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THE EVOLUTION OF THE WEBS OF SPIDERS.

By J. H. Comstock, Cornell University.

ABSTRACT.*

The making of its wonderfully regular web by an orb-weaving spider is a remarkable instance of specialization in habits; and correlated with this are equally remarkable specializations of structure. In the construction of their webs some spiders use several distinct kinds of silk, to produce which several distinct sets of silk glands have been evolved; and to manipulate this silk elaborate spinning organs have been developed.

The tracing of the steps by which these specializations have been evolved must be, in the present state of our knowledge, largely conjectural. We are forced to follow the method commonly employed in constructing genealogical trees. We will look for generalized conditions and from these attempt to trace the evolution of those more specialized.

A very little study by this method is sufficient to show that the web-making habit has not progressed in a single direct line. Beginning with the simplest type of web, we find that this type has been modified in widely different ways in the different families of spiders.

In our search for a starting point we gain no help from a study of other arachnids than spiders. Silk organs are of rare occurrence in the other orders of the Arachnida. It is said that the tailless whip-scorpions carry their eggs in a sac formed of a dark brown transparent material containing some threads; but the source of this material has not been described. It is well-known that the Pseudoscorpions spin silk; but the silk glands of these

*This address, delivered at the annual meeting in Washington, D. C., Dec. 27, 1911, was illustrated by lantern slides made from photographs of the webs described. These photographs are reproduced in a volume on the Arachnida of North America, "The Spider Book," by J. H. Comstock, now in press.

creatures are in the cephalothorax and open through the tips of one pair of jaws, the cheliceræ, while the silk glands of spiders are in the abdomen and open through specialized legs at the opposite end of the body. Any genetic connection that there may be between these two sets of silk organs is too remote to throw any light on the particular problem before us. It is evident that in our study of the evolution of spider webs we are forced to confine our attention to the habits of spiders.

It is probable that the production of silk by spiders was not primarily evolved for the making of webs for capturing prey. The representatives of many families do not spin webs; and there is no reason to believe that these non-web-making families have descended from web-making forms. It seems more probable that the use of silk for making webs for capturing prey is a secondary or tertiary adaptation.

All spiders use silk in caring for their eggs. And it seems probable that this was the primary use of silk in this group of animals.

With some spiders, as *Pholcus*, only a little silk is used for this purpose, merely enough to fasten the eggs together in a ball; with some spiders the habit of making an elaborate egg-sac has been evolved; and many types of these egg-sacs exist. A single illustration of an elaborate egg-sac is sufficient for our present purpose. *Glyptocranium cornigerum* makes an egg-sac, with a vase-shaped outer covering, and fastens it to a twig with bands of silk in a manner which almost suggests human intelligence.

Spiders having acquired silk for the protection of their eggs have utilized it for other purposes, of which the making of webs for capturing prey is but one, and probably not the next one in the sequence of the different uses of this substance.

Many spiders that live in burrows in the ground strengthen the walls of their burrows by a lining of silk. Some of these, the well-known trap-door-spiders close the entrance to their nest by an elaborately constructed lid; and some build a turret over the entrance of their burrow. In the case of the turret spiders we have, I believe, from observations made on one that I kept in confinement in my office for several months, species that build a structure to facilitate the capturing of their prey, the turret serving as a watch tower from which insects invading the region near the nest can be more easily seen.

A much more elaborate provision for capturing prey made by a burrowing spider by prolonging the lining of its tube is the purse-web of *Atypus*.

Another remarkable device to aid in the capture of prey is made by one of the Dysderidæ, the species known as *Ariadna bicolor*. This spider lives in a silken tube built in the hole that serves as a retreat for the spider. This tube is suspended from a frame-work of threads, built at the entrance of the retreat, in such a way that any disturbance of the exposed parts of the nest is communicated to the occupant of the tube. From the frame-work at the entrance of the retreat there extends a series of radiating lines each of which passes over two or more piers which keep it suspended a short distance from the face of the supporting object; so that any insect walking on this object is sure to disturb one of these lines. The touching of one of the trap lines by an insect results like the touching of the spring of a "Jack-in-the-box." The spider comes forth with amazing swiftness, seizes the unlucky insect, and retreats with it instantly to its lair.

Let us pass now from this glance at unusual devices for the capture of prey to a study of the more common forms of spider webs.

How did the web-making habit arise? What were the steps by which the gap between the use of silk for the protection of eggs to its use in the construction of an elaborate web for the trapping of prey was bridged? With our present knowledge our answer can be only an hypothesis.

The most important step I believe to have been the acquiring of the habit of spinning a drag-line, the thread which most spiders spin wherever they go. The first drag-line may have been a thread which a spider was using in the construction of an egg-sac and by which the spider found it could drop from an elevated position to a lower one; from this all of the well-known uses of the drag-line could be evolved.

The complete history of the development of this activity is not so simple, however, as this statement might indicate. For there has been evolved a special kind of silk for use as a drag-line which differs in structure from that used in making egg-sacs and which is secreted by a distinct set of glands. But this is only one of several differentiations that have arisen; for now at

least seven different kinds of silk, each adapted to a special purpose, are spun by spiders.

The step from a drag-line to a web is not a great one. A spider spinning a thread wherever it goes would make a web if by chance it moved about in a limited space as in some nook in which it had taken up its abode. In such a web insects would be trapped, and thus might arise the habit of building webs for the purpose of trapping insects. The simpler webs made by spiders are irregular nets formed of the same kind of silk as that of which the drag-line is made. Such a web is made by *Pholcus*. It consists of a comparatively few threads spun without any regularity of arrangement.

A marked step in advance of the irregular nets of *Pholcus* is illustrated by the regular webs of the sheet-web-weavers, the Linyphiidæ. These are constructed of dry silk, the kind used for the drag-line, but they are of more or less definite form. That of *Linyphia phrygiana* is a flat sheet spun between the twigs of a shrub or a tree. *Linyphia pusilla* makes a horizontal platform between stems of grass and spins an irregular net above it to impede the flight of insects and cause them to fall upon the platform where they can be caught by the waiting spider. *Linyphia marginata* makes a filmy dome beneath which it waits to capture the insects that fall upon it after striking in their flight the irregular net spun above the dome, and *Linyphia communis* spins a bowl-shaped web with an irregular net above and a sheet below it.

A type of web resembling those of the Linyphiidæ in consisting largely of a sheet of silk, but differing in having a funnel-shaped retreat is made by certain members of the Agelenidæ of which the grass-spider, *Agelena nævia* is our most familiar example. A similar web is made in the basement of buildings and in other secluded places by *Tegenaria*.

All of these webs of which illustrations have been shown so far are made of the same kind of silk as that used for the drag-line. Their function is to impede the flight of insects giving the waiting spider time to capture them.

In the course of the evolution of the web-building habit there has been developed in many families of spiders organs for producing a second kind of silk, which being of a viscid nature is fitted to hold fast the entangled insect. The nature of this

viscid silk differs greatly in the different families producing it; and several types of it will be discussed before I close.

Among the spiders that spin a simple web are the members of the Theridiidæ of which the common domestic spider, *Theridion tepidariorum*, is a familiar example. The webs of this spider abound in the corners of neglected rooms, and are nearly as simple as those of *Pholcus*. They probably represent a slight elaboration of the primitive type.

In the family Theridiidæ is found the simplest form of viscid silk, this is merely a viscid liquid which is flung over the entangled prey. But although the silk itself is simple, correlated with its production there has been developed a specialized organ fitted for flinging the silk. This consists of a comb on the tarsus of the fourth legs.

The presence of this comb is a distinctive family characteristic. And the silk is produced by a set of glands, the lobed silk-glands, which have been found only in this family. The Theridiidæ, therefore, judged by their biological features and the correlated anatomical structures represent the tip of a distinct line of specialization.

In the other families of spiders that make use of viscid silk, there is produced a thread or a band that is viscid, and which forms a part of the web.

The webs in the construction of which two kinds of silk are used vary greatly in complexity of structure; and in different families the direction of specialization has been very different.

Two quite different lines of specialization can be recognized. In one group of families the foundation of the web, the part made of dry silk, is comparatively generalized in structure, while there has been evolved a highly specialized band for supporting the viscid silk. In another group of families the foundation of the web is very regular in form, that is to say, highly specialized, while the structure of the viscid silk has remained comparatively simple.

The first of these two lines of specialization, that in which the foundation of the web remains simple while the viscid silk becomes complex is found in a group of families known as the Cribellatæ. These are so called because they possess in addition to the silk glands possessed by other spiders a large number of small silk glands which open through a sieve-like plate, the cribellum, situated in front of the spinnerets. These glands

are supposed to secrete the viscid silk. Correlated with the presence of a cribellum is the presence of a comb of bristles on the metatarsus of the hind legs for manipulating this silk.

It should be noted in this connection that viscid silk is produced by at least three different sets of glands in different families of spiders. By the lobed glands in the Theridiidæ, as already described; by the cribellum glands in the Cribellatæ; and in the orb-weavers to be described later it is obviously produced by some other glands, as these spiders possess neither the lobed glands nor the cribellum glands. Apparently this very useful product has arisen independently at least three times within the order Araneida.

The viscid silk of the Cribellatæ is a band-like structure whose form is partly determined by the combing action of the calamistrum. I have, therefore, termed it the hackled band.

The hackled band of one of the Dictynidæ, that of *Amaurobius* may be taken as an example. This band consists of two parts; first, a supporting structure, which may be termed the warp; and second the viscid silk, which may be termed the woof.

The warp consists of four elastic threads, two of which are straight and two are curled. The woof is a narrow sheet of viscid silk, the edges of which are undulating. It is probable that each undulation was produced by a stroke of the cribellum.

While it is probable that the viscid silk, is spun from the cribellum glands, the threads constituting the warp are doubtless spun from spinning tubes situated on the spinnerets.

Turning to the webs of the spiders that spin a hackled band, we find great differences in the extent to which this band is used and also in the nature of the web of which it forms a part. It is easy to arrange these webs in a series which suggests a possible course of their evolution.

In the Dictynidæ is to be found the simpler types in this series. Here the foundation of the web is irregular, its form depending very largely upon the situation in which it is built. The following will serve as examples:

Dictyna foliacea spins an irregular web of dry silk across the concavity of a leaf; and mingled with the dry threads are strands of viscid silk that have no regularity of arrangement.

Dictyna volucripes spins an irregular web of dry silk upon the stems of herbaceous plants; and upon this foundation stretches its hackled band in comparatively regular ladder-like

frets. In the webs of this species, the larger part of the web is made of dry silk. While the hackled band is doubtless the most efficient factor in the capture of insects, it is still a subordinate part of the web.

In the webs of *Dictyna sublata* the utilization of the hackled band is carried much farther. Here only so much dry silk is used as is necessary to support an elaborate lace-like sheet of viscid silk. This represents the quantitative extreme in the use of viscid silk.

A somewhat similar condition exists in the webs of a species of *Amaurobius* which spins its webs on cliffs.

In the webs of *Hypochilus thorellii* is found the same type of hackled band as in the webs of the Dictynidæ. I have been able to find no differences between the hackled bands of this spider and that of *Amaurobius*. But the web of *Hypochilus* is of regular form being lamp-shade shaped.

It is a remarkable fact that this spider which has retained the most generalized condition of its respiratory organs of all true spiders, being four lunged like the Tarantulas, should have attained the making of a regular web.

While the hackled bands of *Amaurobius* and *Hypochilus* are remarkable structures they lack much of representing the extreme of specialization in this direction. To see this we must examine the web of *Filistata*, a very common house spider in the South. Here the hackled band is composed of four distinct kinds of silk. But the web itself is more simple than that of *Hypochilus*.

Let us turn our attention now to the second of the principal lines of specialization of webs, that in which the attention of the spiders, to speak figuratively, has been devoted to perfecting the foundation of the web, while the viscid silk has remained comparatively simple. The culmination of this line is reached in the webs of the orb-weaving spiders.

There are two families of orb-weaving spiders, the Uloboridæ and the Argiopidæ. In the more typical webs of each of these families the most striking feature is the presence of a central, more or less orbicular part in which the frame-work of the web consists of radiating lines, which in the completed web support the viscid silk. The regular spacing of these radii gives the maximum of stability to the web with the minimum use of material. Most of the webs already described are built against

firm supports. The orb-weavers stretch their webs in mid-air between distant supports. Webs so exposed must be replaced frequently in part at least. It is important therefore that there should be an economical use of the dry silk.

It is only the orbicular part of the web that is renewed at frequent intervals. The outer foundation lines are a permanent investment and are carefully saved.

In the two families of orb-weavers the same type of foundation has been attained. The web of *Uloborus*, so far as its foundation is concerned, closely resembles an argiopid web; but the nature of the viscid silk is very different. The Uloborids possess a cribellum and calamistrum and spin a true hackled band. This, however, is of a comparatively generalized type, the warp consisting of only two straight, elastic threads. The viscid silk is evidently less fluid than that of other families and consequently retains the form given it by the combing strokes of the calamistrum, that is a regular series of overlapping lobes.

A remarkable variation of the uloborid type of web is the triangular web of *Hyptiotes*, which consists of only a sector of a web.

Passing to the webs of the Argiopidæ, we find in the different subfamilies striking variations in the details of the structure of the orb, only a few of which can be mentioned here. But first let us examine the viscid thread.

In these webs where is found the most highly specialized frame-work of dry silk, there is found the simplest type of viscid thread. This consists of a double thread of elastic silk, upon which is poured the viscid silk. This viscid silk, is fluid, and almost immediately the surface tension of this fluid causes it to collect in drops, which are distributed along the elastic support in a very regular manner.

The simplest known orb-web is that of *Theridiosoma*, one of the Argiopidæ. This has few radii and no hub; it is used, however, in a peculiar way, described long ago by Dr. McCook.

Before examining more perfect argiopid webs, I wish to review briefly the steps in the building of an orb-web. These are so well-known that it is only necessary to enumerate them without a detailed description. First the outer frame-work is made; this is a permanent part of the web. In the open space surrounded by this frame-work the radii are then stretched. Upon the radii in the vicinity of the point where they converge

is built the hub of the web, the nature of which varies greatly in the webs of different divisions of the family. Extending from the hub a spiral line is spun upon the radii the turns of which are a considerable distance apart. As the function of this line is merely to hold the radii in place during the later stages of the web building, I have designated it the spiral guy line. This, like all portions of the web made up to this point is composed of dry silk. After the radii have been firmly stayed by the spiral guy line, the spider beginning at the outer edge of the orb and adds the loops and turns of the viscid line, destroying the spiral guy line as it progresses.

Frequently the remains of the spiral guy line can be seen as a series of regularly spaced dots on the radii of completed webs.

Great differences exist in the different webs of orb-weavers as to the relative amount of dry and viscid silk, one extreme is illustrated by the web of *Metepeira;* the other, by the web of *Cyclosa.*

In the webs of most orb-weavers, the entire orb is replaced frequently, only the outer foundation lines being a permanent investment. The spiral guy line is destroyed during the building of the web, the radii and viscid line are sacrificed when it is necessary to renew the orb.

But in the webs of *Nephila* we find that the web is so constructed that it is only necessary to renew the viscid line as it becomes injured or dry.

Here is attained the extreme of economy in the use of the dry silk, although the first investment is somewhat greater than in ordinary orb-webs. The orbicular part of an ordinary orb-web may be compared to a shack built for a day; the orb of *Nephila*, to a permanent structure built to stand during the life time of the occupant.

This difference is brought about by radical differences in the style of architecture. In the orb of *Nephila* the radii are forked, which results in the outer part of the orb being as firm as the central portion. The spiral guy line is attached to each radius lengthwise for a short distance; as this guy line is pulled taut it draws the radius out of its direct course; the course of each radius is, therefore, zigzag. The viscid line is looped back and forth between the turns of the guy line, and gives the web a banded appearance. When the web is repaired only the

old viscid line is removed, the radii and the guy line remaining intact.

An old female *Nephila* which I watched for a number of days at Miami, Florida, carried her economy in the use of silk a step farther. This individual removed the viscid thread of only one half of the web each night, repairing alternate halves on alternate nights.

During the period that this spider was under observation there was a very severe storm, five inches of rain falling in the course of a few hours. When the web was visited on the following morning it was found that it had been repaired throughout.

The steps in the perfecting of the webs of spiders briefly sketched in the preceding pages can be indicated in a tabular form as follows:

WEBS OF SPIDERS.

A. Webs made by spiders that use only dry silk.
  B. Irregular webs ..... **Pholcidæ**
  BB. Regular webs.
    C. The sheet webs ..... **Linyphiidæ**
    CC. The funnel-webs ..... **Agelenidæ**
AA. Webs made by spiders that use both dry and viscid silk.
  B. Webs consisting only of dry silk; the viscid silk being flung upon the prey ..... **Theridiidæ**
  BB. Webs consisting of both dry and viscid silk.
    C. Webs consisting of a comparatively generalized foundation of dry silk and a highly specialized band supporting the viscid silk.
      D. Warp of hackled band consisting of two straight and two curled threads.
        E. Foundation of web irregular ..... **Dictynidæ**
        EE. Foundation of web regular ..... **Hypochilidæ**
      DD. Warp of hackled band consisting of four curled threads and a supporting cord ..... **Filistatidæ**
    CC. Webs consisting of a highly specialized foundation and a comparatively generalized viscid thread or band.
      D. Webs containing a hackled band ..... **Uloboridæ**
      DD. Viscid silk not hackled ..... **Argiopidæ**
        E. Radii and spiral guy line temporary ..... **Most orb-weavers**
        EE. Radii and spiral guy line permanent ..... **Nephila**

NOTES ON THE EASTERN SPECIES OF CERCERIS. (HYM. PHILANTHIDÆ.)

By Nathan Banks.

The species of *Cerceris* are among the prettiest of our entomophilous wasps; usually black, with bands and spots of yellow, of the general appearance of many species of *Crabro*. They are most abundant on flowers in July, some occur in June, and others as late as October. They are not especially shy, so are readily taken in the net.

The sexes are easily distinguished as the male shows seven abdominal segments, while the female has apparently but six. In the male at each side of the clypeal margin is a series of hairs set close together, forming a hair-lobe. In the females of many species the upper part of the clypeus is elevated into various shapes, according to the species. In the female the pygidial area is rather dull, and slightly transversely wrinkled or rugose, with few hairs, while in the male this area is strongly punctate, and hairy.

The characters of value for the distinction and identification of species are the coloration, the punctuation, the breadth of the face, shape of clypeal process in the female, of the clypeal margin and hair-lobes in the male, the length of the second joint of flagellum, and shape of the last joint, the distance of ocelli apart, the sculpture of the triangular area or enclosure at the base of the metanotum, the shape of the basal segment of abdomen, and the pygidial area at tip of body. In a few forms there is a tooth or ridge on each side of mesosternum. The number and spacing of the spines on the hind tibiæ is variable, but sometimes useful.

The color markings, as in other insects, are more or less variable; the spots on the metanotum are especially unstable, while the color of the hind femora is much more constant. All (except one) species have yellow spots or a band on the pronotum, and with one exception there is a yellow band on the second abdominal segment; the face of the male is wholly yellow. The color of the stigma of wings is quite constant, and of considerable systematic value.

The sculpture of the enclosure on metanotum is of great value, but there is some variation observable when one examines a series of one species; however, a considerable difference in

this sculpture seems to be of specific value. It is not always exactly alike in the sexes of a species.

In the tables I have used the coloration as far as possible, not because it is the most important, but because it is easily observable; and the more essential characters are described, or have been described by others.

Most of our species were described many years ago by Mr. Cresson; Packard treated them very briefly in his "Fossorial Hymenoptera"; a few new species have been added by others since, but no synoptic table of the Eastern species. Viereck and Cockerell tabulated the New Mexico species, and Swenk those of Nebraska. Schletterer has revised the European forms, and there are various other tables of local faunæ.

Many other species occur in the Eastern States, and I hope this table will serve to interest others in their collection.

Through the kindness of Dr. Skinner, I have examined the Cresson types in the American Entomological Society at Philadelphia, and wherever I did not already possess the species I have inserted it in the table according to the specimen in the Cresson collection bearing the label, which specimen I consider the type.

A few other species have been described from the Eastern States, principally by Smith, from Florida, and Georgia; his *C. rufopicta* is probably a good species allied to *C. rufinoda*, but much larger. Saussure has described two from Texas which are unknown to me.

MALES.

1. Hind femora pale on base, with a large black spot near apex; rarely spot on scutellum, post-scutellum yellow 19
   Hind femora, mostly dark, mostly pale, or dark on base 2
2. Scutellum not spotted, but post-scutellum yellow; large species; enclosure not transversely rugose 3
   Scutellum marked with yellow 5
3. Wings black; a large lateral spot on each side of face; scape of antennæ black; hind femora and stigma also black ..... **fumipennis**
   Wings sub-hyaline; face all yellow; scape of antennæ yellow beneath; hind femora mostly yellowish; stigma yellow 4
4. Band on second segment of abdomen not emarginate, legs II and III wholly yellow; no tuft of golden hair on last segment ..... **gnara**
   Band on second segment of abdomen emarginate in front, femora II and III black on base; apical segment with tuft of dense golden pubescence each side, basal joint of hind tarsus curved ..... **venator**
5. Enclosure irregularly, transversely rugose; stigma blackish; hind femora mostly black; small, coarsely punctate species 6
   Enclosure more or less smooth, or longitudinally striate 9
6. Basal segment of abdomen mostly reddish 7
   Basal segment black, sometimes with a spot or band of yellow 8
7. Band on second segment of abdomen not emarginate ..... **rufinoda**
   Band on second segment emarginate in front ..... **blakei**

8. Face wholly yellow ..... **finitima**
   Face with a large black spot each side between clypeus and base of the mandibles ..... **finitima nigroris**
9. A yellow band or spots on the vertex; scutellum, post-scutellum, and the metanotum with yellow; legs almost wholly yellow; enclosure mostly smooth 10
   No spots nor band on the vertex 11
10. First segment mostly yellow, second segment yellow on base; vertex with a band; antennæ short; hair-lobes on clypeus very broad, not their breadth apart, clypeus truncate in front ..... **morata**
    First segment mostly black, second segment with yellow band on apical half; antennæ normal; hair-lobes of clypeus very narrow, about twice their breadth apart, clypeus produced in middle below ..... **zelica**
11. No band on the second segment of abdomen, which is wholly black; a band on first segment; no marks on postscutellum ..... **insolita**
    A band of yellow on second segment 12
12. A tooth or ridge each side on mesoternum; antennæ situated high above clypeus, the last joint thick; bands on abdomen subequal in width 13
    Neither tooth nor ridge on mesosternum 15
13. Spine pointed downward, rather slender; no metanotal stripes, hind femora black ..... **compar**
    Spine directed backward, rather the tip of a raised ridge 14
14. No metanotal stripes; hind femora with two black stripes ..... **jucunda**
    Metanotal stripes present, hind femora mostly yellowish ... **jucunda carolina**
15. Hind femora black, except at tips 16
    Hind femora pale, except at base 17
16. Post-scutellum yellow, enclosed area partly yellow; abdomen mostly reddish; stripes on metanotum; head reddish; large species ..... **ampla**
    Post-scutellum black; antennæ situated high above clypeus; stigma dark; small coarsely punctate species ..... **kennicotti**
17. Scutellum and also post-scutellum spotted; last joint of antennæ thick, barely longer than preceding joint 18
    Post-scutellum black; stigma yellowish; clypeus roundedly produced below, terminal joint of antennæ longer than preceding, and concave within at tip ..... **robertsoni**
18. Stigma dark; venter black; no band on basal segment; clypeus acutely produced below in the middle ..... **compacta**
    Stigma yellowish; venter ferruginous; first segment of abdomen often reddish. **mimica**
19. Enclosure irregularly transversely rugose, or obliquely striate on sides, clypeus convex below in middle ..... **clymene**
    Enclosure more or less smooth or longitudinally striate 20
20. Enclosure broad, nearly wholly smooth; lateral spots on first segment of abdomen 21
    Enclosure more or less plainly striate 22
21. Clypeus swollen out transversely above middle ..... **fasciola**
    Clypeus evenly, faintly convex ..... **alaope**
22. Clypeus flat, broadly truncate in front, with a transverse depression before tip; face only slightly hairy; first segment of abdomen with spots; enclosure finely striate; last ventral segment only slightly emarginate at tip. **deserta**
    Clypeus convex, rather rounded below, no transverse impression 23
23. Enclosure with prominent median groove, first segment of abdomen much broader than long, unspotted, body rather finely punctate ..... **chryssipe**
    Enclosure without prominent median groove; first segment of abdomen hardly broader than long 24
24. Rarely spots on first segment; enclosure striate all over, last ventral plate furcate at tip 25
    Spots on first segment; enclosure striate only on sides; venter spotted. **prominens**
    Spots on first segment; ornaments white; enclosure striate all over; venter with large spots or bands ..... **nigrescens**

25. Enclosure finely evenly striate; abdomen very slender, first segment narrow; usually but four or five teeth above on hind tibia.....**imitatoria**
Enclosure more coarsely striate; abdomen broader, more coarsely punctate; six to eight teeth above on hihd tibia.....**clypeata**

FEMALES.

1. Clypeus with an elevation or process with a free apical edge.....2
Clypeus without such elevation, although more or less swollen.....29
2. The clypeal process erect, and as long as broad.....3
The clypeal process broader than long or not erect.....7
3. No yellow mark on first abdominal segment, and that on second not emarginate in front; enclosure longitudinally striate.....**clypeata**
Some yellow on first abdominal segment.....4
4. Pronotum red all across, yellow on scutellum and post-scutellum, abdominal segments broadly yellow, enclosure striate all over.....**morata**
Pronotum black, with yellow spots, scutellum not marked with yellow.....5
5. Band on second abdominal segment not emarginate in front; enclosure finely striate and only on the sides.....**gnara**
Band on second abdominal segment strongly emarginate in front.....6
6. All femora blackish; no metanotal spots; segments beyond second hardly marked; basal joint of antennæ black; enclosure mostly smooth....**alaope**
Only fore femora partly blackish; spots on metanotum; all segments (except first) plainly banded; scape of antennæ yellowish; enclosure mostly striate. **prominens**
7. First, and often second, abdominal segments mostly reddish.....8
First abdominal segment black.....13
8. Enclosure transversely irregularly rugose; small species, head mostly black; stigma dark brown.....9
Enclosure smooth, or punctate on sides; head mostly reddish; large species; stigma yellow.....10
9. Black beneath clypeal process; second segment and metanotum black..**blakei**
Yellow beneath clypeal process; second segment and metanotum partly reddish.....**irene**
10. Clypeal process very broad, broadly and deeply concave in front.....11
Clypeal process not so.....12
11. Lateral angles of clypeal process not much elevated; abdomen pale only on base; wings dark.....**bicornuta**
Lateral angles of clypeal process high, all abdomen pale; wings paler..**frontata**
12. Clypeal process truncate in front; face very hairy.....**mimica**
Clypeal process convex in front, a tooth on each side at its base; face not especially hairy.....**ampla**
13. Clypeal process acute; vertex all red, pronotum red across; metanotum nearly all red, enclosure smooth, scarcely punctate on sides; stigma yellow.....**firma**
Vertex and pronotum not all red.....14
14. From the tip of clypeal process, which is not much elevate hangs a thin lamella, usually divided in middle.....15
No such lamella present.....17
15. These lamellæ or plates very small not half the width of clypeal process, which is low; spots on scutellum, band on second abdominal segment very broad, not emarginate; enclosure smooth in middle, faintly striate on the sides.....**robertsoni**
Lamellæ reach almost wholly across the tip of clypeal process.....16
16. Clypeal lamella not emarginate in middle; spots on scutellum, none on post-scutellum; hind femora more or less blackish; enclosure mostly smooth. **mandibularis**
Clypeal lamella emarginate in middle, practically divided; scutellum and post-scutellum both marked with yellow, hind femora (as well as most of others) yellowish; enclosure strongly rugose.....**compacta**
17. Scutellum marked with yellow; usually a mark on first abdominal segment. 18
Post-scutellum only with yellow.....21

18. Metanotum with yellow stripes; hind femora all reddish yellow, spot on clypeus each side at base of mandibles; clypeal process sub-conic; enclosure smooth in middle, punctate on sides.....**zelica**
No metanotal stripes; hind femora blackish.....19
19. Narrow bands on all segments; clypeal process small; enclosure smooth in in middle.....**compar**
All segments not banded, clypeal process plainly truncate in front.....20
20. Very coarsely punctate; no yellow on interantennal ridge, band on fourth abdominal segment, small species, a small tooth or ridge on mesosternum each side .....**Kennicotti**
21. Enclosure strongly transversely, irregularly rugose; basal segment of abdomen not spotted.....22
Enclosure smooth in part, or longitudinally striate.....23
22. Clypeal process twice as broad as long, yellow beneath, stigma brownish. **halone**
Clypeal process nearly as long as broad, black beneath; stigma yellowish. **clymene**
23. Basal abdominal segment not spotted clypeal process nearly square; stigma yellowish; enclosure coarsely striate.....**chryssipe**
Basal segment spotted.....24
24. Spot at base of mandibles, ususally also on metanotum.....25
No spot at base of mandibles, clypeal process not or but little narrowed in front 27
25. Marks white; enclosure striate all over; clypeal process emarginate in front. **nigrescens**
Marks yellow; enclosure mostly smooth or clypeal process narrowed in front and not emarginate 26
26. Clypeal process narrowed in front and almost rounded below; enclosure finely striate, except at tip, hind femora yellowish.....**psamathe**
Clypeal process broad, emarginate in front, enclosure almost wholly smooth, hind femora black at tips.....**fasciola**
27. Angles of clypeal process very sharply produced; enclosure strongly striate; spots on first abdominal segment connate.....**dentifrons**
Clypeal process only slightly emarginate in front.....28
28. Enclosure large, mostly smooth; no metanotal marks; stigma yellowish; clypeal process not emarginate .....**deserta**
Enclosure finely striate; stigma brownish; clypeal process emarginate in front; scape of antennæ black .....**arelate**
29. Wings wholly black; face with three transverse pale spots, post-scutellum yellow, scutellum unmarked, band only on second abdominal segment, enclosure broad and smooth.....**fumipennis**
Wings not wholly black.....30
30. Second segment of abdomen unmarked.....**insolita**
Second segment of abdomen banded.....31
31. Enclosure transversely rugose; stigma dark brown; spots on scutellum and band on post-scutellum yellow; small, coarsely punctate species.....32
Enclosure smooth in part or longitudinally striate; stigma yellowish; first segment of abdomen with a band.....34
32. First segment of abdomen red; band or second segment usually not emarginate in front 33
First segment of abdomen black, usually with yellow mark; band on second segment usually emarginate in front.....**finitima**
33. Metanotum black.....**rufinoda**
Metanotum reddish (except enclosure).....**rufinoda crucis**
34. Scutellum, but not post-scutellum yellow; clypeus all yellow; band on basal segment of abdomen; hind femora blackish; enclosure punctate on sides. **catawba**
Post-scutellum, but not scutellum, yellow; yellow spot on clypeus; basal segment of abdomen spotted; hind femora yellowish, enclosure mostly smooth **fulvipediculata**

Cerceris ampla n. sp.

♀ Reddish; face yellow; tips of mandibles black; vertex reddish, two elongate yellow spots, and a long yellow patch behind the eyes; antennæ rufous on basal half, rest black; large spots on pronotum, tegulæ, about five large spots on pleuræ; scutellum and post-scutellum, metanotum on sides, and the enclosure, yellow; first segment of abdomen mostly yellow, others with apical yellow bands, very broad on sides of second segment, fourth, fifth, and sixth segments mostly black; venter red on base, black beyond, apical segments with broad apical band of short tawny hairs; legs mostly yellow and rufous, hind femora black behind, and a spot on the middle tibiæ. Wings fuscous on anterior half, stigma yellowish. Body coarsely, confluently punctured. Clypeal process prominent, apex rounded, (as figured) a lateral process on each side-lobe, not erect, and seen from the side as broad at tip as at base; lower edge of clypeus with two teeth near the middle; ocellar triangle very low, rather forming a curved line; enclosure swollen, broad, smooth in the middle, punctate on the sides; first segment of abdomen with nearly parallel sides, hardly one-half as wide as the second segment; pygidial area about twice as long as broad, the sides nearly parallel, but a little bowed outward near base.

The male is colored similar to the female, but more black, especially on the thorax, the metanotum mostly black, side stripes yellow, and a spot on the enclosure, front and middle femora above and hind femora mostly black, tibia black on apical half. Middle joints of antennæ very short, last two joints very long subequal, the last curved, but not tapering; the hair-lobes scarcely more than breadth apart; pygidial area scarcely as long as broad, the apex undulate.

Length ♀ 22 mm., ♂ 18 mm.

From Fedor, Lee County, Texas, (Birkmann) Mr. Rohwer had given this name, but has not published a description. It is related to *hebes* Cam., *bidentata* Say, and *macrosticta* Vier, & Ckll., but differs in several points from each of them.

Cerceris bicornuta Guerin.

From Southern Pines, N. Car. The pygidial area of the female is two and one-half times as long as broad, and very much narrowed near base. It is allied to *C. frontata* by shape of the clypeal process.

Cerceris frontata Say.

This is a Western species, but was described fron "Arkansas"; I have it from Palmerlee, Arizona. The pygidial area of female is of the same shape as in *C. ampla*. The radius of the wing is black until a little before the stigma, other veins yellowish.

Cerceris fumipennis Say.

From Washington, D. C., Falls Church, Va., and Fedor, Texas. The pygidial area of the female is about two and a-half times longer than broad, broadest near base, and much narrowed to the tip. In male this area is more than twice as long as broad, the sides nearly parallel, and as broad at tip as anywhere. The hair-lobes are nearly one and a-half times their breadth apart; the last joint of antennæ is as long as preceding, slightly tapering and somewhat curved.

Cerceris mandibularis Patton.

From Washington, D. C., and Falls Church, Va., in June. It is allied to *C. compacta* by structures of clypeus; the enclosure is very broad and smooth; the pygidial area two and one-half times longer than broad, tip about one-half as broad as in middle, the sides strongly curved, the base very narrow.

Cerceris robertsoni Fox.

From Falls Church, Va., and Southern Pines, N. Car., in June and July. The pygidial area of the female is about two and a-half times longer than broad, broadest near base, about one-half as broad at the rounded tip, the sides curved. In the male it is about twice as long as broad, and plainly narrower at tip than elsewhere; the last joint of antennæ is as long as the penultimate, a little curved, but not concave behind; the hair-lobes are fully three times their breadth apart; the clypeus very hairy.

Cerceris compacta Cress.

This is the most common species in Virginia, and occurs from June to September; also from Southern Pines, N. Car., and Lee County, Texas. The pygidial area of female is nearly twice as long as broad, broadest near base, narrow at tip, the upper part of sides strongly curved. In the male this area is hardly one and a-half times longer than broad, broadest at base; the last joint of antennæ is barely longer than the preceding, tapering, but not concave behind. The hair-lobes are fully twice their breadth apart, the lower part (in fact all) of face is very hairy; in both sexes the stigma is plainly darker than the cell beyond it. In the female the front tarsi are broader and more flattened than in any other species. Cameron's figure shows that *C. mexicana* is perhaps the same species.

Cerceris chryssipe n. sp.

♀ Similar in most respects to C. clypeata, but the clypeal process is broader than long, the abdomen is rather broader and the punctuation less coarse; the enclosure is raised in middle with a median furrow, and very coarsely striate on sides.

♂ The male is similar to C. clypeata in markings and clypeus, but has the abdomen very much broader, and with finer punctuation; the enclosure more coarsely striate than in C. clypeata.

From Falls Church, Va., in July, on *Cicuta*.

Cerceris dentifrons Cress.

The type from Illinois has the clypeal process broad, and the lateral angles are very strongly produced; more so than in any other species seen from the Eastern States.

Cerceris clypeata Dahlbom.

From Ithaca, N. Y., and Falls Church, and Glencarlyn, Va., in June and July. The pygidial area of the female is more than twice as long as broad, the sides sub-parallel, and the tip only a little narrower than the base; in the male this area is scarcely one and a-half times as long as broad, with broad, truncate tip; the hair-lobes are fully twice their breadth apart, I have restricted this species more than Cresson or Packard, with a definite clypeal process.

Cerceris deserta Say.

From Sea Cliff, N. Y., and Falls Church and Glencarlyn, Va., in June, July and September; the September specimens are all males. The pygidial area of female is two and a-half times longer than broad, the sides nearly parallel, and the tip hardly narrowed. In male this area is a little over twice as long as broad, sides parallel; the hair-lobes are very small, fully three times their breadth apart.

Cerceris arelate n. sp.

♀ Black; mandibles all black, barely a trace of pale near base; a spot on clypeal process, a large spot each side on face, tegulæ, post-scutellum, two spots on basal segment (nearly connected), narrow, emarginate bands on other segments, yellow; legs yellow, front and middle femora black, hind femora black on base, inner tip of hind tibia, and most of hind tarsi blackish; flagellum somewhat yellow at base beneath; scape, interantennal carina, and pronotum black, venter also black, unspotted; wings fumose, darker on costal apex, stigma yellowish. Clypeal process moderately elevate, much broader than

long, seen from in front the edge is concave; lateral ocelli as near to eyes as to each other; enclosure large, striate, the lateral striæ rather oblique; abdomen not very broad, basal segment more than one-half width of second segment; pygidial area about two and one-fourth times longer than broad, nearly twice as broad at base as at tip, but the sides are nearly straight; body moderately punctate.

Length 10 mm.

From Great Falls, Va., 20 June. By black pronotum, and scape it is quite distinct from allies, and omitting these it will not fit any other form.

Cerceris morata Cress.

Males from Fedor, Lee County, Texas, (Birkmann). The pygidial area is about one and a-half times longer than broad, broad at base, and fully twice as broad in middle as at the narrow tip. The last joint of antenna is longer than the penultimate, but not concave behind; the hair-lobes are exceedingly large, only about one-third their breadth apart. The second segment is yellow in front, instead of behind as usual. I have figured the clypeal process of the female from the type.

Cerceris prominens n. sp.

♀ Black; base of mandibles, a large spot each side between antennæ and eyes, spot on clypeal process, dot behind eyes, two spots on pronotum, tegulæ, metanotal stripes, two spots on first segment of abdomen, a broad band, deeply, triangularly indented, on second, narrow bands on next three segments, yellow. Legs yellow, front coxæ, and basal part of femora, blackish; rather dark on base of mid femora and tip of hind tibia, hind tarsi dusky; scape and first two joints of flagellum beneath yellowish. Wings dusky, stigma yellow. Body coarsely punctate, clypeal process a little longer than broad, nearly square, enclosure with a deep median groove, and lateral somewhat oblique striæ; pygidial area two and one-fourth times as long as broad, broadest near base, much narrowed at tip (not as narrow as in C. clypeata). Venter black, finely punctate.

♂ With face all yellow, no metanotal marks, that on second segment not indented, front and mid femora black behind, hind femora and tibia black on apical half, last joint of antennæ fulvous; clypeus apparently rounded below, but with three black teeth; hair-lobes about one and a half breadth apart; second joint of flagellum much longer than third, apical joint scarcely longer than the preceding, curved; enclosure smooth in middle, striate on sides; pygidial area about twice as long as broad, scarcely broader in the middle, apical corners rather prominent.

Length 13 mm.

From Falls Church, Va., September and October.

Cerceris firma Cress.

I have seen only the types, these (females) have a small almost acutely pointed depressed clypeal process, partly obscured by hair; it is shown in the figure.

Cerceris imitatoria Schlett.

Specimens from Falls Church, Va., in June, I have placed doubtfully as this species, which in nearly all structures seems almost identical with *C. clypeata*.

Cerceris nigrescens Smith.

From Ithaca, N. Y., and Southern Pines, N. Car. The pygidial area of the female is figured. The male has not been described, so the following is given:

♂ Black, basal part of mandibles, face, two spots on pronotum, tegulæ, post-scutellum, a small spot each side on the metanotum, two spots on basal segment, bands on following segments, all broader on sides, pale yellowish. Venter black, second, third and fourth segments with pale bands; legs pale yellowish, front and mid femora more or less black, mostly behind, hind femora with black apical spot, also on hind tibia, hind tarsi dusky. Scape of antennæ yellow, black above, flagellum more or less fulvous beneath. Wings nearly hyaline, dark on costal apex, stigma yellow. Face and rest of body very finely punctate, vertex more coarsely punctate; second joint of flagellum short, but little longer than the third, apical joint smaller than the preceding joint, curved; lateral ocelli nearer to each other than to eyes; clypeus rounded below, with three blunt, black teeth; hair-lobes three times their breadth apart; enclosure rather broad, striate; pygidial area small, two and one-eighth times as long as broad, tip faintly rounded; about five or six spines on hind tibia.

Length 8.5 mm. to 10 mm.

From Ithaca, N. Y., and Southern Pines, N. Car.,(Manee).

Mr. Rohwer has informed me that the type of Smith has the clypeal process truncate, and differs somewhat in other points; however this is the *C. nigrescens* of Cresson and Packard, and so I leave it until it is shown that there is another species more closely agreeing with the type, or the limits of variation in the shape of the clypeal process are better known than at present.

Cerceris clymene n. sp.

♀ Black; base of mandibles, spot above their base, sides of face, upper surface (except tip) of clypeal process, dot behind eye, two spots on pronotum, tegulæ, post-scutellum, a broad band on second segment of abdomen, a narrow line on each of next two segments, and the fifth

with a spot each side, yellow. Interantennal ridge black, scape yellow, black line above, first and second joints of flagellum partly rufous; wings dark, darker on costal apex, stigma yellow; venter black; legs pale, coxæ wholly and femora partly black, hind tibia dusky at tip, hind tarsi dusky. Body densely and quite coarsely punctate, venter nearly smooth. Clypeal process a little broader than long, emarginate in front; clypeus below the process shows a ridge each side; second joint of flagellum much longer than third; lateral ocelli plainly nearer to each other than to the eyes; enclosure coarsely transversely rugose; abdomen quite broad, the segments not much narrowed at base, the basal segment much broader than long; pygidial area a little more than twice as broad as long, sides sub-parallel; six or seven spines on hind tibiæ, sub-equally spaced. One specimen shows a small spot each side on basal segment of abdomen.

♂ Similar to female, face all yellow, large metanotal spots, small spot each side on basal segment, last segment more plainly banded than in female. Clypeus with three blunt, black teeth below on middle; hair-lobes about one and a half their breadth apart; last joint of antennæ not as long as preceding, curved, and tapering; enclosure with oblique striæ on lateral angles, elsewhere transversely rugose; abdomen rather broad, segments but little constricted at base; pygidial area hardly twice as long as broad, sides parallel, apex truncate, surface coarsely punctate. Legs with front and middle femora largely black, hind femora with large black spot, but the base pale, hind tibia blackish each side near tip, tarsi blackish.

Length ♀ 11 mm. ♂ 10 mm.

From Glencarlyn, Va., 23 June (Ceanothus), and Falls Church, Va., 30 July.

Cerceris psamathe n. sp.

♀ Black; basal half of mandibles, spot above base of mandibles, clypeal process above, spot each side on face, interantennal carina, dot behind eye, two spots on pronotum, tegulæ, post-scutellum, stripes on metanotum, two spots on basal segment, rather broad and broadly emarginate bands on other segments, yellow; band on second segment not much broader than others; legs mostly yellow or rufous, anterior and middle femora black at base, spot near tip of hind tibia, and tarsi dusky; antennæ blackish above, except at tip. Body very finely punctate (not near as coarse as in C. nigrescens), clypeus as figured; enclosure large, finely striate; basal segment of abdomen scarcely one-half the width of second segment; pygidial area long, plainly constricted near tip.

Length 11 mm.

From Lee County, Texas, (Birkmann). *C. convergens* Vier. & Ckll., from New Mexico has a similar pygidial area, but is said to be coarsely punctate, with spots on scutellum, etc. The description of *C. novomexicana* agrees very well, except the constriction of pygidial area is not mentioned.

C. occipitomaculata was described from one male from Kansas; I have not seen it, but it belongs in this group of the genus and was compared with *C. nigrescens*. The female, above described, is near to *C. nigrescens*, and, barring sexual characters, agrees fairly well with Packard's description, however there is some doubt. A female specimen named *C. occipitomaculata* in the Cresson collection is very near to *C. deserta;* until the female of *C. occipitomaculata* is surely known it is better to consider this form new.

Cerceris gnara Cress.

A pair from Lee County, Texas, (Birkmann). The pygidial area of the female is a little more than twice as long as broad, broadest near base, the sides nearly straight, and the tip not much narrowed and rounded. In the male this area is not quite twice as long as broad, with parallel sides and truncate tip; the hair-lobes are about once and a-half their breadth apart; the last joint of antennæ is longer than the penultimate, curved and concave behind.

Cerceris alaope n. sp.

♂ Face, two spots on pronotum, tegulæ, post-scutellum, two spots on basal segment of abdomen, a broad band, emarginate in front on second segment, and narrower bands on following segments, pale yellow. Antennæ black above, scape beneath yellow, flagellum fulvous beneath. Wings fumose, darker on tip, stigma dull yellowish. Legs pale yellow; front and mid femora, apical part of hind femora, and apical half of hind tibia, black; venter black, a few pale spots each side. Clypeus very slightly evenly convex, almost flat, not swollen above, lower margin truncate, upper edge slightly rounded, coarsely punctate; hair-lobes rather narrow, fully twice their breadth apart; second joint of flagellum much longer than the third, apical longer and narrower than the preceding, and somewhat curved; lateral ocelli about as near to eyes as to each other; enclosure very large, smooth, with a median groove and indistinctly striate on base; abdomen (including basal segment) much broader than in C. fasciola; pygidial area hardly twice as long as broad, truncate at tip, sides parallel, rather densely punctate, and very hairy; spines on hind tibia, seven or eight, evenly spaced.

Length 10 mm.

♀ Similar to male; clypeal process black across tip; large spot each side on face, spot at base of mandibles, extreme base of mandibles, spot behind eyes, yellow; flagellum mostly fulvous, abdomen marked as in male, but the bands more narrow, and that on second segment is more deeply emarginate; all femora mostly black, but pale on tips; clypeal process erect, longer than broad; enclosure large, and mostly smooth as

in the male; pygidial area about two and a fourth times longer than broad, sides sub-parallel, but narrowed at tip.

From Falls Church, Va., 5 June on Ceanothus. Related to *C. fasciola*, but with broader abdomen, different clypeus, and more coarsely punctate, especially on metanotum and abdomen.

Cerceris fasciola Cress.

Described from Texas; I have a pair from Lee County. The pygidial area of the male is about twice as long as broad, the sides parallel, the tip truncate. The hair-lobes are plainly more than twice their breadth apart. The female in structure is near *C. nigrescens*, but the smooth enclosure ,and mostly yellow legs will easily separate it.

Cerceris insolita Cress.

From Falls Church, Va., 30 July, and Lee County, Texas, July. In the male the hair-lobes are very broad, so that they are hardly more than one-half their breadth apart; the clypeus shows two little black spots at apex; the last joint of antennæ is thick and short; the pygidial area is less than twice as long as broad, the sides parallel, tip truncate, surface coarsely punctate, but scarcely hairy; on the venter the third segment shows a yellow band. *C. obsoleta* of Mexico is very close to this species.

Cerceris zelica n. sp.

♂ Black, basal part of mandibles, face (except little black spot at tip of clypeus) inter-antennal streak nearly reaching the ocelli, two spots on vertex, spot behind eye, pronotum all across, tegulæ, spot beneath wings, scutellum, and spot on post-scutellum, broad stripes on mesonotum, median spot on basal segment of abdomen, bands on other segments, yellow. Band on second segment broader than others, all narrowed in middle; venter with spots each side, some connected by lines; scape yellow, first joint of flagellum brown, rest rufous, but black above beyond base; legs all yellowish. Body coarsely punctate; clypeus rounded in middle below, hairy each side, truncate above; hair-lobes fully three times their breadth apart; antennæ high above clypeus; second joint of flagellum longer than the third, apical not much longer than the preceding, tapering, not concave within. Enclosure mostly smooth, a median groove, and punctate on sides; abdomen rather broad, the segments strongly constricted at base, first segment plainly broader than long; pygidial area once and two-thirds as long as broad at base, narrowed to tip, which has prominent angles, surface coarsely punctate; venter nearly smooth, punctate a little on sides.

Length 12 mm.

Fedor, Lee County, Texas, 7 June, (Birkmann). The female which seems to agree in all essential points with the male is described as follows:

♀ Black, most of mandibles, spot at base of mandibles, all of clypeal process, above and below, oblong spot each side on face, inter-antennal mark, two spots on pronotum, tegulæ, scutellum, stripes on metanotum, all segments of abdomen with bands, yellow. Band on last segment of abdomen very narrow, on second quite broad, scarcely emarginate, legs yellowish, coxæ and bases of femora blackish. Body not very coarsely punctate; clypeal process small, sub-conic; lateral ocelli as near to each other as to eyes; enclosure mostly smooth, punctate on sides; the abdomen moderately broad, the segments not much constricted at base; pygidial area about three times as long as broad, narrowed at base; hind tibia with about seven spines, nearly evenly spaced; second joint of flagellum plainly longer than third. Wings not very dark, except tip, stigma yellowish.

Length 12 mm.

From Lee County, Texas, 7 July (Birkmann).

Cerceris halone n. sp.

♀ Black; a small spot at base of mandibles, spot beneath clypeal projection, one on its upper surface, a large triangular mark on each side of face, two spots on the pronotum, tegulæ, post-scutellum, a broad band (emarginate in front) on second abdominal segment, an elongate lateral spot each side on third segment, and narrow bands on the next two segments, yellow; basal two joints of flagellum yellowish beneath; legs yellow, coxæ, and front and mid femora black, hind femora black behind, (except tip), black at inner tip of tibia, and the hind tarsi mostly blackish; venter black. Body densely and rather coarsely punctate. Clypeal process small, from above it is about three times as broad as long, and emarginate in front, from in front it shows as an even arch, above it is transversely convex, and very hairy at sides; lateral ocelli a little nearer to each other than to eyes; enclosure not very coarsely but very irregularly and mostly transversely rugose. Abdomen moderately slender but basal segment is much broader than long; pygidial area about two and one-fourth times longer than broad, sides sub-parallel, but narrowed at tip, and margined with much blackish hair; venter rather finely punctate; hind tibia with seven not evenly spaced spines. Wings dusky, darker at tips, stigma yellowish.

Length 12 mm.

From Falls Church, Va.

Cerceris fulvipediculata Schlett.

This is the *C. fulvipes* Cress., the name being preoccupied. From Falls Church, Va., 4 September. The pygidial area of the female is fully three times longer than broad, the sides practically parallel, but the tip rounded, and a little more narrow than the base.

Cerceris kennicotti Cress.

This is a very common species in northern Virginia, and also occurs in Texas. The pygidial area of the female is about twice as long as broad at base. and fully twice as broad near base as at the truncate tip. The male has the hair-lobes fully three times their breadth apart; the pygidial area is hardly twice as long as broad, with curved sides, the tip almost one-half narrower than base.

Cerceris compar Cress.

From Ithaca, N. Y., and Falls Church, Va., The pygidial area of female is two and a-half times longer than broad, broadest at middle, and much narrower at base than at tip. The male has hair-lobes so large that they are less than their breadth apart; the pygidial area is not twice as long as broad, and more narrow at base than at tip, its surface very coarsely pitted except near tip. The spines on mesosternum easily separate the male.

Cerceris catawba n. sp.

♀ Black, face and clypeus pale yellow, on the sides extending above antennæ and a line between them; antennæ yellowish or reddish beneath, dark above, an elongate spot each side on pronotum, the scutellum, a stripe each side on metanotum pale yellow; all segments of abdomen with complete posterior yellow bands, that on the first segment as wide as that on second, but the latter concave in front; legs yellowish, the femora black on basal half or two-thirds, the hind tibiæ black at tip, the mid tibiæ with dark streak behind, the hind tarsi dusky, the basal joint only at tip. Wings smoky, darker in marginal cell and beyond, the stigma brown. Clypeus of female not elevated, produced below in middle, but truncate at tip, above broadly truncate; enclosure smooth in middle punctate on sides, pygidial area two and one-half times as long as broad, nearly as broad at apex as in middle, but narrowed at base.

♂ Similar to female; with clypeus slightly convex, sparsely, coarsely punctate, lower margin slightly rounded but with a black, truncate edge; hair-lobes broad, but about their breadth apart; antennæ high above clypeus, second joint of flagellum short, barely longer than the third, apical joint thick, but a little longer than the preceding; pygidial area twice as broad as long, sides subparallel, tip truncate, surface with a few coarse punctures; last ventral broadly emarginate at tip.

Length 9 mm.

From Southern Pines, N. Car., June, (Manee).

Cerceris jucunda Cress.

From Fedor, Lee County, Texas, 6 April (Birkmann). The hair-lobes of male are scarcely more than one-half their breadth apart. The pygidial area is narrower than in *C. compar*, and more narrowed at base; the last joint of the antennæ is as long as preceding joint, but thick, and not curved.

Cerceris jucunda carolina n. var.

From Southern Pines, I have specimens a little larger than the type, with a rather broad head; there are large yellow stripes on the mesonotum, and the pygidial area is hardly narrowed at base; the mesosternal processes are of the same shape as *C. jucunda*. With a larger series it will perhaps prove a distinct species.

Cerceris blakei Cress.

From Falls Church, Va., 28 July, and Southern Pines, N. Car., June and July. In the female the clypeal process is more erect than in *C. irene*, the pygidial area of female is fully twice as long as broad, the sides convex.

Cerceris rufinoda Cress.

From Falls Church, Va., August, and Fedor, Texas, June. The female from Falls Church has the face black, except a large spot each side; the pygidial area is long, very narrow at base, sides convex, and tip truncate; in the male the pygidial area is short, and not narrowed at base; the clypeus convexly rounded below as in *C. finitima*, the hair-lobes nearly one and a-half times their breadth apart. The variety *C. rufinoda crucis* Vier, and Ckll., comes from Lee County, Texas.

Cerceris irene n. sp.

♀ Face wholly yellow; scape yellow, barely reddish above, flagellum rufous beneath, blackish above; vertex with a reddish spot each side, and reddish behind, and with a yellow spot behind the eyes; large spots on pronotum, tegulæ, large spots (almost contiguous) on the scutellum, and band on the post-scutellum, yellow. Mesonotum mostly reddish, with a black patch each side, meso- and meta-sternum reddish. First and second segments of the abdomen reddish, latter with apical yellow band and moderately wide bands on the next three segments; venter reddish at base; legs wholly reddish yellow; wings fumose, stigma almost black. Body very coarsely punctate; clypeal process but little elevated, apex nearly truncate, and reddish; antennæ situated

more than the diameter of sockets above the clypeus; second joint of flagellum but little longer than the third; lateral ocelli scarcely nearer to each other than to eyes; enclosure coarsely, mostly transversely rugose; basal segment of abdomen hardly one-half the width of the second segment; pygidial area twice as long as broad, sides strongly convex, broadest in middle, and narrower at tip than at base; hind tibiæ with about seven spines above, nearly evenly spaced.

Length, 7 mm.

From Fedor, Lee County, Texas, 25 June, (Birkmann).

Cerceris finitima Cress.

From Falls Church, Va., Southern Pines, N. Car., and Lee County, Texas. The female pygidial area is very slender as figured; in the male it is about twice as long as broad, about equally broad at base and tip, with slightly curved sides; the last joint of the antenna is thick and heavy; the hair-lobes are about once and a-half their breadth apart.

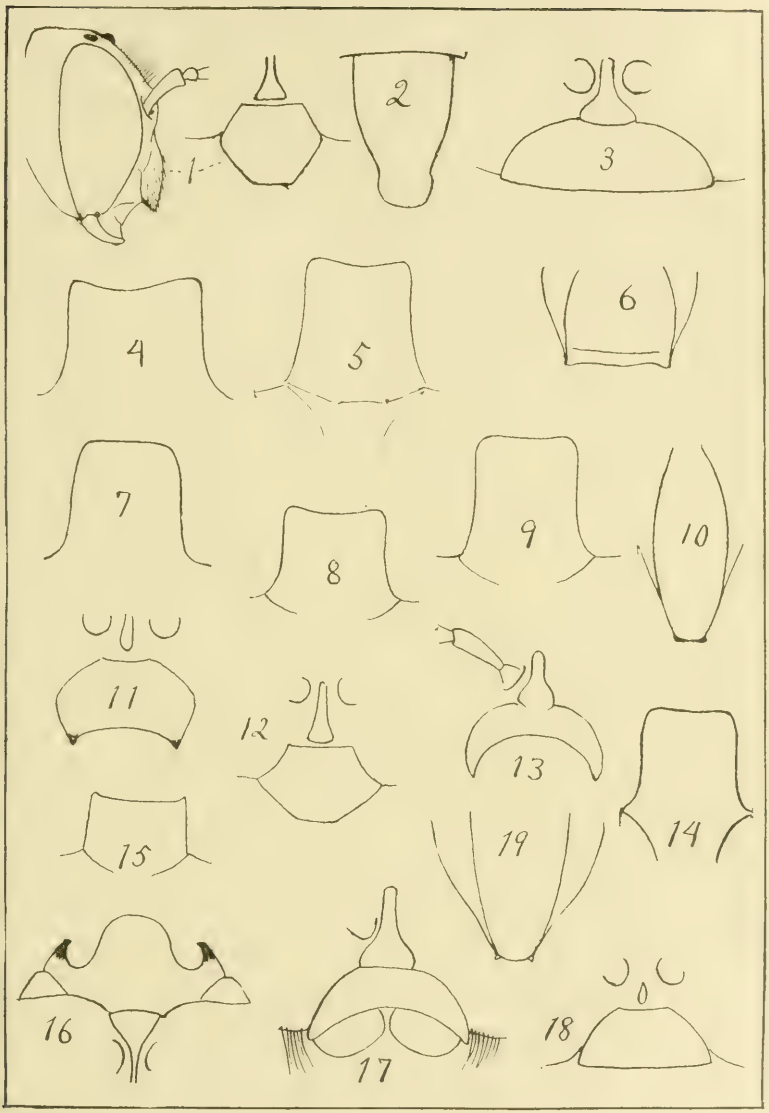
Cerceris finitima nigroris n. var.

This is a variety of the male which is larger than the type, and with a large black spot each side of clypeus above the base of mandibles.

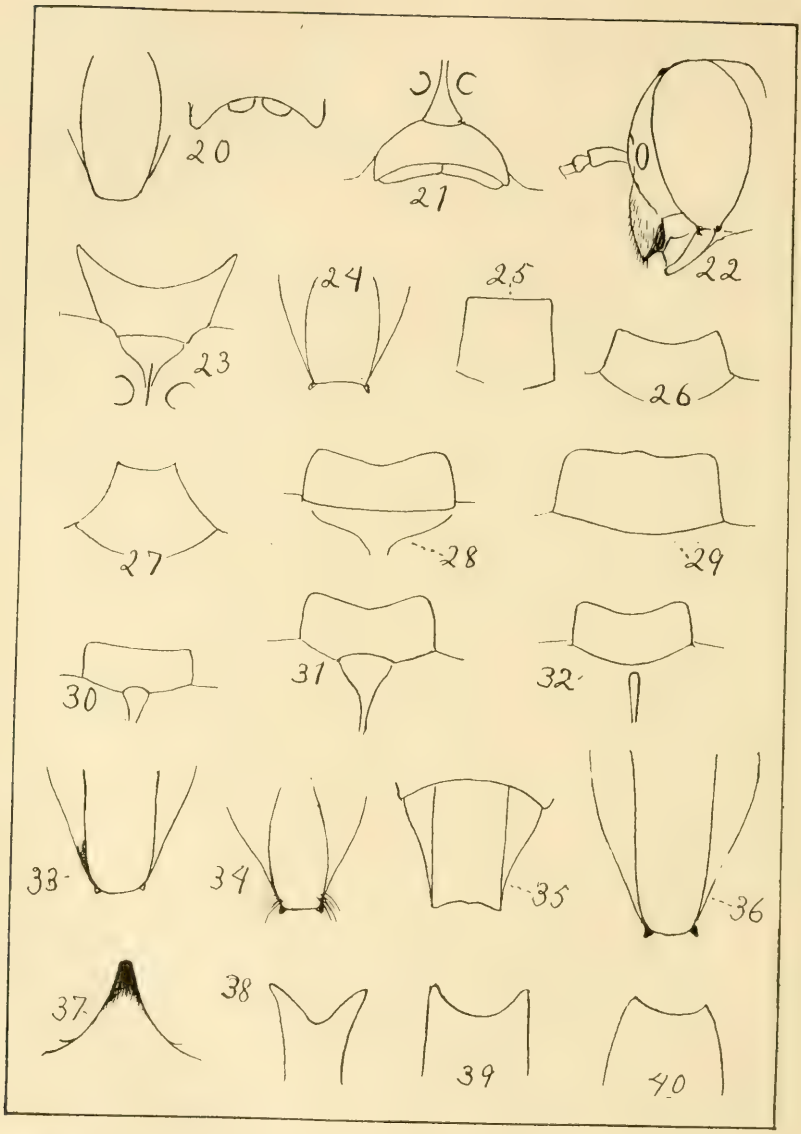
From Falls Church, Va., in August.

EXPLANATION OF PLATES.

Fig. 1. Cerceris psamathe, head, clypeus in front.
Fig. 2. Cerceris psamathe, pygidial area of female.
Fig. 3. Cerceris mandibularis, clypeal process, front from above.
Fig. 4. Cerceris clymene, clypeal process, above.
Fig. 5. Cerceris clypeata, clypeal process above.
Fig. 6. Cerceris ampla, pygidial area of male.
Fig. 7. Cerceris prominens, clypeal process, above.
Fig. 8. Cerceris chryssipe, clypeal process, above.
Fig. 9. Cerceris alaope, clypeal process, above.
Fig. 10. Cerceris finitima, pygidial area, female.
Fig. 11. Cerceris finitima, clypeus in front, female.
Fig. 12. Cerceris zelica, clypeal process, front.
Fig. 13. Cerceris bicornuta, clypeal process, front.
Fig. 14. Cerceris gnara, clypeal process, above.
Fig. 15. Cerceris blakei, clypeal process, above.
Fig. 16. Cerceris ampla, clypeal process, above.
Fig. 17. Cerceris compacta, clypeal process, front.
Fig. 18. Cerceris compar clypeal process, front.
Fig. 19. Cerceris nigrescens, pygidial area, female.
Fig. 20. Cerceris robertsoni, female, pygidial area, and clypeal process in front.
Fig. 21. Cerceris mandibularis, clypeal process, front from below.
Fig. 22. Cerceris kennicotti, head, female.
Fig. 23. Cerceris frontata, clypeal process, above.
Fig. 24. Cerceris compacta, pygidial area, male.
Fig. 25. Cerceris morata, clypeal process, above.
Fig. 26. Cerceris arelate, clypeal process, above.
Fig. 27. Cerceris irene, clypeal process, above.
Fig. 28. Cerceris halone, clypeal process, above.
Fig. 29. Cerceris deserta, clypeal process, above.
Fig. 30. Cerceris mandibularis, clypeal process, above.
Fig. 31. Cerceris fasciola, clypeal process, above.
Fig. 32. Cerceris nigrescens, clypeal process, above.
Fig. 33. Cerceris fasciola, pygidial area, female.
Fig. 34. Cerceris mandibularis, pygidial area, female.
Fig. 35. Cerceris fumipennis, pygidial area, male.
Fig. 36. Cerceris fulvipediculata, pygidial area, female.
Fig. 37. Cerceris firma, clypeal process, above.
Fig. 38. Cerceris clypeata, male, last ventral segment.
Fig. 39. Cerceris prominens, male, last ventral segment.
Fig. 40. Cerceris deserta, male, last ventral segment.



Banks.



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NATURAL HISTORY AND GENERAL BEHAVIOR OF THE EPHEMERIDAE NYMPHS HEPTAGENIA INTERPUNCTATA (SAY).

By J. E. Wodsedalek.

There is a comparatively small amount of literature on the behavior of the Ephemeridæ. Probably the best general account is that given in Miall's "Natural History of Aquatic Insects." This treatise contains greatly abridged and reproduced in English, the useful account of the life history of the Ephemera found in Swammerdam's "Biblia Naturæ," and the very entertaining description of Reamur, but the behavior of these insects has been a subject of practically no experimental investigations. The species upon which the present study is based is Heptagenia interpunctata (Say), which is described in Needham's work on "May-Flies and Midges of New York."

HABITAT AND GENERAL HABITS.

Especially in the fall of the year these nymphs are found in ample abundance clinging to the under sides of rocks on the shores of Lake Mendota. Although they may be found under almost any rock, they are most numerous on greenish brown stones corresponding to the coloration of the nymphs, and presenting a rough surface well covered with small aquatic plants. This choice of habitat is probably determined, to a great extent at least, by their negative phototaxis and strong positive thigmotaxis, since I have never seen the nymphs on the upper or the lateral faces of stones.

In a previous paper* the reactions to light and their control by chemicals in H. interpunctata have been discussed in considerable detail. It was found that when the nymphs are placed in a long glass dish of water near a window they immediately swim away from the light. The same negative reaction takes place when the dish is taken into a dark room and a light is introduced near one end. It was also found that this strong negative phototaxis can be reversed by means of various chemical solutions.

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*Wodsedalek, J. E. Phototactic Reactions and Their Reversal in the May-Fly Nymphs Heptagenia Interpunctata (Say). Biological Bulletin Volume 21, Pages 265–272, 1911.

The nymphs have a wonderful clinging power. Their flattened bodies, and limbs which extend laterally, are pressed close to the rock, thus enabling the insects to retain their hold and escape the full force of the waves. The legs are supported distally with sharp claws which the nymph digs into the small holes and crevices of the stone. While removing the insects from the stones one can often feel the resistance which they offer despite their small size, and in some cases they cling with such force that their stubbornness often results in the loss of a limb or two. This misfortune however does not seem to be disastrous to the vitality of the insect, and the lost appendages soon regenerate.

Although the nymphs spend most of their time lying quietly, it is astonishing to see with what rapidity they can move with their flattened bodies over the moist surface of stones when they are disturbed, even if the stones are inverted so that the insect is compelled to move with its dorsal surface downward. The latter fashion appears to be even less difficult, owing probably to the fact that they almost continually cling to the under side of rocks in their natural habitat. They frequently move sidewise and even backward, and are so active that an attempt to collect them from stones under water is an almost impossible task.

All summer these insects occupy a narrow strip, about three feet wide, along the lake shore and are particularly numerous on the shores of Picnic Point. Along in the latter part of October as the water turns cool, the nymphs slowly begin to migrate into deeper water and practically all desert the shallow water before the ice begins to form. A careful search was made on the day the ice broke up in the spring but not a single specimen was seen. A few days after the ice disappears, however, the nymphs begin to make their appearance.

I have never seen the nymphs swimming freely in their natural habitat, although when a stone to which several of them are attached is suddenly jerked out of the water, some become dislodged and quickly make for a neighboring rock. They swim in an undulating movement, bending the head, now up, now down, but this locomotion is by no means as rapid as when they are in contact with some object under water. Ordinarily the two lateral setæ are distended at an angle of about forty-five degrees, but during the swimming they are drawn in

toward the middle one, thus forming a sort of flexible paddle. When the swimming movements cease, the setæ are again distended, allowing the nymph to sink slowly to the bottom, or to take a short rest in suspension before another seemingly strenuous effort at swimming is resumed. Short distances of two or three inches are usually made with alacrity, but a longer distance seems to fatigue the nymph and little progress is made. However, when shelter is in evidence the movement increases, and almost invariably the nymphs put on extra speed on the home stretch.

May-Fly nymphs obtain their ogyxen from the water by means of the seven pairs of tracheal gills which are attached to the first seven abdominal segments. The nymphs would be quite inconspicuous in their natural habitat were it not for the simultaneous backward and forward motion of the gills. While they are in a quiet attitude, all of the gills are not usually brought into play and their motion varies in proportion to the physical exertion, and to some extent at least, in proportion to the amount of food within the body of the nymph. The motion of the gills can be greatly increased by giving the nymph vigorous exercise and also by keeping it out of water for some time. Specimens destitute of nutrition for several days exercise their gills to a comparatively small degree.

FOOD AND FEEDING.

Ten active specimens were placed in separate dishes of water containing a bare rock, and after a few days of fasting, all chewed at a piece of alga when brought near to their mouth parts, as long as they were attached to a stone, finger, or some other object. It might be well to mention the fact that algæ form the greatest share of the food of these nymphs and that animal food is not taken until the nymphs are well starved, when they chew at almost anything they come in contact with. When the stones were removed, the nymphs refused to eat unless the piece of food was large enough to afford attachment. Some of the nymphs ate almost immediately after coming in contact with the food, while others did not do so until after several days. Others again would attach themselves to smaller pieces of alga, but would not eat unless the particle of food was lightly pressed against their mouth part. Evidently the particle of food was too small to afford comfortable attachment and the

soft consistency of the alga did not offer the proper contact stimulus.

There seems to be sufficient evidence that small objects are not seen by the nymphs, for very frequently they will repeatedly ignore a particle of food held in their immediate neighborhood. This is also true of much fatigued specimens which, during their slow search for food, devour the savory morsels only when they accidently hit upon them.

In another experiment I took ten specimens and placed each in a small dish of water containing a carefully measured piece of food. Daily observations were made and the results obtained are tabulated below. The (—) sign indicates that the food remained untouched; the (+) sign is meant to show that part of the food had been eaten, and (O) marks the day when no food remained in the dish:

Specimen	Size of food	1	2	3	4	5	6	7	8	9	10	11	12
1	1 sq.mm.	—	—	—	—	—	—	—	—	O			
2	1.5 "	—	—	—	—	+	—	—	—	died			
3	2 "	—	—	—	—	—	—	—	—	—	O		
4	2.5 "	—	—	—	—	—	—	—	—	—	—	—	O
5	3 "	—	—	—	—	+	—	—	+	O			
6	3.5 "	—	—	+	—	+	+	O					
7	4 "	—	—	—	—	+	+	+	O				
8	4.5 "	—	—	+	+	?	+	O					
9	5 "	—	+	—	—	+	+	+	O				
10	5.5 "	+	+	+	+	+	?	O					

The experiment was repeated with another set of nymphs, and similar results were obtained. Evidently the specimens in the first few cases did not see the piece of food, and ate it only when they came in contact with it by chance.

THIGMOTAXIS.

The strong positive thigmotaxis of the nymphs, as was stated in speaking of their habitat, is apparently the most pronounced feature of their behavior. When several specimens

are placed in an aquarium they mass together into clusters where they remain for many hours, and if recently collected, even days. As soon as a rock or any other object is placed in the water, the loose forms swim toward it, while considerable time often elapses before the masses are broken up.

Two long bricks were placed one over the other in a basin of water and between them small pebbles varying in size so that the space gradually varied in thickness from one end to the other. Then a large number of nymphs were put in the water, and after a short time it was found that nearly all of the specimens were attached to the lower surface of the upper brick with their dorsal side downward, and a large majority of the specimens were in that portion of the wedge-shaped space where their backs came in contact with the brick below.

Then a stone to which several nymphs were attached, was placed in a tin pan and the temperature of the water was slowly raised. As the temperature approached 42°C. several specimens began to lose hold of the rock, others clung to it until the temperature reached 45°C. and in no case did the specimens desert the stone until they were completely overcome by the heat. Then a large stone was placed in the pan, half of it being above the surface of the water. On top of this were placed other rocks highly heated and thus heating the stone half submerged, to which the specimens were attached. A piece of ice was kept in the water to keep it cool, while the temperature of the rock was quite high. This time the insects did not hug the rock as tightly as is their natural custom, but clung to it in a sort of half fast fashion. That, however, was not the only sign manifesting discomfort, as upon close observation it was noticed that first one foot would be withdrawn from the hot rock and then another, the specimens clinging by four or five feet at a time and cooling the others. The space between the nymph and the rock would grow wider and wider until the insect would hang by only one or two claws and finally fall down backward to the bottom. As soon as refreshed in the cool water it would again attach itself to the hot rock. This same process was repeated over and over, though when long continued the rock was not sought with such extreme anxiety as in the beginning.

Although most of the nymphs behaved in that way, occasionally one would leave the rock when the temperature of the stone was about 40°C. and would not return for a long time.

When it was brought near the stone again, it would at first swim toward it, but as soon as the heat was felt it would again turn and swim away. Some of the forms, upon coming in contact with the hot rock, would suddenly dart off, make a little circuit, and then return. This was repeated several times, the circuit becoming more and more extended until finally the nymph would no longer return to the stone. Still others would leap from place to place on the rock as though in search of a cool spot, some finally deciding to leave the stone, while others would quietly settle down and like the large majority of them, would cling to the stone until overcome by the heat.

While working on the food reactions, I came across a specimen that showed an exceptionally strong thigmotactic propensity. When it was placed in a separate dish of water it swam about very much animated, and after intervals of rest, its vigorous activity was again resumed. When a stone was placed in the dish the nymph eagerly attached itself and remained perfectly quiet, but when the stone was taken out and a small piece of alga was placed in the dish, the insect would come up to it, attach itself, and then quickly swim away again. The soft consistency of the plant evidently did not appeal to it. The circus movements were repeated every time I appeared near the dish. Not until after five days of fasting did the nymph attach itself to the morsel of food, to which it clung so firmly that its body became a complete ring. Then it commenced to feed on the ball of food it held so tightly in its claws. The smaller the piece of alga became the more tightly the specimen seemed to cling to it. Finally when only a small part of the food was left, the nymph discontinued feeding but still clung to the small particle. Thinking that this was probably due to the chemical stimulus of the plant, I took it away and gave the nymph a tiny pebble about the size of an ordinary sweet pea. The pebble was eagerly accepted but being much too small to afford normal attachment, the nymph coiled itself around the pebble and thus brought as much of its body in contact with it as possible. It continued encircling the pebble for six days when I noticed that it was about to moult. This was a difficult task, and although the pebble was cast aside during the attempt to get out of the old skin, the specimen now retained its ringlike shape. As the nymph was unable to moult in that condition, the old integument was carefully torn off, but the unfortunate

specimen still remained helpless, disfigured, and unable to swim. All attempts to make it attach itself to a flat surface were of no avail, as the nymph would spring up like a stretched out hoop and fall to the bottom. When a small pebble was placed against the ventral surface of the insect, it was grasped and held tightly. Every day I gave it a trifle larger pebble and by the time of the next moulting, the nymph almost recovered its normal form.

Undoubtedly the specimen experienced some difficulty from the beginning, in clinging to so small a pebble in such an unnatural condition, and yet the content derived through the contact with the pebble must have been more potent, for the nymph would curl itself about the pebble, getting as much of its body in contact with it as posslble, in spite of the fact that the body coiled itself into a complete ring.

DEATH FEIGNING INSTINCT.

The death feigning instinct is quite pronounced in May-fly nymphs when roughly handled out of water. It is rather difficult, however, to make them feign death in water and when one is successful the feint lasts but a few minutes at the most, usually only a few seconds.* Holmes found that mature Ranatras will feign death very readily when taken out of the water and laid on the table, and that they will endure all sorts of maltreatment during the death-feint, even suffering their legs to be cut off one by one or their bodies cut in two without the least response. Most May-fly nymphs can be made to feign death by taking them out of the water and throwing them on the table, but the time of the feint varies widely in the different individuals, some feigning only a fraction of a minute, and others as long as fifteen minutes. The average death-feint lasts about two or three minutes, but it can be prolonged by stroking the nymph on the sternum or ventral part of the abdomen. Under such conditions some specimens were observed to feign death on a very damp piece of cloth for a period longer than an hour.

By placing nymphs with their backs against a rock, and the abdomen with the tracheal gills submerged under water, I have seen some of them feigning death as long as sixty-five minutes

*Holmes, S. J. Death Feigning in Ranatra. The Journal of Comparative Neurology and Psychology, Volume 16, No. 3, pages 200-216, 1906.

at a time, despite the fact that the anterior part of the body was exposed to the air. I sometimes came across forms that could not be made to feign death at all, in others again, though very rare cases, the feint would be so pronounced that pricking the insects only made them more rigid and apparently under obligation to serve their time in that attitude. Usually, however, a touch with a sharp object makes the nymphs discontinue the feint while a smooth object tends to prolong it. Sometimes, before the recovery from a death-feint, the nymphs begin to move the setæ, or stretch out a limb, and then a quick movement of the other limbs follows. Ordinarily, however, the recovery is a sudden jerk, and occasionally, if the nymph happens to lie ventral side downward, the violent, simultaneous extension of the folded legs throws the nymph into the air. Most nymphs can not be made to feign death longer than fifteen minutes on a dry table, a fact probably due to the disturbance in the metabolism of the body occasioned by the lack of oxygen.

MOULTING AND LIFE CYCLE.

The nymphs moult on the average once in about two weeks; the intervals being largely independent of the age and size of the insect. They grow on the average about one-third of a millimeter during the time which elapses between the two successives moults. They do, however, moult several times after they are apparently full grown, or when the growth in length at least, is not appreciable. The number of moults would probably vary during the different seasons if the nymphs were in their natural out-of-door environment and the almost regular moulting may be possibly influenced by the almost invariable temperature of the water in the aquaria.

Ten individuals varying from one to nine millimeters, were kept in separate dishes with an abundant supply of food; daily observations made, and the dates of the various moults recorded which are given in the following table. Several of the larger forms metamorphosed and some of the small ones died within a month or two, and these I was unable to replace on account of the rare sizes, but two lived as long as the experiment was continued.

I	II	III	IV	V	VI	VII	VIII	IX	X
1 mm.	1.5 mm.	2.5 mm.	3 mm.	4 mm.	5 mm.	6 mm.	7 mm.	8 mm.	9 mm.
Nov. 7	Nov. 8	Nov. 7	Nov. 9	Nov. 8	Nov. 10	Nov. 6	Nov. 8	Nov. 9	Nov. 10
Nov. 22	Nov. 20	Nov. 20	Nov. 22	Nov. 20	Nov. 21	Nov. 18	Nov. 18	Nov. 20	Nov. 20
Dec. 3	Dec. 1	Dec. 1	Dec. 4	Dec. 1	Nov. 30	Nov. 30	Nov. 30	Nov. 30	Dec. 1
Dec. 19	Dec. 13	Dec. 13	Dec. 15	Dec. 12	Dec. 9	Dec. 8	Dec. 7	Dec. 9	Dec. 12
	Dec. 28	Dec. 23	Dec. 23	Dec. 22	Dec. 22	Dec. 21	Dec. 18	Dec. 19	Dec. 30
	Jan. 13	Jan. 5	Jan. 8	Jan. 4	Jan. 5	Jan. 5	Jan. 4	Jan. 6	Jan. 8
		Jan. 23	Jan. 22	Jan. 15	Jan. 16	Jan. 26	Jan. 20	Jan. 18	Jan. 16
			Feb. 10	Jan. 29	Feb. 2	Feb. 10	Feb. 6	Metamorphosed	Metamorphosed
			Feb. 24	Feb. 12	Feb. 16	Feb. 23	Metamorphosed		
			Mar. 5	Feb. 26	Feb. 28	Metamorphosed			
			Mar. 21	Mar. 4	Mar. 12				
			April 3	Mar. 28	Metamorphosed				
			April 18	April 13					
			May 4	April 29					
			May 19	May 16					
			June 2	May 30					
			June 17	June 16					

Just how long *H. interpunctata* live I am not entirely certain, as I have been unable to keep any specimens throughout their whole life history. However, there seems to be sufficient evidence that their life extends through a period of two years. In the observation on moulting careful measurements were made of all the specimens after each successive moult. From these data the entire life cycle can be inferred. For example, specimen I which was one mm. long November 7, was one and one-half mm. long December 3; specimen II, one and one-half mm. long November 8, was two and one-half mm. long December 13; specimen III, two and one-half mm. long November 7, was three mm. long January 23; specimen IV, November 9, was three mm. long, or the same length as specimen III had attained when its record ceased, was seven mm. long in June.

Specimen VIII which was seven mm. long in November 8, metamorphosed three months later.

Specimen I, which was one of the smallest obtained in November, was apparently an offspring of the last adults of the season, which metamorphosed in the latter part of August. On further plausible supposition, that it hatched the first part of September, specimen I was about three months old on December third, when it was one and one-half mm. long. Adding to this the time it required specimen II to become two and one-half mm. long, and specimen III to attain three mm. and so on, we have a total of nineteen months, an apparent gain of five months. This gain, however, is easily accounted for owing to the fact that the specimens had the advantage of wintering over in the aquaria. Such a gain actually took place in the larger specimens, which metamorphosed in January, February, and March, and no doubt would not have metamorphosed until June, July, or August of the following summer had they remained in their natural habitat.

The members of this species do not all emerge in the same day or few days, as is true in many other Ephemeridæ, but adult specimens may be collected near Lake Mendota any time from the latter part of June to the latter part of August. The emergings are most numerous in the afternoon. The nymphs crawl up on the rocks, a split appears in the median line of the mesothorax which quickly extends through the pro and metathorax. The head appears first and then the thorax, closely followed by the first pair of legs. A few jerks cause the extrication of the wings and a moment later they become erect. The other two pairs of legs are pulled out about the same time and soon the entire subimago is exposed. After a short rest the insect flutters upward and usually settles a short distance away. This whole process is completed within five or six minutes. On several occasions, when the lake was quiet, I observed the entire emerging process take place at the surface of the water. The sub-imago skin is usually shed within a few hours after the emergence, and the entire life of the adult is comparatively short, lasting about six days at the most and many of the specimens live a much shorter time.

I wish to express my thanks to Prof. S. J. Holmes for his suggestions and kind criticisms.

Zoölogical Laboratory, University of Wisconsin.

NEW WESTERN TIPULA.

By R. W. Doane, Stanford University.

Kertesz's "Catalogue Dipterorum" vol. II ("conclusum exitu anni 1900") lists 309 species belonging to the genus Tipula. In 1901 I published descriptions of 52 additional species. Between that time and this there have appeared in various journals descriptions of some 16 other species, 7 of which are American. This makes a total of 377 species described before the beginning of 1911.

All who have worked with the genus know that long ago it became unweildy and realize that it should be divided into a number of smaller genera. But no one has yet been able to separate the genus into groups well enough defined to be worthy of generic or even subgeneric rank. My studies have convinced me that any satisfactory division of the group must be founded on a study of the structure of the hypopygium. This will mean that all the types that are available will have to be re-examined, for few if any of the earlier descriptions describe this organ in any detail, even the late descriptions refer only briefly to the more conspicuous parts and pass the others over entirely. That the structure of these often remarkably complicated organs is the final test for the determination of species has been demonstrated time and again when two or more forms, exactly alike in all other respects, have been found to exhibit constant striking differences in the structure of the hypopygium.

Hesitating to add still more species to the genus until some such a division is made, I have refrained from publishing descriptions of new species, having during the last ten years described only a few forms that were, on one account or another, of particular interest. I find now that I have in our collections here many undescribed species some of which I have been sending out to my correspondents with manuscript names. In order that these names may be legitimate and that I may more easily keep our large collection of Tipulidæ in better shape, I have decided to publish descriptions of a few of the undescribed species that I now have before me, confining myself, in this paper, to western forms.

Tipula acutipleura n. sp.

Light brown; head grayish brown, with a brown line above; rostrum yellowish with a brown stripe laterally; palpi brown; first and second segment of antennæ yellow; third segment fusiform, yellowish, darker in the middle, remaining segments growing darker, those beyond the fifth wholly brown, each darker and somewhat incrassated at the base; collare lighter brown with three brown spots; mesonotum very light brown with four rather broad brown stripes; coxæ, pleura, scutellum and metanotum hoary, the latter with three narrow stripes which are less hoary; halteres yellow, knobs brown; legs yellowish, tarsi and the tips of the femora and tibia brown; abdomen light brown with a rather broad brown line above; eighth sternite narrowed posteriorly, posterior margin with a shallow rounded incision from the sides of which arise tufts of rather long, stiff, curved, yellow hairs; ninth tergite small with a deep V-shaped incision and a narrow median depression; ninth sternite almost divided by a deep broad U-shaped incision in which hangs a pair of yellow tumid appendages; pleural suture almost completely setting off the somewhat triangular pleura which are produced posteriorly into a rather long acute black-tipped process; upper pair of appendages spatulate, tips with long black hairs, lower pair broad, flattened, yellow, distal margin black, more strongly chitinized and somewhat twisted; wings hyaline with a slight grayish tinge; an indistinct whitish band beginning in front of the stigma and extending into the base of the fourth and fifth posterior cells; another indistinct whitish spot in the middle of the first and the bases of the second and third posterior cells; stigma and a small spot over the tip of the auxilliary vein brown; discal cell more than three times as long as wide; Length 11 mm., wing 12 mm.

Habitat: San Diego, Cal. 1 male.

Tipula atrisumma n. sp.

Male: brownish yellow; head grayish brown with a darker brown line above; rostrum yellowish, somewhat grayish above; palpi wholly brown; first and second segments of antennæ yellow, others wholly brown, those beyond the fourth slightly incrassate at the base; collare brownish with two yellow spots; mesonotum yellowish, with three broad brown stripes the median one divided by a faint gray line; coxæ pleura and metanotum hoary; scutellum brownish yellow; halteres brownish, knobs darker; legs brownish yellow, tarsi and tips of femora and tibia darker; abdomen yellowish with a very broad brown line above, posterior margin of segments yellow; posterior margin of eighth sternite with a median pair of short yellow projections which are but little longer than wide; median one-third of ninth tergite yellow, rest brown, with a broad deep incision and a median depression; just below the median portion of the groove is a pair of short, black, highly chitinized, triangular plates; ninth sternite with a deep very broad U-shaped incision from the lateral margins of which hangs a pair of short slightly tumid processes; pleural sutures complete; pleura produced into a

rather long somewhat curved process the black tip of which ends in two short points; first pair of appendages spatulate, second pair broad, flattened, twisted and ending in two short black tips the upper one of which is longer, broader and triangular; wings hyaline; stigma brown; the indistinct whitish line not reaching the base of the fourth posterior cell.

Female: First and second joint of antennæ yellow, third and sometimes the fourth somewhat yellowish, others brown; eighth tergite a little shorter than the seventh; eighth sternite about as long as the seventh; posterior margin with a crescent-shaped incision and depressions; the apical appendages, corresponding to the lower valves of the ovipositor, are short, quadrate, upper margins more strongly chitinized with the edge twisted or rolled, posterior margins with sharp-pointed triangular processes ninth tergite about half as long as eighth; tenth tergite narrow, about twice as long as ninth ending posteriorly in a pair of short, round-tipped lobes, beneath which is a broad, short, unchitinized appendage which also ends in a pair of short lobes similar to those above; ninth sternite, lying above the eighth sternite, consists of two strongly chitinized lateral plates which are united posteriorly into a rather long sharp process. Length, male 9 mm.; female 11 mm., wing 10 mm.

Habitat: San Diego, Cal. 11 ♂, 5 ♀.

Tipula incurva n. sp.

Brown; head grayish brown; rostrum yellowish brown; palpi brown; first, second and third joints of antennæ yellow, others brown, cylindrical, slightly darker at base; collare grayish brown with four brown spots; mesothorax grayish brown with four brown stripes, the median ones indistinctly divided by grayish lines; coxæ and pleura hoary; scutellum and metathorax yellowish; halteres yellow, knobs brown; femora yellow; tarsi, tibia and tip of femora brown; abdomen yellowish brown with the anterior margin of each segment darker brown; ninth tergite brown, short, broad, with an inconspicuous median ridge, posterior margin with a slight crescent-shaped incision; posterior lateral angles ending in short, blunt, downward-projecting processes; ninth sternite with a broad rounded incision from the posterior lateral angles of which arises a pair of two-lobed inward and upward projecting appendages, the lower lobe being much the smaller of the two; second pair of pleural appendages almost concealed by the first which are rather broad, flattened and bluntly pointed at the tip; wings with a brownish tinge; a rather broad, whitish band beginning in front of the stigma and extending through the basal cells a short distance from their tips to the sixth vein, along which it extends to the posterior margin of the wing; an irregular whitish spot about the middle of the axillary cell; another covering the basal two-thirds of the discal cell, and another in the base of the second marginal and sub-marginal cell; stigma brown; discal cell twice as long as wide. Length 10 mm., wing 11 mm.

Habitat: Nebraska. 1 male.

Tipula alta n. sp.

Brown; head brown; rostrum yellow; palpi yellow darker toward the tips; first and second joints of antennæ yellow, others brown, segments rather long, cylindrical; collare light brown with three darker brown spots; mesothorax grayish brown with three brown stripes, the median one divided by a grayish line; pleura hoary; scutellum and metathorax yellowish the latter somewhat hoary; halteres brown, knobs darker brown; legs yellowish, tarsi and tips of femora and tibia brownish; abdomen brownish yellow, with a broad dorsal line and interrupted lateral brownish bands; posterior margin of eighth sternite with a cresent-shaped incision from the posterior margin of which arise two tufts of rather long yellow hairs; ninth tergite with a broad, deep V-shaped incision the margins of which are black; ninth sternite yellow, with a broad, deep depression; pleural suture very short; pleura yellow, somewhat triangular, first pair of appendages small, spatulate, second pair broad, flat, the lower branch somewhat hooked-shaped and black-tipped; wings hyaline; stigma brown; an indistinct interrupted whitish band beginning in front of the stigma and extending into the base of fourth posterior cell; discal cell in the single specimen before me open. Length 9 mm., wing 9 mm.

Habitat: Lander, Wyoming. 1 male. Alt. 5,000 to 8,000 feet.

This is the first Tipula I have seen with an open discal cell. As I have only a single specimen before me I do not know whether this is a constant character or only accidental.

Tipula marina n. sp.

Brown; head grayish brown; rostrum grayish brown; palpi dark brown; antennæ wholly dark brown; segments beyond the third somewhat excised below; collare grayish brown; mesonotum light brownish with three broad, dark brown stripes, each of which is divided by a light brown line; coxæ, pleura, scutellum and metanotum grayish, somewhat hoary; halteres brownish, knobs darker; legs brownish, base of femora and tibia somewhat yellowish; abdomen brown, posterior margins of segments narrowly, lateral margins, broadly lighter; ninth tergite reddish brown, darker toward the base, posterior lateral angles somewhat produced, tips rounded; with a median deep, narrow V-shaped incision; no pleural suture; third pair of appendages short, tumid, brownish yellow, covered with short yellow hair; wings with a brownish tinge much lighter toward the base; the rather broad whitish space bordering the fourth vein extends through the discal cell and the fourth posterior cell to the posterior margin of the wing, in the region of the præfurca it widens and extends to the anterior margin and sends a broad irregular shaped arm through the second basal cell; bases of the marginal, sub-marginal and first posterior cells whitish; veins and stigma brown. Length male 13 mm., wing 13 mm.

Habitat: Palo Alto, Cal. 3 males.

Differs from T. tristis Doane, which it somewhat resembles in being larger, darker, wings darker and in the V-shaped incision on the posterior margin of the ninth tergite being broader posterior y, narrower anteriorly and much deeper.

Tipula fulvinodus n. sp.

Brown; head brownish, cinereous above with a median broad, brown stripes; rostrum yellowish on the sides; palpi brown; first and second segment of antennæ yellowish; third brownish yellow, others light brown; dorsum of thorax very light brown with three broad, brown stripes each of which is divided by a gray line; scutellum, metanotum and pleura grayish pruinose; halteres light brown, base yellow, knobs darker brown; legs yellowish, tips of femora, tibia and tarsi darker; abdomen brown, darker posteriorly with three darker brown stripes, posterior margin of each segment yellowish; posterior margin of eighth sternite with a rather deep incision, posterior lateral angles each having a tuft of long yellow hair; posterior margin of ninth tergite with a Y-shaped incision, lateral angles rounded, yellow; ninth sternite with a broad rounded incision in which hangs a pair of whitish appendages the tips of which are brown, flattened and covered with thick, short yellow hair; pleural suture very indistinct, pleura whitish; first pair of appendages whitish, long, very slender, slightly curved; second pair broad, flattened, tips with two black teeth; third pair long, narrow, slightly wider toward the tips; wings hyaline; stigma brown; a whitish spot just beyond the stigma and a faint broken, hardly perceptible whitish band beginning in front of the stigma and extending through the discal cell into the base of the fourth posterior cell. Length 12 mm., wing 13 mm.

Habitat: Grand Coulee, Wash. 1 male.

Tipula nigrocorporis n. sp.

Head and thorax blue-black; palpi dark brown, reddish brown toward the tips; antennæ dark brown, second segment yellowish; joints of flagellum deeply incised, dorsum of thorax with three rather indistinct brown lines; femora yellow, tips brown; tibia and tarsi brown; halteres yellowish, knobs brown; first segment of abdomen black, others brownish yellow with a brown, lateral stripe, the sixth, seventh and eighth quite brown, yellowish posteriorly; ninth tergite with a broad, deep, crescent-shaped incision; ninth sternite with a deep V-shaped incision which almost separates the two sides of the segment; pleural plates distinctly separated from the lateral parts of the sternum; wings light brownish with four indistinct whitish spots, one before and one just behind the stigma, a larger one in the middle of the second basal cell and a fainter one in the middle of the anal and axillary cells. Length male 16 mm., wing 18 mm.

Habitat: Estes Park, Colo. 1 male.

Tipula cylindrata n. sp.

Brown; head very dark brown; rostrum dark brown above, yellowish below; palpi blackish brown; first and second segments of antennæ yellow, third brownish yellow, others dark brown, incised below; collare grayish with three brown spots; metanotum grayish with three brown stripes, each of which is divided by a broad gray line; coxæ, pleura, scutellum and metanotum hoary; scutellum and metanotum with a median brown line; halteres yellow, knobs brown; legs brown, femora somewhat lighter toward the base; abdomen light brown, with a dorsal darker brown line; ninth tergite with a broad deep V-shaped incision, the lateral margins of which are notched; ninth sternite with a narrow very deep incision; the margins of which are continuous for a part of their length; no pleural sutures; pleural margin with a small triangular chitinized projection just outside the base of the short tumid brown third pair of appendages; wings with a grayish tinge, with several irregular more or less distinct whitish spaces; a rather broad, not well-defined whitish band beginning in front of the stigma, covering the distal portion of the first basal cell, crossing the second basal cell a little beyond its middle, and extending along the anal cell to the posterior margin of the wing; indistinct whitish spots in the base of the anal and axillary cells, in the tip of the sub-marginal cell, and in the base of the marginal, sub-marginal, first posterior, discal and fourth posterior cells; stigma and a small spot over the tip of the auxilliary vein and another over the tip of the præfurca, brown. Length 11 mm., wing 13 mm.

Habitat: San Diego, Cal. 3 males.

Tipula flavomarginata n. sp.

Yellow; head cinereous above with a median brown stripe; rostrum, palpi and first two segments of antennæ yellow; third segment yellowish, brownish toward the tip, other segments brown somewhat darker at the base; dorsum of thorax light yellowish with four distinct brown stripes; scutellum and metanotum yellow, with a faint, median, brown line; pleura yellow; halteres yellow toward the base, darker towards the knobs which are dark brown, tips lighter; femora, except the tip, yellowish; tibia and tarsi and the tips of the femora brown; abdomen yellowish at the base, brownish posteriorly, posterior margin of each segment yellow; eighth sternite slightly produced, posterior margin roundly emarginate with two bunches of reddish yellow hairs; ninth tergite produced and narrowed posteriorly, posterior margin with a crescent-shaped incision in the middle of which is a pair of short, black triangular, downward-projecting teeth, the ventral margins of the posterior lateral angles with narrow, elongate, black projections; ninth sternite divided ventrally by a broad membranous area, posterior margin with two pairs of small appendages, the upper pair ovate, tips with long yellow hairs, the lower pair more spatulate, hanging in the crescent-shaped incision in the posterior margin of the sternite; pleural suture distinct; upper pair of appendages narrow toward the base and broader toward the tip the anterior upper corner produced into a finger-

like projection; second pair of appendages broad, irregular in shape anterior margin folded back; third pair broad at the base, slightly narrower toward the tip, anterior upper corner produced into a broad, blunt tip; wings hyaline; the stigma, a small spot over the origin of the præfurca, and a narrow border along the great cross vein and the end of the fifth vein, brown; the whitish band beginning in front of the stigma extends across the discal cell into the fourth posterior cell, (in some specimens reaching almost or quite to the posterior margin); small white spot just beyond the stigma. Length 11 mm., wing 13 mm.

Habitat: San Diego, Cal. 8 males.

Tipula rusticola n. sp.

Yellow; head yellowish, darker above; palpi brown, last segment darker; first and second segments of antennæ yellow, others light brown darker at the base; thorax light yellow, the brownish stripes of the dorsum faintly indicated; halteres yellowish, knobs brown, tips lighter; femora yellowish, tips brown; tibia and tarsus brownish; abdomen yellowish, brownish posteriorly; posterior margin of eighth sternite with two tufts of rather long, reddish yellow, hairs; ninth tergite with a broad, median furrow, lateral angles but slightly produced; ninth sternite divided by a rather broad, whitish membranous portion; from the posterior margin just at the edge of the membrane there arises a pair of chitinized two-parted appendages, the outer posterior part is somewhat spatulate the tip furnished with a fringe of reddish yellow hair, the inner part is broader, longer, somewhat twisted and with a double-pointed tip; first pair of appendages long, slender; second pair broad, black-tipped with three more strongly chitinized ridges; the third appendages are much smaller, unchitinized and have a small soft leaf-like lobe extending outwardly at right angles to the rest of the lobe; wings hyaline, veins brownish yellow; stigma brown; a whitish broken band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell. Length 12 mm., wing 12 mm.

Habitat: Keyport, Wash. 2 males.

Tipula derbyi n. sp.

Yellow; head dark brown pruinose above; rostrum brownish yellow; palpi very dark brown; first, second and basal half of third segment of antennæ, yellow, other segments very dark brown; thorax yellow the three dorsal brown stripes more or less distinctly indicated; halteres brown, yellow at the base, knobs darker; legs yellow, tarsi and the distal portion of the tibia brownish; abdomen yellow somewhat darker posteriorly; dorsal and lateral lines more or less faintly indicated; eighth tergite of male semicircular; eighth sternite produced posteriorly and forming a floor for the genital chamber, posterior margin with a shallow semicircular incision which is filled with a white more or less tumid membrane; posterior lateral angles with sub-triangular chitinized processes, the terminal portion of which bear a few short, curved bristles; ninth tergite divided by a median suture into two sub-rectangular,

somewhat tumid, protruding processes the posterior lateral margins of which are sharply incised; ninth sternite large, lower posterior angles with somewhat curved, downward-projecting spatulate appendages, these are attached by the lateral margin and bear numerous short, reddish brown hairs near the tip; pleural sutures well-developed completely setting off the sharp-pointed triangular pleura, first pair of pleural appendages small, spatulate, second pair with a narrow stalk bearing a large, thin, irregular, rectangular plate; third pair somewhat spatulate, very much larger than the first pair, with rather long reddish hair at the tip; eighth sternite of female rather strongly chitinized, posterior lateral angles produced into short rounded lobes a little longer than wide; two short, broad, two-pointed strongly chitinized appendages arise from the posterior lateral angles of the broad truncate median lobe; ninth tergite very small almost concealed beneath the eighth; tenth tergite also very short, more strongly chitinized, cerci very short, broad, rounded; wings hyaline with a very slight smoky tinge, costal and subcostal cells yellowish; stigma brown, an interrupted whitish band running from in front of the stigma through the discal cell into the base of the fourth posterior cell, another whitish spot behind the stigma, a small indistinct brownish spot at the origin of the præfurca. Length male 13 mm., female 12 mm., wing 12 mm.

Habitat: Stanford University. Many males, 6 females. Larvæ feeding on grain roots in meadows.

Tipula pacifica n. sp.

Brown; head grayish brown with dorso-median and post-ocular broad, brown lines; rostrum grayish brown, sides darker; first and last segments of palpi dark brown, others lighter brown; first and second segments of antennæ yellowish brown others brownish, darker at the base; antennæ of female more yellowish; thoracic dorsum with very broad, brown stripes which are distinctly bordered by darker brown lines; median stripe divided by a fusiform brown line; lateral margins clouded with brown; dorso-pleural membrane whitish; pleura grayish brown with indistinct brown spots; an irregular brownish line just below the dorso-pleural suture; scutellum almost wholly brown; metanotum grayish with three broad, brown stripes; halteres brownish, knobs darker, tips whitish; legs brownish, tarsi and tips of femora and tibia darker; abdomen brown, darker brown laterally; extreme margins whitish, seventh, eighth and ninth segments almost wholly dark brown; posterior margin of eighth sternite yellowish, not produced posteriorly; posterior margin of ninth tergite yellowish, under surface with two black, triangular, downward-projecting processes; posterior margin of ninth sternite with a broad, deep rectangular incision; pleural suture indistinct, lateral margins with a pair of very large whitish irregular-shaped appendages some of the inner and upper folds of which are furnished with thick, short, black hairs or bristles; upper appendages rather broad, lateral margins somewhat rolled, tip rounded; ovipositor of female reddish brown, upper valves rather long, acute; lower valves

reaching about to middle of upper valves; wings long and broad, brown, with whitish spots in all the cells, a spot in the beginning of the basal cells, the origin of the præfurca, the stigma, the tip of the seventh vein and less distinct spots near the middle of the second basal, anal and axillary cells, darker brown; the margin of the wing is marked with larger or smaller whitish spots in all the cells; irregular whitish spots in the region of the stigma, the discal cell and in the basal anal cells; veins brown, some of them with a narrow brown border. Length male 26 mm., female 33 mm., wing 27 mm.

Habitat: Deer Park, Placer Co., Cal. 3 males, 2 females. (Types). Keyport, Wash. 1 female.

One of the males is much smaller measuring only 20 mm. wing 20 mm. In size and general appearance, this specimen looks somewhat like T. abdominalis Say, but the antennæ, the markings on the thorax and the structure of the hypopygium are quite different.

Tipula californica n. sp.

Brownish yellow; head yellowish slightly darker above; palpi brown, yellowish toward the base; first and second and the basal half of the third segments of the antennæ yellow, other segments brown, darker at the base; dorsum of thorax light brownish yellow with four broad, brown stripes; scutellum and metanotum brownish yellow; pleura hoary; halteres whitish, knobs brown, tips lighter; legs yellowish, tips of the femora, tibia and tarsi darker; abdomen yellowish, brownish posteriorly, sides with a distinct broken brown line; posterior margin of eighth sternite with a rounded incision, the middle with a short rounded projection above which arises two slender pencils of yellow hairs; lateral angles with a pair of triangular tooth-like projections which bear a fringe of long yellow hairs on their inner margins; ninth tergite with a deep median furrow and a rather deep V-shaped incision from the apex of which arises a short triangular black-tipped tooth; ninth sternite with a very broad, deep U-shaped incision in which hangs a pair of large, tumid, yellow-haired appendages; apex of this incision with fine short, reddish-yellow hairs which almost conceal two short, conical projections; pleural sutures complete; first pair of appendages somewhat conical, furnished with rather long, black hairs; second pair broad, somewhat flattened edges black; third pair more strongly chitinized, oblong, somewhat twisted, ending in a blunt point; wings hyaline with a slight brownish tinge particularly in the apex; the stigma and a small spot over the tip of the subcostal vein and the beginning of the præfurca, brown; veins with an indistinct whitish border; a whitish spot just before and just behind the stigma. Length 16 mm., wing 20 mm.

Habitat: Palo Alto, Cal. 2 males.

Tipula rupicola n. sp.

Brown; head brownish with broad, darker, dorso-median and post-ocular lines; rostrum darker brown; palpi very dark brown; antennæ yellowish darker toward the tip, base of each segment beyond the third blackish; mesonotum tawny the three brown stripes bordered by distinct darker brown lines, the median one divided by a rather broad, dark brown line; dorso-pleural membrane whitish; pleura grayish brown; an irregular line just below the dorso-pleural suture, and other spots, darker brown; scutellum and metanotum brown; halteres light yellow, knobs brown, tips lighter; legs yellowish brown, tarsi and tips of femora and tibia darker, a broad whitish ring on the femora a short distance from the tip; abdomen brown, darker posteriorly, lateral margin darker; ninth tergite somewhat tumid, posterior margin reflexed and with a pair of inconspicuous black edged teeth; pleural suture complete extending to the anterior margin of the segment thus distinctly separating the pleura from the sternum; ninth sternite almost hidden by the eighth sternite; posterior margin with two broad appendages the edges of which are rolled in such a way that the contiguous edges of the two form a large projecting open tube; posterior margin of the pleura rather strongly chitinized, lower corner produced into a short, sharp point; upper pair of appendages broad, short, tips with a shallow rounded incision and with a fringe of black hairs; upper and posterior margin of second pair of appendages furnished with rather long reddish brown hairs the lower angle produced into a rather long spatulate projection; the upper posterior angle of the third pair of appendages strongly chitinized and bearing a few black hairs; wings rather broad and long, brownish with the following parts darker brown: the stigma, a spot over the origin of the præfurca, the base of the fourth posterior cell, the tips of all the veins beyond the apex of the wing, the middle of the posterior margin of the second basal cell, the middle of the anal cell; the distal portion of the second and fifth vein narrowly bordered with brown; a whitish spot beginning in the margin of the wing just beyond the stigma extends into the first posterior cell and follows it to the tip of the wing; another whitish spot beginning in the margin in front of the origin of the præfurca extends diagonally across the first basal and just into the second basal cell; other smaller spots in the discal, anal, axillary and the margins of all the posterior cells, those in the anal cell extending forward into the second basal cell. Length 25 mm., wing 25 mm.

Habitat: Oak Creek Canon, Ariz. 1 male.

The coloring of the body and the wing markings somewhat resemble T, contaminata Doane, but there are several differences the most important of which is the structure of the hypopygium. This and the following species, T. albimacula, have the pleural sutures well developed thus entirely separating the pleura from the other sclerites. Following Snodgrass, these species

would be in a group lower than any he studied, a group corresponding to the simplest of the brevipalpi where the pleura and sterna are entirely separated.

Tipula albimacula n. sp.

Brownish yellow; head brownish yellow with a darker stripe above; first segment of palpi yellowish others brownish, last segment darker; antennæ yellowish toward the base, growing darker toward the tip, last four or five segments brown; metanotum brown with three broad, darker brown stripes; pleura yellowish, pruinose, with a rather broad, brown stripe extending from above the base of the first coxæ to the base of the wings; scutellum brown with a median lighter line; metanotum yellowish with a very narrow median brown line; legs yellowish, tarsi and tips of femora and tibia darker; abdomen yellowish, spotted with brownish, with dorsal and lateral brown stripes; first, sixth, seventh and eighth terga brownish; ninth tergite tumid, posterior margin with a broad crescent-shaped incision in the middle of which is a small semicircular incision; ninth sternite similar to the preceding sternites, posterior margin bearing a pair of leaf-like appendages which are attached near the middle of their long sides, the margins of the opposing faces slightly curled in, thus forming an incomplete tube; pleural suture extending to the anterior margin of the segment so that the pleural sclerites are completely separated from the others; upper appendages broad, rounded, margins somewhat more chitinized; lower appendages long, rather broad, somewhat twisted, ending in an upper rather broad, blunt arm and a lower narrow, curved, sharp-pointed claw; wings with a brownish tinge with several lighter and darker spots; an irregular broken V-shaped, whitish band beginning in front of the stigma and ending close to the tip of the sixth vein; a rather large irregular whitish spot on the margin of the axillary cell and other smaller whitish spots in all of the cells in the apical portion of the wing; the whitish spots in the margins of the posterior cells are bordered on each side by brownish spots. Length 20 mm., wing 22 mm.

Habitat: Arizona. 1 male.

See the note in regard to the hypopygium of T. rupicola.

Tipula aspersa n. sp.

Brown; head grayish brown with a narrow median, dark brown line above and brownish lines back of the eyes; rostrum grayish brown, darker laterally; palpi dark brown; antennæ yellowish, base of each segment beyond the third black; metanotum grayish with three brownish stripes each of which is margined by darker brown; median stripes divided by a narrow brown line, lower margin of metanotum bordered by a brown line; pleura grayish pruinose with two median brown spots and a brown stripe which begins on the prothorax and ends just beyond the mesopleural suture; scutellum and metanotum grayish, each with a median brown line; a brown spot above the base of the halteres; halteres yellowish, knobs brown; legs yellowish, tarsi and tips of femora

and tibia darker; abdomen brown with darker stripes dorsally and laterally; posterior margin of ninth tergite of male with a pair of shiny. brown, triangular projections between which is a deep narrow U-shaped incision; ninth sternite completely bordered below by a deep V-shaped incision; pleural suture distinct curving upward about the middle of the segment after which it soon disappears; upper appendages long, broad, strap-like, tips rounded; lower appendages broad, the chitinized margins rolled upon themselves, the distal margin with a long, strong claw; upper valves of ovipositor of female long narrow tips rounded; lower valves rather broad, flat, tips acute; wings with a brownish tinge with brown spots at the tips of all the veins, on the origin of the præfurca, and in the second basal and anal cells; third vein and anterior branch of the fourth vein with brownish spots near the middle; second, third and fourth posterior cells with brownish spots toward the bases; stigma brown; an interrupted whitish band beginning back of the stigma and extending across the discal cell into the base of the fourth posterior cell. Length male 14 mm., female 19 mm., wing 17 mm.

Habitat: Pacific Grove, Cal. 1 male, 1 female.

Tipula planicornia n. sp.

Brownish yellow; head yellowish somewhat cinereous above, with a median darker line; palpi yellow, last segment brown; first three segments of antennæ yellow, fourth sometimes also yellowish, others brown, darker at the base; dorsum of the thorax brownish yellow, with three brown stripes the median one divided by a cinereous or yellowish line; scutellum yellow with a median, brown line; pleura and metanotum grayish pruinose; halteres yellow, knobs brown, tips lighter; legs yellow, tarsi somewhat darker; abdomen brownish yellow, darker posteriorly, the median, dorsal, brown line broader than the later lines; posterior margin of the eighth sternite with a shallow rounded incision, middle portion with a whitish membrane from which arises two brush-like tufts of long, light yellow hairs, as both tufts are directed inward they cross each other; lateral angles furnished with a broad, irregular-shaped chitinized appendage, the upper inner angle of which is drawn out into a rather long, flattened, slightly curved claw; the inner (anterior) face of this appendage is furnished with two ridges or keels, the upper one has a serrate, hairy margin, the lower one, running at right angles to the other, is pruduced into a long, narrow, slightly curved arm; ninth tergite small, posterior margin with two small crescent-shaped incisions between which is a sharp, triangular, furrowed tooth; ninth sternite with a very deep U-shaped incision which is filled with a pair of appendages the posterior faces of which are chitinized and each terminating in a pair of backward-projecting claws, the lower ones long and curved, the upper ones short, less strongly chitinized, inconspicuous; pleural suture complete; upper pair of appendages reddish brown, broadly spatulate, furnished with long, brownish and yellowish hairs; second pair elongate, suddenly broadened about the middle, posterior margin with long yellow hairs, distal margin black, strongly chitinized; third pair yellow, narrowly spatulate; the long, strongly chitinized,

black-tipped, shield-shaped penis guard often shows distinctly between these appendages; abdomen of female long, cylindrical; ovipositor reddish brown, upper valves long, slender, acute, lower valves broader, less acute; wings hyaline with a slight brownish tinge; stigma light brown, inconspicuous; a rather distinct whitish band beginning in front of the stigma and extending through the discal cell into the base of the fourth posterior cell. Length male 18 mm., female 27 mm., wing 19 mm.

Habitat: San Diego, Cal. 20 males, 8 females.

Tipula pyramis n. sp.

Brownish yellow; head yellowish, cinereous above, with a median darker line; palpi yellow, last segment darker; first three segments of antennæ yellow, others brown; dorsum of thorax light yellowish brown, with four broad, brown stripes, the anterior ends of each of which curve slightly outward; between the median pair is a narrow, indistinct brown line; metanotum, pleura and coxæ grayish pruinose; halteres yellow, knobs brown, tips lighter; legs brownish, base of femora yellowish; abdomen brownish yellow, darker posteriorly with three brown stripes which are broader and browner posteriorly; eighth sternite somewhat produced posteriorly, posterior margin with a rather broad, elongated round-tipped flap which is margined with yellowish hairs; above this flap, attached to the inner (upper) surface of the eighth sternite and to the anterior margin of the ninth sternite is a long, flat, tapering, slender process the curved tip of which hooks into the median incision of the posterior margin of the ninth sternite; ninth tergite short, leaving the appendages unusually exposed, divided by a deep V-shaped incision and a dorsal median furrow from which arises a short, conical light-colored process; ninth sternite elongated, posterior margin with a deep incision in which, arising from the margin just below the pleural suture, is a pair of long, slender-pointed appendages; pleural suture very short; first pair of appendages rather short, stout, curved forward near the middle; second pair with the edges rolled up, ending in two black teeth; third pair unusually large, narrow at the base, broad in the middle, tapering to a blunt point, on the posterior margin near the base are two blunt teeth; wings hyaline, costal and subcostal cell with a yellowish tinge; stigma brown; a broken, whitish band beginning in front of the stigma and reaching through the discal cell into the base of the fourth posterior cell. Length 19 mm., wing 19 mm.

Habitat: Pyramid Lake, Nev. 7 males.

Tipula sylvicola n. sp.

Brownish-yellow; head yellowish, cinereous above; palpi brown, first segment yellow; first three segments of antennæ yellow, others brown, somewhat darker at the base; dorsum of thorax grayish brown with three broad, brown stripes, the median one divided by a gray line; scutellum light yellow with a faint median brown line; metanotum and pleura yellowish, pruinose; halteres yellow, knobs brown, tips lighter; legs yellow, tips of femora tibia and tarsi darker; abdomen brownish

yellow, darker posteriorly, the darker dorsal and lateral stripes faintly indicated; posterior margin of eighth sternite with a very broad, rounded incision, middle portion with a narrow white membrane from which arises two brushes of very long, reddish yellow hair; lateral angles with more strongly chitinized, triangular, inward-projecting appendages, the tips and inner margins of which are furnished with yellow hairs; posterior margin of ninth tergite with a broad shallow incision and with a less strongly chitinized yellow border which is quite distinctly set off from the rest of the tergite, the middle of this border is provided with a pair of blackish triangular teeth, the inner margins of which are straight and close together; ninth sternite with a deep narrow U-shaped incision in the upper part of which hangs a pair of tumid, yellow appendages; pleural sutures complete; upper pair of appendages spatulate, yellow, furnished with brownish and yellow hairs; second pair broad, yellow, black-tipped; third pair elongate, tips rounded, margins reddish brown; wings hyaline; stigma brown, a broken whitish band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell. Length 16 mm., wing 17 mm.

Habitat: Keyport, Wash. 5 males (Type). S. Cal. 1 male.

Tipula ungulata n. sp.

Brown; head yellowish, cinereous above, with a median darker line; palpi brown, first segment yellow; first three segments of antennæ yellow, third brown toward the tip, other segments brown; thorax grayish pruinose; dorsum with three brown stripes, the median one divided by a gray line; scutellum yellowish with a median brown line; halteres yellowish, knobs brown, tips lighter; legs yellowish, tarsi, tips of femora and tibia brown; abdomen yellowish brown, darker posteriorly with three distinct brown lines; eighth sternite with a slight, rounded incision from which arises two tufts of reddish yellow hair; posterior lateral angles with large more strongly chitinized appendages, the posterior face of which is mostly black, ending in a broad, blunt outer tooth and an inner, narrower, sharper tooth; posterior margin of ninth tergite with a rounded incision in the middle of which are two short, sharp points; ninth sternite divided by a deep, broad U-shaped incision in which hangs a pair of yellowish pendulous appendages and from which projects a pair of conspicuous, strongly chitinized, claw-like appendages; pleural suture complete; first pair of appendages rather broad, brown, tip rounded, with long brown hair; second pair broad, flattened, outer face with a more strongly chitinized fold; third pair elongate, narrowed in the middle, tip rounded; abdomen of female very long, ovipositor reddish brown, upper valves long, acute, tips slightly curved, lower valves long, broad, tips truncate, slightly roundly emarginate; wings hyaline with a brownish tinge; costal and subcostal cell yellowish; stigma and a very narrow border on the great cross vein and the tip of the fifth vein brown; a whitish band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell; and indistinct whitish spot beyond the stigma. Length male 15 mm., female 23 mm., wing 16 mm.

