ yellow, narrowly darkened apically; tarsi brown. Wings subhyaline, or whitish, with a heavy brown pattern; about seven brown marks along the costal margin, the largest at the base of the sector, tip of *Sc*₁ and tip of *R*₁, the last at the tip of vein *R*₄₊₅; similar but smaller brown marks along the cross-veins and deflections and along the margin at

the ends of the longitudinal veins. Venation: the spur in cell 1st M_2 completely traverses the cell (as in *E. bipartita* O. S.).

Abdominal tergites yellowish-brown, the lateral margin darker. Basal sternites yellow, the apical sternites more brownish.

Conosia irrorata (Wied.).

Kioto, May 25, 1914 (Nohira).

Crypteria japonica Alex.

No specific data, but possibly Kioto (Nohira).

Female.—Length, 7.3 mm.; wing, 8–8.8 mm.

Rostrum, palpi, head and antennæ light yellow. Antennæ with the two basal flagellar segments united into a fusion-segment, there being twelve segments beyond it.

Thorax yellow. Halteres yellow. Legs yellow, the tips of the femora and tibiæ narrowly darkened; tarsi yellowish-brown. Wings subhyaline; veins brown, the costal and subcostal veins more yellowish, especially near the base of the wings. Venation: *r* barely evident; *Rs* strongly arcuated; second anal veins ending opposite about mid-length of the sector.

Abdominal tergites dull yellow, the basal third to half of the segments brown; sternites yellow.

Nesopeza geniculata, sp. n.

Similar to the genotype, *N. gracilis* (de Meij.) but somewhat smaller (wing of the female, 9.2 mm.). The wings of the teneral type specimen are not fully colored but the distinctive pattern is well indicated. The ground-color is gray, of a paler shade than the dark costal margin which is narrowly bordered behind by a hyaline line; the dark seams along the cord, at the origin of the sector and at the base of the wing are broader; the hyaline spot in cell 2nd R_1 is trapezoidal in shape, not elongate-oval as in *gracilis*; a small hyaline drop in the end of cell R_5 . The venation is quite distinct. The radial cross-vein is but little longer than the tip of R_1 beyond it; the forks of the medial veins are very short and shallow, not of the deep, narrow type of *gracilis*; vein M_1 is no longer than M_{1+2} alone, in *N. gracilis* it is longer than M beyond the *r-m* cross-vein and before the last fork.

Holotype, ♀, Tokyo, Japan, August, 1912 (Kuwana).

In an earlier paper (Can. Ent., Vol. 46, p. 157; 1914) I determined this species as being *N. gracilis* (de Meij.) of Java. Since that time I have seen authentic specimens of *gracilis* and find the present species to be a very different form. The two species constitute a well-marked group that is quite distinct from the only other described member of the genus, *N. pallidithorax* (de Meij.) of Java.

Dictenidia fasciata Coq.

Iwate, July, 1916 (Nohira).

Ctenacroscelis mikado (Westw.).

Kioto, July 7 to 20, 1917; Yoshino, July 29, 1913; Tajima, July 7, 1913 (Nohira).

Tipula nohirai (Mats.).

Ichijoji, Kioto, July 21, 1916 (Nohira).

Akakura, Province Ichigo, August 7, 1914 (Nohira).

Tipula pulveolosa (Mats.).

Shinano, August 3, 1914 (Nohira).

Tipula aino Alex.

Kioto, March to April 12, 1914 (Nohira).

Tipula coquilletti End.

Kioto, April 20, 1914, (Nohira).

Minomo, near Osaka, October 4, 1914 (Nohira).

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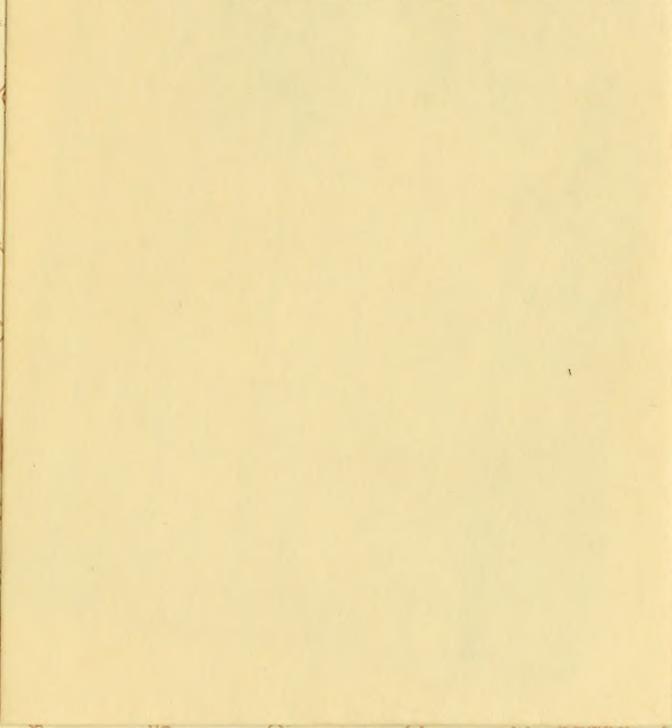
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