Habitat: San Diego, Cal. 16 males, 4 females.

Tipula bifalcata n. sp.

Yellow; head yellow, cinereous above with a median, darker line; palpi yellow, tips somewhat darker; first and second segments of antennæ yellow, others brown; dorsum of thorax honey yellow, stripes very faintly indicated; rest of thorax yellowish, pruinose; halteres yellow, knobs brown; legs yellow, tips of femora, tibia and tarsi darker; abdomen yellow at the base, brownish posteriorly; eighth sternite produced, narrowed posteriorly; posterior margin with a shallow broad, rounded incision from the middle of which arises a tuft of short, thick, stiff, yellow hairs; lateral angles with a pair of conical processes, the tips of each of which are furnished with a pair of close-set, long, heavy, curved, reddish bristles and several shorter yellow hairs; ninth tergite with a deep median furrow, posterior margin ending in a pair of short, broad, blunt, black teeth, between which is a square incision; posterior lateral angles inflexed; ninth sternite with a deep shield-shaped incision from the sides of which arises a pair of rectangular plates which are imbedded in the membrane and to the tips of which are attached the two-parted base of the long, strongly curved, deeply furrowed, two-pointed guard; just below the end of the pleural suture, which is indicated only at the posterior margin, hangs a pair of flat, truncate appendages, the lower edges of which are furnished with long, thick, reddish yellow hair; posterior margin of pleura with a very slight rounded incision; first pair of appendages long, slender, yellow, curved backward near their middle, tips with long yellow hairs; second pair broad, flattened, base narrower, anterior margin strongly chitinized, with a sharp triangular tooth at the tip and a long, narrow spine near the base of the appendage; inner faces with a series of fine chitinous ridges; third pair well separated from the second, spatulate with anterior angle drawn out into a broad, blunt point; arising from the same common base as the other appendages is a fourth pair of strongly chitinized appendages each consisting of a broad base and a long, regularly upward-curved, tapering hook; wings hyaline; costal and subcostal cell lightly tinged with yellow; stigma brown, indistinct; a faintly indicated whitish spot in front of the stigma. Length 18 mm., wing 19 mm.

Habitat: San Diego, Cal. 1 male.

Tipula biarmata n. sp.

Like T. bifalcata with the following exceptions: third joint of antennæ mostly yellow; dorsum of thorax lighter yellow; the posterior margin of the ninth tergite without the median square incision; the truncate appendages just below the end of the pleural suture are more tumid; third pair of pleural appendages elongate, narrow, of the same width throughout; fourth pair of appendages flatter, shorter, less strongly curved; a distinct whitish band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell. Length 18 mm., wing 19 mm.

Habitat: Keyport, Wash. 1 male.

Tipula sternata n. sp.

Yellow; head yellow slightly darker above; palpi brown, yellow at the base; first two segments of antennæ yellow, third brownish yellow, others brown; dorsum of thorax yellow with three brown stripes faintly indicated; scutellum, metanotum and pleura yellowish; halteres brown, base yellow, knobs brown, tips lighter; legs yellow, the tarsi and the extreme tip of the femora and tibia a little darker; abdomen yellow at the base, brownish yellow posteriorly, the three brown stripes only faintly indicated; eighth sternite extending well up on the sides of the abdomen and much produced posteriorly, posterior margin rounded, upper (inner) surface with a median pair of short brush-like tufts of hair and a lateral pair of large whitish, membranous appendages which end in strongly chitinized brown triangular tips; ninth tergite very large about as broad as long, posterior lateral angle produced into a pair of thick heavy, slightly curved pointed horns; posterior margin with two broad, flattened, black-edged teeth between which is a small rounded incision; ninth sternite about concealed by the eighth sternite, only the sides showing; posterior margin with a double incision the heart-shaped anterior part being connected with the rounded posterior part by a narrow channel; in the middle of the heart-shaped part lies the two slender, curved, round-tipped processes which branch off from the base of the guard, the guard itself being long, shield-shaped and with seven black teeth or spines toward the tip, the largest and longest arises from the middle line of the posterior face not far from the tip; pleura very small, suture complete; first pair of appendages small, whitish, spatulate, tip with brown hairs; second pair flattened, posterior margin rounded, anterior margin more strongly chitinized, black, ending in a heavy triangular tooth with a much smaller spine just before it; third pair closely joined to the second forming a rounded lobe on its posterior margin; wings hyaline, costal and subcostal cells and stigma with yellowish brown tinge; veins brown. Length 17 mm., wing 18 mm.

Habitat: Stanford University, Cal. 2 males.

Tipula tergata n. sp.

Brown; head yellowish, somewhat cinereous above; palpi yellow, last segment brown; first two segments of antennæ yellow, the third yellowish, brownish toward the tip, other segments brown, slightly swollen at the base; dorsum of thorax light yellowish brown with four distinct brown stripes; scutellum and metanotum light brown with a median darker line; pleura grayish, pruinose; halteres yellow, knobs brown, tips lighter; legs brown, coxæ and basal portion of femora yellow; first two or three segments of abdomen yellowish, others brownish, posterior margin of each light yellow; eighth sternite very large, the broad posterior margin with a very slight rounded incision, the narrow, whitish membrane at the middle provided with two tufts of reddish yellow hair; lateral angles with irregular-shaped appendages, ending in an upper blunt and a lower sharper lobe, the posterior faces strongly chitinized; ninth tergite large, about as broad as long, posterior latera

angle produced into two long, triangular processes, the tips of which are slightly curved and acute; on the posterior margin at the base of the inner face of these processes is a pair of short, black, blunt projections; ninth sternite divided by a deep broad membranous depression on the lower margin of which are two small chitinous rings and from the upper portion of which arises the long curved, highly chitinized, beak-like guard; in the lateral margin of this depression just below the pleural suture, which is complete, is a small, short, curved claw, and a short yellow-haired, tumid process; the posterior angle of the pleura produced into a short, broad, triangular point; first pair of appendages small, very light brown, gently curved forward, with reddish brown hair; second pair broad, flat, twisted, ending in a heavy, black, triangular tooth; third pair broadly joined to the second, elongate, distal half suddenly narrowed; wing hyaline, costal and subcostal cell yellowish; stigma brown; a faint whitish spot in front of the stigma; Length 17 mm., wing 17 mm.

Habitat: Pyramid Lake, Nev. 2 males, (Type). S. Cal. 1 male.

Similar in appearance to T. sternata but differs in the markings of the thorax and the details of the structure of the hypopygium.

Tipula flavicoma n. sp.

Yellow; head yellow with a narrow brown stripe above; rostrum yellow; first three segments of palpi yellow, last segment brown; first three segments of antennæ yellow, fourth segment yellowish brown, others brown; metanotum brownish yellow with thin indistinct brown stripes, the median one divided and faintly bordered by darker brown; pleura light yellow, pruinose; scutellum and metanotum yellow; halteres yellow, knobs brown; legs yellow, tarsi and tips of femora and tibia darker; abdomen yellow with distinct brown lines above and on the sides, the latter wavy; eighth sternite somewhat produced posteriorly, posterior margin truncate with a fringe of light yellow hairs; inner sides of the lateral angles, which are somewhat produced, with tufts of long yellow hair; ninth tergite with a median rather broad U-shaped incision and lateral very slight rounded incision; ninth sternite with a very deep, broad, rounded incision in which hangs a pair of long, yellow, tumid, hairy appendages; pleural suture complete, the upper portion faintly marked, posterior margin of pleura with a broad, shallow, rounded incision; first pair of appendages small, spatulate, second pair broad, twisted, tips black, third pair broad, flat, tips rounded; wing hyaline; veins and subcostal cell yellowish; stigma brownish, rather indistinct; a whitish interrupted band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell; indistinct whitish spots in the second basal, anal, and axillary cells. Length 17 mm., wing 16 mm.

Habitat: Montana. 1 male.

Tipula biuncus n. sp.

Brownish yellow; head yellowish, cinereous above with a median darker line; palpi yellow, first two segments of antennæ yellow, others brown; dorsum of thorax cinereous with three median brown lines and two lateral broader brown stripes; dorsal pleural membrane yellow; pleura grayish, pruinose; halteres yellow, knobs brown, tips lighter; legs yellow, tarsi and the tips of the femora and tibia brown; abdomen brownish yellow with three brown stripes, the dorsal one broad and distinct the lateral ones broken; posterior margin of eighth sternite with a very slight, rounded incision with a few reddish yellow hairs; ninth tergite with a very deep V-shaped incision; posterior lateral angles sharp-pointed; ninth sternite divided by a deep, broad furrow in which hang two very short, tumid, yellow appendages; pleural sutures complete; lower angle of pleura produced into a short, blunt point; first pair of appendages broad, spatulate, brown, thickly covered with brown hair; second pair flattened, black-tipped, third pair closely joined to second, yellowish, rounded; a pair of long, slender, sharp-pointed, slightly curved hooks projects beyond the appendages; base of ovipositor brown, valves yellow; upper valves slender, straight, tips rounded, lower valves broad, triangular, short, not reaching half way to the tips of the upper valves; wings hyaline; subcostal cell tinged with yellow; stigma brown; a very faintly indicated broken whitish band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell. Length male, 12 mm., female 15 mm., wing 13 mm.

Habitat: S. Cal. 1 male, 1 female.

Tipula meridiana n. sp.

Gray; head grayish, darker above; rostrum grayish above, brownish on the sides; palpi brownish; metanotum light yellowish with three broad, ashen stripes, each of which are distinctly brown bordered and the middle one divided by a narrow brown line; pleura, scutellum and metanotum grayish, pruinose, latter with a median brownish line; halteres yellow, knobs brownish at the base; legs brownish yellow, tarsi darker; abdomen brown; eighth sternite distended below to make room for a rather large, tumid appendage that arises from the ventral side of the base of the ninth sternite; ninth sternite with a deep V-shaped incision and a median suture which extends to the base of the segment; pleural suture complete setting off a large rectangular sclerite, the posterior ventral corner of which is extended into a blunt point which bears the appendages; the first pair of appendages somewhat ovate, second pair broad at the base, distal half twisted and more strongly chitinized; posterior margin of ninth tergite with two close-set, black-tipped, blunt projections; wings almost hyaline with a slight brownish tinge; an indistinct whitish stripe in the first basal cell extending through the first posterior cell to the tip of the wing; all the veins with a more or less distinct brown border. Length 11 mm., wing 15 mm.

Habitat: Arizona. 1 male.

Tipula spatha n. sp.

Yellow; head yellow slightly darker above; palpi yellow; first two segments of antennæ yellow others wholly brown; mesonotum yellowish brown with three brown stripes, the median one divided by a lighter line; pleura yellow, pruinose; scutellum and metanotum yellow; halteres brown, base yellow, tips of knobs yellowish; legs yellow, tarsi and tips of femora and tibia darker; abdomen yellow, darker posteriorly, posterior margin of each segment lighter; eighth sternite very large, brownish yellow; posterior margin with a median rectangular projection, distal side of which is fringed with short yellow hairs; laterad of this is a pair of club-shaped appendages the tips of which are provided with long, stiff, reddish hairs; ninth tergite divided by a deep, V-shaped incision and a deep furrow which reaches to the anterior margin where it widens considerably, the posterior margin ending in two sharp downward-projecting points; posterior margin of ninth sternite with a very deep, broad, U-shaped incision from the anterior margin of which arises a long, rather broad and tumid, light yellowish process; pleural suture complete, setting off a rather large rectangular sclerite; upper appendage broad, flat, rounded, base narrower, margins with long yellow hairs; second appendages broad, thin, margins with fine black hairs; below the pleural suture is a pair of tumid appendages which bear long yellow hairs; between these, projecting from the genital chamber are three long, strongly chitinized organs, the upper pair are long, narrow, sharp-pointed, the lower one is wider and has a broad, downward-projecting tip; wings hyaline, subcostal cell yellowish, a whitish band beginning in front of the stigma and extending across the discal cell into the base of the fourth posterior cell; stigma brown; fifth vein narrowly bordered with brown. Length 23 mm., wing 22 mm.

Habitat: Arizona. 1 male.

Tipula occidentalis n. sp.

Brownish yellow; head yellowish, cinereous above with a median darker line; rostrum yellowish at the base, brownish toward the tip; first three segments of antennæ yellow, others brown, darker at the base, distal end of segments 4, 5, 6, 7, more or less yellowish; dorsum of thorax light yellowish, with three brown stripes, the median one divided by a light line; scutellum and metanotum very light brown with a median brown stripe, sides of metanotum brown; pleura very light yellow, with indistinct grayish spots; halteres yellow, knobs brown, tips lighter; legs yellow, tips of the femora, tibia and tarsi darker; abdomen brownish yellow, darker posteriorly, with three distinct brown stripes, the dorsal one the broadest; posterior margin of each segment whitish; posterior margin of eighth sternite with a rounded incision from the middle membranous portion of which arises two brushes of rather long, yellow hair; lateral angles with triangular hooked appendages the tips of which are furnished with a few yellow hairs; ninth tergite with a very broad, deep, V-shaped incision; ninth sternite divided ventrally by a rather

broad, membranous portion, posterior margin with a broad, shallow U-shaped incision in which hangs a pair of tumid, yellow, hairy appendages; pleural suture complete; first pair of appendages brown, furnished with brown hairs, long, gently curved near the middle, tip rounded; second pair broad, more strongly chitinized, ending in two strong, blunt points; third pair closely joined to the second, quadrate, yellow, less strongly chitinized; wings hyaline with a faint brownish tinge; the stigma and faint spots over the tip of the subcostal vein and the origin of the præfurca, brown; the whitish band beginning in front of the stigma extending across the discal cell into the base of the fourth posterior cell. Length 15 mm., wing 17 mm.

Habitat: San Diego, Ca[1]. 6 males.

Tipula flavocauda n. sp.

Brown; head yellowish brown, cinereous above; palpi yellow, last segment brown; first three segments of antennæ yellow, others brown, darker at the base; dorsum of thorax gray with four brown lines; scutellum, metanotum, pleura and coxæ grayish pruinose; halteres yellow, knobs brown; legs yellow, tibia and tarsi darker; abdomen yellowish brown with three broad, brown stripes; posterior margin of eighth tergite with a median tuft of short, light yellow hairs between a pair of irregular-shaped, six-sided, box-like appendages which, when folded in place, show only one of the broadly triangular surfaces; ninth tergite brown, posterior and lateral margins yellow; posterior-lateral angles produced into two broad, truncate projections each bearing on its ventral side a short, sharp, triangular tooth; between the lateral projections and separated from them by small rounded incisions is a median pair of short, sharp-pointed, broadly triangular projections; posterior margin of ninth sternite with a rounded incision from the membranous middle portion of which arises a pair of rather prominent, strongly chitinized, horn-like projections; above these, usually concealed by the pleural appendages, is a group of four other chitinous appendages, the lateral pair long, slender, sharp-pointed and bent at right angles near the center, the upper member of the group is strong and beak-like, the lower member weak, slender and hooked at the tip; in the lateral margins of the incision, just below the pleural sutures is a pair of very short, yellow, tumid appendages the tips of which are furnished with yellow hairs; pleural sutures complete, posterior margin of pleura with a short triangular tooth; upper pair of appendages slender, whitish with many brown hairs; second pair brown, flat, ending in a sharp, heavy, black, triangular point; third pair closely united to the second, consisting of two lobes the anterior one sharp-pointed, the posterior one truncate; upper valves of ovipositor long, tips rounded and slightly curved upward; lower valves weakly chitinized, short, reaching only to the base of the upper valves; wings hyaline, costal and subcostal cells, the stigma and the veins brown. Length 16 mm., female 20 mm., wing 17 mm.

Habitat: San Diego, Cal. 3 males, 3 females.

CHANGE OF NAMES.

Mr. C. P. Alexander has recently called my attention to the fact that some of the names that I used in describing certain Tipula in my article in Jour. N. Y. Ent. Soc. Vol. IX No. 3 (1901), were preoccupied. Some of these I had noted before but had neglected to change them. I now wish to propose the following changes:

Page 107, for *Tipula clara* substitute *T. pellucida.*
Page 115, for *Tipula concinna* substitute *T. olympia.*
Page 119, for *Tipula albovittata* substitute *T. vittatapennis.*
Page 121, for *Tipula contaminata* substitute *T. commiscibilis.*
Page 124, for *Tipula graphica* substitute *T. fulvilineata.*

A PROBLEM IN THE FLIGHT OF INSECTS.

HERBERT OSBORN.

In the usual explanations for the flight of insects, the mechanism is considered essentially as a plane with a rigid anterior border, flexible hinder border and with a vertical movement so that the vibrations result in the forward propulsion of the insect and, so far as I am aware, no further discussion of the modes of progression have been presented. There is, however, another feature in the flight of insects which appears to me to be well worthy of notice and which is not explained by the application of these principles, at least without some modification. Insects, aside from the direct forward flight, are able to hover or even fly distinctly backward as of course everybody who has observed insects must have noticed. It is only necessary to recall the hovering flight of swarms of insects in the air, such as midges, gnats, certain species of flies, May-flies, and even grasshoppers, to appreciate the distinctness of this feature of flight. For a distinctly backward progression, we may cite the approach and retreat of the hawk moths in their visits to flowers, the backward and forward movements of bees as they light or rest upon plants, the dragon-flies, and perhaps especially the backward flight of the honey bee in its initial flight from the hive when it is fixing the location of the entrance to its hive.

Now if we consider the mechanism of the wing as simply a membrane with a rigid anterior border and the progression

effected by the up and down movement of this membrane, the propulsion being determined by the flexibility of the posterior border, it will be seen that while this device provides beautifully for the forward progression of the insect, it does not account for such backward movements as have been noticed. This problem has been in mind for several years and I have presented it on a number of occasions to my classes in Entomology and it has provoked a good deal of discussion, and it appears to me that it is possible to offer an explanation which may be considered somewhat of a solution of the problem. This solution has been suggested and contributed to by a number of students in these discussions and it may be difficult to credit the explanation to any original source.

The explanation of these movements seems most readily accounted for on the basis of an adaptation in the wing which provides for a forward and backward movement so that the angle of the wing with reference to the axis of the body represents different degrees ranging from a right angle to an angle of 30 to 45 degrees for the anterior quadrant. It will be seen that when rotating forward in this manner, the rigid portion of the anterior part of the wing is shifted so that the flexible apical and posterior margins have a different extent and must present a varying pressure upon the air. It appears quite certain that this rotation would allow for varying degrees of the forward and backward pressure, or to state it in another way that the direction of force of each wing would form an angle to the median axis of the body, and that at the point where these would neutralize each other, the effect would be to produce a stationary condition of the insect whereby it would hover at a fixed point, and that a slight further rotation forward would serve to push the insect in a backward direction.

That this mechanism actually exists in many insects may be determined by the movement of the wing forward or backward in a horizontal plane, and it is easily noted in the position in which wings are fixed at death in many insects. Comparison among different groups of insects will show that the extent of rotation differs greatly in different groups and this would agree thoroughly with the fact that the ability to hover or to retreat in flight is very differently developed in different insects. Furthermore, it appears that the ability for this kind of flight depends in some degree upon the shape and especially upon

the width of the wings, as it will readily be recalled that the broad winged moths and butterflies show little if any flight of this character, whereas the narrow winged hawk moths, flies, bees, etc., which have the property distinctly developed are mostly narrow winged species. Furthermore, it seems that the development of lobes or other variable extentions of the membrane on the posterior border may be significant in this connection. An exhaustive comparison amongst different species of insects, and careful reference as to the extent to which hovering or backward flight is possessed by the different species would be an interesting matter in this connection, but the author has not had time to devote to such a research and the problem is presented here rather as a suggestion for investigation than with the idea that it has been exhausted.

FAUNISTIC STUDIES IN ENTOMOLOGY.

Herbert Osborn.

I desire to call attention in this note to the desirability of more extensive and especially more distinctly correlated studies upon the insect fauna of the country and especially with reference to the localities represented by the members of this society.

There is no question, I think, as to the great desirability of studies on the geographical distribution of insects, but I have been particularly impressed with the necessity for such studies and the desirability that it should be pushed to greater intensity by recent efforts to secure data concerning the distribution of the species in a group upon which I have been engaged.

The records of occurrences for insects have always been a quite prominent feature of entomological journals and to a considerable extent, lists of species in certain groups, for certain localities, states, or districts, have appeared in various journals. While the preparation of such lists may by some be considered as a rather easy part of entomological investigations, it appears to me that accurately done work of this kind becomes of the highest scientific value, and that we may very well encourage it to the greatest extent that is possible. Undoubtedly this particular kind of work is one which could be entered upon with the greatest interest and with promise of most distinct

advancement to the science, if brought to the particular attention of the members of this society, and especially for those who are located in places where such studies have been neglected. In many cases such isolated individuals are deterred from undertaking the listing of their native species because of the idea that such work is not of primary importance, or from the difficulties encountered in finding the most satisfactory methods of preparation for various groups or securing the identification of such groups as may lie outside of their own especial field. These conditions may be greatly helped by the distinct stamp of approval of this society for such work and by some concerted effort to arrange so that determinations may be secured for the collections in different orders. The direct method of encouragement, it appears to me, may be best taken up by the appointment of a standing committee on faunistics, the duty of which committee shall be to suggest means for the encouragement of such local work, the assisting of individuals in placing their collections where they may be identified, the gathering of scattered and isolated local lists into more comprehensive ones, either for certain groups of insects or to cover certain geographical districts, or to develop the faunistic study of Entomology in such other ways as they may deem profitable. If this suggestion appeals to the society, I should be pleased to see such a committee organized at this meeting or at such time as may seem appropriate, and given such instruction as the society may see best. In general, it would seem desirable that such lists as have been mentioned should be published in the various jounrals to which they might be most appropriate, in the proceedings of state academies or other local societies and that the more extended faunistic papers resulting from the collection of these may be finally published in the Annals or in such journal as may give to them the widest distribution and permanence.

Some most excellent work of this kind is in progress in certain states and I think we will all agree as to the useful purpose that has been served by such extensive state lists as that on New Jersey Insects and many of us have had occasion to admire and make use of the extensive work in this line carried along by the State Entomologists of Illinois and of North Carolina. These are by no means the only cases of the kind but may serve to illustrate the utility of work in this field.

AQUATIC HYMENOPTERA IN AMERICA.

Robert Matheson and C. R. Crosby.

This article is intended primarily to call attention to an almost entirely neglected field of entomological research, at least in this country, namely—the study of the habits and life-histories of those minute hymenopterous insects that have assumed aquatic life. In Europe considerable work has been done along this line. As early as 1836, F. Walker observed *Agriotypus armatus* (an anomalous Ichneumon fly) descend some distance into the water. Von Siebold (1858), W. Müller (1888), and others have shown that it is parasitic on Trichopterous larvæ. In 1863 Sir John Lubbock published his well known account of *Polynema natans* and *Prestwichia aquatica*, both with aquatic habits, the former swimming by means of its wings, the latter using its legs. Nothing was known by him regarding their earlier stages. Enock, Heymons and Willem have since reared *Prestwichia aquatica* from a variety of insect eggs, including Notonecta, Ranatra, Dytiscus and Pelobius.

In 1908, Heymons reared from eggs of a dragon-fly a Mymarid (*Anagrus subfuscus*) which although provided with wings kept them closed and swam with its legs. He also observed *Gyrocampa stagnalis*, a Braconid, swimming under water by means of its legs. Other European workers have made similar observations on the same or related species.

Our notes refer to three species, all reared at Ithaca, N. Y.

Hydrophylax aquivolans n. gen. and n. sp.

In September, 1908, Dr. J. G. Needham observed a number of minute Trichogrammids swimming by means of their wings in an aquarium which contained eggs of *Ischnura*, probably *verticalis*. These were again observed by him in the summer of 1911. Nothing is known regarding their earlier stages.

This species is apparently undescribed and runs to the genus *Asynacta* Foerster in Ashmead's tables (Chalcis Flies, p. 359, 1904). Foerster used the name *Asynacta* in a table in his Hymenopteren Studien, II, p. 87, 1856, but no species has ever been placed in the genus, and it is therefore a *nomen nudum*. In any case, although the present species agrees with Asynacta Foerster in antennal characters it would be separated from that genus by the extremely narrow wings which are abnormal to

that group. For it is only fair to assume that the wings in Asynacta are of the usual type, otherwise Foerster would have mentioned it in his description of the genus.

Hydrophylax. New genus. Antennæ 8-jointed; scape, pedicel, ring joint, 2 funicle joints and 3-jointed club. Fore wings extremely narrow, twenty times as long as wide; marginal cilia at least four times as long as the width of wing. Abdomen is conic-ovate, broadly joined to the body. Ovipositor slightly exserted.

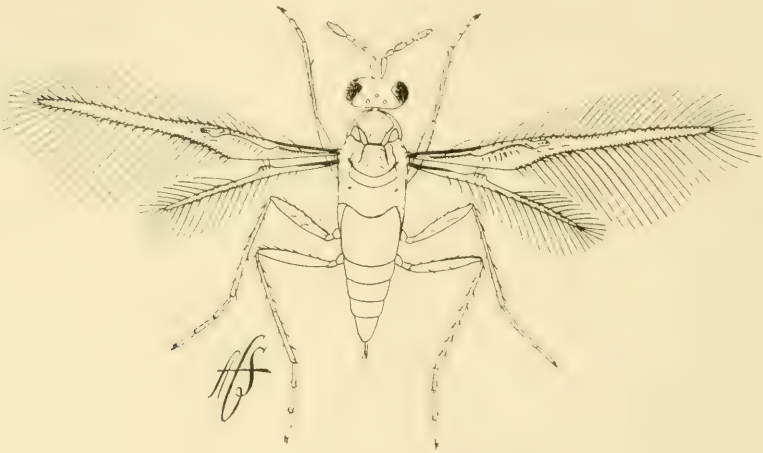

FIG. 1. *Hydrophylax aquivolans.*
Drawn by Miss Anna C. Stryke.

Type, the following species.

Hydrophylax aquivolans. New species. ♀ length .6 mm. Length of fore wing .69 mm.; hind wing .45 mm. (Fig. 1.)

General color light brownish yellow. Legs and antennæ paler. Head seen from above gently concave in front and behind, sparsely clothed with a few stiff setæ. Thorax smooth, clothed with stronger setæ. Scutellum gently rounded behind.

Postscutellum with two fine setæ, close together on each side. Propodeum smooth, without setæ except near the spiracles. Metathoracic spiracles enlarged, with two short, knobbed hairs which appear to arise within the opening.

Abdomen conic-ovate, sparsely clothed with long stiff setæ, broadly joined to the thorax; 5 visible dorsal segments; length of abdominal segments in the ratio of 5, 2, 2, 2, 3. Ovipositor exserted about the length of the shortest abdominal segment.

Antennæ 8-jointed, consisting of scape, pedicel, 1 ring joint, 2 funicle joints and a 3-jointed club. Scape compressed, elongate-oval; pedicel as long as the first joint of funicle and ring joint, elongate-obconic; first funicle joint cylindrical, 1½ times as long as the second; second slightly oval; club elongate-oval, 1-5 longer than the funicle. Anterior and middle femora slightly enlarged medially, the posterior femora more distinctly enlarged. Anterior and middle tibiæ of about same width throughout. Posterior tibiæ somewhat enlarged distally and slightly narrowed just before the tip. First and second posterior tarsal joints of equal length, the third somewhat shorter.

Front wings very narrow, 20 times as long as broad. Marginal cilia very long and evenly spaced, those on the posterior margin four times as long as the wing is wide. Marginal cilia are interspersed with a submarginal row of short setæ.

♂ Length .6 mm. Similar to the female. Antennæ 8-segmented, consisting of a scape, pedicel, a ring joint, 5 funicle joints, the last three more closely united. Scape compressed; pedicel obconic; ring joint distinct; first funicle joint about 1½ times longer than second, thicker at base than apex. The remaining joints sub-equal in length, the last two thicker than the preceding. Apical joint pointed at tip. Antennæ clothed with stiff setæ, which are longer than those of the female.

Limnodytes gerriphagus Marchal.

On June 16, 1911, we reared a species of Proctotrypidæ from the eggs of a water strider (*Gerris remigis*). Both males and females were observed swimming actively under water by means of their wings. They readily broke the surface film and made their escape flying in the air. They were observed to re-enter the water and examine carefully the surface of the leaf as if searching for the eggs of their host. The eggs of Gerris are laid in a single row in gelatine on the under side of the floating leaves of aquatic plants. The females were observed ovipositing in the eggs of Gerris. In the field several of these parasites were found on the under side of a floating leaf on the egg mass of Gerris. Only a single parasite emerged from each egg.

We have determined this species as *Limnodytes gerriphagus* Marchal, described in 1900 from specimens reared from the eggs of Gerris collected in the vicinity of Paris. Although our specimens agree with his descriptions and figures, yet to be

certain of our identification we have sent specimens to Dr. Marchal for comparison. In a letter of February 9, 1912, Dr. Marchal informs us that our specimens are identical with *Linnodytes gerriphagus.*

Caraphractus cinctus Walker.

On December 7, 1911, we collected some aquatic plants (*Ludvigia palustris*) from a small pond at Ithaca, in the stems of which we found an abundant supply of the eggs of one of the back swimmers (*Notonecta*). Over half of these eggs contained larvæ of a Hymenopterous parasite in which could be observed the legs and antennæ of the developing pupæ. Four to five larvæ were found in each egg. The heads of all did not point in the same direction. Plant stems containing a supply of these eggs were kept in aquaria in a warm room and on December 19, some young back-swimmers had hatched and were swimming actively about. Adults of the parasite had also emerged and were observed to be actively swimming in the water. One of the parasitized eggs was removed from the stem and placed under the microscope. It contained four adults, one of which, a male, was beginning to gnaw a hole in the end of the egg shell. This male emerged within five minutes, and taking a position on the top of the egg shell stripped off the pupal sheath from antennæ and legs. This one was followed by a second male and two females, all emerging within nine minutes through the same opening.

The adults of this species seem perfectly at home under water and swim quite rapidly by means of their wings with a jerky motion, corresponding to the wing strokes made at the rate of about two per second. The legs are trailed behind and are not used in swimming. They spend much of their time walking nervously over the stems of submerged plants, the surface of which they examine carefully with the tips of their antennæ, as if searching for eggs in which to oviposit. They are able to walk on the sides of the glass aquaria and on the under side of the surface film. After transferring a jar of water containing these parasites from one building to another a number were found on the upper side of the surface film in the air and flew across the surface trailing their legs attached to the film. They emerge from the water by crawling up some object and forcing their way through the surface film. (Fig. 2.)

In three cases we observed males and females apparently in copulation under water on the stems of the plants. We have not had opportunity to observe oviposition although females have been seen several times attempting to insert the ovipositor in the eggs of Notonecta which were nearly ready to hatch.

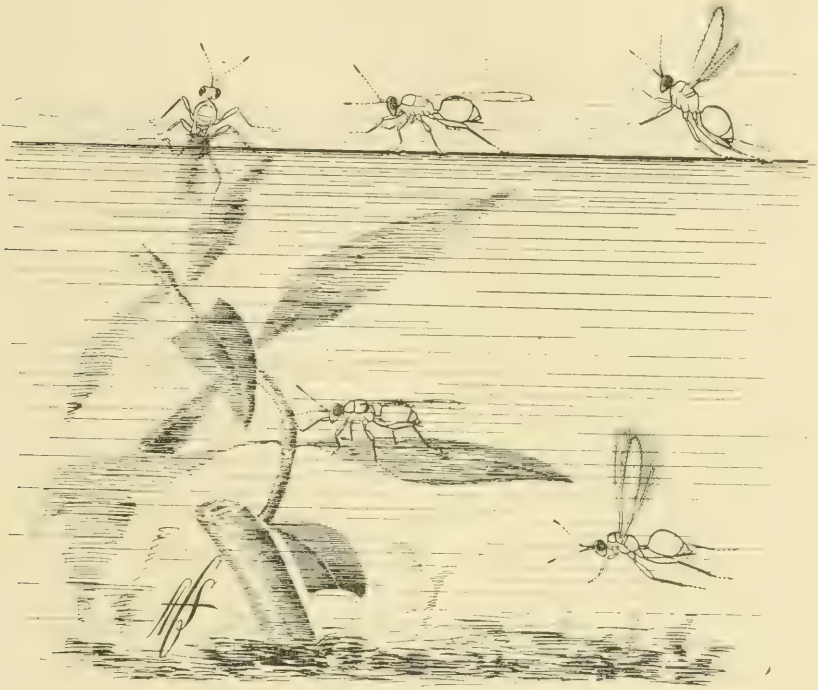

FIG. 2. *Caraphractus cinctus* Walker.
Drawn from life by Miss Anna C. Stryke.

We have been unable to see any external air supply carried by these insects while under water. While submerged they appear to be perfectly wet but as soon as they emerge into the air they seem to be perfectly dry. They are able to live submerged in water for over 12 hours in a bottle filled full of water and corked.

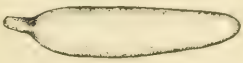

FIG. 3. Egg of *Caraphractus cinctus* Walker.

The egg of *Caraphractus cinctus* as dissected from the female is white, elongate-ovate, and provided with a short pedicel at its larger end (Fig. 3). Length .16 mm.; width .043 mm. The ovaries contain a large number of eggs.

Caraphractus cinctus Walker is an older name for *Polynema natans* Lubbock. Upon finding that our specimens agreed with the figures and description of the latter as given by Lubbock (1863) we forwarded specimens to him for identification. Lord Avebury kindly sent these specimens to Mr. Fred Enock for comparison with British examples. After examination Mr. Enock informs us that he is of the opinion that they are identical.

LIST OF KNOWN AQUATIC HYMENOPTERA.

CHALCIDIDÆ.

Prestwichia aquatica Lubbock, 1863. Parasitic on the eggs of *Notonecta*, *Ranatra*, *Dytiscus*, and *Pelobius*.

Hydrophylax aquivolans Matheson and Crosby, 1912. Parasitic on the eggs of *Ischnura*. (New York).

PROCTROTRYPIDÆ.

Limnodytes gerriphagus Marchal, 1900. Parasitic on the eggs of *Gerris* spp. (France and New York).

Limnodytes setosus De-Stefani Perez, 1902. Parasitic on the eggs of *Gerris* sp. (Sicily).

MYMARIDÆ.

Caraphractus cinctus Walker, 1846. (*Polynema natans* Lubbock, 1863). Parasitic on the eggs of *Notonecta*. (England and New York).

Anagrus subfuscus Heymons, 1908. Parasitic on the eggs of *Calopteryx virgo* L. (Germany).

BRACONIDÆ.

Gyrocampa stagnalis Heymons, 1908. Host unknown. (Europe)

Dacnusa rousseaui Schulz, 1907. (Europe).

Chorebus natator Schulz, 1907. (Europe).

AGRIOTYPIDÆ.

Agriotypus armatus Walker, 1836. Parasitic on larvæ of Trichoptera.

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RESOLUTIONS

On the Death of Samuel Hubbard Scudder.

It is with profound sorrow that we record the death on May the 17th, 1911, of Dr. Samuel Hubbard Scudder. Born of fine lineage in the city of Boston on April the 13th, 1837, he was graduated at Williams College in 1857, taking the degree of B. A., and in 1862 from Harvard, taking the degree of B. S. He was one of the favorite pupils and assistants of the late Professor Louis Agassiz. He was the Secretary of the Boston Society of Natural History from 1862 until 1870, during much of this period being also the Curator of the Museum; and from 1880 to 1887 he served as the President of the Society. From 1879 to 1882 he was the Assistant Librarian of Harvard University. From 1886 to 1892 he held the position of Paleontologist of the United States Geological Survey. His scientific and literary industry was prodigious. His entomological works deal principally with the Lepidoptera, the Orthoptera, and fossil insects. He placed American biologists under everlasting indebtedness to him by the preparation of the "Nomenclator Zoologicus", and by many bibliographies and indices. His great work "The Butterflies of the Eastern United States and Canada with special Reference to New England", and his magnificent volumes upon the "Pretertiary and Tertiary Fossil Insects of North America" will always remain classical. Honors were abundantly bestowed upon him by learned societies both in America and Europe, and he received many richly deserved academic degrees.

Reviewing his work in its entirety, it constitutes one of the most notable contributions made by a single individual to the literature of biological science during the past fifty years. It is a monument attesting the vast learning and the colossal industry of a man, who in circumstances which did not entail upon him the necessity for labor, dignified his life by consecrating his noble powers to the advancement of human knowledge. Though suffering the keenest domestic bereavements, and during the last years of his life compelled to undergo a living martyrdom through paralysis both of hands and feet, he preserved to the last his cheerful disposition and an unclouded intellect. His death came as a gentle release from suffering, leaving our Society and the world the richer by his example of patience and the fruits of his toil; the poorer by his removal hence.

(Signed) W. J. Holland,
C. J. S. Bethune.

DR. S. H. SCUDDER

Plate III

DR. HENRY C. McCOOK

RESOLUTIONS

On the Death of Henry Christopher McCook.

The Reverend Doctor Henry Christopher McCook, an Honorary Fellow of this Society, died at his home in Devon, Pennsylvania, October 31, 1911.

It is fitting that those persons, members of the Society, interested in the same studies that he pursued with such success, for so many years, should place on record their sorrow for the loss of an American pioneer in the study of social insects, who added so much to our knowledge of these creatures and by his many attainments shed lustre on American Entomology. He had a profound love and enthusiasm for all nature; a keen observer, he had the literary ability to translate his observations into word pictures that are an ornament to the literature of Entomology.

He believed that study of the structure, conditions and behavior of all created things highly tends to elevate human character, and we can truly say that our departed friend was a shining example of this fact. He was also distinguished in ways other than in Entomology and we have lost a profound scholar, a deep thinker, an able observer, a great educator, a genial companion and friend, a noble man.

His life work is finished, but what he accomplished still lives and will continue to live, as its foundation is truth and its keystone nature's law.

(Signed) Henry Skinner,
Philip P. Calvert,
Henry L. Viereck.

RESOLUTIONS

On the Death of Henry Ulke.

Whereas, By the death of Henry Ulke the Entomological Society of America has lost one of its most illustrious Honorary Fellows; and

Whereas, Mr. Ulke was known not only for his marked ability as an entomologist and collector, but for his delightful personality and genial temperament; and

Whereas, His personal enthusiasm has largely helped to develop American entomology, and to encourage the studies of others; therefore be it

Resolved, That the Entomological Society of America express, through these resolutions, its sorrow at this loss to American entomology; and be it further

Resolved, That we express to the world our admiration of his industry as a collector, our respect for his entomological knowledge, and our high estimation of his character.

(Signed) A. D. Hopkins,
E. A. Schwarz,
L. O. Howard.

RESOLUTIONS

In Memory of Daniel William Coquillett.

Daniel William Coquillett, a fellow of the Entomological Society of America, died at Atlantic City, New Jersey, the 8th of July, 1911. Born on a farm at Pleasant Valley, Illinois, 23rd January, 1856, he showed, in early life, much interest in birds and insects, and began rearing Lepidoptera and publishing accounts of their larvæ. Compelled by ill health to go to California, he there began the study of Diptera which he continued until the time of his death, having attained world-wide recognition as an earnest, industrious and independent student, and the leading place in American Dipterology, namely; Curator of the collections of Diptera in the United States National Museum. By his painstaking work on difficult and little known groups of his specialty he laid the foundation that will be of use in future years.

His work in economic entomology, particularly the colonization of the Vedalia lady-beetle, and the discovery of the hydrocyanie acid gas process, has been of inestimable value to horticulture.

His kindness of heart, his uniform courtesy and his willingness to aid others awaken us to the great loss that has befallen entomology in general. In admiration of his technical ability and in honor of his unselfishness as a man, we record this appreciation of his life and work.

Nathan Banks,
C. W. Johnson,
Jas. S. Hine,
Committee.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA.

Washington Meeting.

The sixth annual meeting of the Entomological Society of America was called to order by President Herbert Osborn at 10:00 a. m., Tuesday, December 26, in Room 376 of the new U. S. National Museum building. The following committees, appointed previous to the meeting, reported:

Committee to draft resolutions on the death of Dr. Henry Christopher McCook—Henry Skinner, P. P. Calvert, Henry L. Vierick. Report accepted and ordered printed.

Committee to draft resolutions on the death of D. W. Coquillet—Nathan Banks, C. W. Johnson, J. S. Hine. Report accepted and ordered printed.

The chair was directed by motion to appoint the following committees: Committee on Resolutions; Committee on Nominations; Auditing Committee.

The following papers were read, of which abstracts are given for those not to appear in the ANNALS:

Herbert Osborn. *Faunistic studies in entomology.* (Printed in this number of ANNALS).

E. P. Felt. *Numerals as aids in classification.* The habitual use of numbers in catalogues indicates utility. A modified system of decimal notation is adapted to the needs of naturalists, while additions require little change. A general agreement upon the numbers for the major zoological division is suggested prior to the application of the system by cataloguers and other general workers.

E. S. Tucker. *Studies of insects bred and collected from the American mistletoe.* Presented by Andrew Rutherford—By the name of "American mistletoe", the species *Phoradendron flavescens* Nuttall and its several varieties is meant. Two snout-beetles belonging to the same group as the cotton boll-weevil were bred from terminal enlargements of the stem. From the larvæ of one of these beetles five hymenopterous parasites were bred, all of which attack the larvæ of the cotton boll-weevil. About sixty species in all were obtained.

H. C. Severin. *The influence of temperature on the moulting of the walking-stick, Diapheromera femorata.* Read by title.

The president announced the following committees:

Committee on Resolutions—E. P. Felt, E. D. Ball, and R. A. Cooley.

Committee on Nominations—C. W. Johnson, J. G. Sanders, and H. E. Summers.

Auditing Committee—Henry Skinner, J. H. Comstock, and A. D. Hopkins.

The society then adjourned to meet at 1:30 p. m. Upon reconvening, the following papers were read:

R. Matheson and C. R. Crosby. *Notes on aquatic Hymenoptera.* Illustrated. Presented by C. R. Crosby. (Printed in this number of ANNALS).

Ann H. Morgan. *Photographs illustrating the life histories of May-flies.* Illustrated. Photographs were shown which illustrated the life history and biology of about twenty-five May-flies. Both nymphs and adults were photographed alive; the nymphs in a solution of chloretone, the adults without anæsthetic. Nymphs representing the main biological groups were shown and their habitat described. Imagoes and subimagoes of certain genera were shown and their structure and characteristic postures noted.

H. Y. Tsou. *The Chinese wax-scale, Ericerus pe-la.* Illustrated. One of the most beneficial insects of the family Coccidæ has been domesticated by the ancients of the Chinese people for the wax which it produces. This paper consists of (a) correction of errors of European translation from Chinese works; (b) additional statements on the life history of the insect; (c) method of propagating this insect; (d) division of labor in carrying on this industry among the people of different localities, so that the eggs of the insect are produced in the northern district and the wax in the southern district; (e) importance of this industry; and (f) use of the wax.

A. D. MacGillivray. *The lacinia in the maxilla of the Hymenoptera.* Illustrated. (To be printed in the ANNALS.)

Lucy Wright Smith. *Glycogen in insects, especially in the nervous system and the eyes.* Illustrated. In a heterogeneous lot of insects, including representatives of seven orders, glycogen has been found: (1) in immature and adult stages (a) in the crystalline cells of compound eyes, (b) in the crystalline and retinal cells of simple eyes, (c) in the neurilemma; (2) in immature stages only, (a) in the cells of ganglia in all parts of the body. No glycogen has been found in nerve fibers.

J. A. Nelson. *Note on an abnormal queen-bee.* Illustrated. This queen was originally sent from Grand Bay, B. W. I. When received she was alive and quite active. It was planned to introduce her into a hive to test her fertility, but she died by accident before this was done. The dead queen appeared normal in structure with the exception of the abdomen, which was ovoid in shape, instead of conical as in the normal queen; it was also flexed strongly ventrad at the apex, which had consequently a blunt appearance, like that of the abdomen of the drone. The sternites of the 5th and 6th abdominal segments were unusually broad and somewhat asymetrical, as was also the sternite of the 4th segment. The sternite of the 7th segment was the most modified of all, being greatly shortened in the longitudinal axis, and almost concealed by the sternite of the preceding segment. The notch on its posterior border was abnormally broad and deep. The sting had a slight kink midway of its length.

The internal organs were apparently normal with the exception of the genital organs. The left ovary and oviduct were entirely wanting. The right oviduct and ovary were present, but the latter appeared to possess only a single egg tube. The spermatotheca was empty. The bursa copulatrix was also shortened in the longitudinal axis so that the external openings of the spermatotheca and the poison glands were brought close together. No characters suggestive of hermaphroditism were found. The cause of the abnormalities is unknown.

J. Chester Bradley. *The designation of the venation of the hymenopterous wing.* Illustrated. In the higher Hymenoptera, owing to certain remarkable conditions that prevail, the full application of the Comstock-Needham system of venation becomes a very complex matter. This is especially true in the case of the hind wings. By certain simple abbreviations this complexity is avoided, and the system becomes quite conveniently usable for taxonomic purposes.

Ann H. Morgan. *Homologies in the wing-veins of May-flies.* Illustrated. (To be printed in the ANNALS).

A. D. MacGillivray. *The pupal wings of Hepialus thule.* Illustrated. (To be printed in the ANNALS).

J. Chester Bradley. *The wing venation of Chalcid flies.* Illustrated. The hymenopterous family Chalcididæ present a uniform excessive reduction in the number of their wing veins

which is approached elsewhere in the Hymenoptera only by certain Proctotrypidæ and Evaniidæ. This depletion is the result of a degenerative tendency that is manifest wherever there is considerable reduction in the size of the wasp. It is of interest to ascertain with what veins of other Hymenoptera the vein remnants in the Chalcid wing are homologous.

The so-called marginal vein is in reality the elongated stigma, the "post-marginal" is r and R_4 and usually bears on its anterior margin a spur of the base of R_3.

Leucospis is our most generalized group of Chalcididæ so far as its wings are concerned. The wings of Chalcididæ show a close relation to those of Cynipidæ through *Leucospis* in the one group and *Ibalia* in the other.

On motion of Dr. E. P. Felt, the Secretary was instructed to send a message of sympathy and greeting to Dr. John B. Smith.

The society adjourned at 4:30 p. m., to meet Wednesday, December 27, at 10:00 a. m.

The annual business meeting was held by the society upon reconvening, and the following reports were presented:

The report of the Committee on Nomenclature was presented by Dr. H. T. Fernald. The report was ordered accepted and printed.

REPORT OF THE COMMITTEE ON NOMENCLATURE.

There have been no specific problems brought to the attention of your committee during the past year. The recommendations and suggestions submitted by the committee a year ago, are still before the Society, and we would suggest that they should come up for discussion and be voted upon. During the year various proposals for the reform of nomenclatorial practice have been discussed in public and private. One writer proposes a system of numbers to take the place of specific names. In another quarter there is a disposition to propose an entomological code to be independent of the international code of zoological nomenclature. Your committee is strongly of the opinion that the international code should be followed by all entomologists and is herein in hearty accord with the attitude of the last International Entomological Congress. It is desirable to determine the attitude of American entomologists on this important matter, and we would suggest that the question be discussed and voted upon at this meeting. It is to be observed that the adoption of the international code does not prevent entomologists from formulating and urging upon the zoological committee and congress, amendments designed to remove existing ambiguities and difficulties.

The question of *nomina conservenda* is now being discussed by the zoological committee and by zoologists generally. It is one which should not be lightly settled one way or the other, and we commend the matter to the society for discussion.

It is to be remarked that conformity with proper usages in writing and publishing would reduce the number of nomenclatorial problems, and it is a question (not wholly within the scope of your committee) whether the society should not formulate and adopt rules for the guidance of its members.

Respectfully submitted.
E. P. Felt,
H. T. Fernald,
Theo. D. A. Cockerell,
Committee.

Dr. H. T. Fernald also presented the following separate report prepared by Professor T. D. A. Cockerell, with which the other members of the Committee did nor concur. It was ordered accepted and printed. This report was as follows:

REPORT PRESENTED BY PROFESSOR T. D. A. COCKERELL.

When a long-forgotten or ignored type-designation is found to seriously disturb the status of a well-known genus, the International Committee may *arbitrarily* select a type from among the originally included species, in such manner as to retain the generic name with its customary significance; Provided, that such designation be published six months before the next congress, and voted upon in open meeting at the congress.

This was especially suggested by the discovery that apparently, by strict application of the type-designation rule, *Colletes* must be called *Andrena*, with resulting confusion awful to contemplate.

The Committee on Resolutions presented the following report:

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Whereas, The types of insect genera and species must of necessity be the basis of all future taxonomic work; and

Whereas, There is no general uniformity in the selection, labeling, and disposition of types among American entomologists and institutions; neither is there any uniformity of practice among custodians of types in reference to their availability for study; therefore, be it

Resolved, That a special committee of three be appointed to investigate the matter and others of similar import and make suitable recommendations at a subsequent meeting; and be it further

Resolved, That we express to the authorities of the United States National Museum and those of the Cosmos Club our deep appreciation of the many courtesies extended this organization.

Resolved, That we commend the editorial management of the ANNALS of the Entomological Society of America and hereby express our sense of great obligation to Professor Osborn for his part in the undertaking.

Respectfully submitted,

E. P. FELT,
E. D. BALL,
R. A. COOLEY.
Committee.

The Committee on Nominations presented the following list of officers for 1912:

President, S. A. Forbes.
1st Vice-President, A. D. Hopkins.
2d Vice-President, C. P. Gillette.
Secretary-Treasurer, A. D. MacGillivray.

Additional Members of Executive Committee, J. H. Comstock, John B. Smith, Henry Skinner, Herbert Osborn, E. D. Ball, P. P. Calvert.

Member of Committee on Nomenclature for three years, H. T. Fernald.

Respectfully submitted,

C. W. JOHNSON,
J. G. SANDERS,
H. E. SUMMERS.
Committee.

On motion, the secretary was instructed to cast a single ballot for the officers named. They were declared elected.

The Committee to Draft Resolutions on the death of Henry Ulke, consisting of A. D. Hopkins, E. A. Schwarz, and L. O. Howard, reported. The report was accepted and ordered printed.

The Committee to Draft Resolutions on the death of Samuel Hubbard Scudder, consisting of W. J. Holland and C. J. S. Bethune, were not in attendance. It was ordered that these resolutions be filed with the secretary and be included in the minutes.

The secretary presented the following report for the Executive Committee, which met at the Cosmos Club Tuesday evening, December 26:

REPORT OF THE EXECUTIVE COMMITTEE.

The following have died during the year:

Coquillet, D. W.
McCook, H. C.
Scudder, S. H.
Ulke, Henry.
Weems, Mrs. R. A. D.

The following new members were elected by the Executive Committee in June, 1911:

Barrows, W. M.
Crampton, G. C.
Rutherford, A.
Sherman, J. D., Jr.
Smith, Miss Lucy W.
Tsou, Y. H.
Wallis, J. B.

The following new members were elected by the Executive Committee last evening:

Baker, A. C.
Carmody, Miss Mary.
Ely, C. R.
Fracker, S. B.
Funkhouser, W. D.
Glasgow, Hugh.
Glasgow, R. D.
Illingworth, J. F.
Jobbins-Pomeroy, A. W.
King, Vernon.
Knight, H. H.
McIndoo, N. E.
Peterson, Alvah.
Ruth, W. A.
Sanford, H. L.
Timberlake, P. H.
Urbahns, T. D.
Varrelman, F. A.
Williamson, W.

The following resignations were accepted and their membership terminated:

Adams, C. F
Bowditch, F. C.
Brooks, Theo.
Brown, T. E.
Denton, W. D.
Devereaux, W. L.
Frost, H. L.
Hart, W. O.
Hitchings, E. F.
Lovell, J. H.
McCray, A. H.
Montgomery, C. E.
Murtfeldt, Miss M. E.
Sala, August.
Saunders, Dr. Wm.
Slater, Miss F. W.
Smith, H. G.
Strong, W.O.
Walton, W. R.

The secretary presented a list of twenty names of persons who had been dropped by the secretary for non-payment of dues for two years.

The following recommendations were offered:

That members dropped for non-payment of dues shall be required to pay the full subscription rate, three dollars, during the full period of their retirement, in case they wish the ANNALS.

That members who have been dropped for non-payment of dues shall only be eligible for re-election to the society on payment of dues at time they were dropped.

That the Secretary-Treasurer and Professor J. H. Comstock be appointed a committee to deposit the fees of life members in a bank that they consider safe at a good rate of interest.

That the interest on fees of life members be considered an income.

That the Editor of the ANNALS be empowered to get the necessary clerical help that he needs in getting out the ANNALS.

That the publications presented to the Society by Dr. S. H. Scudder be sold and the net proceeds be added to the permanent fund.

The following amendments and additions to the By-Laws were recommended:

To amend By-Law 1, which now reads, "The annual dues for members and fellows shall be one dollar," to read:

1. The annual dues for members and fellows shall be two dollars; this includes a subscription to the ANNALS of the Entomological Society of America.

The following additional By-Laws:

7. Members two years in arrears shall be dropped from the rolls by the secretary after twenty days notice.

8. A member elected shall not be in good standing until he pays his first year's dues. In case he shall not have made such payment at the expiration of one year from the date of his election, he shall be dropped from the roll by the secretary after twenty day's notice.

9. The ANNALS of the Entomological Society of America will not be mailed to any fellow or member whose dues and subscription are not paid on or before March 1.*

The Treasurer presented the following report:

Balance forward		$ 252.49
Life membership fees		100.00
Cash received from Herbert Osborn		179.56
Cash collected as dues		1,004.84
Interest on fees of life members		5.75
		$1,542.64
Bills paid		740.21
		$ 802.43
Life membership fees and interest on same to July 1, 1911, deposited in Rothschild Bros. Savings Bank, Ithaca, N. Y., at 4%	$105.75	
Cash deposited to the credit of the Society in the First National Bank of Champaign, Ill.	696.60	
		$ 802.35

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

The Secretary called attention to the fact that certain amendments to the Constitution, recommended to the Society at the Boston meeting, had not been acted upon at the Minneapolis meeting. These were ordered read:

Article IV. Section 1. The officers of this Society shall be a President, two Vice-Presidents, and a Secretary-Treasurer. The duties of these officers shall be those usually pertaining to their respective offices.

*The wording of this By-Law as submitted at Washington is ambiguous. The following wording was submitted to the Executive Committee and by them adopted:

9. The ANNALS of the Entomological Society of America will not be mailed to any fellow or member whose dues are in arrears. All dues are payable December 1st, and should be received not later than March 1st.

To be amended to read:

Section 1. The officers of this Society shall be a President, two Vice-Presidents, a Secretary, and a Treasurer, but these two last offices may be held by the same person. Adopted.

Article IV. Section 2. The business of the Society not otherwise provided for shall be in the hands of an Executive Committee consisting of the officers named in Section 1, and of six additional members, who shall be elected from the Fellows of the Society. Four members of the committee shall constitute a quorum.

To be amended to read:

Section 2. The business of the Society not otherwise provided for shall be in the hands of an Executive Committee, consisting of the officers named in Section 1, and of six additional members, five of whom shall be elected from the Fellows by the Society, and the sixth shall be *ex officio* the Managing Editor. Four members of the Committee shall constitute a quorum. Adopted.

Article IV. Section 3. The President shall represent the Society upon the Council of the American Association for the Advancement of Science until such time as the Society shall be qualified for representation by two councillors, in which case the second councillor shall be elected from the fellows by the Executive Committee.

To be amended to read:

Section 3. Councillors to the American Association. The President and the preceding Past-President shall represent the Society upon the Council of the American Association for the Advancement of Science.

Referred back to the Executive Committee for further consideration.

The Managing Editor of the ANNALS presented his report, which was accepted. The editor pointed out the flourishing condition of the ANNALS, that the present volume would contain over five hundred pages, and that the number of societies and libraries subscribing was increasing each year.

Dr. Henry Skinner, the delegate of the Society to the First International Entomological Congress, held in Brussells, August 3–6, 1910, presented the following statement:

The First International Entomological Congress was held in Brussells August 3 to 6, 1910, and was very successful, about 137 members and 32 ladies—wives of members—being

present. (There were in all 270 memberships, which number includes museums, universities, and other scientific societies.) The memoirs of the First Congress have appeared, with 41 papers and 520 pages. There were but three persons present from the United States, and one from Canada. It is to be hoped that Americans will take greater interest in the next congress, which will be held in Oxford, England, this year from the fifth to the tenth of August. It promises to be even more successful and interesting than the first, and will afford an unusual opportunity for American entomologists to meet their European brothers under pleasant circumstances. It will also enable them to visit the various museums of England, and the continent, if they so desire. Anybody who takes an interest in any branch of entomology, scientific or applied, may become a member of the Congress. The membership fee will be five dollars. The expense of going to Oxford may be made small or great, according to the tastes or the comparative finances of the individuals attending. The study of entomology has become of very great importance to the world, and the first congress attracted much attention and favorable comment. The advance of entomology in America has been very great, and it is the duty of American entomologists to help advance the study throughout the world, and this they can do by aiding in the work of the next entomological congress.

Dr. P. P. Calvert moved the following resolution, which was seconded by Professor J. H. Comstock:

That the Entomological Society of America strongly recommend to the Second International Entomological Congress the preparation of lists of *nomina conservanda* in the various groups of insects, such names to be adopted irrespective of the strict rule of priority.

This resolution was discussed by Messrs. A. N. Caudell, W. D. Pierce, E. P. Felt, and P. P. Calvert. The motion was lost, 16 affirmative and 31 negative.

The auditing Committee presented the following report, which was adopted:

REPORT OF AUDITING COMMITTEE.

The Auditing Committee examined the accounts of the Secretary-Treasurer, and found them correct, in accordance with the appended report.

Respectfully submitted,

HENRY SKINNER,
A. D. HOPKINS,
J. H. COMSTOCK,
Committee.

The following resolution was introduced by Dr. E. P. Felt:

That the Entomological Society of America place itself on record in favor of delegate action at the International Congress of Entomology. Adopted.

It was then moved by Dr. J. Chester Bradley that the report of the Committee on Nomenclature presented at the Minneapolis meeting be taken up, section by section, at this time, for action. Adopted. (This report was printed in the ANNALS, Vol. IV, pp. 89–91. The sections refer to the numbered parts beginning near the bottom of page 90.) Section 1 was read and adopted. Section 2 was read, discussed by Messrs. Banks and Rehn, and on motion the Society passed to the consideration of Section 3. Section 3 was read, and after considerable discussion was ordered laid on the table for one year.

The following papers were then read:

F. M. Webster. *Our present educational system in relation to the training of economic entomologists.* The demand for trained men capable of engaging in entomological work has increased greatly, but the graduates of the colleges generally are not sufficiently equipped for such work and must have a special training of one to two years before they are available. The author wishes to emphasize the necessity for training in related sciences, in modern languages, and especially in field observation in entomology. The student intending to be an entomologist should begin in his first year with field observations and should be required to gather his own material for study. It would be especially desirable that students training for entomological work should have an experience at least during their vacations in work in some experiment station, and this sort of work should very properly be given credit in the college or university as part of the requirements leading to a degree.

C. W. Johnson. *The use of color in designating types and varieties.* Colored labels for types are being carried to an extreme. At the last meeting of the Cambridge Entomological Club one of our members who makes a specialty of printing labels for entomologists, asked me "what is an allotype, a homotype, a metotype, an autotype, and a topotype, and why don't they use the same color for the same kind of a type? One wants his paratype on light green, another on pink, and a third on brown. Why I can't get enough colors to go around."

An energetic collector with time and money at his disposal can make some sort of a type out of seventy-five percent of his species. These various types may have some value, but they can not always be depended upon. A great number of colors used indiscriminately is very confusing, for there are equally important features that might be designated by color, aside from manufactured types. Colors could be used to advantage to indicate abnormalities, especially today when the experimental biologist is after data as to the number and kinds of abnormalities that occur in specimens in nature. Such specimens are completely overlooked unless they are marked in some way. Not more than two colors should be used for types, red, for the primary, and green, for supplementary types. Then another color, yellow, for instance, could be used for abnormalities.

Herbert Osborn. *A problem in the flight of insects.* (Printed in this number of ANNALS.)

E. P. Felt. *The biology of Miaster and Oligarces.* The widely distributed *Miaster* larvæ reproduce by pædogenesis in the moist, decaying bark of various trees during fall and spring, midges appearing from June till August. A larval generation occupies 3 to 3½ weeks. *Oligarces* is less common than *Miaster.* Both are subject to attack by a number of natural enemies.

Leonard Haseman. *Entomological work in Missouri.* Since the early masterly work of Dr. C. V. Riley, the entomological needs of Missouri have not been properly served. Every line of entomological work is open for study. This department is investigating the more urgent insect problems of Missouri, though it is much handicapped by lack of assistance. The work connected with the instruction, station, nursery inspection, and duties of State Entomologist is more than the present staff can properly handle.

W. L. W. Field. *Hybrid butterflies of the Genus Basilarchia.* Since the Boston meeting two years ago, considerable progress has been made in the experiments with the supposedly hybrid Basilarchias, *B. prosperpina* Edw. and *B. arthechippus* Scud. Their hybrid nature has now been proven by breeding experiments. The data obtained also support the conclusions drawn from earlier experiments, to the effect that in *proserpina* the black of *astyanax* is incompletely but uniformly dominant over the white-banded condition of *arthemis.*

O. A. Johannsen. *Cocoon making of Bucculatrix canadensisella.* Read by title.

J. G. Needham. *Some adaptive features of myrmeleonid venation.* Read by title.

E. H. Strickland. *The Pesomachini of North America.* Read by title.

P. P. Calvert. *Seasonal collecting in Costa Rica.* Read by title.

Z. P. Metcalf. *Homologies of the wings veins of Homoptera Auchenorhynchi.* Read by title.

On motion, the President was authorized to name a committee of three on types, as suggested in the report of the Committee on Resolutions, this committee to report at the next annual meeting.

The following committee was named: T. D. A. Cockerell, Henry Skinner, and L. O. Howard.

On motion, the Society adjourned to meet in one year with the American Association for the Advancement of Science at Cleveland, Ohio.

Since the Washington meeting:

The President has named John B. Smith, L. O. Howard, E. P. Felt, W. E. Britton, and W. M. Wheeler, to represent the Society as delegates to the Centennial of the Academy of Natural Science of Philadelphia, Pennsylvania, held Tuesday, Wednesday, and Thursday, the 19th, 20th, and 21st of March, 1912.

The Executive Committee has named Herbert Osborn as the additional Councillor of the American Association for the Advancement of Science.

The Executive Committee has named the following delegates to the Second International Congress of Entomologists, to be held at Oxford, England, August 5th to 10th, 1912: Herbert Osborn, P. P. Calvert, Henry Skinner, J. H. Comstock, Vernon L. Kellogg, W. J. Holland.

ALEX. D. MACGILLIVRAY,
Secretary.

The Society is indebted to *Psyche* for the use of the plate of Dr. Scudder, and to *Entomological News* for the plate of Dr. McCook.—[EDS.]

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The Entomological Society of America.

FOUNDED 1906.

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First Vice-President—A. D. Hopkins.....Washington, D. C.
Second Vice-President—C. P. Gillette.....Fort Collins, Colorado
Secretary-Treasurer—A. D. MacGillivray.....Champaign, Illinois
Executive Committee—The Officers, and J. H. Comstock, P. P. Calvert
J. B. Smith, E. D. Ball, Henry Skinner, Herbert Osborn
Committee on Nomenclature—H. T. Fernald, E. P. Felt, T. D. A. Cockerell

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ANNALS

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Volume V JUNE, 1912 Number 2

HOMOLOGIES IN THE WING-VEINS OF MAY-FLIES.

Anna Haven Morgan.*

The following paper is an attempt to homologize the wing-veins of May-flies by a study of the tracheæ which precede them in the nymphal wing-pad.

The venation of May-flies has been many times discussed but only one work, that of the well known "Wings of Insects" by Comstock and Needham, has approached it from the standpoint of tracheation. This work suggested the present study.

At the outset I wish to express my indebtedness to Professor J. H. Comstock and Professor J. G. Needham for their many valuable criticisms. The work was done under the supervision of Professor A. D. MacGillivray, and while he disagrees with some of the interpretations herewith presented his constant interest and advice have made this study possible.

Material and Methods.

The genera with which this study deals are Epeorus, Iron, Ameletus, Ephemera, Blasturus, Hexagenia, Polymitarcys, Ephemerella, Siphlurus, Callibætis, Chirotonetes, Heptagenia, Leptophlebia, Choroterpes, and Cænis. Nymphs belonging to these fifteen genera were collected through the months from April to July inclusive, in the streams about Ithaca. They present as wide a range of variation as it was possible to obtain. The nymphs selected were those nearly matured whose wing-pads bore traces of venation easily seen with a hand lens. These were supplemented by younger nymphs showing tracheation only. Recently molted nymphs were used, since the wings of these lie flat upon the slide and both tracheation and venation show with great clearness. The method of preparation was that of the simple glycerine jelly mount. Nymphs were kept at hand in a dish of water. The wing-pad of one of the nymphs

*Entomological Laboratory, Cornell University.

was quickly severed with a razor together with a portion of the thorax, in order to preserve the connection between the wing and body trachea. The wing was then placed upon a moistened slide and a cover glass bearing a little melted glycerine jelly was laid over it. The preparation was immediately cooled upon a slab of iron. It was examined as soon as the glycerine jelly hardened, and a camera lucida sketch or photograph was made. All of the figures here presented were secured by the latter method. From five to ten preparations of each form were photographed. Blue prints were made from the negatives. The outlines of the tracheæ and veins were then traced directly upon the print. Later the blue color of the paper was bleached out with a saturated solution of potassium oxalate. The ink drawing left upon the white field was then used directly for reproduction.

Historical.

The most important discussions of May-fly wing venation are contained in the following works.

Eaton '83 (Revis. Monog. Ephem. '83) divided the veins of the May-fly wing into three groups to which he applied a series of names and numbers as given in the following table. The first group consisted of the longitudinal veins 1 (costa), 2 (subcosta), and 3 (radius), which are all connected by the great cross vein. The second group consisted of veins 4 (sector), 5 (cubitus), 6 (praebrachial) and 7 (pobrachial). The third group consisted of the anal and axillary veins. He called attention to the tendency of the hinder groups to secede from their own set and to annex themselves to the hinder branches of the group next in advance.

Redtenbacher '86 used Eaton's system but altered it so that it would agree with the theory of convex and concave veins, proposed by Adolph, which Redtenbacher had unfortunately adopted. The May-fly wing was considered to be a very generalized type. Redtenbacher emphasized the relationship between May-flies and dragon-flies, stating that though transitional forms are lacking the wings of the two are so like as to be easily ascribed to a common origin.

Comstock '88 adopted Eaton's system using the same grouping and homologies. He used names instead of numerals in labelling the veins.

Comstock and Kellogg '95 built a system upon that of Redtenbacher, but they differed from him in certain particulars as to the homology of some of the veins. These differences are shown in a following table.

Kellogg '95 reviewed the work of Redtenbacher and Comstock and proposed to further reduce the number of names. The result was a nomenclature which nearly approached that later adopted in the "Wings of Insects." Concerning the remnants of tracheation to be seen in an adult wing of Hexagenia he says: "In a mounted wing of Hexagenia sp. I have plainly observed the branching trachea of the sector arising from the radial trunk at an appreciable distance from the base of the radius." This seems incredible since an examination of many nymphs of this genus have failed to show this.

Comstock and Needham '98–'99. In this paper the tracheation of the nymphal wing-pads was discussed for the first time. The wing-veins of the adult were homologized from the tracheæ which preceded them. It was unfortunate that the authors studied only wing-pads in which the bases of the radial and medial tracheæ were approximated, and hence they also fell into the error of considering a part of media to be the radial sector.

For convenience in comparing the various systems of nomenclature I have arranged the following table:

Eaton '83 Rev. Monog. Ephem.	Redtenbacher '86	Comstock '95	Kellogg '95	Comstock-Needham '98	System used in this paper
Costa 1	Costa 1	Costa 1	Costa 1	Costa	Costa
Subcosta 2	Subcosta II	Subcosta II	(Subcosta) II	Subcosta	Subcosta
Radius 3	Radius III_1	Radius III	(Radius) III (R+RS)	Radius	Radius
Radius 4	Radial sector III_2			Radial sector	$Media_1$
	Radial sector III_3			R_3	
	IV	Praemedia IV		Access. radial 1	Rs?
				R_4	Accessory 1
Cubitus 5	Cu VI			R_5	M_2
Praebrachial 6	Praebrachial VII	Media V	V	Media	M_3 and M_4
Postbrachial 7	Postbrachial VIII	Postmedia VI	VII	Cubitus	Cubitus
Anal 8	Anal IX	Cub VII a b		1st Anal	1st Anal
Axil 9_1	Anal X	Anal Furrow VIII	IX	2nd Anal	2nd Anal
Axil 9_2	Axil XI	Anal Vein IX		3rd Anal	3rd Anal

The most generalized tracheation which has been found in May-flies is represented in young stages of the wing-pads of Chirotonetes (Pl. VII, Figs. 33, 34, 35). From these and other generalized wing-pads (especially Pl. V, Figs, 5, 7) the accompanying diagram has been drawn (Fig. 1). The treacheal system of May-flies arises at one point in the longitudinal trachea of the thorax and enters the wing base by a single stem. Near that area which is to be the base of the adult wing the entering stem divides into two trunks. These two trunks remain undivided but a short distance.

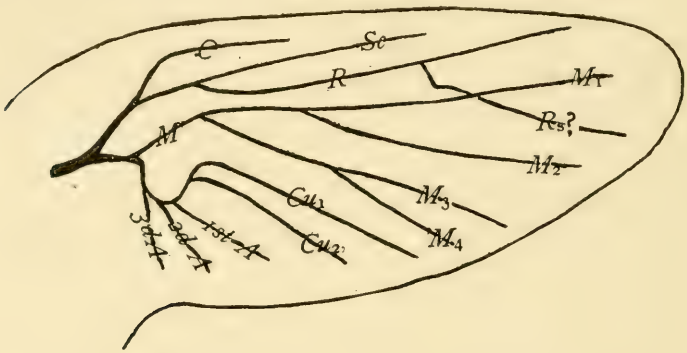

Fig. 1. Tracheation of hypothetical May-fly wing-pad.

The anterior trunk divides into two branches of unequal size. The smaller branch is a delicate trachea which extends forward, and outward parallel with the margin of the wing-pad. This is the costal trachea, (Fig. 1 C). The larger branch divides close to its base into two tracheæ which extend nearly to the margin of the wing-pad. The anterior of these two tracheæ is the sub-costal (Fig. 1, Sc) and the posterior one the radial trachea, (Fig. 1, R).

The foremost branch of the posterior trunk is the medial trachea, (Fig. 1, M). Beyond the point of its separation it divides into four branches. This agrees well with the condition of this vein in insects generally. The posterior branch bends toward the anal margin of the wing-pad. From its basal part three separate branches are given off. These are the 1st, the 2nd and the 3rd anal tracheæ. (Fig. 1, 1st A, 2nd A, 3rd A). A little beyond the 1st anal branch the trachea splits into the two prominent cubital tracheæ. (Fig. 1, Cu_1, and Cu_2).

Peculiarities of May-fly tracheation.

If the tracheation of May-flies (Fig. 1) be compared with the most generalized types of tracheation in other orders several striking peculiarities will be observed.

The radial trachea instead of showing its typical five parts is usually destitute of a sector (cf. Pl. V, Fig. 5 with Figs. 1, 3, 7, etc).

The medial trachea has its characteristic four parts (Pl. V, Fig. 1) but the M_1 trachea bears a branch on the posterior side (labelled R_s ? in the figures) in which it appears to terminate.

If the tracheation in the consecutive figures of the wing-pads in Pls. V, VI, VII, be now examined important differences will be seen. The series shows a continuous reduction of large tracheae and a replacement of them by small tracheal branches. A gradual evolution in the tracheation is thus suggested. An evolution by reduction, which has left some principle tracheæ so reduced as to be hardly recognizable but still holding their proper places.

The Costal and Sub-costal Tracheæ.

The usual course of the costal trachea has been already described. Whenever present in well developed wing-pads it lies without exception in the developing vein which forms the front margin of the wing-pad and which is universally considered to be vein C.

This trachea has been found present as a short, delicate branch in the wing-pads of all but four genera, (Hexagenia, Polymitarcys, Ephemera, Ephemerella, Pl. V, Fig. 13, Pl. VI, Figs. 19, 21, 27). In one, (Ephemerella) this absence may have been due to the rather poor material, but in the others, examinations of many specimens failed to show its presence. The wing-pads of Chirotonetes, Heptagenia, Epeorus, and Iron (Pl. V, Figs. 1, 3, 5, 7, 9,) show a continuous reduction of the costal trachea. In Chirotonetes (Fig. 1) its branches thoroughly aerate the base of the costal region. In the succeeding wing-pads its diminished branching makes the costal trachea less and less important in the aeration of this region. Its work is carried on by branches which spring from the trachea behind it.

The sub-costal trachea is a single usually strong trachea which is parallel to the margin of the wing-pad. It lies in the longitudinal vein posterior to vein C, (Pl. V, Fig. 1). In none

of the wing-pads examined has there been any indication of a splitting of the sub-costal trachea into its two branches Sc_1 and Sc_2.

In the first eleven wing pads in Plates V, VI, (Figs. 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21) and in Siphlurus (Pl. VII, Fig. 29) the sub-costal trachea extends to the tips of the wing-pads. It not only aerates its own area, but in some wing-pads it supplies the region before (Pl. VI, Fig. 15), and in others the region before and behind it (Pl. VI, Fig. 17). The sub-costal trachea of Choroterpes, Leptophlebia, and Blasturus (Pl. VI, Figs. 23, 25, 27) has nearly disappeared from its vein and is replaced by branches from the trachea behind it. This condition is similar to that which has already been noted in the costal trachea. It is a further step in the cutting down of main tracheæ.

Radial Trachea.

The remaining branch of the anterior trunk is a simple trachea parallel to the sub-costal trachea. It never deviates from its pathway in the radial vein. This is the radial trachea. It has been found to be unbranched except in one species of Heptagenia (Pl. V, Fig. 5) and in only half of the specimens of this.

In all cases except in Heptagenia (Pl. V, Figs. 3, 5) it is distinct from the medial trachea throughout its course. In Heptagenia both divisions of the main trunk have coalesced at the base so that the radial and medial tracheæ appear to arise from the same stem (Pl. V, Fig. 3, 5).

The development of the radial trachea is variable and its length has important effects upon the aeration of the region behind it. In the more generalized wings (Pl. V, Figs. 1, 3, 5, 7, 9, 11) it extends to the apex of the wing-pad. Ample aeration of the wing-tip is thus provided. In the more specialized wing-pads the radial trachea extends only through the basal third (Pl. V, Fig. 13, Pl. VI, Figs. 15, 17, 19, 21, 27), or has almost disappeared (Pl. VI, Fig. 25).

A progressive development of fine tracheal branches follows the weakening of the radial trachea. When the trachea is reduced its area is aerated by fine branches from the tracheæ before and behind it (Pl. V, Fig. 13, Pl. VI, Figs. 15, 17, 25, 27, Pl. VII, Figs. 29, 31). Thus the place of a main trachea is again taken by secondary branches.

Medial Trachea.

The fullest development of tracheal branches is found in Chirotonetes (Fig. 2). The four typical branches of media are all present and well developed and there is a large accessory trachea attached posteriorly to the M_1 trachea and smaller ones attached posteriorly to M_4. These accessories are usually wanting and need no further consideration. There is however, one peculiarity of the tip of M_1 which is of great importance since it involves the interpretation of the veins in the area between veins M_1 and M_2. Here lies the most difficult problem in the interpretation of May-fly venation.

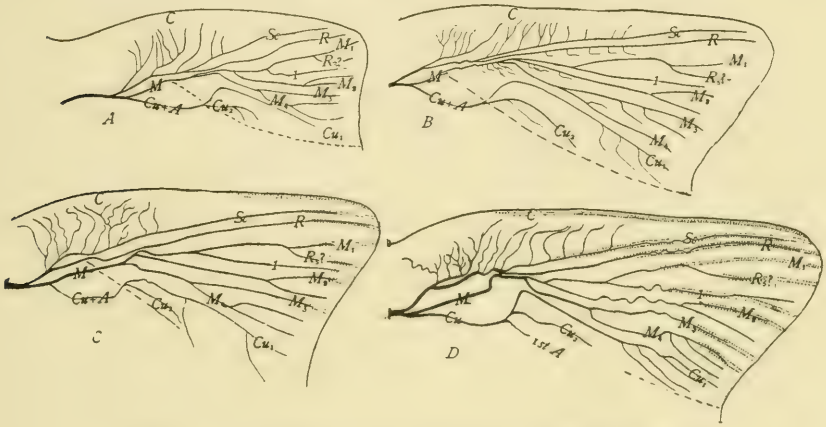

Fig. 2. Tracheation in nymphal wings of Chirotonetes.
A, B, C—Three early stages.
D—Late stage showing venation also.

Trachea M_1 continues through only half its course (Fig. 2, D). An apparent continuation of it turns abruptly rearward and lies in the strong oblique vein Rs?. This condition exists in mature wing-pads of Chirotonetes and in all the most generalized wing-pads, (Pl. V, Figs. 1, 3, 5, 7, 9, 11). In very young wing-pads of Chirotonetes however the M_1 trachea extends through its whole course to the tip of vein M_1, (Fig. 2, A, B, C).

The M_2 trachea lies in the corresponding vein. The M_{3+4} trachea continues for some distance before dividing. It then separates into the two branches M_3 and M_4 which diverge slightly and proceed to the margin in a parallel course.

In Chirotonetes small branches are almost completely absent from the medial tracheæ. In the series of wing-pads

which follow it the progress of the medial trachea from a generalized to a specialized condition is marked by a general development of small tracheoles which aereate this region. This has resulted from the reduction of the main tracheæ. Specialization is also marked by an increasing importance of the forepart of the medial trachea. In this the accessory trachea takes no part, but disappears entirely. The reduction of the tip of the M_1 trachea has taken place because that region is so well aerated by the radial trachea, (Pl. V, Figs. 1, 3, 5, 7, 9, 11). When the radial trachea is greatly reduced (Pl. V, Fig. 13, Pl. VI, Figs. 15, 17, 19, 21, 23, 25, 27) the vein M_1 contains a trachea throughout, although in more generalized forms the terminal portion is wanting, or its area is supplied by tracheoles, (Pl. VII, Figs. 29, 31).

When the costal and sub-costal trachea are also reduced as they are in Choroterpes, Leptophlebia, Blasturus, and Callibætis (Pl. VI, Figs. 23, 25, 27, Pl. VII, Fig. 31) the whole front of the wing is dependent upon branches from the M_1 trachea. With this increase in function the M_1 trachea usually becomes proportionately larger (Pl. VI, Figs. 23, 25, 27) or it gives place to a mesh work of tracheoles (Pl. VII, Fig. 31).

The Accessory_1 (1) disappears early in this series. In Chirotonetes it extends to the margin; in Heptagenia (Pl. V, Fig. 3) it sends a branch over into the tip of vein M_2. In Epeorus (Pl. V, Fig. 7) it has become greatly shortened, and only its stump is left in Iron (Pl. V, Fig. 9). The vein which succeeds it is one of the most prominent accessories in the May-fly wing. In most of the wing-pads this vein is aerated by branches from the tracheæ before and behind it (Pl. V, Fig. 13, Pl. VI, Figs. 15, 17, 23).

The M_2 trachea maintains its full length and gains importance as the tracheæ near it become reduced. In Chirotonetes there is no need for the short posterior branch which it bears, but in Heptagenia (Pl. V, Fig. 5) a branch in approximately the same position aerates vein M_3 and an accessory. This function is similarly performed in Choroterpes and Blasturus, (Pl. VI, Figs. 25, 27) and by means of tracheoles in other wing-pads (Pl. VI, Figs. 15, 17).

If the course of the M_{3+4} trachea be followed through this series it will be seen that there is a continuous reduction of this trachea which ends in its complete obliteration. At first the

M_4 trachea has accessory branches, (Pl. V, Figs. 1, 3). These are lost and the M_3 and M_4 trachea course toward the margin as simple parallel tracheæ (Pl. V, Fig. 7). Later the M_4 trachea becomes reduced (Pl. V, Fig. 9) and ultimately disappears. In Hexagenia (Pl. V, Fig. 13) both the M_3 and M_4 tracheæ have disappeared and a secondary trachea has been developed which lies in the accessory vein between vein M_3 and M_4. A variation of this occurs in Ephemera where the secondary trachea springs from the M_3 trachea (Pl. VI, Fig. 17). In the wing-pads which follow, the M_{3+4} trachea has either nearly disappeared (Leptophlebia and Siphlurus, Pl. VI, Fig. 23, Pl. VII, Fig. 29), or it has become entirely obliterated (Leptophlebia and Callibætis, Figs. 23, 31). In the former cases it is visible in very clear preparations as a small but very distinct trachea lying in the base of vein M_{3+4}. The veins deserted by this trachea are thoroughly aerated by a network of small branches from the tracheæ before and behind. (Pl. VI, Figs. 23, 25; Pl. VII, Figs. 29, 31). Sometimes variable secondary tracheæ from either side (see Blasturus Pl. VI, Fig. 27, and Blasturus Pl. VII, Fig. 40, another specimen) aerate the region between vein M_3 and M_4.

The climax of the changes in the aeration of the medial region is illustrated by the wing-pads of Siphlurus and Callibætis, (Pl. VII, Figs. 29, 31). In the former but two strong tracheæ remain, the M_1 trachea with its apparent continuation and the M_2 trachea. In Callibætis only the M_1 trachea is still strong. All the other tracheæ in the wing-pad are weakened.

The Radial Sector.

In the preceding description no mention of a radial sector has been made, the radial trachea being described as an unbranched trachea and the vein R as an unbranched vein. It is strange that so important an element should be lacking in a wing where the venation is not greatly reduced.

Between M_1 and M_2 there is an undetermined vein which may be an accessory vein or may be the radial sector in an unusual position. This second possibility becomes a very strong probability when we consider what has happened in the Odonata. As has been conclusively shown (Comstock and Needham '98–'99) and (Needham '03) an actual switching of the sector trachea there takes place.

In the dragon-flies (Anisoptera) all stages of this switching are shown. In very young nymphs of dragon-flies the trachea are all separate and in their usual position (Fig. 3A).

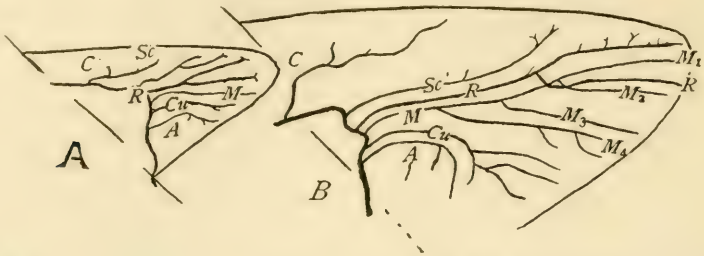

Fig. 3. Two stages of nymphal wings of dragon-fly Gomphus descriptus, after Needham, showing change in position of sector trachea.

In the next stage the radial sector trachea has migrated across the M_1 trachea and reaches the margin between the M_1 and M_2 tracheæ (Fig. 3B). This modification is carried still further in the mature stage where the radial sector is between the M_2 and M_3 trachea. In the adult wing the place where the radial sector crosses over to M_1 is always marked by an oblique cross vein.

In the damsel-flies (Zygoptera) the Rs trachea is always attached to M_1. There is no connection thus far found between the radial trachea and its sector which is completely stranded upon the M_1 tracheae. In the adult wing an oblique cross vein marks the point of crossing over of the sector in only a very few genera.

In May-flies this trachea is one of the most constant features of the tracheation. The vein which follows it is likewise constant in the adult wing. In one species of this series an actual crossing of a strong branch of radius across the M_1 trachea has been found (Fig. V, Pl. 5). A large number of the wing-pads of this species were examined. Half of the wing-pads showed the radial branching just described and half of them gave no sign of it (Pl. VII, Fig. 41). An actual connection between the R and the Rs trachea cannot be shown by constant structures. However, May-flies and dragon-flies are closely allied groups and their general tracheation is similar in many points. Furthermore this condition of the radial sector trachea is exactly the same as that just described in the damsel-flies where there can be no doubt that such a crossing has taken place. It is, therefore,

highly probable that the radial sector is present in May-flies and that both the sector trachea and the vein Rs have been stranded on M_1 and have left no positive trace of their origin.

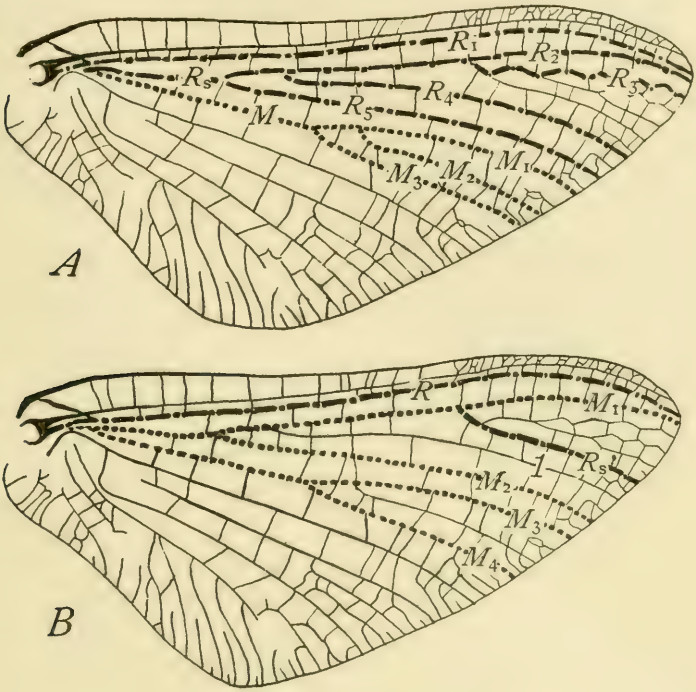

Fig. 4. Wings of Ephemera.
A. Previous interpretation of radius and media.
B. Present interpretation of radius and media.
Radius and its supposed sector are represented by dots and dashes, media is represented by a series of dots.

Such an interpretation involves important changes in the nomenclature of the veins in the radial and medial regions. These changes may be clearly seen by comparing the wings A and B in the accompanying figure (Fig. 4).

The Cubital Trachea.

In Chirotonetes (Pl. V, Fig. 1) the cubito-anal and medial tracheae diverge and then run nearly parallel for a short distance. In this region the anal tracheae branch off (Pl. V, Fig. 1, 1st A). The cubital trunk then bends forward again toward the medial trachea, making a prominent bend just below the first fork of

media. It soon splits into two branches which extend nearly to the anal margin. These branches are the Cu_1 trachea and the Cu_2 trachea. The Cu_1 trachea lies constantly within the vein directly behind vein M_4 and the Cu_2 trachea within the next primary vein behind Cu_1.

A prominent bend in the cubital trunk is a characteristic feature of May-fly tracheation. Variations of it have been found in all but one (Pl. V, Fig. 5) of the wing-pads examined. (Pl. V, Figs. 7, 9, 11; Pl. VI, Figs. 15, 17; Pl. VII, Fig. 31). In the last case (Callibætis) the cubito-anal stem has joined the general approximation of the tracheal trunks outward and the cubital bend is no longer evident.

The replacement of main tracheæ by small branches is not usual in the cubital region as it is in the radial and medial. It does occur however in Blasturus and Siphlurus (Pl. VI, Fig. 27; Pl. VII, Figs. 29, 40) where small branches of the Cu_1 trachea supply the M_{3+4} vein. With few exceptions (Pl. V, Figs. 1, 3, 7) the cubital trachea are entirely unbranched.

The Anal Tracheæ.

The anal stem is a well defined trachea which splits off from the cubito-anal trunk just before the cubital bend.

In the mature wing-pad of an Ephemera (Pl. VI, Fig. 17) the three anal tracheæ are present. In this wing-pad the 1st A trachea is a strong branch which separates from the distal part of the anal trunk and extends to the margin. It lies in the next primary vein posterior to vein Cu_2. From the posterior side of the 1st A trachea several secondary branches are given off. These are followed by secondary veins. The 2nd A trachea separates from the trunk directly behind the accessory tracheæ. The 3rd anal trachea is a short branch which arises posterior to these accessories. Both the 2nd A and 3rd A tracheæ are followed by primary veins (Pl. VI, Fig. 17). From the evidence presented in the nymphal wing-pads and the wings of the subimago we have considered veins 1st, 2nd, and 3rd A to be typical of May-flies.

In Chirotonetes (Pl. V, Fig. 1) I have been able to demonstrate but one anal trachea. In this and all the other genera examined the anal tracheæ appear much later than those lying farther anterior. This fact accounts for their absence in many of these figures. The first anal trachea has been found in all of

the wing-pads examined and the second in three (Pl. V, Fig. 5; Pl. VI, Fig. 17, Pl. VII, 31). All of the anal tracheæ have been nearly always found in recently emerged sub-imagoes.

Replacement of main tracheæ by small branches does not occur in the anal region. As might be expected, the burden of aeration does not fall here but in the middle region of the wing-pad.

The Tracheal Stem.

As already stated, the single tracheal stem of May-flies is similar to that of no other order, those of other insects as far as known having a dorsal and ventral root (Fig. 5, A. a, b).

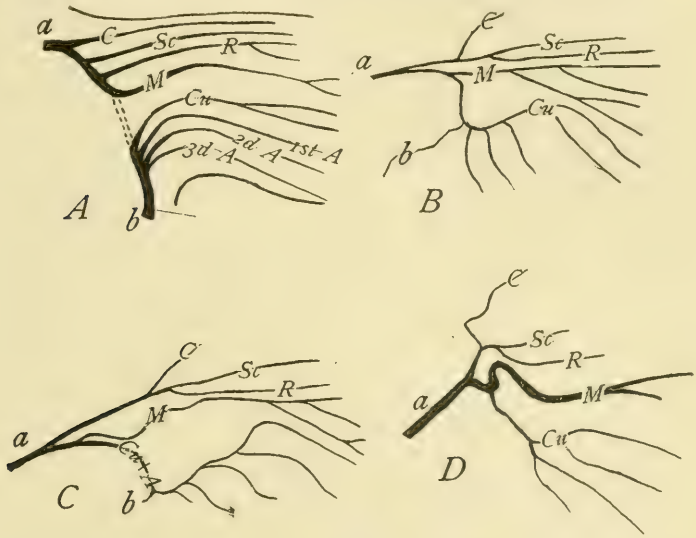

Fig. 5. Diagrams of Tracheal Stems showing shifting of the cubito-anal trachea.
A. Tracheal bases in the hypothetical wing of insects (after Comstock and Needham).
B. In the wing-pad of a hypothetical May-fly.
C. In the generalized wing-pad of Epeorus.
D. In the specialized wing-pad of Callibætis.

In these wing-pads the base of the cubito-anal trachea makes a characteristic prominent downward loop (Fig. 5, B, C). This loop swings the trachea out of the route which it would seem naturally to take. It is more prominent in generalized than in specialized wing-pads (Fig. 5, of C and D).

In some generalized wing-pads a weak branch springs from the cubito-anal loop and extends inward toward the body, nearly parallel with the main stem. (b, in Fig. 5, C). These structures have prompted the suggestion that the weak trachea (b, in Fig. 5, C) may be the remnant of the trachea which connects the trachea of the wing with the ventral body trachea in other orders (b, in Fig. 5, A).

Fossil May-flies.

On account of the difficulty in studying fossil wings only a very brief consideration has been given to them. A few figures of fossil wings believed to be those of May-flies have been copied. (Pl. IX, Figs. 62, 63, 64, 65, 66, 67). The homologies here determined have been applied to these wings. All but the last figure are taken from "Types of Permian Insects" by E. H. Sellards[1]. In these May-flies the fore and hind wings are nearly equal in size, as they are in damsel-flies. The parallel veins of the front part of the wing and the main branches of media are identical with those of modern May-flies. The last figure (Bætis anomala)[2] represents a recent fossil in which the hind wings show the reduction which is the present characteristic of May-flies.

Hind Wings.

The hind-wings of May-flies are greatly reduced in size. In Cænis they are entirely lacking. In consequence of this reduction there are important differences in the front and hind wings. By reason of it also the venation is so reduced as to be of far less value in practical use.

The wing-pads of Chirotonetes show the most generalized tracheation of any which have been studied. In these the bases of the tracheal trunks are similar to those of the front wing (Pl. VIII, Fig. 43). The tracheae however show these differences. The M_1 trachea always extends to the margin of the wing-pad. There is no trace of either the Rs? or the 1st accessory trachea. These veins, however, are present and occupy positions identical with the corresponding veins of the front-wing

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[1]E. H. Sellards. Types of Permian Insects. Amer. Jour. of Science, Vol. XXIII, May, 1907. pp. 345–355.

[2]G. C. Berendt. Die im Berstein befindlichen Organischen Rests der Vorwelt. 1856. Zweiter Band. Abt. II. Neuropteren (Pictet Baraban & Hagen). Tab. VI, Fig. 1.

In the wing-pads figured in Pl. VIII, there is a gradual reduction of the main trachea in the front of the wing. This is shown first in Heptagenia (Pl. VIII, Fig. 45) where the base of the subcostal trachea has apparently fused with the radial trachea, later by its total obliteration, (Pl. VIII, Fig. 51). In all of these except Callibætis the Sc has been the only vein to disappear (Pl. VIII, Figs. 46, 48, 50, 54). Between M_1 and M_2 there are several accessory veins which are generally bent backward and attached to the vein next posterior. The direction of their bending is just the opposite of these same accessories in the fore-wing.

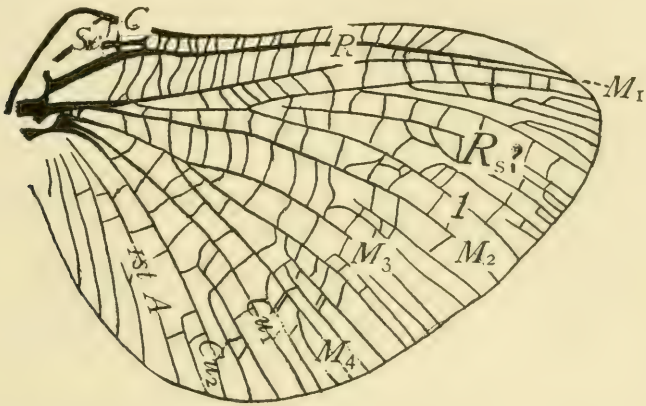

Fig. 6. Hind wing of Palingenia longicauda Oliv. (After Eaton.)

The direction and the attachment of these accessories was traced through a series of hind-wings. In a few of the generalized wings they were bent forward and attached to vein M_1 (Palingenia, Fig. 6) like the similar accessories of the fore-wing. Between this anterior attachment to M_1 and the posterior joining to M_2 figured in Heptagenia (Pl. VIII, Fig. 46) there were many intermediate positions. One of these is represented by Chirotonetes (Pl. VIII, Fig. 44). We may conclude then that the wing of Palingenia represents a generalized type of the hind wing in which a number of accessory veins are joined to M_1 and M_2 is a simple vein. This condition is very near to that in the fore-wing. By a general shifting backward the accessory veins have been thrown upon vein M_2 and have thus made it secondarily a branched vein. There are 3 sizes of

intercalaries as in front wing. The hindmost is longest as in front-wing, two others are of intermediate length. The Acc_1, and Rs? are in positions identical with the corresponding veins of the front wing. Sub-costa is much reduced; in most cases entirely wanting. In Palingenia (Fig. 6, Sc) it is a strong but very short vein.

Summary.

This is a study of the ontogeny of wings representing fifteen genera of May-flies in which the following facts are shown:

1. The main veins of May-flies may be homologized with the veins of insects of other orders.

2. The main tracheæ precede and constantly mark the course of the main veins.

3. The costal and subcostal tracheæ are simple and parallel as are the veins which follow them.

4. The radial trachea (except in one form studied) and the vein which follows it are unbranched.

5. The radial sector is very probably present in May-flies but in an unusual position between the veins M_1 and M_2. It is detached from radius, as in the dragon-flies, and stranded upon vein M_1.

6. The medial trachea and the vein M show four branches which are characteristic of media in its primitive condition. It is similar to the media in the closely allied dragon-flies.

7. The tracheal system enters the wing by a single stem. The course of the cubito-anal trunk shows a possible trace of the double stem of the tracheal system of other orders.

8. In the series of wing-pads studied a remarkable evolution of tracheation is shown. This evolution consists of a gradual reduction of main tracheæ and replacement by small branches.

9. This interpretation of the venation involves the important changes of nomenclature shown in Fig. 4.

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EXPLANATION OF PLATES.

Plate V.

(In the wing-pads continuous lines represent tracheae and tracheoles; dotted lines represent developing veins.)

Fig. 1. Wing-pad of Chirotonetes albomanicatus. Needham.
" 2. Wing of " "
" 3. Wing-pad of Heptagenia sp.?
" 4. Wing of "
" 5. Wing-pad of Heptagenia sp. (nymph No. 3 Needham).
" 6. Wing of "
" 7. Wing-pad of Epeorus humeralis Morgan.
" 8. Wing of " "
" 9. Wing-pad of Iron fragilis Morgan.
" 10. Wing of " "
" 11. Wing-pad of Ameletus ludens Needham.
" 12. Wing of " "
" 13. Wing-pad of Hexagenia sp.?
" 14. Wing of " "

Plate VI.

Fig. 15. Wing-pad of Polymitarcys albus Say.
" 16. Wing of "
" 17. Wing-pad of Ephemera sp.
" 18. Wing of "
" 19. Wing-pad of Caenis diminuta Walker.
" 20. Wing of " "
" 21. Wing-pad of Ephemerella rotunda Morgan.
" 22. Wing of " "
" 23. Wing-pad of Leptophlebia sp?
" 24. Wing of "
" 25. Wing-pad of Choroterpes sp?
" 26. Wing of "
" 27. Wing-pad of Blasturus cupidus Say.
" 28. Wing of " "

PLATE VII.

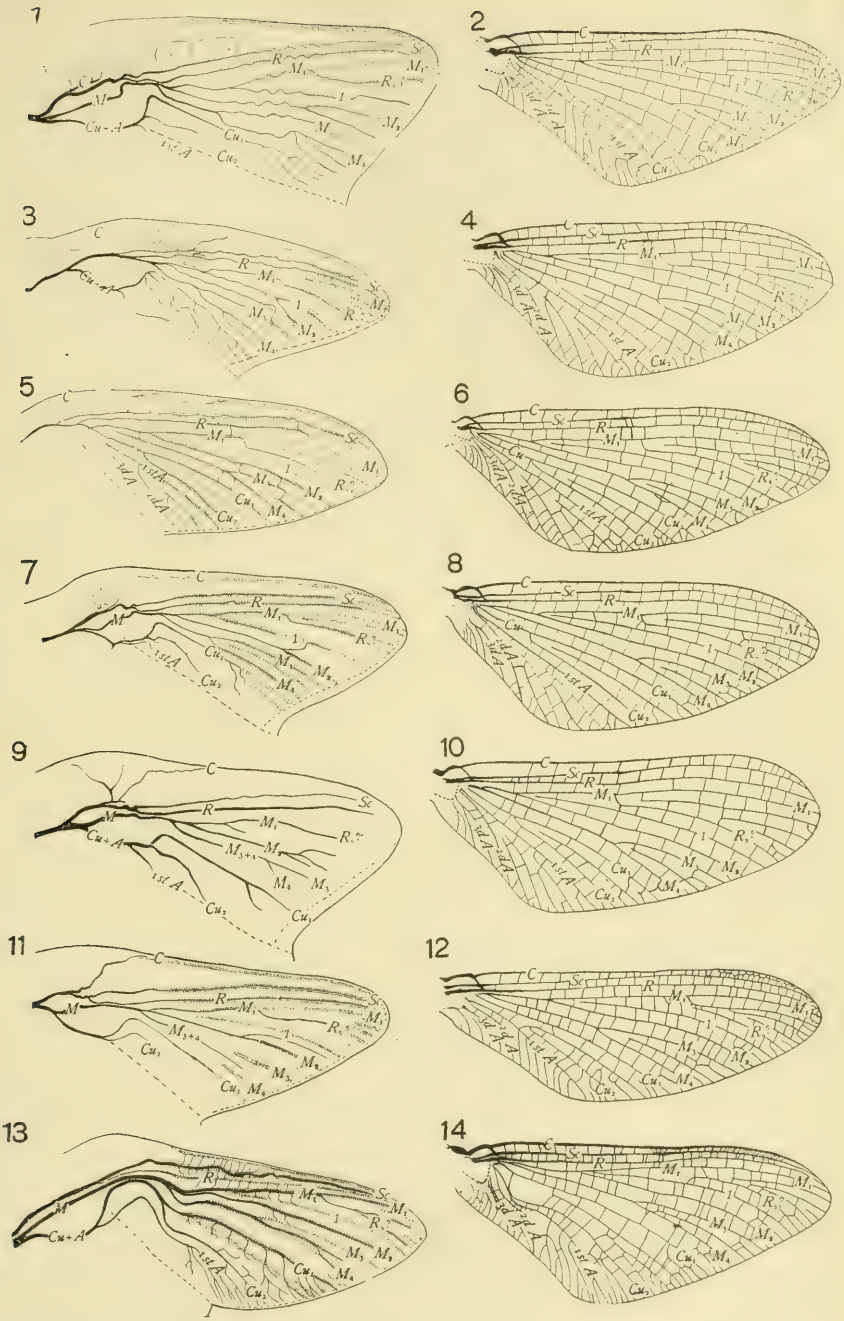
Fig. 29. Wing-pad of Siphlurus sp?
" 30. Wing of " .
" 31. Wing-pad of Callibaetis sp?
" 32. Wing of "
" 33.
" 34. Successive stages of wing-pads of Chirotonetes albomanicatus Needham.
" 35.
" 36.
" 37. Successive stages of wing-pads of Blasturus cupidus Say.
" 38.
" 39. Base of wing-pad of Hexagenia sp?
" 40. Wing-pad of Blasturus cupidus showing variation in aeration.
" 41. Wing-pad of Heptagenia sp? (No. 3 Needham). showing variation in Rs?
" 42. Wing-pad of Ephemera showing slight variation in tracheation.

PLATE VIII.

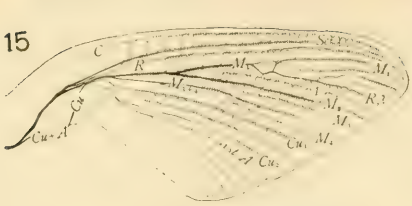
Fig. 43. Hind wing-pad of Chirotontes albomanicatus Needham.
" 44. " wing of " "
" 45. " wing-pad of Heptagenia sp?
" 46. " wing "
" 47. " wing-pad of " sp? (Nymph No. 3, Needham).
" 48. " wing of "
" 49. " wing-pad of Epeorus humeralis Morgan.
" 50. " wing of " "
" 51. " wing-pad of Callibaetis sp?
" 52. " wing of "
" 53. " wing-pad of Leptophlebia sp?
" 54. " wing of "

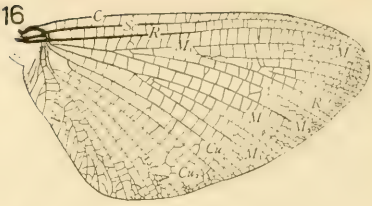
PLATE IX.

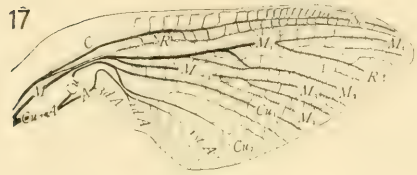
Fig. 55. Wing of Potamanthus luteus (after Eaton).
" 56. " Calliarcys humilis "
" 57. " Tricorythus (Malay sp.) "
" 58. " Spanophlebia Trailiæ. "
" 59. " Lachlania abnormis "
" 60. " Oligoneuria rhenana "
" 61. " Elassoneuria Trimeniana "
" 62. Fossil May-fly. Type of genus Protereisma (after Sellards).
" 63. " " Wing of Prodromus rectus "
" 64. " " Wing of Protereisma minus "
" 65. " " Wing of Protechma accuminatum "
" 66. " " Wing of Rekter arcuatus "
" 67. " " Baetis anomala (after Pictet-Baraban and Hagen).

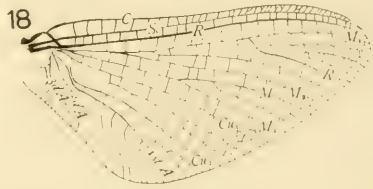


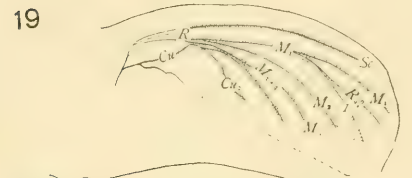
Anna H. Morgan.

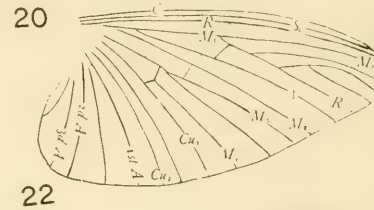


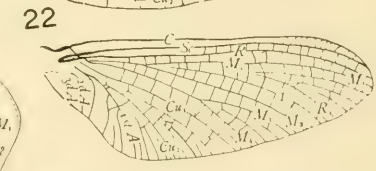


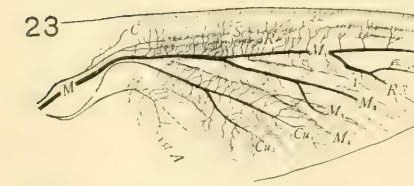


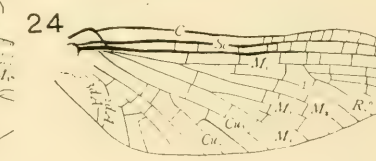


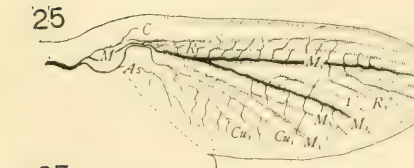


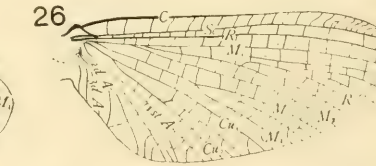


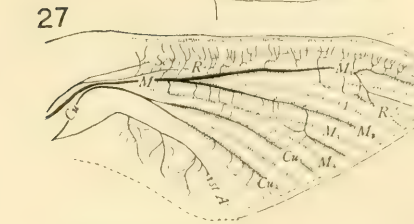


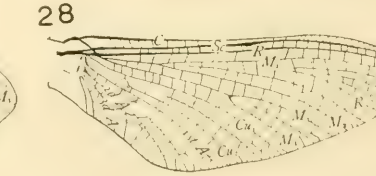












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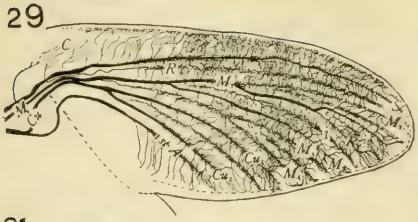

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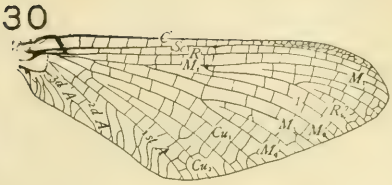

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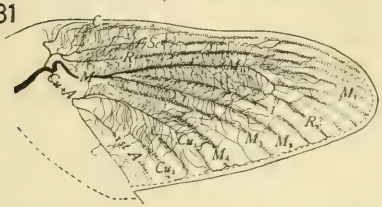

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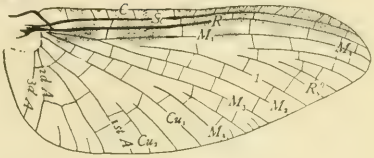

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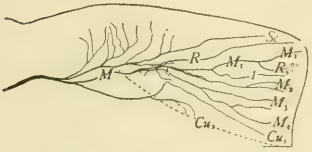

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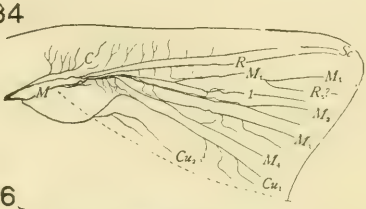

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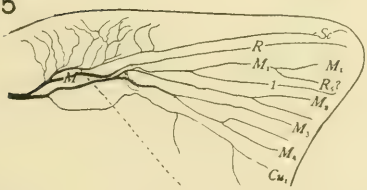

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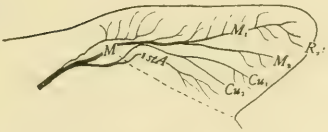

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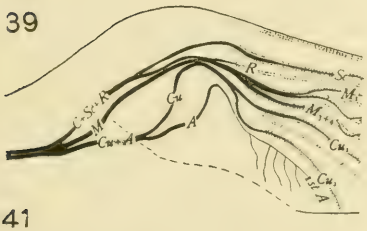

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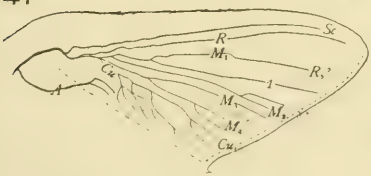

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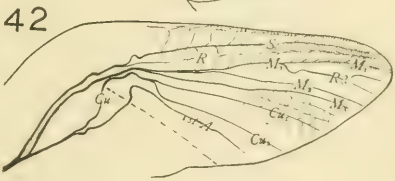

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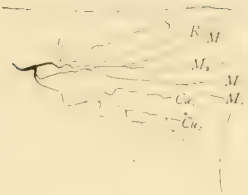

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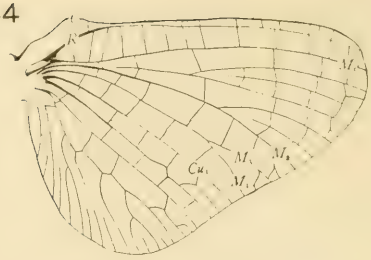

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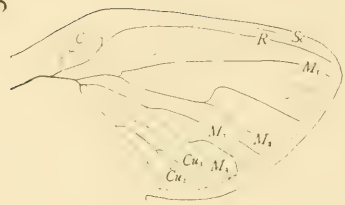

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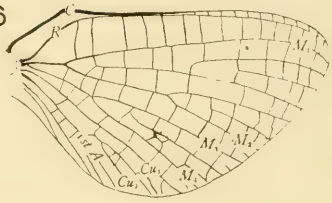

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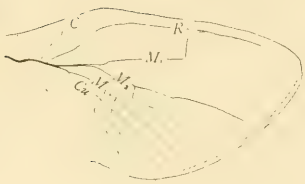

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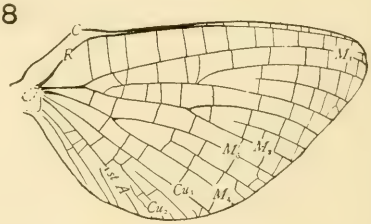

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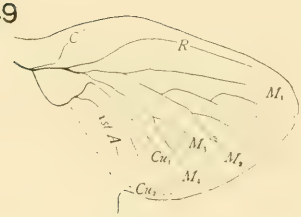

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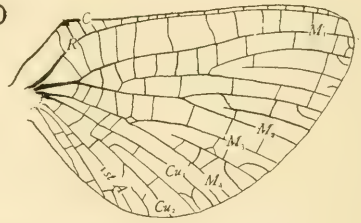

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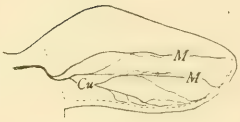

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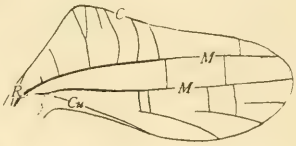

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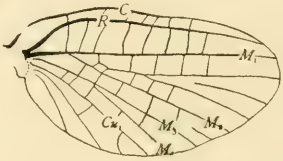

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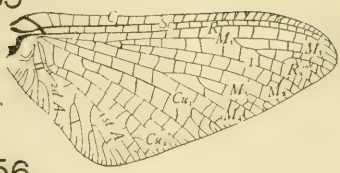

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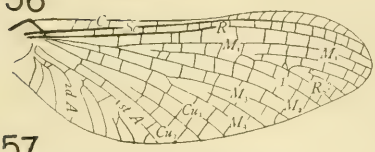

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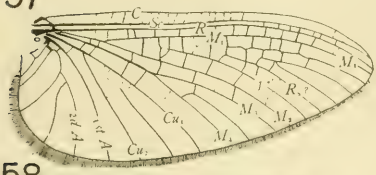

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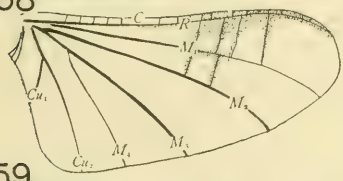

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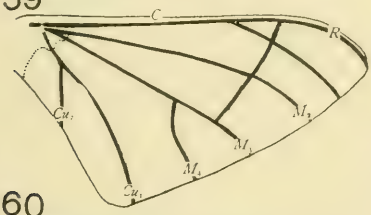

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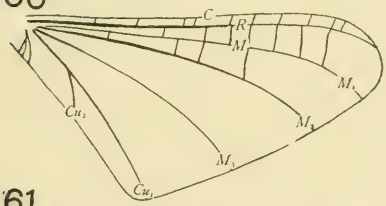

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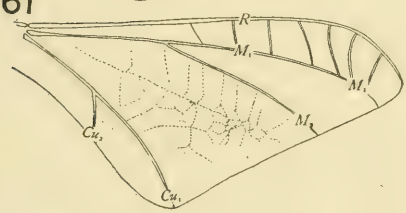

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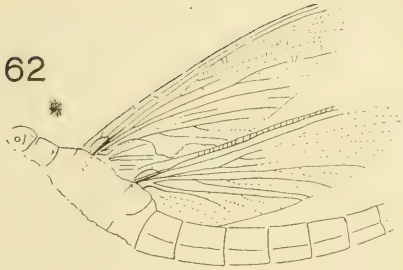

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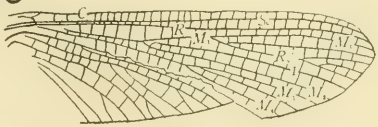

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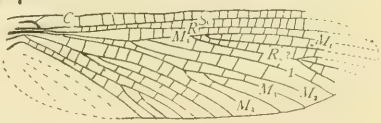

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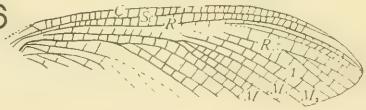

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THE PEZOMACHINI OF NORTH AMERICA.[1]

By E. H. Strickland.

The following paper is based mainly on the unnamed collection of the genus *Pezomachus* belonging to the U. S. National Museum, which was very kindly lent to me during the spring of 1911. The bulk of the collection of 317 specimens was composed of two species, namely: *Pezomachus flavocinctus* Ashm. 112 specimens ♂ and ♀, and *Pezomachus nigrellus* Ashm. 60 specimens ♂ and ♀. The former proved to be the most interesting since the hitherto undescribed male yielded a unique condition of polymorphism, fully described later in the description of the species, and in several cases a hyperparasite, *Hemiteles sp.* was bred from the same egg cocoons as individuals of this species. Many other already described species of Pezomachus were represented as were also 12 apparently new species. I am also indebted to Mr. H. L. Viereck of the National Museum for a small collection containing one new species, and to Dr. W. E. Britton, State Entomologist of Connecticut for a similar collection containing two new species of Pezomachus and one new Thaumatotypus.

In working these over I found several cases in which two distinct species had received the same name, while some cases of wrong generic determination were noticed, which in the following pages I have attempted to correct.

My thanks are due to Mr. C. T. Brues for help received in generic determinations.

The tribe *Pezomachini* of Ashmead[2] included all Cryptines in which the metathorax is not areolated, or at most with only a transverse carina, and consisted of the following genera.

Thaumatotypus Förster.
Cremnodes Förster.
Apterophygus Förster.
Aptesis Förster.
Theroscopus Förster.
Pezomachus Grav.
Pezolochus Förster.
Hemimachus Ratz.

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[1]Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 45.

[2]Proc. U. S. Nat. Mus. Vol. XXIII, p. 36 (1900).

In 1907 Schmiedeknecht[3] limited the tribe to only such Cryptines as are entirely wingless in the ♀ (none of which have an areolated metathorax), and have no scutellum in this sex. This reduces the tribe to the following known genera.

Thaumatotypus Förster.
Pezomachus Grav.
Pezolochus Förster.

all of which are represented in North America.

Three species of the genus *Pezomachus* fall into a group so distinctive that I have proposed a sub-genus *Micromeson*, herein described, to include them.

The discarded genera of the tribe are now distributed as follows:

Cremnodes, *Apterophygus* and *Theroscopus* are now included in the genus *Hemiteles* Grav. and the genus *Hemimachus* is now sunk in *Pezomachus;* while the species of *Aptesis* are included some in *Microcryptus* Ratz. and some in *Hemiteles.*

There are no valid records of any of these genera, as they were then defined, being represented in America, with the possible exception of *Aptesis* the two described American species of which must now probably be included in *Microcryptus.* The three species placed in the genus *Cremnodes* by Ashmead and Harrington must be transferred to *Thaumatotypus*, while of the four species placed by Ashmead in *Theroscopus* three, namely *T. americanus*, *T. kukakensis* and *T. rufipes* belong to the genus *Pezomachus* while the fourth, *T. popofensis* was described from a single winged male and cannot therefore be, with certainty, placed in this genus.

The three genera of Pezomachini Schmied. can be separated as follows:

1. Second abdominal segment very large covering ¾ of the entire length of the hind body, connate with the third segment. Petiole much longer than the metathorax.....**Thaumatotypus** Forst
   Second abdominal segment not covering ¾ of the hind body, not connate with the third segment. Petiole rarely much longer than the metathorax. 2
2. Face much abbreviated ..... **Pezolochus** Grav.
   Face of normal length.....**Pezomachus** Grav.

The subgenera of *Pezomachus* sens, lat. can be separated as follows:

Prothorax much swollen in both sexes so that it is at least as long as the mesonotum along the median line. Petiole long and unusually slender. Subgenus **Micromeson**

Prothorax not abnormally enlarged, shorter along median line than the mesonotum; petiole considerably expanded apically..Subgenus **Pezomachus**

[3]Die Hymenopteren mitteleuropas. Gustav Fischer, Jena. (1906).

Although I have only separated out this one subgenus of Pezomachus it is evident when one is working over a quantity of material that there are several well defined groups of species in this genus which would suggest that though the species, especially in the female sex are very similar, this genus may in reality consist of degenerate forms from more than one genus or even tribe. Unfortunately the species recognized in the male sex, which would probably have more distinctive characters, are much fewer than those now described in the female sex and in only nine American species have the males and females been correlated.

Key to the Species of **Thaumatotypus.**

1. Antennæ 18-jointed..... 2
   Antennæ 16-jointed; petiole striate, piceous species.....**spinulatus** sp. nov.
2. Head and abdomen rufous, thorax, testaceous.....**canadensis** Harr.
   Not so coloured..... 3
3. Petiole striate, metathoracic teeth acute.....**alaskensis** Ashm.
   Petiole smooth, or with median line, metathoracic teeth not prominent **tuberculatus** Ashm.

Key to the New Species of **Pezomachus** here described.

FEMALES.

1. "Metathoracic" carina entirely absent; piceous species; length 4 mm... **P. utahensis**
   "Metathoracic" carina indicated, either completely or only laterally.... 2
2. Ovipositor not more than half as long as the petiole..... 3
   Ovipositor at least about the same length as the petiole..... 4
3. Antennæ 19-jointed, abdominal pubescence dense; bicolored species ferruginous and black; length 3.5 mm.....**P. brevistylus**
   Antennæ 17-jointed, abdominal pubescence sparse, piceous species, length 1.5 mm.....**P. minutus**
4. Ovipositor not much longer or shorter than the petiole..... 5
   Ovipositor 1½ times as long as the petiole; length of species 5 mm..... **P. longistylus**
5. Abdominal pubescence rather long, moderately dense, antennæ 17-jointed piceous species, length 2 mm.....**P. robustus**
   Abdominal pubescence short..... 6
6. Abdominal pubescence dense..... 7
   Abdominal pubescence sparse.....10
7. Metathorax viewed from the side subconical, thorax fuscous, with black blotches, length 4 mm.....**P. maculatus**
   Metathorax normal..... 8
8. Petiolar spiracles so prominent that the general outline of the petiole is altered, sharply bi-colored species, head and abdominal apex black, remainder yellow.....**P. coloradensis**
   Petiolar spiracles not at all prominent..... 9
9. Meso- and meta-thorax sub-equal from above, densely pubescent. Black species, length 4.5 mm.....**P. longipes**
   Mesothorax much shorter than "metathorax" the latter always with a median groove .....**P. standfordensis**
10. Petiolar spiracles so prominent that the general outline of the petiole is altered.....11
    Petiolar spiracles only slightly prominent.....12

11. Spiracles on large thick conical projections; antennæ 18-jointed, length of species 2.5 mm.....**P. spiraculus**
    Spiracles not exceptionally prominent; yellow-ferruginous species, with piceous bands on the abdomen; length 4.5 mm.....**P. dispar.**
12. Small species, 2.5 mm., antennæ 21-jointed, petiole very short and broad. **P. pennsylvanicus**
    Larger species, 4 mm. or more.....13
13. Ferruginous with third and following abdominal segments piceous, in sharp contrast to the rest of the body; length 4 mm.....**P. similis**
    Ferruginous with fourth and following abdominal segments piceous; third piceous at base, but broadly ferruginous at apex. Length 5 mm. **P. nodosus**

MALES.

1. Wings fully developed..... 2
   Fore wings partially developed, hind wings absent....**P. flavocinctus** Ashm.
   Wings absent..... 4
2. Carina roughly semicircular..... 3
   Carina sinuous, abdomen densely pubescent.....**P. flavocinctus** Ashm.
3. Piceoferruginous species with the petiole and segments two and three luteous .....**P. similis**
   Piceoferruginous species with well defined apical yellow bands on the petiole and second abdominal segment.....**P. dispar**
4. Pubescence dense..... 5
   Pubescence sparse..... 7
5. Carina complete, sinous..... 6
   Carina incomplete, antennæ about 22-jointed.....**P. nigrofuscus**
6. Antennæ about 29-jointed, fuscous species though abdominal segments often with narrow yellow apical bands.....**P. flavocinctus**
   Antennæ about 27-jointed, head thorax and petiole ferruginous, remainder of abdomen black.....**P. manni**
7. Piceous black species with golden yellow legs.....**P. auripes**
   Ferruginous species with a partially piceous abdomen..... **P. ottawaensis** Harrington

SUB GENUS **Micromeson.**

FEMALES.

1. Clear ferruginous species with piceous abdominal bandings. Face somewhat sunken between the eyes. Length 6–6.5 mm.....**P. annulatus**
2. Fuscous species with piceous abdominal bandings. Face level with the eyes, length 6–6.5 mm.....**P. lymensis**
3. Pale honey yellow species, length 4 mm.....**P. texanus** Cress

Thaumatotypus spinulatus, sp. nov.

Female. Length 4 mm. Piceous black with very stout fuscous legs and antennæ. Entirely clothed with rather sparse, long outstanding hairs. Petiole very long. Ovipositor stout.

Head from above transverse, this is due to its marked shallowness as it is but little wider than the thorax, rectangular, the margined vertex being slightly excavated; deep black and rather coarsely shagreened. Face rather long, greatly swollen below the antennæ so that this portion projects beyond the eyes. Malar line indistinct, half as long as the width of the face at the lower corners of the eyes. Eyes small, about as long as the malar line, internal margins converging above. Clypeus transverse with a rather large deep fovea on either side. Mandibles testaceous, apparently bifid, teeth black. Antennæ short and very stout, 16-jointed, as long as the head and thorax together, rather densely clothed with a short pubescence.

Thorax short and broad. Mesonotum piceous, similarly shagreened to the head, somewhat gibbous and with an obsolete median furrow. No indication of a scutellum. "Metathorax" black, strongly declivous posteriorly. Transverse carina incomplete medially but with the apophyses produced into extremely prominent projections, which gives the posterior face of the "metathorax" a concave appearance. There are two longitudinal carinæ on either side. Surface rather coarsely shagreened and clothed with long white outstanding hairs.

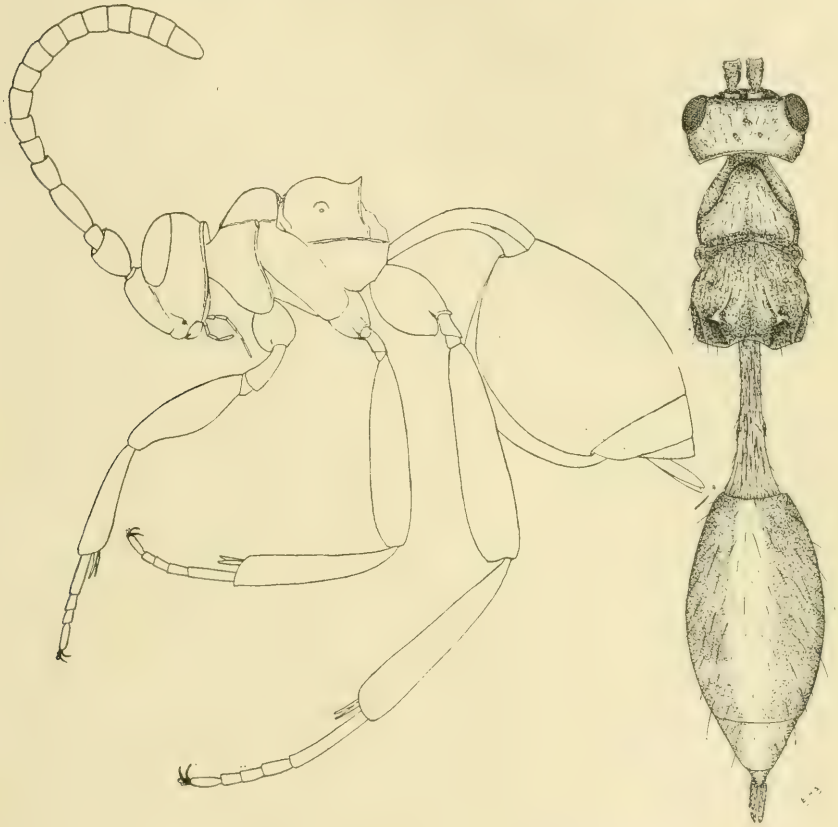


Fig. 1. Thaumatotypus spinulatus.

Petiole very long and not much expanded, as long as the thorax, strongly aciculate and with but slightly projecting spiracles. Remainder of abdomen elliptical, with the apex sharply pointed. Surface black, smooth and shining, with a sparse long pubescence. Second segment greatly enlarged, covering ¾ of the length of the abdomen, the third segment covers most of the remainder. The apex of the fourth is all that is exposed of the remaining segments. There is an indefinite testaceous band near the apex of each segment. Viewed from the side the dorsal sclerites are seen to be much produced below the body of the

abdomen, and the free margins of the second segment meet on the ventral side of the abdomen. Ovipositor about as long as the third segment, sheaths stout, testaceous and densely pilose. Legs very stout but rather long. The swollen femora and tibiæ are piceous black and are densely pubescent. The tarsi, which are quite normal in structure are of a more rufo-testaceous color. Ungues simple.

Described from a single specimen taken at New Haven, Conn., by A. B. Champlain on the 20th of May, 1911.

I am rather doubtful as to the genus in which this species should be placed as in Försters description of *Thaumatotypus* he has "Scutellum distinct". In this species, however, the scutellum is not indicated.

As the generic description was drawn up on a single species and the present specimen agrees with it in all other particulars, notably in the much enlarged second abdominal segment, I have placed it provisionally here.

Schmeideknecht places the genus in the *Pezomachini* and it is probable that he has seen the type so it may be that Försters original description was not correct in this detail.

Pezomachus utahensis sp. nov.

Female. Length 4 mm. Head thorax and abdomen shining black. Antennæ and legs piceous. Metathorax strongly gibbous, without a carina. Petiolar spiracles rather prominent.

Head, from above about twice as wide as thick along the median line, minutely punctulate, shining. Ocellar triangle small. Lateral ocelli nearer to the median ocellus than to the eye margins. Face entirely black, obtusely carinate medially from the insertion of the antennæ to the base of the clypeus. Clypeus transverse, malar line obsolete, about half as long as the face is wide. Inner eye margins parallel and straight. Mandibles and palpi piceous. Antennæ piceous above, lighter below, slender.

Thorax uniformly and closely punctulate, shining. Prothorax rather large, closely connate with mesothorax, suture obsolete; testaceous on median line. Mesothorax rather larger than metathorax, scutellum indicated by a rounded though rather large and prominent tubercle. Tegular tubercles prominent and testaceous. "Metathorax" strongly gibbous, posterior face abruptly declivous. Coxæ black, remainder of legs piceous.

Petiole rather short and broad, evenly widened from the base to the apex except for where the rather prominent spiracles cause a small tubercle. Closely punctured, and with an obsolete median furrow. Remainder of abdomen oval, about 2½ times as wide as the thorax. Segments closely and evenly punctured, and with a sparse pubescence. Ovipositor about as long as the petiole, testaceous with fuscous sheaths.

Observations. Described from a single specimen taken at Park City, Utah. Type in the National Museum.

Pezomachus brevistylus sp. nov.

Female. Length 3.5 mm., ferruginous, with apical half of the abdomen piceous; short and robust with a much abbreviated ovipositor; entire body rather densely pubescent.

Head from above ferruginous, finely shagreened and pubescent, about twice as wide as thick along the median line. Antennæ short and stout, 19-jointed; scape and first few flagellar joints ferruginous, remainder piceous, seventh and neighboring flagellar joints not quite twice as long as thick. Face below antennæ somewhat swollen, subtuberculate, clypeus semi-circular, indefinitely separated basally; malar lines distinct, about 1-3 as long as the face is wide at the lower angles of the eyes. Mandibles yellowish.

Thorax distinctly bi-nodose, ferruginous with a short rather dense pubescence. Scutellum hardly indicated, mesothoracic tegulae small but prominent; "metathoracic" carina poorly defined medially but prominent laterally. Legs ferruginous, hind legs infuscated at apex of the femora and over most of the tibiæ.

Abdominal petiole short and broad, spiracles moderately prominent, surface ferruginous and shagreened; with a fine short pubescence; remainder of the abdomen short oval, second segment ferruginous, following segments piceous, surface punctulate, entirely clothed with a dense short pubescence. Ovipositor very short, about one-third the length of the short petiole; sheaths piceous.

Observations. Described from a single specimen taken at Philadelphia. Closely related to *P. ashmeadii* (*Cremnodes californicus* Ashm.), but readily distinguished by its color and more definite carina. Both of these species fall into a very distinctive group of Pezomachini the most distinctive characters of which are the shortened robust form of the body together with the much abbreviated ovipositor, and it is possible that these characters will be found to be of sub-generic value.

Pezomachus minutus sp. nov.

Female. Length 15 mm. Entirely piceous black, petiole short and broad at the apex. Ovipositor short.

Head transverse, temples swollen, about 2½ times as wide as thick along the median line. Surface polished though very finely punctured. Face below antennæ more coarsely punctured and hairy, produced forward immediately below the insertion of the antennæ, so that the latter are placed on a small horizontal ledge. Malar line distinct, about one-third the width of the face. Clypeus poorly defined, transverse. Mandibles and palpi piceous, concolorous with remainder of the face. Antennæ sub-clavate, piceous, entirely pilose, 17-jointed, reach to apex of petiole. Seventh and neighboring flagellar joints about 1¼ times as long as wide.

Thorax not distinctly bi-nodose; uniformly and finely punctured. Scutellum entirely absent. Tegular tubercles very prominent. "Metathorax" as long as mesothorax, with a definite semi-circular carina, behind which it is abruptly truncate. Legs not stout, concolorous with the thorax.

Petiole short, about ¾ as broad as the apex is long; spiracles not prominent; finely and uniformly punctured. Remaining abdominal segments very shining, with a sparse pubescence and a very fine punctulation. Ovipositor short about ½ the length of the petiole, luteus with dusky sheaths.

Observations. Described from a single ♀ taken at St Pauls Island. This species shows a relationship to *P. ashmeadii* and *P. brevistylus* in the shortened form and abbreviated ovipositor. Type in the National Museum.

Pezomachus longistylus sp. nov.

Female. Length 5 mm. head and thorax ferruginous; abdominal segments piceous basally, yellowish apically. Ovipositor much elongate, about 1½ times the length of the petiole.

Head from above somewhat rectangular, the margined occiput but little excavated; surface shagreened and of a deep ferruginous color. Antennæ longer than the head and thorax together, 24-jointed, slender; seventh and neighboring flagellar joints almost twice as long as thick; scape somewhat yellowish, apical third of flagellum piceous. Face ferruginous, rather long, malar lines distinct, about one-third as long as the face is wide at the lower angles of the eyes. Clypeus not very distinctly separated, mandibles yellowish with piceous teeth; labium prominent, yellow.

Thorax bi-nodose, somewhat slender, its surface evenly shagreened; scutellum poorly defined; "metathorax" somewhat gibbose, with a delicate complete transverse carina. Legs elongate ferruginous.

Abdominal petiole with prominent spiracles; width at apex about three times that at the base; surface finely shagreened, base ferruginous, apex yellowish; remainder of abdomen oval with surface finely shagreened and clothed with a sparse pubescence, all segments piceous basally, second segment yellow apically. On the third and following segments the yellow is gradually replaced by ferruginous. Ovipositor much elongated, almost 1½ times the length of the petiole, sheaths piceous black.

Observations. Described from a single perfect specimen in the National Museum. Habitat and time of capture not noted. It somewhat resembles *P. micariæ* Howard.

Pezomachus robustus sp. nov.

Female, length 2 mm. A robust piceous species, with short, stout antennæ and rather thick legs, "metathoracic" carina present but indefinite. No spiracular tubercles on the petiole.

Head large, from above rectangular, about twice as wide as thick along the median line; surface rather coarsely shagreened. Face swollen below the insertion of the antennæ, and of a lighter color than the vertex. Malar lines distinct, not quite half as long as the face is wide, between the lower angles of the eyes. Clypeus not very well defined basally, the free margin is almost semi-circular. The antennæ are short and stout, composed of 17 joints, of which the seventh and neighboring flagellar joints are only slightly longer than wide. The basal half of the antennæ is of a lighter brown colour than the head.

Thorax distinctly bi-nodose, clothed with a sparse pubescence rather coarsely shagreened. The scutellum is absent. The "metathoracic" carina is poorly defined especially medially. The legs are stout, not very long, and somewhat lighter in color than the thorax.

The abdominal petiole is short and evenly widened from the base to the apex, which is squarely truncate. The spiracles are not prominent. The surface is somewhat aciculate and dotted with an outstanding pubescence. Remainder of abdomen ovoid, shining, with a rather long pubescence. Ovipositor about as long as the petiole, with dusky sheaths.

Observations. Described from a single specimen taken at Tucson, Arizona, by H. G. Hubbard.

This species is similar in general appearance to a small *nigrellus* (Ashm.) but can be at once distinguished by the more robust form and shorter antennæ.

Pezomachus maculatus sp. nov.

Female. Length 4 mm. Bicolored; ferruginous and black; head and abdomen, except petiole, black from above. Thorax mainly ferruginous, but with black blotches, especially on the pleuræ. Legs piceous with lighter colored patches, "metathorax" abnormally gibbose, indefinitely carinate. Thorax and abdomen densely pubescent.

Fig. 2. Pezomachus maculatus.

Head from above coarsely shagreened; with small ocelli which are placed in a large equilateral triangle. The color is piceous black with flecks of dull ferruginous. Antennæ long and slender, 20-jointed, apex

piceous, base ferruginous, first three flagellar joints with basal and apical yellow bands. Face ferruginous, shagreened, transverse. Malar lines indistinct at eye ends, more prominent towards the clypeus, about one-third as long as the face is wide between the lower angles of the eyes. Mandibles rather yellowish, palpi piceous-black.

Mesothorax robust, rather short; with a well defined median sulcus, and a small obsolete scutellar tubercle. The surface is rather coarsely shagreened, and clothed with a moderately dense pubescence. The prevailing color is ferruginous, but there is a definite pre-scutellar piceous spot on the mesonotum, and the pleuræ have two piceous patches on both sides. The "metathorax" is very strongly gibbose; sub-conical, when viewed laterally; the carina is poorly defined. The surface is rather coarsely shagreened and clothed with a moderately dense pubescence. Anterior to the carina the "metathorax" is ferruginous, but on the posterior and lateral faces it is piceous. The legs are long, and piceous, for the greater part, but mottled with dusky yellow, which color is most prominent at the bases of the joints.

Abdominal petiole ferruginous, rather closely shagreened, and pubescent. The spiracles are prominent. Remainder of abdomen ovate deep black, and densely pubescent. Ovipositor long, 1 mm. sheaths piceous.

Observations. Described from a single specimen taken at Point Loma San Diego, California, by P. Leonard. Type in the collection of the Bussey Institution, Harvard University.

This is a very remarkable species which is readily distinguished by its abnormally convex "metathorax" and curiously mottled legs.

Pezomachus coloradensis sp. nov.

Female. Length 4 mm. Ovipositor .75 mm. Very distinctly bicolored species as follows: Head black, entire thorax, legs, petiole and second and third abdominal segments light ferruginous; remainder of abdomen black.

Face ferruginous below the insertion of the antennæ, and slightly so above, along the eye-margins. Mandibles yellow at the base, apical half ferruginous, teeth black. Palpi yellow. Antennæ dusky above, rather more yellowish below, rather long and slender with seventh flagellar and neighboring segments about 1½ times as long as wide. Head from above shagreened, slightly pilose, transverse, over twice as broad as thick along the median line.

Thoracic nodes sub-equal. Mesothorax with a poorly defined median furrow, most distinct just before the slightly raised scutellar area. The "metathoracic" carina which is broadly hastate in form is poorly defined except laterally. The legs, especially the hind ones, are rather more dusky than the thorax.

The petiole is about three times as wide at the apex as it is at the base, but does not widen much after the rather prominent spiracles, it is

somewhat constricted immediately behind these; the entire surface is finely and evenly punctured. The remainder of the abdomen is oval, finely and evenly punctured with a short but rather dense pubescence. Segments 2 and 3 are sub-equal in length and sharply contrasted in color with the remaining black segments. The ovipositor and sheaths are piceous.

Observations. Described from a single ♀ specimen taken in Colorado. Type in the National Museum.

Pezomachus longipes sp. nov.

Female. Length 4.5 mm. Piceous black, densely pubescent, species. Legs very long and slender.

Head from above about twice as wide as thick along the median line, piceous, surface shagreened, not shining, ocelli very small. Antennæ piceous throughout, slender but rather short, 23-jointed, the 7th and neighboring flagellar joints not quite twice as long as thick. Face below antennæ somewhat swollen, piceo-ferruginous, clothed with a rather long pubescence, especially on the clypeus. Clypeal suture obsolete. Malar lines distinct, about half as long as the face is wide at the lower angles of the eyes. Cheeks not swollen.

Thorax piceous black, uniformly shagreened, about three times as long as wide, nodes sub-equal. Mesothorax densely pubescent, tegulæ small but prominent, no indication of a scutellum. "Metathorax" more sparsely pubescent and more shining than the mesothorax. The carina is sinuous and poorly defined medially. Legs long and slender, the hind femora reaching almost to the apex of the abdomen, piceous black and clothed with a dense short pubescence.

Petiole piceous black with an indefinite and variable ferruginous apical band, densely pubescent, evenly widened from the base to the apex, spiracles not prominent. Remainder of abdomen ovate, black, sub-shining though closely punctate and clothed with a dense short pubescence. Ovipositor and sheaths black, somewhat longer than the petiole.

Observations. Described from two specimens taken at Stanford University, California, by William M. Mann, Feb., 1910, and Harold Morrison, Dec., 1910. This species resembles *P. cockerelli* Brues but is readily separated by the presence of the metathoracic carina.

Type in the collection of the Bussey Institution, Harvard University.

Pezomachus stanfordensis sp. nov.

Female. Length 4 mm. Shining black, antennæ, legs, mesothorax and extreme apex of petiole usually lighter in color. Abdomen with a rather dense pubescence. "Metathorax" and usually mesothorax also, with an obsolete median furrow.

Head from above quadrate, temples somewhat narrower than the eyes, rather less than twice as broad as thick along the median line, surface dull black, finely shagreened. Ocelli small, lateral ones nearer to the median ocellus than to the eye margins. Antennæ stout 19-jointed, the seventh and neighboring flagellar joints hardly longer than thick, color ferruginous to dusky with the apex piceous. Face below antennæ short, with the distinct malar lines about a quarter as long as the face is wide at the lower angles of the eyes, mainly ferruginous but with a piceous spot on either side between the bases of the antennæ and the malar line. Clypeal suture poorly defined. Mandibles ferruginous with piceous teeth.

Thorax short and shining though finely shagreened and with a sparse pubescence. Mesothorax piceous, much shorter than the black "metathorax", usually with a poorly defined median furrow. Scutellum not indicated. "Metathorax" with a complete though not very prominent carina, and with a more definite median furrow than on the mesothorax. Legs not very long, rather densely pubescent, color variable from light dusky to piceous black, in the latter case the joints between the coxa and trochanter, and the trochanter and femora, are distinctly lighter than the remainder of the leg.

Petiole piceous black, not very elongate, evenly expanded to the apex which is sometimes indefinitely ferruginous. Spiracular tubercles absent. Remainder of abdomen ovate, shining black, sometimes with apices of all segments slightly tinged with clear ferruginous, rather densely pubescent on the second and third, but more sparsely on the remaining segments. Ovipositor and sheaths piceous, about as long as the petiole.

Observations. Described from two specimens taken by William M. Mann, at Stanford, Cal., on Nov. 23, 1909, and Jan. 5, 1910.

This species resembles *Pezomachus obesus*, Ashm. but is larger and stouter and has a very much shorter mesothorax.

Type in the collection of the Bussey Institution, Harvard University.

Pezomachus spiraculus sp. nov.

Female. Length 2.5 mm. A small robust species, piceous black, except for the antennæ, pro- and mesothorax, legs and petiole, which are dusky ferruginous. Petiolar spiracles abnormally prominent, placed on stout tubercles. "Metathorax" carinate.

Head from above not transverse, piceous and rather coarsely shagreened. Antennæ 18-jointed, fuscous basally, piceous at the apex, short and stout, with the seventh and neighboring flagellar joints about one and a half times as long as thick. Face swollen below the insertion of the antennæ, malar lines black, not quite half as long as the face is wide at the lower angles of the eyes, the inner margins of which diverge slightly below the insertion of the antennæ. Clypeus normal. Mandibles lighter in color than the rest of the face, with black teeth.

Thorax robust, binodose, with the nodes subequal and similar. Mesothorax fuscous somewhat gibbose, with no scutellum indicated. Its surface is coarsely punctulate. "Metathorax" piceous, strongly gibbose, with the carina indistinct medially, but well defined laterally; it is sharply declivous behind the carina and this portion bears two longitudinal carina on each side. Surface dull and coarsely shagreened before the carina, but shining behind. The legs are stout and dusky.

The petiole is dusky and very stout. It is flattened dorsally and is somewhat aciculate, laterally are two very prominent tubercles which bear the spiracles. The remainder of the abdomen is ovate, piceous black and shiny, with a sparse pubescence. Ovipositor ferruginous with piceous sheaths; about the same length as the petiole.

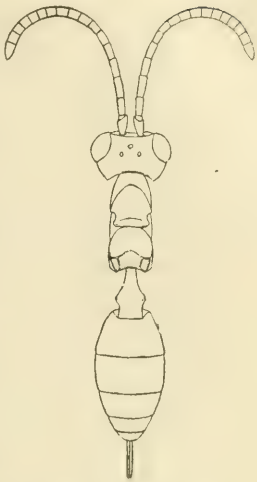


Fig. 3. P. spiraculus.

Observations. Described from a single specimen taken at Round Knob, N. Carolina.

This species is easily recognized by its abnormally large petiolar tubercles. Type in the National Museum.

Pezomachus dispar sp. nov.

Three specimens, 2 ♂ ♂ and 1 ♀ of undescribed species of Pezomachus were bred from a spider's egg capsule taken at Twining, Maryland. The ♀ differed considerably in color from the ♂ ♂ but this appeared to be an insufficient reason for disassociating the sexes. It is proposed however to make the ♂ the type of the species, placing the ♀ provisionally with it till further evidence determines whether this is a valid correlation or not.

Male. Length 5.5 mm., fully winged; slender, head, thorax and abdomen piceous except for a divided ferruginous spot on the anterior portion of the mesothorax and yellowish apical bands on the first three abdominal segments. Legs dusky yellow.

Head from above transverse, piceous though more ferruginous round the eye margins; ocelli large, antennæ long and slender, 27–29-jointed; yellowish at base, mainly dusky. Face below antennæ ferruginous, malar lines distinct short, about $\frac{1}{4}$ to $\frac{1}{3}$ as long as the face is wide at the lower angles of the eyes. Mandibular teeth transparent, palpi dusky.

Mesothorax well developed, surface shagreened, rather coarsely on disc, more finely laterally; clothed with a short pubescence. Parapsidal furrows well defined anteriorly, the space between them is of a fer-

ruginous color except for a narrow median piceous line; remainder of thorax piceous. Scutellum and wings well developed. "Metathorax" rather coarsely shagreened with a well defined semi-circular carina. Legs, including coxæ dusky luteous.

Abdominal petiole long and slender, but little expanded at the apex; spiracles prominent; piceous, with a definite yellow apical band. Remainder of abdomen slender, second segment with a broad apical yellow band, third segment with or without a definite apical band. Remaining segments entirely piceous and more shining. Surface shagreened, with a rather long pubescence. Claspers small.

Female. Length 4.5 mm. Yellow ferruginous except for narrow indefinite basal bands on the abdominal segments.

Head from above somewhat transverse, ferruginous, but more yellowish round the eye margins. Antennæ (broken) long and slender, the scape and first three flagellar segments are luteous. Face below antennæ swollen medially. Malar lines distinct, about one-third as long as the face is wide at the lower angles of the eyes; mandibles yellowish with piceous teeth, palpi yellow.

Thorax yellow ferruginous evenly shagreened, about 2½ times as long as wide. Mesothorax with an obsolete median furrow and no indication of a scutellum. "Metathorax" somewhat gibbose with a delicate but complete carina, which is most definite laterally. Legs dusky luteous.

Abdominal petiole with rather prominent spiracles, apex almost three times as wide as the base, surface finely shagreened, color ferruginous, more yellow at apex. Remainder of abdomen oval, segments piceous at the base merging through ferruginous to honey-yellow at the apex, clothed with a moderately sparse pubescence. Ovipositor elongate luteous, sheaths dusky at the apex.

The ♀ is much like that of *micariæ* How. but is lighter in color and has more prominent petiolar spiracles.

Type of ♂, and ♀ from which this description is drawn, in National Museum.

Pezomachus pennsylvanicus sp. nov.

Female. Length 2.5 mm. A small, slender, fuscous species, with a very short and broad petiole. Antennæ rather long and slender. Ovipositor as long as the petiole.

Head from above rather globose though the occiput is excavated. Surface coarsely rugose. Ocelli small. Face rather broad, malar line distinct, about one-third as long as the face is wide. Antennæ 21-jointed; seventh and neighboring flagellar joints about 1½ times as long as wide. Color fuscous throughout. Clypeus not very well defined. All mouth parts colored as the rest of the head, but mandibular teeth rather more piceous.

Thorax uniformly fuscous, nodes sub-equal. Mesothoracic tegulæ prominent. No indication of a scutellum. "Metathoracic" carina poorly defined, but the somewhat gibbous metathorax is abruptly declivous behind its situation. Legs uniformly rufous brown.

Petiole rather yellow at the apex, short, about 1¼ times as long as broad at the apex. Base broad, but not half the width at the spiracle, beyond which the petiole widens but little. The spiracles are not very prominent. Remainder of the abdomen elongate oval, uniformly brown with a sparse short pubescence. Ovipositor as long as, or slightly longer than, the petiole. The surface of the abdomen, including the petiole, is shining and only shallowly shagreened.

Observations. Described from a single bred specimen collected by Kirby and Champlain at N. Cumberland, Pa.,11-27-'09

Pezomachus similis sp. nov.

The female measures about 4 mm., stout, ferruginous except for apical half of the abdomen which is shining piceous. "Metathoracic" carina indistinct, though apophyses are prominent. Abdominal pubescence sparse.

The male measures about 5 mm. long and slender, fully winged in all specimens seen. The head thorax and legs ferruginous as in ♀, but the petiole and at least the second and third abdominal segments are luteus, remaining segments piceous as in ♀. Metathoracic carina distinct, semi-circular. Abdominal pubescence rather dense.

Female. Length 4–4.5 mm. Head from above ferruginous and finely shagreened; about twice as wide as thick along the median line. The margined occiput is not very deeply excavated. Ocelli small and rather far apart, the lateral ones are about as far from the median as from the eye margins. Antennæ long and slender, entirely ferruginous, 25-jointed. Face rather transverse, malar line not very distinct, about one-third as long as the face is wide at the lower angles of the eye margins. Clypeus transverse, mandibles rather flavous at the base, with two shining rufous apical teeth. Palpi ferruginous.

The thoracic nodes are sub-equal, the surfaces are shagreened and sparsely pubescent. Mesothorax with a distinct median groove. Scutellum indicated by a small rounded tubercle. "Metathorax" rather gibbose, the carina is poorly defined medially, but the apophyses are distinct and appear as two short horizontal lines. Legs long, dusky-ferruginous.

Petiole and second abdominal segment ferruginous, the remaining segments are piceous. The entire surface is finely shagreened and shiny, with a sparse short pubescence. The petiole is about 3½ times as broad at the apex as at the base. Spiracles sub-prominent. Ovipositor ferruginous. Sheaths piceous except at the base where they are yellowish.

Male. Length 5 mm. Head from above transverse, about 2½ times as wide as thick along the median line. Ocelli very large. The occiput is not very deeply excavated. The antennæ are slender and as long as the body, about 28-jointed. Face similar to that of the ♀ but the clypeus is deeper and therefore less transverse.

Thorax entirely ferruginous. The mesothorax is well developed with distinct parapsidal grooves on its apical half, which slightly converge caudad. The surface is finely shagreened with a short, not very

sparse pubescence. The scutellum is large. "Metathorax" rather small and flat with a well defined roughly semicircular carina, and rather prominent straight lateral carinæ. Wings well developed. Legs long and slender, ferruginous.

Abdomen elongate and slender. Petiole and segments 2 and 3 and sometimes part of segment 4 luteus; remainder piceous. Surface shagreened, with rather a dense pubescence. Petiole long and slender, but little dilated at the apex which is only about 1½ times as wide as the base, spiracles rather prominent. Genital claspers small.

Types in the National Museum.

Described from 4 ♀ and 5 ♂ bred from egg capsules of *Algalena nævia* taken at Twining, Maryland, issued Feb. 14 and 15th.

The females are much like those of P. *flavocinctus* Ashm. but have less pubescent abdomens and only 25 joints to the antennæ.

Pezomachus nodosus sp. nov.

Female, length 5 mm. Color ferruginous with metathoracic disc, base of the third abdominal segment, the whole of the fourth and remaining segments piceous. "Metathoracic" carina complete, not prominent.

Head from above about twice as wide as thick along the median line, surface finely shagreened, occiput rather deeply excavated. Ocelli small, lateral ones about equidistant from the median ocellus and the eye margins. Antennæ long and slender, at least 21-jointed (broken) rather more dusky in color than the rest of the head. Seventh and neighboring flagellar joints about 2½ times as long as wide. Face not transverse, cheeks rather swollen; malar line distinct, about one-third as long as the face is wide between lower angles of the eyes. Clypeal suture not very definite. Mandibles ferruginous with piceous teeth. Palpi long and ferruginous.

Thorax rather coarsely shagreened, with a sparse pubescence. Mesothorax elongate, with a broad shallow median furrow and a vaguely defined scutellum. "Metathorax" gibbose, declivous both anteriorly and posteriorly, rather more piceous than the mesothorax on the disc. Carina complete but not very prominent. Legs long and rather fuscous.

Petiole not very elongate, about three times as wide at the apex as at the base, spiracles sub-prominent. Remainder of abdomen ovate. Second segment rather yellow-ferruginous at apex, third piceous at base. The remaining segments and ovipositor sheaths are piceous. The entire surface of the abdomen is shining, obsoletely shagreened and with a sparse pubescence.

Observations. Described from a single specimen taken at Lawrence, Kansas, by Hugo Kahl, on June 19th, 1896. It somewhat resembles *P. ottawaensis*, Harrington in color and the form of the carina, but is much more binodose.

Type in the National Museum.

Pezomachus flavocinctus Ash.

♀ Proc. U. S. Nat. Mus. Vol. 12, p. 421.

♂ The male of this species is polymorphic, the specimens seen however fall into two main categories, namely (1) winged (2) wingless, while a single specimen was found in which the mesothoracic wings were present, but much smaller than normal, while the metathoracic pair were entirely absent.

There is very little uniformity in details in this species but in general appearance and color members of both categories are very similar.

The most constant characters are:

1. The antennæ, which are long and slender, and always about 29-jointed.
2. The general shape of the head, which is about twice as broad as thick along the median line, is finely shagreened and has a sparse pubescence. The ocelli however, are inconstant in size.
3. The "metathoracic" carina. This is not very prominent but is always somewhat as shown in the figure, though it may be less angular.
4. The legs are all rather long and slender, with very small simple ungues.
5. The abdomen is densely pubescent in all forms and is mainly fuscous in color. The petiole and following two or three segments may have dull yellow apical bands.

The most inconstant characters are:

1. Ocelli. These are usually large in winged forms and quite small in wingless forms, but this correlation is not entirely constant.
2. Mesothorax. The development of this varies immensely with the presence or absence of wings. The "scutellum" also is very large in winged forms, but tuberculate in wingless forms.
3. The petiole. The spiracles may be, and usually are, tuberculate, but in some specimens they are hardly if at all prominent. This is in no way correlated with the presence or absence of wings.
4. The size of the individual. Winged forms are typically the larger and vary in length from 4.5–5 mm. Some specimens however, are much more slender than others. The wingless forms vary from 3.5 to 5 mm. in length. They are all slender, but some are more so than others.

Typical winged form.

Length 4.5 mm. Fully winged. Color mainly fuscous, but abdominal segments may have narrow yellow apical bands. Pubescence short and dense especially on the abdomen.

Head from above finely shagreened, about twice as wide as thick along the median line. Occiput not very deeply excavated. Ocelli usually very large, placed on a somewhat raised triangle. The lateral ocelli nearer to the median than to the eye margins. Antennæ long and slender, about 29-jointed; apex piceous, in some specimens this color extends almost to the base. Seventh and neighboring flagellar segments about 2½ times as long as broad. Face rather lighter in color than the vertex. Malar line distinct about $\frac{1}{4}$ to $\frac{1}{3}$ as long as the face is wide as the lower end of the parallel inner eye margins. Clypeus transverse with a distinct basal fovea separating it from the remainder of the face. Mandibles bidentate, concolorous with, or a little more yellow than, the remainder of the head. Teeth somewhat darker. The face may have a longitudinal median swelling running from the insertion of the antennæ to the base of the clypeus, at which point it is widest.

Mesothorax well developed and rounded, with more or less well defined parapsidal grooves. Surface finely and evenly shagreened and clothed in a rather dense short pubescence. Color rather variable, mainly dark fuscous. The space between the parapsidal grooves may be of a somewhat lighter color than the lateral portions and there may be a distinct still lighter median line. Scutellum very large and well defined. Wing veins testaceous. The brown stigma has a very conspicuous white basal spot which extends on to the costa. "Metathorax" with a distinct complete hind carina. Surface rather more coarsely

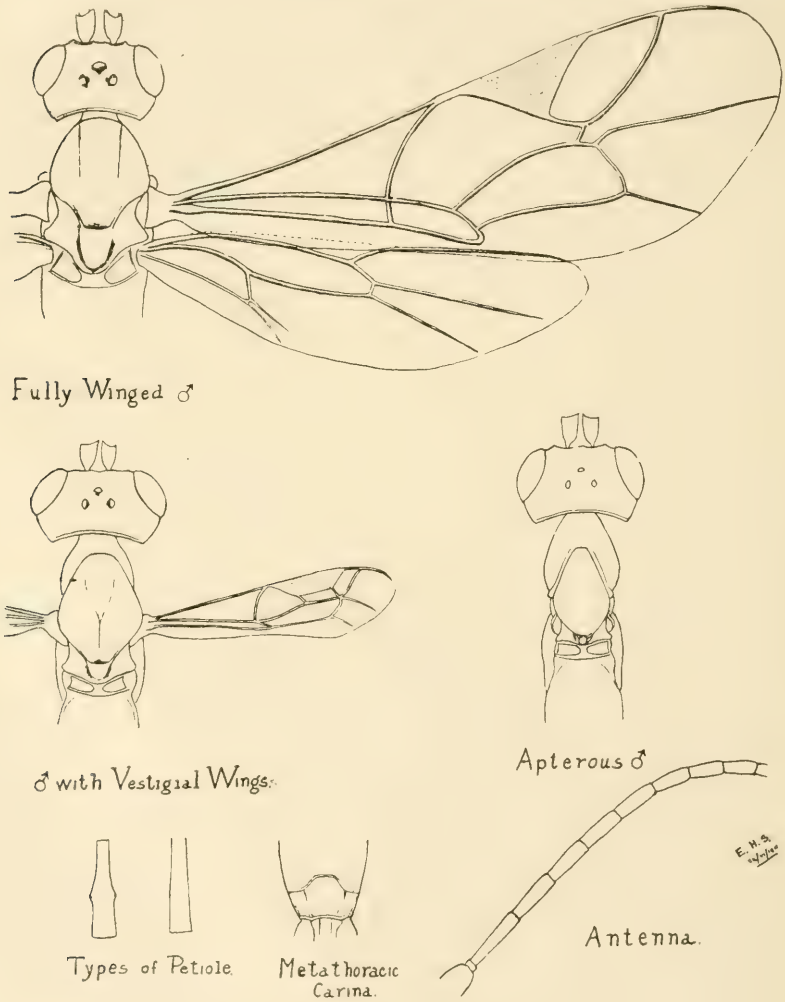


Fig. 4. Pezomachus flavocinctus.

shagreened than that of the mesothorax, especially behind the carina; pubescence more sparse, especially on the disc, but distinctly longer. Legs long and slender, rather lighter in color than the thorax. Fore and mid legs inclined to be testaceous. Petiole long and slender with rather prominent spiracles, behind which the sides are parallel. Remainder of abdomen slender, terminating with broad testaceous claspers. The color of the abdomen is variable, but is mainly fuscous; the petiole and following two or three segments may have dull yellow or whitish apical bands. The entire surface is closely punctulate and covered with a rather dense pubescence.

Observations. Described from 22 specimens taken at Twining, Maryland.

Form with rudimentary wings.

Head, "metathorax," legs and abdomen as in winged form. Mesothorax reduced in size; with a much smaller scutellum. The poorly defined parapsidal grooves are widely separated anteriorly but meet at about the middle of the mesonotum continuing to the scutellum as a single median shallow groove. They thus resemble together the letter Y. Mesothoracic wings small, extending to about the middle of the second abdominal segment. They were much crumpled in the specimen but the venation was apparently not very abnormal. The areolet was missing and there was an extra recurrent vein from the somewhat contorted stigma. The metathoracic wings were entirely missing.

Observations. Described from a single specimen from Twining, Maryland. This specimen was bred from an egg nest from which also emerged, one fully winged male, one apterous male and one female.

Wingless form.

Similar to winged forms except for the mesonotal structure. The ocelli also are always small. Mesonotum much narrower than the head, with a tuberculate scutellum. Parapsidal grooves, may be slightly separated anteriorly, usually only visible as a shallow posterior depression. The surface of the mesonotum is pubescent as in the winged form.

Observations. Described from about 30 specimens taken at Twining, Maryland, and from one taken at Cornell.

On an average these are much smaller than the winged forms which would suggest that their apterous condition is in some way connected with an insufficiency of food.

Both types of male were often bred from the same cocoon together with females which are much more constant in form than the males.

Types in the National Museum.

Paratypes (except brachypterous form) in the Bussey Institution, Harvard University.

The breeding labels show that the majority of these hatched out during the latter part of February, March and the first half of April, extra notes were given on three labels as follows:

1. "From egg capsule of **Prosthesima** sp. Twining City, Md. iss. Dec. 28th, 1897. A. Busck coll."
   The pin bore two wingless males.
2. "♀ iss. Feb. 22, 1898, laid same date one egg unfertilized. From this the ♂ issued April 21, 1898. A. B."
   The pin bore 1 ♀ and 1 fully winged ♂.
3. "♀ issued Feb. 11, 1898. Oviposited unfertilized; male from the eggs issued April 20, 1898. A. B."
   The pin bore one ♀ and one fully winged ♂.

This appears to be the only case of dimorphism in ♂ Pezomachini as yet noticed in this country, but there can be no doubt that this is perfectly valid, and it is probable that similar conditions will be found to exist in others of the species already described in one form, or in both forms under different names.

The condition of small mesothoracic wings being present, while the metathoracic wings are entirely suppressed as found in the intermediate form, is almost unique in the Hymenoptera. As far as I am aware the only analagous case is seen in ants. Professor Wheeler (Ants, their Structure, Development and Behavior, pp. 99 and 102) described and figures abnormal ant workers and solders, which he terms *Pterergates* in which mesothoracic wing rudiments have developed. In the Braconidæ, Chalcidoidea and Proctotrypoidea where forms with rudimentary wings are occasionally met with, and the mesothoracic wings are often reduced far more than in the species under consideration, it is always found that metathoracic wings are also present.

A *Hemiteles* sp. (hyperparasite ?) was in several instances bred out from the same egg capsules as this species.

Pezomachus manni sp. nov.

Male. Length 4 mm. Wingless. Head, thorax and petiole ferruginous, remainder of abdomen black. Antennæ and legs piceous.

Head from above dusky ferruginous, finely rugose and with a very sparse pubescence. The small lateral ocelli are a little nearer to the median ocellus than to the eye margins. Antennæ piceous reaching to about the apex of the second abdominal segment, about 27-jointed, seventh and neighboring flagellar joints twice as long as thick. Face below antennæ ferruginous, malar lines distinct, short, hardly more than ¼ as long as the face is wide at the lower angles of the eyes. Clypeus transverse, truncate. Palpi dusky.

Thorax elongate and cylindrical, ferruginous, mesothorax and portion of "metathorax" behind the carina dusky ferruginous; surface shagreened, with a very sparse pubescence. Wing rudiments white, scutellum tuberculate. "Metathoracic" carina complete but poorly defined, feebly sinuous. Legs elongate and fuscous basally, all tarsi mid- and hind-femora and tibiæ piceous.

Petiole but little expanded, elongate, ferruginous, finely shagreened and sparsely pubescent. Spiracles sub prominent. Apex about twice as wide as the base, and one-third the length of the petiole. Remainder of abdomen elongate, black, rather coarsely shagreened and with a moderately dense pubescence. Claspers small.

Observations. Described from a single ♂ specimen taken by Mr. William M. Mann from the nest of *Formica subpolita* Mayr. at Pacific Grove, California, June, 1909.

This species much resembles *P. macer* Cress. but has much shorter antennæ and the abdominal coloring is quite distinctive. From *P. ottawænsis* Harr. it is distinguished by the much more elongate petiole, and differently colored abdomen.

Pezomachus nigrofuscus sp. nov.

Male. Length 4.5 mm. wingless, slender; head black, thorax and petiole fuscous; remainder of abdomen black with the exception of an apical yellow band on the second segment, moderately dense pubescence.

Head from above black, finely rugose and with a moderately dense pubescence; the small lateral ocelli are as far from the median ocellus as from the eye margins. Antennæ about 22-jointed, scape fuscous; flagellum piceous above, but with numerous small silvery longitudinal lines on each segment, which have the appearance of white hairs. Ventrally the fifth to the ninth flagellar segments are somewhat fuscous. Face below the antennæ somewhat swollen and lighter in color, malar lines distinct, short, hardly more than one-fourth as long as the face is wide at the lower angles of the eyes. Clypeus and cheeks piceous; mandibles yellowish with piceous teeth.

Thorax long and cylindrical; entirely fuscous, "metathorax" somewhat darker than the mesothorax, and more sparsely pubescent. Wing rudiments large and white; scutellum tuberculate; "metathorax" rather coarsely shagreened, carina incomplete on median area but well defined laterally, fore and mid-legs entirely fuscous, hind femora and tibiæ more piceous.

Petiole but little expanded, spiracles not very prominent, surface shagreened, with a sparse pubescence, color fuscous with an indefinite yellowish apical band. Remainder of abdomen slender, piceous black, except for a yellow apical band on the second segment, surface rather coarsely shagreened and with a moderately dense pubescence. Claspers small.

Observations. Described from a single ♂ specimen taken at Philadelphia. Similar to *P. urbanus*, Brues, but smaller and distinguished by the dense abdominal pubescence.

Type in the National Museum.

Pezomachus auripes sp. nov.

Male, length 3.5–4 mm., wingless. Shining black, with bright yellow legs.

Head from above rectangular, not transverse; occiput but slightly excavated, ocelli small. Antennæ about 21-jointed, piceous black, seventh and neighboring flagellar joints about twice as long as thick. Face shining black, closely and evenly shagreened, with a short whitish pubescence. Mandibles and palpi testaceous; malar line obsolete, about one-third as long as the face is wide.

Thorax finely and evenly shagreened, with a moderately sparse short pubescence; scutellum well defined, flat dorsally; tegulæ yellowish white. "Metathorax" with a well defined carina. Legs long and slender, bright yellow including the coxæ. Tarsi rather more dusky. Abdominal petiole short, closely and finely shagreened, with an even sparse pubescence. Spiracular tubercles absent. Remainder of abdomen shining, finely shagreened, sparsely pubescent, elongate oval, terminating with two much enlarged piceous black claspers.

Observations. Described from a single damaged specimen taken at St. Pauls Island, Alaska, by T. Kincaid (Harriman Expedition).

This is a very pretty and distinctive species; it much resembles Ashmead's description of *P. obesus* ♀ (Proc. Wash. Acad. Sci. Vol. 4, p. 192) drawn up from a female specimen taken in the same locality, and it seems probable that it will be found to be the male of this species.

Type in the National Museum.

Pezomachus ottawaensis Harrington.

Female. Can. Ent. Vol. 28, p. 77.

Male, 5 mm. long, wingless. Head and thorax dull ferruginous, abdomen piceous with ferruginous petiole and similarly colored apical band on the second segment.

Head rather large, from above somewhat quadrate, finely shagreened with a short sparse pubescence, uniformly ferruginous, about twice as wide as thick along the median line. Antennæ long and slender, about 25-jointed. Pedicel and first two or three flagellar joints ferruginous, remaining joints piceous black. Malar line indistinct, short, about one-third as long as the face is wide at the lower angles of the eyes, eye margins parallel. Clypeus well defined; mandibles rather more yellowish than remainder of head; teeth piceous.

Thorax narrow, ferruginous, closely and evenly shagreened, sparse minute pubescence. Mesothorax rather strongly margined, with a broad shallow median furrow. Scutellum tuberculate. Tegulæ white. "Metathoracic" carina angular, (i. e., not semi-circular or sinuous) well defined at the sides, but less distinct medially. Legs rather more dusky-ferruginous than the thorax, especially dark on the hind tibiæ.

Abdominal petiole short and broad, typically ferruginous, but dusky in some specimens, as a rule without prominent spiracles, these however, may be placed on small projections, surface shagreened and sparsely pubescent. Remainder of abdomen narrow oval, piceous black except for a ferruginous apical band on the second segment; surface finely shagreened and with a sparse pubescence. Claspers piceous, rather small.

Observations. Described from six specimens bred from spiders nests taken in Connecticut (Linn, New Haven and Ridgefield) and from three specimens bred from a single nest taken in Pennsylvania (N. Cumberland).

Although these specimens were never actually bred out from the same nests as ♀ *ottawænsis* (Harrington) they were bred from nests taken from the same places as nests yielding specimens of the named female, and owing to their striking similarity in color and petiolar form there can be no doubt that they represent the ♂ of this species.

The specimens from which these were described have been sent to the State Entomologist, New Haven, Connecticut.

A winged specimen has been reported[4] as the male of this species but no complete description was drawn up. The only data given was in the specific tables where the following identification characters were given, "Winged". "Black with segments two and three of abdomen yellowish". It would seem that this correlation was incorrect since such a male must be very unlike the ♀. The origin of this report cannot, unfortunately, be traced.

Pezomachus ashmeadii nom. nov.

Cremnodes californicus Ashm.

The female of this species, described by Ashmead as *Cremnodes californicus*, Proc. Nat. Mus. Wash. Vol. XII, p. 420 (1889) is entirely wingless, and has no scutellum. Since Förster in his original description of the genus Cremnodes states "Der Mitelleib mit Flugelrudimenten und abgesetztem Schildchen...." this species must be removed to the genus Pezomachus in which the specific name "californicus" is preoccupied.

[4] C. T. Brues, Trans. Amer. Ent. Soc., Vol. XXIX, pp. 120 and 121.

Pezomachus bruesii nom. nov.

Pezomachus obesus Brues.

The specific name "obesus" proposed by Brues (Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 68) for a Massachusetts species was preoccupied by Ashmead (Proc. Wash. Acad. Sci. Vol. IV, p. 193) for an Alaska species.

A number of specimens of this species, taken at Twining, Maryland, were seen to vary from the typical form in that the whole body was of a ferruginous color with the exception of the apical half of the abdomen which was piceous black.

Pezomachus aciculatus nom. nov.

Pezomachus foersteri Brues.

The specific name "foersteri" proposed by Brues (Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 67) for a Texan species was preoccupied by Bridgeman (Trans. Ent. Soc. London, p. 343) for a British species.

Pezomachus ferruginosus nom. nov.

Pezomachus insolens Brues.

The specific name "insolens" proposed by Brues (Bull. Wis. Nat. Hist. Soc., Vol. VIII, No. 2, p. 67) for a Washington species was preoccupied by Förster (Arch. f. Naturg. Vol. XVI, p. 130) for a Central European Species.

Pezomachus cressonii nom. nov.

Pezomachus gracilis Cress.

The specific name "gracilis" proposed by Cresson (Can. Ent. Vol. 4, p. 63) for a Pennsylvania species was preoccupied by Förster (Arch. f. Naturg. Vol. XVI, p. 209) for a Central European Species.

Pezomachus insularis nom. nov.

Theroscopus rufipes Ashm.

The St. Paul Island, Alaska species described as *Theroscopus rufipes* by Ashmead (Wash. Acad. Sci. Vol. IV, p. 191 1902) is wingless in both sexes and has not a true scutellum in the ♀. It must therefore be transferred to *Pezomachus* where the specific name "*rufipes*" is preoccupied by Bridgeman (Trans. Ent. Soc. Lond., p. 157, 1883) for a British species.

Pezomachus americanus Ashm.

Theroscopus americanus Ashm.

This Virginian species described as *Theroscopus americanus* by Ashmead (Trans. Amer. Ent. Soc. Vol. 23, p. 211) also belongs to the genus Pezomachus.

Pezomachus kukakensis Ashm.

Theroscopus kukakensis Ashm.

This species, described by Ashmead with the preceding, from Kakak Bay must also be transferred to Pezomachus.

Micromeson nov. Sub-genus of Pezomachus.

Head large, wider than the thorax, but not very transverse. Antennæ of ♀ not very slender, longer and more slender in the ♂. Thorax subcylindrical. Prothorax greatly enlarged and swollen, larger than the much reduced mesothorax, the mesonotum of which only covers the median area of the basal half of the anterior thoracic node. Scutellum defined as a small indistinct tubercle in the ♀, but more definite in the ♂.

"Metathorax" strongly gibbous with no carina. Females apterous. Male apterous in only known species.

Petiole very long and unusually slender, somewhat longer than the "metathorax," with or without prominent spiracles. Ovipositor shorter than the petiole.

There are three species belonging to this group:

Pezomachus texanus (Cress.) Can. Ent. Vol. 4, p. 64.
" **annulatus** (sp. nov.)
" **lymensis** (sp. nov.)

They fall into a class so distinct from the other named Pezomachi that they certainly deserve a separate subgeneric if not a new generic name.

The most conspicuous characters are:

1. The much reduced mesonotum, and correspondingly swollen prothorax.
2. The elongated, slender petiole, associated with the uncarinated "metathorax"

Micromeson annulatum sp. nov.

Female 6–6.5 mm. A large conspicuous species with head and thorax entirely clear ferruginous. The abdomen is of a somewhat darker ferruginous color and has a very conspicuous black basal band on the third segment, and a less distinct one on the second segment. Remaining segments with very narrow inconspicuous apical bands.

Head from above shagreened, dull, not quite twice as wide and thick along the median line. Anterior, or facial, border rather concave and sunken between the eyes. The margined occiput is but slightly excavated. Antennæ 23–25 jointed, concolorous with the head, though rather more

dusky apically; rather longer than head and thorax together, not slender, seventh and neighboring flagellar joints about twice as long as wide. Clypeus transverse with deep fovea on either side. Malar lines indistinct, cheeks rather swollen, closely and evenly punctured. Mandibles bifid with dark teeth. Palpi rufous and rather long.

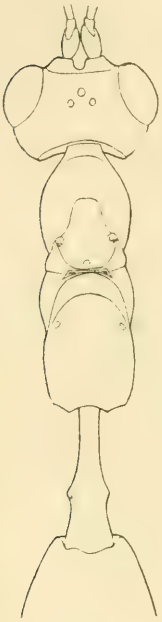


Fig. 5. Micromeson annulatum.

Thoracic nodes sub-equal, shining though finely punctured. The pro- and meso-thorax about the same length medially. Separated by a rather indistinct suture. Prothorax rather sharply constricted anteriorly to form a well defined neck. Mesothorax quite flat in front of scutellar suture. Scutellum indicated by an obsolete tubercle. "Metathorax" strongly gibbous, with no indication of a carina. Legs clear ferruginous, somewhat more dusky than the thorax.

Abdominal petiole as long as the "metathorax", only slightly expanded at the apex, with rather prominent spiracles; concolorous with ground color of remaining segments. Closely and evenly shagreened. Remainder of abdomen oblong oval 2–2½ times as wide as the thorax, ferruginous, closely and evenly shagreened, and with a very sparse minute pubescence; second segment with an indefinite piceous basal band, third segment with a very conspicous broad black basal band. Third and following segments with narrow black apical bands varying much in intensity.

Ovipositor somewhat shorter than the petiole. Sheaths dusky at the base and black at the apex.

Observations. Described from 8 specimens taken at Twining, Maryland, in March and April, This is evidently closely related to *M. lymense* sp. nov. but is readily distinguished by the absence of median furrows on the meso- and "meta"-thorax.

Type in the National Museum.

Paratype in the Bussey Institution, Harvard University.

Micromeson lymense sp. nov.

Female 6–6.5 mm. A large conspicuous species, with head and thorax entirely fuscous. Abdomen fuscous with a conspicuous black base band on the third segment, and a less well defined similar band on the second segment. Mesothorax and "metathorax" medially sulcate.

Head from above shagreened, dull, with a very sparse pubescence; not quite as broad as thick along the median line. Anterior, or facial, border straight, level with the eyes, margined occiput but little excavated. Antennæ about 24-jointed, concolorous with the head, rather longer than the head and thorax together. Seventh and neighboring flagellar segments about twice as long as broad. Clypeus transverse

with a deep fovea on either side. Malar lines indistinct, cheeks rather swollen, closely and evenly punctured. Mandibles bifid with dark teeth. Palpi fuscous with apical joint piceous.

Thoracic nodes sub-equal, rather coarsely punctulate; prothorax constricted anteriorly to form a neck, but not very markedly so. Mesothorax rather shorter than the prothorax, from which it is separated by a well defined suture. Scutellum indicated by a small tubercle. "Metathorax" strongly gibbous, with no indication of a carina but with a median shallow suture on anterior half. Legs rather more piceous than thorax.

Abdominal petiole as long as the metathorax, only slightly expanded toward the apex, but with rather prominent spiracles, evenly shagreened and very sparsely pubescent. Remainder of abdomen oblong oval, 2–2½ times as wide as the thorax, dark fuscous, closely and evenly punctured, and with a short very sparse pubescence. Second segment with an indefinite piceous basal band. Third segment with a conspicuous broad black basal band. Remaining segments unbanded. Ovipositor somewhat shorter than the petiole, sheaths light at the base, black at the apex.

Observations. Described from a single specimen hatched from a Drassid Egg Cocoon on May 7, 1911. Collected by A. B. Champlain, Lyme, Ct., April 30, 1911.

This is evidently closely related to *M. annulatum* sp. nov. from which it can be readily distinguished by its darker color and sulcate thoracic nodes.

NORTH AMERICAN SPECIES OF THE GENUS THAUMATOTYPUS, FÖRSTER.

alaskensis Ashm.	♀	*Cremnodes alaskensis* Ashm. Trans. Am. Ent. Soc. Vol. 23, p. 211.	ALASKA.
canadensis Harrington	♀	*Cremnodes canadensis*, Harrington. Can. Ent. Vol. 24, p. 213.	QUEEN CHARLOTTE ID.
spinulatus sp. nov.	♀		CONNECTICUT.
tuberculatus Ashm.	♀	*Cremnodes tuberculatus* Ashm. Trans. Am. Ent. Soc. Vol. 23, p. 211.	CALIFORNIA,

NORTH AMERICAN SPECIES OF THE GENUS PEZOLOCHUS, GRAV.

bucculatrix Ashm.	♀	Proc. Nat. Mus. Vol. 12, p. 421.	WASHINGTON, D. C.

NORTH AMERICAN SPECIES OF THE GENUS PEZOMACHUS, GRAV.

aciculatus nom. nov.	♀	*P. foersteri* Brues. Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 69.	TEXAS.
alternatus Cress.	♀	Can. Ent. Vol. 4, p. 64.	ILLINOIS.
alaskensis Ashm.	♀	Proc. U. S. Nat. Mus. Vol. 12, p. 421.	ALASKA.
americanus Ashm.	♂	*Theroscopus americanus* Ashm. Trans. Am. Ent. Soc. Vol. 23, p. 211.	VIRGINIA.
angularis Brues	♀	Trans. Am. Ent. Soc. Vol. 29, p. 119.	TEXAS.
ashmeadii nom. nov.	♀	*Cremnodes californicus* Ashm. Proc. U. S. Nat. Mus. Vol. 12, p. 420.	CAL., COLO., UTAH.
auripes sp. nov.	♂		ALASKA.
berkmani Brues	♀	Trans. Am. Ent. Soc. Vol. 29, p. 119.	TEXAS.

bruesii nom. nov.	♀	*P. obesus* Brues. Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 71.	MASS., PA., CONN., MD.
brevistylus sp. nov.	♀		PENNSYLVANIA.
californicus Ashm.	♀	Proc. U. S. Nat. Mus. Vol. 12, p. 421.	CALIFORNIA.
canadensis Cress.	♀	Can. Ent. Vol. 4, p. 62.	ONTARIO.
cockerelli Brues	♀	Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 68.	FLORISSANT.
coloradensis sp. nov.	♀		COLORADO.
compactus Cress.	♀	Can. Ent. Vol. 4, p. 63.	ILLINOIS.
crassulus Brues	♀	Trans. Am. Ent. Soc. Vol. 29, p. 119.	TEXAS.
cressonus nom. nov.	♀	*P. gracilis* Cress. Can. Ent. Vol. 4, p. 61.	PENNSYLVANIA.
delumbis Brues	♀	Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 75.	WASHINGTON.
dispar sp. nov.	♂ ♀		MARYLAND.
ferruginosus nom. nov.	♀	*P. insolens* Brues. Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 74.	WASH., CAL.
fenestralis Brues	♂	Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 67.	NEW JERSEY.
flavocinctus Ashm.	♂ ♀	Proc. U. S. Nat. Mus. Vol. 12, p. 421.	TEXAS, CONN., MD., N. Y.
foveatus Brues	♀	Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 67.	MASSACHUSETTS.
gentilis Cress.	♂ ♀	Can. Ent. Vol. 4, p. 61.	PENNSYLVANIA.
habilis Brues	♀	Bull. Wis. Nat. Hist. Soc. Vol. VIII, No. 2, p. 67.	MASSACHUSETTS.
insolitus Howard	♂	Bull. Dept. Agric. Wash. Sec. Ent. Vol. 5, p. 33.	COLUMBIA.
insularis nom. nov.	♂ ♀	*Theroscopus rufipes* Ashm. Wash. Acad. Sci. Vol. 4, p. 191.	ST. PAUL ISLAND, ALASKA.
keenii Harrington	♀	Can. Ent. Vol. 26, p. 214.	CANADA.
kukakensis Ashm.	♀	*Theroscopus kukakensis* Ashm. Wash. Acad. Sci. Vol. 4, p. 191.	KUKAK BAY, ALASKA.
longipes sp. nov.	♀		CALIFORNIA.
longistylus sp. nov.	♀		
macer Cress.	♂	Can. Ent. Vol. 4, p. 64.	PENNSYLVANIA.
maculatus sp. nov.	♀		CALIFORNIA.
maculicollis Brues	♀	Trans. Am. Ent. Soc. Vol. 29, p. 119.	MASSACHUSETTS.
manni sp. nov.	♂		CALIFORNIA.
meabilis Cress.	♀	Can. Ent. Vol. 4, p. 64.	ILLINOIS.
micariae Harrington	♂ ♀	Proc. Ent. Soc. Wash. Vol. 2, p. 294.	BOR. AMER. PENN.
minimus Walsh	♂ ♀	Ins. Injur. Ill. p. 43.	ILLINOIS.
minutus sp. nov.	♀		ALASKA.
niger Prov.	♀	Addit. Faun. Can. Hymen. p. 362.	CANADA.
nigrellus Ashm.	♂ ♀	Proc. Wash. Acad. Sci. Vol. 4, p. 192.	PRIB. ISLAND, ALASKA.
nigrofuscus sp. nov.	♂		PENNSYLVANIA.
nodosus sp. nov.	♀		KANSAS.
obscurus Cress.	♀	Can. Ent. Vol. 4, p. 62.	N. J., MASS.
ottawaensis Harrington	♂ ♀	Can. Ent. Vol. 28, p. 77.	PENN., CONN.
obesus Ashm.	♀	Proc. Wash. Acad. Sci. Vol. 4, p. 192.	ALASKA.
pennsylvanicus sp. nov.	♀		PENNSYLVANIA.
pettitii Cress.	♀	Can. Ent. Vol. 4, p. 61.	ONTARIO, MASS.
robustus sp. nov.	♀		ARIZONA.
similis sp. nov.	♂ ♀		MARYLAND.
spiraculus sp. nov.	♀		NORTH CAROLINA.
sulcatus Prov.	♀	Addit. Faun. Cab. Hymen. p. 77.	CANADA.
stanfordensis sp. nov.	♀		CALIFORNIA.
tantillus Cress.	♀	Can. Ent. Vol. 4, p. 62.	ILLINOIS.
thripites Tay.		Am. Agric. N. Y. (1860) p. 300.	NEW YORK.
unicolor Cress.	♀	Can. Ent. Vol. 4, p. 64.	MASS., DEL., ILL., MD.
urbanus Brues	♀	Bull. Wis. Nat. Hist. Soc. Vol. 8, No. 2, p. 67.	NEW YORK, CONN.
utahensis sp. nov.	♀		UTAH.
wheeleri Brues	♀	Trans. Am. Ent. Soc. Vol. 29, p. 119.	ILLINOIS.

SUB GENUS MICROMESON.

annulatum sp. nov.	♀		MARYLAND.
lymense sp. nov.	♀		CONNECTICUT.
texanum Cress.	♂ ♀	*P. texanus* Can. Ent. Vol. 4, p. 64.	TEXAS.

NEW NORTH AMERICAN CHILOPODS AND DIPLOPODS.

By Ralph V. Chamberlin,
University of Pennsylvania, Philadelphia.

CLASS CHILOPODA.

Family Lithobiidæ.

Genus **Arenobius** Chamberlin.

Arenobius coloradanus sp. nov.

Dorsum from testaceous to dark brown and dull chestnut with the posterior plates and the first one usually not all darkened. Head mostly the same color as dorsum or very nearly so, or somewhat more reddish. Antennæ concolorous with head, pale distad. Venter from yellow or testaceous to dark brown, the caudal plates usually a little darker. Prosternum and prehensorial feet of same color as head or nearly so. Legs of same color as adjacent portion of venter.

Head widest at level of marginal interruptions; clearly wider than long (11: 10); caudal margin straight. Depressed or furrowed parallel with frontal suture a little cephalad of the latter, from this furrow a median longitudinal furrow extending toward anterior margin. Two, usually clearly impressed, longitudinal furrows on caudal region of head, one a little each side of the middle and the two united in front of the posterior margin by a transverse furrow. Smooth and shining.

Dorsal plates all very finely or obscurely roughened, appearing smooth and shining to the naked eye; usually no furrows distinctly developed excepting the usual depression or furrow immediately within the caudal and lateral margins and on some the short transverse mark on each side near margin at about one-third length of plate from caudal margin. Posterior angles of ninth, eleventh and thirteenth dorsal plates strongly produced; posterior angles of other minor plates rounded or obliquely excised.

Ventral plates all punctate and finely roughened; impressed with three longitudinal furrows of which the median is most distinct, the latter on some of the more posterior plates ending caudad in a deeper pit or depression about one-third the length of plate from caudal edge; mostly with a rather wide transverse depression or furrow caudad of middle of plate. Sometimes an additional longitudinal furrow showing on each side between the median and the lateral, the caudal end often curving mesad to unite with its mate at middle; this furrow often more or less united with the lateral one. The last several plates sometimes with furrows very obscure or practically absent.

Antennæ short or very short, reaching the sixth or seventh segment; articles 30 to 35, the second very long with those more distad much shorter, cylindric, subuniform or, more usually, with longer articles occurring singly at intervals among the shorter ones, in general decreasing in size distad. Hairs of medium length.

Eyes composed mostly of from 9 to 12 ocelli arranged in three series; e. g., 1+ 3, 3, 2, 1+ 4, 3, 3, 1+ 4, 4, 3,. The single ocellus much largest, subvertically elliptic or oval.

Prosternum about 1.6 times wider than long. Teeth 2+2, small acute. Median incision wide and moderately deep, its sides concave. Spine on each side well ectad of outer tooth, much more slender than teeth but stouter at base than neighboring hairs, bristle like distad.

Coxal pores circular, well separated; in number arranged as follows: 3, 4, 4, 3; 3, 4, 4, 4; 4, 5, 5, 5.

Coxæ of anal legs armed laterally and dorsally; other coxæ seemingly unarmed. Spines of first legs $\frac{0, 0, 2, 1, 1}{0, 0, 1, 2, 1}$ or $\frac{0, 0, 2, 1, 1}{0, 0, 1, 3, 1}$; of the second and third $\frac{0, 0, 2, 2, 1}{0, 0, 2, 3, 1}$; of the fourth $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 1}$ or, occasionally, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 1}$; of the fifth $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 1}$; of the sixth to the eleventh, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$; of the twelfth and thirteenth, $\frac{0, 0, 3, 2, 2}{0, 0, 3, 3, 2}$; of the penult, $\frac{0, 0, 3, 2, 2}{0, 1, 3, 3, 2}$, in the female, or $\frac{0, 0, 3, 2, 1}{0, 1, 3, 3, 2}$ in the adult male, each having claw armed with two accessory claws; of anal, $\frac{1, 0, 3, 2, 1}{0, 1, 3, 3, 1}$, the dorsal spine of tibia and also outer one of femur readily lost so that spining may appear thus, $\frac{1, 0, 3, 2(1)\ 0}{0, 1, 3, 3, 1}$, two accessory claws present as in the penult pair. In the female the anal legs are short and very slender, decreasing gradually in diameter from the femur distad, the tibia being intermediate in diameter between femur and first tarsal article as the latter is between tibia and second tarsal article; tibia rather weakly longitudinally furrowed along dorsal surface. Penult legs similar to anal except for smaller size. In the male the anal legs are also rather slender but the tibia is crassate, being fully as thick as the femur and being widest at distal end and abruptly thicker than the first tarsal joint, its dorsal surface shallowly depressed, a longitudinal dorsal furrow also present on femur and prefemur, that of the latter less distinct. Penult legs of male also slender, with joints dorsally longitudinally furrowed; the tibia obliquely excised at dorso-caudal corner of distal end and bearing at this place a small, flattened lobe or crest which is transverse to the axis of the joint, this lobe bearing a few short hairs but nothing like the brush in manegitus.

Gonopods of male relatively wide, flattened, truncate distad; bearing mostly 4–6 bristles in a transverse row along distal edge of ventral side.

Gonopods of female with claw entire, long and stout, acutely pointed, considerably curved, darkened distad. Basal spines 2 + 2, subequal or with the inner in some individuals considerably shorter, stout; in ventral view acutely conical in outline. Articles, especially the second and third, glabrous or nearly so on ventral and mesal surfaces, but clothed with a moderate number of bristles on ectal and dorsal surfaces.

Body rather slender being about 7.5 times as long as width of tenth plate; conspicuously attenuated cephalad from eighth plate, with the first plate much narrower than the third. Width of head, first, third, eight and tenth dorsal plates to each other as 40, 33, 37, 47 and 47, the eight and tenth plates being equal and manifestly considerably wider than the head.

Length from 12 to 15 mm. A male 13 mm. has antennæ 5 mm. long and anal legs exclusive of coxa, circa 4.8 or 5 mm. long, with the tenth plate about 1.7 mm. wide.

Locality: Manitou, Colorado (author, Aug., 1910).

Arenobius sontus sp. nov.

Brown to deep mahogany. Head in some degree darker than dorsum. Antennæ chestnut, paler distad. Prosternum brown to mahogany, paler than head. Venter testaceous to deep brown, the caudal plates darkest. Legs testaceous to brown, the posterior pairs darker with their tarsi usually paler.

Head and first dorsal plate smooth and shining; other dorsal plates rugose, the more caudal ones more strongly roughened than the anterior ones.

Antennæ of moderate length, reaching the seventh segment. Composed of from 40 to 50 articles which beyond the first ones become short, often showing an alternation of a very short article with longer ones in groups between.

Eyes composed of mostly 9 to 12 ocelli arranged in three series; thus, 1+3, 4, 2.

Prosternal teeth 2+2, the two fused at base in a dental plate, the inner larger than the outer and both much stouter than the ectal spines which, nevertheless, is stout and tooth-like and not at all bristle-tipped.

Coxal pores circular decreasing markedly in size proximad, the most distal being large; in number and arrangement, 5, 5, 5, 4; 5, 5, 5, 5,; 6, 6, 6, 5, etc. None of the posterior coxæ armed laterally. Spines of first legs, $\frac{0, 0, 2, 1, 1}{0, 0, 1, 3, 2}$ or $\frac{0, 0, 2, 1, 1}{0, 0, 1, 2, 2}$; of second $\frac{0, 0, 2, 2, 1}{0, 0, 2, 3, 2}$; of third to sixth, $\frac{0, 0, 2, 2, 2}{0, 0, 2, 3, 2}$; of seventh and eighth, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$; of ninth and tenth, $\frac{0, 0, 3, 2, 2}{0, 0, 3, 2, 2}$; of eleventh, $\frac{1, 0, 3, 2, 2}{0, 0, 3, 3, 2}$; of twelfth, $\frac{1, 0, 3, 2, 2}{0, 1, 3, 3, 2}$; of penult, $\frac{1(2), 0, 3, 2, 2}{0, 1, 3, 3, 2}$; of anal, $\frac{1(2), 0, 3, 2, 1}{0, 1, 3, 2, 1}$, with two claws, the penult having three. As noted in the formulæ, the dorsal spine of the posterior coxæ is frequently replaced by two situated close together. The anal legs of the male slender, the tarsal joints especially slender; tibia bearing near distal end of its mesal surface toward dorsal side a small, flattened, subtriangular lobe or crest the long axis of which is parallel to that of the joint and its higher end caudad, its mesal or long edge somewhat convexly curving. Penult legs slender bearing no special lobes

Gonopods of male rather large and broad, conspicuously exposed; distally rounded, bearing about ten or twelve long bristles.

Gonopods of female with claws very long and stout, moderately curved. First article excavated on mesal side toward base as usual, this side strongly chitinized as usual. Basal spines 2+2, large and stout, well separated, the outer larger than the inner on each side.

Gradually and considerably attenuated cephalad, the first plate narrowest as usual.

Length from 22 to 30 mm. A male 26 mm. long has antennæ 11 mm. long and anal legs as 9.5 mm. long with its tenth plate as 3.1 mm. wide.

Locality: Mexico (Guadalajara and Tuxpan).

Genus **Guambius** gen. nov.

Type.—Lithobius euthus Chamberlin.

Other known species belonging to this genus are *pinguis* Bollman, *curtior* Chamberlin and *mississippiensis* sp. n. described below.

Guambius mississippiensis sp. nov.

Dorsum dilute chestnut, with the caudal plates and a median longitudinal line somewhat darker. Head and antennæ dark chestnut, the latter paler distad. Venter testaceous, darker brown caudad. Prosternum and prehensorial feet nearly the same as head. Legs testaceous, the caudal pairs a little darker.

Head slightly wider than long (36: 35 or 34.5); widest at marginal interruptions, between which and the eyes the diameter is nearly uniform, the sides caudad of this convex and strongly converging; the median portion of caudal margin straight. Rather strongly transversely furrowed or depressed immediately in front of caudal marginal thickening, the furrow extending entirely across head and continuous with caudal ends of a wide longitudinal furrow extending cephalad dorsal of level of eyes on each side. A short transverse sulcus a little cephalad of and parallel with median part of frontal suture, a median longitudinal suclus extending forward from this transverse one and showing or passing through a deeper pit-like impression at middle of length. Smooth and shining, or only very obscurely uneven.

Dorsal plates finely roughened. Major plates, excepting the seventh, showing distinctly the short transverse submarginal sulcus on each side about beginning of caudal third of plate, the seventh plate showing a similar sulcus near each caudal corner and one near each anterior corner as well. Most of the major plates marked with two distinct longitudinal sulci which diverge more or less from near the caudal margin cephalad, these sulci in some distinct only cephalad of the submarginal transverse marks. Posterior angles of eleventh and thirteenth plates a little produced, those of others rounded or obliquely excised.

Most ventral plates with a rather deep longitudinal furrow toward each side but mesad of a weaker submarginal furrow also present. The usual median longitudinal furrow with also the transverse depression cephalad of caudal margin also more or less evident.

Antennæ very short, reaching to or nearly to the sixth segment; articles 25, of which the second is longest, those immediately following not abruptly shorter but only very gradually decreasing in size distad.

Eyes about 11 to 14 in number, arranged in four series; thus, 1+ 5, 4, 3, 1 and 1+ 4, 3, 2, 1. The single ocellus much the largest, subvertically elliptic or oval.

Prosternum 1.5 times wider than long or slightly more. Teeth 2+2, subequal, acute, with line of apices manifestly recurved. Median incision rather wide and deep with its sides concave. Ectal spines much more slender than the teeth, bristle-like distad, acute.

Coxal pores circular, of moderate size; in number, in type specimen, 3, 4. 4. 3.

No spines of posterior coxæ evident. Spines of first legs $\frac{0, 0, 1, 1, 1}{0, 0, 1, 2, 1}$; of second, $\frac{0, 0, 1, 2, 1}{0, 0, 1, 2, 1}$; of third, $\frac{0, 0, 1, 2, 1}{0, 0, 1, 2, 1}$ or $\frac{0, 0, 1, 2, 2}{0, 0, 1, 3, 1}$; of fifth and sixth, $\frac{0, 0, 1, 2, 2}{0, 0, 1, 2, 2}$; of seventh, $\frac{0, 0, 1, 2, 2}{0, 0, 2, 2, 2}$; eighth to tenth, $\frac{0, 0, 2, 2, 2}{0, 0, 2, 2, 2}$; eleventh, $\frac{0, 0, 2, 2, 2}{0, 0, 2, 2, 2}$ or $\frac{0, 0, 2, 2, 2}{0, 0, 2, 3, 2}$; of twelfth, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 2, 2}$; of thirteenth, $\frac{0, 0, 3, 2, 2}{0, 1, 2, 3, 2}$; of the penult, $\frac{0, 0, 3, 1(2), 0(1)}{0, 1, 3, 3, 1}$, armed with two claws; of the anal $\frac{0, 0, 3, 2, 1}{0, 1, 3, 3, 1}$, claws in type broken off. The anal legs of male strongly crassate, the prefemur particularly elevated dorsally; femur conspicuously excavated dorsally, the excavation extending from end to end as a broad and rather deep furrow; the tibia much less swollen than the femur, complanate or shallowly furrowed longitudinally on dorsal surface; hairs short and straight, more numerous on dorsal surface of all joint but nowhere dense or forming bunches; articles not laterally furrowed. Penult legs crassate in about same degree as the anal but the tibia relatively larger; distal end of tibia obliquely excised at dorsocaudal corner and bearing there a triangular plate or keel-like lobe which lies longitudinally with the elevated end caudad; prefemur, femur and tibia longitudinally furrowed above, but the furrow of femur scarcely more developed than that of the other articles and this article not otherwise especially modified; none of articles bearing bunches of hair, the latter being everywhere sparse; tarsal joints abruptly more slender.

Gonopods of male wide, truncate distad, flattened in an ectoventral dorso-mesal direction; bearing a few short bristles in a row along distal edge of ventral side.

Body strongly narrowed from eight plate forward to the first which is clearly narrower than the third; the eighth and tenth plates of equal width and much wider than the head, the latter in type being even slightly narrower than the third plate. Body about 7¼ times longer than width of tenth plate.

Length of type (a male) 12.5 mm.; of antennæ 5 mm.; width of tenth plate 1.7 mm. Width of head, first, third, eighth, and tenth plates to each other about as 18, 17, 19, 24 and 24.

Locality: Byram, Mississippi (author, July, 1910).

In ANNALS ENT. SOC. AMERICA, 1911, p. 43 the type of the species was referred tentatively to *A. aedipes* Bollman, but study of the type of the latter shows it to be clearly distinct.

Genus **Gosibius** Chamberlin.

Gosibius monicus sp. nov.

Dorsum brown, with a darker median longitudinal stripe which shows a marked tendency to spread laterally at the caudal end of each plate and often reaches the lateral margins across the caudal border. Head ferruginous; the median longitudinal stripe of dorsum continuing forward upon the head as far as a little caudad of the frontal suture where it ends abruptly at a pale transverse band. Antennæ ferruginous. Prosternum and prehensorial feet pale ferruginous. Venter yellow or testaceous, the caudal segments darker, more reddish or ferruginous. Legs yellow or testaceous like the venter, nearly uniform, or the caudal pairs slightly darker dorsally.

Head subcordate, wider than long in about ratio 47: 45. Caudal margin mesally gently incurved; sides conspicuously converging from the lateral interruptions caudad about the rounded corners. A median longitudinal sulcus extending forward from frontal suture to a transverse depression between the antennæ, narrow and not very deep. A short, deep, transverse sulcus a little in front of median portion of caudal margin, the same being more weakly indicated farther laterad on each side. Smooth and shining, not punctate or roughened.

First dorsal plate smooth and shining like the head, or very obscurely roughened. Other dorsal plates more or less roughened, the more caudal ones most strongly so. Major plates with the short transverse sulcus adjacent to each lateral margin at about one-third its length from caudal end, the seventh having in addition a similar sulcus near the middle of length. A median longitudinal furrow on each side between middle and lateral margin which may be indistinct, especially on caudal portion of plate; this furrow at about beginning of middle third of length sending off a more clearly impressed branch directly mesad which may be united with the corresponding furrow from the other side; often a short sulcus running from near anterior margin obliquely ecto-caudad toward point of origin of this transverse furrow.

Ventral plates apparently smooth and shining; the usual three longitudinal impressions indicated in varying degrees of distinctness. On several of the caudal plates the median furrow may end caudad in a deeper, pit-like and somewhat transverse, depression a little in front of caudal margin of plate.

Antennæ long. In types tips are broken off so that full number of articles can not be ascertained; but the number present indicates that the full number is somewhere above 29.

Eyes in types from 15 to 17 in number, arranged in four series; thus, 1+4 (5), 4, 4, 2; 1+4, 4, 4 (3), 4.

Prosternal teeth 2+2, stout, conical, much closer together than in paucidens and also larger, but the proportion of anterior margin occupied larger than in that species. Ectal spines long and distally drawn out into slender, bristle-like, acute tip; the tubercles contiguous with outer tooth and not well removed from it as in paucidens.

Coxal pores circular, rather small; 4, 3, 3, 3, in the types.

Last four pairs of coxæ laterally armed. Spines of first legs, $\frac{0, 0, 2, 2, 1}{0, 0, 2, 3, 2}$; of second, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 2}$; of the third and fourth, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$; of the fifth to ninth, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 3}$; of the tenth, $\frac{1(0), 3, 2, 2}{0, 0, 3, 3, 3}$; of the eleventh, $\frac{1, 0, 3, 2, 2}{0, 0, 3, 3, 3}$; of the twelfth and thirteenth, $\frac{1, 0, 3, 2, 2}{0, 1, 3, 3, 3}$; of the penult, $\frac{1, 0, 3, 2, 2}{0, 1, 3, 3, 2}$, armed with two (3?) claws; of the anal, $\frac{1, 0, 3, 2, 2(1?)}{0, 1, 3, 3, 1}$, armed with two claws. Anal legs in the female short and moderately slender, the dorsal surface of femur and tibia distinctly longitudinally furrowed, the same articles of penult legs similarly but less strongly furrowed.

Gonopods of female with the claw long and acute, strongly curved and chitinized. Proximal article excavated at base on mesal side, leaving a conspicuous lobe at distal end which projects mesad and meets the corresponding lobe of other gonopod; the caudal and mesal sides of this articles strongly chitinized as usual. Basal spines 2+2, stout, the inner smaller than the outer. Median process of sternite first clavately widening caudad, and then attenuated to a slender acute point.

Length of types 14 to 15 mm. A specimen (female) 14 mm. long has anal legs 5.8 mm. long and the tenth dorsal plate 2 mm. wide, the body being thus seven times as long as the width of this plate. The body moderately narrowed cephalad and the first plate slightly narrower than the third whereas it is wider in paucidens. The widths of head and first, third, eighth and tenth dorsal plates to each other about as 53, 47, 48, 57, and 57.

Locality: Santa Monica, California (author, June, 1909).

Genus **Lithobius** Leach.

Lithobius devorans sp. nov.

Dorsum from brown to chestnut and, in largest individuals in full color, almost mahogany. In lighter individuals the head is chestnut and clearly darker than the dorsal plates excepting the first in some in which it may approach the same color; in the more deeply colored individuals the head is deep chestnut or mahogany of scarcely deeper shade than that of dorsal plates. Antennæ chestnut, usually paler at very tips only. Prosternum chestnut, the prehensorial feet more rufous. Venter fulvous to brown, the caudal plates always darker and either reddish or very deep brown. Legs colored like contiguous portion of venter, the caudal pairs being thus always darker.

Head slightly wider than long (72: 70). Caudal margin straight or nearly so; posterior corners conspicuously and widely rounded, the

sides immediately in front of them but little excurved, diverging forward to the lateral interruptions which are distinct. The short curved transverse submarginal sulcus opposite interruption of each side evident. The usual semi-circular impression on caudal portion clearly marked. There is also present a transverse sulcus immediately caudal of and subparallel with frontal suture, the sulcus being most distinct at the sides. Surface sparsely punctate and moderately uneven.

Posterior dorsal plates conspicuously roughened; the anterior ones less strongly so and the first uneven only in about same degree as head. The short transverse sulci most distinctly impressed on the more caudal plates, mostly weak on the anterior ones. Caudal plates with short hairs more numerous than on the anterior. Posterior angles of the seventh, ninth, eleventh and thirteenth dorsal plates strongly produced; processes of ninth, eleventh and thirteenth long and acute, those of the seventh obtusely rounded, the inner or mesal edges being convex and long with its ectal or distal portion nearly transverse.

Anal segment in the male densely clothed above with rather long hairs, most of which are curved or uncinate at tips, this being a very characteristic feature of the species. In the female the dorsal hairs of this segment are sparse and straight.

The three longitudinal sulci of ventral plates distinct, being on most broadly and deeply impressed to a little in front of caudal margin. Last plate more densely clothed with short hairs. Sternite of genital segment also densely clothed with hairs especially in the male.

Antennæ reaching the beginning of the eighth segment; attenuated, very slender distally. Composed of mostly from 32 to 35 articles which, distad of the first few, are rather short, considerably shorter ones occurring at intervals among longer ones as in related species.

Eyes composed of from 28 to 42, but mostly from 30 to 36, ocelli which are arranged in from 5 to 8 series; e. g., 1+3, 4, 6, 6, 6, 5; 1+3, 4, 6, 6, 6, 6, 3; 1+6, 5, 6, 5, 4, 4, 4; 1+6 5, 6, 5, 5. Single ocellus moderately large, oval. All seriate ocelli deeply pigmented excepting those of first row which are commonly paler as in related species. Of seriate ocelli the caudal ones of first row are clearly the largest.

Prosternum about 1.7 times wider than long. Distance between chitinous spots 1.8 times the width at level of bottom of mesal incision, and 2°5 to 2.7 times as great as length of dental line, the variation depending on number of teeth. Teeth 5+5 or 6+6, or occasionally 5+6; distally narrowly rounded. The prosternal spine situated immediately ectad of outer tooth as usual, slender and bristle like, and curved as in voracior.

In larger specimens the coxal pores are very large and strongly transverse, while in the smaller axults the form may approach that of the pseudomaturus stage, being transversely elliptic and with those at ends of rows often subcircular. In number and arrangement from 6, 6, 6, 5 to 8, 8, 8, 7, other arrangement noted being 6, 7, 7, 6, to 7, 7, 7, 5, and 7, 8, 8, 6.

Last three pairs of coxæ laterally armed. Spines of first legs, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 2}$; of the second, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 2}$; of the third, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$, or $\frac{0, 0, 3, 2, 2}{0, 0, 3, 2, 2}$; of the fourth and fifth, $\frac{0, 0, 3, 2, 2}{0, 0, 3, 3, 2}$, or $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$; of the sixth to the eleventh, $\frac{0, 0, 3, 2, 2}{0, 0, 3, 3, 2}$; of the twelfth, $\frac{1, 0, 3, 2, 2}{0, 1, 3, 3, 2}$, the thirteenth being the same; of the penult, $\frac{1, 0, 3, 1, 0}{0, 1, 3, 3, 2}$, or $\frac{1, 0, 3, 2, 1}{0, 1, 3, 3, 2}$, the anterior or ectal dorsal spine of the fourth joint in the latter case being mostly very small, claws two or three, in latter case the anterior accessory being very small; of anal, $\frac{1, 0, 3, 1, 0}{0, 1, 3, 3, 2}$, the claw single.

The anal legs in the male are short. Fourth article considerably thickened, more so than in voracior; dorsal or dorso-mesal surface conspicuously bowed ventrad or depressed over middle and posterior portion, or the depression often almost strictly mesal, longitudinally furrowed along depressed surface; also longitudinally furrowed along dorsal surface toward ectal edge of latter. Third and fourth articles rather deeply sulcate longitudinally on ventral surface. Tibia longitudinally furrowed dorsally. Tarsal joints not clearly sulcate mesally. Penult legs very similar to anal but the fourth article but slightly enlarged and not at all excavated meso- or caudo-dorsally, though the dorsal longitudinal furrow is conspicuous.

The single article composing the gonopod of male well exposed; directed caudo-ectad; sides nearly parallel; distally subtruncate; bearing mostly about four bristles. In the gonopods of the female the claw is comparatively short; strongly bent; tripartite, the three lobes distinct, the median being considerably larger much as in vorax but not so greatly exceeding the lateral as in mordax, etc. Basal spines stout and moderately long; mostly uniformly attenuated from base to apex. Mesal side of first article straight, diverging cephalad from mesal side of fellow but little.

Body appearing to vary considerably in relative width, the length being mostly as much as eight times longer than width of tenth plate, but in some falling a little below this (7.75) and in others as much as 8.4 times longer. Moderately attenuated cephalad from eighth plate, with the first plate a very little wider than the third and usually a little narrower than the head, occasionally as wide as latter; the average ratio of widths of head, first and tenth plates is 30 : 29 : 35. In one male the widths of head and first, third, eighth, tenth and twelfth dorsal plates stand to each other as 72, 72, 70, 78, 78, and 72.

Length from 18 to 26 mm. A male 25 mm. long has antennæ about 12.5 mm. long, anal legs 8.5-9 mm. long and the tenth dorsal plate 2.9 mm. wide.

Locality: Jackson, Alabama (author, 1910).

This species is very close to the next, L. voracior. Usually both sexes of fully grown specimens of these species are to be distinguished quite readily by the form of the coxal pores

these in voracior being circular or broadly elliptic whereas in devorans they are larger and mostly strongly transverse. In some cases, however, it is difficult to separate the females, although the males are always very readily distinguished by the character of the hair clothing the anal segment dorsally, this in devorans being long and dense with nearly all the hairs uncinate distally whereas they are all straight in the other species. Devorans averages larger. It is relatively more slender and the width of the head as compared with that of the tenth plate is as 60:70 on an average whereas the average corresponding ratio in voracior is 60:65.5

Lithobius voracior sp. nov.

Dorsum brown, the first plate and the several most caudal ones commonly darker and more reddish of chestnut; plates often showing three longitudinal pale lines. Head conspicuously darker than the dorsum, cherry red or chestnut, or in others often very dark, nearly mahogany. Antennæ chestnut, much lighter distad. Prosternum dark brown or dilute brownish chestnut, with the prehensors paler. Ventor yellowish brown, the posterior plates much darker, burnt brown. Legs yellowish brown, the posterior pairs darker, being often somewhat chestnut with distal articles a little paler.

Head wider than long. Widest immediately back of eyes. Sides rather strongly convex and converging caudad of the well marked marginal breaks to the rounded posterior corners. Caudal margin nearly straight or but slightly incurved mesally. The usual subcircular impression on caudal portion. Surface subsparsely punctate, the punctæ varying in size but mostly fine; obscurely uneven.

First dorsal plate with surface similar to that of head. All finely punctate. Plates roughened more especially the caudal ones as usual, the elevations or irregular tubercles small. Posterior angles of seventh, ninth, eleventh and thirteenth dorsal plates strongly produced, processes of the seventh much as in devorans.

Anal segment in male dorsally densely clothed with rather long and strictly straight hairs, these not being at all distally curved or uncinate. In the female the dorsal hairs of this segment are but sparse.

Ventral plates densely punctate and with numerous fine impressed lines which mostly run out from the punctæ. The usual longitudinal furrows clearly developed. Hairs of posterior plates more numerous and longer.

Antennæ of moderate length, reaching mostly to the end of the seventh or beginning of eighth segment. Attenuated considerably but the distal portion not very fine. Articles beyond the first several rather short. Hairs moderately long. Articles in number from 32 to 36.

Eyes composed mostly of from 30 to 35 ocelli, rarely as few as 23, arranged in from 5 to 7 longitudinal series; e. g., 1+3, 5, 5, 5, 4; 1+3, 4, 5, 6, 5, 4, 2; 1+5, 5, 6, 6, 4, 3; 1+3, 5, 6, 6, 6, 4, 3; 1+4, 6, 7, 6, 5, 4, 1.

Single ocellus large subvertically oval. Ocelli of most dorsal row larger and paler as in related species.

Prosternum 1.6 times wider than long. Distance between chitinous spots 1.9 times wider than long of prosternum at levex of bottom of mesal incision; 2.3 or 2.4 times as great as length of dental line usually, this varying with number of teeth present. Prosternal teeth 6+6 to 8+8, other numbers noted being 6+7, 7+7, and 7+8; either uniform or varying irregularly in size; subacute, being but narrowly rounded at tips. Spine proximally clearly stouter than the hairs, but distally bristle-like, curved; situated immediately ectad of outer tooth.

Coxal pores transversely elliptic or in part subcircular; of medium size; in largest specimens more strongly transverse as in the preceding species. In number from 6, 6, 6, 4 to 8. 8, 8, 6, other arrangements frequently noted being 6, 7, 7, 5; 6, 7, 6, 5; 6, 6, 6, 5; 7, 7, 7, 6, and 7, 8, 8, 7.

Last three pairs of coxæ laterally armed. Spines of first legs, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 2}$; of second, $\frac{0, 0, 3, 2, 1}{0, 0, 2, 3, 2}$; of third, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$; of fourth to eighth, $\frac{0, 0, 3, 2, 2}{0, 0, 2, 3, 2}$ or $\frac{0, 0, 3, 2, 2}{0, 0, 3, 3, 2}$; of ninth to eleventh, $\frac{0, 0, 3, 2, 2}{0, 0, 3, 3, 2}$; of twelfth, $\frac{1(0), 0, 3, 2, 2}{0, 1, 3, 3, 2}$ or $\frac{1(0), 3, 2, 2}{0, 9, 3, 3, 2}$, a spine sometimes borne by trochanter of one leg while absent from the other; of thirteenth, $\frac{1, 0, 3, 2, 2}{0, 1, 3, 3, 2}$; of penult, $\frac{1, 0, 3, 1, 1}{0, 1, 3, 3, 2}$, or $\frac{1, 0, 3, 2, 1}{0, 1, 3, 3, 2}$, the anterior spines of fourth joint in latter case being mostly very small, tarsi ending in three claws but the anterior accessory one mostly minute as in related species; of anal $\frac{1, 0, 3, 1, 0}{0, 1, 3, 3, 1}$, the claw single.

Anal legs in female short and rather slender; the third, fourth and fifth articles longitudinally sulcate dorsally, the fourth being most deeply so; the third and fourth articles sulcate ventrally. Penult legs similarly but less strongly sulcate. In the male the penult legs are as in the female; but the anal legs are more strongly modified. Fourth article with dorsal surface depressed or bowed ventrad over middle and proximal portion; relatively thicker than in female; articles longitudinally sulcate along mesal surface, especially so in the more distal ones

Gonopods of male rather small; distally strongly rounded or broadly subconic; bearing 6 or 7 long bristles.

Gonopods of female with claw long and rather strongly bent or curved near middle; tripartite, the median division long and acute, the lateral small and also usually acute, the inner or more dorsal one considerably more distal in position than the outer one which is near the middle of length of claw. Basal spines long and stout, subequal, attenuated uniformly from base distad. Basal article with inner side nearly straight.

Body more robust than in devorans, the length being mostly less than seven times as great as width of tenth dorsal plate (6.8). Considerably attenuated cephalad from eighth plate, with the third plate narrower

than the first and the latter clearly narrower than the head. Average ratio between widths of head and first and tenth dorsal plates 68:65:74.3. A male has widths of head and first, third, eighth, tenth and twelfth dorsal plates to each other as 68, 65, 63, 75, 75, and 68.

Length from 17 to 24 mm. A female 19 mm. long has antennæ 10.5-11 mm. long, anal legs 8.5+ mm. long, and tenth dorsal plate 2.8 mm. wide. Males have similar relative measurements.

Type Locality: Fernwood, Mississippi.

Known Localities: Mississippi (Fernwood, Canton and Byram. Author, collector, 1910).

Although it has seemed impossible on the basis of any previously stated characters to maintain as distinct several species allied to L. mordax and L. vorax, through the use of characters not previously detected the writer finds it now an easy matter to discriminate between them. Such of this group of species, the larger forms dominating in the Southeast, as have the posterior angles of seventh, ninth, eleventh and thirteenth dorsal plates produced thus far known from the U. S., are, in addition to *devorans* and *voracior*, above described, the following: *mordax* K., *transmarium* K, *vorax* Meinert, *tyrannus* Bollman, *suprenans* Chamberlin, and *latzeli* Meinert. The writer's previously expressed opinion that *clarus* McNeill was based upon immature specimens has been confirmed by an examination of the types of this species, these proving to be *vorax* in the pseudomaturus stage; mordax and *transmarinus*, merged by Bollman in *spinipes* Say, are clearly distinct; and study of types shows *tyrannus* and *latzeli* to differ from *vorax* which previously had been thought identical, the published diagnoses revealing no truly distinctive characters.

Genus **Sozibius** gen. nov.

Type.—Lithobius tuobukus Chamberlin.

The following species is placed here only tentatively.

Sozibius pungonius sp. nov.

Dorsum very light brown. Head cephalad of frontal suture and the caudal segments darker, somewhat orange colored. Antennæ yellow. Venter and legs very pale, the posterior pairs bright yellow. Prosternum and ultimate ventral plates dark yellow.

Antennæ short composed of twenty-one articles of which the first six are long, the others shorter.

Ocelli about eleven, small arranged in three curved and rather irregular series; thus, 1+5, 3, 2.

Prosternal teeth 2+3.

Angles of none of the dorsal plates produced.

Coxal pores very small, 2, 3, 3, 2.

Ultimate pair of coxæ armed laterally, the ultimate and penult pairs armed dorsally.

Spines of first legs 2, 3, 2; of the penult 1, 3, 3, 2, the claw single; of the ultimate 1, 3, 2, 1, the claw single.

Anal legs of male long and slender the fourth, fifth and sixth joints longitudinally furrowed on ectal surface, laterally compressed.

Length.

Locality: Marshall, Colorado (Prof. T. D. A. Cockerell).

One male specimen.

Genus **Poabius** gen nov.

Type.—Poabius verdescens Chamberlin.

Other known species belonging to this genus are bilabiatus Wood, pitophilus Chamberlin, sokovus Chamberlin, clavigerens Chamberlin, utahensis Chamberlin, yukus sp. n., and the two new species described below.

Poabius nankus sp. nov.

Light orange brown, caudal borders of major scuta darker; head somewhat darker caudad of frontal suture. Antennæ and legs yellow. Venter yellow, the prosternum and caudal segments a little darker.

Body markedly attenuated from tenth dorsal plate cephalad. Most dorsal plates with a strong median furrow which may be doubled and, on each side, one or two approximate lateral ones diverging from it caudad; within each lateral margin a furrow or sulcus running from near anterior edge at first near to and subparallel with the lateral margin and then bending away from it caudo-mesad to end at the transverse furrow which traverses most plates a little cephalad of caudal margin.

Head subcordiform; caudal margin nearly straight; distinctly margined caudally and along cauda-lateral angles; a short transverse sulcus a little cephalad of caudal margin and between this and the frontal suture a median and several lateral pairs of longitudinal impressed lines or sulci.

Antennæ moderately short, composed of twenty more or less uniform articles.

Ocelli pale, small, fifteen or sixteen in number arranged in four straight and regular series; thus, 1+5, 4, 4, 1 (2).

Prosternal teeth dark, low, 2+2.

Angles of none of the dorsal plates produced.

Coxal pores circular, the edges weakly chitinized; 2, 3, 3, 2.

Last two pairs of coxæ laterally armed; the last three pairs dorsally armed.

Spines of the first legs 1, 3, 2; of the penult, 1, 3, 3, 2, armed with three claws; of the anal 1, 3, 2, 1, the claw single.

Gonopods of female with the claw tripartite; basal spines 2+2.

In the male the anal legs have the prefemur elevated into a rim-like structure on dorsal or dorso-mesal side at distal end, and the femur bears at the proximal end on same side an ear-shaped process which is

excavated above, the depression being continuous with a longitudinal median furrow on dorsal surface. See Pl. XII, fig. 4.

Length 13–14 mm.; width at tenth plate 1.9–2.2 mm.

Locality: Las Valles, New Mexico (Prof. T. D. A. Cockerell)

The types consist of a male and a female.

Poabius iginus sp. nov.

Light brown, scuta mostly with the caudal borders darker, reddish brown; posterior segments darker. Head chestnut, darkest behind frontal suture, a dusky or blackish median longitudinal stripe for a short distance in front of caudal margin. Legs yellowish, caudal pair from base to fourth joint inclusive reddish brown or chestnut, distally like the others. Venter brown, the ultimate plates reddish brown. Prosternum light reddish brown. Antennæ mostly dark brown, becoming pale distad.

Scuta roughened, mostly showing a median and two lateral longitudinal sulci or in some the median replaced by two diverging sulci.

Antennæ moderate, articles 20.

Ocelli distinct, ten in number, arranged in three series; thus, 1+4, 3, 2.

Prosternal teeth 2+2.

Angles of none of the dorsal plates produced.

Coxal pores small, well separated, round, 2, 3, 3 (4), 2.

Last two pairs of coxæ laterally armed.

Tarsi of anterior pairs of legs rather indistinctly biarticulate. Spines of first legs 2, 3, 2; of penult 1, 3, 3, 2, armed with three claws; of the anal 1, 3, 2, 0, the claw single.

Gonopods of female with the claw tripartite; basal spines 2+2, proximally clavate, distally conical.

Anal legs of male with the fourth joint enlarged and bearing mesodorsally and proximad of middle a conspicuous, flattened, keel-like lobe and at its distal end a small wart-like elevation.

See Pl. XIII, fig. 2.

Length 11.5 mm.; width 1.7 mm. Length of antennæ 4 mm.; of anal legs 4.2 mm.

Locality: Madison, Wash. (Dr. E. Bergroth).

Closely allied to *P. bilabiatus* and *P. verdescens;* but manifestly smaller and differing in the lobes of anal legs and in the smaller number of spines born dorsally at distal end of third joint, etc. See Pl. XIII, figs. 1 and 2.

Family Cryptopidæ.

Genus **Kethops,** gen. nov.

Pairs of legs 23.

Seventh segment not bearing spiracles.

First dorsal plate with transverse semi-circular sulcus.

Other dorsal plates excepting the ultimate with two sharply impressed longitudinal and subparallel sulci.

Last dorsal plate margined laterally, caudal margin convexly protruding.

Sternal plates elongate, narrowed caudad the caudo lateral corners obliquely excised. (See Pl. XIII, fig. 5). Each with a distinct longitudinal median sulcus and submarginal sulci.

Pseudopleura produced caudad into an acutely pointed process; porose ventrally; armed ventrally and laterally with spines.

Legs sparsely armed with spinescent bristles which appear spine-like especially on proximal joints. A stout spine at distal end of tibia dorsal in position and a second one ventral. Tarsi, excepting the ultimate, one-jointed, a stout ventral spine distad of middle.

Prefemur of anal legs armed with rows of spines on mesal and ectal surface and on most of the ventral. Femur similarly armed mesally and ventrally. The tibia with similar spines ventrally. Tarsus composed of but two joints and ending in a distinct and very stout claw.

Type: Kethops utahensis Chamberlin.

The type species was originally described from Utah under the genus Newportia, the absence of anal legs from the type specimen leading to the reference to this genus. While close to Newportia, it has various Cryptops-like characters and is readily separated by the character of the anal legs, etc. A short time ago among some old material from New Mexico sent me by Prof. Cockerell, a perfect specimen of the form was found, making possible the diagnosis given above. A description of this specimen follows:

Kethops utahensis Chamberlin.

Ferruginous, uniform; antennæ and legs, excepting the ultimate pair, paler, yellowish; anal legs colored like the body, but pale distad.

Head coarsely punctate, two diverging longitudinal sulci on the caudal portion which begin at a transverse sulcus in front of and parallel the caudal margin.

Antennæ composed of seventeen articles.

First dorsal plate with semi-circular impression deep, somewhat angularly bent caudad at middle, mesal portion in a broad depression or pit on the caudal slope of which there is a distinct W-shaped mark like that found in many species of Newportia, the two usual longitudinal sulci over caudal portion of plate.

Sulci of second plate strongly diverging caudad, those of the succeeding plates nearly parallel.

Last dorsal plate without distinct sulci; caudal margin convexly bowed out; lateral margins armed with two rows of spinules. (See Pl. XIII, fig. 3).

Anterior margin of prosternum straight or nearly so, but slightly indented mesally. Prosternum punctate, two sulci, which, approximate below, diverge distad toward the free margin.

Ventral plates irregularly punctate, more densely so on caudal portion. Median sulcus beginning a little caudad of anterior margin and extending over anterior two-thirds or somewhat more of length of plate; a submarginal sulcus on each side which is deepest mesally; usually two or more weaker and more indefinite transverse sulci as shown in the figure. (See Pl. XIII, fig. 5).

Last ventral plate narrowed caudad; rounded caudally; bearing spinules over entire surface.

Last pleuræ furrowed laterally; with numerous small pores on ventral surface, both the free portion and that covered by ventral plate. Caudal process bearing acute spine distad. Pleuræ with many spines laterally and ventrally. (See Pl. XIII, fig. 4).

Prefemur of anal legs longitudinally furrowed both ventrally and dorsally; armed with numerous spines arranged in obliquely longitudinal rows which cover entire surface excepting dorsal portion and the furrow on the ventral. Femur also longitudinal furrowed dorsally and ventrally, the mesal side of ventral furrow formed by a keel-like elevation which does not quite reach distal end. Spines on edge of keel and elsewhere on ventral surface as shown in figure. Tibia with a mesally bent longitudinal keel, the bent mesal portion lower than end parts, this keel limiting a broad groove mesally, into which groove the tarsi of the specimen are bent or flexed like the blade of a knife. First joint of tarsus with at least one ventral spine; claw long and stout.

Length about 20 mm.

Locality: Glorieta, New Mexico (Prof. T. D. A. Cockerell).

The original type was collected by the author at the Warm Springs north of Salt Lake City in 1908.

Family Scolopendridæ.

Genus **Scolopendra** Linn.

Scolopendra mohavea sp. nov.

Very pale olive brown; the caudal half of body darker brown, dusky, or in one specimen largely solid black, with a pale longitudinal median line, Head paler cephalad of frontal suture.

Head with a transverse sulcus a little ways in front of the caudal margin, and between this sulcus and the caudal margin two straight, short, longitudinal sulci which are parallel. Cephalad of trnsverse caudal sulcus a pair of furrows which converge forward and end caudad of frontal suture, each furrow doubly curved, at caudal portion with concavity ectad, anteriorly convex ectad, the very anterior end bent abruptly mesad; ectad of each one of these furrows a second less sharply impressed furrow which also converges toward the mesal line cephalad; between the two sulci on each side a short sulcus runs obliquely cephalo-ectad. Smooth.

Antennæ long; composed of twenty-six articles of which the first six or seven are comparitively smooth, the scattered hairs upon them increasing on number from the first article distad.

First dorsal plate with sharply impressed cervical furrow. On each side a furrow which caudad is parallel with caudal margin, from there curving obliquely cephalo-ecta. A median longitudinal sulcus cephalad of cervical groove. Smooth.

Second dorsal plate with median longitudinal sulcus on anterior half. The two usual paired sulci crossing the entire plate and diverging caudad. On each caudo-lateral portion of plate a furrow curving obliquely cephalo-ectad as on first plate, similarly taking its origin near caudal margin.

Third and fourth dorsal scuta with median furrow. The paired longitudinal sulci less strongly diverging caudad than on preceding plate. Furrow on each caudo-lateral portion as in the preceding scuta.

On the fifth and subsequent dorsal plates the paired sulci become nearly parallel, but diverging some at the ends. Median furrow evident, but not so the caudo-lateral ones. On each side a longitudinal furrow subparallel with the lateral margin, this furrow often broken. On a few of the more caudal segments a transverse sulcus on each side parallel with and close to the anterior margin. The twentieth plate laterally margined for its entire length; the nineteenth all but a short distance cauded; the eighteenth not margined for a somewhat greater distance caudad and a short distance cephalad; the margination of the seventeenth and sixteenth plates similar to eighteenth but extending less caudad and cephalad reaching the transverse sulcus; other plates not margined.

Lost dorsal plate with caudal margin mesally strongly and evenly convexly extended. A sharply impressed longitudinal median sulcus which does not quite reach the caudal margin. A short furrow parallel to the median one opposite its middle portion on each side.

Prosternum smooth; a median sulcus evident only for a short distance distad; transverse sulcus obscure; two weak longitudinal furrows, which, close to the mesal line caudad, diverge and are more distinct cephalad. Each dental plate with four teeth, of which the three inner ones are basally fused, the two most mesal being free only at their distal points; a deep narrow incision between the plates; the transverse furrow at base of each plate distinct, the two meeting mesally at an obtuse angle.

Basal tooth of prehensorial feet long, subacute, presenting but one point.

Penult article of palpus of second maxilla with a slender spine at distal end.

Ventral plates from the second to the twentieth inclusive with two sharply impressed longitudinal sulci which cross the entire plate.

Last ventral plate narrowed caudad, the sides weakly excurved-caudo-lateral corners rounded; caudal margin a little incurved mesally. Smooth. Depressed along the median line. A weak furrow subparallel with and not far from each lateral margin.

Prefemora and femora of legs of the first to penult pair inclusive without any dorsal spines at distal end; all with a tarsal spine, those of the first pair with two.

Pseudopleura ending in a stout process which terminates in two points or spines and bears proximad on its ectal surface a row of three stout teeth or spines.

Prefemur of anal legs ventrally with seventeen spines arranged in three longitudinal rows, of which the innermost is proximally irregular; these from ectal row mesad arranged thus, 4, 6, 7. Mesal surface with ten spines. Distal process with five spines. Femur unspined. Claw of tarsus with two basal spines.

Length 40–45 mm.

Locality: Fort Mohave, Arizona (March 7 and 18, 1911).

Three specimens received from Prof. Junius Henderson of the University of Colorado Museum.

Family Soniphilidæ.

Genus **Soniphilus** Chamberlin.

Soniphilus geronimo sp. nov.

Yellowish brown anteriorly, becoming clearer yellow caudad. Head darker caudad of frontal suture. Antennæ light brown, paler distad. Legs yellow, those of anterior segments darker. Prosternum and prehensorial feet light reddish.

Antennæ of moderate length; articles moderate, not much differing in length, the ultimate about equal in length to the two preceding taken together.

Cephalic plate longer than wide in about ratio 7:6; narrowed cephalad; lateral and anterior margins convex, the latter a little emarginate mesally; middle portion of caudal margin sub-straight, rounded laterally. A short impressed median line back frontal region; on each side a little mesad from and parallel with margin a longitudinal furrow; on lateral portion of plate on each side a pair of sulci diverging cephalad and a second less distinct pair more mesal in position. Frontal plate not discrete. (See Pl. XII, fig. 4.)

Labrum with median piece comparatively large, bearing about six stout teeth.

Prebasal plate not exposed. Basal plate short, its greatest width more than 4.5 times the median length, a greater length exposed on each side. (See Pl. XII, fig. 4).

Claws of prehensorial feet when closed not reaching anterior margin of head by a considerable distance. None of the joints bearing teeth or nodules. (See Pl. XII, fig. 2).

Dorsal scuta with lateral sulci distinct; a second pair of sulci close to median line and on most also an intermediate sulcus on each side.

Anterior prescuta very short, increasing in length to about beginning of caudal third, then again more rapidly decreasing and becoming again short.

Anterior spiracle moderately large, circular or subcircular, being slightly vertically elongate; succeeding spiracles all circular, very gradually decreasing in size to the caudal ones which are very small.

First pair of legs much shorter and more slender than the second.

Ultimate legs long, the penult and antepenult joints furrowed longitudinally on ventral surface. Claw long and stout.

Sterna with a distinct median longitudinal sulcus or furrow which is crossed at middle by a transverse furrow. Pores not detected.

Last ventral plate very wide, strongly narrowed caudad. Caudal margin straight or a little incurved. (See Pl. XII, fig. 3).

Anal pleuræ bearing a number of small pores which are all wholly covered by the last ventral plate.

Anal pores not detected.

Pairs of legs 73.

Length 34 mm.; width 1 mm.

Locality: San Geronimo, New Mexico, (Mrs. W. P. Cockerell and Miss Mary Cooper, coll.).

CLASS DIPLOPODA.

Family NANNOLENIDÆ.

Genus **Buwatia** gen. nov.

Ocelli none.

Antennæ clavate, the fifth and sixth articles thickest; third and fifth longest, nearly equal in length, the second and fourth next.

Body decidedly narrowed caudad of head to sixth segment.

Body iulus-like in form. Segments without carinæ, nearly smooth, not clothed with hair. All segments striate beneath; a deep sulcus across segment at level of pore.

Claws of legs long and slender.

Type: Buwatia monterea sp. nov.

As but one specimen of the type species has been secured, dissection for fuller structural details has not as yet been attempted. The genus may be distinguished from Nannolene through the absence of ocelli.

Buwatia monterea sp. nov.

Dorsum brown; head and anterior part of first segment whitish brown; first and ultimate segments light brown; a series of small, largely obscure dark spots along each side, one at each pore. Legs and antennæ pale.

Body slender, nearly uniform in width for most of length but decidedly constricted from head and first segment to region of sixth segment.

Head nearly smooth, weakly and very finely punctate; glabrous except for a few bristles on clypeal and labral region. A weak median longitudinal sulcus across vertex. A furrow or excavation from base of each antenna caudad to lower margin of first dorsal plate, the antenna bent back and lying in this furrow.

Antennæ rather short, strongly clavate; the seventh article short, its four sensory cones almost concealed in the terminal pit; clothing of hair becoming more and more dense distad, sparse proximad.

First dorsal plate large, closely embracing caudal portion of head. Anterior and posterior lateral angles rounded, the lateral margin between them extending obliquely caud-oventrad, rather, long, somewhat incurved. Anterior margin incurved at middle curving out convexly on each side and then again at sides incurved bow-shaped. A fine transverse sulcus subparallel to the anterior margin and some distance from it and a second one submedian in position.

Subsequent segments with a longitudinal furrow at level of pore, this more distinct on cephalic portion of segment. A transverse sulcus in front of median suture. Prozonites striate throughout, the main segment strongly striate beneath and on sides below level of pores. Dorsum a little depressed; a weak longitudinal depression each side of middle, leaving mesal portion a little elevated.

Anal scutum considerably exceeded by the anal valves; caudal division short, widely and evenly rounded, set off or limited from major portion in front by a transverse sulcus. Caudal margin with two pairs of long setæ.

Anal valves elongate, their free margins elevated. Each valve bears near its mesal margin a long seta at caudal and second one near middle of length in a furrow or sulcus which curves from mesal margin first laterad and then latero-cephalad.

Anal scale very short; caudally weakly convex, anteriorly strongly so; antero-lateral angles rounded, but not so the caudo-lateral ones.

Legs moderately long and slender; claws long, not robust.

Segments of body forty-five.

Length 11–12 mm.; width as .5-.5 mm.

Locality: Pacific Grove, Cal. (April, 1911, author.)

One specimen secured under a stone in an open field near the Hopkins Laboratory.

Family Cambalidæ.

Genus **Titsona** gen. nov.

Eyes well developed, each consisting of a number of ocelli arranged in a single series parallel with anterior margin of the first dorsal plate.

Antennæ short, very slender proximad but strongly enlarged distad, clavate; the fifth and sixth articles conspicuously and abruptly thicker than others. The third, fifth and sixth articles longest, not much differing in length from each other; second and fourth articles subequal.

Gnathochilarium nearly as in Paiteya. Promentum triangular, completely separating the laminæ linguales which are attenuated proximad to an acute angle. Mentum large, widening proximad.

Body strongly constricted from head and first segment to region of fifth and sixth segments, from where it again increases in width caudad.

First dorsal plate very large, extending over caudal portion of head from which the lateral portions extend free.

All segments striate beneath. Each segment from the fifth to the antepenult inclusive with four carinæ, a dorsal carina each side of median line and one farther laterad on each side, the latter bearing the pore.

Legs sparsely armed with spinescent bristles. First pair in male reduced, composed of six articles normally armed.

Type: Titsona sima sp. nov.

Evidently close to Paiteya, the type of which is likewise a Californian species.

Titsona sima sp. nov.

General color caudad of fifth segment dark brown, the caudal portion of each segment light brown. First dorsal plate light brown, a dark stripe parallel with but a little removed from the caudal and the cephalic border, the two stripes confluent at the sides of plate. Second to fourth segments light brown, each with a narrow transverse stripe of dark brown and especially laterally with a network of lines of same color, the proportion of dark larger the more caudal the segment. Head light brown, darker adjacent to first dorsal plate; on clypeus a square with upper side missing outlined in dark brown and immediately above this a subelliptical outline in same color with dorsal and ventral ends acutely angular. A pair of somewhat confluent brown spots in line from the brown about each eye ventro-mesad toward lower part of elliptical outline of front. Legs very pale.

Ocelli in a single row, 5–7 in number, black, uniform; the series parallel with margin of first dorsal plate which partly covers it on caudal side.

Antennæ short, strongly clavate; the fifth and sixth joints much stouter than the others, the fifth strongly enlarged from its base distad, the sixth more uniform and broadest proximad. Hairs more dense distad as usual. (See Pl. X, fig. 5).

Stipites of gnathochilarium inclusive of processes nearly four times as long as greatest width. Mentum abruptly narrowed at distal end, wider at base than the median length approximately in ratio of seven to six. A semi-circular impression on proximal portion deeply impressed, the concavity directed distad. Promentum narrowly triangular. Laminæ linguales narrowed to an acute angle proximally, about three times as long as greatest width.

First dorsal plate very large, embracing caudal portion of head mesally, its lateral wings separated from sides of head by a space into which the antennæ may be bent back. Anterior margin widely weakly concave, laterally running obliquely caudo-ventrad. Caudal margin nearly evenly convexly rounded mesally, lateral portion of plate bent ventrad and somewhat caudad and then mesad beneath. Caudal portion of plate more constricted than the anterior. On each side above lateral angle are several striæ extending from caudal margin cephalad.

Next three segments striate beneath. Fifth and subsequent segments with prozonites striate throughout, the main division of segment striate beneath and dorsad only about half way to pore-bearing swelling

or carina. Each segment from the fourth to the antepenult with four carinæ, one far dorsad on each side consisting of a hemispherical swelling chiefly on portion cephalad of suture and bearing the pore, the other close to the mesal line and also more thickened cephalad than caudad, low, rounded. All segments constricted dorsad and cephalad from the transverse suture. (See Pl. X, fig. 6).

Anal scutum long, widely rounded caudally; a rather weak median longitudinal sulcus on anterior portion; a bristle borne each side of mesal line near middle of length, and a second pair borne on caudal margin.

Anal valves long, about equalling the anal scutum; smooth; margins elevated; bearing two pairs of bristles close to mesal margin, one pair caudal and the other submedian in position.

Anal scale short and broad, transversely narrowly elliptical. A pair of bristles borne on caudal margin, one each side of mesal line.

Legs rather sparsely provided with short spinscent bristles.

First legs of male reduced, six jointed.

Gonopods of male reduced and nearly wholly concealed.

Segments ad forty-two.

Length about 16 mm.; greatest width 1 mm.

Locality: Oroville, Cal. (April, 1911; author coll.).

Two specimens were secured.

Family Nemasomidæ.

Genus **Nemasoma.**

Nemasoma uta, sp. nov.

Dorsum dark brown, the color nearly solid in band on caudal portion of each segment and in some in a narrower stripe adjacent to anterior margin, the color over remaining portion of segment mostly in a network or areolation over a light background, the light spots often confluent dorsally into transverse band. Sides light brown, the light area extending farthest dorsad at middle of segment, the light area of sides limited on all sides by border of dark brown. Each segment with whitish spot on median dorsal line. Vertex of head areolated with lines of dark brown over a light background, the frons between bases of antennæ and the eyes dark brown, the area enclosing a pair of lighter spots each side of the median line and ventrad of these a second pair of spots between bases of antennæ at lower portion of the area. Clypeal region paler from presence of numerous lighter spots, ventrad and laterally yellow, as is also the lateral portion of head. Stipes of mandibles laterally covered with network of dark brown lines over light background. Eyes deep black. Antennæ brown, each segment whitish proximally and the second article almost wholly so. Legs brown, more or less broken with whitish, paler proximally. Ventral surface light brown. Anal scutum very dark, the anterior portion with numerous light dots. Anal valves pale along mesal border, elsewhere brown.

Body very slender, attenuated cephalad, narrowest immediately caudad of head.

Head smooth, free from hairs except for the usual bristles along labrum. A transverse sulcus between eyes, each side portion bending caudad to meet other at an obtuse angle on mesal line, to which angle the median longitudinal sulcus across vertex extends.

Antennæ longer than width of body; strongly clavate; sensory cones long. Subdensely hirsute distally, more sparsely proximad.

Eyes large, oblong, its upper and lower margins nearly parallel, the mesal convex and the ectal oblique. Ocelli arranged in five series; thus, 3, 4, 4, 4, 2, giving a total of 17.

First dorsal plate narrower than the head inclusive of mandibles, shorter than the two succeeding plates taken together. Middle portion of anterior margin evenly convex, laterally extending obliquely caudo-ventrad and somewhat concave. Caudal margin mesally straight, on sides convexly bending cephalad and meeting anterior margin at an angle. Dorsal of each lateral angles the plate is obliquely depressed or shallowly furrowed.

Subsequent segments smooth above; striate ventrad of level of pores, the lower or ventral striæ deep.

Anal scutum in outline as viewed from above with lateral margins parallel or a little diverging caudad, nearly straight or slightly convex; caudal margin widely rounded, bearing beneath a seta on each side. About equalling the anal valves or a little exceeded by the latter.

Anal valves strongly bulging from base to free mesal edge, the surface of each valve extending very obliquely ventrad. A long bristle borne near mesal edge of each valve near middle of length.

Anal scale with anterior and cadual margins each strongly convex, the two meeting on each side in an acute angle. A pair of bristles springing from mesal portion.

Number of segments 44.

Length 12.5 mm.; greatest width ad .75 mm.

Locality: Little Willow Canyon, Salt Lake County, Utah. (1905; author, coll.).

But one specimen thus far found.

Family Paraiulidæ.

Genus **Paraiulus.**

Paraiulus tivius sp. nov.

Head light brown, a broad transverse band between eyes and ventrad of their level deep brown, the band enclosing above two pairs of light dots, and between antennæ a pair of large obliquely placed, oval light spots, a bristle inserted in each of most dorsal pair of light spots; vertex above the dark band with network of dark lines, a similar network covering the stipes of mandibles laterally, each of the latter with dark transverse stripe across dorsal part. Ventral surface and lower part of sides of body light brown. On each side a series of black dots extending from sixth segment to about the antepenult. Anterior and caudal margins pale, adjacent to the pale marginal stripe in each case a dark transverse band which is much widest mesally; remaining part of plate

broken into network or areolation by light spots which may be confluent into one or more cross stripes. Other segments with the caudal transverse stripe, this becoming broader on more caudal segments and extending on each side to the lateral dark spot, below which it is continued as a more obscure band formed by network of dark lines, the dark band transversely divided by a series of light spots. Prozonites light brown. Anal scutum uniform dark brown, with anterior border pale. Legs light brown or yellowish. Antennæ with proximal portion of each segment yellowish, the distal darker brown, especially in ultimate articles.

A broad transverse depression extending between eyes, in its mesal portion or adjacent to same lying the setigerous light spots above mentioned. A median longitudinal sulcus crossing vertex and ending in the transverse furrow. Head nearly free from ordinary type hairs excepting the two setæ mentioned and the bristles on clypeus and labrum. On lateral portions of clypeus and on the stipes of mandibles is a number of peculiar, probably sensory, hairs, each of which is subclavate in form with a narrow apical process and a slender basal stalk inserted in a corresponding pit, near the upper portion of which it presents a globose enlargement. (See Pl. XI, fig. 7). The tegument about the basal stalk dark.

Eyes triangular, an angle directed toward base of antennæ, upper side straight, outer side convex above and concave below, mesal side concave above and convex below. Ocelli about 45 in 7 or 8 series; counting from above ventral, 8, 10, 8, 7, 5, 4, 2, 1.

Antennæ rather short, conspicuously clavate.

First dorsal plate with lateral borders rounded anteriorly, not produced, angular posteriorly; margined anteriorly and laterally, the elevated anterior margin widest mesally, not margined caudally. One or two rather weak striæ on each side below extending from caudal margin cephalad part way across plate.

Pores moderate, widely separated from the transverse suture which is straight or at most weakly sinuate at their level.

Anal scutum with caudal portion subtriangular as usual, the apical process bluntly rounded and not at all decurved; plate crossed by a series of transverse furrows or sulci of which the more caudal ones are deepest; caudal triangular portion of plate with a series of setæ along each lateral margin, three similar long setæ springing from caudal process. Lower portion of segment bearing a long seta near middle height of caudal margin and a second in line with legs of more anterior segments.

Anal valves nearly smooth, the mesal margins strongly elevated as usual; two setæ on each valve just ectad of elevated mesal margin, one submedian and the second between this and the caudal end.

Anal scale with anterior margin convex, the posterior portion subtriangular its sides convex. A long seta borne on margin each side of mesal line. A dark line paralleling margin but indented mesally gives superficial appearance of caudal emargination to scale.

The gnathochilarium of the male has the promentum very large, broadly elliptical in outline. For form and relations of stipes and other parts see Pl. XI, fig. 6.

First legs of male strongly enlarged, uncinate, as usual; caudal surface glabrous excepting distal article, the anterior surface with long stout hairs. (See Pl. XI, fig. 5).

Second legs as usual greatly reduced excepting for the strongly enlarged coxæ; the latter produced mesally into a long, tongue-like process which extends cephalo-ventrad between the first legs. (See Pl. XI, fig. 4).

Gonopods large and conspicuously exposed, bent above base strongly ventro-cephalad. Inner branch of anterior pair much longer than the outer, contiguous with each other mesally, clavately enlarged distad; outer branches broad, plate-like, densely clothed with long setæ along anterior-ventral and distal borders. Anterior pair apically terminating in two spines, the more anterior of which is a little curved distad and at end is expanded; the other process strongly curved ventro-ectad, crossing the first, and terminating acutely. (See Pl. XI, figs. 1 and 2).

Length ad 20 mm.; width 1.6 mm. (female). Male more slender, length 16–18 mm.; width 1.2 mm.

Locality: Mill Valley, Cal. (April 8, 1911; author, coll.). About a dozen specimens were secured.

Paraiulus timpius sp. nov.

Dorsum with a broad band of light brown, paler than the sides. A median dorsal line of black which expands into a wider dot on anterior portion of each segment. Each segment bordered caudally with a narrow blackish stripe; a broader and more diffuse transverse dark band farther cephalad on segment, this band embracing a transverse row of four light spots of which the two inner ones are smallest, oblong and obliquely placed, sometimes confluent ephcalad with anterior pale portion of segment, the two outer light spots confluent caudad with the pale area between the two dark bands. On the anterior segments the light and dark areas of dorsum merged and the whole covered with a close network or areolation of dark lines over light ground and the median dorsal line as such less distinct. First dorsal plate entirely covered with similar network, the lower portion of sides dark brown or smoky; a narrow dark transverse stripe caudad of anterior margin. Sides of segments dusky or blackish, darkest along caudal margin, in a stripe continuous with the dark dorsal one, prozonites paler; a large light spot below level of pore on each segment, this spot mostly more or less constricted into two or three parts. Venter pale, a large light spot ectad of legs on each segment. Vertex of head with a dense network of black enclosing rows of very small, longitudinally oval light dots; frons between eyes solid black, enclosing a pair of light dots close to mesal line; brown between antennæ the area enclosing a number of paler dots. Clypeal and labral region yellowish. Antennæ deep purplish brown. Legs very pale, distal joints streaked with purplish or purplish brown.

Head finely roughened or rugose; free from hairs excepting the usual ones in clypeal and labral region and a single long median bristle at anterior end of the distinct median sulcus of vertex. A deep furrow extends from mesal angle of each eye to that of the other, the furrow angularly bent caudad mesally, the longitudinal median sulcus of vertex meeting this angle; farther forward a second transverse furrow, in front of which the head appears to bulge in a low transverse ridge.

Eyes large, triangular, its sides a little convex, one angle mesal and another immediately above base of antennæ. Ocelli about 39, arranged in seven transverse and gently curving series; thus, 8, 8, 7, 6, 5, 3, 2.

Antennæ moderate; proximal joints slender; distad thickened, clavate, as usual.

First dorsal plate large; mesal length about equalling that of two succeeding segments together. Anterior margin evenly convex; cephalo-lateral corners strongly rounded, the caudo-lateral more angular. Margined laterally and at sides cephalically, but not so the median portion; caudal border not margined. Not striate on sides below. A fine median longitudinal impressed line extending from caudal margin cephalad about three-fourths of the length of plate, at its anterior end breaking into two lines which diverge cephalad and become indistinct.

All subsequent segments striate beneath and over lower portion of sides, the striæ deep.

Anal scutum rounded caudad, mesally weakly indentate, a slight tooth each side of indentation; smooth.

Anal valves smooth, the mesal margin but wealky and narrowly elevate.

Anal scale with caudal margin convex, the cephalic more strongly so, the two meeting at an angle on each side. A pair of caudally projecting bristles inserted a little in front of caudal edge.

Mandibular stipes considerably produced below, mesally excavated.

Gnathochilarium with the enlarged promentum narrowly elliptical or rather wider distad than proximad as shown in figure; relatively narrower than in most species. (See Pl. XI, fig. 8).

First legs of male strongly enlarged and uncinate in the usual way; mesal surface complanate and strongly tuberculate, the tubercles in distinct cross series. Caudal surface glabrous, long hairs on the anterior.

Second legs with the greatly enlarged coxæ fitting closely against bases of first legs and bent cephalad between the latter; other joints greatly reduced the ultimate densely clothed with short stiff hairs, those at apex longer.

Gonopods of male large and conspicuously exposed. Anterior pair with two main branches, the outer of which is flattened ect-mesally, of nearly uniform width, distally rounded, clothed with long bristles on mesal side; the inner branch also flattened or plate-like, bent cephalad and, as seen from ventro-caudal aspect, appearing expanded at free end into a foot-like shape with the toe mesal and the heel ectal in position. Each of the posterior gonopods enclosed or embraced at base on ectal side with a low plate the extended ends of which bend about it in front

and behind; an inner process which is a narrow thin plate for most of its length, terminating apically in a slender spine which curves cephalad in a sort of hook; outer division consisting of a long slender style or spine which is bent apically and ends acutely, this lying against a twisted plate-like division which at its end is sharply bent about the styliform division some distance below the end of the latter. (See Pl. XI, fig. 9).

Number of segments 46.

Length about 18 mm.; width 1.8 mm. (male).

Locality: Las Valles, New Mexico, (Prof. T. D. A. Cockerell, coll.).

A male and female are in the collection, the description above being that of the male.

Paraiulus garius sp. nov.

Head with brown band bordering labial and clypeal margins, the lower mesal portion of the clypeus being pale, its upper portion of same color as the border but not solid, the dark color a mottling or network over a paler background; a black transverse band between the two black eyes, this band concavely excised on front each side of middle and enclosing a pair of small light spots near median line; vertex of head covered with close network of black or deep brown color over a lighter background, a similar or somewhat paler network covering the stipes of mandibles laterally. Antennæ dark purplish brown or blackish. Body dark or dusky brown the lower portions of sides and the venter paler; a continuous dark median longitudinal line along dorsum and a row of black dots along each side beginning at about sixth segment; a darker ring of more solid color about anterior portion of each segment; a subcircular patch of closely placed light dots on lower portion of each segment, and between this patch and the black dot an elongate patch similarly formed, while dorsad of the black spot is a third area and between the latter and the mid-dorsal line and elongate narrow band or line of such light dots; caudad of the latter line and parallel with it is a light line or narrow band partly encircling the segment but fading out ventrad on each side, this light line being continuous, not broken into dots. First segment dark along both anterior and posterior borders. Anal scutum dark brown, the ventro-caudal margins pale. Anal vales with cephalic portions dark brown, the meso-caudal portions light. Legs proximally clear yellow or light brown, the distal articles covered with network of dark purplish brown.

A deep transverse furrow between mesal angles of eyes, to which the median longitudinal sulcus across vertex extends. A row of setæ along labral margin as usual and also a second row of about nine short setæ across lower portion of clypeus, the latter row being inversely V-shaped with the angle very obtuse.

Antennæ of moderate length, slender, not strongly clavate.

Lateral borders of first dorsal plate not produced; ventro-caudal angle in outline sub-rectangular, the vertex rounded, the margin from here running obliquely cephalo-dorsad; anterior margin widely rounded,

the caudal nearly straight, both margined, more strongly so ventrad over lateral portions. Two deep longitudinal striæ across plate dorsad of lateral margin on each side.

Segments deeply striate beneath and on lower sides, the striæ on some anterior segments extending dorsad nearly to the black spot.

Repugnatorial pores moderate, well separated from the transverse suture which at this level is very weakly curved, remaining almost straight.

Anal scutum with apical process straight, acute, not at all decurved, somewhat exceeding the anal valves; bearing four setæ along each caudo-lateral margin. (See Pl. XII, figs. 6 and 7).

Anal valves with mesal margins elevated, the elevated ridge crossed by a series of transverse sulci; each vale widely depressed caudad of and not quite parallel with the margins of anal scale. Each valve bearing two setæ ectad of elevated mesal border, one at about one-third the distance from each end. (See Pl. XII, fig. 6).

Anal scale with caudal margin subsemi-circular, the lateral angles a little extended; anterior margin widely convex. A little cephalad of caudal margin two pairs of setæ borne on tubercles. (See Pl. XII, fig. 5).

Appendages of the second segment in female consisting of a plate presenting on each side a caudo-ventrally directed lobe which in lateral aspect appears clavate and is densely covered with bristles. Springing from the anterior portion of segment between the folds of plate is a pair of very small leg-like appendages distinctly jointed and terminating in a straight transparent claw; these appendages strongly suggestive of homology with the anterior pair of ordinarily ambulatory appendages of other segments. (See Pl. XII, fig. 8, a drawing from lateral and somewhat anterior direction of a specimen in which the first segment has been partly separated from the second the better to expose the parts; a leg of first segment is shown at left.)

Segments 52.

Length ad 31 mm.; width 2.2 mm. (female).

Locality: Tolland, Col. (Elevation, 8,000 ft.). Two female specimens collected by Prof. Cockerell in Aug., 1911.

Family Polydesmidæ.

Genus **Polydesmus**

Polydesmus bonikus sp. nov.

Dorsum appearing dark brown from a close network of dark reddish brown lines over a ground of light brown; prozonites light brown; a black median dorsal line which is most distinct posteriorly. Head mostly light brown, mandibles and lateral portions palest, median portion covered with areolation of dark brown lines, a dark reddish brown band across region dorsad of level of antennæ, and extending ventral in tongue-like form between the latter. Antennæ light. Venter yellowish, with some parts tinged with pink. Legs yellow, commonly tinged with pinkish distad.

Body with sides almost parallel for most of length, attenuated anteriorly and the last few segments also attenuated in the usual way.

Vertex crossed by a deeply impressed sulcus which ends abruptly in a very short transverse line above dorsal margin of the dark transverse band. Head clothed with intermixed long and short setose hairs which are densest over frontal and clypeal region.

First dorsal plate a little wider than head inclusive of mandibles. Anterior margin weakly convex, meeting the lateral margin on each side at an obtusely rounded angle, the anterior and lateral margins together roughly hemispherical; anterior and lateral borders transparent, distinctly margined. Each lateral margin obtusely incised at a point about one-third the distance from the caudo-lateral angle to the antero-lateral, but no teeth present. Caudal margin concave mesally and convex at each side, bow-shaped. Depressed longitudinally each side of median portion which appears elevated, more especially so caudad.

Second dorsal plate with lateral portions moderately bent cephalad touching or a little overlapped by the first plate. An acute tooth at antero-lateral angle; a little caudad of this a lower, very obtuse denticulation and half way between this and the caudal angle a third very weak or obscure denticulation. A broad longitudinal depression or furrow on each side somewhat less than half the distance from middle to lateral margin of plate. Tubercular areas very weakly developed, plate being nearly smooth.

Third plate very similar to the second but the lateral margins a little shorter. Caudo-lateral corner sub-rectangular, a little obtuse. Lateral teeth as on the second.

Fourth plate with lateral margin much longer than that of second and third plates. First and second denticulations smaller; antero-lateral angle well rounded.

Subsequent dorsal plates similar to the fourth. All with the lateral longitudinal depression as described for the second. Transverse sulcus weak. Distinctly margined caudally and laterally and along free portion anteriorly. The lateral denticulations very small; a fourth weak denticle appearing on some plates caudad of the third. Caudo-lateral angles becoming in posterior segments moderately produced caudad.

Anal scutum with process obtusely rounded and bearing long setæ. Dorsally with conical setigerous tubercles.

Anal valves broad, rounded laterally and caudally. Margined mesally and also caudally and laterally, the lateral margin wide.

Anal scale roughly triangular, the anterior margin convex, the caudo-lateral sides very weakly convex, meeting at middle line in an acute angle.

Ventral plates with longitudinal and transverse sulci well developed.

Legs of moderate length; bristles densest distad; ultimate joint densely and subseriately setose ventrally.

First and second legs in male strongly reduced, the second pair a little larger than the first.

For structure of gonopods of male see Pl. X, fig. 3.

Length 19–20 mm.; width 2.2 mm.

Locality: Madison, Washington. (Dr. E. Bergroth).

Family Xystodesmidæ.

Genus **Xystocheir** Cook.

Xystocheir taibona sp. nov.

Tegument thin, translucent, horn-brown in color, the carinal margins pale brick-red; prozonites paler; pigment about dorsal vessel commonly showing through as a dark median line. Head very light or whitish shining brown, a triangular dark spot below each antenna formed of closely arranged small dots. Antennæ light yellow or whitish. Legs pale yellow or yellowish brown, darker proximally. Venter and sides pale brown to yellowish.

A sharply impressed median sulcus crossing vertex and ending abruptly at about level of upper margins of antennal sockets or but little lower, crossing near its distal end a shallow furrow which arches across from the dorsal edge of one antennal socket to the other. Vertex smooth and shining. A few scattered bristles over frontal and clypeal region.

Antennæ rather long, uniform; clothed with rather short hairs intermixed with long bristles, especially on proximal segments.

First dorsal plate a little wider than the head, shorter than the second. Cephalic and lateral margins together semi-circular. Caudal margin mesally straight or very slightly incurved, laterally extending obliquely cephalad. Entire border margined. Two pairs of impressed lines, the two on each side diverging from near the mesal line caudo-laterad, the anterior one nearly straight, the posterior curved, its convexity caudo-mesad.

Second plate and those immediately following with lateral portions bent cephalad, farther back the plates becoming first straight and then with the lateral portions bent more and more caudad. In the anterior plates the cephalo-lateral portion bulges cephalad, but in proceeding caudad the anterior margin first becomes straight and then the antero-lateral corners more and more strongly rounded caudad, the posterior corners becoming at the same time more and more strongly produced. All scuta distinctly margined. Each segment crossed by two transverse sulci of which the more caudal is deepest and longer.

Nineteenth segment very short, the lateral processes ordinarily exceeded by those of the eighteenth segment.

Anal scutum with process a little depressed, truncate distally where it bears several groups long bristles, crossed with two rugose lines a double one at posterior third and the other midway between this and the apex of process, each line bearing two pairs of double setæ, two being inserted together in each case. In addition there is a marginal couple on each side of scutum farther cephalad.

Anal valves roughened; inner margins strongly elevated; each valve with two sulci extending from anterior margin caudad and somewhat laterad, the more mesal one with a double bristle inserted near its middle and each valve also bearing at its caudo-mesal angle a compact bunch of similar long setæ.

Anal scale with anterior margin incurved mesally and convex laterally, bow-shaped; each caudo-lateral margin convex, meeting its fellow of opposite side in a rounded obtuse angle. Scale crossed with a sulcus ending in the cephalo lateral corners and bending caudad across the plate; a weaker sulcus sub-parallel with this further cephalad; caudad of the first or principal sulcus and extending to caudad margin there is on each side of middle a longitudinal sulcus. Just ectad of the longitudinal sulcus on each side and nearly upon the caudal margin is a double bristle.

In the gonopods of the male the two rami on each side are fused excepting distally, the ventral one not separate and opposed to the other like a thumb as is the case in F. dissecta Wood. The principal or ventral ramus long and cylindrical, terminating in three spines which are inserted at the same level. Spines simply curved, not twisted; the ventral one flat, narrow, apically rounded; the outer one dostally bent ecto-caudad, pointed; the dorsal one most slender. (See Pl. X, figs. 1 and 2).

Length ad 28 mm.; width 5 mm.

Locality: Region of Monterey Bay, Cal. (Pacific Grove,etc.)

A very common species in this locality (Author coll., 1902, 1909, 1911).

Related to X. dissecta (Wood) but the gonopods very distinct. Xystocheir obtusa Cook and Fontaria furcifer Karsch are doubtless synonyms of Wood's species. I have specimens of dissecta from near the type locality and find them to agree with Wood's description as well as with those of the two authors mentioned, when Woods' description is correctly apprehended. The nineteenth segment is somewhat variable in length, its distal processes occasionally extending considerably beyond those of the eighteenth, while in other cases the segment may be wholly covered by the eighteenth in which case the latter might be readily mistaken for the former.

EXPLANATION OF PLATES.

Plate X.

Xystocheir taibona sp. nov.

Fig. 1. Gonopods of male, caudo-ventral aspect.
Fig. 2. The same, lateral aspect.

Polydesmus bonikus sp. nov.

Fig. 3. Left gonopod of male, caudo-ventral aspect.

Titsona sima gen. et. sp. nov.

Fig. 4. Left leg of first pair, caudal aspect.
Fig. 5. Antenna.
Fig. 6. Head and anterior segments, lateral aspect.

Buwatia monterea gen. et sp. nov.

Fig. 7. Antenna.

Plate XI.

Paraiulus tivius sp. nov.

Fig. 1. Gonopods of male, caudo-ventral aspect.
Fig. 2. Gonopods of male, lateral aspect.
Fig. 3. Third pair of legs of male.
Fig. 4. Second pair of legs of male, caudal aspect.
Fig. 5. First pair of legs of male, caudal aspect.
Fig. 6. Gnathochilarium of male.
Fig. 7. Sensory hair from lateral region of clypeus.

Paraiulus timpius sp. nov.

Fig. 8. Gnathochilarium of male.
Fig. 9. Gonopods of male, lateral aspect.

Plate XII.

Soniphilus geronimo sp. nov.

Fig. 1. Head, dorsal aspect.
Fig. 2. Head and prehensorial feet, ventral aspect.
Fig. 3. Caudal region of body, ventral aspect.

Poabius nankus sp. nov.

Fig. 4. Right anal leg, dorsal aspect.

Paraiulus garius sp. nov.

Fig. 5. Anal scale.
Fig. 6. Caudal end of body, lateral aspect, showing anal valves, scutum, etc.
Fig. 7. Same, dorsal view.
Fig. 8. Appendages of second segment of female as seen from lateral and slightly cephalic view. First segment partly separated from the second.

Plate XIII.

Poabius verdescens Chamberlin.

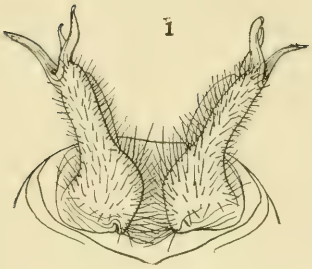
Fig. 1. Right anal leg, dorsal aspect.

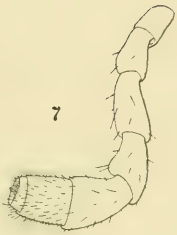
Poabius iginus sp. nov.

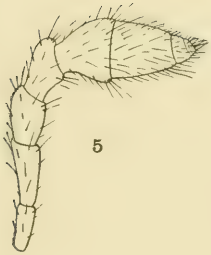
Fig. 2. Right anal leg, dorsal aspect.

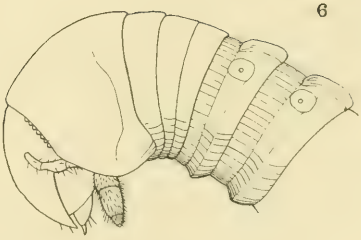
Kethops utahensis Chamb., gen. nov.

Fig. 3. Last two segments, dorsal aspect.
Fig. 4. Last segment, ventral aspect.
Fig. 5. Fourteenth ventral plate.
Fig. 6. Right anal leg, mesal aspect.









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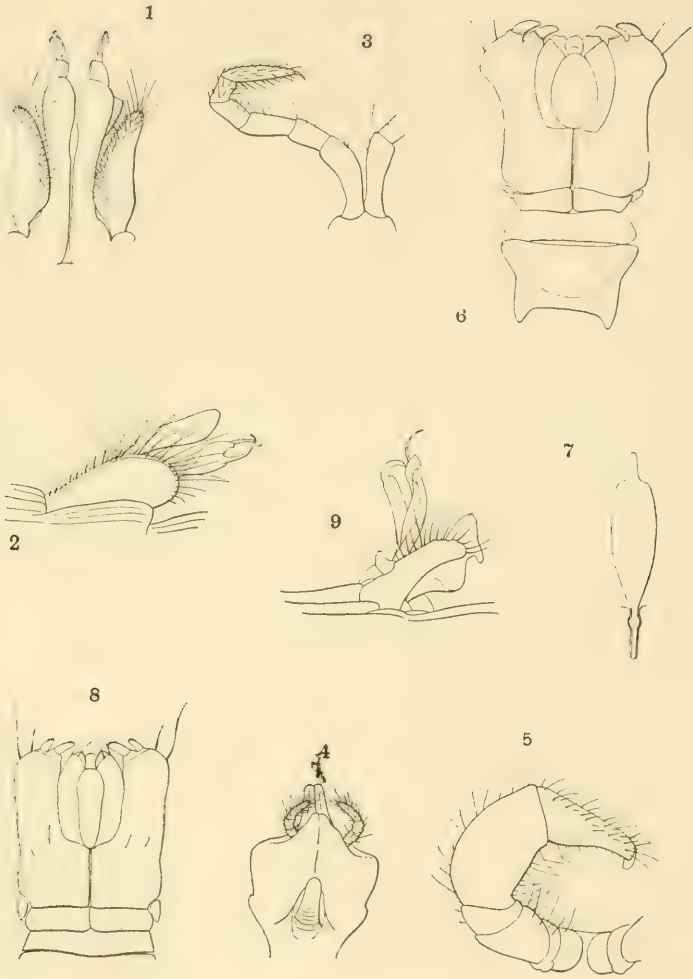

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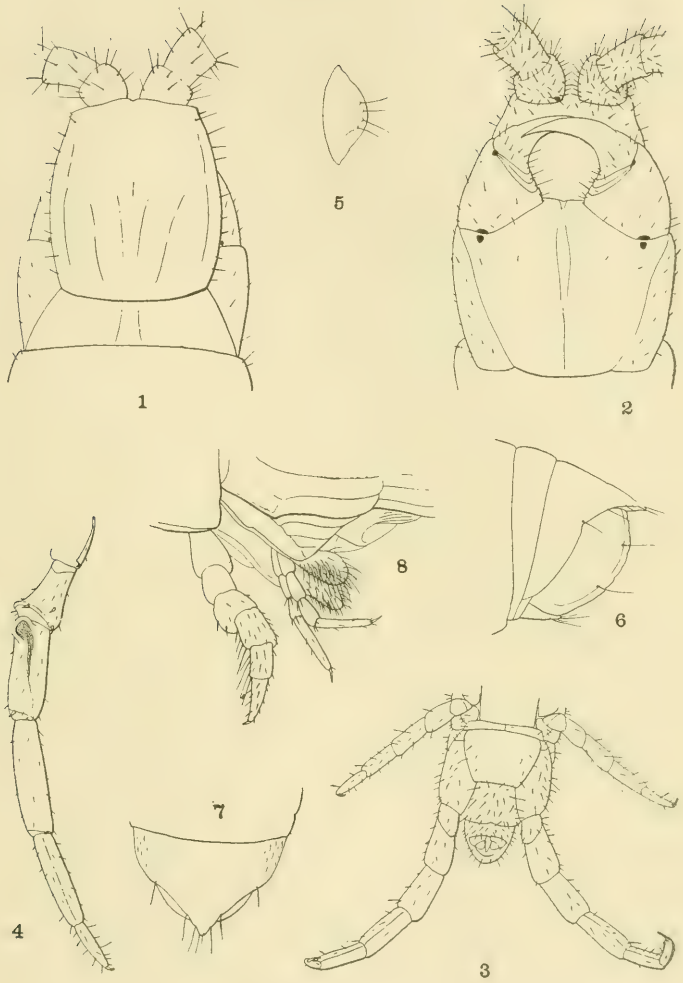

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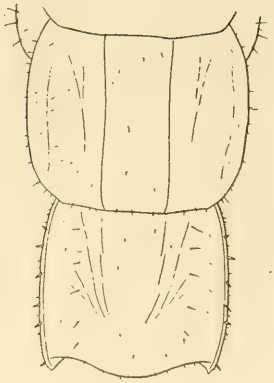

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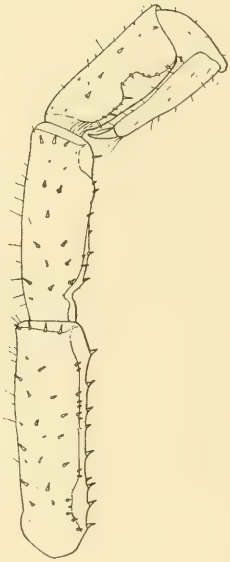

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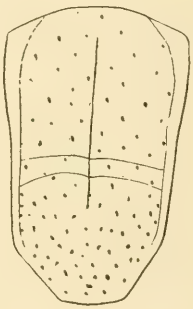

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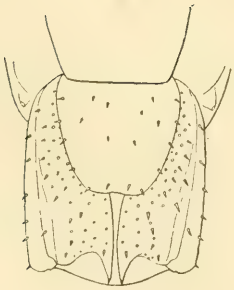


R. V. Chamberlin.

CONTRIBUTION TO THE KNOWLEDGE OF MEALY BUGS, GENUS PSEUDOCOCCUS, IN THE VICINITY OF CAPE TOWN, SOUTH AFRICA.

By Chas. K. Brain, F. E. S.

The material studied was mainly collected by the writer during 1910 and the first part of 1911. Two of the species, however, were collected by Mr. Chas. P. Lounsbury, as mentioned in the descriptions. Sixteen different host plants are involved, but *Pseudococcus capensis* was found on eleven of these, while particular attention was not paid to hosts for *P. longispinus*, which was found exclusively in greenhouses. It should be mentioned that the specimens were collected as noticed while engaged on other entomological work connected with the Department of Agriculture, and it is by no means implied that the seven species mentioned in this paper include all that are present in the Cape Peninsula.

To insure more accurate measurement of the segments of the antennae, and the setae of the anal lobes and anal ring, all specimens were stained by the Carbol Fuchsin method described in a separate section of this article. The photographs and drawings were prepared by the writer hoping that they would facilitate the determination of the species. At this first opportunity I wish to express my gratitude to Mr. Chas. P. Lounsbury, Chief of the Division of Entomology for the Union of South Africa, for much assistance in Entomological work, and also to Prof. Herbert Osborn, of Ohio State University, for his timely criticism and advice.

Pseudococcus longispinus Targ. 1867.

Dactylopius longispinus Targioni. Studi sulle Cocciniglie 1867.
Dactylopius adonidum Signoret. Essai sur les Cochenilles. Ann. Ent. Soc. Fr. 1875.
Dactylopius longifilis Comstock. Ann. Rep. Comm. Agric. 1880. Washington 1881.

This well known insect (Fig. 1) can be readily recognized by its caudal appendages, but the following particulars are added to make the series uniform and to assist in the determination of slide material.

Adult ♀. Largest specimen found measured while alive 4.1 mm., and had caudal appendages 5.5 mm. long.

Antennæ: Measurements in μ.

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements....	54–80	58–82	64–84	30–50	40–62	30–48	40–50	94–110
Most common meas'rem'ts	60.62	65.67	70.74	36.38	46.48	38.42	44	102
Average of 20 meas'rem'ts	64	70	71	39	50	40	45	101

Fig. 1. *Pseudococcus longispinus* ♀

Setæ of Anal Lobes: 110μ to 130μ, with 124 μ the most common length.

Setæ of Anal Ring: 122μ to 148μ with 134μ the most common length.

Remarks: This species is commonly found on ferns, etc., in greenhouses.

Pseudococcus citri Risso 1813.

Dorthesia citri Risso. Essai Hist. Nat. des Oranges, etc. Paris 1813.
Coccus citri Boisduval. Essai sur l'Entom. Hort. 1867.
Dactylopius citri Signoret Essai sur les Cochenilles 1875.
Dactylopius brevispinus (ex. p.) Targioni. Annali di Agricoltura 1881.
Dactylopius destructor Comstock. Ann. Rep. Comm. Agr. 1880. Washington, 1881.

This species—the common mealy-bug of literature—is easily distinguished from *P. longispinus* by the absence of the long caudal filaments, and from the other species of the locality by the fact that the waxy secretion is most scant down the median dorsal line. Its general appearance is well shown in Plate XIV, Fig. 3, which is greatly enlarged. The seventeen lateral wax appendages are often more or less wanting in old rubbed specimens, especially those living in exposed positions.

Ovisac: Small, more or less spherical, at first covered by the body of the female. As the mass increases it is generally seen as a rounded mass protruding beneath, and in front of, the insect.

Ova: Amber yellow, 320–350 μ long, and 146–165 μ broad.

Adult ♀ : Largest specimen found, with ovisac completed, measured while alive 4.45 mm. long by 2.64 mm. broad.

Antennæ: Plate XV, Fig. 5. Antennal segments, measurements in μ.

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements	52–74	58–76	52–76	34–46	36–48	36–48	40–54	96–120
Most common meas'r'm'ts	60, 66	62, 65	60, 65	42	42	44	46	108
Average of 30 meas'r'm'ts	62.6	64.5	64	39.3	43.3	42.8	47.5	106.6

Setæ of Anal Lobes: 180 μ to 270 μ with 225 μ the commonest length.

Setæ of Anal Ring: 108–138 μ with 115 μ the commonest length.

The distribution of spines and pores round the anal lobes is shown in Plate XVI, Fig. 1.

Remarks: P. citri is one of the greatest worries of nurserymen on Coleus, and was also quite common in the Cape Peninsula on Oleander.

Pseudococcus lounsburyi n. sp.

Ovisac: When complete entirely enclosing the adult ♀, large, elongate, oval, composed of threads which, when seen under the microscope have almost a glassy appearance; 4.5 mm. long, by 2.25 mm. broad. Large numbers of ovisacs were often found matted together between leaf-bases, sometimes forming a mass two inches long by almost as wide.

Ova: Closely surrounded by fibres of the ovisac; orange yellow, 340 μ long by 176 μ in diameter.

Larvæ: Newly emerged, are nearly transparent, showing but the slightest tinge of the usual purplish coloring 680 μ long and 260 μ broad; antennæ transparent, of 6 joints.

Male: Puparium small, brownish white. Adult of the usual Pseudococcus ♂ form (see figure) with body purplish red in color, .9 to 1.020 mm. in length and .255 mm. across the thorax, the widest part of the body; legs and antennæ pale yellow, and semi-transparent. Antennæ of 10 joints, .564 mm. long, eyes black; caudal appendages, when living, two stout, .255 mm. long, and two more slender, nearly half as long. Males emerge November and early December.

Fig. 2.
♂ of *Pseudococcus lounsburyi*, greatly enlarged.

Adult Female: At the time of spinning the ovisac, large, 3.7 mm. (4.1 mm. with caudal appendages) by 1.65 mm. broad, becoming somewhat narrower towards the anterior and posterior ends; color purplish, showing distinctly through the ashy white secretion; segmentation very distinct; legs and antennæ very pale; lateral wax appendages absent, caudal ones stout at base, somewhat conical, snow white, and appearing granular. Inner pair longer and stouter than the outer ones. Until the females attain approximately the size 2.4 mm. long by 1.1 mm. broad they remain free-moving. (Plate XIV, Fig. 4). After this the ovisac is commenced—a silky mass which ultimately completely envelopes the insect. This is spun from the posterior end forward, as shown in Figs. 5 and 6, until, in the end, it forms a complete covering for the female, and later the ova.

Antennæ: Plate XV, Fig. 6.

Segments—measurements in μ.

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements	56–66	64–72	43–52	26–36	33–48	26–30	36–42	88–100
Most common meas'r'm'ts	60	68	46	28	42	28	36	88–92
Average of 10 meas'r'm'ts.	61	69	47	28	42	28	37	92

Setæ of Anal Lobes. 144μ to 160μ long (from 5 measurements).

Setæ of Anal Ring. 104μ to 128 μ long.

Unfortunately, although 35 specimens were mounted, nearly all the setæ of the anal lobes were lacking. It commonly happens in clearing specimens in K O H etc., that a number of the hairs, spines, etc., are lost but I have never found it occur to such an extent as in this species. Plate XVI, Fig. 2 shows the distribution of spines and pores round the anal lobes.

Type Slide: On this slide are three specimens, arranged, with the slide in front of one as labeled, in the form of a triangle. The insect at the apex is here described as "a," the one at the left as "b," and the one on the right as "c."

Specimen "a": Size, mounted, 2.8 mm. long by 1.4 mm. broad.

Pores of derm small and scattered, sparingly supplied with small hairs, especially across the middle zones of segments. Hairs on dorsal surface more numerous and longer, sometimes attaining length of 90 μ.

Antennal segments: One antenna folded. Segments of other, in order 1 to 8, measured in μ are 58, 68, 48, 36, 42, 27, 36 and 89. It should be mentioned that Segment IV, measuring, in this specimen 36 μ is the longest found in the whole series. The usual length for joint IV is about 28 μ.

Setæ of Anal Lobes. 154 μ, 160 μ.

Setæ of Anal Ring: About 128 μ.

Legs: The measurements of the legs on the right side of the insect—left side as mounted with ventral side up are given in μ. It should be noticed that seven measurements are given, and the illustration shows the scheme adopted. The Coxa and trochanter are unsatisfactory as

regards measuring in many instances and the method adopted in the scheme used here is to obtain measurements in direct lines from points which remain definite with different ways of folding of the legs in mounting. Hence the trochanter is measured with the femur.

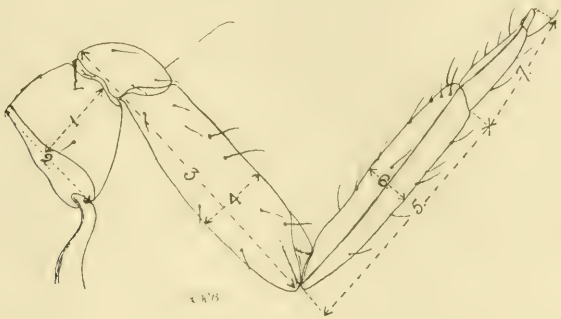


Fig. 3.
Right metathoracic leg of *Pseudococcus lounsburyi* ♀ illustrating scheme of measurments.

The measurements in μ are given in the following order:

1. Length of coxa.
2. Breadth of coxa across base.
3. Length of trochanter plus femur.
4. Breadth of femur.
5. Length of tibia.
6. Breadth of tibia.
7. Length of tarsus plus claw.

Prothoracic leg.....	83	129	281	76	190	38	106
Mesothoracic leg.....	83	121	304	76	205	40	106
Metathoracic leg.....	90	129	334	79	243	48	121

Specimen "b": Size mounted 3.2 mm. by 1.6 mm.

The measurements of the segments of the antenna (one lacking) in this insect illustrate a very good average for the material collected. They are: 58, 64, 44, 26, 42, 28, 36 and 91 μ. The Setæ of the anal lobes unfortunately are missing, while those of the anal ring average from 120μ to 128 μ.

Specimen "c": Size mounted 3 mm. by 1.5 mm.

Antennal Segments: Right—56, 64, 43, 28, 33, 27, 38, 88. Left - 62, 64, 43, 27, 38, 28, 36, 88.

The fifth segment of the right antenna in this insect measures only 33 μ. It is a coincidence that this is the least measurement found for this segment, and it is on the same slide as the specimen showing the maximum length for segment IV. One of the setæ of the anal lobes is missing. The one remaining measures 156 μ, while those of the anal ring average about 108 μ.

Host Plant: Agapanthus umbellatus L'Hérit.

Remarks: This species was first found by Mr. C. P. Lounsbury on the leaf-bases of this plant in the grounds of Indian House, Kenilworth, on September 10, 1910.

Pseudococcus capensis n. sp.

Ovisac: Large, 4.2 mm. long by 3 mm. broad, white, fibrous.

Ova: Bright orange yellow, 344 μ–390 μ long by 170 μ–190 μ broad.

Adult ♀: Largest specimens found were 4.2 mm. long and 3.4 mm. broad. Waxy secretion usually scant, lateral filaments short and very slender; caudal ones (2), when insect is in sheltered spot, sometimes attaining half the length of body.

Antennæ: Plate XV, Fig. 3.

Segments, measurements in μ.

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements	60–76	76–90	76–92	36–50	52–64	36–45	40–52	96–115
Most common meas'r'm'ts	68	80	80	40–42	56–62	40	44	104
Average of 20 meas'r'm'ts.	68	81.5	81	42	59	39	44	105.5

Setæ of Anal Lobes: 117 μ–152 μ, most common length about 128 μ.

Setæ of Anal Ring: 154 μ–180 μ, most common length about 160 μ.

Plate XVI, Fig. 3, shows distribution of glands, etc., round anal ring.

Type: Size mounted 3 mm. by 1.86. Dermis with small scattered pores on ventral surface, with scant short hairs. Dorsal surface with scattered, large pores, some at anterior end with hairs reaching 96 μ in length.

Antennæ: Segments, Right—70?, 80, 72, 50, 53, 40, 43, and 110 μ. Left 75?, 80, 75, 45, 56, 42, 43, and 107 μ.

Setæ of Anal Lobes about 117 μ long, those of *Anal Ring* about 160 μ long.

Legs: measurements in μ.

Prothoracic leg	83	129	304	91	228	38	114
Mesothoracic leg	98	129	327	91	258	38	121
Metathoracic leg	98	129	357	95	311	53	129

Remarks: This species was found on a number of different host plants, viz.: *Phytolacca dioica* Piper, *Albizzia lophantha*, *Solanum sodomæum* Linn., *Clematis vitalba*, *Pelargonium* sp., *Sonchus oleraceus* Linn., *Senecio vulgaris* Linn., *Malva parviflora* Linn., and *Oxalis cernua* Thunb. It was also found on vines at Constantia and on stored pumpkins at Stellenbosch. The following notes made at the time of collecting the material illustrate some phases of the life-history of this species:

(a) On *Phytolacca dioica* Piper, at Rosebank Station. July 17, 1911. Fruit clusters nearly all fallen. These were heavily infested with Mealy Bug, and on falling to the ground many of the adult females made their way back to the trunks of the trees. At this date many females are to be seen walking about the bark, while the trunks are quite noticeable from the number of ovisacs spun in the cracks of the bark. In the four trees there must be some thousands of ovisacs within five feet of the ground, while in one case they are numerous to a height of 25 to 30 feet.

(b) On *Albizzia lophantha.* In winter this species is commonly clustered on the crowns of young seedling plants of this species immediately below the surface of the ground. Others are found in cracks in the bark of larger trees and later in the season when the leaves and flowers appear the insects are scattered over the whole tree. Large numbers of ovisacs have been found matted together in the seed pods.

(c) On *Stored Pumpkins* at Stellenbosch. Dec. 15, 1910. On this date I collected full-grown females (3–4 mm.) from pumpkins of the Turk's Head variety which had been stored on a roof (galvanized iron) for some months. Numerous completed ovisacs were present. All specimens were below the pumpkins and had the appearance of having remained there for a long time. The pumpkins were exceedingly hard and dry and were on a hot, dry, exposed roof, but the insects were quite healthy looking and lively.

(d) On *Vines at Constantia.* Jan. 3, 1911. This material was collected by Mr. C. P. Lounsbury who states that at this date females of all stages were present in the vines but very few had entered the bunches themselves, which were small at that time.

Pseudococcus wachendorfiæ n. sp.

Ovisac: No definite ovisac was found, although where the adult ♀ was situated a definite white granular patch of waxy secretion was noticed on the plant.

Adult ♀ : Largest specimen found measured while alive 4.1 mm. long and 1.9 mm. broad. The body was finely covered with granular secretion, white, but segmentation was still conspicuous. Lateral appendages of wax were absent, but a short caudal tuft was generally noticeable.

Antennæ: Plate XV, Fig. 2.

Segments: Measurements in μ.

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements	60-68	44-64	32-56	18-26	28-44	20-28	28-36	66-96
Most common meas'r'm'ts	60	60	44	24	36	24	28.32	80
Average of 10 meas'r'm'ts.	64	56	43	23	36	24	31	78

Setæ of Anal lobes: 154 μ–180 μ with commonest length about 160 μ.

Setæ of Anal ring: 115 μ–144 μ with commonest length about 136 μ.

Plate XVI, Fig. 4, shows distribution of pores etc., round anal lobes.

Type: Specimen mounted measures 2.7 mm. long by 1.8 mm. broad.

Dermis, with numerous scattered pores and numerous short hairs or spines, especially along the median zones of the segments. On the dorsal surface, towards the anterior end, the hairs are numerous and longer, some reaching 72 μ in length.

Antennæ: The segments measured in μ are: ?, 53, 43, 25, 28, 27, 32 and 80 μ on one side, and 64, 56, 44, 22, 32, 26, 31 and 80 μ on the other. The Setæ on the anal lobes are 155 μ and 158 μ while those of the anal ring average about 136 μ.

Legs: Measurements in μ.

Prothoracic leg	91	121	334	83	212	42	91
Mesothoracic leg	106	136	342	91	235	45	98
Metathoracic leg	129	152	364	91	281	54	114

Remarks: This species was only found on *Wachendorfia paniculata* Linn. The material was collected by the writer on Newlands Flats, about eight miles from Cape Town, on October 3, 1910. The mealy-bug was found on thirty per cent of the plants of this kind pulled up in an area of about two hundred yards square, but was not once found above the surface of the ground. It was between the leaf-bases, and extended from half to one and a half inches down. The ground was composed of white sand. Ants were in constant attendance and had in some cases raised the sand slightly around the stem of the plant. It was this fact that attracted my attention. It was noticeable that some half-mile away, where the plant was fairly plentiful again, no mealy-bug could be found. It might be suggested that the colonies of ants have something to do with the distribution as the plants are generally somewhat scattered.

Pseudococcus muraltiæ n. sp.

Ovisac: Spherical, 2.3 mm. in diameter, white, fibrous. Large clusters of ovisacs occur sparingly, and are generally overrun by ants. Plate XIV, Fig. 1 shows such a cluster three-fourths natural size.

Ova: Orange yellow in color, oval, averaging 240 μ long by 180 μ wide.

Larvæ: (a) newly hatched, orange yellow, legs and antennæ pale, transparent. The larvæ in this stage are very active, oval in form, measuring 358 μ long by 170 μ broad. (b) later, 544 μ long by 255 μ broad. Antennæ of 6 joints, about 170 μ long. Eyes conspicuous, black. Measurements of the larval antennæ in μ gave the following lengths for the segments: 20, 22, 16, 18, 20 and 68 μ. Larvæ began to emerge from ovisacs kept at room temperature on October 25th.

Male: not found.

Adult ♀ : (Plate XIV, Fig. 2) small; largest specimen, with completed ovisac, was 1.9 mm. long by 1.13 mm. broad, slatey-gray in color; waxy secretion scant but segmentation conspicuous. Lateral appendages were absent but usually four caudal ones present, the longest of which measured 330 μ. Color in boiling K O H black, then purple.

Antennæ: Plate XV, Fig. 1.

Segments: measured in μ.

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements	32–42	34–40	26–34	16–23	21–25	20–24	25–32	72–84
Most common meas'r'm'ts	40	38	30	20	24	22	28	82
Average of 10 meas'r'm'ts.	39	38	31	20	23.5	22	29	82

Setæ of Anal Lobes: 120μ –150μ, most common length about 130 μ.

Setæ of Anal Ring: 96 μ –120 μ, most common length about 108 μ.

Plate XVI, Fig. 5, shows the distribution of spines, etc., round anal lobes.

Type Slide: This slide has two specimens mounted on it, but the one to the left as slide is labeled is considered the type specimen. (Specimen A).

Specimen A: Size mounted 1.6 mm. by 1.14 mm.

Dermis: Pores very scattered. Those on the dorsal surface generally larger than those of ventral surface. On both surfaces are a few scattered hairs. Some of these on the dorsal surface, towards the anterior end are long and very slender, reaching in a few cases 90 μ long.

Antennæ: Right—34?, 34, 26, 20, 24, 20, 25 and 78 μ. Left—40, 35, 26, 16, 24, 20, 25, and 80μ .

The setæ of the anal lobes are 128 μ long, while those of the anal ring average about 112 μ.

Legs, measured according to scheme given with description of *P. lounsburyi* are:

Prothoracic leg	45	75	159	60	98	30	84
Mesothoracic leg	45	76	170	60	98	30	98
Metathoracic leg	53	84	190	60	128	28	106

Specimen B. Size mounted is 1.67 mm. long and 1.18 mm. broad.

Antennæ: Right—?, 36, 32, 17, 24, 22, 30 and 72 μ. Left—?, 38, 31, 16, 24, 20, 27, and 78 μ.

The Setæ of the anal lobes are 128 μ and 134 μ long while those of the anal ring seem to vary between 98 μ and 104 μ.

Host Plant: *Muraltia heisteria*, D. C.

Remarks: As far as is known this small species has only the one host plant. It was found by the writer on the Cape Flats east of Newlands and Rondebosch.

Pseudococcus fragilis n. sp.

This material was collected on oranges at Constantia by Mr. C. P. Lounsbury on October 19, 1910. Unfortunately, I have no notes with me concerning the living insect, and have no particulars of the ovisac, etc. The insect is so distinct from the other species collected in the district, however, that I will give the measurements from the slide material, and hope to complete the description on my return to the Cape.

Adult ♀: Size of largest mounted specimen 4 mm. long and 2.4 mm. broad. The integument appears exceptionally delicate, the antennæ unusually long, (Plate XV, Fig. 4) and the spines and setæ unusually thin and fragile, and, in mounted specimens, very much bent.

Antennal Segments:

Joints	I	II	III	IV	V	VI	VII	VIII
Range of measurements	64–70	72–90	80–100	56–62	60–84	50–64	48–60	104–120
Most common meas'r'm'ts	64	76	88	58	64	52	56	112
Average of 10 meas'r'm'ts.	66	80	90	57	70	53	55	114

Setæ of Anal Lobes are about 230 μ long.

Setæ of Anal Ring are about 192 μ long.

Plate XVI, Fig. 6, shows the distribution of spines, etc., round the anal lobes.

Type: Size mounted 4.0 mm. by 2.4 mm.

The pores and hairs on the dermis are scant and the latter are very thin. Near the anterior end, on the dorsal surface are a number of long delicate hairs, some of which reach a length of 160 μ or possibly more.

The Antennal Segments measure: Right—64, 84, 96, 58, 74, 54, 51, 118 μ. Left—64, 80, 96, 60, 80, 50, 56, 116 μ.

The Setæ of the anal lobes measure approximately 224 μ long, while those of the anal ring probably average about 196 μ in length.

Legs measured according to scheme given for *P. lounsburyi.*

Prothoracic leg	121	167	364	106	250	38	136
Mesothoracic leg	129	167	417	102	304	38	144
Metathoracic leg	129	159?	432	106	342	45	144

Host Plant: Orange.

STAINING COCCIDAE FOR DETERMINATION, WITH SPECIAL REFERENCE TO THE GENUS PSEUDOCOCCUS.

During 1910, and the first part of 1911 the writer collected material in the vicinity of Capetown, South Africa, for the purpose of determining what species of the Genus *Pseudococcus* Westwood, were to be found in that locality. Specimens were obtained from twenty-one different kinds of plants, and a series of experiments made to determine which was the most satisfactory way of mounting them for study. Everyone who has worked with this genus will appreciate the difficulties encountered in the determination of species, and also the unsatisfactory nature of the majority of the descriptions given for described species. Most of these descriptions simply give the size, color, amount of waxy covering, antennal formula and host plant. If different descriptions of the same species are available it will at once be seen how variable are the facts given. Smith* (1911) discusses this fact and shows the futility of many of the specific characters generally used.

Notwithstanding the fact that the mere antennal formula is of little value, the relative size of the antennæ as a whole, and of the segments separately, is a very useful character *when the actual measurements are given.* This, together with the average size of the adult ♀ at the time of oviposition, the comparative lengths of the setæ of the anal lobes with those of the anal ring, the nature of the integument and the distribution of pores and spines, furnish, I believe, the best characters obtainable.

For all these characters, except the length of the individuals, specimens cleared and mounted in the usual manner are not the most satisfactory. With regard to the joints of the antennæ especially does this apply, for such specimens are too clear, and the distinction between the joint itself and the conjunctiva is indistinct. Referring to this fact, Smith (loc. cit. p. 313) states: "The chitin is not continuous from one segment to the next and consequently the portion between the chitinous parts of the segments, the conjunctiva, is not visible or only slightly so in well cleared specimens. Consequently, in making

P. E. Smith. "Specific Characters of the Genus Pseudococcus." Ann. Ent. Soc. Am. IV, No. 3. Sept., 1911.

measurements, the determination of the end of a segment will be only approximately at the center of the conjunctiva. This difficulty will be increased if there are some bends in the antennæ."

To overcome this difficulty a number of methods of staining were tried, but the one given below proved the most satisfactory and gave excellent mounts.

Puncture the specimens with a coarse needle or the point of a fine scalpel and treat with K O H in the usual manner. After washing in water transfer to strong Carbol fuchsin and leave until deeply stained. Specimens may be left in this for an hour or more, or over night if the stain is diluted. Wash in weak alcohol and bring up to 95% or absolute alcohol. By the time this stage is reached the specimens should be uniformly deeply colored but translucent. Place in clove oil to clear and bleach. The action of this is slow, and the condition of the specimens can be regulated so that any degree of staining can be retained. If left sufficiently long the integument will be quite clear except for the more highly chitinised parts, i. e., antennæ, legs, mouthparts, spines and pores. At this stage the specimens make exceedingly beautiful slides and quite satisfactory mounts to work with. Specimens should be passed from clove oil through xylol into balsam. The illustration shows a photograph from such a mount.

Fig. 4. Microphotograph of right antenna of *Pseudococcus* sp. showing pseudo-articulation of segment viii.

Armoured scales, (also Mallophaga, Pediculidæ and other soft-bodied insects) may also be improved for purposes of study by a very simple method. After treating with K O H and bringing through the alcohols the specimens should be cleared in Beechwood Creosote to which a little Picric Acid has been added. This turns the creosote a bright brown but does

not interfere with its clearing properties. By this means chitin is stained a bright sulphur yellow. From this the specimens may be mounted direct, but are probably better when passed quickly through xylol or clear creosote into balsam.

EXPLANATION OF PLATES.

PLATE XIV. Fig. 1. Cluster of ovisacs of Pseudococcus muraltiæ ¾ nat. size. Fig. 2. P. muraltiæ, ♀. Fig. 3. P. citri. Fig. 4. P. lounsburyi, ♀♀, before ovisac is begun. Fig. 5. P. lounsburyi, ♀, with ovisac begun. Fig. 6. A slightly later stage.

PLATE XV. Antennae. Camera lucida drawings, all of equal magnification, for comparison of size.

PLATE XVI. Fig. 1. Pseudococcus citri. Fig. 2. P. lounsburyi. Fig. 3. P. capensis. Fig. 4. P. wachendorfiæ. Fig. 5. P. muraltiæ. Fig. 6. P. fragilis.

NEW POSTAL REGULATIONS.

The following statement of the revised regulations of the Post-office department concerning the transmission of insects through the mails has been kindly supplied by Dr. L. O. Howard, Chief of the Bureau of Entomology:

"Queen bees and their attendant bees, when accompanied by a certificate from a State or Government inspector that they have been inspected and found free of disease; beneficial insects, when shipped by departments of entomology in agricultural colleges and persons holding official entomological positions; other live insects, when addressed to the Bureau of Entomology of the United States Department of Agriculture, to departments of entomology in State agricultural colleges, and to persons holding official entomological positions, and dried insects and dried reptiles may be sent in the mails when so put up as to render it practically impossible that the package shall be broken in transit, or the persons handling the same be injured, or the mail bags or their contents soiled.

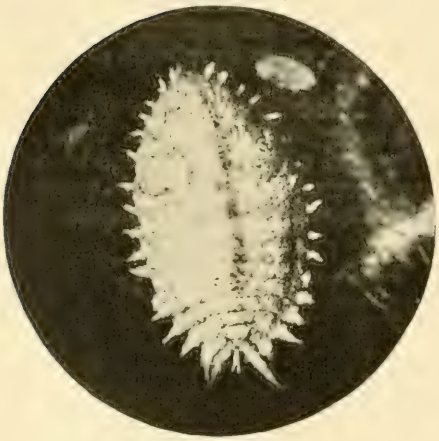
"Nursery stock, including field-grown florists' stock, trees, shrubs, plants, vines, cuttings, grafts, scions and buds (which may carry injurious insects) may be admitted to the mails only when accompanied by a certificate from a State or Government inspector to the effect that said nursery stock has been inspected and found free from injurious insects."

1. Ovisacs of P. muraltiae.

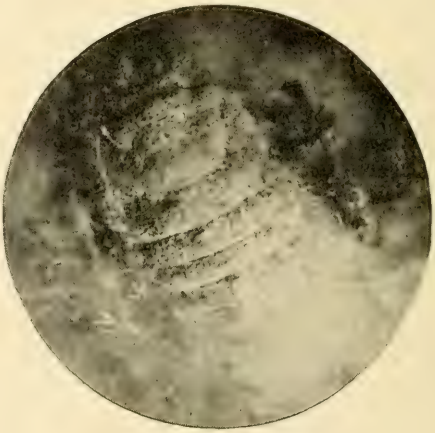
4. P. lounsburyi.

2. P. muraltiae.

5. P. lounsburyi.

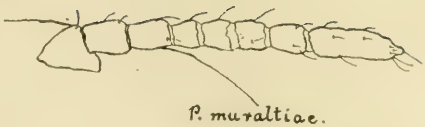


3. P. citri.

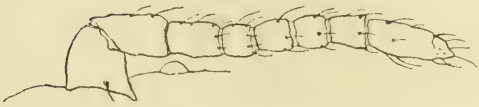


6. P. lounsburyi.

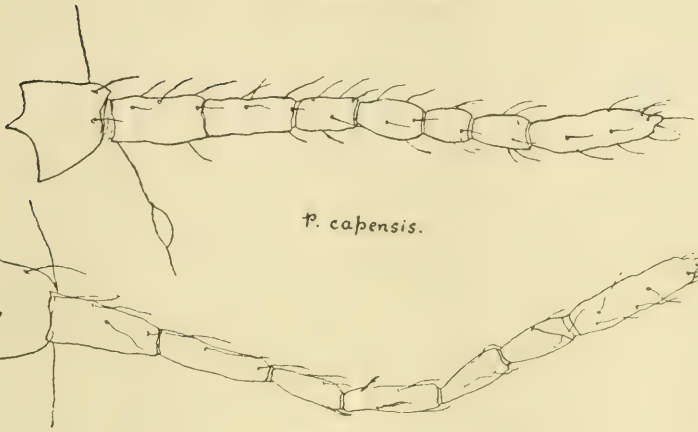
C. K. Brain.



P. muraltiae.

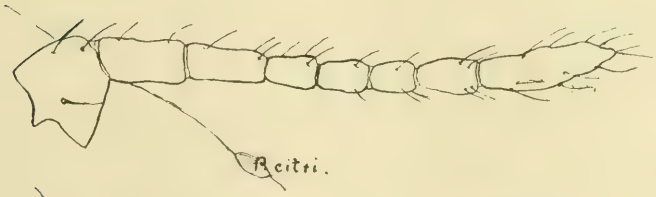


P. wachendorfiae.

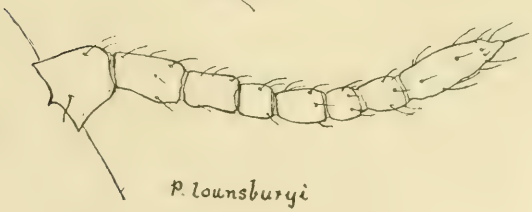


P. capensis.

P. fragilis.

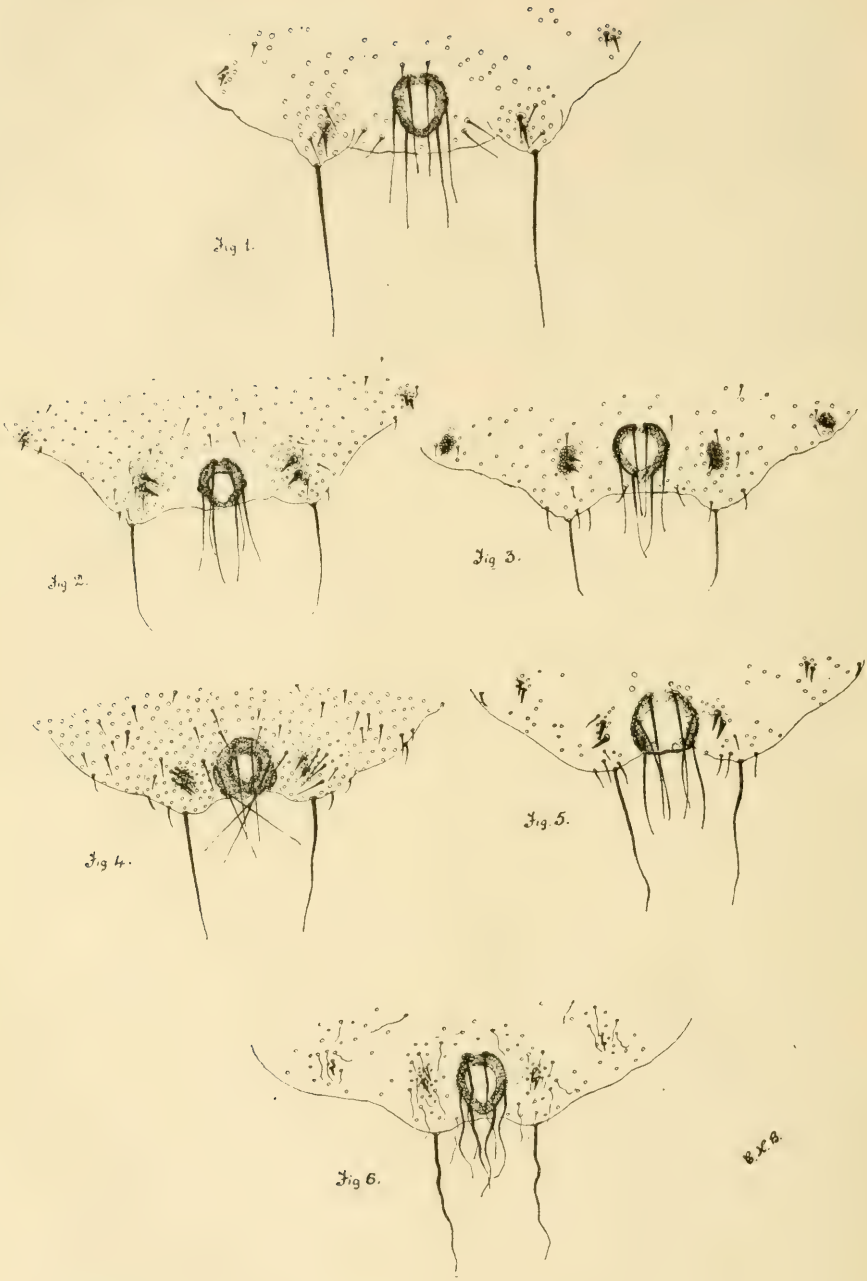


P. citri.



P. lounsburyi

C. K. Brain.



C. K. Brain.

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ANNALS

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The Entomological Society of America

Volume V SEPTEMBER, 1912 Number 3

BRAZILIAN ICHNEUMONIDÆ AND BRACONIDÆ OBTAINED BY THE STANFORD EXPEDITION.*

STANFORD EXPEDITION TO BRAZIL, 1911.
J. C. BRANNER, Director.

By CHARLES T. BRUES.

All of the species considered in the present paper were obtained by an expedition undertaken by a number of naturalists from Stanford University. The party was led by Prof. J. C. Branner, and during a sojourn of several months, they visited a number of regions where little or no entomological collecting had previously been done. Mr. William M. Mann accompanied the expedition as entomologist, and as might be expected, many of the Parasitic Hymenoptera obtained prove to be undescribed.

I have not been able to deal with every species, for example, members of the genus Ophion, as it is quite impossible to recognize with certainty some of the forms described by Fabricius and other of the earlier writers.

A number of genera are here recorded from South America for the first time, and it has been found necessary to propose new genera in several instances for the Brazilian forms.

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 55.

Family ICHNEUMONIDÆ

Subfamily ICHNEUMONINÆ

Cryptopyge obtusa Kriechbaumer.

Berliner Entom. Zeitng., Vol. 43, p. 128. 1898.

There is a female of this species from the Rio Madiera (Madeira-Mamoré, R. R. camp 43).

Kriechbaumer attributes the species to South America with some doubt, but there can be no question regarding the identity of the present female. The antennæ, broken in Kriechbaumer's type, are enlarged from the twelfth joint.

Tetragonochora cetepurange sp. nov.

Male. Length 12.5 mm. Orange yellow, marked with black, the head, pleuræ and venter paler yellow. The black markings are as follows; head above the posterior foramen over the vertex nearly to the antennæ, the yellow extending farther upward on the sides of the front and the orbits where it attains the level of the lower ocellus, on the temples it descends lower, next to the eye, passing the level of the lower ocellus; antennæ; mesonotum on its posterior two-thirds; scutellum with a large spot medially that attains the base, but not the sides nor apex; abdominal petiole at the middle with a V-shaped spot; second, third and fourth abdominal segments each with a broad band that does not attain the sides; fifth segment, except the sides; sixth and seventh and eight segments entirely; posterior knees; posterior tarsi, and apical three joints of middle tarsi. Fore wings deep fulvous on the basal half, then nearly hyaline to the black apex which begins just before the middle of the second section of the radius. Hind wings pale yellowish with blackened tips. Wing veins fulvous before the stigma, piceous beyond; stigma fuscous. Antennæ beyond the middle with the joints dentate below. Head deeply excavated above the antennæ, just below the median ocellus with a transverse tubercular elevation; face on each side with a shallow depression, separated by a median raised portion; clypeus not separated, but with a small, very deep circular impression on each side above, its lower margin straight medially and produced into an angular tooth at each lateral angle. Mandibles with two subequal black teeth. Head entirely smooth and shining, margined behind. Mesonotum minutely punctulate, the middle lobe prominent in front. Scutellum sparsely punctate anteriorly, longitudinally striated on its posterior half; margined laterally and separated from the mesonotum by a deep, longitudinally striated depression. Metathorax punctate; the superomedian area defined anteriorly, but open behind; pleural carina complete to the base of the hind coxa. Abdominal petiole aciculate, its spiracles almost linear, near the tip; second segment aciculate medially and deeply punctate near the lateral margins; third segment with same sculpture, but much finer; remainder of abdomen very finely and sparsely punctulate. Wings with four sided, obliquely trapezoidal areolet. Submedian cell longer than the median by nearly

one-third the length of the basal nervure; discoidal vein arising at the lower third of the second discoidal cell; transverse median vein of hind wing broken almost at its extreme apex.

One male collected by Mann and Baker, at Kete Purange, near Manaos, Brazil.

This species is related to *I. annulata* Brullé from Guiana from which it differs in structure and slightly in color, although of quite similar color-pattern.

Subfamily CRYPTINÆ

Megaplectes branneri sp. nov.

Male. Length 16 mm. Ferruginous, the head and anterior part of the thorax black with yellowish white markings. The entire face and mouthparts are pale, as well as the inner orbits above the antennæ, those behind the upper part of the eye, and the cheeks. The prothorax is also lined above and below, the mesopleura at its anterior upper angle, the scutellum on its sides and behind, and the whole postscutellum and the tegulæ pale. Antennæ black, with broad whitish annulus near the apex. Legs pale yellow, the four posterior ones ferruginous to the tips of the femora. Fore femora along the lower edge, last two joints of fore tarsi, a streak apically below on the middle femur, the middle tibial spurs, last three tarsal joints; second trochanter of hind leg, tip of femur, inner side of tibia and its spurs piceous or black. Wings pale ferruginous, stigma and veins black. Head smooth, impunctate, face with a longitudinal depression each side of the median line terminated below by the large clypeal foveæ; anterior edge of clypeus truncate, very faintly produced at the middle. Antennæ about as long as the body, slender and tapering, the first joint of the flagellum four times as long as thick, following decreasing in length; those toward the middle of the flagellum twice as long as thick; all except a few basal joints slightly nodosely thickened near their tips as in certain genera of Joppini although not so distinctly. Maxillary palpi with the second joint triangularly enlarged, the fifth joint very slender, nearly as long as the two preceding; labial palpi simple. Mesonotum finely, confluently punctate, without parapsidal furrows; scutellum more coarsely and sparsely punctate. Metathorax armed with a pair of unusually large and stout erect lateral spines; incompletely areolated; pleural carinæ complete, very strongly and evenly curved; basal pleural areas complete, sparsely punctate; basal median one smooth medially; hexagonal in position, but open behind, as its sides are prolonged as parallel carinæ the entire length of the metanotum; surface behind the areas transversely rugose, most roughly so behind the lateral spines. All pleuræ shining, more or less punctulate. Metathoracic spiracles elongate, four times as long as broad. Mesoëpisternal groove distinct only in front. Abdominal petiole smooth and shining, with a very few scattered punctures on the sides of the post-petiole. Second segment with deep gastrocœli, smooth at the very base; densely finely punctate elsewhere; third segment similarly punctate except at tip; following segments

faintly punctulate. Second to fifth ventral segments with a fold. Body of abdomen lanceolate, the second segment one-half longer than the third. Legs rather slender. Wings with the submedian cell longer than the median; discocubital vein with a faint stump of a vein near the middle. Areolet of moderately large size, slightly oblique, due to the insertion of the recurrent nervure beyond its middle; discoidal vein broken below the middle; transverse median vein in hind wing broken at its lower third.

Pará, Brazil. W. M. Mann. Named for Professor J. C. Branner, the director of the expedition.

This species exhibits an entirely different color scheme from its European congener, but agrees well in the more important structural details. It is the second species to be described and looks much like a genuine Ichneumon except for the palpi and spined metathorax.

Cryptus heathi sp. nov.

Female. Length 10 mm. Ovipositor nearly as long as the abdomen, exclusive of the petiole, Head, thorax and antennæ black, with yellowish-white markings; abdomen ferruginous, with narrow apical buff bands on the segments. The pale markings on the head and thorax are as follows; labrum, clypeus, except medially below; broad orbits, nearly meeting below the antennæ and covering the entire head behind below the vertex; joints 9–12 of antennæ; anterior edge of prothorax; lateral edges behind; medial spot on mesonotum; both scutellums; tegulæ; median stripes on metathorax behind carina, greatly widened behind; broad oblique stripe on mesopleura; another on posterior part of metapleura; spot behind wings; and a short stripe ventrally in front of each hind coxa. On the abdomen the white is at the base and apex of the petiole and as a narrow apical band on segments 2–7. The fore legs have the coxæ white, with black base and black spot in front and the basal trochanter white with black spot in front, the femur, tibia and tarsus fulvous with black stripe on femur above and last tarsal joint piceous. Middle legs pale ferruginous, with black spot on basal trochanter above, stripe on femur above and last tarsal joint piceous. Hind legs ferruginous, the apical two tarsal joints and tip of tibia blackened, and the three basal tarsal joints white. Wings hyaline, with piceous stigma and veins; the apex lightly infuscated and a narrow, irregular fuscous band just before the third discoidal cell, not ascending above the basal vein. Antennæ slender, 24-jointed, as long as the body; the joints very short apically, but much lengthened at the base of the flagellum; the first flagellar joint nearly as long as the eye and over six times as long as thick. Head twice as broad as thick; shining, finely margined behind, shining, sparsely punctate above the clypeus; the latter truncate; labrum exposed as a broad lobe; mandibles fuscous, black below; palpi pale, slender. Mesonotum finely, deeply punctate, the parapsidal furrows distinct and the median lobe produced forward

to the lateral ones. Scutellum nearly flat, punctulate. Metathorax evenly rounded above, finely closely punctate anteriorly, microscopically transversely rugose-aciculate behind, near the basal third with an evenly arcuate transverse carina; no trace of lateral projections or teeth; spiracles small, circular, behind them a very fine longitudinally impressed line to the base of the coxa. Pro-and mesopleuræ punctulate, a large smooth space below the insertion of the wings. Abdominal petiole shining, smooth, nearly straight below, bent above at the middle, with a longitudinal impression on each side, but without distinct carinæ; apex twice as broad as the base; spiracles barely behind the middle, second segment very finely, almost confluently punctate, following segments becoming smoother till at the tip the surface is not sculptured. Legs long and slender, the fore tibiæ swollen and greatly constricted at the base; fourth tarsal joint on all the legs very short and deeply divided for the insertion of the fifth. Wings with the stigma very narrow, radial cell narrow, as long as the cubito-discoidal; areolet small, scarcely narrowed above and with the second transverse cubitus less distinctly colored than its other sides; cubito-discoidal vein not broken; recurrent nervure received at the middle of the areolet; discoidal vein broken a short way above the middle; submedian cell shorter than the median; transverse median vein in hind wing broken well above the middle.

Independencia, Parahyba, Brazil. (Mann and Heath).

This is a very pretty species of intricate color pattern which resembles Callicryptus in the form of the tarsi, although it is otherwise very different. The areolet is unusually small, and recalls that of the Mesostenini. The color is also similar to certain Mesostenines, but I am quite positive that it is correctly located here.

Mesostenoideus (?) **crassus** sp. nov.

Female. Length 12 mm. Ovipositor one-half longer than the petiole of the abdomen. A stout species, with the general habitus of a *Cryptus*. Black, with joints 8–15 of the antennæ white above; a white median spot behind on the fifth to seventh segments of the abdomen, smallest on the fifth and largest on the seventh; legs, including coxæ bright ferruginous, the hind pair black beyond the trochanters, the middle pair beyond the knees, and the fore pair on the last tarsal joint; basal abdominal segments margined behind with rufous, especially below; wings hyaline, faintly infuscated; palpi fuscous at tips. Head broader than the thorax, nearly three times as broad as thick, arcuately excavated behind; subopaque. Front impressed and shining above the antennæ, with a fine median carina from the ocelli to the antennæ; cheeks and lower part of head behind the eyes smooth and shining. Mesonotum with distinct, sharp, but not broad parapsidal furrows which are strongly convergent behind; middle lobe scarcely elevated above the lateral ones. Scutellum slightly convex, margined at the sides of the base which is crossed by a broad, deep, longitudinally

fluted groove. Metanotum as long as the mesonotum, gradually declivous and impressed behind along the middle, the upper angles produced into sharp, pale-tipped thorn-like spines. One complete, transverse angulated carina just behind the spiracles and traces of a small median basal area. Spiracles elongate, over twice as long as broad; position of pleural carina indicated by a fine denticulate line. Surface of metanotum rugulose, with distinct transverse aciculations medially behind, its pleuræ very finely roughened. Mesopleura at the posterior margin with a grooved line which is crenate on its lower half; also with an arcuate linear impression above the center. Abdomen smooth, but opaque except on the petiole. Latter much broadened behind, the tip nearly four times as broad as the base; spiracles just before the posterior third; two carinæ above each carina which grow weaker apically; center of broadened portion longitudinally depressed. Second segment the longest, one-fourth shorter than the petiole, longer than broad at tip; following transverse. Legs stout, not much elongated Wings with black, narrow stigma and black veins. Median and submedian cells of equal length; cubito-discoidal vein broken, but little angulated by a slight tubercle. Areolet small, open, receiving the recurrent nervure near its outer angle; discoidal vein broken at the middle.

One female from Camp 39, Madeira-Mamoré R. R.

The generic reference is somewhat doubtful as the species has the stout antennæ and heavy-set body of a true member of the Cryptini. The areolet is so small, however, not closed externally, and of such characteristic Mesostenine form, that I think the species must be placed in this tribe, although it will probably find a place in a new genus.

Crypturopsis Ashmead.

There are two species in the collection obtained by the expedition, separable as follows:

1. Wings darker at tips; abdomen banded with black.....*minor* sp. nov.
   Wings not darker at tips; abdomen not banded with black..*brasiliensis* sp. nov.

Crypturopsis brasiliensis sp. nov.

Male. Length 11 mm. Head and thorax black with yellowish-white markings; abdomen and four anterior legs ferruginous; hind legs black beyond the trochanter. Wings subhyaline. The pale markings are as follows. Head both before and behind, below the level of the antennæ; inner orbits to the ocelli; large spot on each side of prothorax before and small one behind; four very much abbreviated longitudinal streaks on the mesonotum behind; spot on scutellum, a spot on each side of metanotum inward from the spiracle and a larger triangular one behind on each side; tegulæ, dash beneath them; two broad horizontal stripes on mesopleura; small basal and large medial spot on metapleura; middle part of fore coxa and middle coxa (except for irregular ferrugin-

ous marks). Fore and middle legs fulvous, paler apically and with the last tarsal joint black on the fore and the last two on the middle pair. Hind coxæ and a part of their trochanters ferruginous. Abdomen ferruginous except for the blackened tip of the petiole and small black stigmatal spots on segments 2–6, becoming obsolete on the later segments. Stigma and veins black. Head as broad as the thorax, nearly three times as broad as thick, rather thin and acute above; vertex punctulate; supra-antennal impression with a median carina and a few irregular radiating lines extending from the anterior ocellus; much deeper and shining just above the antennæ. Face slightly elevated medially, confluently punctulate. Antennæ 36–37 jointed evenly tapering to the apex, basal flagellar joint three times as long as thick, those at the middle twice as long as thick, and near apex, nearly quadrate. Clypeus at each upper angle with a fovea connected with the eye by a fine black line. Mandibles black at tips; palpi pale. Mesonotum closely punctate, without parapsidal furrows although there is a broad rugulose-reticulate streak in their place and between these behind are several short longitudinal striæ. Scutellum very convex, finely punctulate, with a broad, deep fluted furrow across the base which has high raised lateral margins. Metathorax reticulate-rugose, somewhat longitudinally depressed along the median line, its spiracles oval, twice as long as wide. Basal transverse carina present on each side, but curving forward to the margin on each side before attaining the median line; sides with a shallow groove from the spiracle to the base of the coxa, lateral angles produced as blunt teeth, coinciding with the lateral angle of the triangular pale spot. Thorax seen from above, scarcely more than twice as long as wide, truncate posteriorly. Abdominal petiole longer than the metathorax, slender, smooth, the post-petiole longer than broad, with parallel sides; following segments smooth and shining, sparsely clothed with fine, fulvous hairs. Areolet very small, open apically; submedian cell slightly shorter than the median; discoidal vein broken above the middle; transverse median vein in hind wing broken at its lower fourth.

Manaos, Brazil, Mann and Baker. One male.

Crypturopsis minor sp. nov.

Male. Length 9 mm. Similar to the preceding, but with less fulvous on the abdomen, and with the wings very distinctly infuscated apically and the antennæ only 31-jointed. Front before the ocelli rugulose, the median carina present. Color of head and thorax as in the preceding species, except that the post-scutellum is pale and the metathorax entirely black above except for the small rounded lateral pale tubercular teeth. The fore legs are pale yellow with the femora fulvus and infuscated at base and tip; the middle coxæ are yellow before and ferruginous behind and the apical three tarsal joints are black. The abdomen has the petiole entirely ferruginous and the post-petiole narrowed behind, while the following segments are black, with fulvus apical bands. Median and submedian cells of equal length. Otherwise as in *C. brasiliensis*, with the thoracic spots all somewhat smaller.

One male from the Rio Madeira (Madeira-Mamoré R. R. Camp 39), Brazil, Mann and Baker.

These are the first two South American representatives of the genus to be discovered, although three have been described from North America by Ashmead. Only one of these, dyari, is known in the female sex.

Cryptanura uniformis sp. nov.

Male. Length 12 mm. Head, thorax, and antennæ black, with white ornamentation; legs and abdomen, except part of petiole, bright ferruginous. The white markings are as follows; annulus of 6–7 segments on antennæ; clypeus except lower and side margin, face, wide anterior orbits, broad stripe behind eye, and palpi; prothorax with an elongate spot on each side above and below; mesonotum with a round spot on the middle lobe behind the tegulæ; elongate spot at side of scutellar fovea, scutellum and post-scutellum with side lines from each; metanotum with four broad longitudinal stripes on posterior half and a large spot at anterior angles; mesopleura with spot beneath wing and an elongate spot below; mesosternum with an elongate spot on each side. The legs also bear white on the anterior coxæ which are white in front and black behind, while the ferruginous middle coxæ are whitish in front. The ferruginous color is very uniform except that the anterior four legs and hind tarsi are more nearly fulvous. The apical joints of tarsi and the enlarged part of the abdominal petiole are piceous. The head is rather finely punctate on the face and clypeus, and the front bears two small spines above the antennæ; ocelli rather large, the posterior pair closer to one another than to the eye margin; eyes showing a very slight pubescence. Mesonotum deeply and sparsely punctate medially, nearly smooth on the sides, scutellum at the base with a very deep quadrate depression that is longitudinally striated. Metathorax with a complete transverse carina, joining a complete pleural one, and with a basal median and lateral area partly enclosed. Metathorax rugose-reticulate over its entire surface, more coarsely so behind, its spines long, slender, erect. Pro- and mesopleuræ smooth and shining, except for longitudinal striations below on the propleura and mesopleura. Mesopleura with a round impression medially behind, and rugose near the base of the coxa. Hind coxæ punctate near base. Petiole of abdomen very highly polished with a deep groove along the side passing below the spiracle which is situated just before the apical third of the petiole; following abdominal segments smooth, impunctate. Wings hyaline, infuscated at extreme tip; veins black, areolet very incompletely closed, the outer vein nearly hyaline. Submedian cell slightly shorter than the median; discoidal nervure inserted at the middle of the second discoidal cell; transverse median vein of hind wing broken at its lower fourth.

Described from a male taken by Mr. Wm. M. Mann, at Ceará-Mirim, Rio Grande do Norte, Brazil.

The present form approaches *C. hyalina* Brullé, which it resembles almost exactly in color, but the sculpture of the metanotum is very different.

Cryptanura striata Brullé.

Hist. Nat. Ins., Hyménop. Vol. 4, p. 244 (1846).

There is a male from Manaos (Mann and Baker) which appears to be this species, although differing from the female described by Brullé in having a short whitish stripe anteriorly on the inner edge of the lateral lobe of the mesonotum. The metanotal spines are blunt and the median metanotal stripes are abbreviated in front. The mandibles bear a large pale spot externally.

Polycyrtus histrio Spinola.

Ann. Soc. Ent. France, Vol. 9, p. 155 (1840).
Brullé, Hist. Nat. Ins., Hyménop. Vol. 4, p. 214 (1846).

There are two males of this species from Manaos (Mann and Baker).

Ophiogastrella Gen. nov.

Clypeus not pointed, truncate on the anterior margin. Eyes deeply, angularly emarginate on the inner margin. Face without a tooth, but with a faint cariniform tubercle just below the antennæ. Ocelli very large. Head strongly transverse, narrowed behind the eyes, the vertex not margined behind, although the temples and cheeks are distinctly margined. Mesonotum without furrows or parapsidal impressions at the anterior margin. Metathorax short, abruptly declivous; smooth, finely punctulate, entirely destitute of carinæ. Tarsal claws small, pectinate. Basal section of radius straight, not thickened; last section recurved. Submedian cell barely shorter than the median. Discoidal nervure arising at the upper fourth of the second discoidal vein. Disco-cubital vein very strongly bent, but not broken; its basal and apical portions running very nearly at right angles to each other. Cubito-discoidal cell without any dark chitinized spots. Transverse median vein in hind wing broken at its lowest fourth; the first section of the radius in this wing nearly twice as long as the recurrent nervure. Abdomen strongly compressed, very slender at the base, the first segment longer than the second, its spiracles placed at the apical third.

Type. *Ophiogastrella maculithorax* sp. nov.

This genus is related to *Pseudanomalon* Szépligeti, but differs in several important characters, particularly the form of the metathorax, which is neither elongate between the hind coxæ nor rugose-reticulate. From other related genera it differs

by the position of the discoidal nervure (*Banchogastra*) and by the absence of a transverse carina on the metathorax (*Pycnophion et al.*).

Ophiogastrella maculithorax sp. nov.

Female. Length 7–8 mm. Head, thorax and legs pale yellow; metathorax, antennæ at base and abdomen fulvus; remainder of antennæ and indistinct stains at anterior angles of metanotum more or less piceous; a large spot enclosing the antennæ and three broad longitudinal stripes on the mesonotum, deep blue-black. Of the mesonotal stripes, the lateral ones are abbreviated just before the anterior margin, and the median one extends from the anterior margin to just beyond the middle. Head smooth and shining; maxillary palpi slender, with the apical four joints subequal; face much narrowed below and the front above, by the eyes; the latter bare, almost attaining the base of the mandibles. Ocelli forming an equilateral triangle, separated by nearly their own diameter, the lateral ones very close to the eye margin. Entire thorax and pleuræ shining, smooth and polished, except for very fine punctulation on the mesonotum and metathorax. Mesopleura with a moderately distinct punctate impression medially. Abdomen very slender to the base of the third segment, then strongly enlarged and compressed; first segment slightly longer than the second; third, fourth, fifth and sixth subequal, each one-fourth shorter than the second; following segments very short. Ovipositor one-third shorter than the third segment. Wings hyaline, veins piceous, stigma fuscous. Legs very long and slender, tarsal claws small.

Described from three females, collected at light by Mann and Heath. Independencia, Parahyba, Brazil.

This is a small, slender species easily recognized aside from its structural characters, by the striking maculation of the mesonotum.

Ophionellus Westw.

Thesaur. Entom. Oxon., p. 128, Pl. 24, figs. 3, 3a, 3b, 3c. (1874).

Mr. Mann obtained a specimen of this remarkable genus which represents a species different from *O. fragilis* Westwood, the type of the genus. It agrees very closely with Westwood's species and is surely congeneric, but on comparing it with Cresson's *Pharsalia virginiensis*, I find that the latter is generically distinct, although the two genera have been regarded as synonomous.

The more salient differences may be tabulated as follows:

Pharsalia Cress. Sides of head behind the eyes rounded; antennæ short, filiform, about 25-jointed, but little longer than the head and thorax; anterior wing with a distinct, although small stigma.

Ophionellus Westw. Sides of head with a large tooth-like projection behind each eye; antennæ long, setaceous 40–50 jointed, nearly twice as long as the head and thorax; costa in anterior wing without thickening to form a stigma.

In addition to these differences the radial cell is much larger in *O. manni* than in *P. virginiensis*. The hind tibiæ bear two apical spurs in each case, not one as is stated by Szépligeti, although there is only a single one on the middle tibia.

Ophionellus manni sp. nov.

Female. Length 20 mm. (extended). Black, the face, clypeus, cheeks and mandibles, except teeth, yellowish-white. Fore coxæ and base of trochanters pale yellow, as are also the middle coxæ beyond the middle; fore legs rufous, slightly darker toward the knees, and paler on the base of the tarsi; middle tarsi pale on base of first joint; last segment of abdomen testaceous below. Head smooth above on the sides but rugose medially; above the antennæ with a deep depression which includes the median ocellus; face much narrowed below, only half as wide at the base of the eyes as at the antennæ, its surface shining and finely punctulate. Eyes pubescent; oval, nearly twice as long as wide. Head behind shining, punctulate, densely griseous pubescent on and about the tooth-like projection behind the eye. Head behind highly polished, margined. Ocelli large, in an equilateral triangle. Antennæ long and slender, 35-jointed; the first flagellar joint as long as the two following, rest gradually decreasing in length, those near the middle nearly three times as long as thick. Pronotum not visible from above, mesonotum much narrowed anteriorly. Its surface shining, reticulate, the carinæ forming quite regular transverse rectangular areolæ posteriorly. Scutellum sloping in a plane with the metathorax, flat, with a distinct large impression anteriorly. Metathorax long and strongly declivous, projecting considerably beyond the hind coxæ and bifurcate at its tip where the abdominal petiole is inserted. It is densely covered with very short silvery pubescence, but shows a distinct median groove and a lateral carina extending for its entire length. Besides these the surface is distinctly, but not sharply reticulated, the areolæ rectangular and transverse above and more or less polygonal on the sides. Pleuræ densely silvery like the metathorax except for the narrow smooth propleura and for a deep linear depression extending from the middle coxa to the tegula. This groove is coarsely reticulated. Abdomen very slender, the petiole as long as the entire length of the thorax above, swollen on the apical two fifths where the spiracles are placed; its surface smooth and shining, the remainder of the abdomen dull; second segment as long as the first; third, half as long; fourth almost equalling the second; fifth equalling the second; sixth, seventh and eight short. decreasing in length; ovipositor as long as the third segment. Wings perfectly hyaline; radial cell as long as the cubito-discoidal cell, the second section of the radius and the transverse cubitus interstitial; second discoidal cell as high as long above, narrowed behind; costa

without a stigmal thickening; costal vein extending beyond the radial cell for half its length. Hind wing with a single subcostal cell, and the same continuation of the costal vein. This costal projection and the costal vein in the anterior wing black, but otherwise the venation is pale fuscous.

Described from one female collected by Mann and Baker on the Rio Madeira, Brazil, Camp 39, Madeira-Mamoré R. R.

This species differs from *O. fragilis* Westw. the only other described member of the genus, by the absence of a median groove on the mesonotum and by the entirely black tibiæ. The second discoidal cell is also much shorter than the form represented by Westwood's plate.

Family BRACONIDÆ

Subfamily HELORIMORPHINÆ

Helorimorpha brasiliensis sp. nov.

Male. Length 4 mm. Entirely honey yellow, except the space between the ocelli, the entire antennæ, (except the 16th and 17th joints which are rufous) the apical fourth of the hind tibiæ, the hind tarsi and the apical joint of the other tarsi which are black. Wings deeply infuscated, blackish; with black stigma and veins. Head twice as wide as thick antero-posteriorly, smooth except for fine punctulation on the face and clypeus and still finer on the head above. Eyes small, nearly circular, one half longer than the malar space. Front with a sharp median carina extending from the upper part of the face nearly to the ocelli; strongly excavated above the base of each antenna. Ocelli small, close together in a triangle, separated by only their own diameter. Maxillary palpi slender, pale testaceous; 5-jointed, with the basal joint very short. Antennæ black, with the 16th and 17th joints distinctly rufous; scape nearly as long as the first flagellar joint and twice as long as the pedicel; third joint as long as the scape, swollen apically; following joints becoming shorter and distinctly moniliform by the middle of the flagellum, where they are only half longer than thick; again toward the tip the joints become much more slender and lose their moniliform shape. Thorax pitted and reticulate as in other species of the genus, the metathorax deeply excavated medially on its posterior face. Abdomen slender, as long as the head and thorax; petiole curved near its apical third; very slender, but distinctly broadened toward tip both in dorsal and lateral view; spiracles at the posterior third; base not striated. Second segment covering all the remaining parts of the abdomen, smooth and highly polished; narrowly ovate; one third as broad as long and slightly higher than broad; much more strongly curved below than above. Legs formed as in the other species. Wings with the radius arising perpendicularly from the middle of the stigma, the latter nearly half as broad as long; second section of radius nearly half as long as the first and as long as the hyaline second transverse cubitus. Recurrent nervure joining the upper side of the second cubital cell in a straight

line and the lower side originating at the same point so that the cell is thus three-sided. Submedian vein bordered by a hyaline streak as in *H. fisheri.*

One male collected by Mann and Baker; Manaos, Brazil.

This species is very similar to *H. fisheri* Viereck from eastern North America, and aside from the form of the antennæ and wing venation differs only in its color characters. Mr. Mann's discovery of the Brazilian form is very interesting as the first representative of the genus was discovered in 1907 by Schmiedeknecht in Europe. Shortly afterwards it was found to occur in North America.

The four species so far described may be separated as follows:

1. Wings infuscated; body yellow.....2
   Wings hyaline; at least head black.....3
2. Scape of antennæ yellow; flagellar joints twice as long as thick..... *H. fisheri* Viereck
   Antennæ entirely black, except joints 16 and 17; flagellar joints near middle of antennæ less than twice as long as thick.....*H. brasiliensis* sp. nov.
3. Body entirely black.....*H. egregia* Schmiedeknecht
   Body, except head, yellow.....*H. melanderi* Brues

Subfamily MICROGASTRINÆ

Mirax brasiliensis sp. nov.

Female. Length 2.2 mm., ovipositor as long as the head-height. Head and thorax pale honey-yellow, abdomen somewhat lighter; legs whitish-yellow; antennæ fuscous beyond the second joint; wings hyaline, with pale testaceous stigma and veins. Head transverse, twice as wide as thick, rounded on the temples behind the eyes; ocelli in an equilateral triangle, the space between them one third as great as that between the lateral ones and the eye margin. Front excavated on each side above the antennæ, the depressions separated by an elevated triangular space that extends down to the level of the antennæ. Face smooth; elevated medially, broadly so below and narrowly so above where the median line is almost carinate. Clypeus separated by a depressed line and with a large circular fovea on each side, its lower edge projecting but straight in front view. Mandibles black at tip, with two small teeth at apex. Antennæ 14-jointed, as long as the body, tapering; scape short, but little longer then the pedicel which is slightly more than half as long as the first flagellar joint; joints beyond growing very gradually shorter, none less than two and one half times as long as thick. Eyes elongate-oval, much narrower below; malar space very short, with furrow. Mesonotum with crenulate furrows on its anterior half; sharply narrowed in front of the tegulæ. Scutellum long, with parallel sides behind, but widened in front, its base with a curved, deep, linear impression which is crossed on its bottom by numerous carinæ. Metanotum irregularly areolated; with a median carina that bifurcates behind, a straight transverse carina behind, and a curved carina on each side at the base

which marks off a large squarish space at each lateral angle, and with a lateral carina which passes just outside the round spiracle. Mesopleura with a carina along its posterior edge. Abdomen sessile, as long as the head and thorax. First segment with a L-shaped shining elevated portion; the latter swollen anteriorly and widened laterally along the margin of the segment; remainder of the segment paler, whitish; second segment twice as broad as long, longitudinally striated, also pale; following segments shining and smooth, fully colored. Ovipositor ferruginous, its sheaths broad, pilose, piceous with pale yellow bases. Legs moderately stout, blackened on the tips of the tarsi. Wings with broad stigma that is produced apically into a long, narrow point; marginal cell entirely wanting; submedian cell longer than the median by the length of the transverse median vein; recurrent nervure received at the apical fourth of the first cubital cell; second cubital wanting, except for a short stump of a vein that indicates its lower basal corner; subdiscoidal vein wanting. Hind wing with only the median and submedian cells, the latter less than half as long as the former.

One female, Ceará-Mirim, Rio Grande do Norte, Brazil (W. M. Mann).

This is possibly not congeneric with the type of *Mirax* on account of its parapsidal furrows, although otherwise similar.

Subfamily CHELONINÆ

Chelonus brasiliensis sp. nov.

Female. Length 3 mm. Black; the antennal scape, mandibles, anterior legs, including most of their coxæ; trochanters, tip of femora and basal half of hind tarsi dull fulvous-yellow; palpi, tegulæ and four posterior tarsi whitish yellow. Wings subhyaline; stigma black; veins piceous, lighter brown toward the base of the wing. Head transverse, twice as broad as thick, and very short behind the eyes; finely confluently punctate on the vertex, transversely rugulose on the front and face; head behind and cheeks smooth, scarcely punctulate. Eyes oval, thickly clothed with pale pubescence, nearly twice as long as broad; malar space half the width of the eye. Ocelli in a small triangle, the posterior ones closer to one another than to the eye margin. Antennæ in a deep depression; 19-jointed, the scape subcylindrical, curved, as long as the first two flagellar joints together; first flagellar joint nearly three times as long as thick, the following becoming gradually shorter and thinner, the subapical one quadrate. Clypeus separated from the face by a sharp suture, with a foveate puncture near each side; arcuately rounded on its anterior margin; palpi normal, pale yellowish. Mesonotum and scutellum rugose-punctate, the parapsidal furrows and a scutellar margin more or less distinctly indicated by a series of larger, more regular punctate impressions. Scutellum, aside from its basal strip, nearly triangular. The basal strip sculptured across its entire extent by a series of large squarish foveate impressions. Metanotum short, declivous, rugose reticulate with several somewhat irregular areas behind. Abdominal carapace oval, rather coarsely rugose anter-

iorly; very finely so posteriorly; rounded behind. The apical opening oval twice as broad as high. Pleuræ rugose-reticulate, more coarsely so behind. Legs very stout, especially the hind pair. Stigma broadly oval, over half as broad as long, emitting the radius just beyond its middle; parastigma distinct, fuscous. Radial cell short, the postmarginal vein no longer than the stigma; length of first, second and third sections of the radial vein in the proportions of 2, 3 and 7. Submedian cell longer than the median by the length of the first section of the radius; recurrent nervure interstitial with the first transverse cubitus which it equals in length; discoidal vein broken near its lower end.

Natal, Brazil. One specimen collected by Mr. W. M. Mann. This is the first South American species to be described.

There are two other specimens, somewhat smaller and with darker legs, from Independencia, which may possibly represent another species, but structurally, there are only slight differences.

Phanerotoma trivittata sp. nov.

Male. Length 5 mm. Buff-colored, the abdomen paler, almost cream-colored; head above and hind femora yellowish; first joint of antenna fuscous, the flagellum pale ochreous yellow. Marked with black as follows; tips of mandibles, a dumb-bell shaped spot between the ocelli; an elongate spot on the mesonotum anteriorly, a longitudinal stripe on the parapsides; scutellum; spot on mesopleura below base of wing; spot before tip of all femora; anterior and middle tibiæ, except base; extreme base and apical third of posterior tibiæ. Wings yellowish at base with yellow veins and stigma; apically subhyaline, with fuscous veins, stigma slightly mottled with fuscous. Head one half broader than thick, arcuately rounded behind the prominent eyes; vertex finely rugose, the ocelli close together, the hind ones five times as far from the eye as from one another. Front just above the antennæ with a margined depression which includes the anterior ocellus and bears a fine raised median line that extends halfway down the face; face finely rugose. Antennæ 23-jointed, tapering; as long as the body; scape almost cylindrical, as long as the first flagellar joint which is four times as long as thick; following gradually growing shorter, at middle of antenna three times as long as thick. Eyes bare, cheeks with an indistinct malar groove half as long as the diameter of the eye. Head behind finely punctulate. Mesonotum faintly rugulose, with feebly impressed parapsidal furrows. Scutellum triangular, longitudinally rugulose, the thoracic dorsum longitudinally striated on each side of the scutellum. Metanotum rugulose, exareolated, the upper hind angles produced into short blunt teeth. Abdomen as long as the thorax; three segmented, the third segment longest; first a little shorter and second still shorter; its upper surface longitudinally rugose-aciculate, less distinctly so on the third segment; first segment with a carina arising at the anterior angle, slanting toward the median line and fading out at the middle of the segment. Apex of abdomen rounded. Pleuræ faintly roughened. Hind legs much thickened, others slender. Wings

with the submedian cell longer than the median; subdiscoidal vein arising near the lower angle of the second discoidal cell; recurrent nervure inserted near the base of the second cubital cell; second section of the radius a little longer than the first; second transverse cubitus half as long as the first.

Manaos, Brazil (Mann and Baker).

This species is very distinct on account of the disposition of its peculiar pale color and sharp black maculation.

Subfamily CENOCŒLIINÆ

Cenocœlius tricolor sp. nov.

Female. Length 9 mm., ovipositor 7 mm. Head above the level of the antennæ, spot above hind coxa, four posterior legs and abdomen above, except on the sides, black; remainder of head and thorax honey-yellow except the metanotum behind which is whitish, and also the anterior legs, except most of the femora and the apical tarsal joint. The abdomen is maculate with yellowish white as follows: hind angles of petiole; a band along each side of segments 3–7 which extends inwards half way to the median line along the sutures; these incisures narrow and pointed except at the base of the third segment where they form a broad, widely interrupted transverse basal band. Sides of abdomen whitish; ventral plates black. Wings blackish with a hyaline streak crossing at the insertion of the recurrent nervure. Head twice as broad as thick, arcuately emarginate on the occiput; vertex with a deep median depression extending down the front to the base of the antennæ. The median ocellus lies at the bottom of the depression and the lateral ones on the edge, a carina extending downward from each to the level of the antenna; sides of front and face sparsely punctate; middle of face confluently so; clypeus punctate like the face. Eyes small, rounded oval, as long as the malar space. Posterior edge of head with a high raised margin. Antennæ 32-jointed; scape cylindrical, three times as long as thick; first flagellar joint slightly longer than the second which is three times as long as thick; joints near the middle twice as long as thick. Mesonotum with coarse punctate parapsidal furrows, the middle lobe prominent, twice as long as the lateral ones and prolonged backward between the convergent furrows as a raised line. Scutellum with a broad impressed line at the base composed of four large foveæ. Metathorax above irregularly reticulate; behind and on the sides rugose reticulate. Propleura sparsely punctate; mesopleura smooth with a crenulate mesoëpisternal furrow, a carinate posterior margin and several foveæ above. Abdomen polished; first segment one-third as broad at base as at apex, longer than the width at apex (exclusive of the white corners); with a number of curved carinæ on each side of a median smooth space, the median pair of carinæ attaining the base and the lateral pair the apex of the segment; second segment more closely striated except around the edges and on a median stripe which is smooth and slightly elevated into an obsolete tubercle anteriorly; following segments smooth and highly polished. Legs

stout, thickly hairy on the tibiæ and tarsi, sparsely so elsewhere. Stigma lanceolate, black; second section of radius one-half longer than the first and one-third the length of the third; second cubital cell narrowed above, its tip one-half as high as its base; recurrent nervure received at the apex of the first cubital cell; submedian cell longer than the median; subdiscoidal vein arising from the apex of the discoidal vein, the second discoidal cell narrowly open at this point; first section of cubitus straight; submedian cell in hind wing two-thirds as long as the median.

One female from Camp No. 28, Madeira-Mamoré R. R. Co., Rio Madeira, Brazil (Mann and Baker).

This species will be easily recognized on account of its striking color.

Subfamily BRACONINÆ

Binarea calida sp. nov.

Female. Length 13 mm., ovipositor 11 mm. Black, ferruginous and fulvous; wings yellowish with fuscous tip and a median transverse piceous band. Black as follows; head, antennæ, prothorax except hind part of pleuræ; mesosternum and large blotch on mesopleura; hind legs with coxæ, spot on hind femora above at base, knees, stripe on outer side of tibiæ and entire tarsi; apical joint of fore and middle tarsi; abdomen beyond third segment (the fourth fuscous) and ovipositor. Thorax otherwise ferruginous, and the legs and abdomen fulvous. Wings with the venation pale fuscous on the clear parts, black elsewhere; stigma black, rufous below apically. Wing tip fuscous from just beyond the second transverse cubitus, the dark cross-band embracing the basal half of the first cubital cell and the apical half of the first discoidal; fore wing also with a hyaline spot in the radial cell and a large one behind the second cubital cell. Hind wing fuscous beyond the base of the radial cell. Head one-fourth broader than long, entirely smooth above; face irregularly rugose, slightly elevated into an indistinct tubercle medially which is more finely rugose; just below each antennal tubercle a short deep groove meets the one of the opposite side to continue upwards between the antennal tubercles. Malar space and cheeks sparsely punctate. Eyes nearly round, twice as long as the malar space. Antennæ long and slender, the joints not distinctly separated; scape and pedicel fringed at tip with ferruginous hairs as in *B. spinicollis*. Palpi pale yellow, the lower side of the head clothed with long buff-colored hairs. Pronotum margined in front; medially behind with a short blunt spine or tooth; prothorax below near the middle with a sharper thorn-like tooth on each side and a second conical elevation or tooth on the anterior margin further forward. Prothorax smooth above and on the sides, finely and densely punctate below. Mesonotum with the middle lobe twice as long as the lateral ones, the parapsidal grooves deep, but impressed only anteriorly. Scutellum immargined, with two large deep, quadrate depressions at the base. Metathorax with a median furrow, more distinct anteriorly and with a large, deep impression behind on each side of the middle. Thorax

smooth except the metapleuræ which are sparsely punctulate. Pro- and metapleuræ thinly clothed with pale hairs. Metathoracic spiracles small, elongate oval. Abdomen as long as the head and thorax together; its surface shining, impunctate. First segment scarcely widened apically, twice as long as broad at tip, the median portion raised and carinate laterally at the base; toward each side with a carina separated from the median elevation by a broad smooth groove and from the extreme lateral edge by a linear furrow. Second segment fused with the third, but the suture indicated medially by a broad crenulate furrow; anteriorly with a trifoliate elevation consisting of a narrow pointed median elevation and lateral ovate elevation; sides of second segment separated from the median part by a longitudinal impressed line and from the base of the third by an oblique impressed line. Third segment with a small lozenge-shaped tubercle medially at the base, on each side of which is a large, faintly raised elevation; anterior angles also slightly elevated into a rounded convexity. Following segments not sculptured. Legs stout, the hind pair considerably thickened; fore tarsi distinctly more than twice as long as their tibiæ, each of which bears along its front side a series of five short, stout fuscous spines or thorns. Tarsal claws large, simple, wings with the submedian cell longer than the median by one-fifth the length of the basal vein; recurrent nervure received at the apical sixth of the first cubital cell; discoidal nervure arising at the posterior angle of the second discoidal cell. Submedian cell in hind wing more than half the length of the median; radial cell divided by a cross-vein.

One female from Abuná, Rio Madeira, Brazil, Mann and Baker.

This species differs from *B. spinicollis* Brullé, the only species hitherto described, by its entirely red mesonotum, red middle coxæ, and the much greater amount of black on the abdomen. Brullé does not mention the second pair of teeth on the margin of the prothoracic pleuræ, nor the spines on the anterior tibiæ. These may be present in his species, but it does not seem possible that he could have overlooked both these striking characters.

Parabinarea Gen. nov.

Similar to *Binarea* Brullé, but differing by the presence of three spinose tubercles on the pronotum, the absence of tubercles on the propleuræ, the structure of the metathorax, which is covered with flat, circular impressions, and the aciculate sculpture of the first two abdominal segments.

Head nearly quadrate, strongly rounded off behind and excavated on the occiput; with a large shallow impression above the antennæ which are long slender and many jointed. Pronotum with a pair of spinose tubercles near the anterior margin, and with a single median one behind. Propleuræ convex, not tuberculate. Mesonotum with deep

parapsidal grooves, the median lobe extending far forward of the lateral ones; scutellum flat, with a pair of large foveæ at its base; postscutellum produced into a minute spine or tubercle. Metathorax not areolated, but covered with well-separated rounded shallow impressions above. Along the median line there is an indistinct carina with a series of these impressions on each side, then a narrow smooth space reaching back to the middle of the segment, followed by a lateral area of impressions. The metapleuræ are smooth above and very coarsely reticulate below; apex of metanotum with three deep impressions. Mesopleura smooth, separated from the metapleura by a deeply impressed line composed of large foveate punctures. Thorax as a whole long and somewhat flattened. Abdomen as long as the head and thorax; first segment but little widened behind, carinate; second and third tuberculate; first two segments longitudinally aciculate; second and third fused. Ovipositor long. Legs stout, the fore tibiæ in front with a series of five short, thorn-like spines. Tarsal claws small, simple. Wings as in *Binarea*, the submedian cell longer than the median; radial cell in hind pair divided by a cross-vein.

Type: *P. manni* sp. nov.

This is a most remarkable form on account of the peculiar sculpture of the metanotum. It is very clearly related to *Binarea*.

Parabinarea manni sp. nov.

Female. Length 8–11 mm., ovipositor 7–8 mm. Fulvous and black, the wings yellowish, bifasciate with black. The fulvous color is distributed as follows; tegulæ; entire metathorax; first four segments of abdomen and often fifth, except for spot in front and a band behind; fore coxæ almost entirely; anterior and middle legs, except tips of last tarsal joint; hind legs on second joint of trochanters, basal four-fifths of femora, and basal third of their tibiæ. Palpi pale yellow. The apex of the hind wing, and that of the fore wing beyond the basal fourth of the third cubital cell is black, and the black cross-band on the fore wing embraces the stigma and wing from the origin of the cubitus to the origin of the radius; there is a faint oblique hyaline streak in the first cubital cell and a hyaline spot below the insertion of the recurrent nervure. Head smooth above, the frontal depression immargined, shallow, almost surrounding a small elevation which bears the closely approximated ocelli. Face finely rugose at the middle, very coarsely so on the sides, the furrow between the antennal tubercles not extending down onto the face. Cheeks finely punctulate, malar space two-thirds as long as the diameter of the eye. Head behind punctulate and sparsely clothed with long white hair which is also present on the orbits, clypeus and sides of the face. Palpi long and slender. Pronotum above impunctate; pleuræ punctate, with an oblique carina for their entire length. Triangular part of pronotum that extends toward the tegulæ separated from the collar by an oblique impression that bears a number of raised cross-lines. Mesonotum smooth, the parapsidal furrows strongly convergent, not reaching the scutellum, but continued

to the latter as a pair of *raised* lines. Scutellum with a pair of large quadrate depressions at the base separated by a fine median raised line. Mesopleura elevated along its upper edge and near the upper anterior angles, and with an oblique impressed groove (larger behind) below. Metathorax as described in the generic diagnosis, its lateral angles slightly toothed. Abdomen as long as the head and thorax together; first segment but little widened apically, the central raised portion bordered by lateral carinæ and with a pair of converging carinæ on its disk, on the sides with a carina above the lateral margin; its surface coarsely aciculate except at the base of the median lobe. Second segment with a pair of approximate rounded elevations behind and with a deep moderately oblique groove from each anterior angle which defines a triangular lateral piece. Third segment tuberculate, raised in front on each side of the middle and also at the anterior and posterior angles; following segments smooth. Legs stout; fore tarsi twice as long as their tibiæ; hind femora much thickened, less than four times as long as broad. Wings with lanceolate stigma which is black before the origin of the radius, and pale brown beyond; veins dilute fuscous, piceous under the black markings; submedian cell longer than the median by one-third the length of the transverse median vein; recurrent nervure received at the apical sixth of the first cubital cell; discoidal nervure arising at the posterior angle of the second discoidal cell. Hind wing with the submedian cell two-thirds as long as the median; the resurrent nervure distinct.

Four females from Abuná, Rio Madeira, Brazil, collected by Mann and Baker.

Cervulus nodicornis (Brullé).

Hist. Nat. Ins. Hyménop. IV, p. 408. (1846) (*Bracon*).

Mr. Mann obtained a female of this species at Baixa Verde, Rio Grande do Norte. It agrees well with Brullé's description, except that it is a trifle smaller (12 mm. ovip. 6.5 mm.) and the vertex is rufous like the rest of the body.

Bracon paraensis sp. nov.

Female. Length 4.5 mm., ovipositor 1.4 mm. Honey-yellow marked with black, paler on the lower parts of the head and abdomen below. The following parts are black: antennæ; broad bands on the second, third, fourth and fifth segments, all of equal length and crossing the fifth segment completely but leaving broad pale lateral spaces on the more anterior segments; sixth segment entirely; ovipositor sheaths, apical joint of four fore tarsi; and hind legs beyond the trochanters, although with the knees and tarsal articulations yellowish. Wings deeply infuscated, more strongly so at the base. Head two and one-half times as broad as thick, rapidly narrowed behind the eyes and not excavated behind. Vertex smooth, ocelli equidistant, separated from one another by their own diameter. Front shagreened medially, with a central finely impressed line above the antennæ to the ocelli. Antennæ

37-jointed; scape short, obliquely truncate at tip, less than twice as long as thick; flagellar joints all about one-half longer than broad, the first longer, twice as long as thick. Face smooth, with a slight convexity below the antennæ. Clypeus deeply impressed along its upper margin and with the lower edge narrowly reflexed. Head behind smooth, cheeks sparsely punctulate. Palpi slender. Eyes four times as long as the malar space. Mesonotum not noticeably trilobed; parapsidal furrows distinct, complete, scarcely convergent posteriorly; its surface smooth and shining. Scutellum nearly flat anteriorly, with a transverse crenate furrow across the base. Metanotum with a very much abbreviated median carina posteriorly which is continued in front as a very finely impressed line. Pleuræ shining; mesopleura with a small median circular impression. Metapleura with a deep horizontal sulcus just below the small circular spiracle. Abdomen short, ovate. First segment with a pair of divergent grooves that define a triangular elevation medially on the segment behind. Second segment with a pair of small oval, very deep and sharply defined impressions anteriorly near the median line and also on each side with a much more feebly impressed and irregular longitudinal depression. Third segment on each side basally with a somewhat oblique transverse impression that does not reach the lateral margin however; fourth and fifth segments with similar transverse impressed grooves at the middle of the segment, these are not oblique and reach the sides of the abdomen, simulating additional intersegmental sutures. Legs slender, sparsely clothed with pale testaceous hairs as is the entire body in an irregular way. Wings with the stigma lanceolate, black, as are also the veins. First section of the radius as long as the width of the stigma; second segment twice as long; second cubital cell with parallel upper and under sides, the first transverse cubitus very oblique and the second vertical; recurrent nervure received just before the tip of the first cubital cell.

One female collected by Mr. Wm. M. Mann at Pará, Brazil.

In general appearance this is very much like the nearctic *Microbracon mellitor* and its alies, but the sculpture of the abdomen is of an entirely different type.

Iphiaulax xantothorax Brullé.

Hist. Nat. Ins. Hyménop., Vol. IV, p. 393 (1846). (*Bracon*).

There is a female from Porto Velho, Rio Madeira, Brazil, which agrees well with Brullé's description. The specific name is evidently intended to be *xanthothorax*, but the spelling given above appears in the original.

Bracon crassitarsis sp. nov.

Female. Length 10–11 mm.; ovipositor 7–7.3 mm. Pale ferruginous with head, most of legs and abdomen beyond fifth segment, black; wings blackish, yellow at base. The black is as follows; head except base of mandibles and tip of last palpal joint; antennæ; prothorax, except upper hind angles; metathorax; fifth abdominal segment (some-

times in part); all following segments; ovipositor and its sheaths; legs, except anterior knees and four basal joints of anterior tarsus; the middle tarsi brownish on first four joints. The wings have the stigma black and are strongly infuscated beyond the basal vein, though pale yellowish toward the base. Head nearly twice as wide as thick, rounded and narrowed behind the eyes. Front above the antennæ with a deep depression that is divided by a fine, sharp median carina; antennal tubercles rather short. Face finely rugose, faintly reticulate, with a vertical raised line extending from each antennal tubercle to the clypeus and a second near to the eye. Clypeus crescentic, margined above by a fine line and fringed below with a brush of porrect pale yellow hairs. Eyes large, oval, fully five times as long as the malar space. Antennæ a little shorter than the body; scape as long as the width of the eye, broadened apically; first flagellar joint nearly twice as long as wide; second not quite half longer than wide; following nearly quadrate. Mesonotum with the parapsidal furrows impressed anteriorly, convergent. Scutellum with a smooth impressed line across the base. Metathorax smooth and polished; sparsely punctulate on the sides. Abdomen elongate, as long as the head and thorax, and but little wider; raised median portion of first segment narrowed in front, but attaining the base of the segment; close to it on each side is a carina. Second segment with a small median tubercle in front, on each side of which is a foveate depression, without lateral carinæ or separated corners; its suture with the simple third segment smooth. Third segment the longest, nearly half as long as broad. Mesopleura with the femoral furrow narrow; the metapleural depression rather deep and lying just outside the elongate reniform spiracle. Legs stout, the tarsi much shortened and flattened, especially those of the middle and fore legs; clothed with sparse, glistening pale hairs, denser on the tibiæ and black on the hind ones. Wings with the stigma lanceolate; submedian cell as long as the median; first section of cubitus strongly curved so that its base runs nearly parallel for a short distance, its origin being at the upper third of the basal vein; recurrent nervure received at the apical fifth of the first cubital cell; first section of radius one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus slightly oblique, with a hyaline spot near its top and bottom; discoidal vein broken at its lower third.

Male. Length 9 mm. In this sex the anterior tibiæ are almost entirely fulvous; the second trochanters of the fore and middle legs are ferruginous and the first four joints of the middle tarsi are yellowish. The tarsi are not thickened and their pile is dark, except on the anterior pair. Palpi entirely pale. The black on the fifth abdominal segment is also more extensive, covering the surface except on the sides and the posterior edge.

Five specimens, four females and one male from Rio Madeira, Brazil (Camp 39, Madeira-Mamoré R. R.) Mann and Baker.

This is a very distinct species on account of the peculiar form of the tarsi in the female and the conspicuous color pattern.

Bracon thalessiformis sp. nov.

Female. Length 18 mm.; ovipositor 55 mm. Black, with most of the thorax and the first segment of the abdomen pale ferruginous. Wings blackish, with a pale band before and another after the middle. The ferruginous thorax has the prothorax black, except on its posterior third and the metathorax is blackish medially, in addition to a triangular black spot on each side before the hind coxa. The second abdominal segment is tinged with brown and ferrigunous along the sides and the venter is colored almost as the dorsal aspect. The fore wing is black at the base, becoming paler to the end of the submedian cell, when it is black to the base of the radial cell, then pale through most of the second cubital and finally blackish beyond to the tip. The hind wing is blackish, with an incomplete pale band at the middle. Head scarcely wider than thick, sharply excavated behind at the middle of the occiput, the face receding so that it is almost horizontal. Eyes small, round, removed by their own diameter from the base of the mandibles; surface smooth and polished above and behind, sparsely punctulate on the cheeks. Face subshining, closely punctulate except for a small, nearly smooth, central portion; clypeus shining, with a complete, fine, sharply raised margin. Front with a shallow depressed space including the ocelli; antennal tubercles rather small. Antennæ as long as the body; scape cylindrical, elongate, nearly as long as the thickness of the head; first flagellar joint twice as long as thick; second one-half shorter; remainder nearly quadrate. Palpi long, very slender, the last joint yellowish at tip. Prothorax smooth and shining. Mesonotum without parapsidal furrows, although the median portion is somewhat produced anteriorly. Scutellum with a narrow, smooth groove separating it at the base from the mesonotum. Metathorax without carinæ, polished, smooth except for small very sparse punctures on the sides. Abdomen long and narrow, no wider than the thorax. First segment one-half wider at apex than at base, its median elevation ovate, pointed anteriorly, on each side of this with two smooth grooves separated by a carina before the raised margin; second segment one-half longer than broad; smooth, except that the anterior corners and the lateral margins are separated by a smooth groove from the central portion; third segment about quadrate, the anterior angles very indistinctly separated, following segments growing shorter; hypopygium longer than the pygidium. Pleuræ smooth, with a deep femoral groove extending from the fore coxa to the root of the hind wing and a less pronounced groove just external to the oval metathoracic spiracle. Legs long and rather slender, with the hind femora clavate. Wings with the submedian cell indistinctly longer than the median, recurrent nervure interstitial with the first transverse cubitus; first section of the radius one-fifth as long as the second and half as long as either of the transverse cubiti; second transverse cubitus with its lower half perpendicular, but strongly bent toward the wing tip above; discoidal vein broken at its lower two-fifths. Stigma black, fulvous on its lower half.

One female from Rio Madeira, Brazil (Madeira-Mamoré R. R. Co., Camp 39), collected by Mann and Baker.

This is a very remarkable species on account of the long ovipositor, although several others are known in which this organ attains a similarly great length.

Iphiaulax Förster.

Of this genus, so richly represented in the neotropical fauna, a considerable number of species were obtained, at least five of which are undoubtedly undescribed. These may be separated as follows:

1. Wings dark at apex.....2
   Wings with dark cross-band, but the anterior ones white at apex. *I. reduvioides*
2. Wings with distinct dark cross band before apex.....4
   Wings without distinct dark cross-band before the dark apical portion; legs in part pale.....3
3. Face with a median furrow or depression, abdomen rather narrow; length 12 mm.....*I. fortis*
   Face not excavated medially; abdomen rather broad, length 7.5 mm..*I. starksi*
4. Legs entirely black abdomen broad; ovipositor shorter than abdomen..... *I. carapunæ*
   Legs in great part pale; abdomen slender; ovipositor longer than the body. *I. abunensis*

Iphiaulax reduvioides sp. nov.

Female. Length 11 mm.; ovipositor 5 mm. Black, with the first abdominal segment except the apical portion of the central elevation, the sides of the second and third, extending inwardly somewhat along sutures, and the extreme lateral edge of the fourth, rufous. Tips of maxillary palpi yellow. Wings pale brown at the base nearly to the basal vein, then with a black band which includes over half of the second cubital cell, and apically white. Basal third of stigma bright fulvous, the color extending somewhat into the upper part of the first cubital cell; third discoidal cell with a hyaline spot basally above, hind wing black on apical half, basally pale brown. Venter fulvous on second, third and fourth segments, black beyond. Antennæ as long as the body and ovipositor together, head one half broader than thick, obliquely narrowed behind the eyes; ocelli surrounded by a grooved line; face finely rugulose punctate, slightly convex, with a faint, fine median carina, and an indistinct grooved line on each side near the eye-margin; front and vertex shining, impunctate, the former extending between the antennal tubercles as a polished median groove, malar space very short. Mesonotum highly polished, the parapsidal furrows smooth, but slightly convergent and obsolete behind. Scutellum smooth, with a line of large confluent punctures at the base. Metathorax without carinæ, smooth medially, punctulate laterally. Abdomen broadly oval, much wider than the thorax, the first segment quadrate, not narrowed basally, the swollen pleural portions visible from above on each side, as wide as the segment and blackish-yellow in color; median elevation narrowed

and rounded basally, separated from the lateral carinæ by a broad, smooth groove. Second segment four times as broad as long, the median field narrow, much attenuated behind. Third segment without median line or carina, the lateral angles separated by deep grooves; barely longer than the second medially and much shorter laterally, excluding the produced lateral angles. Third and fourth segments each divided by a transverse groove, the third with the lateral angles separated. Ovipositor fuscous, its sheaths black. Wings with the venation fuscous basally, black at the middle, and pale brown on the hyaline apical portion; second cubital cell half as long as the marginal, nearly one half longer below than above; recurrent nervure received almost at the apex of the first cubital cell, parallel with the first transverse cubitus.

One female from Abuná, Rio Madeira, Brazil, Mann and Baker.

This is a stout, heavy-set species with quite conspicuously pilose shining body and densely hairy legs.

It resembles most closely two neotropical species, *I. tristis* and *I. semialbus* recently described by Szépligeti (Termes. Füzetek., Vol. 24, p. 397, (1901)), but may be easily distinguished from the first by the form of the first abdominal segment and the wing pattern, and from the second by the absence of a carina on the third segment and the different color of the wings. It is a very striking form, reminding one of a Reduviid bug in shape.

Iphiaulax fortis sp. nov.

Female. Length 12 mm., ovipositor 9 mm. Black, palpi pale; first four abdominal segments and base of the fifth ferruginous; coxæ and femora, except base of four anterior ones, hind tarsi, and hind tibiæ except bare inner edge, black; remainder of legs honey-yellow, except upper side of trochanters. Wings pale brownish-yellow, infuscated at tips. A rather slender species, with the abdomen elongate, the head distinctly broader than thick and rounded off behind the eyes. Face confluently punctate, with the median depression between the low antennal tubercles extending down to the finely punctate, margined clypeus. Eyes oval, four times as long as the malar space. Antennæ slightly longer than the body; scape twice as long as thick; first flagellar joint distinctly longer than the second; following about quadrate. Parapsidal furrows distinct anteriorly; scutellum with a line of square punctures across its base. Metanotum punctulate on the sides, thinly clothed with thin pale hairs, the lateral groove nearly divided by the oval spiracle. Abdomen sparsely and coarsely punctate except at base and apex. First abdominal segment with its median elevated portion somewhat narrowed and rounded anteriorly, but little narrowed behind, separated from the lateral carina by a coarsely crenulate groove; the segment about as long as broad behind. Second segment rugose-

punctate, the middle field smooth, triangular, short, but prolonged behind as a narrow elevation; on each side with a deep; oblique impression reaching to the posterior angles. Second suture straight medially, curved forward laterally, very broad, crenulate or striate, the anterior angles separated by a lateral, nearly transverse, crenulate groove. Third segment with separated anterior angles and a deep crenulate transverse groove near the base; fourth and fifth segments similarly sculptured, and the sixth obsoletely so. Legs slender. Wings with black stigma; first section of radius one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus with a hyaline spot below, slanted outwards above; cubitus not very strongly curved at base; submedian cell as long as the median; recurrent nervure received just before the apex of the first cubital cell; discoidal vein broken a little below the middle.

One female from Camp 39, Madeira-Mamoré R. R., Rio Madeira, Brazil (Mann and Baker).

This does not seem to be very closely related to any other species of similar color.

Iphiaulax starksi sp. nov.

Female. Length 7.5 mm., ovipositor 3 mm. Black, the scutellum and metanotum rufous, first four segments of abdomen, sides and base of fifth, fulvous; four anterior legs beyond the knees, and a stripe on the outer edge of hind tibiæ yellowish; ovipositor fuscous. Wings yellowish hyaline, slightly darkened below the black stigma and infuscated beyond the base of the third cubital cell, veins all fuscous. Head one-third broader than thick, obliquely rounded behind the eyes. Face flattened, finely rugulose, the clypeus with a sharp, raised marginal line. Palpi pale. Antennæ nearly as long as the body; scape almost three times as long as thick; first flagellar joint longer than the second; following quadrate. Mesonotum with the parapsidal furrows distinct anteriorly; scutellum with a crenulate line across the base. Metathorax scarcely punctulate laterally, its spiracles round. Abdomen rather broad. First segment at apex nearly twice as broad as at base, its median elevation oval, much narrowed basally and separated from the lateral carina by a rugose groove. Second segment with a short, broad basal median elevation which is prolonged to the apex as a carina; on each side with a deep oblique depression that marks off the anterior angles, but does not attain the posterior margin. Second suture broad, striate, straight medially and curved forward laterally as the separated angles of the third segment are produced forward; second to fourth segments sparsely, deeply and coarsely punctate. Legs slender. Wings with the first section of the radius nearly one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus nearly perpendicular, with a hyaline dot above and below, cubitus bent at the base; recurrent nervure received well before the tip of the first cubital cell; discoidal vein broken a short distance below the middle; submedian cell as long as the median.

One female from Pará, Brazil (Wm. M. Mann) named after Prof. Starks, a member of the expedition.

This species falls near two Brazilian species, *I. hirtulus* and *I. semiflavus* described by Szépligeti, but differs by its much longer ovipositor and different abdominal sculpture.

Iphiaulax carapunæ sp. nov.

Female. Length 9.5 mm.; ovipositor 3 mm. Black, with the apical two joints of the palpi pale yellow and the first four, and base of the fifth abdominal segments bright ferruginous. Wings with a black transverse band beginning at the origin of the basal vein and extending into the base of the radial cell, beyond this infuscated and basally pale yellowish; stigma wholly black; hind wings pale yellowish at base, infuscated on apical half. Head one-half wider than thick, obliquely narrowed behind the eyes. Front impressed on each side above the antennæ and with a median carina that extends down between the short antennal tubercles. Face irregularly rugulose, the small clypeus distinguishable as a smooth spot; malar space short, one-fourth as long as the large, oval eye. Prothorax smooth on the sides, distinctly punctate medially. Mesonotum with smooth, parallel parapsidal furrows that extend to the posterior third. Scutellum convex, with a smooth impressed line across its base. Metanotum evenly rounded, without carinæ; punctulate on the sides. Mesopleura with a deep, oblique femoral furrow; and metapleura with a groove just external to the rounded-oval spiracles. Abdomen one-half broader than the thorax; first segment with an oval elevated portion that is rounded in front. On its sides is a pair of parallel smooth grooves, each separated from a second lateral smooth groove by a strong carina. Second segment with the middle field triangular, reaching beyond the middle of the segment and continued for a short distance as a raised line; sides and anterior angles separated by a very deep depression. Third segment with the basal suture strongly bisinuate and crenulate; the anterior angles separated by very deep impressions; with a triangular middle field that reaches nearly to the middle. Fourth segment with the anterior corners separated and with a transverse groove near the center. This groove is repeated on the fifth segment, and less distinctly on the sixth. Hypopygium shorter than the pygidium. Legs short, stout, and densely hairy, especially the hind pair. Wings with the submedian cell barely longer than the median; recurrent nervure received at the tip of the first cubital cell; first section of radius one-third as long as the second and two-thirds as long as the first transverse cubitus; second transverse cubitus straight, perpendicular; discoidal vein broken at its lower third. Stigma narrowly triangular.

One female, Rio Madeira Brazil (Camp No. 39, Madeira-Mamoré R. R.) (Mann and Baker).

This species resembles *I. polybothris* Brullé, but differs structurally as well as in color.

Iphiaulax abunensis sp. nov.

Female. Length 11.5 mm.; ovipositor 14 mm. Fulvous; the head, except for the pale palpi and the red tip of scape and underside of pedicel; prothorax, except posterior angles; abdomen above, beyond the base of the fifth segment; ovipositor and its sheaths, all coxæ, middle of fore femora, middle femora, except base and apex, hind femora apical half of tibiæ, their tarsi, and apical joint of four anterior tarsi black. Fore wings pale yellowish with an uneven blackish median band and infuscated tips from the base of the third cubital cell; stigma black, hind wings slightly infuscated. Head transverse, not quite half broader than thick; antennæ slightly shorter than the body, the scape twice as long as thick; first two flagellar joints subequal, each twice as long as thick. Face sparsely and irregularly punctate on the sides, with a median flat, polished area showing traces of fine aciculations; clypeus finely irregularly punctate; antennal tubercles short. Eyes oval, three times as long as the malar space. Mesonotum with the parapsidal furrows indicated only in front. Scutellum with a crenulate line across its base. Metanotum smooth above, punctulate on the sides, with a deeply impressed groove just outside the elongate oval spiracles. First segment of abdomen, exclusive of its membranous sides, twice as long as wide, the lateral margins parallel; the median elevation ovate, pointed in front, constricted and truncate behind; on each side of this is a deep, narrow, groove before the carinate margin. Second segment nearly as long as wide behind, the median field long and narrow, reaching beyond the apical third of the segment; on each side of this is a broad longitudinal depression, then a carina, then a second similar, but narrower depression that extends to the posterior corner. Second suture rather wide, obsoletely crenulate, slightly extended forward at the middle where the apical margin of the second segment is raised. Third segment the widest; twice as broad as long and faintly concave on its posterior margin; the anterior angles not produced forward, but separated as large spaces by a groove that curves across the segment from near the median line to the center of the lateral margin; with an indistinct, narrowly triangular median elevation. Fourth segment with an arcuate groove, interrupted at the median line, across the middle of its base. Legs rather long, not stout, wings with the cubitus strongly bent near the base; recurrent nervure received at the tip of the first cubital cell; first section of the radius one-third as long as the second and two-thirds as long as the slightly oblique second transverse cubitus; submedian cell slightly, but distinctly, longer than the median; discoidal vein broken near its lower third.

One female from Abuná, Rio Madeira, Brazil (Mann and Baker).

This is related to *I. excisus* Szépligeti, but differs by its shorter ovipositor and different abdominal sculpture, the second segment having two pairs of longitudinal grooves, and the fourth having an arcuate line, without lateral curved lines.

Subfamily RHOGADINÆ

Rhogas Nees.

There are two species, both undescribed, in the collection, which brings up the total of Brazilian species to five. These may be distinguished as follows:

1. Recurrent nervure inserted in the first cubital cell.....2
   Recurrent nervure interstitial or nearly so.....4
2. Wings of uniform color.....3
   Wings distinctly bifasciate.....*R. bakeri* sp. nov.
3. Pale yellow, with head, antennæ and four hind legs beyond the knees deep black .....*R. insignipes* sp. nov.
   Yellowish red, with abdomen blackened above; all legs pale beyond the knees.....*R. braziliensis* Szép.
4. Legs entirely pale, wings distinctly bifasciate.....*R. maculipennis* Szép.
   Hind femora mostly black; wings very indistinctly maculate..... *R. pulchricornis* Szép.

Rhogas insignipes sp. nov.

Male. Length 8 mm. Uniformly pale ochre-yellow, very conspicuously and sharply marked with black as follows; entire antennæ and head, except palpi; last joint of fore tarsi; middle legs beyond the basal third of the tibia, and hind legs beyond the extreme base of the tibia. Wings tinged strongly with yellowish-fuscous; veins pale brown; stigma wholly piceous; pale parts of body with pale yellow pubescence; black parts with black. Head somewhat over twice as broad as thick antero-posteriorly, the front occupying only one-fourth the width of the head when seen from above. Face of the same width as the front, transversely rugose aciculate, with a short, sharp keel below the antennæ. Eyes very large, deeply emarginate opposite the antennæ; malar space extremely short, only half as long as one of the middle joints of the antennæ. Ocelli very large, the lateral ones nearly touching the eye-margin, due to the narrowness of the front. Antennæ as long as the body, about 65-jointed, gradually tapering, the joints about quadrate. Head behind the eyes microscopically rugulose. Mesothorax dull, but not punctate, the parapsidal furrows sharply defined but not at all crenulated. Scutellum with a broad, deep, longitudinally fluted and medially divided depression across its base, dull like the mesonotum; post-scutellum paler and polished. Metathorax with the median and lateral carina complete, though delicate, the former bifurcating behind to form a very small petiolar area; surface of metanotum faintly roughened. Pleuræ smooth and polished. Abdomen with the median carina distinct on the first two segments, but without any distinct longitudinal aciculation; first segment one half longer than wide at tip; base two-thirds as wide as tip; second segment slightly transverse; following becoming more strongly so. Legs moderately slender. Wings ample; stigma lanceolate, emitting the radius at its middle; first section of radius two-thirds as long as the second; recurrent nervure received at half its own length before the tip of the first cubital cell; transverse median nervure entering the first discoidal cell before the middle.

One specimen from Independencia, Parahyba, Brazil (Mann and Heath).

The conspicuously blackened legs of this species render it very conspicuous and easily recognizable.

Rhogas bakeri sp. nov.

Female. Length 6 mm. Very pale luteous, with the stemmaticum black, and the hind femora, tip of their tibiæ and tips of all tarsi slightly infuscated. Wings pale yellow, with a basal cross-band of fuscous which is more or less separated into two spots, one on the basal vein and the other below the apical part of the submedian cell. Veins and stigma pale luteous, fuscous along the clouded parts of the wing. Head twice as broad as thick antero-posteriorly, the narrowest part of the front one-third as broad as the head, face faintly rugulose, with a short carina below the antennæ. Antennæ (broken at tips) probably about 40-jointed, the joints quadrate. Eyes large, emarginate opposite the antennæ, but not very deeply so; malar space as long as the basal joint of the antennal flagellum. Ocelli large, the posterior ones as far from the eye-margin as from one another. Head punctulate behind the eyes. Mesonotum dull, with the parapsidal furrows present, but very weakly impressed. Scutellum with the basal impression coarsely striated, not divided by a median carina. Metanotum rugulose, with a median and lateral carinæ, weakly elevated. Pleuræ impunctate, the mesopleura larger and extending farther downward than usual. Abdomen with the median carina extending to the middle of the third segment; first and second segments very faintly longitudinally aciculated; first segment one-third longer than broad at tip, its base two-thirds as wide as the tip; second segment slightly longer than broad; third transverse, following much shorter, ovipositor nearly one-third as long as the second abdominal segment. Legs stout, the femora thickened, especially those of the hind pair. Wings with the stigma rather broad, its width nearly equal to the length of the first section of the radius which is fully as long as the second; recurrent nervure received more than half its own length before the tip of the first cubital cell; second cubital cell almost as high at apex as at base, the second transverse cubitus hyaline except at the corners of the cell; transverse median vein entering the first discoidal at its middle.

One female from Rio Madeira (Camp No. 39, Madeira-Mamoré R. R.) Brazil, Mann and Baker.

This is a rather anomalous species, showing somewhat of a transition to *Heterogamus* in the length of the first section of the radial vein. It is quite similar to the West Indian, *R. bifasciatus* Ashm., but the abdominal carina extends beyond the first segment.

Eucystomastax gen. nov.

Related to *Cystomastax* Szépligeti which it resembles in the peculiarly swollen palpi, but differing in the broadly sessile abdomen, longer submedian cell, smaller eyes, round metathoracic spiracles, etc.

Resembling *Rhogas* in general habitus. Head transverse, narrowed behind the eyes; margined behind. Malar space as long as the mandible; eyes moderately emarginate opposite the antennæ. Maxillary palpi 5-jointed, with the first to third joints greatly swollen, but not flattened; labial palpi 3-jointed, first joint thickened, but cylindrical. Clypeus sharply projecting, with a porrect mystax of stiff black hairs. Ocelli moderately large and close together. Antennæ setaceous, a little longer than the body. Thorax with the parapsidal furrows deep anteriorly, but abbreviated behind. Metathorax with a complete median and lateral carinæ; its spiracles rather small, round; mesopleural suture complete, crenulated. Abdomen with a strong median carina on the first two segments; a little longer than the head and thorax; coarsely longitudinally aciculated on the first, second and base of third segment; first segment one-third longer than the second, less than twice as long as broad at tip; second segment slightly transverse; third twice as broad as long; fourth to seventh strongly transverse; all the sutures very deeply impressed. Legs long, rather slender, densely hairy. Wing with the marginal cell nearly reaching to the tip, stigma lanceolate, radius originating just before its middle; first section of radius one-third as long as the second; second transverse cubitus not swollen; not so stout as the other veins; recurrent nervure at the apical fourth of the first cubital cell; transverse median vein inserted beyond the basal third of the first discoidal cell; discoidal vein broken far below the middle. Hind wing with the submedian cell half as long as the median.

Type. *E. bicolor* sp. nov.

This genus may be separated from the related genera of Rhogadinæ having dilated palpi as follows:

1. Palpi with the joints in part flattened, leaf-like.....2
   Palpi with the joints swollen, but not flattened.....3
2. Second section of radius twice as long as the first; upper and lower sides of second cubital cell parallel.....*Macrostomion* Szep.
   Second section of radius less than twice as long as the first; second cubital cell distinctly narrowed toward its tip.....*Pelecystoma* Wesm.
3. Metathoracic spiracles round; abdomen sessile....*Eucystomastax* gen. nov.
   Metathoracic spiracles slit-like; abdomen petiolate.....*Cystomastax* Szep.

Eucystomastax bicolor sp. nov.

Male. Length 9.5 mm. Black, with the base of the mandibles, fore coxæ, and entire thorax except tip of metathorax, orange-yellow. Head twice as broad as thick, strongly convex below the antennæ; the face with a short median carina just below the antennæ; front smooth and shining, slightly concave; vertex and cheeks smooth; hind head punctulate; face smooth below on sides; elsewhere microscopically rugulose-punctulate. Mandibles with the upper tooth twice as large as

the lower one. Antennæ 68-jointed, slender, longer than the body, the flagellar joints all about twice as long as thick; the first three times; scape oval, twice as long as thick. Prothorax smooth and shining, deeply impressed across each side. Mesonotum smooth, strongly elevated, especially the middle lobe in front; the parapsidal furrows not sharp, but more or less indicated in front by broad impressions. Scutellum triangular, margined only at the sides of the basal impression; its disc with a few large punctures. Metanotum smooth medially in front, on the sides punctate and behind irregularly rugose. Pleuræ smooth, with a few punctures only on the metapleuræ. Abdomen highly polished, smooth beyond the base of the third segment. Legs long and thickly hairy on the tibiæ and tarsi. Wings deeply infuscated, nearly black, but with very little violaceous reflection; veins black, piceous beyond the cross-veins.

One male. Pará, Brazil. Mr. Wm. M. Mann.

This is a very conspicuous species on account of its brightly contrasting thorax, black wings and polished body.

Subfamily SPATHIINÆ

Heterospilus fasciiventris sp. nov.

Female. Length 2.2 mm.; ovipositor 0.7 mm. Meso- and meta thorax, first segment and posterior third of second segment of abdomen black; head dilute piceous, black above. Scape, base of antennæ, ovipositor and legs pale yellow. Abdomen, except for the black markings, pale honey-yellow. Extreme tips of tarsi and ovipositor black. Head twice as broad as thick, moderately narrowed behind the eyes and somewhat excavated behind; strongly margined behind. Vertex shining; feebly, but distinctly transversely aciculate; with a circular impression to the side of each posterior ocellus, the two narrowly connected above the ocelli; posterior ocelli nearly as far from each other as from the eye margin; front slightly concave, weakly transversely aciculate, the lateral margin slightly carinate just above the antennæ. Antennæ long and slender, basal flagellar joint six times as long as thick; the joints near the middle of the flagellum four times as long as thick. Face honey-yellow, rugulose, clypeus honey-yellow, very convex. Mesonotum shagreened, with deep, convergent crenulate parapsidal furrows; middle lobe aciculate behind as in the following species. Scutellum shagreened, with a broad, deep longitudinally fluted groove across its base. Metathorax partly areolated; its upper face with a lateral carina, and the sides of a posterior carina, enclosing a large rugulose area which is angularly excavated behind by a large diamond-shaped supero-median area that is open behind at the apex of the metathorax and closed near the base; surface except on the basal area coarsely rugose-reticulate. Pro- and mesopleuræ shagreened, the former with a deep, oblique groove, the latter with a deep groove along its lower margin, several oblique foveate impressions at its anterior angle and with a crenate line along its posterior edge. Metanotum rugose-reticulate, with a minute thorn-like projection just above the middle

coxa. Abdomen as long as the head and thorax together; ovate-lanceolate; first segment twice as long as broad at tip, with a somewhat raised median space bounded by carinæ converging from the anterior angles, but not very clearly differentiated from the irregular longitudinal aciculations which cover the segment. Second segment nearly as long as broad at tip; aciculated on its basal two-thirds; crossed just before the middle by a crenulate impressed line, and at its posterior third by a broad, shallow groove; third to sixth segments smooth and shining. Legs scarcely thickened, sparsely beset with pale hairs. Wings subhyaline; stigma and veins dilute fuscous; the former, very narrowly triangular, emitting the radius somewhat before the middle; first section of radius two-thirds as long as the second; cubitus arising a little above the middle of the basal vein; first transverse cubitus wanting, second weak, but distinct; submedian cell a little longer than the median, the transverse median vein very short, almost punctiform; subdiscoidal vein interstitial, the second discoidal cell wide open.

One female from Ceará-Mirim, Rio Grande do Norte, Brazil. (Wm. M. Mann).

This species is much more slender and structurally quite different from the following, and when these small Braconidæ are better known the two will probably fall into different genera.

Heterospilus meridionalis sp. nov.

Female. Length 2.6 mm.; ovipositor 1.5 mm. Black; apical half of antennæ and abdomen beyond the second segment piceous; scape and base of antennal flagellum castaneous; palpi whitish; coxæ pale yellow; tegulæ and legs dull brownish yellow. Wings slightly infuscated, with dark brown stigma and veins. Head shagreened above, rugulose on the face; barely twice as wide as thick and sharply narrowed behind the eyes; with a strong margin behind. Front concave above the antennæ, but not deeply impressed; ocelli in a triangle with its shortest side above, the posterior ones nearly twice as far from the eye as from one another. Face evenly convex, piceous, with a small raised smooth spot below the antennæ; clypeus dull yellow, semicircular, with the arcuate upper margin indicated by a fine raised line. Cheeks smooth and polished, malar space about one-third as long as the nearly circular eye. Antennæ 25-jointed, very slender; scape subcylindrical, twice as long as thick; pedicel quadrate; first flagellar joint four times as long as thick; following gradually shortening, those near the middle of the flagellum three times as broad as thick. Thorax finely shagreened, with a faint æneous tinge; parapsidal furrows deep and crenulate; middle lobe of mesonotum with three short, deep longitudinal grooves before the base of the scutellum. Scutellum with a broad, deep, longitudinally fluted groove across its base. Metathorax rugose-reticulate, with a rather ill-defined area on each side at the base; these areas much more finely sculptured except around the border. Propleuræ

with a broad horizontal, crenulate furrow, rugulose anteriorly and rugose-reticulate behind; mesopleura shagreened, with an arcuate crenate groove near the upper anterior angle and a similar one along its posterior edge. Abdomen as long as the head and thorax, curved downwards and obovate when seen from above; sessile, the first segment as long as broad at tip, the base somewhat over twice as broad as the apex. First and basal two-thirds of second segment longitudinally aciculate, the striæ becoming finer apically; beyond to the apex smooth and shining, with broad rufous margins on the second to fifth segments; sixth entirely castaneous. Second segment with a fine impressed line across its middle and traces medially of a second groove just behind this line. Legs slightly thickened on the femora; sparsely pilose with pale hairs. Wings subhyaline, the stigma narrowly triangular, emitting the radius at its center; cubitus arising near the top of the basal vein, first transverse cubitus barely discernible, interstitial with the recurrent nervure; second one weak, but distinct; first section of the radius three-fourths as long as the second; submedian cell slightly longer than the median; subdiscoidal vein interstitial, the second discoidal cell wide open. Hind wing with a closed basal cell, but without a radius. Ovipostor as long as the abdomen, fulvous, black at tip; its sheaths piceous.

One female from Ceará-Mirim, Rio Grande do Norte, Brazil, collected by Mr. Wm. M. Mann.

This species approaches *H. nigrescens* Ashm. from the Island of St. Vincent, but has no white ring at the base of the antennæ, and the ovipositor is twice as long.

Heterospilus dubitatus sp. nov.

Female. Length 2 mm., ovipositor 0.6 mm. Piceous, varied with rufous; legs testaceous, wings subhyaline. Antennæ with the scape yellow, except at tip; flagellum piceous, fuscous toward the base; palpi whitish; collar, mesonotum and mesopleura black; remainder of thorax rufous; abdomen black beyond the transverse groove on the second segment; rufous basally; ovipositor yellow, with black tip; legs pale testaceous, blackened on the tips of the tarsi.

Resembles *H. meridionalis* very closely in structure, but the antennæ are 23-jointed, the triangular area on each side of the metathorax at base is sharply defined, and not at all sculptured, except for a row of punctures around its edge, the first abdominal segment has a very distinct elevated median portion defined by a pair of carinæ that converge somewhat from the anterior angles to near the tip of the segment; the second segment bears two complete, approximate transverse furrows near the middle, this segment being considerably longer than wide instead of quadrate; and the first section of the radial vein is fully as long as the second.

One female from Ceará-Mirim, Rio Grande do Norte, Brazil. (W. M. Mann).

The three species of *Heterospilus* here described may be distinguished as follows:

1. First segment of abdomen as long as broad at tip; abdomen conspicuously banded with yellow.....*H. fasciiventris*
   First segment distinctly shorter then broad at tip; abdomen black, more or less rufous at base.....2
2. Ovipositor as long as the abdomen; first section of the radius much shorter than the second; abdomen black.....*H. meridionalis*
   Ovipositor scarcely more than one-half as long as the abdomen; first section of the radius as long as the second; abdomen rufous on the first segment and basal half of the second.....*H. dubitatus*

Family ALYSIIDÆ

Idiasta nigripennis sp. nov.

Male. Length 5.5–6 mm. Black, with the thorax and basal half of the abdomen honey-yellow; wings very strongly infuscated, almost black. Head large, highly polished, a little more than twice as broad as long, not narrowed behind the eyes. Clypeus very small, sharply triangular, closely punctate, face punctulate; front smooth and highly polished with a deep transverse depression above the antennæ and below the ocelli which occupy a small triangle far from the eyes; antennæ long, one-half longer than the body; with fifty joints. The fourth very distinctly longer than the third. Mandibles fuscous, with black teeth, coarsely punctate externally. Palpi very delicate and slender, pale yellow. Eyes almost circular, their diameter equalling the length of the fourth antennal joint. Mesonotum smooth and polished, with deep strongly convergent parapsidal furrows which unite far before the scutellum. Scutellum strongly convex medially in front, straight on its posterior edge, and at the base with a broad deep depression separating it from the mesonotum. This groove is divided on the median line by a fine carina. Pleuræ smooth and shining, the mesopleura deeply impressed just below the wing and with a foveate impression just before the carina which separates it from the metapleura. Metathorax smooth, with a strong median carina that bifurcates behind to form a broad triangular petiolar area; also with a lateral, strongly sinuate carina that curves laterally to go out beyond the moderately small, circular spiracle. Metapleura with a large deep foveate impression just anterior to the spiracle and a smaller one below, near the middle, just behind the anterior margin. Abdomen broadly sessile, peculiarly formed at the base in that the ventral part of the first segment spreads out laterally beyond the dorsal part; seen from above it is exposed behind on each side to a width of nearly one half the dorsal plate. The latter is less than twice as long as broad at the tip which is twice as wide as the base; spiracles at the middle, very prominent, their tips as far apart as the posterior angles; petiole at base with two short, convergent carinæ. Abdomen smooth and shining, but little widened medially and one-half longer than the head and thorax together; black above beyond the second segment. Legs slender, loosely hairy; entirely black, except for yellowish tips to the trochanters, bases to the tibiæ and a fuscous tinge on the tarsi and anterior tibiæ. Wings blackened,

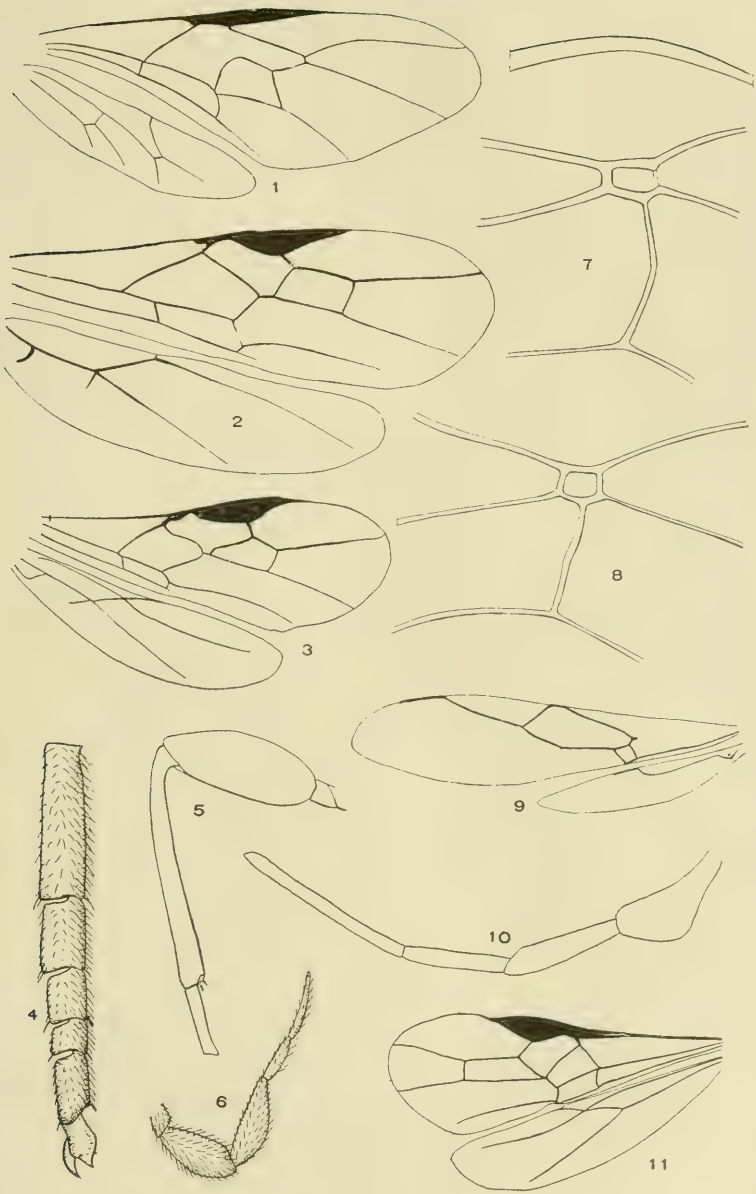
piceous with black stigma and veins. Stigma lanceolate, the radius arising at its posterior third; half as broad as the radial cell; second section of radius twice as long as the first. First section of cubitus sinuate, the recurrent nervure received distinctly before the tip of the first cubital cell; submedian cell considerably longer than the median; subdiscoidal nervure arising below the middle of the discoidal vein, although in position it lies far forward, due to the upper section of the discoidal vein being nearly parallel to the axis of the wing. Hind wing with the radius and subdiscoidal vein well developed.

Four specimens, showing practically no variation, from Abuná, Rio Madeira, Brazil.

This is the first species of *Idiasta* to be described from the neotropical region.

EXPLANATION OF PLATE.

Fig. 1. *Ophiogastrella maculithorax* sp. nov., wings.
Fig. 2. *Eucystomastax bicolor* gen. et sp. nov., wings.
Fig. 3. *Idiasta nigripennis* sp. nov., wings.
Fig. 4. *Bracon crassitarsis* sp. nov., fore tarsus.
Fig. 5. *Parabinarea manni* gen. et sp. nov., hind leg.
Fig. 6. *Eucystomastax bicolor* gen. et sp. nov., maxillary palpus.
Fig. 7. *Mesostenoideus crassus* sp. nov., portion of fore wing.
Fig. 8. *Cryptus heathi* sp. nov., portion of fore wing.
Fig. 9. *Ophionellus manni* sp. nov., wings.
Fig. 10. *Megaplectes branneri* sp. nov., maxillary palpus.
Fig. 11. *Bracon paraënsis* sp. nov., wings.



C. T. Brues.

THE LACINIA IN THE MAXILLA OF THE HYMENOPTERA.*

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The maxilla of biting insects consists of six pieces. There is at the proximal end a two segmented cardo (*c*), which articulates the maxilla to the head capsule (Figs. 1 and 2†). Attached to the distal end of the cardo there is in the cockroach (Fig. 1) a rhomboidal-shaped piece, the stipes (*s*). The stipes in the locust (Fig. 2) is also rhomboidal in outline but is limited in its articulation to the mesal portion of the cardo. There is borne at the distal end of the stipes in the cockroach a two-segmented, somewhat bent tongue-shaped piece, the galea, (*g*). The galea of the locust is also two-segmented but borne at the distal and lateral margin of the stipes. At the proximal end of the galea against the lateral margin of the stipes, there is a small sclerite, the palpifer (*p*), which bears the five segmented maxillary palpus. The proximal segment of the galea and the palpifer in the locust constitute the lateral margin of the stipes. There is borne at the distal end of the stipes on the mesal side another appendage, which bears three prominent teeth at its distal end. This is the lacinia (*la*). The arrangement of the parts in the maxillæ of biting insects is for all practical purposes identical with the above description and the figures of the maxillæ of the cockroach and the locust, showing two distal pieces, a lacinia on the mesal side and a galea on the lateral side, with a segmented maxillary palpus attached on or near the lateral margin at the proximal end of the galea, and is characteristic.

If the maxilla of *Macroxyela infuscata* (Fig. 3), one of the most generalized members of the order Hymenoptera, a tenthredinid, known to me, is compared with that of the cockroach

*Contribution from the Entomological Laboratories of the University of Illinois, No. 29.

†The cardo of *Melanoplus differentialis* as here figured shows a narrow proximal piece with two projections at its proximal end; the shorter piece articulates against the ectal surface of the head capsule and the larger piece passes beneath the margin of the head capsule and serves for the attachment of muscles. These pieces are characteristic of this and some other species. It has been overlooked because it usually remains attached to the head capsule when the maxilla is removed.

or locust, a somewhat similar condition is found. The cardo, however, consists of a single piece which bears at its distal end an irregular-shaped stipes. The stipes bears at its distal end on the mesal side a quadrangular-shaped sclerite, which from its position must be the lacinia. There is borne on the lateral part of the distal portion of the stipes a two-lobed piece, the galea, which consists of a larger outer and a smaller inner lobe. The suture dividing the galea into two pieces is obsolete. Although not demonstrable, it is quite likely that the small mesal lobe of the galea is derived from the proximal sclerite of the galea and the large lateral lobe from the distal sclerite of the galea. The palpifer and maxillary palpus occupy corresponding positions to these sclerites in the cockroach. The maxilla of *Macroxyela* is short and broad and retains many of the general features and appearances of the maxillæ of the cockroach and locust.

The maxilla of *Dolerus unicolor* (Fig. 4), another tenthredinid, differs from that of *Macroxyela* in that it shows some of the tendencies so characteristic of the maxillæ of the higher Hymenoptera, an elongation and narrowing of the parts. This is especially marked in the cardo of *Dolerus*. The maxilla of *Dolerus* also has three lobes at the distal end. The rounded setaceous lateral portion is the homologue of the large lateral lobe of the galea of *Macroxyela*, while the mesal and proximal rounded lobe is the homologue of the small mesal lobe of the galea of *Macroxyela*. The lacinia is a long, pointed lobe projecting beyond the mesal lobe of the galea but attached to the stipes beneath this lobe of the galea. *Dolerus* is a comparatively generalized tenthredinid yet it shows an early stage in the migration of the lacinia from the distal end of the maxilla. A somewhat similar condition is shown in the maxilla of an ichneumonid, *Ophion bilineatum* (Fig. 5). The two lobes of the galea are large, the mesal lobe is a broad flat plate and almost completely covers the lacinia, which is a broad lobe attached to the side of the stipes. The lateral lobe of the galea is elongated and terminal as in the higher Hymenoptera.

In the white faced hornet, *Vespa maculata* (Fig. 6), the maxilla shows a decided elongation of all the parts, the cardo, stipes, and lateral lobe of the galea. The sclerites are not all arranged in the same plane as with the maxillæ previously described. This is due to the fact that the maxillæ are closely appressed to the sides of the convex labium or lower lip, which

has changed somewhat the orientation of the parts. The galea is almost as long as the elongated stipes and is composed for the most part of a large lobe which is the homologue of the lateral lobe of the galea of the maxillæ previously described. The homologue of the mesal lobe is much smaller and has changed its position somewhat. It is a small lobe placed on the surface of the larger, lateral lobe, nearer its lateral than its mesal margin. The mesal margin of the small, mesal lobe is marked by a row of long setæ. All the sutures between the parts of the galea and the stipes are obsolete. There are several dark and light areas with oblique ridges where they probably fuse, but specimens prepared with caustic potash show no indication of a suture in this region. The lacinia is a small but well marked lobe attached to the mesal margin of the proximal end of the stipes. Its position is clearly indicated in figure 6. The distal end of the lacinia is usually folded under the proximal end of the galea and more or less concealed. It shows distinctly on unmounted specimens studied in alcohol.

A thread-waisted wasp, *Sphex pennsylvanicus* (Fig. 7), shows a somewhat different condition. In the maxilla of this insect the small, mesal lobe of the galea is wanting and the lateral lobe developed into a greatly elongated, blunt piece, which projects for some distance beyond the stipes and is almost as long as the maxillary palpus. There is a groove along the lateral margin of the galea that may mark the line of separation of the small, mesal lobe of the galea. Unfortunately it was not discovered until it was too late to remedy the defect, that the figure of this maxilla was turned in the oppsite direction from the others. The lacinia is located at the proximal end of the galea in this maxilla. It is a broadly rounded lobe. Its location and the development of the proximal end of the galea as an overhanging projection would suggest that the lacinia had been modified into a supporting piece.

The greatest modification of the maxillæ is found with the bees where they have been greatly elongated into plates for close appression against the labium for the formation of a tube. The maxilla of a bumble bee, *Bombus terricola* (Fig. 8), shows this condition well. The galea is a sword-shaped blade as long as the remainder of the maxilla. It is attached to the distal end of the stipes. The two are fused without any indication of a suture. There is an oblique ridge marking the edge of a deep

furrow with lighter intervening parts. It is likely that this oblique, clear area distad of the ridge marks the distal limit of the stipes. This would make the union between the stipes and galea an oblique one with the maxillary palpus attached to the distal prolongation of the stipes. A similar condition will be noted in the other maxillæ figured. The furrow extending across the maxilla is the limit of the distal part of the maxilla that is folded under the labium. If this ridge be considered as the suture between the stipes and the galea, it would place the maxillary palpus on the galea, which is an impossible interpretation in the light of the other maxillæ studied. In the more specialized Hymenoptera, wasps and bees, there is a cuticular membrane connecting the maxilla and the labium, which serves to close the mouth cavity on the ventral side. The distal edge of this membrane is attached to the stipes near the proximal end of the lacinia. This membrane is particularly well marked in mounts of the entire maxilla and labium of *Bombus*. In such mounts, the lacinia can be identified as a round lobe with long setæ on its distal and lateral margins. It is placed adjacent to the distal margin of the membrane extending from the maxilla to the labium and is attached to the mesal margin of the stipes near its distal end or to the uncolored area of the stipes. This lobe is so distinct, once it has been seen, it is hard to understand how it has remained undescribed for so long. The lacinia, while showing distinctly in specimens mounted in balsam, can be studied to better advantage on maxillæ that have been cleared in caustic potash and examined in a watch glass in alcohol.

Insect morphologists have been fairly uniform in their statements regarding the lacinia in the honey bee, *Apis mellifica* (Fig. 9). All the more important text-books on entomology figure a maxilla of *Bombus* or *Apis*, but without indication of the lacinia. The following quotations are typical for the maxilla of *Apis*. Comstock and Kellogg* describe these parts as follows:

"*Stipes*. The stipes is an irregular, elongate sclerite, strongly chitinized. Its proximal end is bluntly rounded and swollen. The stipes articulates with the proximal segment of the galea (see below) by a diagonal face.

*Comstock, John Henry and Kellogg, Vernon L. The elements of insect anatomy. Ithaca. 1901. Pp. 78–79.

"*Galea.* The *galea* (we incline to believe this part homologous with the galea of the locust's maxilla, rather than with the lacinia, because of its two-segmented condition) extends distad from the stipes as a tapering blade-shaped piece. It is composed of two segments. The proximal one is small and triangular, articulating by the entire length of one of its margins with the stipes. The distal segment or sclerite constitutes the real blade-like portion of the maxilla, and nearly equals in length the ligula and labial palpi (see below). Its surface is unequally divided into two portions by a submedian, dark-brown, longitudinal line. (This line may indicate a coalescence of galea and lacinia into this one blade-like compound sclerite). This line bears several hairs, and there are scattering hairs elsewhere on the sclerite, especially toward the distal end."

Snodgrass† writes as follows of the maxilla of the honey-bee:

"Let us now return to a study of figure 15D. The series of lateral pieces as already explained are the maxillæ. A comparison with figure 3B representing a generalized maxilla will show that these organs in the bee have suffered a greater modification than has the labium, but the parts can yet be quite easily made out. The main basal plate (*st*) is the combined *stipes*, *subgalea*, and *palpifer*, the basal stalk is the *cardo* (*cd*), and the little peg-like process (*mx plp*) at the outer end of the stipes is the greatly reduced *maxillary palpus*. Hence, we have left only the terminal blade-like lobe (*mx*) to account for, and it is evident it must be either the galea or the lacinia (See fig. 3B, *ga* and *lc*) or these two lobes combined. Here again a comparative knowledge of the mouth parts of Hymenoptera comes to our aid and shows clearly that the part in question is the outer lobe or galea, for the inner one becomes smaller and smaller in the higher members of the order and finally disappears."

There is expressed in these two quotations very different views, the former that the galea and lacinia are probably coalesced and the latter that the lacinia is wanting. This is the status of the lacinia in the higher Hymenoptera, writers consider it either as fused with the galea or as obsolete.

A comparison of the drawing of the maxilla of the honey bee with that of *Bombus* shows it to be similar in form but shorter and consists of a long, slender, proximal piece, the cardo,

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†Snodgrass, R. E.—The anatomy of the honey bee. U. S. Dept. Agr., Bur. Entom., Tech. Ser. No. 18. 1910. Pp. 45–46.

and a distal piece divided into two regions by the difference in coloration. The distal two-thirds is a blade-shaped piece with a median ridge bearing setæ. This blade-shaped piece is the galea and the median ridge is the supposed line of coalescence of the galea and lacinia of Comstock and Kellogg. There is borne on the lateral margin at the proximal end of the galea a two-segmented appendage, the palpifer and a one-segmented maxillary palpus. The palpifer is inserted in a furrow in the side of the maxilla and can be pushed back against the bottom of this furrow so as not to project beyond the lateral margin of the maxilla. There is a distinct convexity at the distal end of this furrow and an oblique line extends across the maxilla from this point, which probably marks the division between the galea and the proximal piece of this portion of the maxilla, the stipes. The suture between the galea and stipes is obsolete. The lacinia is a thin, cuticular lobe attached near the mesal margin of the stipes at its distal end. It is not attached at the margin of the stipes but a short distance within. The lacinia at its distal margin is developed into a lobe which rests upon the base of the galea. It is so delicate that where it rests upon the galea, its distal end appears like a faint, curved, transverse suture. The distal end of the lacinia resting upon the galea is evidently what Comstock and Kellogg have mistaken for a suture separating the galea into a triangular proximal piece and a distal blade-like piece. The lacinia is larger and more distinct in the honey bee than in *Bombus*. It shows very distinctly on specimens cleared in caustic potash and studied in alcohol.

The lacinia was found to be present in the maxillæ of practically all the Hymenoptera examined. It is very large and distinct in *Priocnemis*, fully one-third the size of the galea which is greatly expanded and consists of two distal lobes. In the large carpenter ant, *Campanotus*, the lacinia is a distinct lobe at the proximal end of the galea. Wheeler* considers it as present but his figures of the maxillæ copied from Janet do not show it. A species of *Andrena* also shows it as a lobe similar in form and location to that of *Bombus* and *Apis* but smaller. The only hymenopterous insect examined where the lacinia was found to be completely wanting was the short tongued bee,

*Wheeler, W. M.—Ants, their structure, development, and behavior. New York. 1910. P. 19.

Augochlora. In this bee the galea has been reduced to a mere oblique knob at the distal end of the maxilla and the stipes transformed into a blade-shaped organ with a distinct palpifer and a five segmented maxillary palpus on the lateral margin near the distal end of the maxilla.

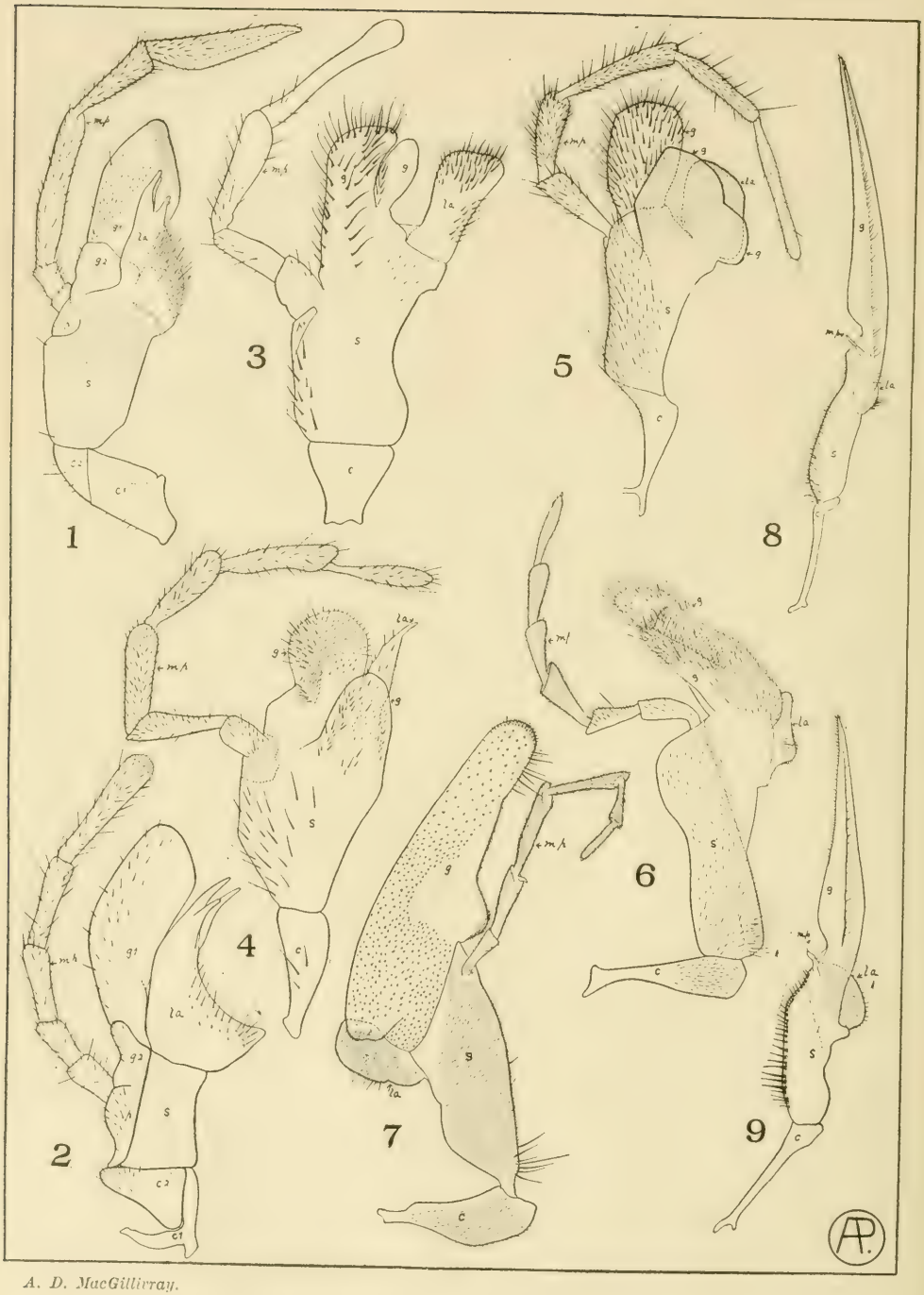
LIST OF ABBREVIATIONS.

c. Cardo.
c1. Proximal segment of cardo.
c2. Distal segment of cardo.
g. Galea.
g1. Distal segment of galea.
g2. Proximal segment of galea.
la. Lacinia.
mp. Maxillary palpus.
p. Palpifer.
s. Stipes.

PLATE XVIII.

(Drawings by Alvah Peterson.)

1. Periplaneta orientalis.
2. Melanoplus differentialis.
3. Macroxyela infuscata.
4. Dolerus unicolor.
5. Ophion bilineatum.
6. Vespa maculata.
7. Sphex pennsylvanicus.
8. Bombus terricola.
9. Apis mellifica.



A. D. MacGillivray.

THE PUPAL WINGS OF HEPIALUS THULE.

By Alex. D. MacGillivray,
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The adult wings of the different species of the genus *Hepialus* are of particular interest because they show such a generalized condition. They approximate the closest to the hypothetical wing type of Comstock and Needham of any insect's wings with which I am acquainted. This hypothetical type is supposed to show the number and arrangement of the longitudinal veins as they existed in the primitive insect's wing. These authors have shown that a study of the arrangement of the tracheæ preceding the formation of the veins in developing wings throws much light on the homology of the veins of the adult wing. Many developing wings of Lepidoptera have been studied and figured, but so far as I am aware no investigator has studied and figured the developing wing veins of a species of *Hepialus*. It was my good fortune, through the kindness of Professor J. M. Swaine of MacDonald College, Quebec, Canada, to obtain pupæ of *Hepialus thule* hardened in formol in the right stage for a study of the developing wing veins. These specimens showed not only the tracheæ, which are represented as black lines on the accompanying figure, but also the veins, which are represented as white bands. Unfortunately nothing could be determined as to the arrangement of the tracheæ after they left the veins and entered the body. The various veins will be taken up in order.

Costa.—The costa can be traced as a distinct, unbranched vein in both wings a short distance within the costal margin. A trachea was found only in the costa of the front wings and this was only a mere stub.

Subcosta.—The subcosta shows as a two-branched vein, identical in form with the subcosta of the hypothetical type. The tracheal stem of subcosta is distinct and in the front wing branched midway between the base of the wing and the point of separation of subcosta into Sc_1 and Sc_2, though in the hind wings the point of branching of the trachea is much nearer the point of separation of the two branches of subcosta. The

*Contribution from the Entomological Laboratories of the University of Illinois, No. 30.

tracheal branch supplying Sc_1 is much weaker than that extending through Sc_2. The preservation of both branches of subcosta is peculiar to the Jugatæ among the Lepidoptera. In the Hepialidæ, this condition differs with the different species; in some species they are both well preserved, in others the portion representing the free part of Sc_1 is sometimes present in both wings, sometimes present in the front wing and wanting in the hind wing or *vice versa*, or it may be entirely wanting in both wings, while in still other species no trace of it is ever found. The portion of subcosta always preserved is the long, straight stem representing Sc_2, so that if we may judge from the form of the vein preserved and the decadent condition of the trachea of Sc_1, as shown here, the tip of the subcosta as preserved throughout the higher Lepidoptera must be Sc_2.

Humeral Cross-Vein.—The humeral cross-vein is usually preserved in the Hepialidæ. It is distinct in this species and located in its usual place between costa and subcosta near the base of the wing.

Radius.—The radius, both so far as the tracheæ and the developing veins are concerned, consists of five branches. A basal stem dividing dichotomously into an unbranched vein, R_1, and a stem which divides dichotomously into R_{2+3} and R_{4+5}. Each of these in turn divide dichotomously, the anterior into R_2 and R_3 and the posterior into R_4 and R_5. The number of branches and their method of dividing is identical with the hypothetical type. The radius of the hind wings of *Hepialus* as is common in the Jugatæ, contains as many branches as the radius of the front wings.

Media.—The media of both wings is similar in form and consists of three branches. The median trachea of each wing lies in the same vein cavity as the radial trachea at the proximal end of the wing. They extend along side by side for some distance, then the medial trachea bends away from the radial trachea, and pass into the median vein cavity. The median tracheæ branch dichotomously near the base of each wing, the anterior branch from this dichotomy after a short distance divides again dichotomously into M_1 and M_2. The posterior branch from the first dichotomy passes unbranched directly to the wing margin. This branch of media in the hypothetical type gives rise to M_3 and M_4. None of the pupal wings of *Hepialus* examined gave indication of smaller

branches arising from this trachea. The cross-veins are all without tracheæ as is the usual condition in generalized wings. The posterior branch arising at the first dichotomy of media in *Hepialus* is undoubtedly the homologue of the posterior branch at the first dichotomy of media of the hypothetical type. This branch in the hypothetical type divides dichotomously

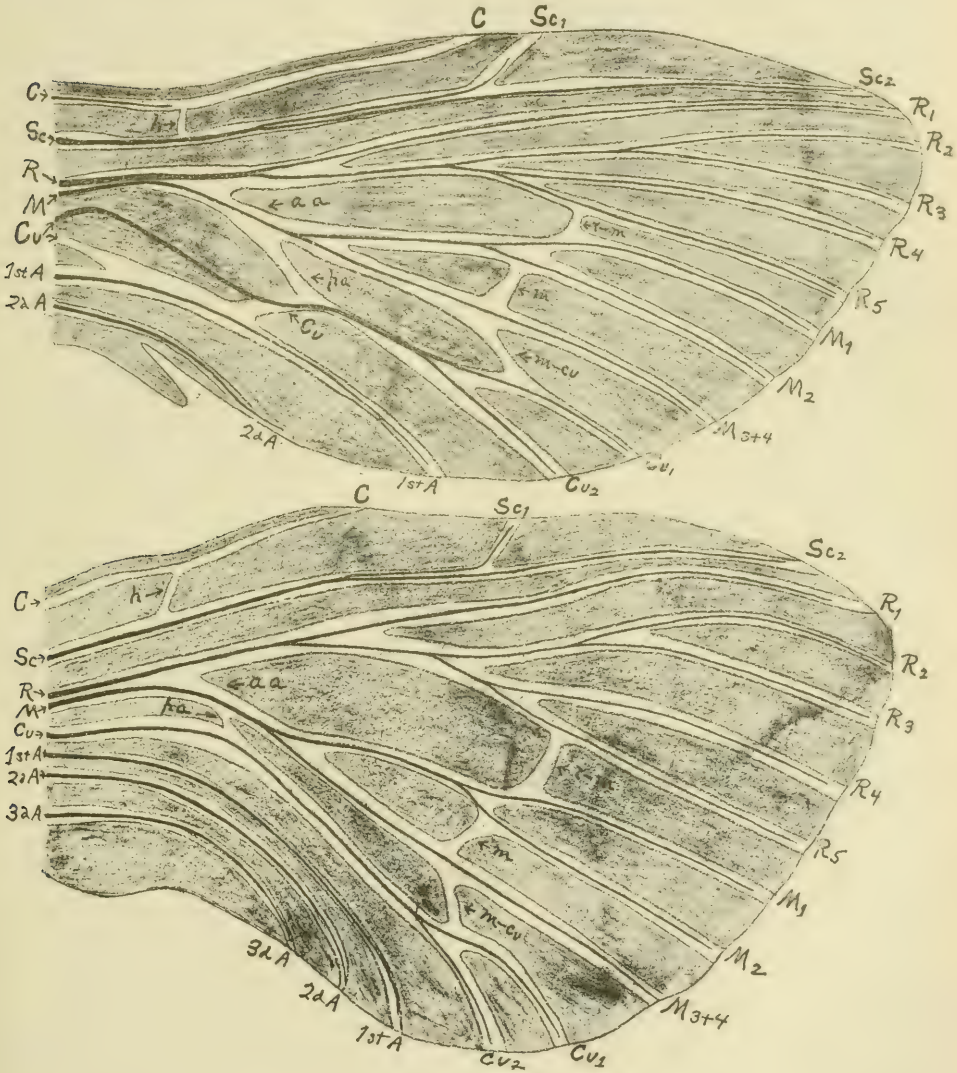


Fig. 1. Hepialus thule, pupal wings.

into M_3 and M_4, so that this branch in *Hepialus* must represent M_3 and M_4 or as it is here labelled, M_{3+4}. The position of the branch M_4 in the Lepidoptera has not been definitely placed. Comstock and Needham figure the wings of *Sthenopis*, in the hind wing of which there is an extra branch on Cu_1, which they label as M_4. This would mean, if this interpretation is correct, that M_4 is coalesced with Cu_1 in the higher Lepidoptera. The wings figured are of a species in which Cu_1 is usually unbranched. The specimen figured is undoubtedly an abnormal specimen so far as the branching of Cu_1 is concerned and should have no weight in deciding what has become of M_4. That the above authors were in doubt is shown by the following foot-note taken from their paper: "With our present knowledge it is impossible to determine the way that vein M_4 has disappeared in the Frenatæ. We have seen no indication that it coalesces with vein Cu_1 as in *Sthenopis*, for in all pupæ of this suborder that we have examined the medial trachea is only three-branched. We are obliged, therefore, to omit any further reference to this vein in the discussion of this order." The venation of certain species of *Hepialus* is frequently abnormal. This is strikingly true of *Hepialus humuli*. I have seen wings which had extra branches on both media and radius. In the case of radius, specimens have been examined that contained six, seven, and even eight branches. So that the condition figured in the hind wing of *Sthenopis* is not unusual. The fact that none of the pupal wings showed any branching of this portion of the tracheæ of media in either wing and the further fact that *Hepialus* is one of the most generalized of lepidopterous insects, where of all places positive evidence should be sought for demonstrating this point, the interpretation must be, that the third branch of media in both wings, not only of *Hepialus* but of the Lepidoptera, is M_{3+4}.

Radio-Medial Cross-Vein.—The radio-medial cross-vein is distinct, in its usual place between R_5 and M_1, and is not preceded by a trachea.

Medial Cross-Vein.—The medial cross-vein is present, distinct, in its usual position between M_2 and M_3, and is not preceded by a trachea.

Cubitus.—The vein cavity of the cubitus of the front wings is located some distance behind the radio-medial vein cavity. It is free for a short distance at the base of the wing, then is

fused with another vein to a point opposite the point of separation of media and radius. Here the cubitus bends abruptly toward the apex of the wing for a short distance and then turns abruptly again toward the wing margin, parallel with M_4. Just before reaching the wing margin, it divides into Cu_1 and Cu_2. The basal part of the cubital trachea of all the front wings studied did not lie in the cubital vein but took a short cut toward the base of the wing. With the limited material at hand it is impossible to determine whether this is a normal condition or an artifact due to the mounting. The cubital vein cavity and trachea of the hind wing is situated much nearer to the medial trachea and vein cavity than in the front wing. The cubitus extends parallel to the media until near the wing margin where it divides into two branches, Cu_1 and Cu_2.

Medio-Cubital Cross-Vein.—The medio-cubital cross-vein is present, distinct, and in its usual position between M_{3+4} and Cu_1. This cross-vein differs from the other cross-veins in its oblique direction, a direction very suggestive that this was the course of the fourth branch of media. The entire lack of tracheæ in these veins defeats such an interpretation.

Arculus.—The arculus is a cross-vein-like structure at the base of the wing extending between radius and cubitus. The term arculus was first used for this structure in the wings of the Odonata, but as pointed out by Comstock and Needham, it is present in the wings of many insects. It is well developed in the wings of many Diptera but has not been pointed out hitherto in the wings of the Lepidoptera. The arculus, while cross-vein-like, is in reality a compound structure. The stem of media passes to the base of the wing midway between radius and cubitus to the arculus, makes an abrupt bend to the front of the wing, forming the anterior portion of the arculus, extends to radius, and then makes another abrupt bend and extends to the base of the wing in combination with radius. The posterior part of the arculus is a true cross-vein, extending from the first abrupt bend of media to the cubitus. The anterior or median portion of the arculus may be designated as the anterior arculus (*aa*) and the posterior part, consisting of a cross-vein as the posterior arculus (*pa*).

Both front and hind wings of *Hepialus thule* show a well developed arculus. Practically all of the carefully prepared drawings of the wings of the Jugatæ give some hints as to the

actual condition, though most of them indicate the media as coalesced at base with cubitus. An examination of the figures of the pupal wings of *Hepialus thule* shows the tracheæ of media lying along side the tracheæ of radius in the wing cavities of radius. A short distance from the base of the wing the median trachea diverges from the radial trachea into a broad vein cavity of its own, which passes obliquely across the wing for a short distance and then turns toward the margin of the wing between and parallel to the radial and cubital vein cavities and tracheæ. The oblique part of the median vein cavity is the anterior arculus (*aa*). Near the point where the median trachea bifurcates, a broad vein cavity joins the median vein cavity and passes obliquely, posteriorly to the cubitus. This latter oblique vein cavity is not supplied with a trachea. It is the cross-vein part of the arculus, the posterior arculus (*pa*). The posterior arculus of the front wing is much longer than that of the hind wing. This explains why in adult wings, the media frequently appears to be joined to the radius in the front wing and to the cubitus in the hind wing.

There is a great variation in the constituent parts of the arculus in the wings of different insects. This is especially true in the Diptera. A generalized condition is found in many wings, such as those of *Tabanus* or *Leptis* where the median vein joins the middle of the arculus. In such cases, the anterior arculus and the posterior arculus are subequal in length. Two lines of modification may be developed from this generalized condition. The media may migrate along the arculus nearer and nearer to the radius until it actually joins the radius. The anterior arculus through this migration becomes shorter and shorter, with a corresponding lengthening of the posterior arculus. When the media joins the radius, the anterior arculus is obliterated and the arculus is wholly cross-vein in structure or posterior arculus. If the posterior arculus atrophies in the descendants of such forms, the radius would appear to arise directly fron the radius without an abrupt bend. The second condition is found where the media migrates toward cubitus. There results a similar shortening of the posterior arculus and an elongation of the anterior arculus. This may proceed until the media is free from the arculus and coalesced with the cubitus as in the wings of *Pantarbes* or *Erax*. Whereas the cross-vein like structure was all cross-vein or posterior arculus in the first

case, in the second case it is all median or anterior arculus. A similar atrophy of the anterior arculus may take place and a condition like that found in the wings of the muscids exist, where media appears to arise from cubitus. This shows how even in the two wings of the same species, as certain Jugatæ, the media may appear to arise from the radius in the front wings and from the cubitus in the hind wings.

Anal Veins.—The front wings of *Hepialus thule* has two anal veins, each represented by a trachea. The first anal vein is coalesced for a part of its course with the stem of cubitus. many figures of wings of *Hepialus* show a cross-vein between cubitus and the first anal vein, the cross-vein is the true course of cubitus. The apparent continuation of cubitus proximad of this cross-vein is the posterior arculus. The second anal vein lies close to the wing margin and the vein cavity is not well developed. The hind wing has three well developed anal tracheæ in three equidistant vein cavities. The vein cavity of the first anal vein is not so distinct as the others.

ANATOMY OF THE TOMATO-WORM LARVA, PROTOPARCE CAROLINA.*

By Alvah Peterson.

The larvæ of *Protoparce carolina* are excellent subjects for the study of the anatomy of a developing insect. Its size and abundance during the late summer and early fall make it an available subject throughout the middle west. There are no detailed investigations of the larva of this family, so that a discussion, such as is given in the following pages, would not seem out of place. This investigation was started under Dr. A. D. MacGillivray, in order to acquire some information as to the internal anatomy of insects. Since there is such a dearth of literature dealing with the larvæ of American Lepidoptera, I have prepared, at his suggestion, the following descriptions and figures. I am greatly indebted to Dr. MacGillivary for suggestions and other help. I have found Mr. A. G. Hammer's excellent paper on the nervous system of the larva of *Corydalis cornuta* L. very useful and wish to express my appreciation of it.

METHODS.

When the work was first taken up, it was doubtful if it could be completed in one season, for only a limited amount of good material was available. There still remain a few points that need further observation, and these will be mentioned later. The best material for dissection proved to be larvæ that had been killed in hot water and preserved in 70% alcohol. Even with the largest and the best prepared specimens, one finds that the internal structures are not as easy to follow as one might expect. Especially is this true with respect to the nervous and circulatory systems. The factor causing the greatest difficulty outside of the frailty of the material, is the existence of a superabundance of adipose tissue or fat. To remove this fat, without tearing or destroying other parts, in order to observe the various organs, is difficult. The larvæ were opened by cutting a longitudinal slit along the meson on the dorsal or ventral aspects and laid out flat and pinned in dissecting trays. By gently rubbing and teasing the masses of adipose tissue, one can remove a sufficient amount to be able to observe the covered

*Contribution from the Entomological Laboratories of the University of Illinois, No. 31.

parts. Staining the tissues with a weak solution of Delafield's hematoxylin was found very useful in differentiating the finer structures. This was especially true in working with the nervous and circulatory systems. The resulting light-bluish coat given to the tissues, when not stained too deeply, proved to give the best results. Stained material will retain the stain for three or four days without becoming muddy and indistinct. To stain a certain area, the obstructing material was cleaned away and rinsed clean with running water. Pouring off all the water, two or three drops of the stain were dropped on the moist parts. The stain in no case was allowed to remain on the tissues over thirty seconds. As a general rule, the surplus stain was immediately washed off with running water.

The various parts of the larva will be discussed in the following order:—

A. External Anatomy:—Head, Thorax, and Abdomen.

B. Internal Anatomy:—Adipose Tissue, Digestive System, Silk Glands, Salivary Glands, Respiratory System, Muscular System, Circulatory System, Reproductive Organs, Wing Buds, and Nervous System.

A. External Anatomy.

The larva of *Protoparce carolina* when mature is approximately 9 cm. in length and 12–15 mm. in diameter. It has a distinct greenish cast with diagonal lines of dark brown, pigmental blotches, which extend from the dorso-caudal part of each abdominal segment ventro-cephalad. The body is divided into three regions, head, thorax, and abdomen.

Head (Figs. 1, 2 and 3).—The head is the smallest division of the body. It is a non-wrinkled, yellowish-white region, which from a lateral or ventral aspect is oval in outline, while from a cephalic view, it is spherical. On the median portion of the cephalic aspect, there exists a distinct inverted Y-shaped suture (*e*), the epicranial suture, which divides the fixed parts of the head into three regions. Connected with the ventral part of the region included within the arms of the Y, are the mouth parts. The large areas laterad of the epicranial suture have on their ventral aspects the antennæ and simple-eyes.

Eyes.—The simple eyes (*o*) consist of two groups of six ocelli, five of which are arranged in a semicircle with the sixth on the median part of the diameter of the circle. These groups

viewed from the cephalic aspect, are on the ventro-lateral regions of the head.

Antennæ.—Mesad and slightly ventrad of the ocelli are located the three-segmented antennæ (*at*). Each consists of a conical-shaped basal segment bearing on its distal end two similar, cylindrical segments. On the distal end of the third segment, two unequal setæ are borne, the mesal one being the longer.

Front.—The triangular area included within the arms of the Y, is the front (*f*).

Clypeus.—The clypeus (*cl*) is attached to the ventral edge of the front and forms a transverse bar, bearing a single seta on each lateral end.

Labrum.—At the apex of the clypeus, there is borne a bilobed area (*lr*), which has on its ventral edge a deep notch, which makes the labrum bilobed. On the lateral and ventral parts of these lobes are borne setæ. Three large setæ for each lobe seems to be the constant number in the various specimens examined, while there is a variation in the number of small setæ on the depressed region above the notch.

Mandibles.—The two stout mandibles (*md*) meet in a zigzag line caudad of the labrum. The zigzag line is due to the interlocking of the four dark, tooth-like projections which occur on the mesal edge of the laterally opening mandibles. The mandibles are connected to the head proper at the lateral margins of the labrum and maxillæ. Each mandible bears on its distal median portion a single seta.

Maxillæ.—Directly caudad of the proximal portion of the mandibles are two globular maxillæ (*mx*), each of which bears ventrally a three-segmented, tapering palpus. The distal segment of the palpus is very small.

Labium.—Mesad of the two maxillæ, there is a wedge-shaped labium (*lb*), which gives rise to a tubular projection at its caudo-distal edge.

Spinneret.—This tubular projection (*i*), which extends caudad and ventrad, is the spinneret, from which the silk is exuded.

THORAX.—The thorax, being the second region of the body, is adjacent to the head and consists of three segments as follows:

Prothorax (Fig. 1).—The prothorax is the cephalic segment of the thorax and is comparatively smooth and not transversely

wrinkled on its dorsal aspect. It bears on its ventral side a pair of true legs. On the caudal part of the lateral surface of the prothorax can be seen an oval spiracle.

Mesothorax and Metathorax (Fig. 1).—The mesothorax and metathorax are very similar, consequently the description of either will answer for both. Six, transverse furrows cut the dorsal surface of each segment and a pair of true legs is found on the ventral aspect of each. These two segments bear no spiracles.

Legs (Figs. 1*lg* and 5).—The three pairs of legs on the thorax are approximately alike. On all these legs numerous small setæ are borne. A leg consists of the following parts. At the base of each leg is a widened, oval, furrowed area, which constitutes the coxa (*co*) of the leg. The trochanter (*tr*), a wedge-shaped, darkened sclerite, exists on the ventro-mesal margin of the coxa adjacent to the following segment of the leg, the femur. The femur (*fe*) is the large, cylindrical segment distad of the trochanter. The tibia (*ti*) follows the femur and bends slightly mesad. The distal segment of the leg is a small, cone-shaped tarsus (*ta*), which bears on its distal end, minus an intervening suture, a single, dark-hooked claw (*ca*).

Abdomen (Fig. 1).—The abdomen is by far the largest portion of the larva, for it consists of eight, possibly nine, large segments. Some writers consider the eighth segment, as it is here called, as made up of two segments. The proleg (*a. pl*) of the last segment in this case would be attached to the ninth, while the anal horn (*ah*) would be borne on the caudo-dorsal part of the eighth segment. In the abdominal segments one to seven, a distinct similarity exists. However the abdominal segments three, four, five and six, give rise to pairs of prolegs (*pl*).

Fourth Abdominal Segment (Fig. 1).—Taking the fourth abdominal segment as a typical segment, one finds it is composed of eight, distinct, transverse, ridges on its dorsal and dorso-lateral aspects. Numerous pigmental areas can be found in the furrows. The most striking pigmental arrangement is the diagonal line of spots running from the dorso-caudal angle of the segment toward the ventro-cephalic portion. The large, oval spiracles (*s*) are located on the lateral aspects of the segments in the ventral and cephalic portion. These oval, darkened areas (Fig. 6, *s*) on magnification appear to be made up of a fine network of dark chitin and also show an indefinite,

median, dorso-ventral slit, which opens into the trachea. The prolegs (*pl*) on the ventral aspect of this segment, are a pair of fleshy appendages, which bear on their distal margins a convex, double row of black hooks, which point mesad (Fig. 4).

Eighth Abdominal Segment (Fig. 1).—The last segment of the abdomen is somewhat elongated and not so excessively cut by transverse furrows as the preceding segments of the abdomen. At the middle of the dorsal surface of the segment, a spine-like anal horn (*ah*) arises. From this point the segment is cut off obliquely at an angle of 45°. At the dorsal edge of this sloping portion the triangular anal plate (*ap*) is located. The anus (*a*) is situated ventrad of the anal plate. The anal prolegs (*a. pl*) resemble in most details the prolegs of the fourth abdominal segment. However their size is a trifle larger and the relation of their connection with the ventral surface of the segment is somewhat different. The spiracle (*s*) of this segment may be seen in its usual position.

B. Internal Anatomy.

ADIPOSE TISSUE.

On opening a larva, the first thing noted is the abundance of fat, or adipose tissue (Fig. 10). Adipose tissue, as seen throughout the body, is the white, flocculent, lobulated, ribbon-like material surrounding and adjacent to the various organs in the body cavity. This fat tissue is stored up for future metamorphosis. Sections and mounts of adipose tissue stained with eosin show (Fig. 10) its oily nature. The large spherical, fat cells in their crowded, massed condition assume a polygonal form. Internally, the cells are filled with oily globules of fat and possess also a dark-staining, centrally located nucleus. To rid the larva of this fat, one needs carefully to rub and tease it loose.

ALIMENTARY CANAL.

Extending from the mouth to the anal opening of the larva, there is a long, straight, locally constricted tube, which in the abdominal region occupies the greater portion of the body cavity. This is the alimentary canal, or digestive tract. On opening a larva from the dorsal aspect (Fig. 7), the following structures may be observed:—

Pharynx (Figs. 7, 8, and 18).—The pharynx (*p*) is the smallest part of the digestive tract and is located at the extreme

cephalic end within the head. It proceeds from the ventrally-located, mouth opening, dorsad and caudad till it enlarges into a region called the œsophagus. The more or less distinct flexure in the pharynx occurs for the most part caudad of the two head ganglia. The abruptness of this flexure depends in great part upon the position of the head. The pharynx as represented in the figures has been straightened. Arising from the pharynx are bundles of muscles that attach themselves to the head capsule.

Œsophagus.—As the pharynx begins to widen caudad of the flexure within the head, the œsophagus (*oe*) here begins and extends caudad to the ventriculus (*ve*), which is in the cephalic region of the metathorax. This trumpet-shaped piece has a finely, transversely striated ectal surface.

Ventriculus.—The ventriculus (*ve*), is a long, straight, large, transversely folded tube, which extends from the caudal end of the œsophagus to the caudal portion of the sixth abdominal segment. The transverse, folded, outer covering of the ventriculus is divided into six areas by means of six fine, longitudinal bands of muscles, which extend the full length of the ventriculus. The six bands have the following positions. One band is dorsal along the meson, one ventral along the meson, two dorso-lateral, and two ventro-lateral.

Gastric Cæca.—Located at the dorso-cephalic end of the ventriculus, between the terminations of the muscle bands, there are four groups of small, white, rounded bodies (*ce*), the gastric cæca.

Small Intestine.—Caudad of the smooth, slightly converging, caudal end of the ventriculus, there is a distinct constriction, which is immediately followed by a small ring-shaped area, the small intestine (*s. i.*) On the ectal surface of the small intestine, pits exist through which tracheæ and muscles fibres-enter. From the ventral aspect, two small bladders may be seen, which enter the small intestine at its latero-cephalic portions.

Large Intestine.—The smallest constriction in the caudal region of the alimentary tract, which is just caudad of the small intestine, is the beginning of the large intestine (*l. i.*). Immediately following this middle constriction there is a flaring shoulder, which again becomes constricted caudad, but not to as great an extent as the constriction just described. Two more small, shoulder-like areas follow this constriction, the

anterior one being very slight. This constitutes the large intestine. The above shape and form holds true only when the intestine is completely empty and relaxed. Excreta within will cause the large intestine and rectum, which follows, to assume various shapes.

Suspensory Muscle of the Large Intestine.—These two muscles (*s. m.*) extend from the ventral side of the cephalic margin of the caudal enlargement of the large intestine to the latero-ventral portion of the transverse conjuctiva, between the sixth and seventh abdominal segments. These two cord-like muscles can be best seen from the ventral aspect.

Rectum.—The rectum (*re*) is the caudal termination of the alimentary canal and occupies the caudal portion of the seventh abdominal segment and the entire portion of the eighth. The rectum is the largest in diameter of all the portions of the alimentary canal. On the dorsal surface of the rectum, there are located two prominent, longitudinal bands of muscles that converge at the cephalic end of the rectum and connect at their caudal end to the body wall. By means of the contraction of the rectum, the characteristic form is given to the excreta of lepidopterous larva.

Tracheæ of the Alimentary Canal. (Fig. 7, *t*).—The tracheæ of the oesophagus and pharynx are very small and their arrangement is difficult to trace. From the adjacent first six abdominal spiracles there is a fan-like arrangement of tracheal branches which enter the lateral, folded area of the ventriculus. These tracheæ support the ventriculus and supply it profusely with air. Tracheæ from the seventh abdominal segment lead to the large and small intestine and the cephalic area of the rectum. However, the rectum obtains most of its oxygen by means of the tracheæ coming from the eighth abdominal segment.

URINARY SYSTEM.

The urinary system (Figs. 7 and 9) of *Protoparce carolina* is composed of two bladders, right and left, and their respective tubules. Fig. 9 shows a bladder (*b*) and how it enters the anterior part of the small intestine on the ventro-lateral portion. It has been pulled out of its normal position in order to show the place of attachment of the bladder with the small intestine. It turns back on itself, as in Fig. 7, and thus conceals its place of entrance. Leading cephalad from the small, delicate, white

bladder, there is a common duct, which splits immediately and gives rise to two branches; one continues cephalad on the ventral side (*v. m. t.*), while the other passes dorsad and divides into two branches (*d. m. t.*), both of which proceed cephalad along the dorso-lateral part of the ventriculus. Tracing a ventral Malphigian tubule, we find that it extends cephalad in a nearly straight line, adjacent to the ventro-lateral portion of the ventriculus to the second abdominal segment. At this point it turns abruptly back and continues caudad and parallel with itself until it reaches approximately the seventh abdominal segment, where it becomes very convoluted and soon loses itself in the mass of convoluted, terminal, Malphigian tubules and adipose tissue. The pairs of dorsal tubules proceed cephalad and parallel into the second and third abdominal segments. The mesal tubule of the pair within the third abdominal segment, turns mesad and caudad, while the lateral tubule turns laterad and caudad within the second abdominal segment. After turning, both tubules proceed caudad and parallel with their cephalad-extending portion until they reach the sixth abdominal segment, where they turn laterad and continue into the seventh abdominal segment soon to become highly convoluted and intertwined with the ventral, terminal tubules and adipose tissue. The tubules are easily detected not only from their position, but from their form. They appear like long, white, knotted strings. The proximal portion of a tubule is more or less flattened and consists of scattered, white, globular nodules. As a tubule proceeds distad, the nodules become more frequent until finally at the terminal part of a tubule, as it enters the seventh abdominal segment, the tubule consists of a series of closely packed, irregularly arranged nodules. It was impossible to determine the termination of a tubule on account of the intertwining of the tubules, their delicate consistence, and the ever present adipose tissue.

SILK GLANDS.

Running along each side of the lateral portions of the ventriculus (Fig. 7, *sg*) and imbedded in the adipose tissue of the lateral body wall, are two opaque, smooth, yellowish-white cords. These two cords are the silk glands. They extend from the base of the spinneret on the labium into the seventh abdominal segment. The right and left silk glands of this larva

are practically of the same size thoughout their length. However, the cephalic end from the metathoracic region to the point of attachment to the spinneret is much smaller and serves probably only as a conducting tube. These conducting tubes can be traced into the head until they reach the chitinous projections on the caudal margin of the head, around which they bend at right angles and unite on the meson. Farther than this the duct was not traced. As one traces, caudad from the metathoracic region, a silk gland proper, one sees the beginning of the coiled or rather convoluted portion of this organ. Within the fifth and sixth abdominal segments the convolutions are most abundant. The gland terminates in the mass of Malphigian tubules and adipose tissue within the seventh abdominal segment.

SALIVARY GLANDS.

The two salivary glands (Fig. 7, *sl*) appear as delicate, white, nodulated, twisted tubes on each side of the pharynx and œsophagus. They extend from the anterior portion of the head to the region of the metathorax and here end within a flattened mass of adipose tissue on the ventral wall of the thorax marking the line of division between the mesothorax and the metathorax. Tracing a gland into the head, it follows along the space between the muscles and the lateral margin of the pharynx to the margin of the tendon of the adductor muscle of the mandible, where it becomes much reduced in size.

RESPIRATORY SYSTEM.

In the discussion of external anatomy, it was noted that there were nine spiracles, eight of which were abdominal and one thoracic. Opening a larva from the ventral side and removing the alimentary canal and a part of the adipose tissue, a system of more or less transparent, white, smooth tubes, similar to Fig. 11, reveals itself. To follow the tracheæ with most satisfactory results, one should open a freshly killed larva and immerse the same in water. In this case the tubes would be filled with air and appear as glistening, silver cords.

Arising from each spiracle, there is an immense, bush-like mass of tracheæ, that branch into many fine tubes, which in most cases extend to the various parts, such as muscles, nerves, alimentary canal, legs, heart, etc., of the same body segment. This holds true of the abdominal segments only. All the

spiracles of each side open into the main, longitudinal trachea which extends between the spiracles and is amply long to allow for expansion of the body segments. A unique fact, to note in regard to these connecting tracheæ, is that each gives rise to small lateral branches varying from two to six or more in number.

In examining specimens for transverse tracheal connections between spiracles of the same segment, none were found on the dorsal aspect except from the thoracic spiracle and the eighth abdominal spiracle. If other dorsal cross tracheæ exist, they must be very minute and delicate, for they were carefully sought. In the case of the eighth abdominal segment, only one minute dorsal cross trachea was found (Fig. 11), while in the prothoracic region, two distinct, cross tracheæ were observed, the cephalic one being the larger and giving rise to two pairs of tracheæ, which proceed cephalad and ventrad into the anterior portion of the head. The caudal cross trachea of the two gives rise to four or five minute pairs of tracheæ, which diverge in various directions. It should be mentioned, that the tracheal system varied considerably in minor details in different specimens. Looking on the ventral aspect for cross tracheæ, it was found that a small cross trachea existed near each ganglion of the nervous system (Fig. 13) except the supra-oesophageal ganglion, which is located dorsad and cephalad of the pharynx. The cross tracheæ adjacent to the metathoracic and mesothoracic ganglia seemed to originate from branches of the connecting tracheæ between the first and second spiracles of the body. In all cases, with one exception, the cross tracheæ lie ventrad of the nerve cord and in the abdominal region caudad of the ganglia. The one exception is the cross trachea that lies adjacent to the suboesophageal ganglion. In this case the trachea is dorsad of the commissure (*H.* 2*g.*). Each cross trachea on the ventral aspect gives rise to a pair of tracheæ that supplies the adjacent ganglion.

MUSCULAR SYSTEM.

In the gross treatment of the muscular system (Fig. 12) of this larva only the more prominent bands of muscles will be mentioned. The muscular system of the larva is segmentally arranged. The muscle fibres are confined in their extent to a single segment and furthermore the muscular arrangement is similar in each segment on the whole. This is especially true

with the abdominal segments. Consequently the description of a single segment will answer as a type of all the segments. The muscles of the thorax are more complex, due to the muscles of the legs.

Great Dorso-Recti Muscles (*g. d-r.m.*).—The broad area of white, opaque muscles lying to the right and left of the heart are the great dorso-recti muscles. Upon a superficial examination of the ends of the muscles at the conjunctiva, one might be led to think that the muscles were continuous, except for a slight depression. But as a matter of fact, they are contiguous and separated by a narrow, hyaline, cuticular line at the point of the depression. These particular muscles attach themselves to the cephalic side of the transverse conjunctiva.

Small Dorso-Recti Muscles (*s. d-r. m.*).—Laterad of the lateral margin of the great dorso-recti muscles, the small dorso-recti muscles are located. This band of muscles consists of three to five small fibres that are fastened to the caudal margin of the transverse conjunctiva. Laterad of this bundle of muscles an area exists, which is free of longitudinal muscles but contains the spiracles and their accompanying tracheæ.

Great Ventro-Recti Muscles (*g. v-r. m.*). If the larva is spread out as in Fig. 12, the large band of muscles laterad of the free area consists of the great ventro-recti muscles. This group is ventrad of the spiracles. These muscles attach themselves to the cephalic aspect of the transverse conjunctiva.

Small Ventro-Recti Muscles (*s. v-r. m.*).—These muscles are located mesad of the great ventro-recti muscles along the ventral area of the larva adjacent to the nervous system. They are attached to the caudal side of the transverse conjunctiva. All these muscles are supplied by tracheæ.

Dorso-Ventral Muscles (*d. v. m.*).—The dorso-ventral muscles are the two groups of short muscles that extend dorso-ventrad across the free area existing between the great ventro-recti muscles and the small dorso-recti muscles, one group at the cephalic end of the segment and the other at the caudal end. Two fibres, the cephalic group, cross immediately cephalad of the spiracle and mesad of the longitudinal trachea between the abdominal spiracles and mesad of the small dorso-recti muscles. The other remaining fibres disappear dorsally in the cephalic part of the segment as the two already described fibres but ventrally they cross at an angle the transverse conjunctiva

and disappear from view in the extreme caudal part of the preceding abdominal segment. Other muscles besides those thus far discussed are present in each body segment. By carefully lifting the longitudinal fibres, one finds other bands of muscles running at an angle to those named above. This is indicated in Fig. 12, (*x*), where in the caudo-dorsal angle of the free part about the spiracles in each segment one sees the ends of such diagonal bands.

CIRCULATORY SYSTEM.

Dorsad of the alimentary canal is a long slender tube (Fig. 12) embedded to some depth in a mesal cavity of adipose tissue between the right and left bands of the great dorso-recti muscles. This tube, which comprises the whole of the enclosed circulatory system, extends from the eighth abdominal segment to and within the head. The enlarged part of this tube, extending from the eighth abdominal segment into the metathoracic region, is the pulsating organ, the heart.

Heart.—The heart (*h*) is a very delicate, flattened, muscular tube closed at the caudal end and presumably opening in each segment by a system of valves. Owing to the lack of fresh and living material the valves of the heart were not studied. After injecting some colored fluid into fresh specimens, the valves should readily show themselves.

Wings of the Heart.—Within the area of the first to the fifth abdominal segments, four pairs of laterally extending fan-like rays of tendons (*w. h.*) are seen. The tendons extend from the ventro-lateral edges of the heart and converge at the point where the three anterior dorso-ventral muscles penetrate between the great dorso-recti muscles and the small dorso-recti muscles. The wings are composed of connective tissue and muscle fibres, connecting themselves to the body wall beneath the small dorso-recti muscles. The function of the wings of the heart is probably to protect the heart from the peristaltic movements of the alimentary canal. Between successive fans the heart proper is distinctly constricted. In these regions without much doubt the valves of the heart are located. The caudal part of the heart, extending from the midportion of the fifth abdominal segment to the caudal end, is supported by scattered, irregularly arranged tendons on the ventral surface, that attach themselves to the nearby body wall.

Aorta.—The cephalic extension of the heart, the aorta (*ao*), starting within the metathoracic region and passing into the head, is a much smaller and smoother muscular tube. It runs close to the dorsal surface of the œsophagus and the pharynx and finally terminates with a slight dilation after it has passed beneath the supra-œsophageal ganglion (Fig. 8 and 18). This location of the outlet allows a constant and abundant supply of fresh blood within the head region. The mouth-like opening of the aorta is held in its characteristic position by means of tendons that connect themselves to the head capsule (Fig. 8).

The heart, like the other organs of the body, is well supplied with air tubes. The arrangement of the heart-tracheæ is shown in the fifth abdominal segment (Fig. 12).

REPRODUCTIVE ORGANS.

After examining numerous specimens for gonads, two white, opaque, ovate bodies (Fig. 12, *r*) were found on each side adjacent to the heart in the fifth abdominal segment. Difficulty was experienced in locating these organs on account of their close similarity to adipose tissue and their being embedded in the same. It was impossible to determine the sex of the glands on account of the limited material at hand. From the fifth abdominal spiracle, tracheæ arise that supply the reproductive organs.

WING BUDS.

The wing buds (*f. b.* and *h. b.*) are the histoblasts, imaginal discs, or imaginal buds of the future wings of the adult insect. They are formed as invaginations of the hypodermis, to which they are attached. They are small, kidney-shaped bodies located in the dorso-lateral portions of the mesothorax and metathorax. If a larva is cut along the ventral meson, the wing buds will be seen about midway between the meson and the outer cut body wall. Two tracheæ enter the wing buds at their base, one into the caudal portion and the other into the cephalic portion.

NERVOUS SYSTEM.

The nervous system (Fig. 13) of *Protoparce carolina* consists of a long, white cord, knotted at segmental intervals, which extends for the most part along the meso-ventral portion of the body. This ventrally located, simple nervous system is made up of three parts: ganglia, commissures, and nerves. The

enlarged, oval knots, found in each segment of the body, are the ganglia. Only one ganglion exists in each body segment outside of the head and the seventh and eighth abdominal segments. The cords running between the ganglia, which in some cases are double or partially so, are the commissures. The nerves are the branches of various sizes extending from each ganglion and in some cases from the commissures. These fine threads permeate all parts of the body. The nervous system will be discussed under the following divisions: Abdominal Ganglia, Thoracic Ganglia, Head Ganglia, and Sympathetic Systems of the Head.

Abdominal Ganglia (Fig. 14 and 15).—The abdominal ganglia are the simplest in type. The distinct similarity between the first six abdominal ganglia makes it possible for one description to answer for all. The seventh and eighth abdominal ganglia will be discussed under a separate heading.

First Six Abdominal Ganglia (Fig. 15, *A*. 1*g*).—The first six abdominal ganglia are located in the middle or cephalic part of each abdominal segment and consist of the following parts:—

Lateral Nerves.—The lateral nerves (*l*) are the two branches, which arise from the cephalic part of the lateral margins of the ganglia and innervate the latero-dorsal portion of the body.

Ventral Nerves.—Directly caudad and slightly ventrad of the lateral nerves, the ventral nerves (*v*) arise and extend caudo-laterad to innervate the ventral area of the body segments Near the point of entrance of the ventral nerves, a pair of small nerve-like tracheæ enter the ganglia. These two tracheæ, one on each side, are derived from the transverse tracheæ located in each abdominal segment ventrad of the nerve cord. The tracheæ can be distinguished from the nerves by staining with Delafield's hematoxylin as heretofore advocated. A stained trachea is more deeply colored than a nerve and also shows its distinct ringed nature on high magnification.

Ventral Sympathetic System (Fig. 15, *m*. and *t. n*.).—Extending between the ganglia there is a single, large, white cord, the commissure. Just before the commissure enters the cephalic end of a ganglion, it divides into two cords or is furrowed on the dorsal surface. The ventral sympathetic nerves arise from the cephalic end of this fork. With some of the ganglia, this forking or splitting of the commissure is not very great but can in each case be detected.

Median and Transverse Nerves.—The median nerve (*m*) arises from the commissure at the cephalic end of this inverted V-shaped split and extends caudad for a short distance. At its caudal end near the ganglion, it forks and gives rise to two transverse nerves (*t. n.*), that extend in opposite lateral directions and more or less parallel with the lateral nerves. In the short distance in which the transverse and lateral nerves are parallel, the transverse nerves give rise to a web of nerve fibres (*px*), which connect with the lateral nerves and the ganglion. Beyond this web or plexus, the transverse nerves diverge from the lateral nerves in a cephalo-lateral direction.

Ganglia Seventh Abdominal Segment. (Fig. 14, *A*. 7 and 8 *g*). —Within the seventh abdominal segment, is a double ganglion, or rather two ganglia, but no visible commissure connects the two because of the close approximation of the ganglia. This modification brings about a change in the nerves.

Seventh Abdominal Ganglion.—The seventh abdominal ganglion is comparable to the ganglia of the first six abdominal segments. It gives rise to nerves arranged in the same manner and does not need further description.

Eighth Abdominal Ganglion.—The elimination of the commissure between the seventh and eighth ganglia has not only brought the ganglia together but has lengthened as well as changed the place of origin of the nerves from the ganglion.

Lateral Nerves.—The comparatively large lateral nerves (*l*) arise not from the lateral margin of the ganglion but from its dorso-caudal end and extend with a slight divergence far into the eighth abdominal segment before branching.

Ventral Nerves.—Ventrad and slightly laterad of the lateral nerves, there arises a small pair of ventral nerves (*v*), which also extend into the eighth abdominal segment before branching. Adjacent to these ventral nerves the accompanying tracheæ, which resemble nerves closely enter the ganglion. The ventral trachea of the eighth abdominal segment, however, still exists in its normal position within the eighth segment. This elongates to a great extent the pair of tracheæ that arise from it to supply the eighth abdominal ganglion.

Ventral Sympathetic System (Fig. 14, *m*. and *t. n.*).—The fusing of the seventh and eighth abdominal ganglia causes the sympathetic system apparently to arise from the dorso-caudal end of the seventh abdominal ganglion.

Median and Transverse Nerves.—The median nerve (*m*) arises from the mid-dorsal area of the double ganglion. It is very short. On teasing apart the two ganglia, the median nerve remains attached to the caudal end of the seventh abdominal segment. It immediately gives rise to its pair of transverse nerves (*t. n.*), which extend caudo-laterad into the eighth abdominal segment more or less parallel to and laterad of the pair of lateral nerves. However, no plexus exists between the transverse and lateral nerves of this ganglion, as was noted in the other segments.

Thoracic Ganglia (Fig. 17, *T.* 1*g*, and *T.* 2*g*, Fig. 16, *T.* 3*g*).—The thoracic ganglia are three in number, the mesothoracic and metathoracic ganglia are similar in form.

Mesothoracic and Metathoracic Ganglia (*T.* 2*g* and *T.* 3*g*).—The mesothoracic and metathoracic ganglia are slightly larger than the abdominal ganglia and are not as far apart. Extending from the caudal ends of all the thoracic ganglia, there is a large commissure (Fig. 17) which, in case of the prothoracic and mesothoracic, proceeds but a short distance and then forks and forms the diamond-shaped area in which the ventral sympathetic nerves are located. In both cases, the diamond-shaped area between the metathoracic and mesothoracic and between the mesothoracic and prothoracic ganglia occupies about two-thirds of the distance between the ganglia.

Lateral Nerves.—The lateral nerves (*l*) proceed from the ganglia at their latero-cephalic part and are adjacent to the lateral edges of the commissures. The lateral nerves extend in a latero-cephalic direction.

Connective Nerves.—The connective nerves (*c. n.*) arise from the lateral edges of the commissure and extend in a caudal direction. In the case of the diamond-shaped area between the mesothoracic and metathoracic ganglia, the connective nerves arise midway between the anterior and posterior angles of the diamond. While, with the diamond-shaped area between the prothoracic and mesothoracic ganglia, the commissure gives rise to its connective nerves very much nearer the mesothoracic ganglion than to the anterior end of the opening. The connective nerves proceed a short distance caudad, then turn laterad and somewhat cephalad, and soon fuse with the lateral nerves laterad of their connection with the commissure. Before fusing with the lateral nerves, the connective nerves give rise

to a branch that extends cephalad and somewhat parallel with the lateral nerves. This branch soon forks, one branch extends laterad across the lateral nerve, the other branch cephalo-laterad and parallel with the lateral nerve.

Ventral Nerves.—In the mesothoracic and metathoracic ganglia, the ventral nerves (*v*) arise from the lateral margin of each ganglion in a plane ventrad of the lateral nerves. The metathoracic, ventral nerves extend cephalo-laterad, while the ventral nerves of the mesothoracic ganglion project directly laterad. In both cases the ventral nerves innervate the ventral portion of the body. At the point of entrance of the ventral nerves, one finds the usual tracheæ that supply the ganglion with air.

Ventral Sympathetic System (Fig. 16, *T.* 3*g*, Fig. 17, *T.* 2*g*.)—With the mesothoracic and metathoracic ganglia, the ventral sympathetic system consists of a median nerve and transverse nerves.

Median and Transverse Nerves.—The median nerves (*m*) arise from the commissure in the cephalic angle of the diamond-shaped areas and in both cases are of considerable length before the fork. The mesothoracic median nerve is longer than the metathoracic median nerve. In both cases the transverse nerves (*t. n.*), after arising from the caudal end of the median nerve, proceed in such a direction as to cross the commissure at the point near where the connective nerves arise. After crossing the commissure, they tend to take, as usual a course parallel to the lateral nerves. The web or plexus (*px*) of nerves in these two ganglia is very distinct; this is especially true in the metathoracic ganglion. The plexus occurs principally in the triangular area between the commissures, the lateral nerves, the transverse, and the connective nerves. In Fig. 17 (*T.* 1*g*, *T.* 2*g*), one may note a dark line drawn from the median portion of the prothoracic ganglion caudad. The true connection and relation of this nerve-like thread was not determined.

Prothoracic Ganglion (Fig. 17, *T.* 1*g*).—The prothoracic ganglion is very similar in form and in the arrangement of its nerves to the abdominal ganglia. As heretofore mentioned, the commissure, which projects caudad from the prothoracic ganglion, is simple and large. The ganglion cephalad of the prothoracic ganglion is the subœsophageal ganglion and is located only a very short distance from the prothoracic ganglion.

The commissure extending between these two ganglia fail to unite before entering the caudal end of the subœsophageal ganglia; consequently the two ganglia are connected by two distinct parallel strands.

Lateral Nerves.—The lateral nerves (*l*) are the two branches which arise from the cephalic part of the lateral margins of the ganglion. These nerves soon divide into many small branches and innervate the lateral areas of the prothorax.

Ventral Nerves.—The ventral nerves (*v*) project from the caudo-lateral margin and are accompanied by the usual pair of tracheæ. In this ganglion however, the ventral nerve of each side is not single but is composed of two small branches.

Ventral Sympathetic System.—With the prothoracic ganglion, the customary median and transverse nerves are wanting but the following new arrangement exists:—

Subconnective Nerve (Fig. 17, *T.* 1*g*).—Dorsad and cephalad of the prothoracic ganglion, the large subconnective nerves (*sn*) exist, which cross the commissure. Within the region adjacent to the ganglion, a plexus or web of nerves (*px*) extends between the subconnective nerve, the ganglion, and the proximal ends of the lateral nerves.

Ganglia of the Head (Fig. 17, *H.* 1*g* and *H.* 2*g*, Fig. 18).—In the alimentary tract as it extends to the mouth by means of the pharynx, there is to be noted a distinct flexure in the head. The two head-ganglia are located slightly distad of this flexure. The corresponding flexure in the nervous system is located between the subœsophageal and prothoracic ganglia. The two head-ganglia rest on the pharynx but on opposite sides (Fig. 18). The more distal ganglion, the supraœsophageal (*sp*), is cephalad of the pharynx and entad of the front of the head capsule. The subœsophageal ganglion (*su*) is caudad of the pharynx and connected to the supraœsophageal by means of two commissures, which together with the two ganglia form a complete ring about the pharynx.

Suboesophageal Ganglion (Fig. 17 and 18, *su*).—The subœsophageal ganglion is located caudad of the pharynx and in a plane ventrad of the supraœsophageal. It gives rise to the following nerves:—

Crura Cerebri.—The crura cerebri (*c. c.*) arise from the cephalo-ventral portion of the lateral margin of the subœsophageal ganglion very close to the pharynx. This pair of large

cords arising from the lateral margins help to complete the circle about the pharynx by connecting themselves to the latero-caudal portions of the supraœsophageal ganglion.

Mandibular Nerves.—Adjacent to the crura cerebri and extending in a caudo-mesal direction, there arises a pair of nerves (*md. lb. n.*), which are of approximately the same size as the crura cerebri. These nerves extend ventrad and divide into two nerves of unequal size; the larger nerve (*md. n.*) proceeds cephalad and ventrad and innervates the mandible.

Labial Nerves.—The labial nerves (*lb. n.*) arise from the mesal side of the mandibular-labial nerve (*md. lb. n.*). They extend ventro-caudad and innervate the labium.

Maxillary Nerves.—Caudad and adjacent to the mandibular nerves, the maxillary nerves (*mx. n.*) arise. They are smaller and soon branch and innervate the maxillæ.

Unidentified Nerves.—Caudad and slightly dorsad of the maxillary nerves, there arises on each side a nerve of considerble size (*z*), which extends laterad into the muscles of the head toward the salivary ducts but I have been unable to determine what they innervate.

Ventral Nerves.—From the mid-lateral area of the ganglion, the ventral nerves (*v*) project accompanied by their accustomary tracheæ. In this ganglion a light stain brings out very successfully the branches of the tracheæ (*t*) as they radiate over the surface of the ganglion. The ventral nerves in this case project dorso-caudad into the caudal part of the head.

Supraœsophageal Ganglion (Fig. 17 and 18, *sp*).—The supraœsophageal ganglion (*sp*) is the largest ganglion of the nervous system and is located on the cephalic surface of the pharynx. The transverse diameter of the ganglion is about twice that of the ventro-dorsal diameter. The ganglion is constricted along the meson into two lobes. The following nerves arise from this ganglion:—

Crura Cerebri.—The two large crura cerebri (*c. c.*) that proceed from the subœsophageal ganglion in a dorso-cephalic direction, connect with the supraœsophageal ganglion on the latero-dorsal margins. The two trunks are comparable to the commissures that extend between the ganglia in other regions of the body. Just dorsad of where the crura cerebri arise from the supraœsophageal ganglion, a large trachea enters the ganglion on each side of the head. These tracheæ, a short distance from

the ganglion, fork, one branch extending ventrad and the other more or less dorsad. These particular tracheæ arise from branches that lead into the head from the spiracle located in the prothorax.

Subœsophageal Commissures.—The subœsophageal commissures (*s. c.*) are the branches that arise from the ventral side of the crura cerebri near the supraœsophageal ganglion. These two branches encircle the pharynx. On the caudal part of this semicircle two small branches occur which extend dorsad and innervate the large muscle fibres of the pharynx. These semicircular nerves have received the name of commissures, but a comparison with other ganglia shows that they are not the true commissures. The crura cerebri should be called the commissures. It is probable that the so-called subœsophageal commissures are nothing more than connective nerves that have united to form a semicircle about the pharynx. The following nerves arise from the supraœsophageal ganglion:—

Optic Nerves.—The small optic nerves (*o. n.*) arise the most cephalad of any of the nerves from the supraœsophageal ganglion and without branching extend to the groups of ocelli on each side of the head where they break up into small branches and supply each ocellus.

Antennal Nerves.—The antennal nerves (*at. n.*) are of about the same size as the optic nerves and arise from the ganglion caudad of and adjacent to the optic nerves, and extend cephalad and ventrad. Not far from the ganglion, they fork and form two branches, one of which innervates the area at the base of the antenna and the other the antenna itself.

Clypeo-Labral Nerves.—The pair of clypeo-labral nerves (*cl. lr. n.*) are the most caudal pair of the nerves arising from this region of the supraœsophageal ganglion. Each clypeo-labral nerve gives rise to several cephalo-mesal extending nerves and one caudo-lateral branch. The latter branch, arises from the clypeo-labral nerve in a plane slightly ventrad of the frontal ganglion and terminates in an enlarged ganglion-like structure on the labral aspect of the pharynx. This ganglion-like structure gives rise to several small nerves. The first cephalo-mesal branch from the clypeo-labral nerve is very short and arises in a plane slightly dorsad of the frontal ganglion. The succeeding or second cephalo-mesal nerve from the clypeo-labral nerve connects with the Y-shaped branch given off from the frontal

ganglion. In different specimens examined variations often occurred in respect to the exact origin of these nerves. For example, it was found that in some cases this second cephalo-mesal nerve arose at times ventrad of the caudo-lateral branch, while in the majority of cases it arose from the clypeo-labral nerve dorsad of the caudo-lateral branch. Further ventrad on the clypeo-labral nerves two or three other cephalo-mesal nerves project and innervate the cephalic area of the pharynx.

Sympathetic Systems of the Head (Fig. 17 and 18).—Two sympathetic systems exist in connection with the supra-œspohageal ganglion. The vagus system is an unpaired system while the sympathetic system located laterad and dorsad of the pharynx is paired.

Vagus or Unpaired Sympathetic System (Fig. 17 and 18).—The vagus system originates from the ventro-lateral part of the supraœsophageal ganglion near the clypeo-labral nerve and consists of the following parts:—

Arched Nerves.—The pair of arched nerves (*ar*) is one of the pairs of nerves which arise from the ventro-lateral area of the supraœsophageal ganglion and project ventrad on each side of the head adjacent to and somewhat cephalad of the clypeo-labral pair of nerves. They extend a short distance ventrad in a curved line then turn mesad and unite on the meson ventrad of the supraœsophageal ganglion and form a small ganglion.

Frontal Ganglion.—The enlarged, fused, mesal part of the arched nerves is the frontal ganglion (*f. g.*). It rests on the pharynx and is located caudad beneath the mouth-like opening of the aorta (Fig. 8). Nerves entrad and dorsad extending arise from this ganglion.

Frontal Nerve.—The nerve extending ventrad from the frontal ganglion is the frontal nerve (*f. n.*). It is very short and soon divides into two branches which proceed latero-ventrad for a short distance and then turn directly ventrad. At the point where they turn ventrad, the second cephalo-mesal branch arising from the clypeo-labral nerve fuses with them.

Recurrent Nerve.—The nerve extending dorsad on the meson from the frontal ganglion is the recurrent nerve (*r. n.*). It extends in its dorso-caudal course between the aorta and the pharynx and œsophagus (Figs. 8 and 18). As it continues its course between these organs, it follows the flexure of the pharynx so that it extends caudad as well as dorsad. In its course along

the cephalic and dorsal surface of the pharynx and œsophagus, it gives rise to paired and unpaired laterad extending branches which innervate the cephalic and dorsal parts of the pharynx and œsophagus respectively and probably also the aorta. As the recurrent nerve approaches the caudal end of the œsophagus, it divides into two branches, which pass around the side of the œsophagus.

Vagus Ganglion (Fig. 7, *v. g.*).—At the point of the forking of the recurrent nerve near the ventriculus, a minute ganglion exists, the vagus ganglion (*v. g.*).

Stomogastric Nerves (Fig. 7, *st.*).—The branches that proceed from the vagus ganglion on each side are the stomogastric nerves (*st*). These nerves curve laterad around the oesophagus and innervate its caudal portion.

Paired Sympathetic System (Fig. 17 and 18).—On each side of the pharynx dorsad of the supraœsophageal ganglion, a sympathetic system exists, composed of two distinct nerves and two ganglia.

Lateral Nerve.—Just dorsad and slightly mesad of the large trachea that enters the supraœspohageal ganglion is the point of origin of the very small lateral nerve (*l*). This nerve continues dorsad and slightly caudad till it ends in an enlarged, irregular, ovate-shaped ganglion on the lateral aspect of the pharynx cephalad of the subœsophageal ganglion. Running parallel with this nerve is a minute treachea which resembles a nerve very closely and is easily mistaken for one. This trachea is not indicated in Fig. 18. Often the lateral nerve, before entering the anterior, lateral ganglion, gives rise to a small branch which either connects directly with the ganglion or with the fronto-lateral nerve.

Anterior Lateral Ganglion.—The ganglion in which the lateral nerve ends, is the anterior lateral ganglion (*a. l. g.*). This ganglion gives rise on its caudal and cephalic ends to two or three nerves of various sizes which extend caudad between the muscles of the pharynx. On its dorsal margin, it gives rise to a lateral commissure (*l. c.*) which connects with the posterior lateral ganglion.

Fronto-Lateral Nerve.—The fronto-lateral nerve (*f. l.*) arises from the cephalic end of the anterior lateral ganglion adjacent to and cephalad of the point where the lateral nerve enters. The fronto-lateral nerve continues ventrad to the caudo-lateral

aspect of the supracœsophageal ganglion and connects with the ganglion by means of a short stub and then continues ventrad into the head for a considerable distance.

Lateral Commissure.—The lateral commissure (*l. c.*) is a short nerve that arises from the middle of the dorsal surface of the anterior lateral ganglion and unites with a larger ganglion dorsad and caudad of the anterior lateral ganglion. This commissure gives rise to a nerve which extends ventrad.

Posterior Lateral Ganglion.—The posterior lateral ganglion (*p. l. g*). is larger than the anterior lateral ganglion and is located dorsad and somewhat caudad of it. It likewise gives rise to several nerves at its caudal and cephalic ends.

EXPLANATION OF PLATES.

Plate XIX.

Fig. 1. Lateral aspect of an entire larva of *Protoparce carolina.*
Fig. 2. Cephalic aspect of the head.
Fig. 3. Ventral aspect of the head.
Fig. 4. Ventral aspect of an abdominal proleg.
Fig. 5. Cephalic aspect of a thoracic leg.
Fig. 6. Spiracle, enlarged.
Fig. 7. A larva opened from the dorsal aspect showing the digestive tract. On the left the salivary glands and the tracheæ are represented which enter the canal, while on the right the malphigian tubules and silk glands are shown.
Fig. 8. Dorsal aspect of the pharynx, enlarged.
Fig. 9. Enlarged ventral aspect of the region of the alimentary canal, showing where the bladder of the malphigian tubule is attached.
Fig. 10. Cells of the adipose tissue, enlarged.

Plate XX.

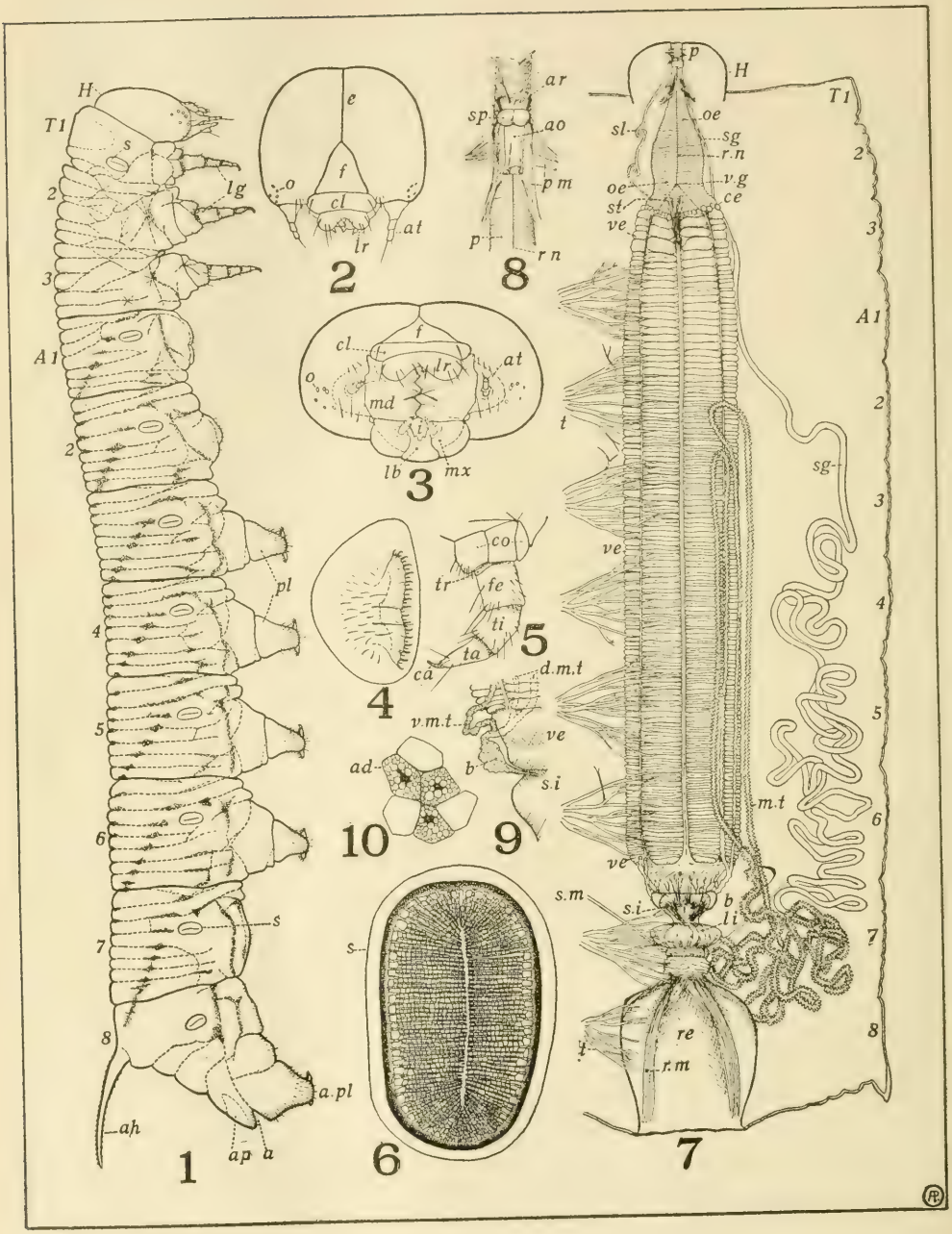
Fig. 11. A larva opened from the ventral aspect showing the respiratory system.
Fig. 12. A larva opened from the ventral aspect showing the muscular system, circulatory system, reproductive organs, and wing buds.

Plate XXI.

Fig. 13. A larva opened from the dorsal aspect showing the entire nervous system.
Fig. 14. Dorsal aspect of the seventh and eighth abdominal ganglia.
Fig. 15. Dorsal aspect of the first abdominal ganglion.
Fig. 16. Dorsal aspect of the metathoracic ganglion.
Fig. 17. Dorsal aspect of the mesothoracic ganglion (*T. 2g*), prothoracic ganglion (*T. 1g*), subœsophageal ganglion (*H. 2g*), and the supracœsophageal ganglion (*H. 1g*).
Fig. 18. Lateral aspect of the pharynx showing the nerves of the supracœsophageal and subœsophageal ganglia.

LIST OF ABBREVIATIONS.

A.	Abdomen.
A. 1-8.	Abdominal segments one to eight.
a.	Anus.
ad.	Adipose tissue.
an.	Anal horn.
a. l. g.	Anterior lateral ganglion.
ao.	Aorta.
ap.	Anal plate.
a. pl.	Anal proleg.
ar.	Arched nerve.
at.	Antenna.
at. n.	Antennal nerve.
b.	Bladder of malphigian tubule.
c.	Commissure.
c. c.	Crura cerebri.
ca.	Claw.
ce.	Cæca.
cl.	Clypeus.
cl. lr. n.	Clypeo-labral nerve.
c. n.	Connective nerve.
co.	Coxa.
d. m. t.	Dorsal malphigian tubule.
d. v. m.	Dorso-ventral nerve.
e.	Epicranial suture.
f.	Front.
f. b.	Mesothoracic wing bud.
f. e.	Femur.
f. g.	Frontal ganglion.
f. n.	Frontal nerve.
g.	Ganglion.
g. d.-r. m.	Great dorso-recti muscles.
g. v.-r. m.	Great ventro-recti muscles.
H.	Head.
h.	Heart.
h. b.	Metathoracic wing bud.
i.	Spinneret.
l.	Lateral nerve.
lb.	Labium.
lb. n.	Labial nerve.
l. c.	Lateral commissure.
lg.	Leg.
li.	Large intestine.
lr.	Labrum.
m.	Median nerve.
md.	Mandible.
md.-lb. n.	Mandibular-labial nerve.
md. n.	Mandibular nerve.
m. t.	Malphigian tubule.
mx.	Maxilla.
mx. n.	Maxillary nerve.
o.	Ocelli.
oe.	Œsophagus.
o. n.	Optic nerve.
p.	Pharynx.
pl.	Proleg.
p. l. g.	Posterior lateral ganglion.
p. m.	Pharyngeal muscle.
px.	Plexus.
r.	Reproductive organ.
re.	Rectum.
r. n.	Recurrent nerve.
r. m.	Rectal muscle.
s.	Spiracle.
s. c.	Subœsophageal commissure.
s. d.-r. m.	Small dorso-recti muscles.
sg.	Silk gland.
s. i.	Small intestine.
sl.	Salivary gland.
s. m.	Suspensory muscle.
s. n.	Subconnective nerve.
sp.	Supraœsophageal ganglion.
st.	Stomogastric nerve.
su.	Subœsophageal ganglion.
s. v.r-. m.	Small ventro-recti muscles.
T.	Thorax.
T. 1-3.	Thorax segments, prothorax, mesothorax and metathorax
t.	Trachea.
ta.	Tarsus.
ti.	Tibia.
t. n.	Transverse nerve.
tr.	Trochanter.
v.	Ventral nerve.
ve.	Ventriculus.
v. g.	Vagus ganglion.
v. m. t.	Ventral Malphigian tubule.
wh.	Wings of the heart.
x.	Unidentified muscle.
z.	Unidentified nerve.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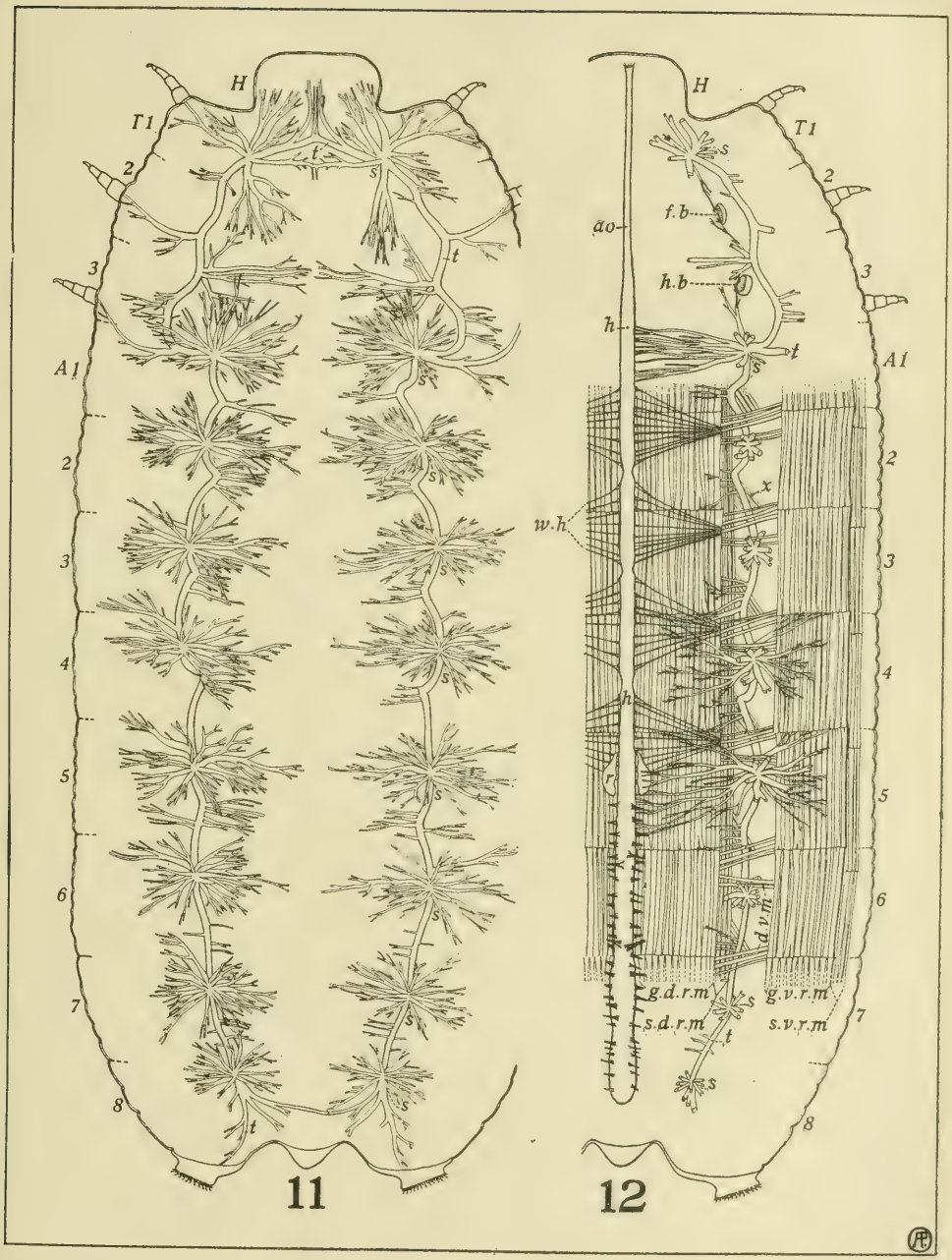
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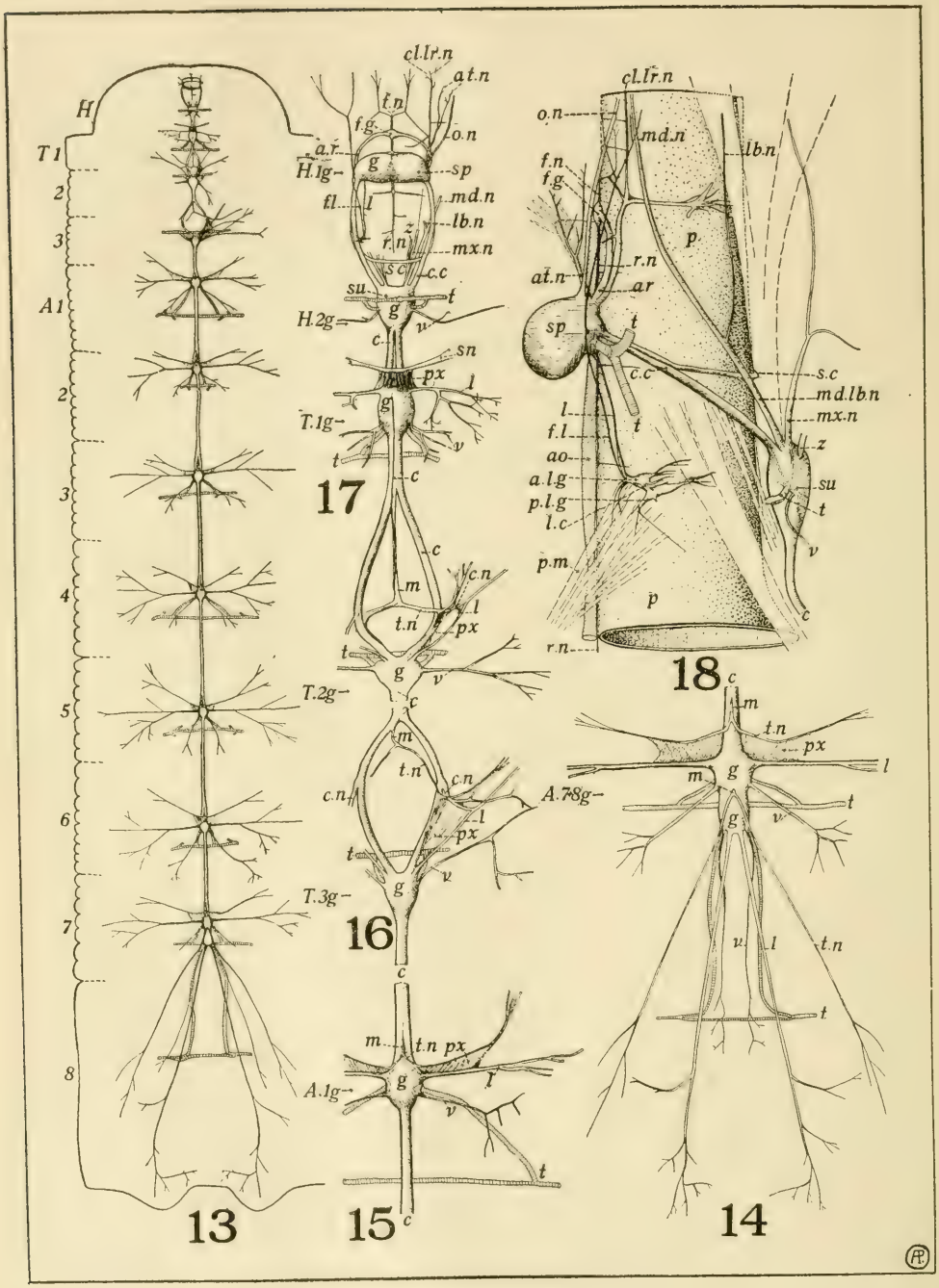
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OBSERVATIONS ON THE ECOLOGY OF DRAGON-FLY NYMPHS: REACTIONS TO LIGHT AND CONTACT.*

By C. F. Curtis Riley.

CONTENTS.

INTRODUCTORY.

The greater part of this work was completed several years ago. Publication has been delayed through various causes; chiefly because it had been the purpose of the writer to incorporate other experiments in the paper. The present communication is really an abstract of a more detailed piece of research which is practically completed, except for certain minor matters.

The research was undertaken at the suggestion of Professor S. J. Holmes. The writer desires at this point to express his appreciation of Doctor Holmes's kindly criticisms and also of his stimulating interest in the work of those associated with him. Thanks are also due to Doctor C. C. Adams for free access to his library and for many helpful suggestions.

The work was done upon certain forms of Agrionid nymphs. Many hundreds of different individuals were used in the experiments. It proved to be impracticable to identify the forms as the work progressed. A representative series of the nymphs were sent away for determination and, unfortunately, were lost in the mail. No essential differences have been found in the reactions of the different species, other than those of differences in degree, as evidenced in a few cases by relative inertness and activity.

* Contributions from the Zoölogical Laboratory of the University of Illinois, under the Direction of Henry B. Ward, No. 20.

The insects were collected in the vicinity of Ann Arbor, Michigan, from various ponds, lakes, and marshy ground along the margins of streams. The Three Sister Lakes formed an excellent environment for collecting the nymphs. A large number of the organisms were taken in a pool, directly below the mill-dam, formed by the overflow of the Huron River, at Ann Arbor.

METHODS.

The experiments were performed in a dark room kept at a temperature of about 22°C. The intense artificial light was from the electric arc of a Thomson projection lantern. For the weaker artificial light, a 16 c. p. electric incandescent light was used. Experiments were also performed with diffused daylight, its source being a south window 5 m. distant from the dark room. The light entered through a small circular opening in the side of the dark room. The nymphs were placed in a glass trough with parallel sides which was half filled with tap-water. The trough was then placed on a table top, painted black. The table was so situated that the glass vessel lay in the beam of light, entering through the circular opening, with its long axis practically parallel with the rays of light.

RESPONSES IN NATURAL HABITAT.

In their natural habitat, Agrionid nymphs react strongly to contact. They are found clinging tightly to the stems, branches, and leaves of *Elodea* and *Ceratophyllum*. This is an indication of their decided thigmotactic proclivities. They tend to place as much as possible of the external parts of their bodies in contact with a solid surface. This is accomplished by clinging to the aquatic plants, in such a manner that the long axes of their bodies lie parallel to the long axes of the stems and the branches. The nymphs frequently assume a somewhat different position, with the long axes of their bodies rather oblique to the long axes of the stems and branches. The creatures are frequently found with their bodies closely applied to the *Elodea* and *Ceratophyllum* at the points where the branches are given off—that is, in the forks formed by the stem of the main plant and the lateral branches. They are also found on both plants in the angles formed by the whorls of leaves arranged around the stem. Pearl (1903, pp. 560–562) records similar observations in his work on Planarians. This writer has given the name

goniotaxis to such responses. In an interesting paper on the death-feigning of *Belostoma*, Severin and Severin (1911a, p. 38) have described how this insect also reacts to the contact of aquatic vegetation.

The dragon-fly nymphs lie in wait for their prey on these aquatic plants. They are effectually concealed in such positions. The diameter of their bodies is about that of the thicker stems, and the creatures lie so quietly that they are easily overlooked. Then also their colors are much like those of the vegetation—browns and greens predominating. Facts of somewhat similar nature have been recorded by Holmes (1905, pp. 308–309) in his observations on *Ranatra*. In collecting the dragon-fly nymphs, the writer often rakes some of the plant material out of the water. The animals are then picked from the *Elodea* and *Ceratophyllum*. It is not at all an uncommon thing for many of them to be overlooked; because after the plants have been taken to the laboratory and placed in an aquarium jar containing water, the nymphs can be seen swimming about freely or resting on the bottom. Having been disturbed in transit, they frequently leave their positions on the aquatic vegetation. The reason that some of them are so easily overlooked is due to three facts. First, they remain very quietly in their positions —though some of them are seen crawling over the vegetation after it has been shaken from the net; second, their shape and color resembles that of the plants on which they live; and third, they frequently feign death. The writer believes that the instinct of death-feigning is of much importance in the ecology of the animal. It is a form of response which is certainly often highly protective. Many workers have frequently observed the death-feigning reaction among insects and to some extent the rôle which it plays in their lives. Among these observers may be mentioned the names of DeGeer, Fabre, Darwin (1884), Romanes (1884), and Whitman (1899). More recently papers by Holmes (1906) and Severin and Severin (1911a) have been written. Both of these deal with the death-feigning responses from a careful experimental point of view and are extremely valuable pieces of research. That the larvæ, nymphs, and imagoes of many aquatic insects evidence this interesting form of behavior is well brought out by these workers. This is especially the case in the paper by Severin and Severin (1911a, p. 36).

Agrionid nymphs are found in quiet waters at a depth varying from 10–80 cm. deep. So they live in an environment where the light is dim, a sort of twilight, certainly not a bright light. Then frequently there are reeds, sedges, cat-tails, pond-lilies, arrowheads, and other aquatic plants which form shadows, so modifying the action of the sun's rays. It is not at all uncommon to find willows and alders shading the pools which serve as the living places for dragon-fly nymphs. The "selection" of such a habitat is influenced, to a considerable extent, by the natural responses of the animals. They react negatively to bright light and respond positively to contact. The laboratory experiments largely bear out these environmental observations.

ENEMIES.

Before considering the reactions of Agrionid nymphs to photic stimuli, it seems worth while to discuss briefly their food and enemies. While no extensive notes were taken on either of these subjects, yet some observations were recorded which indicate that the facts discussed in the last three paragraphs have a more or less direct bearing upon the relations of the nymphs to their food and enemies. In the states of Michigan and Minnesota, the two gamy little fishes, the common sun-fish, *Lepomis gibbosus*, and the yellow perch, *Perca flavescens*, are very abundant. Both of these species have frequently been taken by the writer in considerably numbers. It was often noticed that among other insects, found in the digestive tract, Odonate nymphs were present and many of them were Agrionid nymphs. It is very likely that Agrionid nymphs form a large portion of the diet of many other species of fish. In fact, Forbes (1888, pp. 485–524) found that the nymphs of Odonata formed a very important article of food in the case of the following fish: the common perch, *Perca flavescens*, the pirate perch, *Aphredoderus sayanus*, the crappie, *Pomoxis annularis*, and the grass pickerel, *Esox vermiculatus*. In the case of each of the three first named fishes, it was found that dragon-fly nymphs formed 10–13 per cent. of their food; and in the case of the grass pickerel, they formed 25 per cent. of the food. Needham (1898, p. 86) states that he has seen dragon-fly nymphs taken in numbers from the stomachs of the Great Blue and Green Herons. Aaron (Lamborn, 1890, p. 50)

states that *Ranatra*, *Notonecta*, and *Belostoma* all prey upon the young nymphs of dragon-flies. From the context, one infers that Aaron's statement is based upon out-of-door observations.

Incidental observations were made upon the enemies of the dragon-fly nymphs when kept in confinement. In one aquarium, there were a number of the Agrionid nymphs and three Belostomas. In another aquarium, there were several of the nymphs and one *Ranatra*. It was found that both of these aquatic bugs preyed on the dragon-fly nymphs. At least three definite records were obtained with reference to *Belostoma* and two with reference to *Ranatra*. The nymph is seized by means of the first pair of legs—in the case of both *Belostoma* and *Ranatra*—and after the bug has placed its prey in a convenient positon, the "bill-like" mouth parts are pushed into the softer portions of the body, and the juices sucked out. Bueno (1903, p. 235) gives a good description of the method used by *Ranatra* in catching its prey. The behavior of *Belostoma*, when engaged in obtaining food is interestingly described by Severin and Severin (1911, pp. 101–102). Other naturalists have observed that many insects are enemies of dragon-fly nymphs while in confinement. Severin and Severin (1911, pp. 102–104) state that *Belostoma* and *Nepa* are both enemies of dragon-fly nymphs and prey upon them. Weed (1889, pp. 11–12) has noticed that in his aquaria the most important element of food of *Belostoma*, consisted of the nymphs of the larger dragon-flies.

FOOD.

The Agrionid nymphs are largely predaceous in their manner of feeding. They feed upon small Crustaceans and the nymphs of certain other small forms, particularly upon the nymphs of May-flies. It is a task of considerable difficulty and one requiring much patience to observe these organisms feeding in their natural habitat. The writer has observed, that in captivity, they feed upon each other, especially is this true, when the food supply is not abundant. Three dozen specimens were placed in an aquarium jar, no food being added, and at the end of three months there were two nymphs alive in the jar. One can readily see the nymph in the very act of seizing its food, in an aquarium jar. The prey is seized by the lobes of the labium, this organ being thrust forward with great rapidity. The

Agrionid nymphs usually remain obscured among the vegetation, where they seize the prey which approaches them. However, the writer has frequently observed them to move a distance of 30 or 40 mm. toward their prey. The general movements remind one very much of those of a cat stealing upon a bird. The body crouches low, almost touching the substratum. The animal moves forward slowly, with bent legs, until it is close to its victim, then the lower lip is suddenly darted forward and the prey is captured. They will also feed upon freshly killed *Physa*, and small pieces of fresh beef.

Needham and Hart (1901, p. 17) make the following statement regarding the food of dragon-fly nymphs. "The nymphs are all predatory in habit. Most species remain in ambush, aided by coverings of sand, mud, silt, and algal growths, and by their own protective coloring, until their prey wanders within reach. *Anax junius* and a few others choose their prey. All capture it with a marvellously sudden extension of the labium, bringing it into the grasp of the formidable lateral lobes. Almost all kinds of small aquatic animals appear on the bill of fare of the group as a whole. The *Agrionidæ* have a seeming preference for *Entomostraca* and May-fly nymphs. The vegetation-inhabiting species have the most varied diet, including especially back-swimmers (*Notonecta*) and water-boatmen (*Corisa*), small crustaceans, such as *Asellus* and *Allorchestes*, thin-shelled mollusks, like *Physa*, coleopterous and dipterous larvæ, and even the younger or weaker members of their own order. *Anax* takes even the thicker-shelled univalves, like *Amnicola*. The deep-water *Epicordulia* feeds principally on small mollusks, such as *Amnicola* and *Physa*, as well as on other life of the bottom. The *Aeschnidæ*, especially *Anax*, are most omnivorous creatures. The larger odonate nymphs eat very young fish, and in some cases appear to have caused a sweeping destruction of large numbers of them."

RESPONSE TO INTENSE ARTIFICIAL LIGHT.

There is a considerable amount of literature treating upon the photic responses of insects. The papers of Loeb (1905) are perhaps the most widely quoted. These have recently been translated and published. Little work has been done on the reactions of dragon-fly nymphs to light and contact. Plateau (1888) experimented with dragon-flies, but his observations are

from a different viewpoint—"visual perception of movement"—than that presented in the present paper. Further, Plateau's work was done with the imagoes and not with the nymphs. Some research has been carried on by Sondheim (1901) in connection with damsel-fly nymphs, regarding the power of associating certain appearances with food. Radl (1903) is the only author, of which the writer is aware, who has published any observations of this nature upon dragon-fly nymphs. Attention should also be called to the very interesting work of von Uexküll. One of his investigations in a series of Studies on Tonus was on the dragon-fly (1908).

Agrionid nymphs react strongly to the light from the electric arc of a Thomson projection lantern, swimming away from the source of illumination. Experiments were performed with separate individuals and also with a number of nymphs in the glass trough at the same time. After placing the vessel, containing the specimens, in the beam of light entering the dark room, it is seen that they swim away rapidly from the light to the far end of the dish—to the end farthest from the source of illumination. If the position of the trough is now reversed—the far end being placed in such a position that it is in the beam of light and facing its source—the creatures again swim away from the light. This experiment was repeated many times. Fresh nymphs were used from time to time.* At each experiment the animals swim away from the source of light and tend to congregate at the end of the glass trough most distant from the lantern.

MOVEMENT AWAY FROM THE LIGHT NOT A RESPONSE TO TEMPERATURE.

An observer of my experiments, who was at the time engaged upon some temperature studies of hydra, believed that the reactions described were responses to heat. That such was not the case was readily demonstated. A cell containing distilled water was placed in front of the projection lantern. The animals respond to the light in the manner previously stated and swim to the far end of the glass trough. A second cell was placed immediately in front of the first, so that the beam of

*The specimens were taken from aquaria standing in a moderate light at some distance from a south window. Such nymphs had not been subjected to the kind of stimuli used in the experiments. Of course, this does not mean that no stimuli had been acting upon them, for stimuli constantly impinge upon all animals.

light now passed through a wall of water approximately 15 cm. in thickness. My records show that, in a period of 30 minutes, the increase in temperature is very small. The dragon-fly nymphs react negatively to the light, as they did before either of the two cells were placed in position. This shows their movement to be a response to light, and not a reaction to temperature.

RESPONSE TO CONTACT.

When experiments are performed with a number of individuals in the glass trough, it is found that their movements are often very much modified. As they swim away from the source of illumination, they frequently come in contact with the sides of the vessel and with other individuals. This contact, in many instances, impedes the movement away from the light, and causes the nymphs to become practically motionless. This is the result of the contact stimulus. They usually assume a position with the long axes of their bodies parallel to each other and in close contact, although this relation may be modified considerably. Another response, which the writer designates as the "clasping response," quickly follows. The nymphs clasp each other closely around the thorax and abdomen. The preliminary contact of their bodies causes locomotion to cease, being an example of true thigmotaxis. Then as the full surface of the body of one is applied to the body of another the "clasping response" results.

FORMATION OF GROUPS.

The reactions above described often result in the formation of groups of nymphs. In this manner one large cluster may be formed, or a number of smaller ones. These collections may be formed at various points in the glass trough, but seldom at the end next to the source of light. They frequently form first at the end of the vessel farthest from the source of illumination. They may, however, form at other points nearer the light. As many as forty and fifty individuals, clinging together, are not infrequently counted in one cluster. The origin and permanence of the groups are due to the contact and clasping reactions. As various individuals swim away from the light, they may come in contact with other individuals, thus eliciting the thigmotactic response. Locomotion ceases and, as a greater bodily surface is applied in the case of the various nymphs, the "clasping response" is invoked, causing the creatures to hold each other tightly by means of their thoracic appendages.

INHIBITION OF PHOTIC RESPONSE.

It is evident from the above observations that the reactions to light may be largely overcome by the response to contact. The efforts of the nymphs to swim away from the light are inhibited by thigmotaxis. The thigmotactic tendencies are evidenced by the organisms forming rather closely grouped aggregations. Various authors have called attention to somewhat similar facts. Formerly, comparatively little importance seems to have been attached to such observations, at least, among insects. More recently, however, certain workers have been impressed with phenomena of this nature. Holmes (1905, pp. 324–325) in his experiments with *Ranatra* has observed that, "The phototactic responses of *Ranatra* which usually occur with such regularity and precision are sometimes checked when the insect is engaged in performing some other function. * * * * Efforts to go toward the light are frequently inhibited by contact stimuli. When several individuals are put into a dish of water near a window they commonly cease, after a time, to swim towards the light and form a cluster in which they lie at all possible angles to the direction of the rays." The same writer (1905, p. 320) also describes how Ranatras group themselves into "a dense bunch at the negative end "of the dish. Again, Holmes (1905, p. 323) while working with the same aquatic forms, states that, "In cool water there is a marked tendency to form a dense cluster in the negative end of the dish." Severin and Severin (1911, pp. 100–101) in connection with some work on the thigmotactic responses of *Belostoma flumineum* Say make the following statement: "Again, it was not unusual to find two or more Belostomas or somewhat larger clusters clinging together at the surface or bottom of the water, a characteristic which is also noticed with *Lethocerus* (=*Belostoma Aucct.*) *americanum*, *Benacus griseus*, *Nepa apiculata*, *Ranatra americana*, and *Ranatra kirkaldyi*. This habit is probably a manisfestation of their thigmotactic response." This tendency to cluster together has frequently been observed by the writer in the case of *Gerris remigis* Say.

CHANGES OF BODILY CONDITIONS.

Much very valuable work has been done upon changes of bodily condition, especially among the Protozoa, as for example the researches of Putter (1900), Moore (1903), and particularly

Jennings (1906, pp. 92–102). The following interesting quotation (pp. 92–94) is taken from the latter's observations upon Paramecia: "If the animal is at rest against a mass of vegetable matter or a bit of paper under the action of contact stimulus and it is then struck with the tip of a glass rod, we find that at first it may not react to the latter stimulus at all. * * * * Finally a strong blow on the anterior end causes the animal to leave the solid and give the typical avoiding reaction. * * * * If specimens showing the contact reaction are heated, it is found that they do not react to the heat until a higher temperature is reached than that necessary to cause a definite reaction in free-swimming specimens. * * * * On the other hand, both heat and cold interfere with the contact reaction. Paramecia much above or below the usual temperature do not settle against solids with which they come in contact, but respond instead by a pronounced avoiding reaction. * * * * Specimens in contact with a solid react less readily to chemicals than do free specimens. * * * * On the other hand, immersion in strong chemicals prevents the positive contact reaction * * * *. The contact reaction may completely prevent the reaction to gravity."

The inhibition of one stimulus by another is a somewhat puzzling matter. Why should a dragon-fly nymph reacting negatively to light, as it comes in contact with another nymph, cease this function and display its thigmotactic proclivities? The stimulus from the electric arc of a projection lantern is so strong that we might expect the organism to continue to react to the light rather than to respond to contact. However, this is not the case for the stimuli are sufficiently powerful to overcome the response to light. The explanation seems to lie with certain changes which take place within the animal. The external conditions are the same—the stimuli from the electric arc are still present—but the nymphs no longer react; the organisms now respond to contact stimuli. (However, some of the nymphs continue to react to the light.) One form of response gives way to another. This is probably due to certain changes in the bodily state of the organisms. We are unable to witness these changes as they occur within the animals themselves, but they can be inferred from the difference in the external response. Jennings (1904, p. 120), in connection with his discussion of the reactions of Stentors, has stated that, "We

must conclude then that contact with solids so alters the physiological condition of the organisms that they no longer react to the other stimuli." This change in the internal condition of dragon-fly nymphs must take place very rapidly, for as soon as an organism—that is swimming along under the influence of photic stimuli from the projection lantern—comes in contact with other nymphs, locomotion stops, and the animal responds to contact stimuli. If the electric arc should be turned off—thus doing away with photic stimuli—it would not be surprising to see the nymphs react in a different manner. Such a change is undoubtedly physiological, and must be largely explained by the new external stimuli acting upon the organism. Moreover, it may be possible that the stimuli from the electric arc have so modified the animal's internal condition that it responds to contact stimuli more readily than if it had not previously been subjected to photic influence. As Jennings (1906, p. 96) has well brought out in his work upon Paramecia, "The essential factor in the interference is a physiological one. When reacting to the contact stimulus, the animal is less easily affected by other stimuli, and when reacting to the other stimuli, it is less easily affected by the contact stimulus. Since the two stimuli in question require behavior of opposite character, it is indeed inevitable that one should give way to the other, or at least modify the behavior toward it; both cannot receive the usual reaction." Mast (1911, p. 287) in his discussion of "the effect of internal changes" makes the following interesting statement: "As a matter of fact, all reactions are directly controlled by internal forces which are in turn influenced by external factors." Jennings (1904, pp. 109–127) and (1906, pp. 283–313) has written full and elaborate discussions concerning "physiological states." Both of which are extremely interesting and suggestive.

DISINTEGRATION OF GROUPS.

Holmes (1905, p. 308) has found that Ranatras form a cluster in an aquarium. "In this way they may lie for hours in an almost motionless state." While somewhat similar conditions may be observed in the case of dragon-fly nymphs, the periods of quiet are very much shorter and the disintegration of the groups occurs from time to time. This is brought about by mechanical—contact—stimuli and response to the

strong electric light. At irregular intervals the nymphs in the cluster make "spontaneous" movements—or at least movements that are often difficult to interpret from any external cause, though some of them may be due to the continued action of the electric arc—and such movements act as mechanical—contact—stimuli on other members of the group. This naturally tends to cause the animals to change their relative positions to some extent; and no matter how slight a change in position this may be, there is, for a short space of time, a slackening of the grip of the appendages. At such moments an opportunity is presented for photic stimuli to act upon the nymphs, and they frequently break away from the aggregation, responding with the negative reaction to light. This is more readily understood if we realize that the organisms are probably in a different physiological state than they were when the group was first formed—a state which now results in a response to the photic stimuli, and not to thigmotactic stimuli. The "spontaneous" or other slight movements of the animals in the closely packed masses are of great importance in initiating the breaking up of the clusters. Holmes (1095, p. 323) has observed in his experiments with *Ranatra* that the groups are more apt to be broken up as the insects become more active. The dragon-fly nymphs in the peripheral portion of the clusters are more likely to swim away first, while those in the central part are the last to leave the collections, as it is more difficult for the electric light to affect them in such a position. They are largely shut off from the light because of the nymphs surrounding them, besides being more largely influenced by contact stimuli. Holmes (1905, p. 308) states that in these clusters formed by *Ranatra*, the insects "are often so closely aggregated and so tangled together that those which are near the center of the group experience much difficulty in disengaging themselves."

We have noticed that dragon-fly nymphs respond negatively to photic stimuli. It has also been shown that they are positively thigmotactic. Their negative response to light often brings them against the sides of the experimentation dish and against each other. This contact invokes thigmotaxis, and the animals become grouped together. Mechanical—contact—stimuli plus the influence of the strong electric light inhibits the contact reactions for the time being, and the aggregation is broken up, the organisms swimming away from each other in response to

their phototactic proclivities. Later on the nymphs may again form a group which in turn will be dispersed. Observations very similar to these have been recorded by Holmes (1901, p. 212) upon *Gammarus locusta*. When these Crustaceans are exposed to light, they swim away from the *Ceratophyllum*, in the dish of water, to which they were clinging. They move rapidly to the negative end of the vessel, where they dart actively about, as if attempting to get farther away from the light. If these movements bring the animals in contact with the *Ceratophyllum* again, there they remain. If there are no objects in the water, the contact response is not invoked, and the organisms are found at the negative end of the dish. If there are objects in the water, the Amphiopods react to contact stimuli whenever their chance movements bring them against a solid surface. The creatures remain in such a position until the phototactic impulse again causes them to swim away.

INDEFINITENESS AND CHANGE OF PHOTIC RESPONSE.

Sometimes, immediately following the breaking up of the aggregation of dragon-fly nymphs, the movements of the animals appear to lack definiteness. They swim away from the groups at various angles to the rays of light. While most of them sooner or later move toward the negative end of the glass trough, there are some whose reactions are indifferent, and a few evidence a tendency to positiveness in their responses to the light. This again the writer attributes to a change in the internal condition of the creatures, induced perhaps either by thigmotaxis or by the effect of the light from the projection lantern. Holmes (1905, pp. 318–325) has performed some very interesting experiments with *Ranatra* along similar lines. The insect is usually strongly positive in its responses to light; but this worker has been able to cause the animal to become negatively phototactic through the agency of contact stimuli. This change in the photic response, he was able to bring about many times. On one occasion the Ranatras were exposed to the light from a window for more than an hour and half, and it was found at the end of that time that all the specimens had become negatively phototactic. Previously they had all reacted positively to the light, yet they had become negative in their reactions although the intensity of the light had increased. He has also demonstrated that the negative phototaxis of these

animals may be held in check by contact stimuli, as stated in the following quotation (1905, p. 325): "Contact stimuli not only inhibit positive phototaxis, but they produce a negative reaction as we have already seen; the latter tendency, however, is often held in check by the same cause by which it is brought about."

RESPONSE TO LESS INTENSE ARTIFICIAL LIGHT.

My experiments on dragon-fly nymphs with a 16 c. p. incandescent light show that the animals respond negatively, their movements taking them to the end of the glass trough farthest from the source of illumination. Frequently the organisms walk from one end of the vessel to the other in a rather leisurely fashion. In such cases the swimming mode of locomotion seems to be inhibited. The reactions are often lacking in promptness and precision as the following experiments will show:

Experiment A. The nymph is placed, by means of a camel's hair brush, in the glass trough facing the light. The creature is slightly nearer to the left than it is to the right side of the vessel. Immediately the animal turns slowly half way around. This movement is slow. Now, the anterior pair of legs come in contact with the side of the dish. It walks entirely onto the side of the trough. At the same time it continues the turning movement, until the head points away from the light. It walks slowly along the side for half the length of the vessel. The nymph stops for 5 seconds. Again it moves forward until within 4 cm. of the end of the trough. It stops and performs cleaning reactions. In a few seconds, the animal walks slowly to the end of the trough.

Experiment B. The nymph is placed in the center of the glass dish, at the end near the source of light. It remains stationary for 7 seconds. The animal then turns slowly to the right until in a position oblique to the direction of the rays. It again remains quiet for 3 seconds. It turns slowly further to the right and at the same time moves slightly toward the right side of the vessel. The front legs come in contact with the glass side and the nymph stops for 4 seconds. The creature turns very slowly until it is in a position at right angles to the rays of light. As it turns, it walks slowly up the side of the dish. It remains here for 5 seconds in a position perpendicular to the floor of the trough. The animal turns slowly, the long axis of its body becoming parallel with the rays of light. It moves away from the light for a distance of 5 cm. It then stops for 2 seconds. It again moves forward for a distance of 5 cm. The nymph now stops for 3 seconds. It moves forward slowly for 2 cm. It stops for 2 seconds and then goes ahead a distance of 4 cm. The creature remains quiet for 3 seconds, after which it walks forward for 1 cm. It again stops; this time for a period of 16 seconds and performs cleaning reactions. It then moves slowly to the end of

the dish, passing the concave corner, and comes to rest at the end of the trough at right angles to the rays of light.

Experiment C. The nymph is placed in the glass dish at the end toward the light. It turns slowly toward the left until the body is at right angles to the rays of light. It remains in this position for 2 seconds. The animal turns further to the left. Its body is now oblique to the rays of light. It moves obliquely forward 1 cm. The nymph turns to the left so that its body is now parallel with the rays of light. It swims forward 8 cm. and then stops, resting on the bottom of the vessel. It remains stationary 6 seconds. Then it walks forward 4 cm. It stops for 3 seconds with its body slightly oblique to the light rays. The animal walks forward 6 cm. and then comes in contact with the side of the dish. It remains in a resting position for 25 seconds. It walks along the side of the vessel for 4 cm. and then reaches the water. It walks forward for 2 cm. and then stops, performing cleaning reactions. After remaining quiet for 20 seconds, it swims to the end of the dish.

The responses of the nymphs as indicated in these experiments are suggestive of those described by Holmes (1902, p. 212) for *Gammarus* and *Amphithöe*. This observer states that, "If a single individual be watched it will be seen to struggle for a time, to move away from the light; it will then rest, for a longer or shorter period, only to resume its struggle later." The writer performed a large number of experiments similar to those described as A, B, and C. In each case different nymphs were used. It is evident that such photic responses are conspicuously lacking in the factors of directness and precision. While the three experiments described are more or less similar in details, it is obvious that there are differences. The nymphs appear to possess some individuality. The movements are not so stereotyped, but that they allow of considerable modification.

A number of experiments were performed in which the same nymph was exposed to the light from the incandescent lamp. Usually there were ten trials in a series, and the same individual was used throughout each series. In referring to the details of my experiments, they indicate, in a general way at least, that in the first few trials of the series, the reactions to light were fairly definite—the animal moving away from the source of illumination. The animals frequently responded by the swimming movement. Toward the end of the series, there were more pauses as the organisms traveled from one end of the dish to the other. The cleaning reactions were performed from time to time as the nymph rested, and walking was the principal method of locomotion.

RESPONSES TO DAYLIGHT.

Daylight was used as the source of stimulation for a large series of experiments. Many observations were recorded upon a great many different dragon-fly nymphs. In general it may be said that there was no evidence of orientation to the direction of the rays, and there seemed to be little indication of response to the light intensity, and the light was certainly brighter at the opening into the dark room than it was some distance away, within the dark room. The animals seemed to be generally indifferent to the light. At times, a few organisms indicated a tendency toward the positive reaction, but such facts are not uncommon in any experiments with light. Unless the dragon-fly nymphs are nothing more than reflex machines, it is to be expected that there will be some physiological variation in the internal condition of the different individuals even under the effect of the same stimuli. There are usually a few animals which appear to vary in their responses from the majority at any given time.

SUMMARY AND CONCLUSION.

The Agrionid nymphs discussed in this paper were collected in the vicinity of Ann Arbor, Michigan. In their natural habitat they respond strongly to contact. They are frequently found clinging to *Elodea* and *Ceratophyllum*, and are generally in close contact with these plants. They are also found in the angles formed by the various parts of the plants. The nymphs are obscured in such positions because of certain resemblances in color and form between themselves and the plants to which they cling. These factors are probably protective, as is the death-feigning instinct which is so well developed in these insects. In the vicinity of Ann Arbor, Michigan, Agrionid nymphs were taken in abundance in still waters, at varying depths from 10—80 cm. They are not generally found in bright light, but are more abundant in habitats shaded by aquatic vegetation and trees. The fact that they inhabit such situations is probably due to their negative response to strong light and to their positive response to contact. Two common enemies of these dragon-fly nymphs are the two species of fishes *Lepomis gibbosus* and *Perca flavescens*. The aquatic bugs *Ranatra* and *Belostoma* destroy large numbers of nymphs, when kept in confinement. Agrionid nymphs are

predaceous insects. They feed upon small Crustaceans and the nymphs of May-flies. When kept in the aquarium, they prey upon each other. They also feed readily upon freshly killed *Physa* and small pieces of fresh beef. The nymphs usually wait for their prey to approach them before seizing it, but they may move a distance of 30—40 mm. toward it. The food is seized by the lobes of the labium as this organ is suddenly darted toward the prey.

Agrionid nymphs respond negatively to the light from a Thompson projection lantern. They swim away from the source of illumination. This occurs both in the case of single individuals and also when a number of specimens are in a glass trough at the same time. If the position of the trough is reversed, the nymphs again swim away from the light. This sort of response continues even when the experiment is repeated a number of times. The movement away from the light is a photic response, and not a reaction to temperature. Frequently, when a number of specimens are placed in the glass trough, the response to light is modified by contact with the sides of the dish and with other individuals. This contact causes the nymphs to become more or less motionless, and to remain in close contact with each other, with their bodies more or less parallel. Such responses are examples of their thigmotactic proclivities. They also exhibit a "clasping response," seizing each other around the thorax and abdomen by means of their thoracic appendages. The thigmotactic and "clasping responses" result in the grouping of the nymphs in clusters. These groups tend to form at the end of the trough farthest from the source of light, although they also occur at other points. Sometimes there are as many as fifty individuals in a group. The origin and permanence of the groups are due to the contact and "clasping responses." The response of Agrionid nymphs to photic stimuli may be overcome by the response to contact stimuli; there is an inhibition of the one by the other. The explanation of this phenomenon seems to rest in part at least, with certain changes—bodily conditions—which take place within the animal concerned. In many instances such changes probably occur rapidly. The clusters of nymphs break up from time to time. The disintegration seems to be due to several causes. The "spontaneous" movements of the insects in the groups are a factor in this. Such

mechanical—contact—stimuli bring about changes in the relative positions of some of the individuals in the various groups. At such times there is a slackening of the grip of the appendages, so permitting photic stimuli to be more effective. The disintegration of the groups, then, is due to mechanical—contact—stimuli plus the stimuli of the powerful electric light. Immediately after the disintegration of a group, there appears to be a lack of definiteness in the responses of the nymphs to the electric light. They swim away from the cluster at various angles to the rays of light. While the majority of them eventually arrive at the end of the trough farthest from the source of light, certain individuals exhibit a tendency to positiveness in their photic responses. This result may be due to a change in bodily condition, induced, possibly, either by thigmotaxis or by the effect of photic stimuli. Agrionid nymphs respond negatively to a 16 c. p. incandescent light, swimming away to the end of the trough farthest from the source of illumination. When responding to such photic stimuli, the insects frequently walk from one end of the trough to the other. The swimming reaction appears to be inhibited. The responses often lack promptness and precision. When the same individual is used in a series of experiments, the responses in the first few trials prove to be fairly definite, the animal swimming away from the source of illumination. Toward the end of the series there are pauses as the animal moves from one end of the trough to the other, and cleaning reactions are performed. When diffuse daylight is used as a source of illumination, the nymphs exhibit practically no response either to light intensity, or to the direction of the rays. A large majority of the insects appear indifferent to the light. A few individuals tend to exhibit a positive response to photic stimuli of this nature.

It seems possible to the writer that the behavior of Agrionid nymphs with respect to light and contact, may not be entirely of a reflex, mechanical nature. Such reactions are not always precise and definite; sometimes they are considerably modified. May they not, as Holmes (1905, pp. 337–349) has shown with respect to *Ranatra*, possess some of the concomitants of the "pleasure-pain" type of reaction? This form of response has been excellently discussed by Holmes (1910), (1911), and (1911a), in several suggestive papers. The thigmotactic and photic reactions of these dragon-fly nymphs appear to be bene-

ficial. Such responses not only aid in concealment from enemies, but also assist in obtaining food. Beneficial reactions are frequently "pleasureable"; at least they are not usually "painful". On the other hand injurious responses are often "painful"; certainly they are not "pleasant". The nymphs are guided fairly well if they follow their "likes" and "dislikes", if such terms may be used. Spencer (1885) has maintained, and Holmes (1910) and (1911a) has discussed the probability that the connection between "pleasure" and "pain" has arisen through natural selection. If this should prove to be true with respect to other animal groups, there seems no reason why it should not apply to Agrionid nymphs.

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THE NORTH AMERICAN DIGGER WASPS OF THE SUBFAMILY SCOLIINAE.*

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INTRODUCTION.

This contribution to our knowledge of the sub-family Scoliinæ (digger wasps) found in North America, Central America and the West Indies, is the result of work done at the Massachusetts Agricultural College under the direct supervision of Doctor H. T. Fernald, and forms a portion of a thesis for the degree of doctor of philosophy. In it, an attempt has been made to place before those interested, a paper in which our present knowledge of these wasps is systematically arranged and the identification of the species facilitated.

There are given here the descriptions of nineteen species and two genera, while four unknown species and one unidentified subspecies are listed at the end. Of the above mentioned species three are new. The type of each genus has been given in the historical sketch and so far as is known, the location of all the types has been stated in each specific description. Whenever the writer thought it necessary, translations from the original descriptions or direct copies have been made. In each case full credit has been given to the original writer.

Several workers have published descriptions of members of this subfamily in various publications and many have from one to several references to the group, showing the scattered character of the information. Works which the writer has found most important are: Saussure and Sichel, Catalogus Specierum Generis Scolia, 1864; Burmeister, Bemerkungen über Bau u. Gesechlechtsunterscheide Gattung Scolia, Abh. Nat. Gesell. Halle, 1854; Saussure, Desc. esp. nouv. Scolia, Ann.

*A portion of a thesis for the degree of Doctor of Philosophy at the Massachusetts Agricultural College.

Ent. Soc. France, (3), 1858; Saussure, Quelques Scolies de Basse-Californie, Ann. Ent. Soc. France, (4), 1863; Cresson's descriptions in the Proceedings of the Entomological Society of Philadelphia and in the Transactions of the American Entomological Society; Cameron's descriptions in the Biologia Centrali-Americana; the writings of Say, and the Catalogue of the Hymenoptera of the British Museum by F. Smith.

All terms used are fully explained in Smith's Glossary of Entomology. Cresson's system of nomenclature for the wing venation is used.

I am under many obligations to those who have assisted me in making this paper more complete, either by lending specimens to Professor H. T. Fernald that I might use them for study, or by giving me counsel at times when such was needed, especially Dr. Guy C. Crampton, S. A. Rohwer of the National Museum, E. T. Cresson, Jr.; and to Dr. H. Skinner for the privilege of study at the American Entomological Society at Philadelphia. I wish to thank Mr. W. S. Regan who so kindly spent valuable time while studying at New York, Brooklyn, Philadelphia and Washington, in securing for me material to work upon. It was my good fortune to have studied a part of the time under Professor Charles H. Fernald whose aid and assistance I greatly appreciate.

To Doctor H. T. Fernald I wish to express my gratitude for the many ways he has encouraged and guided me in my work and for the aid so willingly given at all times.

COLLECTIONS.

The work in this paper is based upon the collections of the National Museum together with the collections made by members of the Bureau of Entomology in Texas in connection with the Southern Field Crop investigations directed by W. D. Hunter; and the excellent collection at the American Entomological Society at Philadelphia. The American Museum at New York and the Brooklyn Museum at Brooklyn contain valuable material. Besides these, the collections at the Alabama Polytechnic Institute and the Rhode Island Agricultural College are worthy of mention.

NOTE.—Since finishing this paper the writer has seen an article on this group by Mr. N. Banks (New Scolioidea, Can. Ent., XLIV, p. 197, 1912). Although arriving too late for consideration in this paper, it does not appear probable that it would involve any changes in it.

HISTORY

The genus Scolia was established by Fabricius in 1775. In 1802 Latreille established the family Scoliites, including the genera Sapyga and Scolia. In 1810 Latreille designated *Scolia quadripunctata* as the type of the genus Scolia. In 1817 Leach established a tribe Scolides containing two families, the Tiphida and Scolida. In the latter family he made two divisions to which he gave no names, placing in the first division the genera Myzine and Meria and in the second division the genus Scolia, while he placed Sapyga in a separate tribe, the Sapygides. Westwood in 1839 changed Leach's tribe Scolides to the family Scoliidæ including under this the subfamily Scoliides and mentioning the genus Tiphia but not Scolia, apparently because Scolia did not occur in Great Britain. For his second subfamily he adopted Leach's tribe Sapygides thus bringing together under the family Scoliidæ Leach's tribe III Scolides, and tribe IV Sapygides. He does not appear to have recognized Leach's families Tiphida and Scolida.

Cresson, 1887, included under the family Scoliidæ, Tiphia, Paratiphia, Myzine and Scolia, placing the Sapygidæ as a separate family.

Ashmead, 1903, removed everything from the Scoliidæ except Scolia and Elis and a few genera so closely related to these that they have frequently been regarded as only subgenera. He also made two subfamiles the Scoliinæ and Elidinæ (now Campsomerinæ). Here Ashmead designated the type of Scolia as *Scolia flavifrons* Fab. evidently following Bingham who (Fauna Brit. India: Hymen., Vol. I, p 89) had already designated that species as the type of the genus.

May 26, 1911, S. A. Rohwer, in No. 1837 of the Proceedings of the U. S. Nat. Museum Vol. XL, pages 551–587 calls attention to Latreille's paper in 1810 and writes as follows:

"Family Scoliidæ, genus Scolia Fab. Type *Scolia quadripunctata* Fab. Latreille 1810. Mr. C. Schrottky has contended that the type of the genus Scolia Fab. is *Scolia atrata* Fab. *Scolia atrata* was the first species included and according to the system used by Saussure and Sichel, belongs to Elis. In stating that the type of Scolia is *atrata* Fab., Schrottky adheres to the antiquated first species rule. This adherence is unfortunate as the idea has been entirely done away with by most

systematists in all groups of animals, as well as being ruled against by the International Congress of Zoological Nomenclature."

The genus Scolia as originally defined by Fabricius included 10 species. The eighth species, *Scolia quadripunctata* Fab., was chosen as the type by Latreille in 1810. No older designation of type for this genus is known to the writer, therefore *Scolia quadripunctata* Fab. is considered the type of the genus Scolia. From this it is evident that the designation of Scolia *flavifrons* as type of the genus cannot hold.

Saussure and Sichel divided genus Scolia into the subgenera Triscolia and Discolia. As already stated *Scolia flavifrons* was selected by Bingham as the type and belonged to the subgenus Triscolia. The type *Scolia quadripunctata* selected by Latreille belongs to the subgenus Discolia however and upon raising these subgenera to generic rank, Discolia becomes a synonym of Scolia while Triscolia, regarded by Ashmead as a synonym of Scolia because *flavifrons* which he selected for the type belonged in that section, necessarily is restored from a synonym to a valid genus. Triscolia was established by Saussure and Sichel and under it were placed twenty-five species, none of which was designated as the type. So far as the writer has observed the only species of this list which has been designated as the type since, is *Scolia flavifrons* Fab. which was done by Bingham as already indicated. Accordingly therefore the subfamily Scoliinæ may be considered so far as North America forms are concerned, as including the genus Scolia with *Scolia quadripunctata* Fab. as its type, and the genus Triscolia. As the latter had the species *flavifrons* designated as its type when it was supposed that it was a synonym of Scolia, it would seem desirable to retain this same species as the type now that it has become an established genus. *Scolia flavifrons* Fab. is therefore here designated as the type of the genus Triscolia, no earlier designation for this genus having been observed.

The above is the history of this group that the writer wishes to adhere to, yet Schrottky in the Deutsch Ent. Zeitschr 1910, Heft II, page 196 says that Triscolia of Saussure and Sichel should become Ascoli of Guerin. In tracing Ascoli back to the reference, (Guerin, Duperry: Voy. Coquille. Zool. II, 1830, page 247,) I find it indeed true that this is the first reference to the insects included in the group Triscolia, that is so far as can

be ascertained by a study of the work concerned, for the factors which were used to separate the sections of Guerin's groups when compared with the important writers on Scolia become hard to discern. The following is a translation of Guerin's classification leading to Ascoli:

I. Superior wings with four cubital cells.
(The writer's three *closed* cubital cells.)
II. All the cubital cells reach to the radial cell.
A. Two recurrent nervures. (Cosila).
B. One recurrent nervure. S. G. Ascoli.

As an explaining phrase Guerin writes beneath division B "Nous n'en connaissons pas encore." Of course he does not give any examples as he has under his other divisions in his tables. Under these conditions the writer is not yet prepared to use the term Ascoli. If it should ever be adopted the writer sees no reason why *Scolia flavifrons* Fab. could not still remain the type under this older name.

HABITS.

Having never been able to study this group of insects in the field the writer has been obliged to depend on other writings on Scolia for information as to their habits. Westwood says that the genus Scolia comprises many species, inhabiting the hottest regions of the globe. Dufour states that Scolia hortorum abounds in the very hottest situations and that it is very fond of revelling in strong scented flowers. A correspondent of the Entomological Magazine (Vol. III, p. 436) states that Scolia bicincta Fab. makes its burrows in sand banks, to the depth of eighteen inches, with a very wide mouth; in digging into one a female had entered he found a large locust, L. lineola, which is probably its prey. The males of this genus are usually taken singly on flowers, but the males of Scolia interrupta and four-punctata, which are extremely sluggish, are found crowding on the ears of grass near the seaside, where they pass the night. Latreille thought that Scolia punctata was parasitic upon some of the bees which build in old wood, and Shuckard states he caught S. punctata entering into the cells of Osmia bicormis. Robineau Desvoidy has proved this fact, having found cocoons of S. punctata in the cells of Osmia helicicola, in which situation he observed the metamorphosis of this species without however, having detected the female in her operations. Riley in the sixth report of the Missouri

State Entomologist says that *Scolia flavifrons* attaches its egg to the venter of the larva of a common European lamelicorn beetle larva. Ashmead, Can. Ent. 35, states: "So far as is known the species are parasitic upon the larvæ of ground beetles belonging to the family Scarabæidæ and probably also upon other ground inhabiting beetle larvæ."

The following is a translation from Burmeister (Naturf. Ges. Halle): To see strange insects emerge from ant heaps is always surprising to the entomologist; he has every reason to assume that, if this is repeated often, then a normal condition exists. This is true of *Scolia campestris* of Brazil. I am therefore inclined to the opinion the *Scolia campestris* lives in the inside of the ant hills as larvæ and probably feeds as a parasite on the larvæ of the *Atta cephalotes*.

Such observations as the above would seem to imply that the insects belonging to the family Scoliidæ are parasitic on larvæ of a great many insects and that they are solitary, never living together in numbers in the same nest. The males are very apt to frequent highly scented flowers and a great many that the writer has examined show this, because the body, usually quite hairy, is well covered with pollen grains in many cases. So little data has been submitted on the habits and life of this group that an investigation of them should prove worth while and very interesting.

EXTERNAL ANATOMY.

Head. Viewed from in front the hypognathous head is subcircular but apparently elongated beneath by the projecting mandibles. At the sides are the somewhat kidney shaped eyes, made so by a deep emargination just above the middle of the inner borders which leaves the lower lobe much larger. In the male the emargination is well up toward the top of the head causing the lower lobe to be comparatively much larger than in the female.

Clypeus. The clypeus extends downward from the bases of the antennæ, its edge between these points being emarginated. Laterally it extends nearly to the eyes, the suture curving downward somewhat, and is separated from the eye by a narrow extension downward of the frons. Its lower margin varies from a broad gentle curve to nearly a straight line in some cases and this margin is liable to be reflexed. In the male the clypeus

is more triangular in outline, with the base of the triangle below. Except for a small area in the center it is punctured everywhere, the punctures gradually becoming deeper and closer from the central space outward. It is more or less covered with short stiff hairs but the whole surface has a shining appearance.

Frons. The frons extends upward from the base of the clypeus to the ocelli where it joins the vertex though no suture is present.

There is a downward projection on each side of the clypeus to the base of the mandible, narrow in the male and wide in the female. A transverse suture extends just behind the ocelli and then in some cases a little forward and outward toward the eyes. The antennæ are inserted in the frons close to its lower border, beneath two strongly developed oblique ridges, these insertions being slightly farther apart than the distance of either from the compound eye. The frons is more or less deeply punctured and hairy, particularly so between and around the base of the antennæ. The hair may become worn away to very short stubs, apparently a result of the digging habits of the insect.

Ocelli. The anterior ocellus is the larger. Behind the ocelli the head gradually rises to its highest point. It is rather sparsely punctured near the ocelli but behind its highest point its punctures become quite close again. This portion of the head may be termed the vertex but no sutures are present separating it either from the cheeks at the sides, the frons in front of the ocelli, or the occiput behind. The hinder part of the head behind the vertex and cheeks bears a narrow semicircular ridge within which is the articulation with the thorax. The back of the head close to the ridge is thickly clothed with rather long, stiff hairs.

Cheek. The portion of the head behind the compound eye is called the cheek. Viewed from the side it is widest behind the top of the eye. For a short distance downward it is of about the same width and then narrows very rapidly to the base of the mandibles. It is punctured and hairy more or less everywhere.

Labrum. A short distance above the lower edge on the inside of the clypeus the labrum is attached. In preserved specimens it is bent backward at right angles to the clypeus,

covering the cavity which holds the folded sucking mouth parts. With the large mandibles closed over it the labrum is not accessible for study except by dissection. There has therefore been no attempt made to use its characters for classification.

Mandibles. Each mandible is a fairly long and strong hook decidedly suggesting rapacious habits. The front surface has a deep longitudinal furrow at its inner border while the hind surface is set with stiff outstanding bristles, extending from a deep furrow at its outer border. Between these two and on the front surface is a third shallow furrow which runs the whole length of the mandible. A study of many individuals shows a variation in the structure and relative proportions of the mandibles, they probably being worn and modified by the digging habits of this group. In the female the middle of the inner margin sometimes shows tiny blunt projections (hardly long enough to be called teeth) varying in size with the different species and in the same individual. The male mandible is more delicate than the female. Its inner middle margin shows three well defined teeth besides the sharp end tooth. The surface of the mandibles is smooth and shining.

The maxillary palpus is composed of six segments and the labial palpus has three segments.

The other mouth parts cannot be studied except after dissection and therefore are not readily available for analytical work. For this reason they are not considered here.

Antennæ. In the male these are long, almost cylindrical and almost straight. The basal portion of the first segment or scape is a small spherical bulb which has every appearance of being a separate segment. This is not the general opinion however so it is here considered a part of the scape. The distal portion of the segment is long and very near a perfect cylinder. It narrows quickly at either end to articulate with the bulb and the pedicle. The pedicle is small and cup-shaped, its smaller end toward the body. These segments are smooth and shining. The filament consists of eleven cylindrical segments, very little thickened in the middle and only separated from each other by a fine seam. As a whole it is stout gradually increasing in diameter to near its end, then gradually reducing. The segments of the filament are considerably longer than their diameter and are dull, not reflecting the light.

In the female the antennæ are more condensed, being thicker and shorter. The scape is large, stout, elongate-ovate, with its greatest diameter near its outer end. The second segment is similar to that of the male but articulates somewhat obliquely with the scape which tends to turn the outer part of the antenna backward. The ten segments of the filament with the exception of the last are no longer than their diameter and articulate with each other quite obliquely. Their surface in general is dull though the first segment or two may be somewhat glistening. The outline of the filament as a whole resembles that of the male.

THORAX. The pronotum aside from the portion forming the upper side of the neck extends to the tegulæ, below which it projects a little farther backward. From this point its edge then runs forward and downward, forming a curve to the base of the fore coxæ. Between the tegulæ its margin is deeply excavated to accomodate the front of the mesonotum. The front margin of the prosternum on the neck is considerably posterior to that of the pronotum making the articulation with the head quite oblique. A Y-shaped groove a short distance behind its anterior margin separates what may be considered the neck portion of this plate from a swollen lateral lobe on each side, at the hind end of which the fore coxa articulates.

The surface of the pronotum is more or less coarsely punctured and provided with hairs except along a strip where its neck and vertical portions meet. The sternum is everywhere similarly punctured but the hairs along the Y-shaped groove are much smaller and decumbent.

The mesonotum is a broad convex plate, very near a regular hexagon in outline, lying between the wings and extends forward to the prothorax, and to the tegulæ at the sides. From the middle of the anterior edge a groove extends backward varying in length and distinctness. From a point just inside of the place where the edge of the scutellum joins the mesonotum a pair of grooves pass forward from its posterior margin parallel to each other. These grooves varying in length, depth and width are probably the parapsidal grooves. The mesonotum is coarsely but somewhat sparsely punctured except near its center which is smooth. Just behind the mesonotum lies the scutellum. It is more or less deeply punctured and hairy, and is a transverse plate with its central portion

raised about as high as the mesonotum. Its sides are abruptly bent downward along a line beginning at the parasidal grooves and extending backward and toward the center of the body giving this portion the form of a trapezoid whose basal angles are equal, with its longest base toward the anterior end of the body. The lateral, sharply depressed portion of the scutellum narrows quickly as it passes outward and downward and the hind wing arises from just behind its outer end while the fore wing arises somewhat lateral to its outer end which extends forward somewhat below the hinder corners of the notum.

The mesothoracic pluron is large and lies below the wings. The whole surface of this plate is gradually raised to a rounded ridge which runs downward and backward through its middle and is more or less hairy and coarsely punctured. The anterior margin of this plate is indicated by a curved suture running downward and slightly forward to the base of the fore coxa while its posterior margin is indicated by a suture starting just in front of the margin of the posterior wing and running downward and backward to the highest point of the mesocoxa in front of which it forms the anterior edge of the coxal cavity. This plate fuses beneath with the mesosternum, no suture being present to separate the plates. The anterior margin of the mesosternum is formed by the contiguous fore coxæ and its posterior margin is in part formed by the inner sides of the mesocoxal cavities and in part by a free edge between them, the two mesocoxal cavities being suddenly separated. The intercoxal margin of the mesosternum varies from a nearly straight to a more or less curved line with a notch in the middle. A longitudinal median line varying in distinctness divides the mesosternum into two equal parts. The mesosternum is more or less coarsely punctured and haired.

The postscutellum which lies just behind the scutellum is a similar plate but a little narrower. Its central portion is raised to about the same height as the central portion of the scutellum and becomes narrow behind and then broadens somewhat, close to its hinder margin. Its sides beginning on a line with the sides of the scutellum are abruptly bent downward to correspond with the similar portions of the latter plate and its margins running downward and forward nearly parallel, end at the base of the posterior wing. The plate is more or less coarsely punctured and haired.

The metapleuron extends downward and backward from the base of the posterior wings. Half-way between the base of the wings and the base of the metacoxa the plate narrows and appears to be separated into two parts by a transverse furrow. The upper part is very near the shape of a triangle, with one side, the hinder one, rounded. The lower part continues downward and backward between the edges of the median segment behind and the mesopleuron in front forming the posterior part of the mesocoxal cavity, the upper and anterior parts of the metacoxal cavity and passing between the two coxal cavities to unite with the metasternum though there is no trace of the suture between these two plates. Both parts of the metapleuron are more or less coarsely punctured and hairy. The metasternum extends backward from the mesosternum between the meso and meta coxæ, its sides in part forming the ventral edges of the coxal cavities and the apparent posterior margin is free. This part of the metasternum is only sparsely punctured and covered with hairs while its shape varies. It has a median groove extending forward from the apparent hinder margin for a varying distance. This apparent hinder margin is not the real one, however, the plate turning backward on itself for a short distance, then bending at right angles and passing dorsalward, thus forming a backward projecting flange. The vertical portion is bilobed and at its dorsal magrin (the real posterior margin of the plate) articulates with the sternal plate of the petiolar segment. This flange is covered with coarse punctures and long coarse hair.

Median segment. The median segment is really the first segment of the abdomen which has become closely connected with the thorax and has often been considered one of the segments of this division. It is followed by the petiole, a constricted portion which extends backward and suddenly enlarges to the regular size of the abdominal segments. For any morphological consideration this arrangement should be remembered but for convenience in this paper the petiole with its enlarged portion is considered the first segment of the abdomen.

Viewed from above the median segment appears to be composed of a central portion and a lateral portion on each side, the separation of these parts being indicated by a depressed line or shallow groove arising at the front margin of the plate nearly opposite the point where the central elevated part of the

postscutellum joins the side portion and becomes depressed. These two lines converge as they pass backward and continue to the sides of the base of the petiole. The central portion of the median segment extends backward a distance about equal to the length of the scutellum then sharply bends downward to the petiole, its two surfaces forming nearly a right angle. Both of these surfaces bear coarse punctures and hairs. A short distance behind the upper posterior corner of the metapleuron a long narrow, nearly vertical, spiracle occurs near the anterior margin of the latter portion of the median segment. The groove separating the metæpisternum from the metæpinuron appears to continue upward and backward into the side of the median segment, passing below the spiracle and extending a short distance behind it. From a point near the lower end of the spiracle this lateral portion appears to become sharply compressed into a dorsal, nearly horizontal and a lateral surface, the latter being so bent inward that the sides of the insect in this region actually overhang. These lateral portions extend somewhat farther back than does the central portion so that the posterior end of the median segment as a whole has its lateral corners projecting farther backward. At its lower hinder edge the median segment articulates above with the dorsum of the petiolar segment. The surface of the lateral portions is more or less coarsely punctured and haired.

Abdomen. The abdomen has six visible segments in the female and seven in the male which excepting the first and the sixth, seem to have no structures of importance. The part of the abdomen behind the petiolar segment viewed either from above or below enlarges for a short distance then gradually narrows in a regular curve, to where a pair of spines project from the surface of the last segment. The sternum of the second segment shows a distinct anterior face where it bends abruptly downward from its articulation with the posterior lower margin of the petiolar sternum, thus giving the middle portion of the abdomen its greatest vertical diameter. Behind the second segment the distance apart of the dorsal and ventral plates gradually decreases. The surface of each segment is more or less coarsely punctured and hairy and close to the posterior margin of each the punctures are more numerous. From these punctures project stiff hairs overlapping the anterior edge of the next segment beyond, to form a fringe. All the hairs are quite decumbent particularly those above.

In proportion to the rest of the insect the abdomen as a whole is heavy causing it to sag downward and gives the insect a clumsy appearance especially the female.

First segment of the abdomen. The narrow part of the first segment of the abdomen known as the petiole, viewed from above is about one-third as wide as the median segment or of the widest portion of this segment itself while the vertical diameter of this part is about two-thirds its width. It continues backward from the base of the median segment for a very short distance then rises sharply and gradually broadening, to a point about the level of the top of the median segment. It then bends backward to form the dorsal surface of the hinder non-petiolar portion of this segment. The ventral part of this segment is divided into two portions. The first is a small, convex, somewhat oblong area with rounded corners and a posterior median shallow notch, the whole much resembling in form the labrum of some Acrididæ. Its surface is finely and closely punctured and is well covered with long hair.

The posterior portion of this sclerite is markedly triangular, all its margins being concaved. The posterior angles are quite sharp but the anterior one where it joins the front section first described is about the width of the petiole. The posterior margin has a rather dense fringe of short backward directed hairs. The surface of this portion of the sclerite is rather sparsely covered with punctures and hairs.

A somewhat triangular projection forward and outward from the anterior corner of the second dorsal abdominal plate seems to wedge itself between the hinder corners of the notum and sternum of the first segment and a line arising near the base of the projection on the notum of the first segment and running obliquely downward and forward to meet the lateral margin of this plate at the hinder edge of the first section of the sternum already described may perhaps represent the former line of separation between the notum and pleuron in this segment: if so the pleuron is now the lateral margin and an actual part of the notum.

Last segment of the male. The terminal segment of the male requires a separate description. In this sex the lateral margins of the dorsal sclerite overlap the corresponding margins of the sternal sclerite from the base of the segment backward to the point where a lateral spine protrudes from between the two

plates of the segment. From this point backward there is no lateral portion to the plate it being entirely dorsal and with its margin rather oval in outline varying somewhat perhaps in some species.

The base of the ventral segment at its sides is concealed by the lateral margins of the dorsal plate. Its lateral margins are nearly parallel almost to the end of the segment, the hinder margin being very broadly and bluntly acuminate. Along the median line of the plate extends a distinct ridge.

Between these two plates projects the end of a third, only the outer portion of which is strongly chitinized. Its sides are approximately parallel and at the hinder end it bears three spines one in the center and one at each corner. The median spine is larger and stouter than the lateral ones and extends backward some little distance into the body of the plate forming a distinct central ridge on the under surface. The body of the plate as a whole is somewhat convex from side to side beneath. The homology of this three spined plate has not been worked out by the writer but as the reproductive organs are just above it, it would seem not impossible that it is the ventral plate of another segment partly drawn within the one described as terminal and of which the dorsal portion has either been lost or at least has not been observed in the course of this work.

Last segment of the female. The lateral margins of the last dorsal sclerite in the female are considerably prolonged ventrally over the corresponding margin of the sternum of this segment thus concealing the latter. The edge of this portion extends backward and upward to the base of the spine near the margin on the ventral plate (to be described later) above which it turns backward and gradually inward to form the hinder margin. The outline of this portion varies greatly in different species. On the side of the dorsal plate near its base and close to the edge of its dorsal surface a ridge arises extending backward and finally ending above the more or less spine-like structure of the ventral plate. This ridge varies in form in different species.

The last ventral plate in the female is quite convex from side to side and its lateral margins turn inward almost horizontally, the two edges nearly meeting at the nearest point. This inflexed portion of each side is concealed by the dorsal plate only the hinder margin which varies in outline in different

species, being visible. At the side of the visible portion of the plate close to the margin of the dorsal sclerite is a projection more or less of the form of a spine but sometimes shorter and with a blunt end. It projects outward and backward from the general surface of the body at this point and its antero-posterior location on the plate varies somewhat in different species.

Wings. The wings of this group as far as observed are generally fuliginous with a bluish, purplish, or even somewhat greenish reflection. In a few cases the wings are nearly hyaline but then are liable to have a yellow tinge and more or less well developed fuliginous areas particularly toward the apex, and at these places the reflection appears.

In this paper wing areas entirely enclosed by veins are termed closed cells while those not entirely enclosed by veins and extending to the margin are regarded as incomplete or open cells. At the base of the wing are three rather long closed narrow cells. These passing backward from the costal margin are respectively, the costal, median and submedian cells. Between the latter and the hinder margins is an open anal cell. Between the outer end of the costal cell and apex of the wing are two closed cells, the one next to the costal occupying the place where the stigma is usually found and which may therefore be called the stigmal-cell. It is quite narrow. External to this is the much larger radial cell and extending from the latter to the apex, is a large open cell. Behind the stigmal cell lies the first cubital, lying behind the outer end of the costal cell and at the outer anterior corner of the median cell while its outer end is behind the inner portion of the radial cell. Behind the greater part of the first cubital and the radial cells lies the second cubital and in some cases, is a small closed cell, the third cubital between the outer end of the second cubital and the apex of the wing. The area sometimes occupied by the third cubital cell is sometimes thrown into the open cell already referred to which extends to the apex of the wing, there being no third cubital present in such cases. Behind the outer part of the median, the base of the first cubital and the base of the second cubital cells, lies the first discoidal and at the outer end of the submedian and behind the basal half of the first discoidal lies the second discoidal cell. External to the second discoidal cell and behind the outer parts of the first discoidal and second cubital cells lies the third discoidal cell, combined

with the second apical cell which is open at its outer end, no cross vein separating these two being present in the American members of this subfamily. Behind this cell is a space extending to the hinder margin, the first apical cell.

There is a variation in the number of cubital and discoidal cells and upon this variation depends the separation of the group into genera. There also seems to be a variation in the shape of the radial and cubital cells which may be of some specific value. The radial cell differs in the different sexes and there seems to be an area more or less confined to the costal, median, stigmal, first cubital and radial cells which is usually covered with hairs. The region beyond the closed cells is very finely striate with parallel lines. This fact alone would serve to separate this subfamily from two of its nearest allies, the Myzinidæ and Tiphiidæ if other structures were not available.

The veins which appear in the front wing of this group are the costal, subcostal, externo-medial, anal, basal, first, second and third transverse cubital, transverse medial, discoidal, cubital, first recurrent and subdiscoidal veins. Their arrangement and relation to each other are shown by figure. Either the presence or absence of a third transverse cubital nervure causing either the presence or absence of a third closed cubital cell is a generic character as before stated.

The fact that there is but one recurrent nervure is of subfamily value separating the Scoliinæ from the Campsomerinæ, the other subfamily of this family Scoliidæ.

Along the central portion of the hinder margin of the anterior wings just internal to a nearly central notch of this margin on the anal cell is a fold known as the frenal fold, in which the frenal hooks of the hind wing catch so that the two wings may act together.

There seems to be nothing of systematic importance in the structure of the hind wing. About one-third of the distance from the base of the wing on the posterior border there is a deep narrow sinus and at about the center of the anterior border are the frenal hooks spoken of above. Except for a very few hairs mostly near the costal border the hind wing is naked.

Tegula. The tegula is a small three sided, very convex, plate lying over the base of the fore wing, separating it from the dorsal plate of the prothorax in front and from the mesonotum above. The surface of the tegula is usually smooth and shining.

except near its base where it shows a few punctures and hairs. Beneath the base of each wing there is only one principal long narrow plate, called the subalar by Crampton in a treatise on the thorax of insects in 1909. Above the base of each, just behind the tegulæ are located two plates which probably represent detached portions of the basal parts of the veins of the wings.

Legs. The legs of this subfamily are not long but are stoutly built, the general structure being reenforced by spines and hairs of unusual length and thickness especially in the female. The front legs of the female are especially developed probably to aid in digging in the earth.

The coxa, trochanter and femur of the front leg have no spines in either sex. The femur of the middle leg in the female however bears on the outer side of its outer end, one or sometimes two small spines and at the same place on the hind femur a transverse row of similar spines. In the male the mid femur has, in rare cases, such a spine at the above location and the posterior femur always bears a row of short spines at the same place. The other segments of the legs are more or less covered with rows or else isolated stout spines especially in the female. The front legs in both sexes are always the shortest and the parts beyond the femur in the female are somewhat flattened. The size and length of the legs increases from in front backward and the length of the first tarsal segment in the three pairs of tarsi from front to rear is very nearly in a ratio of one, two and four in both sexes.

In the front leg the tibia is much shorter than the femur; in the middle leg it is but little shorter; while in the hind leg the two segments are about equal in length.

The mid coxæ are always far apart, (a character used to separate the Scoliidæ from the other closely allied families) and are small globular or subconical in form. The fore and hind coxæ are quite large, of about the same size and conical. The former are contiguous but the latter are widely separated.

At the top of the last tarsal segment is a pair of simple claws, (a character used to separate Scoliidæ from the Myzinidæ). Between these claws is a good sized pulvillus.

At the end of the tibia there are always several spines and at the end of the middle tibia is always a spine much larger and longer than the others, while at the end of the hind tibia there

are always two such spines of about equal length and much larger and longer than the others.

All the segments of the legs are more or less covered with coarse punctures and long hairs.

The three pairs of trochanters are well developed and are longer at the outer end where they articulate with the femur which also enlarges outward to where it articulates with the tibia. The fore tibia has at its end just beneath its anterior edge a large, curved, much modified spine which in connection with a corresponding modification at the base of the first tarsal segment, acts as a cleaning apparatus. Beginning at the base of this enlarged spine on the tibia and extending backward along the anterior margin is an area of short, fine hairs set close together to form a pad-like structure. This is not so strongly developed in the male but there is a sericeous appearance in its place. Beneath the hind margin near the outer end three stout spines usually project and a row of short stout spines projects from beneath the edge of the end.

There are five tarsal segments. The first and fifth are much longer than the others and in the female the tarsal segments of the fore leg are somewhat flattened. Their posterior edges bear a row of long stout spines and their ends and anterior edges have a row of similar spines except the part of this edge of the first segment which is opposed to the large modified spine of the tibiæ. Here the edge is sharply concave and has short, blunt, tooth-like projections. On the ventral surface of the same segment, behind this concave edge and near its base, a row of long stiff hairs projects downward.

The dorsal surfaces of the mid and hind tibiæ are set with longitudinal rows of stout spines. The mid and hind tarsal segments except the last, are cylindrical and bear irregularly set spines. Their ends are encircled by a row of stout spines.

The relative size of the segments of the legs increases from front to rear and there are no spines on their ventral surfaces.

Sex differences. Most of the differences of sex have been mentioned above. Some of the more conspicuous are restated as follows: In comparison with the female, the male is much more slender and always smaller. The outline of the clypeus is much different; the antennæ of the female have twelve segments which are short, blunt and recurved while those of the male have thirteen segments and are long, slender and usually

straight. The female abdomen has at its end a sting while the male has three sharp spines. The segments of the fore tarsi in the female are flattened somewhat while those of the male are cylindrical. Legs of the male have fewer spines and hairs than those of the female which present a very bushy appearance. The abdomen of the female has six segments and that of the male seven.

GEOGRAPHICAL DISTRIBUTION.

The insects of this group occur in all the continents of the world but are most abundant in tropical regions. There the specimens are usually very large and although in the greater number of cases the ground color is very dark or black, there are spots, bands, etc., of the brighter colors.

Specimens of this group become more and more rare as the climate becomes colder. Apparently the Upper Austral zone marks their northern limit with perhaps the exception of occasional stragglers into the Transition zone.

Within the territory this paper attempts to cover, namely North America, the species of the subfamily Campsomerinæ seem to far outnumber those of the Scoliinæ.

Subfamily SCOLIINÆ Ashmead.

SCOLIA: Fab., Syst. Entom. 1775, p. 355, n. 111.
SCOLIETÆ: Latr., Hist. Nat. Ins., 1805, Vol. XIII, p. 270.
SCOLIDA: Leach, Edinb. Encyl., 1812.
SCOLIDES: Leach, Encyl. Brit., 1817.
SCOLIDA: Leach, Edinb. Encyl., 1817.
SCOLIITES: Newm., Ent. Mag. II, 1834.
SCOLIIDÆ: Westw., Intr. Class. Ins., 1840, Vol. I, p. 82.
SCOLIIDES: Westw., Intr. Class. Ins., 1840, Vol. I, p. 82.
SCOLIA: Burm., Abh. Naturf. Ges. Halle, 1853.
SCOLIA: Sauss. and Sichel, Cat. Spec. Gen. Scolia, 1864, p. 14, genera Scolia and Elis.
SCOLIA: Cresson, Syn. of Hymen. of Amer. north of Mex., 1887, p. 108.
SCOLIA: Bingham, Fauna Brit. India; Hym., Vol. I; 1897.
SCOLIIDÆ: Ashmead, Can. Ent., Vol. XXXV, 1903, p. 7.
SCOLIINÆ: Ashmead, Can. Ent., Vol. XXXV, 1903, p. 7, (subfamilies Scoliinæ and Elidinæ).
LIACOSINÆ: Schrottky, Deutsch. Ent. Zeitschr., 1910, Heft. II, p. 196.
SCOLIIDÆ: Rohwer, Proc. U. S. Nat. Mus. Vol. XL, p. 552,1911.

SYNOPTIC TABLES FROM VESPOIDEA TO SUBFAMILY SCOLIINÆ

The writer has used portions of Ashmead's tables published in the Proceedings of the U. S. National Museum, Vol. XXIII, and in The Canadian Entomologist, Vol. XXXV.

Abdomen sessile or petiolate, with the first ventral segment distinctly separated from the second by a more or less deep constriction or transverse furrow; legs most frequently fossorial.....1.

1. Middle coxæ contiguous or nearly so.
   Cosilidæ, Rhopalosomidæ, Thynnidæ, Myrmosidæ, Mutillidæ.
   Middle coxæ distant, usually wide apart.....2.
2. Stigma of front wing not well developed, at most only slightly developed, either very small or linear; eyes most frequently emarginate within; middle tibiæ with two apical spurs.....3.
   Stigma of front wing well developed, ovate or subovate; eyes entire, never emarginate within; pygidium in male entire, the hypopygium terminating in a sharp aculeus, which curves upward.....*Tiphiidæ.*
3. Pygidium in male entire or at most with only a slight sinus; the hypopygium ending in three spines; claws simple.....*Scoliidæ* 4.
   Pygidium in male deeply emarginate at apex, the hypopygium terminating in a sharp thorn or aculeus, which curves upward and rests in the emargination of the pygidium; claws cleft.....*Myzinidæ.*
4. Front wings with only one recurrent nervure; if with two the second recurrent is incompletely formed, and bends backward so as to unite with the first; the second cubital cell receiving only one recurrent nervure .....Subfamily *Scoliinæ.*
   Front wings with two complete recurrent nervures, both of which are received by the second cubital cell.....Subfamily *Elidinæ.*

TABLE OF SPECIES.—SCOLIINÆ.

1. Fore wing with three closed cubital cells .....**Triscolia.** 2.
   Fore wing with two closed cubital cells.....**Scolia.** 3.
2. Black; abdominal segments beyond the second, reddish brown; wings with slight greenish reflection.....**T. fervida** Burm. (315)
   Entirely reddish brown; wings with a strong green metallic reflection...
   T. badia Sauss. (314)
3. Body entirely without color markings.....4.
   Body not entirely without color markings.....6.
4. Second abdominal segment more or less tubercular beneath.....5.
   Second abdominal segment not more or less tubercular beneath.....
   S. monticola Cam. (330)
5. Body entirely black, hairy and densely punctured. Wings dark fuliginous. A darker area along the costal border.....**S. guttata azteca** Sauss.. (326)
   Body entirely dark brown, smooth and shining; wings light fuliginous throughout.....**S. cubensis** n. sp. (318)
6. Body with yellow markings.....7.
   Body without yellow markings, head and thorax black, segments of the abdomen beyond the second, ferruginous..**S. dubia hæmatodes** Burm. (320)
7. Second abdominal segment more or less tuberculate beneath.....8.
   Second abdominal segment not more or less tuberculate beneath.....9.
8. Wings with metallic color reflections, blue and purple, larger hind tibial spur less than one-half the length of the first tarsal joint.....
   S. guttata guttata n. subsp. (325)
   Wings without metallic reflections, shiny brown, length of the longest hind tibial spur about one-half the length of the first tarsal joint....
   S. fuscipennis n. sp. (324)

9. Venter of the abdomen all black.....10.
Venter of the abdomen ferruginous or partly so.....11.

10. Head all black, body covered with black hair. Free edge of the clypeus a regular curve.....**S. bicincta** Fabr. (316)
Head with yellow marks behind the eyes, body covered with grey hair. Free edge of the clypeus very near a straight line with the lateral edges meeting this edge close to the perpendicular. **S. vintschgaui** D. T. (336)

11. Thorax all black, dorsum of third abdominal segment has two oval yellow spots.....**S. dubia dubia** Say. (319)
Thorax not all black.....12.

12. Venter of abdomen all ferruginous, body covered with greyish white hairs, antenna slightly ferruginous .....**S. fulviventris** n. sp. (323)
Venter of abdomen not all ferruginous, maybe black or yellow ferruginous. 13.

13. Thorax covered with yellowish grey hair; antenna black. **S. consors** Sauss. (317)
Thorax not covered with yellowish grey hair. (Yellow or darker).....14.

14. Wings fuliginous throughout.....**S. nobilitata** Fabr. (332)
Wings not fuliginous throughout.....15.

15. Ventral abdominal segments beyond the second, dark ferruginous slightly mottled with yellow; dorsal segments 3, 4, 5, 6, yellow except the anterior edges slightly ferruginous.....**S. otomita** Sauss. (333)
Ventral abdominal segments beyond the second, not dark ferruginous and not mottled with yellow.....16.

16. Head all black except yellow marks behind the eyes and along the inside edges of the lower lobes of the eyes.....17.
Head, except yellow marks behind the eyes and along the inside edges of the lower lobes, not all black.....18.

17. The dorsum of the abdomen has no yellow on it, except on the third segment which has two oval yellow spots.....**S. inconstans** Cress. (327)
The dorsum of the abdomen beyond the first segment, more or less marked with yellow.....**S. flavocostalis** Cress. (321)

18. Top of head behind the lower ocellus and body color of the thorax black.....**S. lecontei** Cress. (329)
Top of head behind the lower ocellus and body color of the thorax ferruginous .....**S. ridingsii** Cress. (334)

DESCRIPTIONS.

The lists of references to these insects given by Saussure and Sichel and especially by Dalla Torre are so full that it has not seemed necessary to copy them here. It has therefore been my intention only to make the American references complete by publishing any that were not in Dalla Torre's Catalogue:

Genus **Triscolia.** Saussure and Sichel.

Genus *Triscolia.* SAUSSURE and SICHEL, Cat. Spec. Gen. Scolia, 1864, p. 14.

Generic characters: Three closed cubital cells.

Type: *Scolia flavifrons* Fab.

BIBLIOGRAPHY.

Ascoli GUERIN, Duperry, Voy. Coquille, Zool. II, 2, 1830, p. 247.
Triscolia SAUSS. and SICHEL, Cat. Spec. Gen. Scolia, 1864, p. 14. (subgenus).
Scolia BINGHAM, Fauna. Brit. India, Hymen., Vol. I, 1897.
Scolia ASHMEAD, Synopsis, Can. Ent., 1903, p. 7, (subgenus).
Ascoli SCHROTTKY, Deutsch, Ent. Zeitschr., 1910, Heft. II, p. 196.

Triscolia badia (Saussure).

Scolia badia SAUSS. Am. Soc. Entom. France (4), III, 1863, p. 17 ♀ ♂.

The location of the type is unknown to the writer.

Saussure and Sichel have recorded the female of this species as 31 mm. in length and the male as 18 mm. in length. The specimens that the writer has personally examined vary, the females ranging from 22 to 26 inches in length. Only one male was examined. It measured 19 mm. in length.

The body of the species is reddish brown except for a few parts which are black or have black markings. The wings are uniformly fuliginous with metallic reflections, green at some angles, blue at others and purplish at others. The nervures are dull black. This species is one of the largest found in the group.

The specimens which the writer has examined agree well with Saussure's description of the species and also with a good illustration published in Saussure and Sichel's Catalogue, plate IX, except for a few details. In the female the antenna, except more or less of the scape, is black as is also the end and more or less of the margin of the mandible. The small inner plate at the base of the fore wings behind the tegula is also black. In addition a number of the thoracic sclerites frequently show a slight tendency toward blackish at their margins and this also is the case with the lateral and hinder margins of the last ventral abdominal plate. The tips of the claws are also nearly black. The coarse hairs clothing the body are orange yellow, lighter than the color of the plate from which they arise.

In the male the antennæ are entirely black except the underside of the scape which is dull ferruginous. The head from the insertion of the antennæ upward is black except for the emargination of the eyes and a narrow light band behind the eyes which widens below. The tips and inner and outer margins of the mandibles are dark reddish brown. The mesonotum is black except at its extreme lateral margins. The anterior face of the propleuron is also dark tending toward black and the bases of the femora each have a more or less blackening. The posterior plate at the base of the fore wing behind the tegulæ and the three spines at the base of the abdomen are also black.

Saussure and Sichel record this species as from Lower California. The specimens which the writer has examined are also labelled Lower California.

This is the only species occurring in the territory covered by this paper in which the body is practically all ferruginous.

Triscolia fervida (Burmeister).

Scolia fervida Burm., Abh. Naturf. Ges. Halle, I, p. 4, 1853, p. 20, n. 12 ♀ Am.: Texas, Mexico.

The location of the type is unknown to the writer.

Burmeister has recorded this insect as from 14 to 16 lines long, while Saussure and Sichel have recorded the length as from 35 to 40 mm. The females which the writer has examined vary in size from 20 to 28 mm. in length and the males from 15 to 21 mm.

The body of this species is black except the segments of the abdomen behind the second. These are dark reddish brown with very little variation. The wings are uniformly fuliginous with intense metallic reflections, green at some angles, deep blue at some and purplish at others. The nervures are black. This species is one of the largest in this subfamily.

The typical examples are described by Burmeister as all black except the part of the abdomen beyond the second segment which he describes as red, red brown, or rufous. Saussure and Sichel describe a variation in which the posterior part of the second segment is also rufous.

The specimens that the writer has personally examined agree quite well with Burmeister's typical description and also agree with a good figure published in Vol. II of Cameron's Biologia, plate 12, figure 17, except that the posterior part of the second segment was always reddish brown or rufous, more evident on its under surface, and the parts described as black by Burmeister have a slight tendency when observed under the lens toward a rufous tinge. The edge of the clypeus, emargination of the eyes, edges of the mandibles, the legs especially the end segments and the spines are usually quite rufous. The edges of the segments of the abdomen described as rufous have a tendency toward darker, sometimes blackish coloring.

Burmeister records the habitat of this species as Mexico: Saussure and Sichel as Mexico and Texas. The writer has seen specimens from Mexico, Arizona, Texas and New Mexico.

Genus **Scolia** Fabricius.

Scolia Fab., Syst. Ent., 1775, p. 355, n. 11.

Generic character: Two closed cubital cells.

Type: *Scolia quadripunctata* Fab.

BIBLIOGRAPHY.

Scolia Fab., Syst. Ent., 1775, p. 355, n. 11.
Scolia Latr., Considerations generales sur l'ordre Naturael des Crustaces, Arachnides et Insects, 1810.
Lacosi Guerin, Duperry, Voy. Coquille, Zool. II, 1830, p. 246.
Discolia Saussure and Sichel, Cat. Spec. Gen. Scolia, 1864, p. 14 (subgenus).
Lacosi Schrottky, Deutsch. Ent. Zeitschr., 1910, Heft. II, p. 196.

Scolia bicincta Fabricius.

Scolia bicincta FAB., Syst. Ent., 1775, p. 356, n. 6.

Location of the type not known to the writer.

Saussure and Sichel have recorded size for the species as ranging between 20 and 25 mm. in length. In the specimens that the writer has personally examined the females range between 15 and 18 mm. in length and the males between 12 and 16 mm.

The body of this species is black except for yellowish white markings on the abdomen varying somewhat in different specimens. The wings are uniformly fuliginous with metallic reflections, blue at some angles, purplish at others. The nervures are black. This is a medium sized species.

The typical examples of this species are described by Fabricius as being black with two broad ferruginous bands at the base of the second and third segments of the abdomen. There are variations from this however. Burmeister in his work describes the spots as yellowish white instead of ferruginous and describes a specimen which has white markings on the first segment of the abdomen and the band on the third segment broken into spots.

Saussure and Sichel in their catalogue describe several specimens differing from the typical form. One of these has a yellowish white spot on the first abdominal segment, another has the bands interrupted forming spots and another has a yellowish band on the first segment and two yellowish white spots on the ventral part of the second segment.

The specimens that the writer has personally examined agree quite well with Fabricius' description except a few specimens which have the usual bands interrupted, forming spots; a few which have a narrow band of yellowish white across the dorsum of the first abdominal segment, others which have a small yellowish white mark on the postscutellum and some which have two oval spots on the ventral part of the second abdominal segment and two very small yellowish white marks on the dorsum of the fourth segment.

This species is recorded by Saussure and Sichel from boreal America. The writer has seen specimens that were collected from points that show its distribution in the United States from Texas to Massachusetts. Probably it does not occur much farther north than the latter state.

The Insect Book by L. O. Howard (plate I, No. 3), gives a good illustration of this species.

Scolia consors Saussure.

Scolia consors Saussure, Ann. Soc. Ent. France, (4), III, 1863, p. 18, ♂
Scolia amœna. Cresson, Proc. Ent. Soc. Phil., IV, 1865, p. 447, No. 3. ♂

The type of *amœna* is at the American Entomological Society rooms at Philadelphia.

Cresson describes the species as follows:

"Scolia amoena, n. sp.

"Black; orbits, two spots on prothorax, postscutellum, two large marks on third segment of abdomen, a broad band on the fourth and a narrow line on the fifth, yellow; most of legs, sides of first and second abdominal segments and most of the venter dull rufous; wings subhyaline, the costa fuscous.

"Male.—Black, clothed with short pale pubescence, rather sparsely punctured; orbits, narrow behind, yellowish, indistinct; mandibles rufous at base, antennæ as long as the head and thorax, entirely dull black. Thorax: two small triangular spots on the prothorax in front, and a transverse line on the postscutellum, yellowish; metathorax immaculate, very abrupt behind and concave; tegulæ piceous. Wings subhyaline, the costa broadly fuscous. Legs piceous, with palish pubescence; all the femora more or less rufous. Abdomen robust, black, sparsely punctured, shining, somewhat iridescent; sides of the first and second dorsal segments and the whole of the second ventral, rufous; two large, irregular, almost confluent, yellow marks on the fourth segment above; a broad, yellow band on the fourth segment, scalloped anteriorly, and on the fifth segment a narrow transverse yellow line; apical segment piceous, with three very short, subacute teeth. Length 7 lines; expanse of wings 12 lines.

"One specimen. A very handsomely ornamented species."

The writer has carefully examined the type specimen at Philadelphia and has also examined one other specimen at the same place. This last varies from the above description somewhat. The orbits of the eyes are not all yellow but there is a broad yellow mark starting within the lower part of the emargination of the eyes and extending downward along the border of the lower lobe; there is also a narrow streak of the same color behind the eye. The yellow on the postscutellum is a band instead of a line. The tegulæ are ferruginous. The coxæ are black and ferruginous in varying proportions.

The trochanters, bases of the femora and the tarsi are blackish ferruginous. The rest of the legs are light ferruginous with the broad faces of the femora lightest. The dorsum of the first segment of the abdomen has a ferruginous band and its under side is ferruginous behind. The front face of the venter of the second segment is black and the venters of the segments from the fourth backward with the dorsum of the last two segments are obscure ferruginous. The wings

are fusco-hyaline with a darker area along the costal margin including the costal end of the median, stigmal, first cubital, and radial cells and continuing beyond the cellular area nearly to the tips of the wings. The part of this darkened area within the cells is faintly yellowish, that beyond is smoky. The wings have slight purplish metallic reflections when held at certain angles. The nervures are dark ferruginous. The specimen is quite coarsely covered with whitish hairs except the dorsum of the last three segments of the abdomen where they are yellowish.

The above specimen, a male, was taken in Lower California and is now in the collection of the American Entomological Society at Philadelphia.

The type specimen was taken in Colorado.

These two specimens agree very well with Saussure's description of *consors* and the writer thinks that they will probably prove to be the same species. Because so little material could be examined, further collecting and study should prove or disprove the above conclusion. If the writer is justified in the above statement then the name *amoena* should fall and *consors* take its place. The specimens in the Philadelphia collection have been placed under the name *consors*. The writer does not know who is responsible for this.

Scolia cubensis. New species.

Type, a female from Cuba now in the collection of the American Entomological Society at Philadelphia, and the only specimen I have seen.

The specimen measures twenty-three mm. in length.

The body color is dark brown, almost nigro-ferruginous. The wings are uniformly brownish-fuliginous with metallic reflections blue at some angles, purplish at others. The nervures are brown. The specimen as a whole has a glistening appearance and is remarkably free from punctures or hairs. Most of the hairs present are deep red brown, and the punctures are shallow.

The head is more triangular than those of the other species of this subfamily and the eyes are comparatively much smaller. In other species they extend from very close to the base of the mandibles to quite near the top of the head: here they start well up from the base of the mandibles and reach only about 2-3 of the distance to the top of the head. Viewed from the side they take up only about one-third of the usual space.

The anterior lateral margins of the clypeus are set with short bristle-like yellow hair arising from an area which is obscurely yellow. The outside of the antenna beyond the third segment is quite ferruginous and the prothorax in front is rather thickly punctured and covered with long brownish hairs. The rest of the body except the venter of prothorax, pronotum, ridge of the mesopleuron, legs, and front face of the dorsum of the first segment of the abdomen is remarkably free from punctures and hairs, the top of the head, centre of the mesonotum and the central portion of the scutellum and postscutellum being particularly free. The abdomen as a whole has a slender appearance being narrow and long. At the point where the second segment of the abdomen beneath bends abruptly upward to meet the first segment and on either side of the mid line of the body there is a slight tubercular tendency. The larger spine at the end of the hind tibia is a great deal less than half the length of the first tarsal joint.

The writer has seen no other specimen like the above and no description that he has been able to find agrees with it. He has therefore described the form as a new species. He believes that when the male is studied it will be found to have distinct rounded tubercles on the ventral surface of the second abdominal segment where the segment bends upward to meet the first. This last is because of the slight tubercular tendency spoken of above in the female studied and in all species observed by the writer having these tubercles the male always has them well developed, the females only slightly or not at all.

Scolia dubia dubia Say.

Scolia dubia. Say, Boston Jour. Nat. Hist., I, p. 4, 1837, p. 364, n. 2.

The type of this species is not in existence.

Say has recorded the length of the species as four-fifths of an inch. Saussure and Sichel record the females as 22 to 25 mm. and the males as 15 to 23 mm. in length. The length of the specimens that the writer has had the opportunity to personally examine vary in the female from 15 to 22 mm. in length and the males from 13 to 19 mm.

Except for slight variations, the body of this species is black to the end of the second segment of the abdomen and the rest of the abdomen is reddish brown. The third segment of the abdomen has on each side of its dorsal surface, an ovate yellow spot. The wings are uniformly fuliginous, with metallic reflections, blue at some angles, delicately purple at others. The nervures are black.

The typical examples of this species are described by Say in the Boston Journal of Natural History, Vol. I, page 363. The body is black; head and thorax immaculate; wings dark violet blue; cubital cells two, with no appearance of more than one recurrent nervure; abdomen, first and second segments black; remaining segments ferruginous, more hairy than the others; the third segment, however, more or less tinged with blackish and with two transversely oval, a little oblique, bright yellow spots.

The specimens that the writer has personally examined agree quite well with the above description except that there is a strong tendency for variation in three directions. In one direction the specimens have the first two segments quite ferruginous. In another the whole abdomen is very black, only the edges of the segments beyond the second being ferruginous. In the other specimen the yellow spots gradually diminish until they entirely disappear. Smith in his Catalogue of Hymenopterous Insects of the British Museum describes a variety in which the yellow spots are obsolete. It is probable that this form without spots is the one that has been described by Burmeister as a separate species hæmatodes. The writer thinks that this form should be regarded as a subspecies of dubia. This would cause the name dubia to become Scolia dubia dubia; and hæmatodes, Scolia dubia hæmatodes.

Saussure and Sichel have recorded this species as found in North America; Carolina, Louisiana, Maryland, Tennessee, and Mexico. The writer has seen specimens from Mexico, Texas, Arizona, Georgia, Carolina, Virginia, Maryland, New York, and Massachusetts. Probably this species does not exist farther north than the last named state.

The Insect Book by L. O. Howard, plate I, fig. 7, gives a cut of this species.

Scolia dubia hæmatodes Burmeister.

Scolia hæmatodes Burm., Abh. naturf. ges. Halle, I., p. 4, 1853, p. 33, n. 49. ♀ ♂

The location of the type is unknown to the writer.

Burmeister describes the species as follows: Black, hairy, abdominal segments 3 to 6 rufous, wings nigro-cyanis. The length 7 to 8—^{111}♂+ ♀—Mexico.

This insect looks like and is colored and haired like Scolia dubia except that the two yellow spots on the third abdominal segment are wanting. As a whole, it is much smaller than dubia.

The writer has seen a large number of specimens that agree with this description except that one male specimen he has before him, has the sclerites of the abdomen black or slightly ferruginous and only the hairs

which clothe those segments from the second back are rufous. The venter of the second abdominal segment is usually rufous except in the darker specimens.

The length of the female ranges between 15 and 22 mm. and the males between 10 and 18 mm.

This species is fully accounted for under the variations in the description of *Scolia dubia dubia*, which see for further information on the subject.

The specimens I have seen were taken in Mexico, Texas, California, and Arizona.

Scolia flavocostalis Cresson.

? Scolia tricincta Say West. Quart. Reporter, II, 1823, p. 74.
Scolia flavocostalis. Cress., Trans. Amer. Ent. Soc., I, 1868, p. 377, no. 6, ♂

The type is in the collection of the American Entomological Society at Philadelphia.

Cresson describes the species as follows:

"*Scolia* (*Discolia*) *flavocostalis*, n. sp.

"Male.—Black, deeply and rather closely punctured, clothed with long, golden pubescence; a spot on the anterior orbits, below the emargination of the eyes, and a narrow line on lower half of posterior orbits, yellow; mandibles bright fulvous, black at tips; antennæ entirely black, robust; a spot on each side of prothorax anteriorly and another on postscutellum, yellow; scutellum with large, scattered punctures; tegulæ fulvous; wings hyaline, with an opaline reflection, costa broadly yellow to the tip of marginal cell, beyond which it is violaceous-black; anterior wing with two submarginal cells, the second receiving one recurrent nervure; legs rufo-ferruginous, clothed with yellowish hair, most of coxæ black; abdomen black, clothed with yellowish hair, especially dense on the apical margins of the segments, apex of the three basal segments more or less ferruginous; on each side of second and third segments above a yellow ovate spot, large and transverse on the third segment; fourth segment with a narrow, apical, yellow band, interrupted in the middle, and dilated laterally; apex with three short spines; venter blackish, most of the second segment ferruginous. Length 4½ lines.

"One male specimen. This may be the male of *S. Lewisii*. It is, however, much smaller."

Besides the type in the American Entomological Society's collection at Philadelphia, the writer has studied several specimens and has several before him, three of which closely agree with the description except that one has two large ferruginous spots on the dorsum of the first abdominal segment, one has a broad ferruginous band on the posterior part of the above segment and the fifth and sixth segments have an apical band of yellow, and the third has a narrow interrupted band of yellow on the fifth abdominal segment. The other specimens that have been studied

vary somewhat in the amount of yellow and ferruginous color present, especcially on the abdomen where the spots gradually enlarge to become bands, and the bands on the posterior segments are much broader. The dorsum of the median segment and the first and second segments of the abdomen gradually become ferruginous until they are practically all of that color. The writer thinks that perhaps this variation which is possibly in the direction of either *ridingsii* or *lecontei*, indicates the relationship of the three species, especially as all the specimens of *flavocostalis* seen were males. It is probable that more material will throw light on this subject.

The above specimens are all males all taken in New Mexico, except one from Texas and one from Kansas. They measure between 10 and 15 mm. in length.

Four other specimens have been studied, a female and three males, which starting with the more typical *flavocostalis*, vary toward a blacker body color and a reduction of yellow. One specimen has the body black except for a slight tendency toward ferruginous on the venter of the abdomen. The coxæ, trochanters and a small part of the femur next to the body are black. The tarsi and tarsal claws are dark ferruginous. The dorsum of the fourth segment of the abdomen has two yellow spots and the fifth segment has an obscure, interrupted, apical yellow band. One specimen has no yellow mark behind the eyes and no yellow on the fifth abdominal segment, with the body color practically all black except a slight tendency to ferruginous at the edges of the sclerites. Much more of the femur is black than in the other specimen. The female specimen has the mandibles except the tips, an obscure streak behind the eyes, the dorsum of the prothorax and the dorsum of the first abdominal segment ferruginous. The legs are nearly all ferruginous with a blackish tendency on the basal segments. The dorsum of the second and third abdominal segments have spots and the fourth and fifth have narrow yellow apical bands. The head in the above specimens except for the slight yellow marks spoken of, is all black.

These four specimens were all collected in Texas. The female measures about 11 mm., the males 9 to 11 mm. in length.

Some of the last described specimens came very near to Say's *tricincta* (Western Quarterly Reporter Cincinnati, II, 1823, p. 74, n. 2), and the writer does not agree with Cresson in placing *tricincta* under *nobilitata* but thinks further studies will probably place it somewhere in the above range. If this is correct, then *flavocostalis* will ultimately fall as a synonym of *tricincta* or become a subspecies of it.

Scolia fulviventris. New species.

This species is described from a type and five paratypes, all females; the type and two paratypes are in the collection of the American Entomological Society at Philadelphia, two paratypes in the collection of the Museum of the Brooklyn Institute and one in the collection of the Massachusetts Agricultural College.

The specimens range between eleven and fifteen mm. in length.

The ground color of the species is black with yellow markings. The wings are dark fuliginous with a darker area running along the costal border from near the end of the costal cell to the tip of the wing, and give off metallic reflections, blue at some angles, purplish at others. Most of the dorsum of the abdomen is yellow and its whole venter is ferruginous.

The head is black except a ferruginous, almost yellow spot just below the emargination of the eyes, a yellow streak behind the eyes and the middle of the anterior margin of the clypeus, which is ferruginous. It is quite thickly covered with yellowish white hairs especially thick and long in the area between the bases of the antennæ and the anterior ocellus and on the occiput. The mandibles are ferruginous, more or less streaked with black. The antennæ are black, the three basal segments glistening.

The thorax is black except two large triangular marks on the pronotum running nearly back to the tegulæ and a band covering the entire central portion of the postscutellum which are yellow. The dorsum of the mesothorax is covered with short yellow hairs, the rest of the thorax with short grey hairs. The tegulæ are black ferruginous. The legs to the end of the femur are black ferruginous, the tibia and tarsus becoming lighter. The larger spines are light ferruginous and the smaller ones yellowish. The tarsal claws are ferruginous, blackish at the tips. All of the legs are covered with rather long yellowish white hairs and the large spine at the end of the hind tibia is nearly one-half the length of the first tarsal segment.

The first two segments of the abdomen are black above, with two small yellow spots on the first and two large confluent spots on the second. The third, fourth and fifth segments above are yellow, narrowly margined with ferruginous, the yellow band on the third being slightly constricted in the middle. The sixth segment above and the venter are entirely ferruginous. All the segments are covered with short, and their edges fringed with long yellow hairs, paler beneath.

The paratypes differ from the above type in one or more of the following features. The ferruginous on the clypeus and along the inner margins of the eye varies greatly in amount. The pronotal yellow spots differ much in size. There may be a pair of ferruginous or yellowish spots on the median portion of the scutellum. The first abdominal segment above may be more or less tinged with ferruginous or may be black and without spots in either case. The spots on the second segment may not be confluent and the band on the third may be practically transformed into two spots. The distribution of ferruginous on the legs varies, sometimes extending well upward toward the body.

All the specimens were collected in Arizona.

The writer thinks that perhaps these insects may ultimately prove to be the females of *otomita*: See statement under *otomita*.

Scolia fuscipennis. New species.

Type and paratype in the United States Museum at Washington, D. C.

This species was described from two male specimens taken at Cordoba, V. C., Mexico; the type Jan. 16, and the paratype Feb. 8, 1908, by Fred K. Knab.

Type number 15092, U. S. Nat. Mus.

The ground color of this species is jet black with yellow markings on the thorax and abdomen. The wings are dark fuliginous, distinctly glossy brown, without color reflections and have a darker area along the costal cells. A light streak runs downward and backward from the end of the costal cell across the first cubital. The nervures are dark brown or black.

The head is black, deeply and rather closely punctured and is well covered with brownish hairs. The mandibles are dark ferruginous. The antennæ are black with scape and pedicle glistening, their remainder dull. Behind the eye in the type is a faint yellow spot absent in the paratype.

The thorax is black except two large marks on the pronotum running back to the tegulæ, a large mark on the upper part of the mesopleuron, two narrow longitudinal lines behind the middle of the dorsum of the mesothorax, the entire central portion of the scutellum, the elevated portion of the postscutellum slightly separated from the scutellar spot in front by a black narrow band, large marks on the lateral lobes and a small mark on the central part of the median segment above, are yellow. It is deeply and closely punctured and thickly clothed with dark

or black hairs except those which arise from the yellow spots which are pale, almost white. The legs are black, covered with black hairs and spines except the large spine belonging to the cleaning apparatus at the end of the fore femur which is ferruginous and the small pad at its base which is yellowish. The fore tarsi have a somewhat ferruginous tinge. The longer spine at the end of the hind tibia is about one-half the length of the first tarsal segment.

The abdomen is black except a broad yellow band on the dorsum of the first segment, which in the paratype is evidently a pair of confluent spots. There are also two large spots on the dorsum of the second and third, two small spots toward the sides of the fourth and two large spots on the venter of the second segment which are yellow. The abdomen is quite closely punctured and is well covered with black hairs except on the spots where they are pale. At the point where the second ventral segment bends abruptly upward to meet the first and on either side of the midline of the body are two bluntly rounded tubercles.

The paratype has no yellow marks on the mesopleuron, dorsum of the mesothorax, scutellum and middle part of the median segment and the pronotal spots are much smaller.

The length varies from 18 to 20 mm. and the body is rather slender.

Scolia guttata guttata Burm.

Scolia guttata. Burm., Naturf. Ges. Halle, I, p. 4, 1853, p. 36, n. 57, ♀
Scolia (Discolia) hecate. *W. F. Kirby*, Trans. Ent. Soc. London, 1889, p. 449, ♀ ♂ T 15 F 4.

The location of the type is unknown to the writer.

Saussure and Sichel have recorded size for this species as follows: females 22 to 35 mm. long and males 15 to 28 mm. long. Specimens that the writer has personally examined vary in length. The females range from 21 to 28 mm. in length and the males from 15 to 23 mm. in length.

The body of this species is black except for yellow markings, varying in number and size on different individuals. The wings are uniformly fuliginous with metallic reflections, blue at some angles, purplish at others. The nervures are black in some specimens and ferruginous in others. This species is one of the largest of this subfamily.

The typical examples of this species are described by Burmeister as having a round golden spot on each side of the second and third segments with small round golden spots on the underside of the fourth segment. There is considerable variation from this however, as is stated by Cameron in the Biologia. He says that this is a very variable

species not only in size but in coloration. He describes several specimens showing a gradation in variation from yellow markings on the clypeus, pronotum, mesopleura, scutellum, postscutellum, first, second, third, fourth and last abdominal segments to two specimens which had no yellow at all. He says the most common form is the one with the maximum yellow upon it and that the male examples do not show much variation. They have either two yellow marks on the first and second abdominal segments or two on the second segment only.

The specimens that the writer has personally examined agree quite well with Burmeister's typical description except that the yellow markings on the fourth abdominal segment would hardly be regarded as being on the under side of the segment though well down on the side. At the point where the second segment of the abdomen bends abruptly upward to meet the first ventral segment and on either side of the midline of the body are two bluntly rounded tubercles quite large in some specimens especially in the males, smaller and almost disappearing in the females.

Between this species and *azteca* the writer has been able to find no structural difference and it is his opinion that the two forms can be separated only by the color, *azteca* being entirely black and *guttata* as described above. This color distinction has been easily drawn in all the specimens observed and so the writer has chosen to consider the above as two forms, with *azteca* a subspecies of *guttata*. This causes the name *Scolia guttata* to be changed to *Scolia guttata guttata* and *Scolia azteca* to *Scolia guttata azteca*.

Saussure and Sichel have recorded this species from Mexico.

The specimens that the writer has seen came from the plains of Mexico and from the southern part of Texas.

Scolia guttata azteca Sauss.

Scolia azteca Sauss., Rev. et Mag. Zool, (2), (IX), 1857, p. 281.

Location of the type unknown to the writer.

Saussure records the length of the species as 27 mm. The length of the specimens that the writer has had the opportunity to examine varies in the female from 18 mm. to 29 mm. The males measure about 20 mm.

The color of this species is deep black. The wings are uniformly fuliginous throughout with metallic reflections, blue at some angles, purplish at others and greenish at still others. It is one of the larger species of the group.

The typical examples are described by Saussure as follows: The female on the average of a deep black, shining, with black hair. Head and thorax very finely punctured; the metathorax deeper than the rest, abdomen irregularly punctured, wings deep black with bluish or steely reflections. The nervures are black. Males are very densely punctured.

The specimens that the writer has studied agree with this description except that the wings held at some angles have a greenish reflection as well as the bluish and purplish reflections spoken of above. At the point where the second ventral segment of the abdomen bends abruptly upward to meet the first ventral segment and on either side of the midline on the body is a bluntly rounded tubercle quite large in some specimens especially in the male, smaller and almost disappearing in some of the females.

Saussure and Sichel in their catalogue give the habitat of the species as Mexico. All specimens that the writer has seen came from Mexico.

So far as structure goes the writer has been unable to separate this species from *guttata* Burmeister. He is of the opinion that aside from the color they cannot be separated and for this reason he would consider this form a subspecies of *guttata*. See what already has been said on this subject under *guttata*.

Scolia inconstans Cresson.

Scolia inconstans Cress., Proc. Ent. Soc. Phila., IV, 1865, p. 446, No. 2.

The type is in the collection of the American Entomological Society at Philadelphia.

Cresson describes the species as follows:

Scolia inconstans, n. sp.

"Obscure ferruginous; head, antennæ and most of thorax blackish; sides of prothorax with a large luteous spot; third segment of abdomen with a yellow spot; wings subhyaline, the costa yellowish, with a dark streak beyond the marginal cell.

"Male.—Head black, with yellowish pubescence; the orbits, more or less interrupted, yellowish; anterior margin of the clypeus, and the mandibles, except tips, luteous; antennæ nearly as long as the head and thorax, dull black, somewhat brownish beneath. Thorax blackish, with rather dense, prostrate, yellowish pubescence, and close, rather deep punctures; on each side of the prothorax a large luteous spot; lateral margins of the mesothorax obscure testaceous; pleura sometimes with a ferruginous stain; postscutellum luteous, and sometimes the scutellum is tinged with the same color; metathorax black, sometimes rufo-piceous, on each side a large rufous or ferruginous spot or stain,

the posterior face abruptly truncate and somewhat concave; tegulæ ferruginous. Wings hyaline, slightly dusky on the broad apical margins, and with a slight violaceous reflection; the costa yellowish, especially about the marginal and submarginal cells, and beyond the former a blackish streak extending to the tip of the wing; nervures fuscous. Legs ferruginous, with yellowish pubescence. Abdomen obscure ferruginous, punctured, shining, iridescent, clothed with yellowish pubescence, more dense on the apical margins of the segments; basal segment rounded at base and more closely punctured than the following segments, the apical margin slightly contracted; third segment with a large, transverse, yellow macula on each side, and the apex, of the fourth segment is narrowly margined with yellowish; in one specimen the spots on the third segment are very large, while the two basal segments have a small obsolete, luteous stain on each side at base, and the fourth segment has an angular yellow mark on each side; the base of the third, fourth, and fifth segments are sometimes more or less blackish; the apical segment is armed at tip with three long acute spines, the central one the longest; ventral segments ferruginous, with their base more or less blackish. Length 6—6¼ lines; expanse of wings 11—11½ lines.

"Two specimens. This species has some resemblance to S. dubia Say, in the markings of the third abdominal segment, but is otherwise very distinct."

There are two specimens in the collection at Philadelphia both marked types. The writer has examined both and has one before him marked type number 568–2 which varies a little from the above description. The yellow mark in front of the eyes starts well within the emargination, is quite broad and extends downward along the lower lobe of the eye. There is a narrow yellow streak behind the eyes. The antennæ are slightly ferruginous beneath. The body color of the thorax is black but all the sclerites have a marked tendency to be tinged with ferruginous. The pronotum has two large triangular spots which are joined together in front by a narrow darker band and extend back to the tegulæ. The postscutellum has a broad yellow band and the tegulæ are light ferruginous almost flavous. The median or last segment of the thorax, has a ferruginous spot on the dorsal surface of each side lobe and on its central part a slight tinge of the same color. The wings are subhyaline with a stained area along the costal border. The costal, end of the media, stigmal, first cubital and radial cells with a small portion just beyond the radial are light yellow and covered with short yellow hair. The area from just beyond the radial to near the end of the wings is slightly smoky and gives a light purplish metallic reflection at some angles. The nervures are light ferruginous or flavous. The base of each segment of the abdomen has a black band and there

are two large transverse oval spots on the third with a narrow line at the end of the fourth segment which are yellow. All the rest of the abdomen is ferruginous. The length of this specimen is about 12 mm.

The two specimens that the above description was written from were collected in Colorado. The writer has seen no other specimens like these in the Philadelphia collection, although he has seen several collections from that or adjacent territory. It is the writer's opinion that further collections from Colorado would throw much needed light on the identity of this species.

Scolia lecontei Cresson.

Scolia lecontei Cress., Trans. Am. Ent. Soc., I, 1868, p. 376, n. 5 ♀.

Type in the collection of the American Entomological Society at Philadelphia.

Cresson describes this species as follows:

Scolia (*Discolia*) *Lecontei*, n. sp.

"Female.—Head black, sparsely punctured, a large rufous spot on the front, extending from the lower ocellus to and including the space between the antennæ, and also the emargination of the eyes; posterior orbits, clypeus and mandibles, except tips, rufous; occiput clothed with a dense golden pubescence; antennæ short, robust, black, scape dull rufous; thorax with deep, rather close punctures; prothorax, except its anterior middle, extreme lateral margin of mesothorax, tegulæ and scutellum rufous, the latter flat, with a few scattering, deep punctures; postscutellum bright yellow; rest of thorax black, sparsely clothed with golden pubescence, more dense on prothorax in front, and on metathorax, the prominent, lateral lobes of the latter with an obscure rufous spot; wings fusco-hyaline, strongly tinged with yellowish, especially along the costa to the tip of the marginal cell, beyond which it is violaceous-black; both wings have a beautiful purple reflection, especially towards the apical margin; anterior wing with two submarginal cells, the second receiving one recurrent nervure; legs rufo-ferruginous, clothed with yellowish hair, most of coxæ black; abdomen rufo-ferruginous, sparsely punctured, shining, second to fifth segments above stained more or less with blackish, second and third segments above with a large, ovate, bright yellow spot on each side, nearly meeting on the disk, those on the third segment more transverse and regular; fourth segment with a transverse yellow band at tip; fifth segment with a subobsolete, narrow yellowish stripe near the tip, sub-interrupted in the middle; apical margins of all the segments with a dense, rather long fringe of yellowish hairs; venter dull ferruginous, the third segment black at base. Length 6 lines.

"One female specimen. At first sight this species has much the appearance of *Elis Xantiana* Sauss."

The writer has one specimen before him which agrees very closely with the above description except for an obsolete yellow spot behind the eyes. Study has been made of other specimens that vary somewhat from the above. Two of these have no yellow marks on the fourth and fifth segments of the abdomen and the whole insect has a dark rufous to blackish appearance, showing a tendency to vary toward a loss of yellow and ferruginous on the abdomen especially and has a general darker appearance as a whole. Probably these forms stand somewhere between the typical *lecontei* and Say's *tricincta*.

The writer has seen several other specimens which show a gradual increase in the yellow and ferruginous from the type to a specimen which has the yellow mark behind the eyes and the spots on the prothorax much larger while the spots on the second segment are very large, those on the third have become a broad band and there are two wide bands on the fourth and fifth. Possibly this variation of increasing yellow and ferruginous is in the direction of *ridingsii*.

The specimens that the writer has seen are all females measuring from 12 to 15 mm. in length and were all collected in Texas except one which was taken in New Mexico.

No one specimen has all the marks spoken of at their extreme development as indicated. The head of this species has the occiput quite black and this color encroaches downward upon the upper part of the frons. The rest of the face is ferruginous.

It is probable that further collection will throw much needed light on the relation of *ridingsii*, *lecontei*, *tricincta*, and *flavocostalis*, which seem in many respects to be closely allied.

Scolia monticola Cameron.

Scolia monticola CAMERON, Biol. Centr. Amer., P. 112, 1873, Hymen. II. p. 223, n. 3, ♀ ♂.

The type is probably in the British Museum.

Cameron describes the species as follows: "Deep black, shining; the head and thorax densely covered with short, thick, black pubescence; the back of the abdomen densely covered with short, the ventral surface with long, black hairs. The head covered with large, distinctly separate punctures; the mesonotum and scutellum coarsely and strongly punctured, somewhat smaller than those on the mesonotum. Abdomen closely and finely punctured; the hair on the apical segments above long, black and thick. Legs deep black, the spines and hair also black. Wings deep violaceous-blue. The male is similarly colored and clothed, the antennæ in this sex bearing a close microscopic greyish pile, which gives them a paleish appearance. Size of the female 18 to 20 mm., of male 15 to 18 mm."

At the end of the above description Cameron says: "It is obvious that the insect is nearly related to *Scolia azteca;* the latter, however, differs from *Scolia monticola* in having" (from this point to the end of the paragraph is a translation) an obtuse median tubercle at the base of the second ventral segment which is subtruncate. In the female this tubercle is minute almost disappearing. In the male it is larger, somewhat broader transversely emarginate in the middle and subcarinate on either side.

The writer has but two specimens which he could consider as this species. They measure about 13 mm. in length and agree well with the above description. The point of difference in the presence or absence of the tubercle on the venter of the second abdominal segment is borne out. These specimens do not have it. The whole specimen is black and the body except the front of the head is thickly punctured and haired. A part of the frons starting just below the bases of the antennæ and continuing upward between them, then gradually widening to a straight transverse line which if continued would intercept the eyes at the upper edges of their emarginations, is raised above the rest of the face enough to allow for the insertion of the antennæ in its sides instead of in the usual depressed space. The part of this raised portion posterior to the bases of the antennæ is closely and deeply punctured. The rest of the face is sparsely indented with rather deep punctures. Starting at a point just posterior to the larger ocellus a continuous ridge passes downward and outward across the frons to a point within the emargination of the eyes. The wings are fuliginous with a darker area along the costal border, and they have conspicuous metallic reflections, blue at some angles, green at some and bright purple at others with perhaps a slight tendency toward magenta in places.

This species is easily distinguished from others in this subfamily by the peculiar elevation of the portion of the frons spoken of above. This is not referred to by Cameron and therefore possibly the insect here described is not *monticola*. If it should prove not to be *monticola* it may be given the name *nigrescens*.

The two specimens are now in the American Museum at New York City. Locality unknown. They agree quite closely with a specimen in the American Entomological Society collection at Philadelphia marked *nigrescens* type, undoubtedly a manuscript name. More material should throw needed light on this species.

Scolia nobilitata Fabricius.

Scolia nobilitata FABRICIUS, Systema Piezatorum, 1804, p. 244, n. 32.

Smith in his catalogue of the British Hymenoptera, page 206, records a Fabrician specimen in the Museum of the Linnaean Society of London.

Burmeister has recorded size for this species as 5 to 8 lines. The length of the specimens that the writer has had the opportunity to examine vary in the female from 12 to 16 mm., in the males from 8 to 12 mm.

In comparison with the group as a whole this is a small species. The body is black and there are always four yellow spots on the abdomen, the second and third segments each having two. In a large number of cases there is a ferruginous tinge to the abdomen and the yellow markings on the body are encroached upon by this coloring. The wings are uniformly fuliginous with violet reflections at some angles, blue at others. The nervures vary from dark ferruginous to quite black.

Fabricius described the type as hairy and black, with two yellow spots on the prothorax and the scutellum yellow, base of the abdomen ferruginous and bearing four yellow spots.

Head black, antennæ cylindrical, thorax globose, black, prothorax has two yellow spots, postscutellum yellow. Abdomen hairy and black, the three basal segments obscurely brick red. Segments two and three each with two yellow spots. Legs ferruginous, femora black.

The Insect Book by L. O. Howard (plate I, fig. 2) gives a good cut of a female of this species.

The specimens that the writer has examined agree quite well with Fabricius' description and also with the illustration given by Howard, except for slight variations. The average female has a black head except for the mandibles and the underside of the antennæ. The mandibles are ferruginous, becoming almost black toward their tips and the antennæ though mainly black have a ferruginous tinge, particularly beneath.

The thorax is black except for two yellow triangular spots on the pronotum, a large yellow mark on the postscutellum and the tegulæ which are ferruginous. Coxæ and trochanters black, femora partly black, partly ferruginous and the remaining portions of the legs ferruginous except the tips of the claws which are black, spines ferruginous. Wings uniformly fuliginous, with blue and violet reflections. The ground color of the abdomen is black but there is a tinge of ferruginous especially in the first three segments, more generally present in the first.

The second and third segments have on each side of their dorsal surface a large oval yellow spot.

The writer has seen several specimens which varied from the above in that although the ground color of the body was black, a great part of the head, edges of the sclerites of the thorax, scutellum, dorsal part of the median segment, nearly all of the legs and the dorsum of the first segment of the abdomen were ferruginous while the rest of the abdomen was deeply tinged with the same color. A few specimens had two small yellow spots on the first segment of the abdomen and a yellow streak behind the eyes. The above description with the same variations will apply to the male. The writer has also seen a male with two small yellow marks on the fourth segment of the abdomen. The antennæ of the male are entirely black. The variety *maculata* Guerin, of this species the writer has been unable to recognize in the material available.

Fabricius records this insect from Carolina, Burmeister from North America. The writer has seen specimens from Florida, Georgia, North Carolina, Pennsylvania, Virginia, Texas, Long Island, N. Y., and Arizona.

Scolia otomita Saussure.

Scolia otomita Sauss. Am. Soc. Ent. France, (3), VI, 1858, p. 223, No. 35 ♂.

The location of the type is unknown to the writer.

Saussure and Sichel describe the species in their catalogue. The following is a translation of the description:

Male.—Small, black, greyish haired, abdominal segments three to five with yellow fascia. Length 12½ mm.; wings, 10 mm.

Small, black, densely punctured, covered with grey hair. A small yellowish silvery spot on each side of the face outside of the clypeus. Two yellow spots on the prothorax and postscutellum yellow. The tegulæ are brown, segments three, four, and five of the abdomen bear a yellow band which is margined only at the fifth. The smaller margins of the segments brown. All the segments of the abdomen strongly ciliated with tawny yellow hair. The end of the abdomen brown. Legs black, clothed with grey hairs. Tibial spines ferruginous. Wings transparent, nervures brown, radial cell subtriangular, large and truncate. Habitat Mexico.

The writer has seen but one specimen, a male, which he could consider as this species. This specimen measures 13 mm. in length. Its ground color is black. The wings are fusco-hyaline, a much darker portion extending from within the end of the median cell along the costal border almost to the tip of the wing; metallic reflections are present, blue at some angles, purplish at others. The nervures are

black. The head is black except a narrow streak extending downward from the emargination of the eyes along the edge of their lower lobes and a narrow line behind the eyes which are yellow. The mandibles except their edges and tips are ferruginous. The antennæ are black, tinged with ferruginous beneath. The thorax is black except two triangular yellow marks on the pronotum and a transverse yellow band on the postscutellum. The legs are black with a very faint ferruginous tinge and their spines are ferruginous. The first and second segments of the abdomen are black or ferruginous black and the venter of second is slightly tinged with ferruginous. The dorsum of each of the other segments of the abdomen is yellow, their margins ferruginous-brown except the last which is nearly all of this color. The undersides of the last named segments are ferruginous-brown, faintly mottled with yellow. The edges of the segments behind the first are fringed with greyish yellow hairs, with the remainder of the body and legs sparsely clothed with grey hairs except on the clypeus where they are yellowish ferruginous.

The above description was made from a specimen now in the collection of the American Entomological Society at Philadelphia. It was taken in Nevada.

It may be unsafe to draw any conclusions from the study of a single specimen. The writer is of the opinion however that the specimen here described though differing in a few minor details, is *Scolia otimita* Saussure, and that the females described as *Scolia fulviventris* will ultimately prove to be the females of this species.

Scolia ridingsii Cresson.

Scolia ridingsii. Cress., Proc. Ent. Soc. Phila., IV, 1865, p. 445, No. 1 ♀.

The type is in the collection of the American Entomological Society at Philadelphia.

Cresson describes the species as follows:

"*Scolia ridingsii*, n. sp.

"Ferruginous; sides of prothorax, scutellums, and a large spot on each side of four basal segments of abdomen above, luteous; wings deep yellow, the apical margins broadly fuliginous with a beautiful violaceous reflection, and a dark cloud beyond the marginal cell.

"Female.—Ferruginous, clothed with fulvous or golden-yellow pubescence, closely and rather deeply punctured; the sinus of the eyes and the outer orbits, sometimes luteous, and in one specimen extending entirely across the occiput; mandibles piceous at tips; antennæ piceous, the two or three basal joints ferruginous. Thorax: sides of the prothorax, a spot on the pleura, scutellum and postscutellum, and a spot on each side of the metathorax, sometimes much reduced, luteous; the

scutellums with large, deep, scattered punctures; metathorax short, broad, more finely punctured than the rest of the thorax, abruptly truncate and somewhat concave behind. Wings: the superior pair deep yellowish-hyaline, the apical margin broadly fuliginous with a beautiful violaceous reflection; beyond the marginal cell a broad blackish cloud extending to the tip of the wing; nervures honey-yellow; posterior wings fuliginous, with a purplish reflection, the base subhyaline. Legs ferruginous, with golden-yellow pubescence, the tibiæ tuberculate above, the tarsi spinose. Abdomen sparsely punctured, faintly iridescent; on each side of the four basal segments above, a rounded luteous spot; sometimes slightly confluent; the spots on the first and fourth segments smallest, and when confluent, they form a rather broad transverse band; those on the second and third segments are large, the former round and the latter rather transverse; all the segments densely fringed with fulvous pubescence; the apical segment densely clothed with dense, prostrate, fulvous pubescence; venter paler ferruginous, the second and third segments obsoletely stained with obscure luteous, the basal segments deeply contracted. Length 8 lines; expanse of wings 13½ lines.

Two specimens."

The writer has before him three specimens, one marked type 565–2 and has carefully studied four other specimens at Philadelphia, all females. These agree well with the description except the marking described as luteous which the writer would prefer to term yellow. The costal, subcostal and basal nervures of the front wings are ferruginous. The rest of the nervures except the subdiscoidal nervure which is bluish, are yellow. The parts of the fore wing not inclosed within the cells are slightly fuliginous with a much darker area reaching from near the ends of the radial and from within the submarginal, to near the tip of the wing. A streak running along the frenal fold is quite fuliginous. These last areas have metallic reflections, blue at some angles, purplish at others. The hind wings are somewhat fuliginous with slight purple metallic reflections. The end of the fifth abdominal segment has a narrow yellow band and the venter of the first segment is obsoletely stained with yellow.

The other two specimens that the writer has before him differ from the above in that the antennæ beyond the three or four basal segments are quite black above but faintly ferruginous beneath. The yellow band behind the eyes and reaching across the occiput is interrupted in the middle with ferruginous. A band along the parapsidal grooves is black and the anterior edge of the mesopluron is darker than the plate as a whole. The tips of the tarsal claws are ferruginous to black. The yellow marks on the last or median segment of the thorax are obscure in one specimen and wanting in the other.

The head in the above described forms is yellowish ferruginous.

The type specimen and four others were taken in Colorado. The other two whose differences from the type have just been described were taken in California and Lower California. They are all in the collection of the American Entomological Society at Philadelphia. These specimens measure about 15 mm.

The writer also has two specimens before him, one from the United State National Museum, collected in New Mexico and the other from Philadelphia collected in Texas, which vary from the above specimens toward *lecontei*, but standing closer to *ridingsii* than to the other. They vary from *ridingsii* in having the part of the head behind the emargination of the eyes and a large part of the thorax quite black. The specimen at Philadelphia has two yellow spots on the pronotum nearly obsolete and the three spots on the dorsum of the median segment are ferruginous. The dorsum of the second segment of the abdomen has very small round black spots on its sides and the anterior edges of the third and fourth segments are very dark, almost black. The abdomen of the specimen from the United States National Museum has only the small black spots on the sides of the second segment of the abdomen above.

The writer thinks that perhaps further collecting in the above territory may result in uniting *ridingsii* and *lecontei*.

Scolia vintschgaui Dalle Torre.

Scolia saussurei CAMERON, Biol. Cent. Amer., p. 112, 1893, Hymen. II, p. 226, n. 10 ♀; Pl. 12, f. 9.

Scolia vintschgaui Dalla Torre, Cat. Hym., VIII, 1897, p. 187, (new name).

The type is probably in the British Museum.

A good figure of this species is given in Cameron's Biologia Centrali-Americana, plate 12, fig. 9. The name *saussurei* used by Cameron, according to the rules of the International Zoological Congress will have to give way to *vintschgaui* because *saussurei* had been already used in 1864 by Saussure and Sichel for an African species of *Scolia*.

Cameron describes the species as follows:

"Black, hairy, two spots on the pronotum and the postscutellum yellow, abdomen bifasciate with yellow, prothorax reddish haired, wings smoky. Length of female, 14 mm.

"Head coarsely punctured; the front ocellus in a deep round pit. Mesonotum coarsely and strongly punctured all over; scutellum punctures larger and more widely separated. Median segment, mid portion finely, lateral portions strongly, punctured. Head and thorax covered

with fulvous hair, that on the median segment being longer and paler. Yellow marks on the pronotum somewhat triangular. Abdomen above covered with long fulvous hair, the fifth and six densely covered all over with fulvous golden hair; basal segments finely punctured, the segments fringed with pale golden hair, third segment for the greater part yellow, the back basal band projecting in the middle; fourth segment is yellow, except for a very black apical band. The legs are black, covered with long, pale hair; tarsal spines rufous. Wings are fusco-hyaline, the fore margin much darker, the dark band extending from the base to near the apex; the costa dark testaceous."

The writer has seen but one specimen, a female, which he could regard as this species. This specimen measures 14 mm. in length. Its ground color is black. The fore wings are fusco-hyaline with a darker streak extending from near the base of the first discoidal cell outward a short distance behind the costa and extending about halfway from the end of the radial to the apex where it gradually disappears. The area between this band and the costa has a distinct yellowish tinge. The wings have metallic reflections, blue at some angles, purple at others. The nervures are black ferruginous. Head, all black except mandibles which are partly ferruginous, antennæ entirely black, thorax all deep black except two triangular spots on the pronotum and a transverse band on the postscutellum which are yellow. Legs black, the tarsi particularly the front pair with a tendency toward ferruginous, spines light ferruginous. Abdomen black except two very small spots on the second segment, broad bands on the dorsum of the third, fourth and fifth, which are yellow. The dorsum of the last segment is black. The dorsum of the third, fourth, and fifth are narrowly margined with black, both in front and behind. The dorsal plate of the mesothorax, posterior dorsal margins of the second, third, fourth and the dorsal and ventral posterior margins of the fifth segments of the abdomen are fringed with yellow hair. The dorsal surfaces of the segments from the second segment back are covered with yellow hair. The rest of the specimen is sparsely covered with whitish hair.

The specimen was collected at Guadalajara Jal. Mexico. It is a female and is now in the collection of the American Entomological Society at Philadelphia.

This is the only specimen seen by the writer, which appears to agree with Scolia vintschgaui and this one differs slightly in distribution of color. More are needed in order to determine the amount of color variation in this species.

UNIDENTIFIED SPECIES.

I am unable to recognize the following species, which have been described as having been taken within the geographical limits covered in this paper, though I have in some cases ventured to guess at what they may be. The name given is that under which the description was published.

SCOLIA ANCEPS Saussure.

Scolia anceps SAUSS., Ann. Soc. Ent. France, (3), VI, 1858, p. 221, n. 32, ♂.

I think from Sassure's description that this species is the one that Burmeister has described as *haematodes*.

SCOLIA BIDENS.

Sphex bidens L., Syst. Nat., Ed. XII, I, 1767, p. 943. ♀ ♂ Eur. mer.; Afr. bor.; (Am. bor.).

This is a well known Old World species and as there is no recent record of its capture in America it is probably an erroneous record and may safely be omitted from the American faunal list. Saussure and Sichel in their Cat. Spec. Gen. *Scolia* say it is recorded from North America (by error?).

SCOLIA BIFASCIATA Swederus.

Sphex (*Scolia*) *bifasciata* SWEDERUS, Svensk. Vet. Akad. Handl. VII, 1787, p. 281, n. 35. New York.
Scolia bifascata GMELIN, Linne, Syst. Nat., Ed. 13, I, 5. 179a, p. 2738, n.26.

I have not seen the original description by Swederus but only that of Gmelin which I assume is a copy. From this I am unable to determine anything in regard to this species.

SCOLIA MEXICANA Saussure.

Scolia mexicana SAUSS., Ann. Soc. Ent. France, (3), VI, 1858, p. 213, n. 23, ♀. Mex.

From Saussure's description I am unable to recognize this insect, but it is probably only a variation of *Scolia guttata guttata*.

SCOLIA NOBILITATA variety MACULATA Guerin.

Scolia maculata GUERIN, Duperry, Voy. Coquille, Zool. II, p. 2, 1830, p. 255 ♀.
Scolia nobilitata var *maculata* Sauss. and Sichel, Cat. Spec. Gen. Scolia, 1864, p. 132.

I have not seen Guerin's description but Saussure and Sichel in their catalogue give what I suppose is a copy of it. From this the writer has been unable to draw any conclusions in regard to *maculata*.

GENERAL INDEX TO SCOLIINÆ.

INDEX TO SPECIES AND GENERA OF SCOLIINÆ.

INDEX TO LETTERING OF PLATES.

a	anal cell.
a_1	anal nervure.
ab	abdomen.
ap	apical cell.
b	bulb.
bn	basal nervure.
c	costal nervure.
c_1	costal cell.
cc	coxal cavities.
cl	clypeus.
cu	cubital nervure.
cu_1	first cubital or submarginal cell.
cu_2	second cubital or submarginal cell.
cu_3	third cubital or submarginal cell.
cu_4	fourth cubital or submarginal cell.
d	discoidal nervure.
d_1	first discoidal cell.
d_2	second discoidal cell.
d_3	third discoidal cell.
e	eye.
em	externo-medial nervure.
ep_3	mesothoracic episternum.
f_1	filament.
ff	frenal fold.
fh	frenal hooks.
m	radial or marginal cell.
m_1	radial or marginal nervure.
mc	median cell.
md	mandible.
mn	mesonotum.
mp	metapluron.
ms	median segment.
mt	metatergum.
n	neck.
o	ocellus.
p	parapsidal groove.
pc	anterior coxa.
ped	pedicle.
pe	prothoracic episternum.
pn	pronotum.
pt	antennal pit.
re_1	recurrent nervure.
s	spiracle of median segment.
sc	subcostal nervure.
scp	scape.
sct	scutellum.
sd	subdiscoidal nervure.
sm	submedian cell.
sp	spine.
st	sting.
t	tegulæ.
tc	first transverse cubital nervure.
tc_1	second transverse cubital nervure.
tc_2	third transverse cubital nervure.
tm	transverse medial nervure.
wc	wing cleft.

EXPLANATION OF PLATES XXII–XXIII.

The figures were drawn with the Camera Lucida.

Plate XXII.

Fig. 1. Dorsal view of the last segments of a female Scolia guttata.
Fig. 2. Ventral view of the last segments of a female Scolia guttata.
Fig. 3. Dorsal view of the last segments of a male Scolia dubia.
Fig. 4. Ventral view of the last segments of a male Scolia dubia.
Fig. 5. Antenna of a female Scolia dubia.
Fig. 6. Antenna of a male Scolia dubia.
Fig. 7. Front view of the head of a male Scolia dubia.
Fig. 8. Front view of the head of a female Scolia dubia.

Plate XXIII.

Fig. 9. Anterior wing of Triscolia fervida.
Fig. 10. Anterior wing of Scolia dubia.
The missing guide line from re_1 in this figure should lead to the nervure joining d and cu.
Fig. 11. Posterior wing of Scolia dubia.
Fig. 12. Side view of the thorax of Scolia dubia.

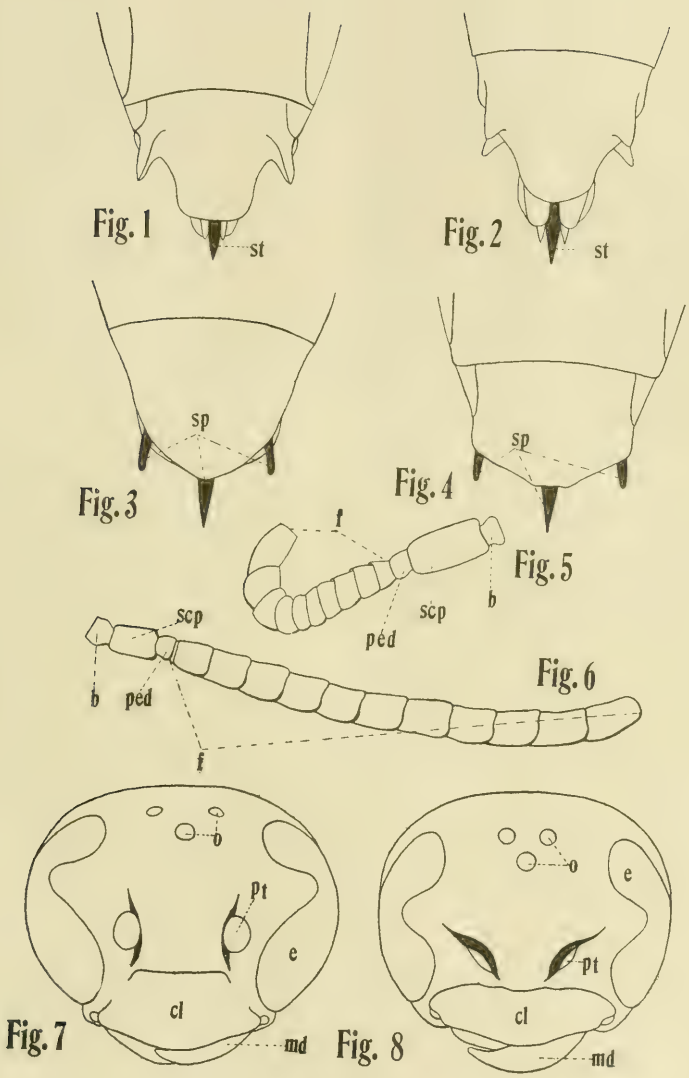
Fig. 1
st
Fig. 2
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Fig. 3
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Fig. 4
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Fig. 5
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Fig. 6
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Fig. 7
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Fig. 8
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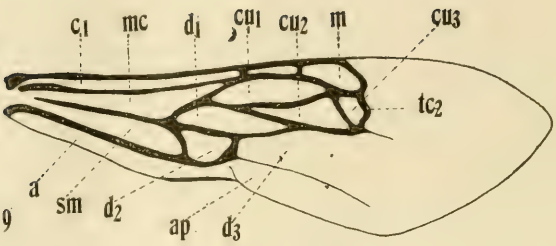

Fig. 9

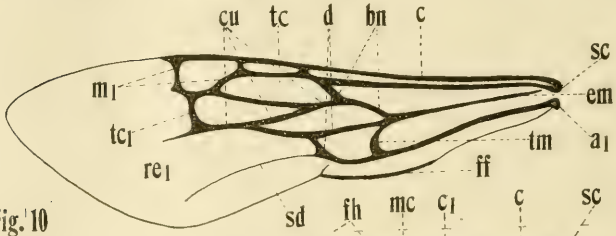

Fig. 10

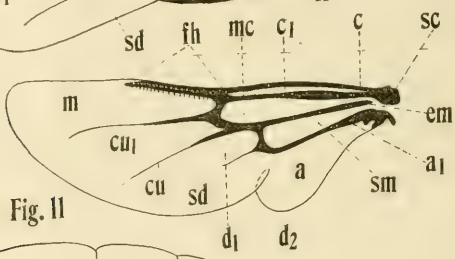

Fig. 11

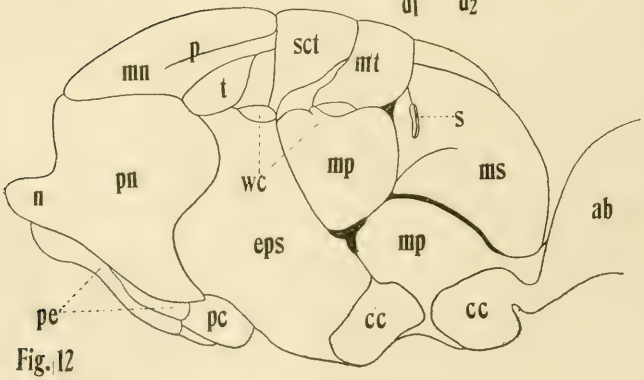

Fig. 12

O. C. Bartlett.

NEW NEOTROPICAL TIPULINÆ (TIPULIDÆ, DIPT.).

Charles P. Alexander, Ithaca, N. Y.*

The following species are included in four collections that I have had for study, received from the following sources: The American Museum of Natural History, including the Williston collection, received through Mr. J. A. Grossbeck; the Cornell University Collections consisting of Mr. H. S. Parish's extensive Brazilian material, through Dr. J. C. Bradley; the United States National Museum Collections, through Mr. Frederick Knab, and a small lot received from Staudinger-Bang-Haas and now in my cabinet. I wish to thank the above named gentlemen for the loan of this and other interesting crane-fly material.

The *Tipulini*, containing the great genera *Tipula* and *Pachyrhina*, is, in any region, in a very chaotic condition. The genus *Tipula* with its hundreds of described species has become so unwieldly as to be almost unusable. In the Neotropical fauna there are described up to the date of this writing, 46 species of *Tipula* and 12 of *Pachyrhina*. Some of these, however, are undoubtedly synonomous (as *moniliformis* Röder and *ornaticornis* v. d. Wulp). The future student of the *Tipulini* should make it a point of obligation to his fellow students to describe in detail, and figure if possible, the genitalia of the male and female. Mr. R. E. Snodgrass (Trans. Am. Ent. Soc.; Vol. XXX, pp. 179–236) laid a firm foundation for the study of the male hypopygium, and American authors are using this character to some considerable extent. As an example of a splendid revision of a genus of this tribe, I will cite Mr. M. P. Riedel's excellent paper on the Palæarctic Pachyrhinæ.†

It is probable that hypopygial characters can never be made the main basis of subdivision into groups because of the great differences in closely-related species and the consequent tendency to separate forms that are closely allied. At present it seems as if Schummel's old division of species into groups on wing-pattern is the best for main group characters. Nevertheless, hypopygial characters are so constant and so extremely important that it would be impractical to ignore them.

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*Entomological Laboratory, Cornell University.

†Deutschen Entomol. Zeitschr.; Vol. for 1910, p. 409–437, 4 fig.

I have before me male specimens of the following species which I expect to characterize more fully in the third part of my "Synopsis of the Neotropical Tipulidæ."

Pachyrhina nigrolutea Bellardi.
Macromastix chilensis Philippi.
Tipula albifasciata Macquart.
Tipula craveri Bellardi.
Tipula edwardsi Bellardi.
Tipula microcephala v. d. Wulp (which seems to belong to *Holorusia* Lw.). This name is preoccupied by *T. microcephala* Big. (1858), and I rename the South American species, *Tipula vanderwulpi* n. n.
Tipula monilifera Loew.
Tipula moniliformis Röder.
Tipula subandina Philippi.
Tipula apterogyne Philippi.
Tipula rufostigmosa Macquart.
Tipula variinervis Bigot. (= *picti-pennis* Walker.)

Pachyrhina macrosterna, sp. n.

Thoracic stripes not complete, represented, when at all evident, only by spots at the margins of the præscutum; dorsal apical appendage of the ♂ genitalia prolonged, stylet-like.

♂ Length, 10.3—10.8 mm.; wing, 11.4—11.8 mm.
Middle leg, femur, 8 mm.; tibia, 8.9 mm.
♀ Length, 12.8 mm.; wing, 13.2 mm.
Fore leg, femur, 8.9 mm.; tibia, 10.7 mm.
Hind leg, femur, 9.3 mm.; tibia, 10.6 mm.

♂ Head: Anterior prolongation of the front brownish-yellow, clearer yellow beneath and on the sides; palpi brownish; antennæ, basal segments orange-yellow; 3d segment brownish-yellow; remaining segments dark brown basally, gradually fading into the yellowish-brown apical portion of the segment; terminal three or four segments uniform brown. Front, vertex and occiput yellow, more brownish in the middle of the vertex, very broadly shiny, this mark not clearly delimited but embracing most of the space between the eyes.

Thorax: Pronotum dull pale yellow; mesonotum, præscutum shiny, brownish-yellow, without clearly defined stripes; pleuræ dull with a pale yellowish bloom. Halteres, stem pale, knob brownish. Legs: coxæ and trochanters yellow; femora brownish-yellow, the extreme tip dark brown; tibiæ yellowish-brown, extreme tip indistinctly darker; tarsi brown. Wings hyaline or nearly so, cells *C* and *Sc* yellow, stigma pale. Venation: Rs short, a little longer than R_2; petiole of cell M_1 long, as long as the basal deflection of R_{4+5}.

Abdomen: Tergum, segments shiny, segment 1 yellow, narrowly margined with brown behind; segment 2, yellow, brown on the caudal half, a large rounded brown spot on the lateral margin; segments 3 and 4 mostly brown, more yellow basally, with a gradually smaller brown spot on the lateral margin of each of the sclerites; segments 5 and 6, brighter, more yellowish; segment 7 dark, almost black, margined with pale; hypopygium orange-yellow; sternum, yellowish. Hypopygium: 7th tergite, short, shorter than the tergites immediately preceding; 8th

tergite distinct, about as wide as the 7th, its caudal margin straight, its lateral corners evenly rounded; 7th sternite rather broad, broader then the sixth sternite; 8th sternite very large, longer than the three preceding segments combined and projecting caudad beyond the remaining appendages; its ventral face is evenly rounded, broad at the base, narrowing apically, at its tip turned abruptly dorsad and ending in two blunt teeth, these teeth bifid with the caudal denticulum rather the longer. Above the origin of the 8th sternite arises the 9th sternite: broad basally, rapidly narrowed toward the tip into a chitinous, spoon-like appendage, convex on its outer face, concave on its inner. 9th tergite with the caudal margin rather deeply incised medially, the adjacent lobes brown, chitinized, and bent ventrad at the tip. Two distinct sets of apical appendages arising from the genital chamber, which may, or may not, be connected with one another nearer their bases; first, a pair of dorsal-lieing appendages which are bifid with the ventral tooth greatly prolonged, stylet-like (see Fig. k_1). Beneath these are two large complex appendages (see Fig. k) which may be described as being three-branched, the ventral branch is strongly chitinized and expanded, six-toothed, of which the most dorsad is the largest; the dorso proximal branch (a) is flattened, its margin chitinized and somewhat reflexed, bearing a spine near its outer edge at the tip; the dorso-distal branch (b) is slender, more fleshy and bears scattered hairs at its apex. Between the ventral organs, just ventrad of the dorsal pair is a large, pale fleshy organ.

♀ Antennæ mostly yellowish excepting the apical segments which are brown. On the cephalic margin of the mesonotal præscutum is a dark brown spot on either side of the usual broad median stripe which is here not indicated; a large brown spot on the sides of the sclerite about at the anterior end of the usual lateral stripe. Ovipositior (see Fig. r) with the valves very short, blunt, evenly rounded on their lateral margin.

A paratype male shows the fore portion of a lateral stripe on the præscutum.

Holotype, ♂, Antigua, Guatemala. Sept., 1902 (Dr. G. Eisen).

Allotype, ♀, with the type.

Paratype, ♂, Aguna, Guatemala. (Dr. G. Eisen). (Received at U. S. National Museum, Jan. 6, 1903).

Types in U. S. Nat. Mus. Coll. (No. 15,072).

Paratype in author's collection.

Pachyrhina macrosterna, and the following species, *trinidadensis*, are closest allied to *circumscripta* Lw, *ferruginea* Fabr. and *elegantula* Will., in the respect that the thoracic stripes are not jet-black. The other nine Neotropical species are all black-striped species. These two species form a distinct group, (*macrosterna* group), differing from the species named above in their petiolate cell M_1 and powerful hypopygium. The petiolate cell M_1 suggests *collaris* Say of the Northeastern United States, a very different insect.

Pachyrhina trinidadensis, sp. n.

Similar to *macrosterna* but antennæ darker; three distinct brown thoracic stripes; dorsal apical appendage of the ♂ genitalia chisel-shaped, sub-truncated at its apex.

♂ Length, 11 mm.; wing, 10.8 mm.; antennæ, about 4.5 mm.
♀ Length, 12—13.2 mm.; wing, 12.2—12.8 mm.
Fore leg, femur, 7.7—7.8 mm.; tibia, 9.4—9.8 mm.
Middle leg, femur, 8.5 mm.; tibia, 8.8 mm.
Hind leg, femur, 9 mm.; tibia, 9.9 mm.

♂ Head: Anterior prolongation of the front and the palpi brown. Antennæ, two basal segments light orange-yellow; 3d segment, basal half brown, apical half yellow, remaining segments brown, extreme apice of each segment yellowish, this yellow color becoming obsolete on the outer segments. Front, vertex and occiput brown, the center of the vertex broadly shiny and brighter brown.

Thorax: Pronotum very pale yellowish-white, not shining; mesonotum shiny, præscutum light yellow with three dark brown uniform stripes; the middle stripe is broadest on the anterior portion of the sclerite, rather narrower behind; the lateral stripes bent strongly ventrad at the pseudosuture (*humeral pit* or *dorso-pleural* suture of Osten Sacken); scutum yellowish with two dark brown spots on each lobe; scutellum lighter brown; post notum brownish-yellow, thinly pale pollinose; pleuræ pale with a sparse greyish pollen. Halteres pale, gradually darkening to the brown knob. Legs: coxæ and trochanters light clear yellow; femora brown, the tip narrowly dark brown; tibia and tarsi brownish. Wings: color and venation almost exactly as in *macrosterna* of Central America (see Fig. h.).

Abdomen: Tergum brownish, the lateral margins of the sclerites clearer yellow, not darker on segments 2 to 4; segment 7 with the basal half dark brown; remainder of tergum and the sternum, brownish-yellow. Hypopygium (see Fig. j); 7th and 8th tergites and 7th sternite as in *macrosterna;* 8th sternite with the caudal denticula (d) about equal to the cephalic one; 9th sternite (9s) viewed from the side with an obtuse notch on the ventral face. Apical appendages: The dorsal-lying appendage (c) projects straight backward, enlarged at the apex, chisel-shaped, the outer angles equal, the caudal margin gently concave (see Fig. j_2); the appendages lie in a vertical plane and side by side, separated from one another by a distance about equal to the width of one. The second, or ventral, appendage (see Fig. j_1) the ventral branch of *macrosterna* is, apparently, lacking; the dorso-proximal branch is chitinized and bears a sharp spine on the caudal margin, this spine being bent outward (a); on the sides of the appendage is a large prominent spine which projects ventrad and outward (x) toward the appendage of the 9th sternite which it almost touches; at its base, a small hair-bearing projection; the margin of the appendage below the large spine curves distad, is chitinized on the extreme edge and bears long hairs; I cannot perceive any structure corresponding to the dorso-distal branch of *macrosterna;* a large pale organ lying between these ventral appendages and just beneath the paired dorsal appendages.

♀ Quite similar to the ♂, the shiny spot on the vertex brown; the median præscutal stripe very broad, in front almost touching the anterior end of the lateral stripe; a brown spot on the mesopleuræ about midway between the coxa and the pseudo suture; ovipositor about as in *macrosterna;* upper valves tipped with black; lower valves, viewed from the side, broad at the base, the ventral margin concave, obtuse at the tip; viewed from beneath, flattened, bearing scanty long hairs on the outer face, the tips touching.

Holotype, ♂, Port of Spain, Trinidad, Sept. 25, 1901, (H. Carciniola).

Allotype, ♀, with the type.

Paratype 1, ♀, with the type.

Paratype 2, ♀, Trinidad, West Indies, (Aug. Busck).

Types in U. S. Nat. Mus. Coll. (No. 15,073) except paratype No. 2, in author's collection.

Tipula armatipennis, sp. n.

Color light yellow; wing unmarked; a distinct spur on the costa near the stigma in the ♂.

♂ Length, about 13.5 mm.; wing, 14.4 mm.; antennæ, about 6 mm.

♀ Length, about 15.5 mm.; wing, 14.8 mm.

♂ Head: Anterior prolongation of the front yellowish-brown; mouth-parts similar. Palpi light yellow, more brown apically, the last segment about as long as the basal three combined. Antennæ, scapal segments yellow, the first cylindrical, the second very short, broader than long, with a thick brush of stout black hairs on its inner face; flagellum, segments (except the first) more or less enlarged at the base and slightly constricted in the middle, the swollen base with a few long black hairs, the segment densely clothed with a pale pubescence; segments 3—4, yellowish, except at the black knot, this color passing into a uniform dark brown on the apical segments. Front, vertex and occiput pale brownish-yellow with a sparse greyish bloom.

Thorax: Pronotum light yellow; mesonotum, præscutum, light yellow without distinct stripes; scutum orange with indistinct darker spots; scutellum depressed on the sides, swollen medially, brownish-yellow; post-notum dull yellow. Pleuræ yellow, with a sparse greyish bloom. Halteres uniform yellow, knob brownish. Legs broken. Wings: subhyaline; stigma large, oval, brown; cells *C* and *Sc* tinged with yellow; the apices of cells R_2 and R_3 tinged with brown; veins brown. On the costal margin of the wing, above the middle of the stigma, is a distinct spine or spur. Venation (see Fig. g); Sc long ending at the base of the stigma; Rs short, less than twice as long as the deflection of R_{4+5}; R_{2+3} short, forming the caudal margin of the stigma; R_2 short, subperpendicular, basally forming the distal side of the stigma; cell 1st M_2 small, pentagonal.

Abdomen: Tergum, segment one dark brown, indistinctly black medially; remaining segments reddish-brown, darker basally. Hypopygium swollen. Sternum brownish-yellow; 7th segment black both on the sternite and pleurite. Hypopygium: (see Fig. o); 7th sternite, caudal margin almost straight; lateral margin impressed, wavy; 7th tergite, caudal margin straight; 8th sternite, (8s), broad at the base, narrowed apically, running caudad slightly beyond the remaining appendages; the base is shiny, the tip short-cylindrical, dull, opaque; the tip bent strongly dorsad and deeply notched at its base; the dorsal surface of the eighth sternite is deeply concave, hollowed-out; at the notch, on the dorsal margin, is a small flattened lobe (c), directed upward, its caudal margin narrowly chitinized, the tip densely fringed with long pale hairs. 8th tergite very narrow (8t.) represented only by a narrow strip, concave on its caudal margin and consequently even more reduced on the middle line. 9th sternite (9s) broad basally, the dorsal margin with a broad, obtuse notch; a blunt tooth on its caudal margin, ventrally the margin is rolled inward, forming a broad, obtuse notch on the margin; the inward-projecting arm is chitinized, its inner margin thinned and bearing a dense fringe of long pale hairs which overlap those of the opposite side and form a dense mat under the apical appendage and over the 8th sternite. 9th tergite (9t) moderate, medially with a deep notch on the caudal margin; the adjacent lobes being sharply pointed, bent ventrad at their tips, sub-chitinized and with hairs and minute denticulæ along the inner face; the latero-caudal margin of this sclerite is thinner and bears a fringe of sub-equal, pale hairs. The apical appendage (a) is dorsal, flattened, bearing two teeth, the most dorsal and innermost project inward, very sharp, slender, chitinized, almost touching its fellow on the middle line; the ventral tooth (a) longer, directed more caudad; the outer margin of this appendage clothed with long hairs; below the apical appendage, a flattened median organ (b), its caudal margin vertical, evenly convex, narrowly chitinized, and fringed with fine hairs. Below the 9th tergite and between its arms, in the specimen at hand, the penis (p.) projects; it is extremely elongated and if straightened would be considerably longer than one-half of the abdomen.

♀ Like the ♂ but the antennæ short, the flagellar segments cylindrical, subequal, not swollen basally, basal half of each segment brown, apex yellow. Wing without a spur, but venation as in the ♂. Ovipositor: (v, v_1) 8th tergite, concave on the caudal margin; 9th tergite very narrow and not as wide as the rest of the abdomen, its caudal margin concave. Base of the ovipositor short, almost as broad as long, the valves short, their tips chitinized and sub-spatulate, viewed from the side (v_1), the valve is wider than its base narrowed near the tip, the tip again expanded; lower valve shorter than the upper, directed caudad and upward, the valves extremely high, blunt at the apex. The 9th sternite is very long.

Holotype, ♂, Chapada, Matto Grosso, Brazil (H. H. Smith, coll.)

Allotype. ♀, with the type.

Types in Am. Mus. of Nat. Hist., New York.

I know of no species of *Tipula* that even approaches this remarkable fly. No form in the American fauna has a spur on the wing.

Tipula guato, sp. n.

Color light yellow; flagellum of antennæ bi-colored; wing subhyaline.

♂ Length, about 12 mm.; wing, 11.5 mm.

Fore leg, femur, 7.6 mm.; tibia, 9 mm.

Head: Anterior prolongation of the front rather short; nasus not distinct, but with a long brush of hairs in its normal position; dull yellow, brightest on the sides. Palpi, light yellow, short. Antennæ, basal segments yellow, second segment with a brush of hairs on the inner face; flagellum, segments swollen on the ends, narrowed medially; the basal knot blackish, and with a few prominent hairs; the entire segment clothed with dense pale hairs; basal segments of flagellum with apices yellow, this color gradually passing into the dark brown of the terminal segments. Front, vertex and occiput dull brownish-yellow.

Thorax: Mesonotum, præscutum dull yellow without apparent stripes; scutum, scutellum and post-notum similar but more or less suffused with brown. Pleuræ dull yellow, sparsely greyish pollinose. Halteres, stem yellow, knob brown. Legs: coxæ and trochanters light yellow gradually passing into the brown of the tarsi (only fore legs remain). Wings: Subhyaline; stigma oval, pale brown; cell C and apices of cells R_2 and R_3 tinged with yellow; veins brown, Sc more yellowish. Venation: (see Fig. e); Sc long ending far beyond Rs; Rs short, about as long as M_{1+2} between cross-veins *r-m* and *m;* R_{2+3} in a line with R_3; R_2 oblique; cell 1st M_2 rather elongated; petiole of cell M_1 short; cross-vein *m-cu* distinct.

Abdomen: Tergum light brown, almost uniform; 7th and 8th black; hypopygium yellow; sternites light brown; 7th and base of 8th black. Hypopygium: (see Fig. p); 7th sternite broad, its caudal margin almost straight; 7th tergite almost convex; 8th sternite (8s) broad at the base with a very obtuse tooth on its dorsal margin; produced behind into a blunt point which is broadly and obtusely notched at the tip; 8th tergite (8t.) moderately broad, about one-third as wide as the 7th, rather widened at the ends, but the caudal margin almost straight; 9th sternite (9s) subquadrate, large, its dorsal margin straight; its caudal margin truncated; ventral margin with an obtuse ventral-projecting tooth; the inner margin is bent inward and has a dorsally-directed tooth; this inward projection of the 9th sternite fills a considerable portion of the genital chamber between the 9th sternites and just dorsad of the 8th sternite. Along the median line it is deeply notched, and the whole external face is densely covered with delicate, silvery-white, appressed hairs. 9th tergite (9t.) rather short with an obtuse median notch, the adjacent teeth broad, obtuse, projecting downward, densely covered with short, stout hairs, the extreme base of each tooth,

on either side of the median notch, produced ventrad into a small spine. The apical appendage is dorsal; the caudal margin is rather straight, the outer upper angle produced dorsad into a chitinized tooth which is slightly bifid at its apex, the chitin continuing down the anterior side of the appendage in a narrow line; the inner margin of the appendage straight, with scanty long hairs which cross over the median space and meet those of the other side. Between the chitinized teeth, on the median line, is a pale, horse-shoe shaped organ which probably surrounds the penis which is not exserted in my single specimen.

Holotype, ♂, Chapada, Matto Grosso, Brazil (H. H. Smith, coll.)

Type in Am. Mus. of Nat. Hist., New York.

The specific name is derived from a native tribe. "The central parts of Matto Grosso at the foot of the plateaux are occupied by the Guatos, some of whom are still in the wild state." Reclus, Universal Geography, Vol. XIX, p. 258. The latest and best account of this tribe is by Dr. Max Schmidt, "Reisen in Matto Grosso in Jahre 1910."*

Tipula smithi, sp. n.

Light brownish-yellow; costal margin of wings brown.

♀ Length, about 13 mm.; wing, 12.8 mm.

Head: Anterior prolongation of the front, short, light greyish-brown; palpi light brown. Antennæ, first eight segments clear light yellow, the apical segments gradually suffused with brownish. Front, vertex and occiput greyish-brown. Thorax: Mesonotum, præscutum light brown without apparent stripes; scutum similarly brown; scutellum and post-notum light yellow. Pleuræ yellow with a pearly-grey bloom. Halteres light brown. Legs: coxæ yellowish with a grey bloom; trochanter light yellow; rest of legs gone. Wings: Nearly hyaline; stigma rounded, dark brown; the costal margin suffused with brown, the brown pattern including cells C, Sc, the cephalic half of R (where it becomes paler, more yellowish); basal third of cell 1st R_1; all of cell 2d R_1; cell R_2; cell R_3, except a hyaline spot in the proximal end and another over the middle of vein R_{4+5}; brown clouds at origin and tip of cell R_5; along basal deflection of Cu_1; along cross-vein *m;* at fork of M_{1+2}, and at the ends of the longitudinal veins. Venation: (see Fig. f); cross-vein *r* about as long as that portion of R_2 below it; R_3 short, about twice as long as R_2; basal deflection of R_{4+5} long, almost obliterating cross-vein *r-m;* petiole of cell M_1 almost as long as that cell; fusion of M_3 and Cu_1 extensive, not quite as long as cross-vein *m*.

Abdomen: Tergites brownish-yellow; sternites clearer yellow; second segment very long, as long as 3 and 4 combined; 9th tergite with caudal margins concave (see Figs. w, w_1), the caudo-lateral angles

*Zeitschrift fur ethnologie; vol. 44, pt. 1; p. 130–174; especially, p. 131–137; (1912).

produced into short obtuse points; valves of the ovipositor very short, divergent, the basal piece longer than the tips; lower valves (see Fig. w_1, *l*); very short, broad at the base, truncated at the tip.

Holotype, ♀, Chapada, Matto Grosso, Brazil (H. H. Smith). Type in Am. Mus. of Nat. History.

This handsome species is named in honor of the pioneer collector, Mr. Herbert H. Smith.

Tipula inca, sp. n.

Grey; wings indistinctly spotted; legs short, stout.

♂ Length, 11.5 mm.; wing, 13.4 mm.; antennæ, about 8.5 mm. Fore leg, 21 mm.; middle leg, fem. 6.8 mm.; tibia, 5.6 mm.; tarsus, 6.5 mm.; hind leg, fem. 7.8 mm.; tibia, 8.3 mm.; tarsus, 7.9 mm.

Head: Anterior prolongation of the front white, very pale, with numerous brown hairs on the distal half above; nasus not prominent; palpi brown, first segment light brown, shorter than the second, slender; second, paler brown basally, greatly thickened distally; 3d segment again slender except at the base; 4th very irregular, brown, except at the extreme base where it is yellowish; mouth parts dark brown. Antennæ, 1st segment short, much thickened distally; 2nd short; 3d one and one-half the length of the 1st; remainder very flexible, elongated, at the basis armed with four or five strong, black hairs, the whole surface covered with a fine pubescence. Basal segment light yellow, somewhat darker at tip; 2d brownish-yellow; 3d silvery greyish-brown; remainder light brown. Front pale silvery-white; vertex and occiput grey with a dark brown median line beginning between the antennæ, running caudad. Head closely applied to the prothorax.

Thorax: Pronotum silvery-grey, medially with a broad brown stripe. Mesonotum, grey with a very narrow dark brown median line, broadest before, gradually narrowing toward the suture, lateral margins of præscutum dark brown except extreme edge; between this brown and the median stripe, an indistinct pale brown stripe on the caudal half, ending at the suture; scutum, grey medially, yellowish on the sides; scutellum grey, a large flattened brown area on the sides above the wing-roots; post-notum grey, brownish medially and on the sides. Pleuræ and sterna silvery-whitish, tinged with grey. Halteres long, yellowish. Legs short, stout, femora somewhat incrassated at tip, pale yellowish-brown, tip rather darker; tibiæ and tarsi brown.

Wings: Hyaline, cells *C* and *Sc* tinged with yellow; stigmal area pale greyish; a vague grey suffusion around cross-vein *m* and on outer deflection of M_3; caudal third of cell M along vein *Cu*, grey, this also continuing onto Cu_1 and Cu_2 as a very narrow seam; cells of wing in vicinity of anterior (cephalic) half of the cord, greyish; two pale clouds in base of cell *Cu;* margin of anal angle grey. Venation as in Fig. c.

Abdomen: Pale brownish-yellow; middle of 1st tergite brown, which color continues back over the succeeding three segments as a narrow line; sternites brownish-yellow, the sclerites at pleural margin

deeply incurved, dusky, giving an indistinct lateral stripe. Hypopygium: (Fig. 1); 8th tergite, (8t), moderately long, its caudal margin almost straight, its caudal margin very feebly concave medially; 8th sternite, (8s) short and high, only about two-thirds as long as the 7th sternite, but very high at its base; viewed from the side, triangular, its tip turned dorsad and clothed with long hairs; 9th tergite (9t) broad, viewed from above, much broader than the 8th tergite, swollen basally, the caudal margin broadly concave, in the middle, feebly convex and here with a minute square median notch (Fig. 1_1); viewed from the side (1) the 9th tergite is truncated at its tip and broadly notched, its ventral-caudal margin gently concave; the suture separating the 9th tergite and sternite not complete. 9th sternite, viewed from the side (1, 9s), its dorsal margin about straight attached to the tergite on its cephalic or anterior portion; its caudal margin about straight; along its caudal face, an elongate body (y), convex outerly; its ventral margin applied to the caudal prolongation of the ventral face of the 9th sternite; at its dorsal end it is produced into a fleshy, feebly chitinized body (a), densely covered with pale hairs which are longest apically; viewed from the side, it is slender with a bump on the middle on its outer face. Proximad of this organ, in the notch of the ventral paired organ on the 9th sternite, is an elongate, slender organ (b) directed dorsad; its base is slightly enlarged, its stem very slender with long pale hairs on its inner face, these directed toward the median line; the tips of these organs are greatly produced on the proximal side, here sub-chitinous, the tip chitinized, black. In a position of rest, the inner edge of this organ is closely applied to its fellow at the median line; the caudal face of this broad expansion is provided with three or four transverse ridges and its ventral margin is fringed with long pale hairs; viewed from above this organ resembles Fig. 1_1; the outer tooth most chitinized, black; the inner, less chitinized except on its outer margin; recurved at the tip and directed cephalo-ventrad. Viewed from beneath, the 9th sternite has the caudal margin concave, a pair of elongate median organs directed caudad, these organs (c) slender, swollen at their tips, the tips closely applied, densely clothed with appressed, pale hairs.

Holotype, ♂, Callanga, Peru. (Rec'v'd from Staudinger-Bang-Haas).

Type in author's collection.

The specific name is derived from the great Indian nation formerly inhabiting Peru.

Closest related, apparently, to *glaphyroptera* Phil.; *subandina* Phil., and *apterogyne* Phil., of Chile in the greyish color. I have before me specimens of all of the above, excepting *glaphyroptera*, which differs widely from *inca* in *antennal* and *wing* characters.

Tipula aymara, sp. n.

Orange; costal margin of the wings dark; cross-veins not seamed with brown; radial cells light brown.

Length, ♂, 15 mm.; wing, 17 mm.; antennæ, about 7.6 mm.
Length, ♀, 13.8 mm.; wing, 14.6 mm.
Hind leg, ♂; fem. 10.4; tibia, 13.3; tarsus about 25.5 mm.
Hind leg, ♀; fem., 8; tibia, 9.6 mm.

♂ Head: Anterior prolongation of front short, light brown; palpi, segment one, shorter than two, brown; 3d about equal to 2d, dark brown at base; pale, yellowish, at tip; 4th, very long, lash-like, twice as long as the rest of the palpus together, yellow. Antennæ, segments 1 to 3 orange-yellow; remainder brown, with a fine white pubescence; three or four bristles at the base of each segment and a single one near the middle. Front and vertex brownish-orange; occiput brown; the vertex very thickly beset with numerous long hairs; this including the whole region bounding the eyes, both above and beneath.

Thorax: Collare orange. Pronotum orange-yellow. Mesonotum, præscutum and scutum orange without distinct markings; scutellum and postnotum yellow. Pleuræ and sternites clear yellowish-orange. Halteres yellow, knob darker. Legs: coxæ, trochanters and extreme base of femora light yellow; rest of femora, tibiæ and tarsi brown; all of the coxæ thickly beset with long yellow hairs. Wings (see Fig. b) with a pale brownish-grey tinge; cells C, Sc, most of 2d R_1 light brown; the distal half of cell 1st R_1 dark brown, forming the stigma; no brown seams on the cross-veins or deflections. Radial cells, indistinctly suffused with very light brown distally; cross-vein *r-m* slightly margined with brown.

Abdomen: Tergum, 1st segment, yellow; 2d brown; 3d, 4th, dark brown; 5th, 6th, lighter brown; 7th, 8th, black; the 1st to 5th tergites are very deep, so that viewed from the side, they conceal the sternites; the 6th sternite shows caudally, the 7th is one-third as high as the 7th tergite, the 8th sternite subequal to the 8th tergite. Sternum, segments one to five, invisible, 6, orange, 7—9, black. Hypopygium (Fig. m). 7th sternite almost straight along the caudal margin; 7th tergite, broad, its caudal margin almost straight, very feebly concave. 8th sternite (from beneath), broad, the caudal margin with an obtuse median notch, the adjacent lobes broadly rounded and clothed with a dense brush of long yellow hairs; (from the side) (8s) with the dorsal margin gently sloping; the tip truncated: 8th tergite, (8t) reduced to a mere strip, its caudal margin rather strongly concave so that the median portion is scarcely visible. 9th sternite (9s) appearing as the half of an oval, the outer face sub-shiny, convex, a small group of long hairs on its dorsal angle; the dorsal margin strongly bent entad, the proximal margin straight, almost in a line with the notch on the 8th sternite, the two together making a very deep V-shaped niche; the proximal-ventral side is strongly produced into a rectangular arm, projecting entad, its tip strongly truncated, almost touching its fellow of the opposite side. Looking into the end of the genital chamber (see Fig. m_1) there appears

to be an appendage to the 9th sternite, a semi-lunar, feebly-chitinized piece (z) flattened and the tip slightly expanded, bearing a fringe of long pale hairs on its proximal margin, these projecting inward; at the tip, the hairs become very stout, bristle-like, black, and the organ ends in two or three chitinized teeth which are directed dorsad and slightly outward; underneath the tip of this appendage is a rounded, chitinized organ (b) produced caudad into a long spine; it is black, very conspicuous, occupying the niche between the 9th sternite and tergite, its rounded face directed outward through the niche. 9th tergite (9t), rectangular, its sides square, its caudal angles almost right; on the caudal margin, a broad median lobe, very obtuse and enlarged at the apex, black and very densely clothed with short hairs; the very conspicuous lobe is concave at its tip, projects caudad, the tip very slightly ventrad. Apical appendages, from the genital chamber: dorsal lying, on either side of the median line, an elongate-triangular organ (w) broad at the base, directed dorsad and slightly caudad, the tips touching, the cephalic margin densely clothed with pale hairs; the opening between them (looking into the genital chamber) is elongate-oval and in it is a perforate membrane through which the penis is probably exserted. The ventral lying appendage (a) viewed from the side, roughly triangular, one angle directed caudad, another ventrad; caudal face gently concave; the whole organ densely clothed with long pale hairs, longest on the dorsal margin; viewed from above, it is seen that the dorsal edge is thickened, narrowing to the sharp ventral margin (Fig. m_1 *a*).

♀ Similar to the ♂, but antennæ much shorter, segments 1—5, yellow; abdomen, segments 1—2 yellow with lateral margin of tergum black; segments 2—6, black, yellowish in the middle of the lateral margin of tergites; 7—8 black; 9 yellow. Sternites 4—6 distended with eggs; shoved out of the tergal covering, black with a yellow wash. Genitalia: 9th tergite about as long as the 8th, its caudal margin broadly impressed medially; appendage to the 9th tergite broad basally, sub-shining, ending in a blunt lobe, its tip rounded, deeply notched, the lobes fringed on the inner edge with short pale hairs. From beneath, the 9th sternite is very long, its caudal margin deeply notched, the valves projecting from the middle of this notch, the lateral margins lobed and bent inward; 9th sternite very long. (See Figs. s, s_1).

Holotype, ♂, San Antonio, Bolivia (Recv'd from Staudinger-Bang-Haas).

Allotype, ♀, with the type.

Types in author's collection.

The specific name is that of a native tribe. "The Aymaras, who constitute the chief ethnical element of the Bolivian nation, are in almost exclusive possession of the plateau regions and their domain also encroaches northward on Peruvian territory. The true center of the race lies in the islands, headlands and shores of Lake Titicaca." Reclus, Universal Geography, Vol. XVIII, p. 368.

This species and the next, *parishi*, are members of the *longitarsis* Mcq't group, possessing elongated antennæ in the ♂; costal margin of wings darkened, with the remainder of the wings subhyaline, no white longitudinal stripe in under R, (*oleracea* group, as *virgo* O. S., *virgulata* Will.); ♀ ovipositor with remarkably shortened valves; color of the species yellow or orange with one or more subterminal abdominal segments black. Here belongs *longitarsis* Macquart, *tabida* End. (Peru) and *appendens* End. (which is certainly not a *Macromastix* as its describer believed) from Ecuador, as well as the two new species. *T. aymara* differs from *appendens* in being much larger; veins not seamed with brownish and distal ends of the radial cells uniformly suffused with darker. From *tabida*, it differs in wing coloration; not only the penultimate abdominal segment is black, but the antepenultimate as well (and most of the remaining tergites in the ♀). T. *longitarsis* has a large quadrangular brown spot in cell M_1 near the cubital vein.

Tipula parishi, sp. n.

Small; orange; costal margin of wings dark; veins in distal portion of the wing seamed with brown.

♂ Length, 11.9 mm.; wing, 11.8 mm.; antennæ, about 8 mm. Middle leg, femur, 8.6 mm.; tibia, 8.8 mm.; tarsus, about 23 mm.

Head: Anterior prolongation of the front brown; palpi brown. Antennæ, two basal segments yellow; 3d dull yellow; remainder, base black, tip dull yellow; on the 6th and following segments the yellow color is very much reduced. Antennal segments covered with a dense pale pubescence and a few long black hairs; the segments are all elongate-cylindrical, the base only a trifle more enlarged than the stem. Front, vertex and occiput dull brown; eyes metallic.

Thorax: Dull brownish-yellow without distinct præscutal stripes; the scutum, scutellum and postnotum even darker brown. Pleuræ yellowish-brown, lighter ventrally, passing into the clear light yellow of the coxæ. Halteres brown, stem a little paler. Legs: coxæ, trochanters and femora yellow, the femora gradually becoming brownish-yellow apically; tibiæ and tarsi brown. Wings: Subhyaline, cells C, Sc, extreme cephalic margin of R, base and tip of 1st R_1, 2d R_1 and tips of R_2, R_3 and R_5 brown, the stigmal area rather the darker. Brown seams along the cord, including a large seam on the basal deflection of Cu_1 near the fork of Cu; cross-vein *m* seamed with brown. Venation: Rs short, arcuated, about as long as the basal deflection of Cu_1; R_{2+3} short, less than Rs, about equal to R_2; cross-vein *r-m* not reduced, about one-half as long as the deflection of R_{4+5}; fusion of Cu_1 and M_3 about as long as *r-m*.

Abdomen: Tergum, segments 1—3, yellow, the lateral margins of the sclerites broadly brown; on the 4th and succeedings tergites, the brown lateral margins of the sclerites are paler but suffuse the whole segment; 7th and 8th sclerites black; 9th yellow. Sternites, 7th black, 8th black basally; remainder of sternum yellow. Hypopygium: (see Fig. n). 7th sternite and tergite about as in *aymara;* 8th sternite rather short, its length scarcely more than the 7th, its caudal margin quite straight, as in the 7th. 8th tergite, broad on the sides, the caudal margin quite deeply concave, reducing the median portion very considerably. 9th sternite (see Fig. n, 9s); cylindrical, rather elongated; viewed from beneath (n_1) the whole caudal margin is squarely notched, this notch toothed and notched again. Viewed from the side, the dorsal margin is straight basally, then straight apically, the angle being about 150°; near its tip, produced into a complex appendage (Fig. n, *v*) its cephalic arm conspicuously chitinized, black, its caudal margin conspicuously fringed with hair. 9th tergite (see n, 9t); caudal angles evenly rounded; caudal margin gently concave with a distinct blunt median tooth, which, on the ventral surface of the sclerite, is seen to be bent ventrad and continued cephalad, as an oval organ densely covered with minute chitinized teeth on the ventral surface, these denticules more numerous on the margins. Apical appendages; dorsal-lying, viewed laterally, (a), elongate, slender, projecting straight backward, the tips expanded, rounded; viewed from above, it is seen that this organ is median, but deeply bifid at its tip (n_2), giving the appearance of being a paired organ; the tips are divergent, enlarged apically into a rounded knob. Ventral-lying appendage, viewed laterally (b) subequal to the dorsal appendages in length, project caudad and slightly dorsad, the tips acutely pointed; from above, this organ is broad, slightly notched at the tip, and its dorsal surface appears to be concave.

Holotype, ♂, Igarapé-assú, Para, Brazil, Jan. 26, 1912, (H. S. Parish, coll.)

Type in Cornell University Collections.

I take pleasure in dedicating this interesting species to the well-known South American traveller and collector, Mr. H. S. Parish.

This little species is allied to *appendens* End. but differs considerably in coloration; the basal deflection of Cu_1 is distinctly seamed with brown. This insect bears a certain resemblance to *aymara* but is strikingly distinct in wing coloration and hypopygial characters. The flagellar segments in *aymara* are distinctly enlarged at the base; in *parishi* not at all swollen basally, the segments being uniformly cylindrical.

Tipula atacama, sp. n.

Small; yellow and brown; wings reddish-brown with hyaline spots; femora dark with a light subapical ring.

♀ Length, about 12 mm.; wing, 14.2 mm.

Fore leg, femur, 6.8 mm.; tibia, 7.6 mm.; tarsus, about 12.5 mm.

Head: Anterior prolongation of the front and palpi light yellowish-brown, the latter darker toward the tip. Antennæ, segments 1—3, orange-yellow, remainder black. Front with a distinct protuberance just behind the antennæ; front, vertex and occiput pale yellow.

Thorax: Pronotum light yellow, a brown transverse mark in front; a semi-lunar brown spot on either side behind. Mesonotum, præscutum dark brown behind, a broad dark liver-brown median stripe of this color beginning near the cephalic margin of the sclerite, broadest in front, narrowing behind, reaching the suture; the caudal half of the sclerite is thinly grey pruinose; cephalic half, on either side and in front, of the median stripe, bright orange; scutum dark brown, thickly grey pollinose; scutellum and postnotum dull yellow, brown on the sides. Pleuræ, brown, more yellowish ventrally; sternum yellow. Halteres yellow, knob slightly darker. Legs (fore only remain): coxæ and trochanter yellow; femur, light yellowish-brown, a dark brownish-black ring at the tip with a light yellow subapical ring; tibia and tarsus brown. Wings: suffused with pale reddish-brown, adorned with hyaline spots arranged about as follows: (1) the clearest fill most of cell 1st M_2 and extends down into the base of cell M_3, the outer deflection of M_3 being whitened; (2) in cell $1R_1$ above the fork of Rs; (3) In cell C above the tip of *Sc*. Less clear spots are in the center of cell R and, nearer the tip; a double spot near base of cells R_3 and R_5; one at base of M and cu; pale centers to cells M, Cu and 1st A. Venation as in Fig. d.

Abdomen: Tergum, light yellow, segments 3—8 slightly darker brown caudad; extreme ventral margin of tergites dark brownish-black. 8th tergite narrow, especially medially, due to the concave caudal margin. 9th tergite (see Fig. u) narrow, moderately long; base of the ovipositor cylindrical; the valves (u) broad at the base, rapidly narrowing to the slender, sub-spatulate tips. 9th sternite broad basally, conical, the valves (e) flattened, blade like, shorter than the upper valves.

Holotype, ♀, San Antonio, Bolivia, (Received from Staudinger-Bang-Haas).

Type in author's collection.

The specific name is that of a native tribe of Indians dwelling west of the Andes and south of the region inhabited by the Aymaras.

It may be allied to *decorata* Phil. and *frauenfeldi* Schin. (Chilian species) in the tuberculate front, but is little related in other respects. In wing-coloration, *atacama* shows some resemblance to *flavipennis* Phil. (Chile) but is only about half as large and shows conspicuous colorational differences.

Tipula maya, sp. n.

Large; thorax brownish-yellow, striped; wings brown; cross-vein *r* before the fork of R_{2+3}.

♀ Length, 28 mm.; wing, 27.6 mm.
Fore leg, femur, 14 mm.; tibia, 16.8 mm.
Middle leg, femur, 15.9 mm.; tibia, 15.4 mm.
Hind leg, femur, 16.2 mm.; tibia, 18.7 mm.; tarsus, seg. 1, 18 mm.; seg. 2, 4 mm.; seg. 3—5, 3.5 mm.

Head: Anterior prolongation of the front, and the palpi, dark brownish-black. Antennæ, basal segments brown, flagellum broken. Front, vertex and occiput dark brown, occiput paler.

Thorax: Pronotum dull yellow, the scutum and caudal margin of the scutellum brown. Mesonotum, præscutum dull brownish-yellow, brighter, yellow, along the lateral margin of the sclerite; extreme cephalic margin of the sclerite dark brown, continued backward as a narrow median stripe broadening out in the middle but soon becoming faint and almost obsolete; the lateral stripe begins at the front angle, continues caudad; at about one-third the length of the sclerite it forks, the inner branch continuing directly caudad in a line with the main stem and running to the transverse suture; it is palest medially, the edges brown. The outer branch bends toward the edge of the sclerite and continues back to the side of the scutum; scutum brown, dark brown on the sides and on the caudal margin; scutellum dark brown medially, the sides light brown, a narrow yellow stripe on the cephalic margin; postnotum dark brown with a pale narrow, median vitta. Pleuræ very pale brown except the dorsal edge which is yellow; a dark brown band extends from the cervical sclerites across the dorsal portions of the pleuræ, under the root of the wing, fusing with the dark brown of the postnotum. Halteres dark brown. Legs: coxæ and trochanters light yellow; femora light yellowish brown, tip broadly and abruptly dark brown; tibia light brown, the tip indistinctly darker; tarsi light brown, the tips o the individual segments dark brown. Wings: Uniformly suffused with brown; cells *C* and *Sc* more yellowish-brown; stigma brown; cell 2nd R_1, R_2 and tip of R_3 darker brown; a brown seam on most of the veins and a brown cloud in cell *M* at about four-fifths the length of Cu_1. Venation. (see Fig. a); Rs long, gently arcuated, twice as long as R_{2+3} before *r;* about as long as the basal deflection of Cu_1; R_{2+3} straight, R_2 about two-thirds as long as R_{2+3}. The radial cross-vein connects R_1 with R_{2+3} before its fork, this distance on R_{2+3} between *r* and the fork about equal to the cross-vein *r-m*. Basal deflection of R_{4+5} a trifle longer than *r-m;* cross-vein *m* about twice as long as *r-m;* cell 1st M_2 about pentagonal, its inner face (segment one, M_{1+2}) about as long as the cephalic face (segment two, M_{1+2}); cross-vein *m-cu* obliterated by fusion. Petiole of cell M_1 about as long as this cell. Cu_2 about as long as the deflection of Cu_1.

Abdomen: Tergum, segment 1, yellowish on basal half, dark brown on caudal half and on the sides; segment 2 deep reddish-brown with an indistinct dark brown median stripe and lateral margins; in the

middle an interrupted narrow grey transverse stripe; segments 3—7 similar, but the transverse grey impression is close to the base of the sclerite; segment 8 narrow, its caudal margin with an obtuse median tooth and an obtuse notch on either side (see Fig. t); 9th dark brown; sternites yellow, on segments 4—6 darker, brownish. Upper valves of the ovipositor (u) very slender, the tip not enlarged; 9th sternum long, its caudal margin deeply notched; valves short, acicular (l).

Holotype, ♀, Aguna, Guatemala, Cent. Am. (alt. 1030 ft.) Aug. 6, 1902, (Dr. G. Eisen, coll.)

Type in U. S. Nat. Mus. Coll. (No. 15,075).

The specific name is derived from an ancient tribe of Indians dwelling in Yucatan and the adjoining parts of Guatemala, famous for their high degree of culture and the wonderful structures that they built.

In the size and wing-coloration, this species suggests certain members of the *oblique-fasciata* group, (*oblique-fasciata* Mcqt.; *craveri* Bell.), but differs notably in venational- and leg-characters. In general color it resembles the next species, *fumipennis*, of Peru.

The venation is very like *Holorusia* Loew, and it is quite possible that *maya* may prove to belong to this genus. It is much smaller than *rubiginosa* Loew, which has the wings more uniform, dorsal thoracic stripes not clear, petiole of cell M_1 short, etc.

Tipula fumipennis, sp. n.

Large; thorax dark brown; wings brown; tarsi very long.

♀ Length, about 19 mm.; wing, 23 mm.
Fore leg, femur, 13.6 mm.; tibia, 14.5 mm.; tarsus, about 35 mm.
Hind leg, femur, 13 mm.; tibia, 15.3 mm.; tarsus, about 39 mm.

Head: Anterior prolongation of the front rich reddish-brown; palpi dark brown. Antennæ basal segments reddish; flagellum broken. Front reddish; vertex rich reddish-brown, pale, almost white medially, this pale color including the occiput.

Thorax: Pronotum rich brownish-yellow with two parallel dark brown marks on either side of the median line. Mesonotum, præscutum dark chocolate brown without distinct stripes; scutum and scutellum gradually paler brown, the postnotum yellowish with a very narrow, indistinct median brown line. Pleuræ, propleuræ and cephalic portions of the mesopleuræ dark brown, except a very broad, conspicuous, yellow band running across the dorsal portions of the pleuræ from the pronotal scutellum back to under the wing-basis; remainder of pleuræ yellow. Halteres brown, extreme base of stem yellowish. Legs: coxæ, anterior and middle, dark brown, hind coxæ lighter, yellowish-brown; femora, tibiæ and tarsi brown. Wings: Infumed with brown; cells *C* and *Sc* brighter, yellowish; above the stigma grey; stigma and cell

2d R_1 dark brown; a brown cloud at the origin of Rs; veins broadly margined with the dark-ground color leaving the centers of the cells pale. Venation: Rs rather long, somewhat angulated basally; R_{2+3} about one-third longer than R_2; cross-vein *r* connects R_2 far beyond the fork of R_{2+3}; deflection of R_{4+5} and *r-m* about subequal; sides of the elongate cell 1st M_2 parallel, petiole of cell M_1 short, only about one-third as long as the cell; cross-vein *m-cu* indicated by a point. Cu_2 one-half longer than the basal deflection of Cu_1.

Abdomen: Tergum, brown, 2d segment deeply impressed in the center, except at the median line; lateral margins of the sclerites with a basal yellow triangle; sternites yellow, caudal margins darker, brownish. Ovipositor: Segment 9 short, the valves slender, but flattened blade-like; lower valves, short, very high, blade-like; nearly twice as high as the tergal valves.

Holotype, ♀, Piches and Perene Vs., Peru, 2000–3000 feet, (Pres. by Soc. Geog. de Lima).

Coll. U. S. Nat. Mus. (No. 15,074).

Microtipula, gen. n.

Antennæ elongated in the ♂ and apparently 12-segmented, the flagellar segments very elongated, clothed with a long, pale pubescence; two or three bristles at the base of each segment and, usually, one near the middle. Anterior prolongation of the front short; nasus not distinct. Wings: Sc long extending beyond the origin of Rs to a distance about equal to R_{2+3}; Rs long, gently arcuated, not quite as long as R_3; cross-vein *r* at the fork. R_2 indicated only basally, *its tip atrophied.* Cross-vein *r-m* short, about as long as *r;* cross-vein *m* long, a little less than the basal deflection of M_{1+2}; cross-vein *m-cu* obliterated by the touching of Cu_1 and M_3. Hypopygium complex, penis very long.

Type, M. amazonica, sp. n.

This genus is proposed for a tiny species from Eastern Brazil, which, by its combination of characters, will not fit into any of the existing genera. In its venation (i. e. obliteration of the terminal section of R_2) the species suggests certain *Dolichopezine* genera. In my key to the *Dolichopezini** it would not fit in either of the primary sections; in the *Megistocera* group because of its complex hypopygium or in the *Dolichopeza* group because of its 12-segmented antennæ. It bears a slight resemblance to *Megistomastix* which has a very different hypopygium and 13-segmented antennæ. I prefer to believe it to belong to the *Tipulini.* In Skuse's key† to the Tipuline genera it would run down to *Habromastix* of Australia. However, this genus as well as all the *Tipulini* known to me,

*Psyche; Vol. 19, p. 64 (April, 1912).

†Dipt. Austral.; pt. 8; Tipul. longipalpi (Proc. Linn. Soc. N. S. W.; Vol. 5, (2d series). Feb. 26, 1890; p. 78–81.)

has the terminal section of R_2 more or less preserved.‡ I prefer to believe that the species represents a new genus to which I have applied the above name from the small size of the included form.

Microtipula amazonica, sp. n.

Bluish grey; ♂ antennæ elongated, ♀ short; wings hyaline with brown markings.

♂ Length, 6.2 mm.; wing, 7.2 mm.; antennæ, about 5.5 mm.
Fore leg, femur, 4.4 mm.; tibia, 5.9 mm.; tarsus, 9.4 mm.
Middle leg, femur, 4.5 mm.; tibia, 5.3 mm.
♀ Length, about 6.8 mm.; wing, 7.4 mm.
Fore leg, femur, 4.9 mm.; tibia, 6 mm.
Middle leg, femur, 5.2 mm.; tibia, 5.3 mm.; tarsus, about 9.4 mm.
Hind leg, femur, 4.9 mm.; tibia, 5.4 mm.; tarsus, about 10 mm.

♂ Head: Anterior prolongation of the front short, dark brown; palpi, lighter, yellowish-brown. Antennæ, segments 1—2, yellowish-brown; segment 3 brown; remaining segments dark brownish-black, the segments elongated, not enlarged basally, covered with a long pale pubescence; a few long dark basal bristles. Front brown; vertex and occiput clear bluish-grey.

Thorax: Cervical sclerites bluish-grey; pronotum clear light grey, unmarked. Mesonotum, præscutum greyish with a thick blue-grey bloom, especially thick on the sides and in front, leaving a cuneiform median mark, grey; scutum and scutellum grey; postnotum with a decided blue-grey bloom. Pleuræ bluish-grey. Halteres brown, the knob dark brown. Legs: coxæ yellow, greyish pruinose on the front; trochanters dull yellow; femora yellow, the tip broadly dark brown; tibiæ yellowish brown, the tip darker; tarsi brown. Wings: Subhyaline; cells *C* and *Sc* dark brown; stigma oval, brown, filling in the tip of cell 1st R_1 and the extreme base of cell 2d R_1. Tip of cell 2d R_1, most of cell R_3, cephalic portion of R; median portion of M, and seams along most of the veins paler brown. Venation (see Fig. i) as in the genus.

Abdomen: Tergum, segments 1—2 yellow, dark brown apically and on the sides of the sclerites; 5th dark brown, except the basal third; 6th mostly yellow, darker, almost black, on the apical half and along the lateral margin of the sclerite; 7th black; base of 8th suffused, black. Hypopygium (see Fig. q): 8th sternite rather long, at least twice as long as the 7th and even higher; 8th tergite short, about two-thirds as long as the 7th and not as deep. 9th sternite, viewed from the side, rather short, the ventral margin about straight, the caudal end gently rounded, with an appendage (e); dorsal side with a rounded, chitinized black knob; appendage of the sternite broad, bi-lobed, the ventral lobe with a long flexible, finger-like tip projecting caudad and dorsad; the upper, or cephalic, lobe lying closely appressed to its dorsal margin, elongate-cylindrical, rather fleshy. 9th tergite (in the drawing, Fig. q, 9,

‡*Pehlkea* End. show a species in which R_2 seems to be present; the venation, apparently, is misinterpreted in the figure. (Zool. Jahrb.; Vol. 32, pt. 1, p. 15.)

the 9th tergite is seen from a dorsal aspect) viewed from above, rectangular with a very deep oval notch, the lateral lobes squarely truncated at the tips, clothed with long hairs, these longest at the apex; a few hairs on the ventral face. Penis (p.) extremely long and slender projecting far beyond the genital chamber and is almost half as long as the whole abdomen.

♀ Like the ♂, but antennæ short; segments 1—5 light yellow, these gradually darkened; pleuræ lighter grey; dark femoral tips not so broad. Abdomen, tergum, segments 1—2, yellow, tip and margin darker; segment 3 almost all black except the base; segments 4—5, yellow except the black lateral margin; segments 6—7 black; tip of abdomen yellow; valves of the ovipositor quite short and blunt.

Holotype, ♂, Igarapé-assú, Para, Brazil, Jan. 29, 1912, (H. S. Parish, coll.)

Allotype, ♀, same locality and collector; Jan. 27, 1912.

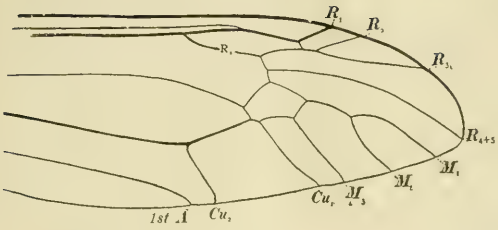
Type in Cornell University Collection.

This insect differs considerably from all the described forms in its small size and blue-grey coloration.

EXPLANATION OF PLATES XXIV, XXV, XXVI.

The wings are all drawn to scale by the projection microscope in Cornell University.

Fig. a. Wing of ♀ *Tipula maya*, sp. n.
Fig. b. Wing of ♀ *Tipula aymara*, sp. n.
Fig. c. Wing of ♂ *Tipula inca*, sp. n.
Fig. d. Wing of ♀ *Tipula atacama*, sp. n.
Fig. e. Wing of ♂ *Tipula guato*, sp. n.
Fig. f. Wing of ♀ *Tipula smithi*, sp. n.
Fig. g. Wing of ♂ *Tipula armatipennis*, sp. n.
Fig. h. Wing of ♂ *Pachyrhina trinidadensis*, sp. n.
Fig. i. Wing of ♀ *Microtipula amazonica*, sp. n.
Fig. j. Hypopygium of *Pachyrhina trinidadensis*. (lateral aspect). 8t, 9t=8th and 9th tergites; 7s, 8s, 9s=7th–9th sternites; *c* equals dorsal apical appendage. j 1=ventral apical appendage enlarged. j. 2 is tip of dorsal apical appendage enlarged.
Fig. k. Hypopygium of *Pachyrhina macrosterna*, sp. n. The ventral apical appendage enlarged. k_1 tip of dorsal apical appendage, enlarged.
Fig. l. Hypopygium of *Tipula inca* (lateral aspect); l_1, (dorsal aspect).
Fig. m. Hypopygium of *Tipula aymara* (lateral aspect) m_1. Looking into the genital chamber.
Fig. n. Hypopygium of *Tipula parishi*, sp. n. (lateral aspect). n_1, ventral aspect; n_2, tip of dorsal apical appendage.
Fig. o. Hypopygium of *Tipula armatipennis*. (lateral aspect). p=part of the exserted penis.
Fig. p. Hypopygium of *Tipula guato*. (lateral aspect.)
Fig. q. Hypopygium of *Microtipula amazonica* (lateral aspect). (N. B.—The 9th tergite is shown from a *dorsal* aspect.)
Fig. r. Ovipositor of *Pachyrhina macrosterna*. (dorsal aspect).
Fig. s. Ovipositor of *Tipula aymara* (dorsal aspect). 8t, 9t=8th and 9th tergites. u=upper valve (tergal); l=lower valve (sternal). s_1=ventral aspect.
Fig. t. Ovipositor of *Tipula maya*. (dorsal aspect).
Fig. u. Ovipositor of *Tipula atacama* (dorsal aspect).
Fig. v. Ovipositor of *Tipula armatipennis* (ventral aspect). v_1, lateral aspect, 9s=9th sternite.
Fig. w. Ovipositor of *Tipula smithi*, (dorsal aspect). w_1, lateral aspect.



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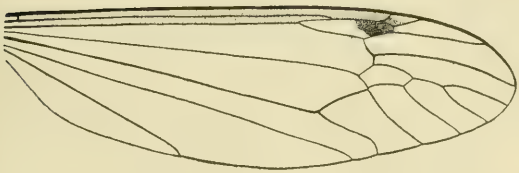

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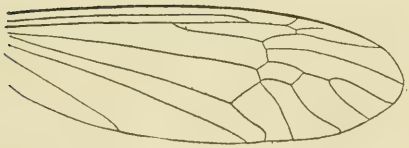

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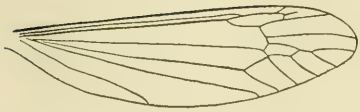

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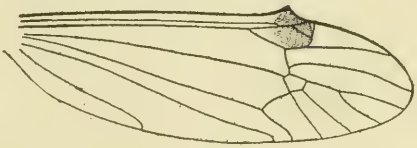

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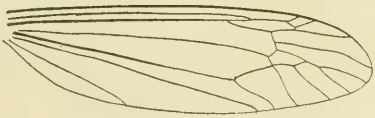

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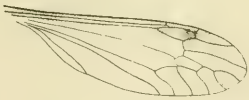

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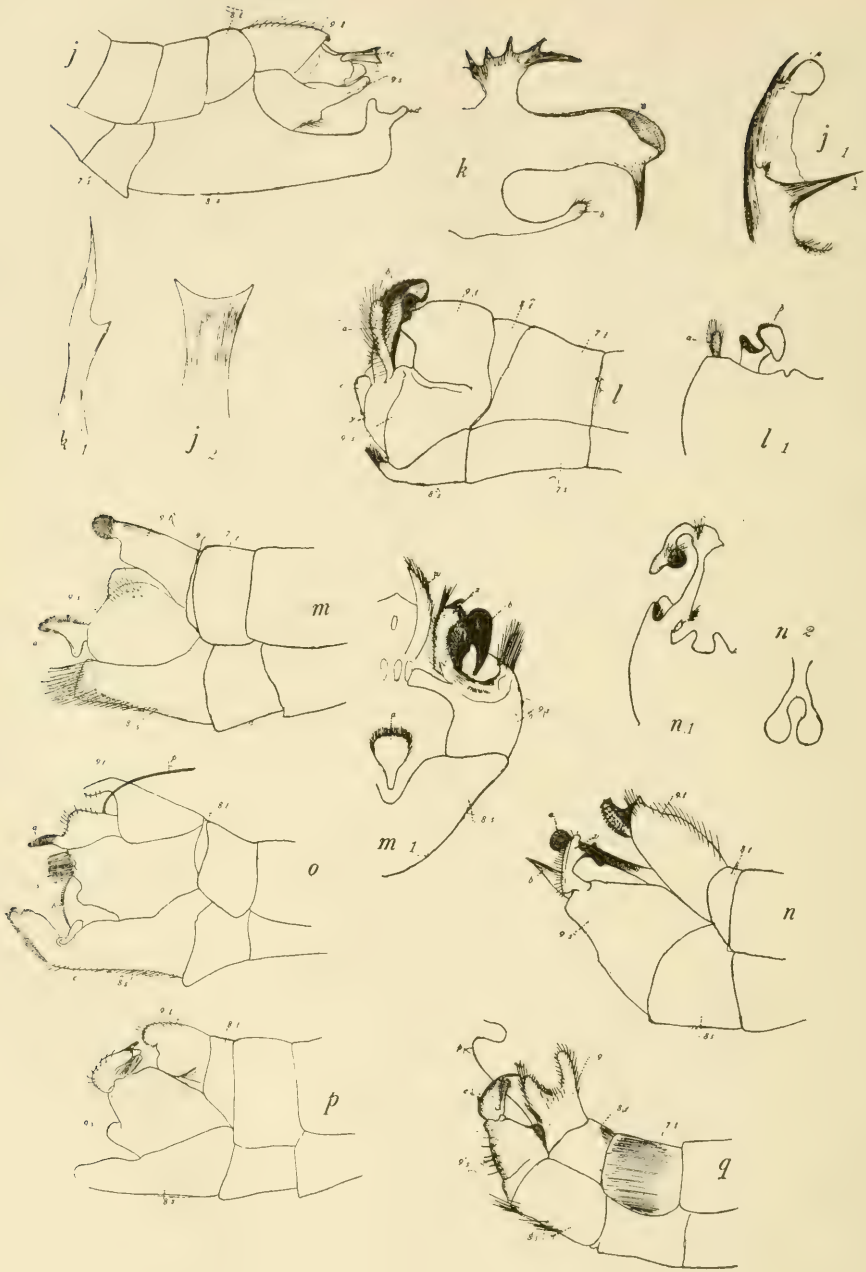

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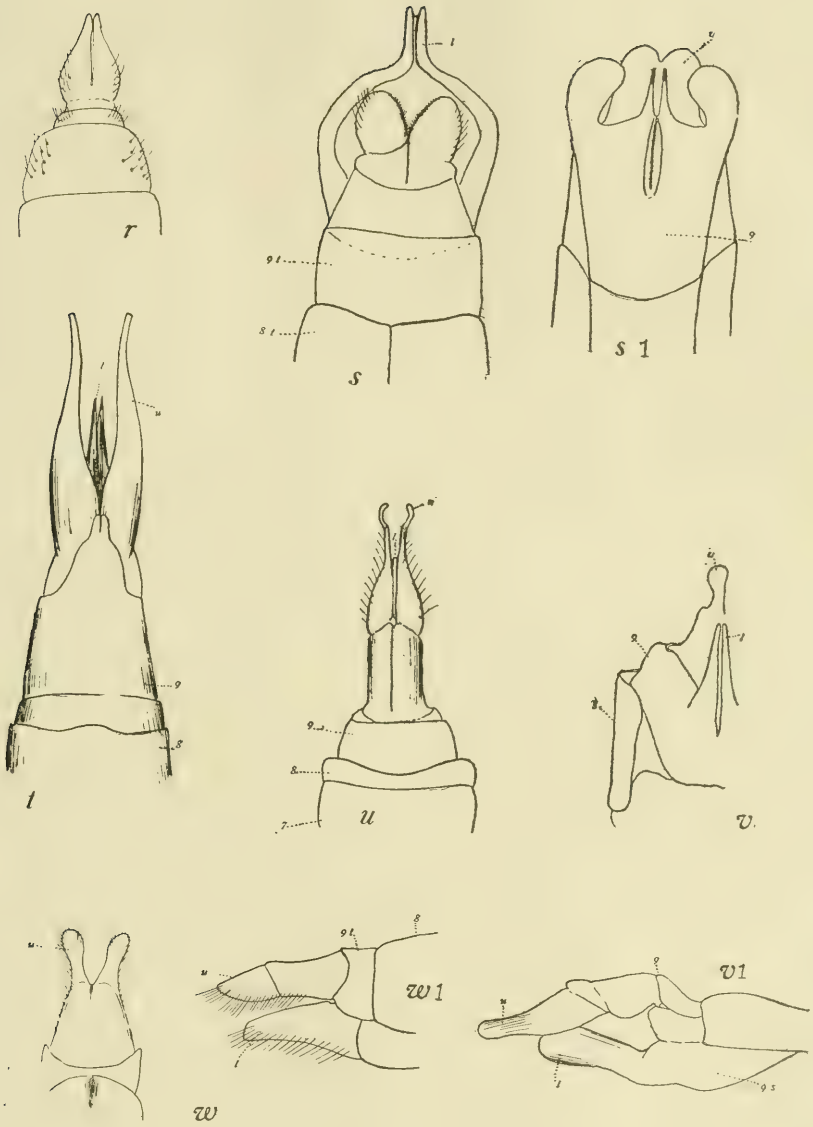

C. P. Alexander.

LIFE HISTORY AND HABITS OF TROGODERMA TARSALE (MELSH.), A MUSEUM PEST.

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CONTENTS.

1. Description.

H. F. Jayne (1882) in his "Revision of the Dermestidæ of the United States" gives the following description of *Trogoderma tarsale*, which he says is identical with *T. inclusum*:

"T. inclusum (Lec.)—Oval, somewhat oblong, black, clothed with moderately long, semi-erect black pubescence. Elytra with four sinuous confluent bands of red, bearing whitish pubescence. Head coarsely and densely punctured, quite sparsely pubescent. Eyes deeply emarginate in front, not very prominent. Antennæ testaceous. Thorax finely punctate, moderately pubescent. Elytra black, with four irregular bands of red, bearing grayish pubescence, the rest with sparse black pubescence, coarsely punctate. Body beneath piceous, coarsely punctate, with cinereous recumbent pubescence. Antennal fossa deep, occupying nearly all the space between the front and lateral margins. Prosternum short, moderately wide, convex, not carinate. Abdominal segments rufous, apical margins paler, pubescent. Legs rufo-testaceous. Length .08—.16 inch; 2—4 mm. Male antennal joints 1 and 2 large, 3—4 very small, 5—11 forming the club, which is not deeply pectinate.

"Female. Antennal joints 1 and 2 large, 3—7 small, 8—11 forming the club. T. tarsale and T. pallipes are identical with this species."

F. H. Snow (1882) gives the following description of the larva and pupa. "In Dr. Hagen's list of Museum pests observed in Cambridge," published in the Proceedings of the Boston Society of Natural History, Vol. XX, I find no mention of the above species, and in order that eastern collectors may guard against its introduction into their cabinets I give the following brief description of its larva and pupa.

LARVA.

"Measurements, when full grown: Length, exclusive of caudal hairs, 5.4 mm.; inclusive of caudal hairs, 8 mm.; breadth, 1.6 mm. Upper dermal surface reddish brown; lower surface vitreous white; entire surface covered with short, soft, yellowish brown hairs; each stigmatic orifice surrounded by a stellate tuft of longer setose hairs, of variable length and of the same color as the general hairy covering. The upper surface of the last three segments is entirely concealed by a dense mass of short, erect dark brown hairs so nearly equal in length as to present the appearance of having been cut off with shears, like the bristles of a very compact brush. The sides of the upper surface of the two preceding segments have a similar covering. The two caudal appendages, which attain one-half the length of the body are noticeably separated when the larva is in motion, often appear to the eye to consist each of a single, stout, elongated bristle, but, under the microscope, are seen to be composed in each case of from twenty to twenty-five hairs.

PUPA.

"Length, 4 mm.; breadth, 2 mm.

"Enclosed within the larval skin, and visible only from above, where the larval skin is longitudinally split open along the median dorsal line from head to anal segment. Abruptly narrows to a point at the anal extremity. Removed from larval skin, the entire surface of the pupa is seen to be covered with short, soft, light yellowish brown hairs, except at the center of dorsal surface which contains three minute transverse incisions or furrows. The anterior margin of each furrow is straight while the posterior margin is curved. Examined under the microscope, both margins of each incision are seen to be minutely dentate, but the teeth of the posterior margins are more prominent than those of the anterior margins."

Dr. Snow has apparently obtained and measured larvæ of the average size, for the larvæ attain a much larger size than 5.4 mm. We have collected and raised a large number of specimens which have attained the size of 7 mm., and not infrequently do we obtain larvæ as long as 8 mm., exclusive of the caudal hairs, and 10 mm. including the caudal hairs. The breadth of such specimens is 2.5 mm. Very frequently in the full grown larvæ the upper surface of the last five segments is entirely concealed by the dense mass of hairs and the sides of the upper surface of as many as four of the preceding segments have a similar covering.

The life history of T. tarsale has never been worked out, and a few scattered notes, most of which are subsequently quoted in this paper, comprise the literature on this well known museum pest.

2. Distribution and Damages.

C. V. Riley (1883) says, "It is in fact the most common museum pest in this country and it is strange that Dr. Hagen in his paper on museum pests does not mention it. It is by no means peculiar to the West as the Professor seems to suppose. Here in Washington it is by far the most dangerous enemy to insect collections, and much more frequent than Anthrenus varius. In the field its larva is occasionally found in the cracks of hollow trees and similar situations, feeding on dead insects, but it is far more common in the deserted cells of Pelopoeus, Odynerus, Anthophora and other Hymenoptera, that store their cells with spiders or other insects."

The various notes on this beetle plainly indicate that in the United States it is distributed from coast to coast, and that it is especially abundant in the northern states. As a museum pest no other beetle can do more harm than T. tarsale which when once introduced into a building, is by no means easy to exterminate. Mounted insects especially suffer from the pest and large collections are often wholly destroyed by the larvæ. Here at the University of Wisconsin, as well as in numerous other places, in spite of the great pains taken in frequently inspecting the insect boxes, and in keeping them tightly covered, a large number of useful as well as rare specimens belonging to Dr. William S. Marshall are annually destroyed by the larvæ. Dr. Marshall says that they have even entered Riker mounts and eaten the insects contained therein. Not only do the larvæ attack animal matter such as dried insects, cocoons, furs, skins, wool, feathers, etc., but very frequently they are found devouring vegetable matter as cereals, seeds of all sorts, nuts, and even spices. In the University Drug Collection they were found by the thousands devouring flax and cotton seeds which had been stored away for a long time.

F. H. Chittenden (1895) in a paper on some Dermestidæ says, "T. tarsale Melsh., a common museum pest, was found to infest flax seed, castor beans, and cayenne pepper that had been on exhibition in the museum of the U. S. Dept. of Agric., the larvæ being reared from the eggs deposited in these substances and the adults having been bred from other larvæ feeding on them."

L. O. Howard (1904) in the extracts from correspondence gives the following note: "Dr. George S. Yingling, Tiffin, Ohio, sent to this office (U. S. Dept. of Agric.) with accompanying letter dated May 30, 1903, a glass charm with sterling silver band, inclosing a common French beetle, frequently used as an ornament, together with larva of the cabinet beetle (T. tarsale) which was destroying it. By careful examination of the top of the charm it was seen that there was a crack large enough for the admission of the larva when it was young."

Another note, found in Insect Life (1894) is as follows: "Trogoderma tarsale (Melsh.). Breeding by thousands in silkworm cocoons in the U. S. Gov't Bldg,, a well-known museum pest, probably identical with European species."

3. Life History.

T. tarsale may be found in all stages of development throughout the year in well-heated buildings. Under favorable conditions such as are found in the average museum, with the ordinary room temperature and plenty of food, I have obtained two and a partial third generation in one year. Some of the specimens which hatched in January metamorphosed in June and some of their young in turn matured and laid eggs in October, thus giving rise to a third generation before the end of the year.

The beetles usually pair on the day following their emergence from the pupal skins. The eggs, varying in number from as few as three to as many as sixty, are laid in convenient places from three to five days after copulation. The young larvæ hatch from ten to fourteen days later, the time depending largely on temperature. Under ordinary room temperature they hatch on the average in twelve days. The larvæ, almost immediately after hatching, begin to feed on the material at hand and, as a rule, do not wander unless the food is decidedly poor or scarce. Quite frequently a large number of them hatch in the same insect which had reared the parents and very seldom they desert it until it is almost completely devoured.

In one case eighty-six larvæ hatched in the dry body of a May-beetle (*Lachnosterna*) in which the parents had completed their life history, and, although several other dried insects were present in the same small dish, they were not attacked until the May-beetle was almost completely devoured. The

growth of the larva depends to a considerable extent on temperature and the abundance of food, and it is retarded by cold weather and scarcity of nourishment.

The foregoing factors, however, are not always the cause of slow development. I have noticed that in almost every brood there is a wide variation in the growth of the various specimens under identical external conditions. Very often some specimens attain full size, metamorphose, and produce young long before others are half grown; but not infrequently do these young overtake the other members of their parent group and even reach maturity much sooner under the same conditions. The small, oblong, white eggs are apparently all of the same size and yet some of the larvæ hatching from them seem to be unable to get started in their development. The majority of the specimens, however, mature in about the same length of time, which is from five to six months.

Another very interesting thing which occurred regularly in these studies is the fact that frequently some individuals attain an apparently full size within a comparatively short time, but do not enter the pupal stage for a surprisingly long period thereafter. These larvæ are active, continue to feed, and are normal in their behavior, but there must somewhere be a cause for the sudden halt in their development. We are keeping in the laboratory a large number of larvæ which have been full-grown for over two years, and even very favorable conditions do not seem to effect a metamorphosis. A number of specimens are being kept under different conditions, but thus far nothing entirely conclusive has been obtained.

Summary of Variations in the Life History of Different Individuals of the Same Generation.

1. The adults lay eggs from three to seven days after emergence.
2. The number of eggs laid by different individuals varies from five to sixty-two in number.
3. The eggs hatch in ten to sixteen days, depending largely on temperature.
4. Larval life lasts from five to forty months or more.*
5. The time of pupation is from eleven to seventeen days.
6. The age of adults varies from ten to thirty-two days.

*At present we have a number of live larvæ which have lived forty months.

4. Moulting.

There is an extremely wide variation in the rate of moulting and the number of larval skins shed by the different individuals of this species. In general, under normal conditions, the larvæ moult once in about every two weeks, but there are many peculiarities worthy of mention. The same specimen often sheds its skin very irregularly, sometimes within ten days and then again, under practically the same conditions, not until a period of three weeks or more has elapsed. In general, growing individuals moult more frequently than do those which have attained their full size. Specimens which are slow in their development, as a rule moult less frequently than do the larvæ which develop at the average rate. Not infrequently, however, does a decidedly slow growing specimen moult almost regularly once in every two weeks. The full grown larvæ, previously spoken of, which continue to live for a long time before entering the pupal stage, have, in general, a decidedly slow rate of ecdysis. The average rate is about once in every four weeks and this gradually decreases as the specimen grows older; but here again there is a wide variation, the different specimens moulting once in a period of time which varies from three to nine weeks.

Thus we see that the number of moults is by no means constant. The majority of the specimens which complete their life history in about five months shed their skins from eight to twelve times, whereas, many of the individuals with the prolonged larval history moulted more than twenty times. The greatest number of moults which I have recorded to the present time for any individual is thirty-two, but the number will probably be much greater as these larvæ are still alive and in apparently good condition.

The larvæ never eat their own skins nor the skins of other individuals of this species, even though they may be in a starving condition. This was conclusively proved by placing specimens singly, or in numbers, in glass vials for the purpose of starving the larvæ, and even after many months of starvation, and after the larvæ had moulted several times, the skins were never atacked.

Shortly before moulting the specimen becomes inactive, and a split soon appears in the larval skin along the median dorsal

line; this extends from the head, through the thorax and partly down the abdomen. The larva bends over and assumes a semicircular position which permits the extrication of the thorax and head. The legs are then pulled out of their coverings and the light colored larva crawls out of the exuvia. Its new, soft, chitinous covering soon hardens and assumes the natural yellowish brown color within a few hours.

C. V. Riley (1883) in an article on the number of moults and length of larval life as influenced by food, says, "Since March 13, 1879, we have kept two larvæ of that common museum pest (Trogoderma tarsale) in a light tin box with an old silkworm cocoon. They were half grown when placed in the box. On Nov. 8, 1880, there were in the box twenty-eight larval skins, all very much of a size, the larvæ having apparently grown but little. The skins were removed and the box closed again as tightly as possible. Recently, or after a lapse of two years, the box was again opened and we found one of the larvæ dead and shriveled up, but the other was living and apparently not changed in appearance. There were fifteen larva skins in the box. We cannot tell when the one larva died, but it is certain that within a little more than three and one-third years two larvæ shed not less than 43 skins, and that one larva did not, during that time, appreciably increase in size.

"We know of no observations which indicate the normal or average length of life or number of molts in either Tenebrio or Trogoderma, but it is safe to assume from what is known, in these respects, of allied species, that in both the instances here referred to, but particularly in the case of Trogoderma, development was retarded by insufficient nutrition and that the frequent molting and slow growth resulted therefrom and were correlated."

My observations and numerous experiments on the starvation of T. tarsale do not corroborate Riley's statement that insufficient nutrition of larvæ in all stages of development show that a lack of nutrition retards the frequency of moulting. Specimens which ordinarily on favorable diet moulted once in two weeks, moulted on the average less than half as frequently when deprived of food.

Summary of Variations in Moulting.

1. Larvæ shed their first skin from four to nine days after hatching.

2. The period between the next succeeding moults, in growing individuals, varies from nine to thirty-six days.

3. The number of moults in different individuals varies from eight to thirty-two or more.*

4. The rate of moulting in full grown larvæ, more than one year old, is once in eighteen to sixty-five days.

5. Specimens under starvation moult once in fourteen to seventy-eight days.

5. Pupation.

When the larva reaches full growth the pupa begins to form within the last larval skin; and from three to five days later the skin splits down the median dorsal line and the light-yellowish pupa is exposed. The period of pupation lasts from eleven to seventeen days, though this may be considerably increased by low temperature, and we have noticed that the males are somewhat more precocious than the females. When the insects are fully developed they emerge through the large dorsal opening of the pupal skin. Should a specimen be forced out of the larval case when not fully matured though capable of locomotion, it invariably returns to its former position within the protective larval skin upon coming in contact with it. The females, after their elytra attain the dark adult color, usually remain in the pupal cases a day or two longer than the males. The average life of the adult insect lasts about three weeks.

6. Courtship and Mating.

The females, on the day of their emergence, avoid the male specimens, but the following day or later they become submissive and copulation takes place. The male on coming in contact with a sexually excited female rubs his antennæ against her abdomen and then quickly turning around brings the point of his abdomen in contact with that of the female. Promiscuous mating is general; a male usually impregnates a number of females and a female usually accepts several males. It might be well in this connection to mention the fact that the sense of smell is not well developed in this species. Experimental work shows that male specimens are unaware of the presence of sexually excited females, even when they are but a very short distance apart.

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*Some of the larvæ previously mentioned as having already lived almost three and a half years, have up to the present time moulted thirty-two times.

A large number of females, immediately after the completion of metamorphosis, were placed in separate vials and not allowed to be fertilized. In a single case only were there any eggs laid and those were only three in number. The life of non-pregnant females is, in general, somewhat prolonged. It was also found that extremely small female specimens are sterile.

7. Feeding.

The wide variety of substances upon which this species can subsist has already been mentioned when speaking of their ravages, but it might be well to give the relative value of some of the substances as food for the larvæ. The pests seem to thrive best on dried insects and fish, and although they can live on wool and feathers their growth is decidedly slow when they feed on these materials. A number of specimens immediately after hatching were placed on a feather diet and, although they are now over two years old, they have grown but very little, When they were a year old they were very little larger than the newly hatched individuals, and at the end of the second year of life, they reached a meager size equal to that which specimens fed on insects ordinarily attain in two weeks. Their development on wool is even slower.

F. H. Chittenden (1897) says, "One jar of flaxseed from the museum exhibit of the department is infested chiefly by this common museum pest. Many of the larvæ may be seen through the glass, and large patches of their yellowish-brown gnawings and excrement show where they have been at work. In castor beans a few larvæ were present.

"That these species of Trogoderma can subsist on a vegetable diet is as positive as it is surprising. No other Coleoptera to my knowledge live on oil seeds, and I had nearly arrived at the conclusion that as this form of matter was the nearest approach to animal food available, that these insects could only thrive on such vegetable substances as contain a considerable portion of oleaginous matter. Judge of my astonishment, then, when a few weeks after the discovery of the Trogoderma living in oil seeds, Dr. Howard brought me a box nearly full of cayenne pepper in which were several Trogoderma larvæ. The most careful search failed to show even fragments of that well-known red pepper pest, Sitodrepa panicea, or of any other insect than the dermestid. Subsequently the adult was reared and proved to be Trogoderma tarsale.

"It seeming desirable to ascertain if this species would breed on so pungent a substance as cayenne pepper, a few adults were confined with a quantity of this condiment. In due time larvæ appeared and when examined August 20, or nearly ten weeks from the time the eggs were deposited, were in vigorous condition, the average individual measuring a tenth of an inch in length, or about half that of the full-grown larva. Toward the end of September, while passing through the museum of this department, my attention was attracted by an accumulation of powder and dust about the edges of an exhibit of peanut oil cake, and another of Indian turnip bulbs. A great number of the larvæ and their cast skins were found under and on the under surface of the cakes; also in flour and meal prepared from peanuts. The Indian turnip bulbs were very old and dry, and might have been on exhibition twenty years or more.

"When this insect infests a substance of similar color and consistency to flour and meal only a few larvæ are sufficient, on account of their extraordinary habit of frequently molting, to occasion alarm. In fact, appearances are much worse than the reality. Thus, in a small box of peanut meal in which these larvæ had taken up their abode, about forty larval skins had accumulated when examined September 27, completely covering one-half of the surface of the meal, and giving the impression of a whole colony of the insects.

"After the experiences narrated I was prepared for almost anything, and was expecting that as this species was as nearly omnivorous as the preceding, it would in time be found like them to be granivorous. Having convinced myself by the process of 'reasoning by analogy' that the insect *must* be a grain feeder, I had resolved to experiment with a view of ascertaining if the species would feed upon cereal food. A compulsory delay of a few days saved me the trouble. While the Division of Entomology was moving into new quarters a bag of "Saskatchewan fif" spring wheat, formerly kept in stock for gratuitous distribution, and described on the label as a hard, amber variety with an exceedingly heavy grain, was unearthed, in which the larva of this insect was living, there being present no other insects except a colony of Anthrenus and a single stray Silvanus. In fact, this grain is so hard and flinty that weevils would not flourish on it.

"Soon afterwards I found larvæ in another lot of wheat infested with Silvanus, and in corn containing *Calandra oryza* and other small beetles. About the same time, Mr. Frank Benton brought me larvæ found in beehives, where they apparently fed upon propolis, or bee glue. There are several recorded instances of *Dermestes lardarius* feeding upon wax,* or, more properly speaking, honeycomb, and it is therefore fairly certain that Trogoderma has the same habit, although not previously reported in beehives.

"Among the divisional notes I find one recording the receipt of six larvæ of this species in a box of red pepper, from a correspondent in Utah, November 22, 1882. These larvæ were kept in the box of pepper for a year, at which time fifty-four cast skins were noticed. The box was examined January 14, 1887, or over four years from the time of its receipt, when two larvæ and seventy more cast skins were found, but no trace of beetles, although it had been kept closed, so that it was impossible for either larvæ or adults to escape. It is very obvious that four larvæ, or the beetles that developed from them, had died in the interim and were then devoured by their fellows. In any case, the adult was not reared, and no published statement was made of the larva having been found living in the condiment.

"The capability of this species to breed in other seeds was demonstrated by the discovery of the larvæ living upon "kolu", an edible leguminous seed somewhat resembling a cowpea. The insect had evidently been first attracted by the dead bodies of the original inhabitant of the seeds, the weavil, *Bruchus chinensis*, but had afterwards fed upon the seeds, even hollowing them out and leaving only the empty shells. In a similar manner, larvæ were found, together with those of Attagenus, in millet and pumpkin seeds that had formerly been inhabited by the polyphagous Indian-meal moth, *Plodia interpunctella*."†

In the case of the six larvæ found in the red pepper it is not likely that four of them metamorphosed, because if they had it is certain that they would not have been entirely devoured by

*See Lintner's 6th Report, pp. 122–123; Dubini (L'Ape e il suo Governo, 1881, p. 266.)"

"†Since the preparation of this paper was completed Dr. John Hamilton has recorded the breeding of Trogoderma tarsale in packed figs (Canadian Entomologist, Vol. XXVIII, p. 262, Oct., 1896)."

their fellows. The hard chitinous covering and the elytræ are never completely devoured even by starving specimens. It is much more probable that they died in the larval stage and were later devoured by the other two larvæ; or they might have shrivelled up and darkened, and were thus easily overlooked. That the two larvæ which were present four years later were two of the original six is highly probable. There are several larvæ in our laboratory which were obtained three years ago, when they were full grown, and they have apparently not changed any since.

8. Variation in Size. Among the Adults.

The adult male specimens are smaller, as a rule, than the female insects, but the small individuals are not necessarily always males. There is an extemely wide variation in the sizes of both sexes which in the adult stage vary from 1.25 mm. to 4 mm. in length, the width also being proportionate. It is difficult to determine just what is the cause of such a pronounced difference. Although poor nutrition gives rise, in general, to smaller insects, very small individuals also appear among the large ones which have lived under very favorable conditions. A marked variation in size of the different larvæ of the same brood is apparent within a few days after they hatch. Observations show, however, that the small, slowly developing larvæ do not always give rise to small adults, as in some cases it is merely a matter of taking more time for development.

9. Phototactic Reactions and Death Feigning.

The larvæ immediately after hatching manifest a strong negative reaction to light, concealing themselves in any available shaded area. If placed near a window they at once begin to crawl away from the light, and the reaction is even more pronounced when the specimens are taken into a dark room and a strong light is introduced at one end of the glass dish containing them. This negative phototaxis persists throughout the larval life, and just before the larvæ pass into the pupal stage the reaction becomes even more pronounced. Thus, the pupæ are almost invariably found in dark places which afford them a favorable means of protection.

The adults, both male and female, usually retain their negative response to light after emerging from their pupal skins.

During the period of sexual excitement which follows a day or two later the insects are still negative and the females remain decidedly so until their eggs are safely deposited. Several hours later, or the day following the egg-laying, they gradually become indifferent to light and finally a complete reversal of their former reaction follows. The males, too, become positively phototactic during the last days of their lives. Although ordinarily the adults remain in the cabinets where they had developed till death occurs, we find some occasionally on the windows in the rooms where they make their abode. A number of such specimens were at different times collected and dissected, but in no case were there any eggs found within the bodies of the females. This also indicates that the females lay their eggs before they reverse their reaction to light and desert their places of concealment, and apparently their destruction as a museum pest at this late stage is futile.

The larvæ in all stages of development feign death when disturbed. The period of death feigning, however, is very short, lasting only half a minute at the most and usually only a few seconds. If the disturbance is continued they no longer respond in the same manner. The adult insects when disturbed fold up their legs and antennæ and feign death for a much longer time than do the larvæ; the average feint lasting only about half a minute; but specimens frequently feign death as long as fifteen minutes. This reaction in the adults, too, wears out if the disturbance is repeated.

10. Results of Experiments on Starvation of the Larvæ.

The most interesting feature of the studies on T. tarsale is the extremely long period of time that the larvæ can go without food. Even the newly hatched specimens which never had a morsel of food to eat live as long as four months. Many of the older larvæ, which are being kept in the laboratory, have not had a particle of food during the surprisingly long period of a whole year and are still alive and active; and at this stage of the experiment it is not possible to say just how long the larvæ in various stages of development are able to exist under such conditions.

A large number of larvæ of at least eight representative stages, varying from newly hatched to full grown individuals were collected and placed in covered glass vials, without any food whatsoever, for the purpose of starvation.

Ten larvæ of each representative stage, varying from full grown to newly hatched specimens, were placed in individual vials and also a large number of all the possible combinations in two were made. For example, eight full grown larvæ 7 mm. long were placed in eight different vials and together with each of these was placed one individual of each of the other representative stages. Thus, we had a vial containing two full grown larvæ, one containing a full grown and a larva about 6 mm. in length, and so on down the series with a gradually greater and greater difference in the size of the two larvæ within the same vial, until the last one contained both a full grown and a newly hatched larva.

The same process was repeated with a larva of 6 mm., 5 mm., and so on, to the larva 1 mm. in length, and thus all the possible combinations between the larvæ of practically all sizes were made. The additional purpose of this latter experiment was to determine the extent of cannibalism among the species.

Three such large groups of vials, as that described above, were made and each was placed under somewhat different conditions. One group was exposed to day-light in the laboratory, another was kept continually in the dark, and the third in a box under a constant thirty-five candle power electric light. The last mentioned group of larvæ had a somewhat higher temperature caused by the presence of the electric light in the box.

Measurements of all the individuals were made and a careful record is being kept. The vials are examined regularly and measurements of the several individuals of each representative stage are taken and recorded. A record of the cast skins is also kept; from some of the vials the exuviæ are removed as soon as shed and in others they are allowed to remain continually for the purpose of determining whether the larvæ ever eat them. It was found that the larvæ never devour their own nor the skins of other specimens. There is absolutely no evidence of cannibalism among the larvæ; even the full grown starving specimens never attack the much smaller individuals. Practically all of the insects shed their skins shortly after they were placed without food; but between the other following ecdyses a period much longer than the normal elapsed. Careful measurements soon revealed the surprising fact that the larvæ were actually decreasing in size. In all

three of the groups many of the specimens which were less than half grown, or 3 mm. in length, at the beginning of the experiment, had reduced within about six or seven months to the minimum size of 1 mm. in length. Many of the full grown larvæ which were 7 mm. in length have fallen back to less than half this size within one year of starvation; others decrease less rapidly, some having lost only 2 mm. during the same long time. The larvæ under the constant electric light had a somewhat higher temperature and decreased more rapidly than did those of either of the other two groups; Even some of the full grown larvæ of this group had actually reduced their size within eleven months to practically the same measurements they had upon hatching, about 1 mm., and then finally died. The results of these experiments will be published in detail as soon as they are completed.

I wish to express my thanks to Prof. William S. Marshall for his suggestions and kind criticisms in preparing this paper.

Zoological Laboratory, Univ. of Wisconsin,
October 15, 1912.

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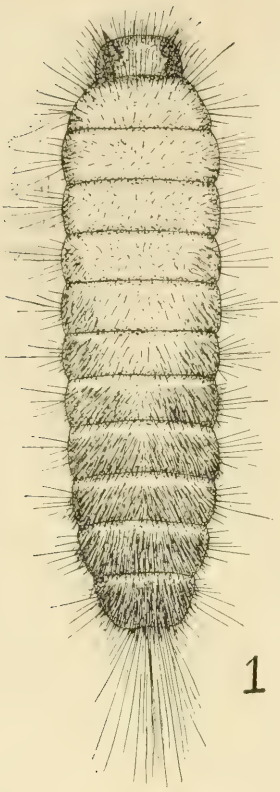
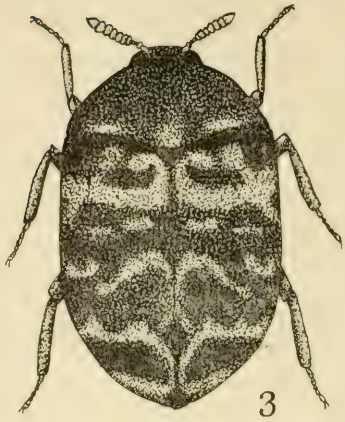
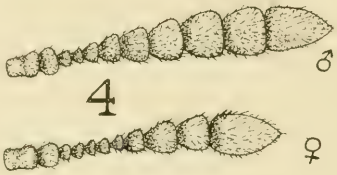
EXPLANATION OF PLATE XXVII.

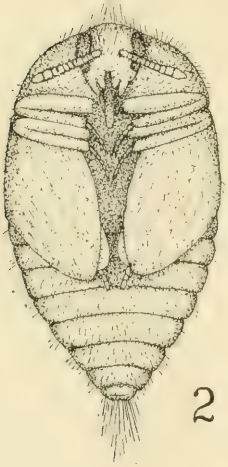
All drawings (except Fig. 4) made with a camera lucida. x 10. Stages in the Life History of Trogoderma tarsale (Melsh.)

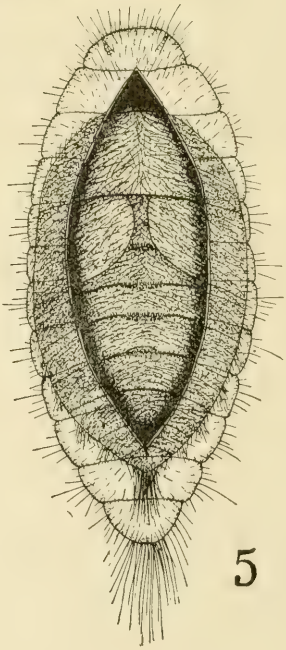
Fig. 1. A full grown larva.
Fig. 2. Ventral view of pupa removed from the pupal case.
Fig. 3. Adult male.
Fig. 4. Male and female antennæ.
Fig. 5. Dorsal view of pupa as seen through the split in the pupal skin.











J. E. Wodsedalek.

THE INTERNAL ANATOMY OF ICERYA PURCHASI.

Carl E. Johnston, Stanford University, California.

The external anatomy, habits and life history of *Icerya purchasi* are well known through the work of Riley, Comstock and others. The present paper contains notes on the internal anatomy of the female, certain details of which depart from any Coccid anatomy previously described.

This work was done in the Entomological Laboratory of Stanford University.

MOUTH PARTS.

(Plate XXVIII, Fig. 1.)

The essential features of the mouth parts of *Icerya purchasi* are the internal chitinous framework, pharynx, and labial cavity, the buccal setæ, and the external labium. The framework lies on the ventral body wall in a median line opposite the bases of the fore legs, only the posterior ventral side being exposed. The bases of the setæ and the pharynx are contained in the typical Coccid chitinized box-like structure, lying between two indefinitely five-sided areas. The lower plane, or area inferior, is considerably the larger. It is bounded on the front by the arcus formed by the fusion of the interior end of the costæ superiores and the costæ inferiores, and on the side by the right and left costæ inferiores, each of these, consisting of two parts, articulating with it. (Pl. XXVIII, fig. 1 b). The posterior end of each costa inferior joins with the corresponding part of each costa superior to form the clavus. (Pl. XXVIII, fig. 1 u).

On each side, joining the costæ as shown at the point b in fig. 1 of Plate XXVIII, and running ventrad toward the costæ superiores, is a chitinous piece, L, which branches just before reaching these costæ. One branch goes ventrad a short distance, lying free in the cavity; the other branch extends a little way caudad and serves as a support for the conical base of one of the setæ.

The upper plane, or area superior, is bounded on the front by the same fused arcus that bounds the lower area. On the sides it is bounded by the costæ superiores, each of which

consists of an anterior and posterior part, fused or articulated at the point o. A heavily chitinized plate, t, connects the entire lower halves of the costæ superiores.

The setæ consist of four very long, slender, solid rods, the bases of each being enlarged and forming an elongated cone, s, — s. Two of these cones lie on either side of the box, one pair being supported by branches from the piece l. The other pair of cones is supported by a heavily chitinized elongated structure, x, arising from the posterior surface (base) of the framework, and standing up within it, its anterior end being just above the point of articulation of the upper and lower halves of the costæ, and lying free within the cavity. Between the conical bases of the setæ and arising from the clavus is a short cone-shaped organ, lying just below the pharynx and œsophagus and possibly serving to protect them.

The four setæ come together at the clavus and are appressed to form a tube. This tube then passes backward into a long transparent pocket, the labial cavity, c. This pouch lies in the body cavity next to the ventral body wall, running back to the fourth segment. The tube extends the entire length of the labial cavity and forms a loop, returning to the point of entrance and passing out of the body through the labium.

The labium, z, is an external organ and does not have much movement except a slight backward and forward motion. It is a heavily chitinized, more or less heart-shaped structure, the lateral halves of which, originally separate, have been fused together. The setæ pass through the center and upper part of the labium and pass out of the lower or apical end. The labium is heavily musculated, and at its external opening a cross section shows a ridged or serrated structure.

ALIMENTARY CANAL.

(Plate XXVIII, Figs. 3 and 4.)

The œsophagus is long and slender, widening out as it approaches the proventriculus. It is strongly musculated with circular muscles, the inner wall consisting of a layer of small single-nucleated cells. Passing upward and backward it goes through the œsophageal commissures and enlarges into the proventriculus. Back of the proventriculus is the ventriculus proper.

The parent digestive cells of the ventriculus contain as many as five nuclei each, and there can be seen free cells in the ventriculus which have been given off from the attached parent cells. These free cells possibly assist in digesting the food.

The ventriculus runs back a short distance farther to about the junction of the sixth and seventh segments, and then turns abruptly and runs forward well past the junction of the œsophagus and the proventriculus. Here it makes a couple of turns, going backward and then forward to its junction with the ileum, at which point it widens out for a short distance.

The ileum is very short and is small in diameter. The colon is largest at its anterior end and then, growing smaller, runs backward and finally merges into the rectum. The rectum is in the seventh abdominal segment, and the anal opening is on the dorsal surface of this segment.

Salivary Glands. (Plate XXVIII, fig. 2).

The salivary glands are located on each side of the chitinized box of the mouthparts. There is one gland on each side, made up of three spherical cells, heavily nucleated. A duct, carrying the secretion, leads from each gland to the mouth.

Malpighian Tubules. (Plate XXVIII, fig. 3).

The malpighian tubules are three in number, convuluted and considerably longer than the intestine from its point of junction with the œsophagus to its most posterior point. The tubules are very dense, with heavily nucleated cells, and besides being convuluted, are curved to a certain extent at their posterior ends, and seem to be fastened to the ventriculus by a few very fine muscular fibres.

RESPIRATORY SYSTEM.

(Plate XXVIII, Fig. 7.)

There are two pairs of spiracles, the first pair being located on the ventral side of the prothorax, posterior to the anterior pair of legs, and the second pair between the meso- and metathorax on the ventral side posterior to the middle pair of legs. A groove extends from each spiracle to the margin.

Each spiracle has a somewhat kidney-shaped funnel-like opening, very strongly chitinized. A large trachea extends in from each spiracle on either side; this soon divides into three main tracheæ in the anterior system and four in the posterior

system. The anterior system of tracheæ soon re-divides many times. One of the secondary divisions forms, with the similar division of the opposite trachea, a transverse trunk just behind the chitinized box supporting the mouthparts. The other branches go to the antennæ and to the fore and mid legs and anterior part of the body.

From each spiracle of the posterior system four branches are given off, two very large, one smaller and one very small. These subdivide many times but, as far as could be determined, there is no connecting trunk between the two posterior tracheal systems. These posterior systems supply the hind legs, alimentary canal, reproductive system and all of the posterior portion of the body.

CIRCULATORY SYSTEM.

No definite dorsal vessel was found. The blood probably simply circulates through the open body cavity.

NERVOUS SYSTEM.

The nervous system consists of two large fused ganglia, lying ventrally in a median position and several nerves connected with these ganglia. The cephalic ganglion lies above and largely in front of the framework of the mouthparts. Its anterior and principal portion is large and triangular in shape and is distinctly bilaterally depressed into two large lobes. The posterior portion of the ganglion greatly diminishes in size and divides into two commissures, passing around the œsophagus.

From the under part of the central and most anterior portion of each lobe in the anterior part of the cephalic ganglion a small nerve runs to the antenna and from the anterior angles of each lobe and laterad of each antennal nerve the optic nerves proceed to the eyes.

The œsophageal commissures continue backward, passing above the fused arcus and gradually re-uniting and enlarging into the thoracic or infra-œsophageal ganglion. The thoracic ganglion is slightly depressed above the mid-dorsal and mid-ventral line. There are four very obvious transverse divisions, making in all four double-lobed parts or divisions of the thoracic ganglion. The posterior division is somewhat narrower and possibly more plainly divided than are the three

preceding ganglia. These "lines of division" are really, probably, lines of fusion of pairs of ventral ganglia distinct in embryonic life.

No nerves were found issuing from the first ganglion. From the second and third thoracic ganglia, rather large and prominent nerves proceed at nearly right angles. From the posterior division, two long, slender nerves extend back into the sixth or seventh abdominal segment, dividing along their course into three or four smaller nerves which run backward parallel to these posterior divisions.

REPRODUCTIVE ORGANS.

(Plate XXVIII, Fig. 5.)

The reproductive organs of the female consist of the ovaries, oviduct, vagina, spermatheca and vulva. The ovaries are very curiously developed in this insect. Instead of the customary pair of separate ones, lying one on either side of the alimentary canal and running caudad to unite in a common duct, ending in the vagina, the two ovaries are found united. No anterior division can be found and the whole forms a loop united by a continuous membrane. The posterior ends unite, forming the vagina, and run ventrad to the external opening. This oviduct widens and narrows with no apparent regularity. The ovarioles are fastened to the oviduct throughout its anterior half. They are not found on the posterior ends of the loop, but the point where they stop is not clearly defined. In some specimens it is much nearer the vagina than in others. The ovarioles are given off from the oviduct either as single expansions connected by a long, slender tube, or in bunches or groups of from two to eight or ten. Usually the connecting tube is longer where there is but a single ovariole than where there are several. The larger ovarioles are all given off singly, while the clusters occur as a number of much smaller ovarioles. Each ovariole, no matter what its size may be, is more or less oval in shape, and at its distal end there is always a constriction and a head, fitting the larger part of the ovariole like a circular cap.

The spermatheca is a transparent pouch given off midway of the vagina. The vulva is a strongly musculated, oval, external orifice.

WAX GLANDS.

(Plate XXVIII, Fig. 6.)

The wax glands are scattered pretty well over the body, especially on the dorsal aspect of the thorax and on the dorsal and lateral aspect of the last three segments of the abdomen.

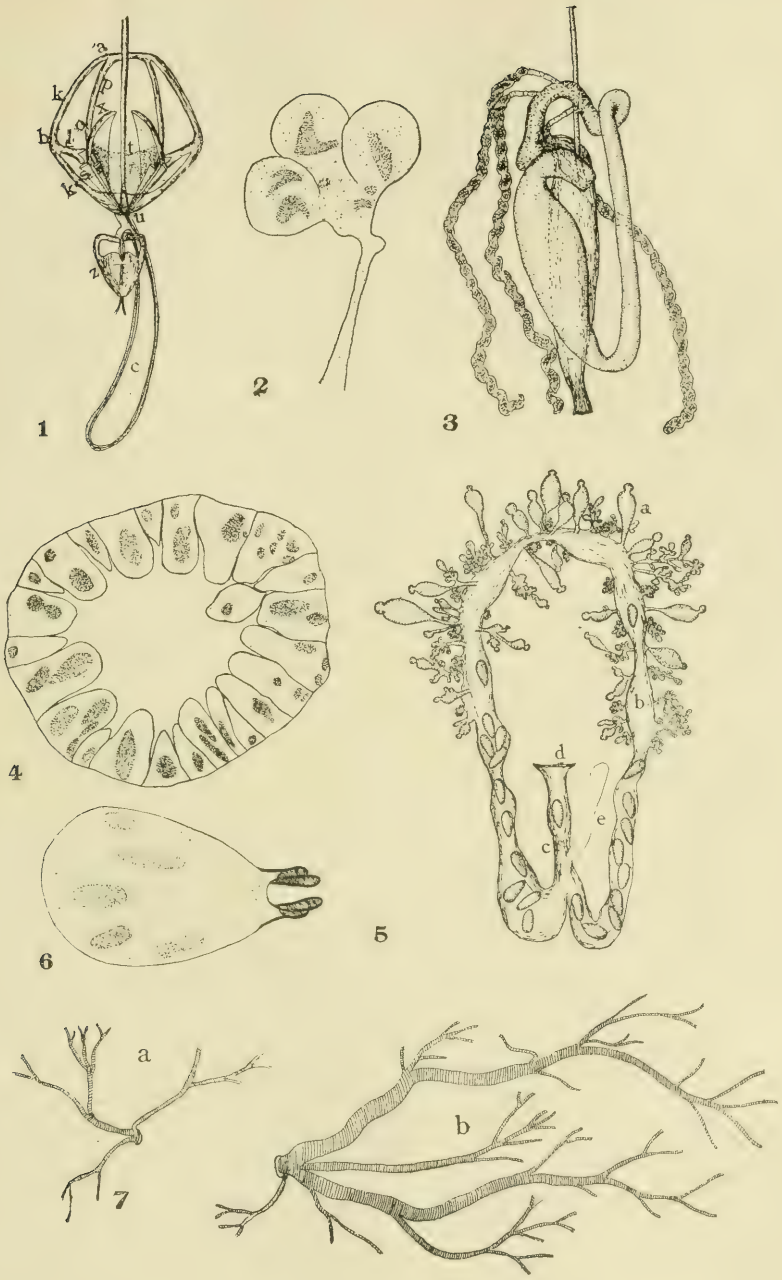
There are two kinds of glands, the most numerous consisting of a single more or less balloon-shaped or oval cell with an external chitinized pore. This cell contains several nuclei and very faint longitudinal divisions, each division containing one of these nuclei. The external pore is very heavily chitinized, and is more or less horse-shoe-shaped with semi-circular chitinized structures lying on each side of the horse shoe.

The second kind of wax glands has the chitinized pore or tubercle prolonged into a long, stout spine at the base of which is a cup-shaped secretory gland.

EXPLANATION OF PLATE XXVIII.

Anatomy of **Icerya purchasi.**

Fig. 1: Mouthparts.
Fig. 2. Salivary glands.
Fig. 3. Alimentary canal and malpighian tubules.
Fig. 4. Cross section of ventriculus.
Fig. 5. Reproductive system.
Fig. 6. Wax gland.
Fig. 7. Respiratory system; a, anterior aspircle and trachæa; b, posterior spiracle and trachæa.



C. E. Johnston.

DEATH FEIGNING IN CONOTRACHELUS NENUPHAR HERBST.

Wilson P. Gee and F. H. Lathrop.

Peculiarities in behavior of insects have many times been used with distinct advantage in the control of injurious forms. The heliotropic reaction of moths—that is, their tendency to fly towards the light—has given rise to the trap lantern; and a knowledge of the nocturnal habits of the malarial and yellow fever mosquitoes has made it possible for the diseases caused by these insects to be avoided by housing oneself during their period of activity. One of the most striking cases of the direct economic application of an instinct in insects is that of death feigning or "playing possum" in the plum curculio, *Conotrachelus nenuphar*, Herbst.

It is true that the introduction of arsenical sprays marks an epoch in the control of the curculio, and quite deservedly has caused the old method of "jarring" to be largely superseded by the newer one of spraying. The practice of "jarring", however, is still in vogue in sections where the spray pump has not come into general use. Therefore, a study of the features of the instinct is of interest, not only from the biological point of view, but also due to the fact that at a not remote time it provided the most effective measure of control for the plum curculio.

In speaking of the preventive measures for lessening the injury of this pest, Johnson and Girault (8: 1906), of the Bureau of Entomology, U. S. Department of Agriculture, have the following to say: "Among these jarring is the method which is perhaps in most general use in protecting plums and peaches, and by many orchardists it is believed to give the best results. Early observations upon the plum curculio showed that this insect has a habit of falling to the ground and "playing possum" when disturbed. A knowledge of this habit has led to the capture of the beetles on sheets, held or spread beneath the trees, the trees being jarred by a sudden forceful blow struck with a padded pole or mallet in order to dislodge the beetles." A field test of the efficiency of the method made by these same men in a Georgia orchard showed "that the amount of the

curculio damage in this orchard for the season was placed at about four per cent of the crop. In an adjacent orchard of 130,000 peach trees not jarred, curculio injury was placed at forty per cent of the crop."

Owing to these facts, the writers considered it worth while to devote their leisure time during the past summer to a study of some of the general features of this exceedingly interesting mode of behavior. The work of Holmes (5, 6, 7) on the water scorpion, *Ranatra quadri-dentata*, and of the Severins (10) on *Belostoma flumineum* and *Nepa apiculata* make an exhaustive study of little significance. The work embodied in this paper was done at Clemson College, S. C., during the latter part of June and the month of July, and consequently upon forms which had emerged at the earliest only a few weeks before.

Death Feigning Attitudes.

It was found possible to produce the feint by three methods, and when one was not successful, the others were employed. The one most used is the same as that by which it is evoked in the natural environment of the insect—by dropping it from some distance in the air. When the insect is allowed to fall to the top surface of a table from a height of a few inches, the feint seems to be as effectively produced, usually, as when dropped through a space of several feet. By pressing the lateral surfaces of the abdomen and thorax, at short intervals, either by means of the fingers or forceps, the same effect may be secured. A third method is that of grasping the insect between the thumb and forefinger and blowing a sudden breath upon the ventral surface of the abdomen and thorax.

There are two distinct postures assumed by the insect in feigning death. In the first (fig. 1, A), the insect draws the thoracic appendages closely against the ventral surface of the body. The first pair of legs extend forward and are tightly pressed against each side of the proboscis. The second and third pairs are closely flexed, and held securely against the ventral surface of the thorax and abdomen. In the second position, the legs are folded closely together and held somewhat perpendicular to the line of the body (fig. 1, B). The tarsi of the first two pairs of legs are drawn tightly against the tibiæ; but in the last pair they are held approximately parallel to the ventral surface of the thorax. The first position is usually the

one more easily evoked; the second being given upon more vigorous stimulation. However, there seems to be considerable individual variation in this respect, some curculios assuming the second position more readily than the first. It was found possible to elicit the two types of response in the several individuals experimented on in this connection.

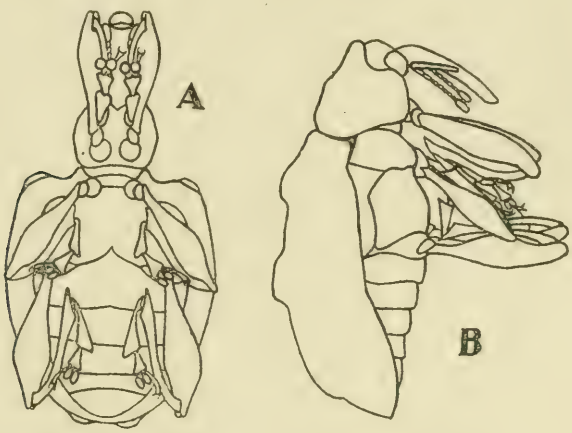


Figure 1. Attitudes assumed in the death feint.

Several specimens were starved to death, and others killed by a slow poisoning. All of these assumed a position very similar to that of the death feint indicated in fig. 1, B. The only difference to be noted was that in most cases, the tips of the tibiæ were farther apart, the legs being held not quite so perpendicular to the ventral surface of the thorax. This simulation of the natural death attitude in the death feint is in accord with the results of Kirby and Spence (9), who in the case of the dung-chafer, *Geotrupes sterocarius* found the same thing to occur. While not true in *Belostoma*, yet it is very closely parallel to what the Severins (10) found in *Nepa*, where "it becomes at times impossible to distinguish with the eye alone, a death feigning specimen from one that is really dead." However, in the majority of forms which have been studied, as recorded by Darwin (2) and other workers, the death attitude is found to be quite distinct in character from that assumed in the death feint.

Duration of Successive Death Feints.

It was the experience of Fabre (4) that when a large beetle, *Scarites gigas*, Fabre was put into five successive death feints, they lasted 17 minutes, then 20, 25, 33, and 50 minutes respectively. From this behavior, he draws the conclusion: Ils nous qu'en général le *Scarite* prolonge advantage sa pose inerte à mesure que l'epreuve se répète." The results of the Severins (10), however, do not agree with those of Fabre. They find a "wide variability in the duration of the first five feints in the different individuals under uniform conditions", and also "that the duration of successive death feints in each individual also varies."

Our experiments show results much more in accord with the Severins than with Fabre as observation of the following table will serve to show. Quite a wide range of variation is here to be seen, three of the six individuals showing a less duration of response in the fifth than in the first feint into which they were placed.

TABLE I.

Duration in Minutes of First Five Successive Death Feints in Six Curculios.

A	B	C	D	E	F	Averages
1.	10.	8.	6.	6.	3.	5.66
12.	2.	11.	2.	8.5	5.5	6.83
2.5	5.5	5.5	2.5	2.	9.	4.66
3.	1.5	2.5	1.	1.	10.	3.16
8.	3.	1.5	1.	7.	28.	8.

Six specimens were tested in order to determine the length of time the feint might be successively induced. Holmes (6) found in the case of ten *Ranatras* successively put into death feints, that these were continued without interruption from 9 a. m. to 5 p. m., when the last specimen refused to feign longer. The Severins (10) found it possible in the case of *Belostoma* to induce feints successively for a total of five hours. The responses of the curculio were very much less pronounced than was the case of these forms. Feints could not be elicited

successively for a period of greater length than two hours, fifty-three representing the largest number of feints successively produced in a single individual. The feints, after the first several, tended to show a decrease in duration, some of them continuing for only a few seconds. Finally the curculio refused to feign longer, no matter how treated, and in many cases made strenuous efforts to fly away.

The muscular system of the insect, while in the death feint, is in a tensely contracted condition. When held in a pair of forceps by the tip of one tibia, the entire body may be held out horizontally without signs of bending or movement on the part of the curculio. After a short time, however, the weight of the body causes a gradual relaxation of the leg muscles, and the animal is inclined downwards. Holmes (7) found the same thing to hold true in *Ranatra*, and says: "It is as if a man were seized below the knee and held out straight, face upward, without causing the knee to bend, only the legs of a *Ranatra* are several times more slender than those of the most attenuated of the human species, and the muscular tension which the insect maintains must therefore be intense." Undoubtedly, the acclimatisation of the insect to the extent that failure to respond with the death feint occurs after several successive periods of it have been passed through is to be explained in part at least as due to the muscular fatigue resulting from this rigidly contracted condition.

Effect of Temperatures on the Death Feint.

According to DeGeer (3), from his work on a small timber-boring beetle, *Anobrium pertinax*, "you may maim them, pull them limb from limb, roast them alive over a slow fire, but you will not gain your end; not a joint will they move, nor show by the least symptom that they suffer pain." In order to determine whether such a condition held in *Conotrachelus nenuphar*, many feigning specimens were placed on a thin piece of glass and gradually heated over the flame of an alcohol lamp. Though this experiment was repeated many times, the insects without a single exception, recovered activity as soon as the glass became heated. Individuals with the abdomen removed, others consisting of only the head and prothorax, and still others with all of the appendages removed, were placed in the

death feint and subjected to the same conditions as the normal ones, but not a one of them was found which would allow itself to be injured by the heat before attempting to escape.

Several specimens were taken and the time of six successive death feints was determined, and found to compare very closely with the results given in Table 1. These individuals were then placed, ventral surface uppermost, on a thin glass plate which was in contact with a block of ice. For approximately one minute the curculios made no movement. Then the abdomen was raised upwards out of the wing covers, as though to remove it from contact with the cold glass. The wing covers were then slowly spread away from under the body until they were well open. The legs were partially relaxed, but the movement was so gradual as to be almost imperceptible. This position was continued for a short time, and then the wing covers were drawn to their former position, the legs again becoming rigidly contracted. The insects were again motionless, and continued so until removal from the glass, forty minutes later. After a short interval had elapsed from the time of their removal, activity was manifested almost simultaneously among them. It was now found very difficult to induce these individuals to feign death.

A mixture of crushed ice and ammonium nitrate was now prepared and test tubes containing feigning curculios were placed in it. No movement whatever was manifested from the time they were placed in the test tube. When removed thirty minutes later, they were found to have sustained death as the result of the low temperatures (−15°C to −20°C) produced by this mixture.

These results in general agree with those of Fabre (4) on the Buprestid, *Capnoides tenebrinionis* Lin; and Holmes (6) on *Ranatra*, who find that cold has the effect of increasing the duration of the death feint to a marked degree.

Influence of Gases on Death Feint.

Many curculios were induced to feign death, and test tubes containing a wad of cotton saturated with ether were slowly placed over them. Without exception, the curculios revived almost instantly, many of them recovering before the tube touched the table. The same experiment was made with

chloroform, carbon di-sulphide, and carbon-di-oxide with similar results. Mutilated specimens put into the death feint were also tested and it was found that the most of them responded in the same manner. Thus in the case of the gases, as in that of heat, we see an adaptive feature in the nature of the instinct that tends to remove the animal from a stimulus of such a character as would result in injury to the organism.

Effect of Mutilations.

Holmes (6) found in *Ranatra*, that the appendages could be removed one by one, while the animal was in the death feint without evoking any response from the insect. The Severins (10) found in *Belostoma* that "if one of the limbs be snipped in two with a pair of fine scissors, the bug may not respond at all, or the limb may twitch or quiver, or the insect may right itself and scramble eagerly to get away. One or two repetitions of this experiment with those specimens which did not come out of the death feint immediately after the cut was made were sufficient to bring them out." In the case of *Nepa*, however, the results were more in accord with those reported on *Ranatra*.

The appendages of eight feigning curculios were removed one by one. With the exception of two of these curculios, every one of them showed absolutely no signs of recovery from the feint until several minutes after the operation. In the case of these two, recovering activity took place immediately after severing the first appendage. They were very easily made to feign again, and the operation proceeded without any apparent objection on their part.

Seven feigning individuals were decapitated with a pair of small, sharp scissors. The result was an immediate relaxation of the legs followed by efforts on the part of the body to right itself. In one case the wings were outstretched as though attempting to fly. The bodies were placed in the normal position with the result, however, that only two of them walked in a co-ordinated manner, and these for only a short time. This behavior is no doubt due to the shock effects of the operation. It was found possible to induce the death feint in these decapitated specimens, but with much more difficulty and with a shorter period in the duration of the response than was the case in the normal specimens.

Several specimens were placed in the death feint, and the abdomen of each was clipped away. No movement was made except a slight twitching of the tarsi in a few of the specimens. The insects remained in the feigning attitude for the normal length of time, and upon recovering activity walked about in a perfectly co-ordinated manner, except for the difficulty of balancing the body. They were thrown into the feint in this condition with about as much readiness as were the normal specimens.

The next operation performed was to sever the body between the prothorax and the mesothorax. The result without exception was an instant manifestation of activity on the part of the body, in some cases the wings becoming extended as if to fly. The head and prothorax, however, showed no shock effects of the operation, but remained in the feint for some time afterwards. This portion of the body could be readily induced to feign death, but the posterior part only to a very slight degree even upon vigorous stimulation. These results in general accord with those of investigators on other forms.

Nature of the Instinct.

The instinct of feigning death occurs in almost all of the orders of insects. While it is perhaps within this group that it reaches its most marked development, it is to be found to a slight extent in all of the higher phyla of the animal kingdom. It has been studied by Holmes in the amphipod crustaceans, and has been found by Andrews (1) in the breeding habits of the cray-fish. It occurs rarely among the fishes, and to a certain extent in the amphibians. In varying degrees, it is found expressed in the reptiles and birds; while among the mammals, from the behavior of the opossum, the common synonym "playing possum" has come to be derived.

It is Holmes' (5) conclusion from his work on the amphipod, *Talorchestia longicornis*, "that the death feigning instinct of *Talorchestia longicornis* is an instinct which has its roots in the thigmotactic response common among amphipods." The Severins (10) say: "Among aquatic *Hemiptera*, the death feint may have arisen out of positively thigmotactic propensities which are manifested to such a marked degree by various members of the families *Belostomatidæ and Nepidæ*." It is evident without statement, from the results discussed in this

paper, that the behavior of *Conotrachelus* serves to corroborate these conclusions and it is a striking fact that the response can be secured upon such slight contact stimulus, scarcely more than a touch being necessary to elicit a well marked death feint. The fact that the body deprived of its head, can be induced to give the response, removes the greater part of the psychic speculation in regard to the nature of the instinct.

Just what the value of it to the curculio in its native environment may be is largely a matter for conjecture; but that it has been used very effectively in combatting this common and injurious insect remains an incontrovertible fact.

It is with grateful appreciation that the writers here express their indebtedness to Dr. S. J. Holmes for the valuable suggestions arising from his critical reading of this article.

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THE FLIGHT OF TWO THOUSAND MARKED MALE MEDITERRANEAN FRUIT FLIES (CERATITIS CAPITATA WIED.).

Henry H. P. Severin, Ph. D., Honorary Fellow, University of Wisconsin, and William J. Hartung, B. S.

Mally (1, p. 8) Entomologist for the Eastern Province, Cape Colony, South Africa, discusses the migration of the adult Mediterranean fruit fly as follows: "There is no evidence to show how far the adults will travel in their search for food. Some observers think they migrate but very little, citing instances where well-kept premises have been fairly free although in close proximity to neglected and badly infested ones. Under such conditions there is no necessity for migration, ample food-supply being already at hand. There is no clear evidence to show how they get to new orchards on farms where fruit trees have never been grown before. Men who have laid out new orchards say that the 'maggot' was in evidence the first time the trees came into bearing. * * * It is a popular belief that the flies come in from the veld. The most unrelenting search has failed to demonstrate their presence in bush or veld 500 yards from an orchard."

"Prevailing winds are perhaps the most potent factor. How far the flies are liable to be carried by the wind it is impossible to say. One would hardly expect that they would be blown very far at once. It seems easily within the range of possibility that they should be involuntarily caught up by the wind when they attempt to fly and lodge on a bush or in the veld some distance away; and then be caught up again and carried still farther, and so on indefinitely. There is little doubt that certain Aphididæ do make use of the wind in migrating to their secondary host plant, but I have found nothing to indicate the presence of the same trait in the fruit fly."

Newman 2, (p. 7) Entomologist of Western Australia writes as follows concerning the migration of the Mediterranean fruit fly: "This fly is not an insect that migrates any great distance. As long as a food supply is available, it remains in an orchard. I have known instances where one orchard was swarming with the pest and the one next door or on the opposite side of the street was perfectly clean. Strong winds are the most potent factor in the spread of the fly; there is no saying how far she may be carried."

The conditions existing in South Africa are entirely different from those in Honolulu and the outskirts of this city where our experiments on the flight of the marked Mediterranean fruit flies were performed. There are only a very few small orchards in and around the city of Honolulu but in practically every dooryard surrounding a residence a great variety of fruits are grown such as various kinds of citrus fruits, coffee, figs, garden varieties and wild guavas, mangoes, papaias, peach, plum, rose apple, tropical almond (umbrella tree or "kamani" nuts) sour sop, star apple, etc., from which we have bred the pest. These cultivated fruits ripen at different times of the year and offer the insect a regular succession of fruits in which to breed. In the uncultivated as well as in the mountainous districts of Honolulu the prickly pear which is also attacked by the fly is scattered over large areas. Different species of wild guaves which are hosts of the pest cover thousands and thousands of acres on the slopes of the mountains, in the gulches, in uncultivated portions of the valleys and plains, along the banks of streams and along some of the roads and paths leading from the city. These different species of wild guavas bear fruit practically the year around. Other wild fruits which the insect attacks are the mountain apples and the wild coffee berries. The climatic conditions in the Hawaiian Islands are also very favorable for the development of this trypetid, a generation of flies appearing about every four or five weeks throughout the year. In the city of Honolulu there is thus, a regular succession of cultivated fruit for the fruit fly to breed in, and in the outskirts of the city and in the mountainous districts wild fruits are available for the pest during the entire year.

In order to determine positively the powers of flight of the Mediterranean fruit fly, two thousand male specimens, which were bred in the laboratory from infested fruits, were handled and marked so that they would be injured as little as possible by employing the following methods: Hundreds of fruit flies were liberated under a small cheese-cloth tent which was fastened at its base to the three sides of a table and at its apex to the ceiling by a string. The head and shoulders were thrust under the tent at the open side and each specimen was captured in a small vial. The fly within the vial was seized by one wing with a pair of forceps, around the end of one prong a small elastic band had been wound. The fruit fly held by one wing,

was then placed upon a piece of white paper and usually in endeavoring to free itself, the fly would extend, spread and then catch hold of the paper with the legs on the opposite side of the body from the imprisoned wing, and attempt to pull its body away from the forceps. With the limbs in this position any leg on one side of the body could be easily cut through with either a sharp, spear-pointed or triangular-shaped needle, without danger of injuring the other appendages.

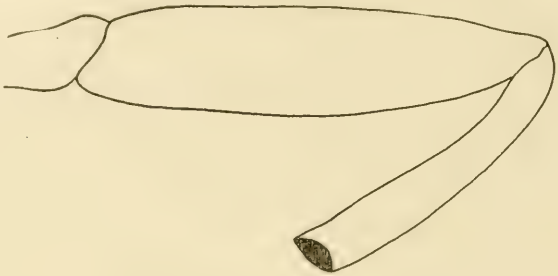

Fig. 1. Middle leg of Mediterranean fruit fly cut through the tibia. This specimen thus marked had been set free from the side of a mountain at an elevation of about three hundred fifty feet and was captured in a kerosene trap a mile and a half from the point of liberation.

After the amputation, the flies were put into breeding jars for a number of days to allow the wounded leg to heal. During this time they were fed with dilute molasses and water. The molasses was daubed on the sides of the jars by means of a camel's hair brush, while the water was sprayed into the jars in the form of a mist. The tops of the jars were covered with cheese cloth to allow free circulation of the air and the bottom of the jars were covered with sand to absorb the access of moisture and molasses.

The two thousand marked male flies were liberated on the outskirts of Honolulu in Manoa Valley which is walled in by mountains on all sides except the seaward side. This valley is more than two miles in length; in width, it varies from a half mile at the head end to a little more than a mile at its mouth, the greater portion of the valley being about three-quarters of a mile wide, (Pl. XXIX). The elevation of the mountains surrounding this valley varies from two thousand to two thousand five hundred feet at the head end but gradually becoming lower towards the mouth, (Pl. XXIX). At some places the sides of

the mountains rise very abruptly but in general the slope is quite gradual. The bottom of the valley consists largely of taro patches, (Pl. XXX).

At the head end of the valley, in a circle about a half mile in diameter, fifty kerosene traps were wired among the branches of citrus, fig, guava, hau and tropical almond trees. In a previous experiment we found that of every thousand Mediterranean fruit flies captured in kerosene only three were females and for this reason only marked males were used.

Fig. 2. Kerosene trap wired to a branch of a lemon tree. The white enameled pan containing the oil is covered with a galvanized iron cover to keep out the rain. The fruit flies enter the trap in the space between the cover and the rim of the pan.

The Mediterranean fruit flies were set free in lots containing from two to six hundred specimens. When the first lot of flies were set free, the jars containing the marked individuals were

held on a level with the eye to better enable the observer to note the direction of flight. In order to arouse the flies into activity and hasten their departure, the sides of the jars were snapped lightly with the fingers, with other lots, however, the jars were placed upon the ground and the males were allowed to escape. With the sky as a background, the unaided eye could follow the insects in their flight to a distance of about a hundred feet, but with the use of a field glass, the flies could be followed to a much greater distance.

While liberating the first lot of five hundred fruit flies in the center of the circle of traps it was observed that the wind played an important part in their direction of flight. A heavy north-east wind was blowing from the mountains to the sea, while these marked diptera were liberated, and it was striking to note that they flew and were carried with the wind down the valley with extreme rapidity towards the city of Honolulu. Since the prevailing winds at this time of the year are from the north-east, a change in the arrangement of the traps was made. The traps that had been located in that half of the circle nearest the head end of the valley, were placed amongst the trees of two citrus grooves, (Pl. XXX, 4), situated on the leeward side of the remaining semicircle of traps. (Pl. XXX, white line.)

The trypetids were liberated from three different points. As was already mentioned five hundred fruit flies with the hind leg cut, were liberated in the center of the circle of traps, about a half mile in diameter. After the traps had been rearranged a thousand specimens with the front leg severed were set free from the head end of the valley about a half mile from the traps. Five hundred males with the middle leg amputated were freed at the head end of the valley from the side of a mountain at an elevation of about three hundred fifty feet and at a distance of about one mile from the traps. A glance at the photograph shows the three points of liberation. (Pl. XXX, 1, 2, and 3).

The orientation of the marked individuals was carefully noted with the liberation of each lot of flies under the different climatic conditions. Whenever a heavy or light north-east wind blew from the mountains to the sea, the insects as soon as liberated would orient themselves with the wind and fly down the valley but when a south-west wind from the sea to the mountains prevailed, the specimens again oriented themselves

with the wind and in this case flew up the valley towards the mountains. In no case did the fruit flies attempt to orient themselves against even the lightest breeze. During calm spells no orientation took place and the flies darted off in all directions.

From time to time some of the kerosene traps were moved farther and farther into the city of Honolulu and were again hung among the branches of fruit bearing trees, usually citrus trees. These traps were visited every day, the fruit flies captured in a trap were put into a vial labeled as to the location of the trap. The kerosene was renewed daily in each trap.

The varying climatic conditions under which the different lots of flies were set free are indicated in the following table:

TABLE I.

Date	No. of Flies Liberated	Leg Cut	Conditions of weather at time of liberation		Total pptd. U. S. Weather Report
			Winds	Precipitation	
Feb. 21	500	Hind	Heavy N. E.	Frequent heavy rains	.72
24	600	Front	Light N. E.	Light rains, occasional heavy showers.	1.12
25	200	Front	Gusts of N. E. and Calm Spells	No rain.	.26
26	200	Front	Light N. E. and Calm Spells	No rain.	.21
29	500	Middle	Moderate S. W.	No rain.	.00

The total number of fruit flies captured during one month in the fifty kerosene traps was two thousand three hundred and nine, of this number one hundred fifteen were marked specimens from the two thousand that had been liberated. Of the marked individuals captured there were seventy-three with the front leg cut, eleven with the middle leg and thirty-one with the hind leg. Most of the one hundred fifteen marked insects were captured during the first fifteen days after the experiment had been started.

The first lot of five hundred Mediterranean fruit flies were set free during light rains followed by frequent heavy showers and yet thirty-one of these marked specimens were captured in the kerosene traps; apparently the drops of rain striking the fruit flies did not disable them for flight. The last lot of five hundred marked males was liberated while a south-west wind was blowing away from the city of Honolulu towards the mountains and yet eleven of these marked individuals were captured in kerosene traps located in the outskirts of the city at distances varying from a mile to a mile and a half from the point of liberation. The explanation of this fact may be that some of these marked insects were caught up by changes of wind carrying them first towards the mountains and then back again into the city of Honolulu.

Marked Mediterranean fruit flies were captured at distances varying from a quarter of a mile to a mile and a half from their respective points of liberation. In all probability some of the flies which had been set free during a strong wind were caught up and carried far into the city of Honolulu or even way beyond into the sea miles away from the points of liberation. In numerous instances kerosene traps were kept in the same tree for a period of two weeks and marked specimens were captured from time to time. The explanation of this fact may be that the fruit flies did not make one continuous flight from the point of liberation to the trap in which they were caught, or that the trypetids were not immediately attracted to the kerosene after getting into the vicinity of them.

On account of using male fruit flies only, the argument may be raised that there is no evidence from this experiment that the female flies are carried by the winds. How would the rapid distribution of the pest in the guava belt, often at high altitudes in the mountains, be explained? In all probability the answer to this question is best explained by the fact that the wind, which is such a potent factor in influencing the flight of the males, as demonstrated by this experiment, has carried the females as well as the males into the guava belt.

Clean culture to control the Mediterranean fruit fly as carried on by the Board of Agriculture in the Hawaiian Islands consists in stripping all fruit trees, except mangoes and papaias of infested and ripe fruit and also of picking up and destroying

fallen fruit. Attention has already been called to the fact that the wild guavas which are available for the pest to breed in during the entire year cover thousands and thousands of acres in the mountainous districts. If only a small per cent of the fruit flies breeding in these wild fruits are caught up by the winds blowing from the mountains towards the city of Honolulu, *what ultimate results can be expected from the clean culture methods of the present Mediterranean fruit fly campaign!*

After sending this manuscript to the editor we received from Dr. A. Berlèse a paper entitled, "Expériences Exécutées en Italie pour Combattre la Mouche des Oliviers." presented at "Ier Congrès International d'Oléiculture (Toulon, 1908)" in which he states that the olive fly, Dacus oleae Rossi obeys "l'instinct de diffusion, émigrent au loin, à la recherche de nouveau ambients.

En outre, dans la première génération printnaière-estivale l'instinct de migration se montre très développé chez les femelles. A cette époque l'on constate que certaines émigrations couvrent de grandes distances. Cela est éstrange, lorsqu'on pense a la commodité qu'auraient les mouches àdéposer, a cette époque, leurs oeufs là ou elles sont nées. Au contraire, elles vont parfois les pondre à plusieurs kilomèters (k—3,280.8 feet) de distance."

We are deeply indebted to Prof. Harry C. Severin, State Entomologist of South Dakota, who has given us valuable suggestions in reading the manuscript with us.

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EXPLANATION OF PLATE XXIX.

Map of Manoa Valley. This valley is walled in by mountains on all sides except the seaward side. The elevation of the mountains are indicated. The two thousand marked, male Mediterranean fruit flies were liberated at the head end of the valley.

EXPLANATION OF PLATE XXX.

Head end of Manoa Valley. Some of the fifty kerosene traps were wired among the branches of fruit trees situated along the white line. 1, 2, and 3 points of liberation of the two thousand marked, male Mediterranean fruit flies. 4, Citrus grooves. (Reproduced by permission of E. Bonine, photographer.)

H. P. Severin and W. J. Hartung.

HEAD END OF MANOA VALLEY.

Bonine, photo by permission.

Severin and Hartung.

OBSERVATIONS ON THE LIFE HISTORY OF A NEW SPECIES OF PSYCHODA.*

PAUL S. WELCH.

During the first three weeks of October, 1912, while engaged in certain biological investigations at the Chicago Sewage Testing Station, the writer's attention was attracted to a little white moth-like fly which occurred in great abundance in certain of the experimental tanks. An inspection of the form showed that it was one of the Psychodidæ belonging to the genus Psychoda. An examination was made of the rather extensive series of tanks and filters and it was found that these flies were confined to the immediate vicinity of the sprinkling filters and occurred in such great numbers as to indicate that not only were they breeding in or near the filters but that the environment must be a very favorable one. A survey of the animal life of the sludge of the sprinkling filters was being prosecuted at that time and the collections contained large quantities of a dipterous larva which when bred out produced the Psychodid fly. It was a very easy matter to rear this form and all the life history stages were observed. Furthermore collections from the filters often contained all of the life history stages from the egg to the adult.

In attempting to establish the identity of the adult it was found that it does not agree with any of the descriptions given for known species. It belongs to the group including *Ps. schizura* Kincaid, and *Ps. floridica* Haseman, which resemble each other in the mottled black and white character of the wings. However, this species possesses characters which differ distinctly from either of the above mentioned forms. After making careful comparisons with the descriptions of the species of Psychoda, the writer is convinced that this form must be regarded as a new species.

Psychoda albimaculata, n. sp.

Male: Smaller than the female; length of body (exclusive of extended genitalia) about 1.74 mm. Head and thorax yellowish gray, densely clothed with long, erect, mingled black and gray hairs. Abdomen white, covered thickly with erect white hair; very few dark hairs. Brush of gray hair, about one-fourth the length of the abdomen, extending caudad from the dorsal posterior edge of the thorax. Antennæ white;

*Contribution from the Entomological Laboratories of the University of Illinois, No. 33.

length equal to the width of the wings; 14 segments;[1] composed of spherical nodes joined by clear internodes; first segment cylindrical, the second spherical and distinctly larger than any of the other joints, and both the first and second segments with numerous fusiform scales as well as strong hairs; segments three to twelve inclusive with basal nodes and distal slender internodes; nodes with whorls of long white hair directed distad and projecting beyond the node of the adjacent distal segment; internodes clear, nodes slightly yellow; length of the internodes about the same length as the adjacent nodes; segment 13 bilobed, the basal lobe exceeding the other in diameter, separated by a broad shallow constriction, coating of hair similar to that of middle segments; segment 14 small and inconspicuous, about one-fifth the length of segment 13, with a few hairs and usually three or four terminal scales. Wings ovate, rather acutely angulated at tip of median vein, thick coating of hair on upper surface, moderate coating of hair on under surface; average length 2.1 mm., extremes of variation 1.74 to 2.28 mm.; average width 0.85 mm., extremes of variation 0.66 to 1.02 mm.; upper surface with distinctly mottled appearance, due to the presence of alternate patches of white and black erect hair; basal region of wing with black patches on or near veins III_1, III_2, V_3, VII_2; middle region of wing with black patches on or near veins III_1, III_2, III_4, V_1, V_2, VII_2; distinct tufts of black hair at the distal ends of veins III_1, III_2, III_4, V_1, V_2, VII_2; all intermediate spaces on surface between black patches occupied by white hair; rarely a very indistinct black tuft at distal end of V_2 and VII_1; fringe on anterior margin smoky, length about one-fifth the width of wing; posterior fringe smoky, length about one-fourth the width of wing; distinct tuft of long smoky hairs on costal margin at base of wing; hair on ventral surface of wing short, white, and nearly prostrate; cubital furcation nearer base of wing than tip. Legs white with slight tinge of yellow; extremities of distal segments of the tarsi tipped with brown; tibiæ and femora with scattering long black hairs, also some short prostrate black hairs intermingled with the white. Abdomen white, thickly clothed with long erect white hairs, originating on the posterior margin of each abdominal segment, thus producing a series of rings of erect hairs; black and gray hairs scanty. Inferior genital appendages of male prominent; length (including basis) 0.64 mm.; basis strongly developed, broad towards caudal extremity, with median conical projection, lateral margins converge towards base; inferior appendage expanding gradually towards basis; somewhat sigmoid in shape; heavy fringe of long white hair on caudal aspect; terminal spinule small, clavate. Superior genital appendages well developed; two segments; a little over one-third the length of the inferior genital appendages, proximal segment a little more strongly developed than the distal; with a few short whitish hairs. Intromittant organ slender.

1. Care must be taken in estimating the number of segments in this species since the thirteenth is of such a nature that an error can easily be made. The antennæ should be mounted so that the tip lies exactly in a plane at right angles to the objective of the microscope, otherwise the superimposed curved surfaces of adjacent parts produce appearances which easily lead to error.

Female: More robust than male; body slightly longer, and diameter of abdomen much larger. Head slightly yellowish, thickly set with white and gray hairs. Thorax white, densely clothed with white erect hairs; a few gray hairs present. Abdomen white, clad in white semi-prostrate hair. Antennæ white; two basal segments slightly yellowish; agree with the male in all other respects. Wings with average length of 2.58 mm., extremes of variation 2.28 to 3.06 mm.; average width 0.98 mm., variation from 0.90 to 1.14 mm.; otherwise like male. Legs with tarsal segments distinctly yellow, extreme tips dark; tibiæ and femora white with scattering black hairs, some long and others short. Ventral plate yellow; about as broad as long; emargination almost circular in outline. Ovipositor yellowish; almost straight.

Habitat: Chicago, Illinois. Described from 25 specimens, 10 males and 15 females.

In looking over the literature on *Psychodidæ* the writer was surprised to discover how little of it has to do with the life histories of the various species of this family. Forty-four species have been described from North America, and the life histories of only five are known. Kellogg (1901, p. 46) described briefly the life history of *Pericoma californica* Kincaid; Haseman (1907, p. 324) described the stages of *Psychoda floridica* Haseman; Fullaway (1907, p. 386) reported on the immature stages of *Psychoda schizura* Kincaid; and Haseman (1908, p. 274) described the life histories of *Psychoda nocturnala* Haseman and *Psychoda domestica* Haseman.

THE EGG.

(Fig. 3, Pl. XXXI.)

Eggs were easily obtained by confining females in stender dishes which contained a small quantity of sludge and water from the filter beds. Females were frequently put into the dishes in the evening and by the next morning clusters of eggs had been deposited. They were laid in masses on the bottom or sides of the dish or on fragments of rock which projected from the surface of the mass of sludge. Egg masses deposited in the dishes were never laid in the water, but just above the water and at the edges of moist areas on the bottom. These egg masses contained a varying number of eggs ranging from 20 to over 100. The masses were irregular in shape and the eggs which composed them were deposited in no definite order. They adhered strongly to the glass and were apparently cemented there at the time of oviposition. Under normal conditions the eggs are laid on the surfaces of the filter stone. It is very probable that eggs are not only deposited near the top surface of the

filter but at some depth since larvæ, pupæ, and adults were found two feet below the surface and it was evident that the adults encounter no difficulty in traversing the interstices.

The eggs are oval in shape and the majority show a slight concavity on one side accompanied by a corresponding convexity on the other, thus giving the eggs the appearance of being slightly bent in one plane. Sometimes this concavity is so reduced that this aspect of the egg is almost straight. A large number of eggs were measured, and it was found that they are quite constant in size. The length varied only from 0.32 mm. to 0.34 mm., and the measurements of the greatest diameter showed a variation of only 0.09 to 0.1 mm. The yolk is centrally located and comprises about one-half of the bulk of the egg. It is opaque, granular, and shows a homogeneous distribution in the freshly deposited egg. The substance outside the yolk is transparent and homogeneous. This substance is largely confined to the ends of the egg, and one end usually containing a larger quantity than the other. The outer egg membrane is smooth and transparent.

Development proceeds rather rapidly and in about sixteen hours after oviposition most of the eggs are in an advanced stage of development. Not all of the eggs of a given mass develop at the same rate, but some lag behind and therefore hatch later. The time between the laying and the hatching of the eggs was found to vary from about thirty-four to forty-eight hours.

THE LARVA.

(Fig. 6, Pl. XXXII.)

Larvæ in all stages of development occurred in great abundance in the sprinkling filter beds. The influents of these filters come from the settling and septic tanks and are thrown out into the air in a spray which falls on the surface of the filter bed and filters through about ten feet of crushed limestone. This influent carried considerable solid organic matter in suspension, some of which is retained in the filter. This sludge accumulates in some quantity on the surfaces of the stones and in the interstices formed by them, particularly in the upper part of the bed. The larvæ are found crawling through and over this sludge, and no doubt derive their food from it. Often larvæ may be found completely buried in the sludge with only the posterior breathing tube projecting into the air. They are active in their habits, and their characteristic crawling and wriggling form of locomotion is moderately efficient. They crawl with comparative ease over the surface of the filter rocks and even have the ability to crawl up the side of a glass vessel in which they may be confined.

At the time of hatching the larva is small, measuring only about 0.5 mm. It is whitish in appearance and quite transparent. It is active from the time of the emergence from the egg, and increase in size takes place rapidly. At this stage the two reddish-brown eye spots on the lateral aspect of the head are quite distinct. Immediately after hatching the little larva places itself, if possible, in a position which allows the breathing tube to be exposed to the air.

The mature larva is cylindrical, slender, and from 8.5 mm. to 9.5 mm. long. The greatest diameter, which occurs in the anterior region of the body, is about 1 mm. The color is light brown. In the mid abdominal region a whitish or silvery appearance is common and is in part due to the fact that the longitudinal tracheal trunks show through the integument to some extent. The body is composed of the head, three thoracic segments, and eight abdominal segments.

The head is much smaller than the adjacent thoracic segment. It is smooth, deep brown in color, and strongly chitinized. A pair of oval brown eye spots are present on the anterior lateral aspect. The head is to some extent retractile, and may be partially withdrawn into the thorax. The lateral margins of the clypeus converge posteriorly. Minute antennæ appear as a number of tiny rods of similar shape and size. The tip of the labrum is spiny and also bears a few setæ. The mouth parts, which are setose and denticulate, are enclosed in a sunken space on the anterior part of the ventral aspect of the head. On either side of the labrum and attached to the ventral surface is a pair of setose segmented appendages which in the living larva are in constant motion being rapidly extended and retracted and apparently serving as prehensile organs. Two pairs of clusters of setæ occur laterally, one pair near the eye spots and the other pair nearer the prothoracic segment. Setæ also occur on the dorsal aspect of the head, one aggregation located midway between the eye spots, two setæ near the middle, and two setæ near the caudal margin.

The thoracic segments are distinct and each shows one well marked constriction which divides it into an anterior and a posterior annulus. The posterior annulus of the prothoracic segment bears four groups of setæ (usually two in each group), two dorsal and two ventral. The ventral group usually has one long seta. The dorsal surface of the posterior prothoracic annulus bears two small brown protuberances, one on either side and dorso-lateral in position. The tip of each protuberance bears a closed spiracle which is the terminus of a branch of the tracheal system. The mesothorax and metathorax have one constriction each, and in other respects are similar to the prothorax, with the exception that the diameter is slightly increased. The thorax as a whole is smooth, and the fine chitinous surface spines are much smaller than those on the abdominal segments.

The first abdominal segment has one constriction, but the following six have two thus marking off each segment into an anterior, a median, and a posterior annulus. The setæ on the first segment are arranged as in the thoracic segments, while in the following segments ventral groups

occur on the anterior and posterior annuli of each. Two groups of setæ occur on the dorsal aspect of each posterior annulus. The entire surface of the first seven abdominal segments, excluding the intersegmental grooves and the constrictions, are thickly studded with fine brown chitinous spines. The eighth, ninth and tenth abdominal segments bear, on the dorsal surface, nine chitinous plates, one on each annulus. These plates are brown, heavily chitinized, and transversely elongated. They are not uniform either in size or shape, but in general the nearer the caudal region the larger do they become. The plates on segments nine and ten are approximately constant in size and shape in the different specimens, but in segment eight there is some variation. Usually three plates are present, but occasionally a specimen is found in which one may be very diminutive, or even entirely lacking. The plate on the posterior annulus shows the greatest variability. In exceptional cases it may be entirely absent, but the common form of the variation is in the size and shape. Judging from the predominance of the specimens showing it, the common form seems to be a central, somewhat quadrate plate with a small circular plate on either side. Other specimens may show the middle plate reduced to the size of the two small lateral ones. Still others show one of the lateral plates apparently fused with the central piece, and finally, specimens were examined in which the lateral plates were absent and the middle plate well developed. It seems probable that the latter has come about by the complete fusion of the two lateral plates to the median.

The terminal (eleventh) segment is smooth, heavily chitinized, and tapers caudad. The tip is emarginated. It bears two dorsal projections which show a few strong bristles; also two ventral projections, longer than the dorsal. Each of the four projections is armed at the extreme end with a crown of strong bristles. The anal opening is on the ventral side of segment eleven and near its base. The opening occurs on an anal papilla which is composed of four lobes. The region immediately surrounding the papilla is not chitinized, but close behind it is a lunate chitinous plate. Several long setæ occur near the papilla.

This larva differs distinctly from that of *Ps. schizura* in length and in diameter, in the number of chitinous plates on the dorsal posterior part of the abdomen, and in the presence of eye spots. It differs from the larva of *Ps. floridica* in the annulation of the body, in the number of setæ present and in the number of dorsal abdominal plates. The larva of *Ps. domestica* differs chiefly in the length and in the number of dorsal thoracic and abdominal plates. The larva of *Ps. nocturnala* differs principally in the form of the body and the number of dorsal abdominal plates.

THE PUPA.

(Figs. 1, 2, Pl. XXXI.)

The pupa rests on the sides of the filter stones, often completely surrounded by sludge with only the breathing tubes

exposed. It is rather sluggish and moves about slowly from place to place by means of a wriggling movement of the abdomen.

A large number of pupæ were measured and it was found that the average length exclusive of the respiratory tubes was 4.5 mm. The range of variation was from 4.02 mm. to 4.86. The greatest diameter which is in the region of the developing wings had an average length of 0.84 mm., the variation being 0.72 mm. to 0.9 mm. When first transformed the pupa is pale in color like the larva but soon becomes darker.

The head and thorax with their accompanying parts are usually deep brown. The thoracic respiratory tubes (Fig. 9, Pl. XXXII) are long and slender. Measurements show the average length to be 0.58 mm. and the extremes of variation from 0.54 mm. to 0.66 mm. Each consists of two parts, a short, yellow, indistinctly wrinkled, proximal stalk, and a much longer, dark, distal part. The latter has its maximum diameter at the base and tapers gradually towards the tip. Under magnification it shows a large number of fine transverse wrinkles. On the dorsal surface two approximately parallel rows of small clear circular spots extend from the base to the tip and there are aggregated into a small terminal cluster. According to Miall and Walker (1895, p. 146) these spots are the external openings of the large trachea which traverses the organ. Dell (1905, p. 303) however, has shown in *Psychoda sexpunctata*, a European species, that in places the tracheal extension bulges through the wall of the respiratory tube thus giving rise to the clear circular spots.

The abdomen is widest at its junction with the thorax and it gradually tapers caudad. The spines along the lateral margins are moderately developed and each normally ends in a fine stiff hair. The intersegmental grooves are both wide and deep, distinctly marking off the segments. Chitin is minimized in these intersegmental grooves and this accounts for the ability of the abdomen to perform rather active movements. These grooves are also much lighter in color than the contiguous parts thus giving the abdomen a banded appearance. The regions between the intersegmental grooves are strongly chitinized. Each bears an armature of spines on both the dorsal and ventral surfaces. On the former there is a single row of spines on the caudal margin of each segment while on the latter there are two rows on each segment, one near the middle of the segment and composed of large spines only, the other on the caudal margin of the segment and composed of large and small spines. Figures 1 and 2 show the number, comparative sizes, and disposal of these spines on the two surfaces. The examination of a large number of pupæ showed that the size and arrangement of these spines are constant and that there is only a very slight variation in the number, the variation being confined to the small spines. These small spines may be simple or compound (with double tips) and those on a given segment may vary to the amount of one or two in different specimens. The dorsal surface of the base of the last segment bears two simple laterally projecting spines and two similar spines occur on the ventral surface.

The caudal extremity of the last segment is laterally compressed and is equipped with two pairs of spines, one dorsal and the other ventral in position. The former is only moderately developed while the latter is strongly developed. The spines in both pairs diverge caudad and in each pair the component spines are separated by a distinct emargination.

This pupa differs from that of *Ps. schizura* in the length and diameter, in the number of abdominal spines, the character of the intersegmental grooves, and the character of the head region. It differs from the pupa of *Ps. floridica* chiefly in the character of the respiratory tubes and the number and arrangement of the abdominal spines. The pupa of *Ps. nocturnala* differs in the number of rows of spines on the first abdominal segment, and in size. The pupa of *Ps. domestica* differs markedly in the shape of the abdomen, in size and in the character of the abdominal spines.

Studies on the structure and activities of the different stages of this species are now in progress and the results will be published later.

The writer considered it unnecessary to give a complete bibliography of the literature on *Psychodidæ*. The following list includes only the papers referred to in the article.

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EXPLANATION OF PLATES.

Plate XXXI.

Psychoda albimaculata, n. sp.

Fig. 1. Dorsal view of the pupa.
Fig. 2. Ventral view of pupa.
Fig. 3. Eggs. Drawn shortly after oviposition.
Fig. 4. Basal joints of the antenna. Hairs and scales not shown.
Fig. 5. Distal joints of the antenna. Hairs and scales not shown.

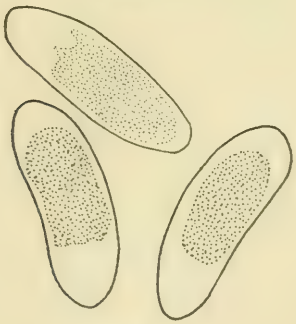
Plate XXXII.

Fig. 6. Dorsal view of the mature larva.
Fig. 7. Dorsal view of the male genitalia. Hairs not shown.
Fig. 8. Lateral view of the male genitalia. Hairs not shown.
Fig. 9. Dorsal view of one of the pupal respiratory tubes.
Fig. 10. Ventral plate of the female.
Fig. 11. Ovipositor.

1

2

2 mm.



1/16 mm.

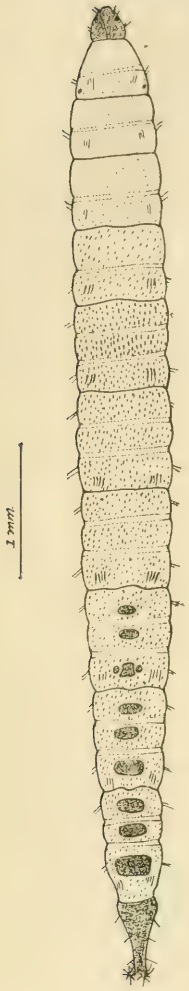
3

4

5

1/4 mm.

P. S. Welch.



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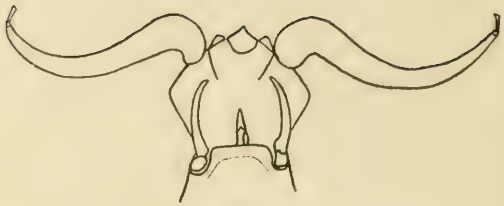

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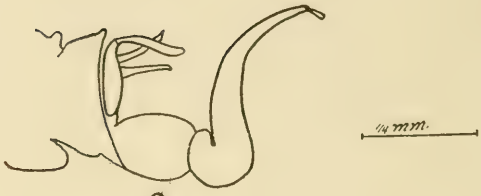

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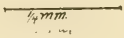

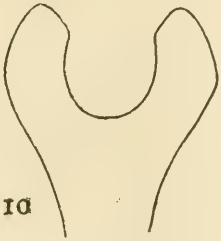

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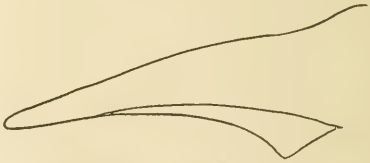

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P. S. Welch.

STOMOXYS CALCITRANS LINN.

Chas. K. Brain, B. A., F. E. S., Entomologist.*

Stomoxys calcitrans Linn. has often been suspected of being an agent in the transmission of disease, and the recent experiments of Rosenau, Anderson and Frost seem to show conclusively that this insect can, and may, transmit Acute Poliomyelitis in animals—monkeys were used.

Fig. 1. Stomoxys calcitrans Linn. ♀. (After Austen.)

It is not said that *Stomoxys calcitrans* is the actual carrier of Infantile Paralysis in Nature, but its common occurrence in localities where the disease is most prevalent, and its ability to transmit the disease from sick to healthy animals, makes further study of the species desirable. Considerable mention has been made of this fly in the entomological literature of the last fifty years, chiefly in relation to its occurrence in stables, and various methods have been recommended for its destruc-

*This work was undertaken in connection with experimental work now being conducted by the Ohio State Board of Health, and the blocks used for the illustrations are the property of that Board.

tion, but, as far as I could ascertain, no work has been done in this country on its mouthparts and internal anatomy. Four papers in England and one of minor importance in France, which apply to this genus, if not to this particular species, are included in the Bibliography.

Facts relating to its life-history have been recorded by Packard and others, and Prof. James S. Hine of Ohio State University is at present working on this side of the subject. The writer made observations on its life-history in South Africa, and conducted feeding experiments in connection with the transmission of a Trypanosoma disease from Portuguese East Africa. When on this work it was noticed that very few *Stomoxys calcitrans* larvæ could be obtained from old, heating manure, but that, as a rule, perfectly fresh horse dung was chosen for oviposition. Where this was collected into heaps with stable refuse, and generated heat, nearly all the larvæ found in it were of *Musca domestica*. In rooms where food was kept the majority of flies were of the latter species, *Stomoxys calcitrans* being most prevalent in such places on dull, cool days. Counts were made of flies caught in the windows of two rooms of the Government Experiment Station at Rosebank, near Cape Town in 1910. In room A, the laboratory, over 40% of the flies caught in a week were *Stomoxys calcitrans*, while in room B, one of the living rooms, *Musca domestica*, comprised 93% of the flies caught, while *Stomoxys calcitrans* was rarely taken, representing less than 3% of the whole. The distance between the two rooms was approximately 35 feet. The three flies most common in houses, all of which have a very wide distribution, being almost universal, are *Musca domestica*, the House-Fly, *Homalomyia canicularis*, the Lesser House-Fly, and *Stomoxys calcitrans*, The Stable-Fly. The particulars given with the accompanying figures in Plate XXXIII will suffice for their identification in the various stages.

Musca domestica Linn. The House-Fly.

Egg: About 1 mm. long, elongate, cylindrical, oval, rather more pointed at the anterior end, dull chalky white in color. About 100 to 150 eggs laid in a mass in crevices in house refuse or accumulations of horse manure. Eggs hatch under favorable conditions in 8 to 24 hours.

Larva: 7 to 10 mm. long when full grown, greasy white in general color, except for the darker color of the contents of the alimentary tract. This larva can be distinguished from others by the shape and size of the plates which surround the posterior respiratory apertures.

These are situated on the broad end of the body and are close together, comparatively large, and circular except for the inside edges, which are straight. Under favorable conditions the larva is full grown and pupates in from 4 to 7 days. (See Fig. 2).

Pupa: Yellowish brown to dark reddish brown, barrel shaped, but tapering slightly towards the anterior end, 6 to 8 mm. long. (See Fig. 3.) Under most favorable conditions of temperature and humidity the pupal stage lasts 3 to 5 days.

Adult: The normal length is about 6 or 7 mm., mouse gray in color, while the thorax has four black, longitudinal stripes, which are usually most sharply defined in front. It may be noticed that the compound eyes more nearly meet on top of the head in the male than in the female. The proboscis, at rest, is not visible from above. The end of the 4th longitudinal vein bends sharply up so as to nearly join the vein above it. (See Fig. 1.) Females hibernate in winter. The House-Fly cannot bite and does not suck blood.

Homalomyia canicularis, Linn. The Lesser House-Fly.

Egg: This has not been studied by the writer but it is reported to be deposited in decaying animal and vegetable matter.

Larva: About 8 mm. long when full grown, brownish yellow in color and somewhat abruptly narrowed in front. This larva may readily be distinguished from that of *Musca domestica* or of *Stomoxys calcitrans* by the presence of spines shown in Fig. 5.

Pupa: The bristles of the last larval stage still persist in the pupa as does also the brownish coloration. The case is, however, somewhat shorter than the extended larva. (See Fig. 6.)

Adult: Normal length about 6 mm., but this fly is much more slender than the common house-fly. The thorax is blackish or dull grey, but the distinct longitudinal stripes are not noticeable in the ♂.

Front of head shining white in the ♂, while that of the ♀ is darkish grey. Width of vertex in the ♂ is one-seventh; in the ♀ one-third the total width of the head. *The proboscis is not visible from above.* End of 4th longitudinal vein not bent up towards the vein above but parallel to it. When this fly is at rest the tips of the wings are nearer together than in *Musca domestica*. This adds to the narrower and smaller appearance of the insect, and no doubt accounts, in some degree, for the common, but erroneous idea that these are young house-flies. Like the house-fly this species cannot bite and does not suck blood.

Stomoxys calcitrans Linn. The Stable Fly.

Egg: About 1 mm. long, white, elongate and banana-like in shape. One side straight, with a deep groove, the other curved. Laid in small masses of 40 to 70, in accumulation of moist and fermenting vegetable matter (straw, etc.), or in fresh horse manure. At favorable temperature the eggs hatch in 2 to 4 days.

Larva: Length when full grown about 10 mm., very similar in appearance and color to the larva of *Musca domestica*, but may be readily distinguished by the plates of the respiratory tubes which are dis-

tinctly smaller, circular, and from 4 to 6 times as far apart. (See Fig. 8.) Larval stage usually lasts 15 to 21 days, but may be extended under unfavorable conditions up to 80 days.

Pupa: Bright reddish brown to chestnut brown in color, and normally 6 mm. long; precisely similar to that of *Musca domestica* from which it may be distinguished by the plates in the same manner as the larva. In summer the adults usually emerge in 9 to 13 days after pupation. (See Fig. 9.)

Adult: Normal length about 7 mm., rather more robust in shape than either of the foregoing, darkish grey. Thorax with 4 conspicuous blackish longitudinal stripes. Abdomen without ochraceous-buff patches but dotted with clove-brown, the spots usually more conspicuous in the ♀. Vertex $\frac{1}{4}$ in ♂, and $\frac{1}{3}$ in ♀ the width of the whole head. Proboscis shining black, projecting horizontally in front of the head, *visible from above* when not feeding. The end of the 4th longitudinal vein bent up, but not so much as in *Musca domestica.* (See Fig. 7.) A biting fly, *both sexes suck blood* from human beings as well as from cattle, horses, etc. Common about farmyards and stables, and common in houses near such places, especially on dull days. This accounts for the old saying in the country districts, that it is a sign of rain when the flies bite.

External Mouth Parts.

Unlike some of the other well known Blood-Sucking Diptera the male of this species feeds also on blood, and I have been unable to determine any difference between the mouth parts of the two sexes of *Stomoxys calcitrans.* The following description will therefore apply equally well to male or female. The external mouth-parts consist of maxillary palpi and the proboscis. (Plate XXXIV, Fig. 1. *mxp.* and *pr.*) Maxillæ proper and mandibles are not found, the proboscis consisting of the labrum, hypopharnyx and the labium.

The *maxillary palpi* consist of a single segment and are approximately one-fourth the length of the proboscis.

The *proboscis*, in a resting position, extends horizontally below the head and may be plainly seen projecting for about one-third of its length in front of the head. In this position its base is closely applied to the lower part of the head in the ventral groove, but when extended it will be observed that its attachment to the lower chitinous skeleton is membranous, except for the two strong apodemes. (*ap.* in Figs. 1, 2 and 4, Plate XXXIV.)

The *maxillary palpi* are attached to this membranous cone, and do not, in any part, enclose the proboscis. The proboscis is

somewhat longer than the height of the head, distinctly thickened, in the basal half, black, shining, and practically smooth.

The *labium*, or lower lip, is the strong black part referred to, and this constitutes the sheath for the labrum and hypopharynx. The labium consists of three segments. (Plate XXXIV, Fig. 1, *i*, *ii*, *iii*). Segment *i* is eight to ten times the length of the other two together. Segment *ii* is very small and inconspicuous, and segment *iii* is composed of the labella. Throughout the whole length of the labium is the dorsal groove, in which lie the labrum and hypopharynx. This dorsal groove is deep in the basal part and becomes gradually more and more shallow distally. Near the extreme base it is practically closed above by the overlapping of the dorsal margins of the labium. (Plate XXXIV, Fig. 3.)

The outer chitinous walls of the labium are comparatively thin but very hard, while the interior is completely filled by muscles and tracheæ. (Plate XXXIV, Fig. 3 *mc.* and *tr.*)

Segment *ii* of the labium, as has been said, is very small, and appears as a small section of chitin in the joint between *i* and *iii*. Segment *iii* is composed of the labella, fitting together as one might place the palms of the hands together with the fingers pointing forward. Around the margins of the labella, under low power, smaller and larger hair-like processes may be seen projecting, while if a labellum be removed and its inner surface examined under the microscope its structure will be found to be elaborate and interesting.

Figure 5 shows the inner surface of the right labellum, with its lower or ventral wall at *vw*, and the dorsal margin at *dm*. It will be seen that there are five strong chitinous teeth, *ct.*, and a series of chitinous blades, *cb.*, which are more delicate. In addition to these there are a number of longer or shorter setæ on the distal and ventral margins.

The Labrum (of Hansen) or upper lip, (*lb*, Figs. 2, 3 and 4) (=labrum-epipharynx of Newstead) reaches nearly to the base of the labella. Its shape in section is readily seen from Figure 3, *lb.*, where it will be noticed that its lateral margins are incurved below to form a definite tube with a rather broad slit. When feeding the tube is completed by the hypopharynx. (*hp.*, in Figs. 2, 3 and 4). The labrum is thickened at the base, is somewhat strongly chitinised, and has a sharp, flattened, tri-

angular, and highly chitinized point. At intervals along the inner surface, are sense organs, each with a short clear hair.

The Hypopharynx is as long as the labrum, and consists, until its distal end is neared, of a tube. (Fig. 3, *hp.*,) The apical part, however, is flattened and membranous, and quite unsuited for piercing.

Method of Feeding.

When about to feed *Stomoxys calcitrans* raises the body somewhat higher than the normal position on the legs, and brings the proboscis into practically a vertical position. The posterior part of the body is, in some cases, decidedly elevated. The tip of the proboscis is in this manner brought into contact with the skin of the host and the first puncture made. This, I believe, is performed by the labella, which are slightly parted so that the chitinous teeth and blades can be brought into operation. If blood emerges from the puncture it is sucked up, but if not I imagine the labella are depressed laterally and the point of the labrum forced into the host. I have observed on several occasions, when allowing *S. calcitrans* to bite, that there is often a decided stab after the first puncture had been completed.

The saliva is conducted to the wound by means of the hypopharynx, into the base of which the salivary duct opens. (*sd.*, in Figs. 2 and 4; *sc.*, Fig. 3.)

The blood is conveyed to the pharynx by means of the tube formed by the labrum and hypopharynx combined, which is in turn enclosed by the dorsal groove of the labium.

The pharynx proper has strongly chitinised walls, and powerful muscles, which make it well adapted for sucking.

Digestive System.

The relative position of the different parts of the alimentary canal in Stomoxys calcitrans are shown, in diagrammatic form, in Fig. 2. Beginning with the proboscis it will be seen to consist of the following parts: *l. hp.*, the canal formed by the labrum and hypopharynx combined. *g.*, the tube leading from this canal to the pharynx proper. *ph.*, the pharynx proper. *oe.*, the oesophagus, which passes through the brain at the point indicated. *pr.*, the proventriculus, from which two ducts pass backward, viz., *d. ss.*, the duct of the sucking stomach,

and the one dorsal to this, which is the thoracic intestine. *s. st.*, the sucking stomach. *in.*, the abdominal intestine. *m. t.*, the junction of the abdominal intestine and the proctodæum, at which point the Malpighian tubes enter. *r.*, the rectum. *a.*, the anus.

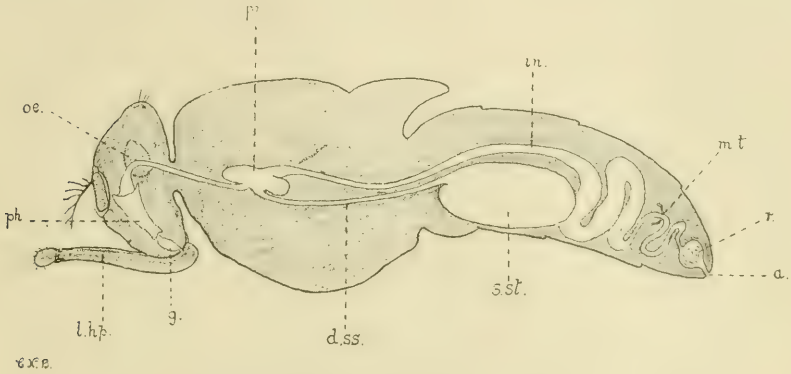

Fig. 2. *Stomoxys calcitrans* L. Semi-diagrammatic view of longitudinal section showing alimentary canal.

The food canal of the proboscis was described earlier in this paper, and this leads to a sausage-shaped tube, which has chitinous, and spirally thickened walls, and which is plainly seen in the membranous cone when the proboscis is extended for feeding. (Plate XXXIV, Figs. 2 and 4, *g.*) This, in turn, opens into the pharynx, which is roughly triangular in shape, having its upper edges drawn out into chitinous projections as muscle attachments. The œsophagus, on emerging from the pharynx, is wide and flattened, but soon becomes narrower and assumes a cylindrical form. It passes slightly forward and upward, turns abruptly backward through the brain and into the thorax, where it enters the ventral, anterior part of the proventriculus. The proventriculus is situated in the anterior third of the thorax, and, when seen from above, is a delicate white sac, circular in outline. It is roughly the shape of a mushroom, with its convex surface upward. The intestine arises from its posterior upper surface, while the œsophagus enters the ventral surface. Slightly posterior to this, again, on the ventral surface, the duct of the sucking stomach arises.

During its course through the thorax the intestine is practically of uniform thickness, but at about the point where it passes over the sucking stomach it becomes thicker, its walls,

at the same time, becoming thinner. The abdominal intestine is approximately three times the length of the fly. The thickened part, *i. e.*, that nearest the sucking stomach, is the only part coiled, and this lies in three simple, superposed coils, gradually narrowing to each end. Posterior to this the intestine continues, of practically uniform thickness, to the rectum.

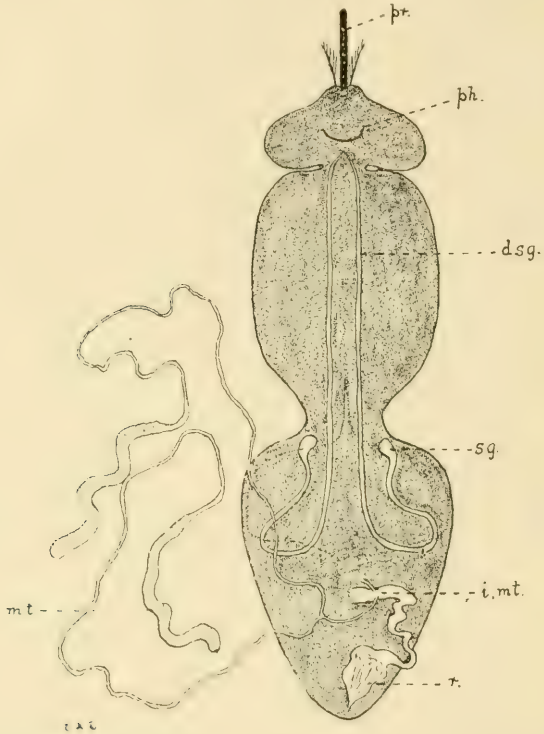

Fig. 3. *Stomoxys calcitrans* L. Salivary glands and left Malpighian tube (semi-diagrammatic).

The rectum is a transparent sac, cone-shaped, with the apex toward the anus. It contains four rectal glands, which are long and trumpet like in shape, and terminates in a narrow tube leading to the anus. The appendages of the alimentary canal are the sucking stomach, the salivary glands, and the Malpighian tubes.

The sucking stomach, when filled with blood, occupies the greater part of the abdomen, but when examined before the insect has fed, it lies in the anterior third, immediately above the salivary glands. Its walls are thin, being composed of a single layer of cells with interrupted strands of muscle fibre.

The salivary glands (Fig. 3, *s. g.*) are situated partly in the thorax, and partly in the abdomen. Their two ducts arise from the common salivary duct (Plate XXXIV, Figs. 2 and 4, *sd.*) in the head, and follow a parallel course through the thorax until the abdomen is reached. Here they become slightly wider apart, and then make a sharp turn outward and forward. Their extreme ends are slightly enlarged. Throughout their whole course they occupy a ventral position to the remainder of the alimentary canal.

The Malpighian tubes, *m. t.* in Fig. 3, are long, slender, and much coiled. They are readily seen in dissections, being easily distinguished by their opaque and yellowish appearance. They arise from the narrow, lower intestine, a single tube on each side. From each of these, in turn, two tubules branch, those of the left side only being indicated in the figure.

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Tulloch, F. M. G. The Internal Anatomy of Stomoxys. Proc. Roy. Soc. Lond. Ser. B., Vol. 77. 1905–6, pp. 523–531. Also in Jour. Army Med. Corps, Lond. Vol. 7. 1906. pp. 154–162. 5 Figs.

The species dealt with in this paper is not known, as Lieut. Tulloch states: "The dissections of the local variety of Stomoxys, which form the subject of this Note, were made at the suggestion of Prof. Minchin, during his direction of the Royal Society's Commission on Sleeping Sickness in Entebbe, Uganda. Lieutenant Tulloch describes the Digestive System, the Nervous System, the Circulatory System, and the ♂ and ♀ Generative Organs.

Giles, G. M. The Anatomy of the Biting Flies of the Genus Stomoxys and Glossina. Journ. Trop. Med. Lond. Vol. 9. 1906. pp. 99, 153, 169, 182, 198, 217, and 235. 1 Pl. and 36 Figs.

The parts dealing with the digestive tract, and the reproductive organs are taken mainly from Tulloch and Minchin, whose figures are reproduced.

Stephens, J. W. W., and **Newstead, R.** The Anatomy of the Proboscis of Biting Flies Ann. Trop. Med. & Parasitol. Liverpool, Vol. 1. 1907. pp. 171–198. 8 pls.

Surcouf, J., and **Picard, F.** Note sur les diptères du genre Stomoxys en Abyssinie Bull. Soc. Path. Exot., Par. Vol. 1, 1908. pp. 195–198.

This paper deals with the Genus Stomoxys in general but the following particulars are given on the mouth parts:

"Appareil buccal: L'appareil buccal est réduit; il se compose en dessus, d'un labre triangulaire, tranchant sur les bords et limitant une cavité ou se trouve la langue ou hypopharynx, non piquante et percée d'un canal en son milieu.

"La lèvre inférieure, tranchante, faite en forme de gouge, pénètre dans les tissus et forme le dessous. Cette lèvre inférieuer porte deux prolongements nommés paraglosses, qui sont hérissés de grosses épines tactiles. Elle porte les palpes près de sa base, et, au repos, sert à envelopper la langue."

DESCRIPTION OF PLATES.

Plate XXXIII.

Figs. 1—9 after drawings by Terzi in Reports to Local Gov. Bd. on Public Health, N. S. No. 5. 1909. London.

Fig. 1. Musca domestica Linn., perfect insect.
Fig. 2. Musca domestica Larva.
Fig. 3. Musca domestica Pupa.
Fig. 4. Homalomyia canicularis, Linn., perfect insect.
Fig. 5. Homalomyia canicularis, Larva.
Fig. 6. Homalomyia canicularis Pupa.
Fig. 7. Stomoxys calcitrans Linn., perfect insect.
Fig. 8. Stomoxys calcitrans Larva.
Fig. 9. Stomoxys calcitrans Pupa.

N. B.—All figures are 4 times natural size.

Plate XXXIV.

External mouth parts of Stomoxys calcitrans Linn.

Fig. 1. Median longitudinal section of skeleton of front of head showing antennae, maxillary palpi and proboscis; v, vertex; ant., antenna; ar., arista; mxp., left maxillary palpus; ap., apodeme; pr., proboscis; I, II, III, segments of labium; III, showing left labellum.

Fig. 2. Proboscis with labium removed; ap., apodeme; ph., pharynx; sd., salivary duct; g., lower part of oesophagus connecting the food canal of proboscis with the pharynx; I, portion of base of labium; lb., labrum; h. p., hypopharynx.

Fig. 3. Transverse section of base of proboscis. I outer wall of base of Segment I of labium; m. c., muscle cells; lb., section of labrum; h. p., section of hypopharynx; fc., food canal formed by labrum and hypopharynx combined; s. c., salivary canal of hypopharynx; tr., trachea; k., keel of chitin which gives rigidity to the base of labial groove.

Fig. 4. Base of proboscis with labium removed (adapted from Hansen's fig.); m., right muscle of enlargement of salivary duct s. d.; ph., pharynx; g., tube leading to pharynx; ap., base of apodeme.; lb., labrum; h. p., hypopharynx; b. h. p., base of hypopharynx; k, part of keel; see Fig. 3.

Fig. 5. Inner surface of right labellum; vw., ventral wall; d. m., dorsal margin; ct., chitinous teeth; cb., chitinous blades; h., hair-like processes (adapted from Hansen's fig.).

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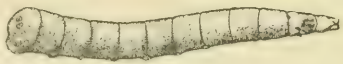

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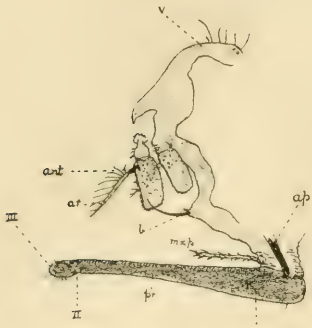

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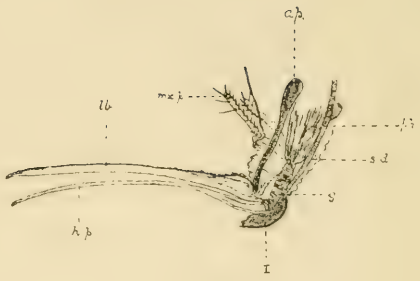

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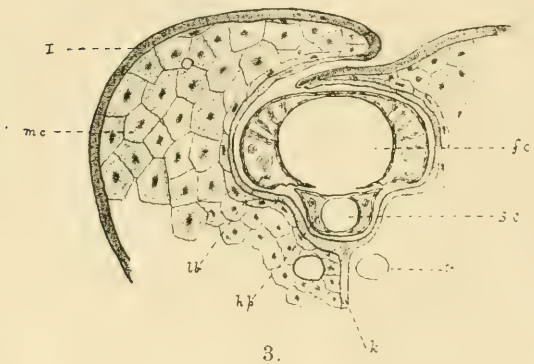

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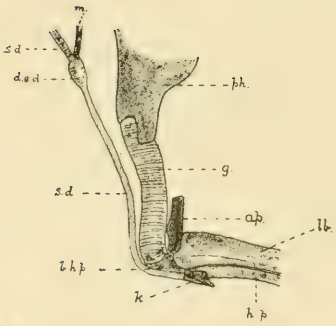

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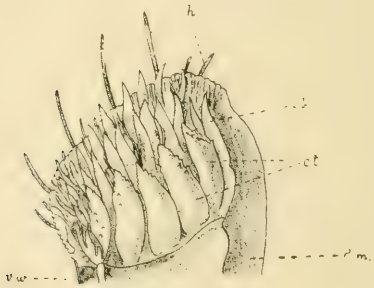

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SECTION 1. This organization shall be known as THE ENTOMOLOGICAL SOCIETY OF AMERICA.

ARTICLE II.

OBJECT.

SECTION 1. It shall be the purpose of this society to promote the science of entomology in all its branches, to secure cooperation in all measures tending to that end, and to facilitate personal intercourse between entomologists.

ARTICLE III.

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SECTION 1. The membership of this society shall consist of three classes—members, fellows, and honorary fellows.

SEC. 2. All persons interested in entomology shall be eligible to membership.

SEC. 3. Members who have made important contributions to the science of entomology may be elected fellows or honorary fellows of the society.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of this society shall be a President, two Vice-Presidents, a Secretary, and a Treasurer; but these two last offices may be held by the same person.

SEC. 2. The business of the society not otherwise provided for shall be in the hands of an executive committee, consisting of the officers named in Section 1, and of six additional members, five of whom shall be elected from the Fellows by the Society, and the sixth shall be *ex officio* the Managing Editor. Four members of the Committee shall constitute a quorum.

SEC. 3. The president shall represent the society upon the Council of the American Association for the Advancement of Science until such time as the society shall be qualified for representation by two councillors, in which case the second councillor shall be elected from the fellows by the Executive Committee.

ARTICLE V.

ELECTIONS.

SECTION 1. Election of Members—Nominations for membership may be made by any two members, and election shall be by the Executive Committee.

SEC. 2. Election of Fellows—All nominations for fellows shall be signed by three or more fellows and each nomination shall be accompanied by the following information concerning the nominee: Name, address, occupation, branches of entomology engaged in, positions held involving entomological experience, entomological work done, and list of more important publications. Election shall be by ballot by the Executive Committee, a majority vote of the committee being necessary for election.

SEC. 3. Election of Officers—All officers shall be elected by ballot at the annual meeting for the term of one year and shall be eligible for re-election. Their term of office shall commence with the first of June following their election.

SEC. 4. Election of Honorary Fellows—All nominations for Honorary Fellows shall be made in the manner prescribed for the nomination of Fellows, the nominations being presented to the Executive Committee, who shall mail the ballots to the Fellows. Election shall be by mail ballot of the Fellows of the Society, a two-thirds vote of all the Fellows being required for election.

ARTICLE VI.

MEETINGS.

SECTION 1. An annual meeting shall be held in conjunction with the annual meeting of the American Association for the Advancement of Science, and at such time and place as the officers may elect.

ARTICLE VII.

AMENDMENTS.

SECTION 1. This constitution may be altered or amended at any annual meeting by a two-thirds vote of the members present, a copy of each amendment proposed having been presented at the previous annual meeting.

BY-LAWS.

1. The annual dues for members and fellows shall be two dollars. This includes a subscription to the Annals of the Entomological Society of America.

2. A majority of the members present at any annual meeting shall constitute a quorum for the transaction of business.

3. Notice of all meetings of the society shall be sent to all members at least one month in advance.

4. The Executive Committee shall provide a program for all meetings, including at the annual meeting a popular lecture and a technical entomological exhibit of materials and methods.

5. The time of the business session shall be published prior to the opening session of the annual meeting.

6. Any member may become a life member upon payment of $50 at one time, and shall be exempt from further assessments. He shall receive during his life one copy of each issue of the Annals.

7. Members two years in arrears shall be dropped from the rolls by the Secretary-Treasurer after twenty days notice.

8. A member-elect shall not be in good standing until he pays his first year's dues. In case he shall not have made such payment at the expiration of one year from the date of his election, he shall be dropped from the roll by the Secretary-Treasurer after twenty days notice.

9. The Annals of the Entomological Society of America will not be mailed to any fellow or member whose dues are in arrears. All dues are payable December 1st, and should be received not later than March 1st.

MEMBERSHIP OF THE SOCIETY.

HONORARY FELLOWS.

Cresson, Ezra Townsend, Hedgleigh, Swarthmore, Pa. *Aug., '07.*
Uhler, Dr. Philip Reese, 254 W. Hoffman St., Baltimore, Md. *Aug., '07.*

FELLOWS.

Aldrich, Prof. J. M., University of Idaho, Moscow, Idaho. *Aug., '07.*
Ball, Prof. E. D., Director, Agr. Exper. Sta., Logan, Utah. *Dec. '08.*
Bethune, Dr. C. J. S., Ont. Agr. College, Guelph, Ont. *Dec., '06.*
Beutenmüller, W., 879 Whitlock Av. Bronx, New York, N.Y. *Aug., '07.*
Bruner, Prof. Lawrence, Univ. of Nebraska, Lincoln, Neb. *Dec. '07.*
Calvert, Dr. P. P., Univ. of Pennsylvania, Philadelphia, Pa. *Aug., '07.*
Cockerell, Prof. T. D. A., Univ. of Colorado, Boulder, Colo. *Dec., '08.*
Comstock, Prof. J. H., Cornell University, Ithaca, N. Y. *Dec., '06.*
Dyar, Dr. H. G., U. S. Nat. Museum, Washington, D. C. *Aug., '07.*
Emerton, J. H., 194 Clarendon St., Boston, Mass. *Aug., '07.*
Fall, Prof. H. C., 191 N. Raymond Ave., Pasadena, Cal. *Dec., '07.*
Felt, Dr. E. P., N. Y. State Entomologist, Albany, N. Y. *Dec., '08.*
Fernald, Prof. C. H., Mass. Agr. College, Amherst, Mass. *Aug., '07.*
Folsom, Dr. J. W., Univ. of Illinois, Urbana, Ill. *Dec., '07.*
Forbes, Prof. S. A., Univ. of Illinois, Urbana, Ill. *Aug., '07.*
Gillette, Prof. C. P., Colorado Agr. College, Fort Collins, Colo. *Dec., '07.*
Henshaw, Samuel, Harvard University, Cambridge, Mass. *Aug., '07.*
Holland, Dr. Wm. J., Director, Carnegie Museum, Pittsburgh, Pa. *Dec., '07.*
Hopkins, Dr. A. D., Bureau of Entomology, Washington, D. C., *Aug., '07.*
Howard, Dr. L. O., Chief, Bureau of Entomology, Washington, D. C. *Aug., '07.*
Johnson, C. W., Boston Soc. Nat. Hist., Boston, Mass. *Dec., '06.*
Kellogg, Prof. V. L., Leland Stan. Jr. Univ., Stanford University, Cal. *Aug., '07.*
Lyman, H. H., 74 McTavish St., Montreal, Can. *Aug., '07.*
MacGillivray, Dr. A. D., Univ. of Illinois, Urbana, Ill. *Dec., '08.*
Marlatt, C. L., Bureau of Entomology, Washington, D. C. *Dec., '07.*
Needham, Prof. J. G., Cornell University, Ithaca, N. Y. *Aug., '07.*
Osborn, Prof. H., Ohio State University, Columbus, O. *Dec., '06.*
Schwarz, E. A., U. S. Nat. Museum, Washington, D. C. *Aug., '07.*
Skinner, Dr. Henry, Academy, Nat. Sci., Philadelphia, Pa. *Dec., '06.*
Smith, Dr. J. B., Rutgers College, New Brunswick, N. J. *Dec., '06.*
Webster, F. M., Bureau of Entomology, Washington, D. C. *Dec., '06.*
Wheeler, Dr. W. M., Harvard University, Boston, Mass. *Dec., '06.*
Williston, Prof. S. W., Univ. of Chicago, Chicago, Ill. *Dec., '08.*

MEMBERS.

Abbott, Dr. James F., Washington University, St. Louis, Mo. *Dec., '07.*
Abbott, W. S., Ill. State Lab. Nat. Hist., Urbana, Ill. *C.*
Ainslie, C. N., Bureau of Entomology, Washington, D. C. *June '08.*
Ainslie, George G., U. S. Ent. Lab., Nashville, Tenn. *Dec., '07.*
Akerlind, G. A., 3618 Lexington St., Chicago, Ill. *C.*
Alexander, C. P., Cornell University, Ithaca, N. Y. *June, '10.*
Back, E. A., Bureau of Entomology, Washington, D. C. *C.*
Baker, Arthur Chaden, Bureau of Entomology, Washington, D.C. *Dec., '11.*
Baker, Prof. C. F., Pomono College, Claremont, Cal. *C.*
Banks, Chas. S., Chief Entom., Bureau of Sci., Manila, P. I. *C.*
Banks, Nathan, U. S. Nat. Museum, Washington, D. C. *Dec., '08.*
Barber, H. G., 12 Clay St., Roselle Park, N. J. *C.*
Barber, H. S., U. S. Nat. Museum, Washington, D. C. *C.*
Barber, Thos, C., Audubon Park Exper. Sta., New Orleans, La. *Dec., '09.*
Barlow, Prof. John, College of Agriculture, Kingston, R. I. *C.*
Barnes, Dr. Wm., 152 E. Prairie St., Decatur Ill. *C.*
Barrows, Prof. W. B., Mich. Agr. College, East Lansing, Mich. *C.*
Barrows, Prof. W. M., Ohio State University, Columbus, O. *June, '11.*
Bartholemew, Prof. C. E., Iowa State College, Ames, Ia. *C.*
Becker, Geo. G., Univ. of Arkansas, Fayetteville, Ark. *Dec., '10.*
Bentley, Prof. G. M., State Entomologist, Knoxville, Tenn. *C.*
Berger, E. W., Agr. Exper. Sta. Gainesville, Fla. *June '09.*
Berrenger, D. F., 314 Masonic Block, Fostoria, O. *June '08.*
Betten, Dr. C., Lake Forest College, Lake Forrest, Ill. *C.*
Bird, Henry, Rye, N. Y. *C.*
Bishopp, F. C., Bureau of Entomology, Dallas, Tex. *C.*
Blaisdell, Dr. F. E., Leland Stan. Jr. Univ., Cal. *C.*
Blumenfeld, S. F., Miss. Agr. Coll., Agricultural College, Miss. *Dec., '09.*
Bodine, Dr. D., Wabash College, Crawfordsville, Ind. *C.*
Bradley, Dr. J., Chester, Cornell University, Ithaca, N. Y. *C.*
Braucher, Ralph W., 115 Stewart Ave., Ithaca, N. Y. *Dec., '08.*
Braun, Miss A. F., 2702 May St., Cincinnati, O. *C.*
Brehme, H. H., 74 13th St., Newark, N. J. *C.*
Bridgham, J., East Providence Center, R. I. *C.*
Britton, Dr. W. E., Agr. Exper, Sta., New Haven, Conn. *C.*
Brooks, F. E., French Creek, W. Va. *C.*
Brues, C. T., Bussey Institution, Forest Hills, Boston, Mass. *C.*
Bryant, Owen, Cohasset, Mass. *Dec., '08.*
Buchholz, Otto, 710 Monroe Ave., Elizabeth, N. J. *C*
Bueno, J. R., de la Torre, 25 Broadway, New York, N. Y. *C.*
Burgess, A. F., Bureau of Entomology, Washington, D. C. *C.*
Butler, Miss Hortense, Peterson, Ia. *Dec., '08.*
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Carmody, Miss Mary, 3055 Q St., Washington, D. C. *Dec., '11.*

Chagnon, G., Box 521, Montreal, Quebec, Canada. *C.*
Chamberlin, Dr. R. V., Univ. of Pennsylvania, Philadelphia, Pa. *C.*
Chatterjie, B. M., 37 Jaliapara Road, Bhowanispur, Calcutta, India. *Dec., '08.*
Chittenden, Dr. F. H., Bureau of Entomology, Washington, D. C. *C.*
Clickener, Chas., Rural Route No. 1, Box 12, Silverwood, Ind. *C.*
Coleman, G. A., Univ. of California, Berkeley, Cal. *C.*
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Conradi, Prof. A. F., Clemson College, S. C. *June. '08.*
Cook, Prof. A. J., State Comm. Horticul., Sacramento, Cal. *C.*
Cook, Prof. M. T., Agri Exper. Sta., New Brunswick, N. J. *C.*
Cooley, Prof. R. A., Montana Agr. College, Bozeman, Mont. *June, '10*
Crampton, Dr. G. C., Mass. Agr. College, Amherst, Mass. *June, '11.*
Crampton, Prof. H. E., Columbia Univ., New York, N. Y. *C.*
Crane, M. S., Westville Ave., Caldwell, N. J. *C.*
Crawford, J. C., U. S. Nat. Museum, Washington, D. C. *C.*
Cresson, E. T., Jr., Acad. Nat. Science, Philadelphia, Pa. *C.*
Criddle, N., Freesbank, Man. *C.*
Crosby, Prof. C. R., Cornell Univ., Ithaca, N. Y. *C.*
Currie, R. P., Bureau of Entomology, Washington, D. C. *C.*
Cushman, R. A., Bureau of Entomology, Dallas, Tex. *Aug., '07.*
Daecke, V. A. E., Office State Zoologist, Harrisburg, Pa. *C.*
Davenport, Prof. C. B., Cold Spring Harbor, Long Island, N. Y. *C.*
Davis, J. J., Exper. Sta. Building, La Fayette, Ind. *C.*
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Doane, Prof. R. W., Leland Stan. Jr. Univ., Stanford University, Cal.C.
Doten, Prof. S. B., Agr. Exper. Sta., Reno, Nev. *C.*
Durrant, Prof. E. P., Ohio State University, Columbus, O. *June, '08.*
Dutt, Asutash, Coochbehar, Bengal, India. *Dec., '08.*
Easton, N. S., 458 High St., Fall River, Mass. *C.*
Edwards, E. H., 7317 Clinton Ave., N. W., Cleveland, O. *C.*
Ehrhorn, E. M., Bureau of Entomology, Exper. Sta. Honolulu, T. H. *C.*
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Erb, H. J., 536 Blum Place, Union Hill, N. J. *C.*
Essig, E. O., Sec. State Comm. Hort., Sacramento, Cal. *Dec., '10.*
Evans, J. D., Trenton, Ont. *C.*
Ewers, E. V., 140 N. Goodman St., Rochester, N. Y. *C.*
Ewing, Dr. H. E., Oregon Agr. College, Corvallis, Ore. *Dec., '10.*
Fenninger, C. W., 409 Chestnut St., Philadelphia, Pa. *C.*
Fenyes, Dr. A., 170 N. Orange Grove Ave., Pasadena, Cal. *C.*
Fernald, Prof. H. T., Mass. Agr. College, Amherst, Mass. *C.*
Field, W. L. W., Milton Academy, Milton, Mass. *C.*
Fink, D. E., 1204 Cascadilla Building, Ithaca, N. Y. *Dec., '10.*
Fisher, W. S., Highspire, Pa. *Dec., '07.*

Flint, W. P., 1231 W. Edwards St., Springfield, Ill. *June, '08.*
Forbes, Dr. W. T. M., 23 Trowbridge Road, Worcester, Mass. *Dec., '08.*
Foster, S. W., Bureau of Entomology, Washington, D. C. *C.*
Fracker, S. B., Iowa State College, Ames, Ia. *Dec., '11.*
Francisco, Campos R., Guayaquil, Equador, S. A. *Aug., '07.*
Franck, George, 55 Stuyvesant Ave., Brooklyn N. Y. *C.*
French, Prof. G. H., State Normal School, Carbondale, Ill. *C.*
Frost, C. A., 40 Grant St., South Framingham, Mass. *C.*
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Fullaway, D. T., U. S. Agr. Exper. Sta. Honolulu, T. H. *C.*
Funkhouser, W. D., 415 N. Tioga St., Ithaca, N. Y. *Dec., '11.*
Gahan, A. B., College Park, Md. *C.*
Garman, Prof. H., Agr. Exper. Sta. Lexington, Ky. *C.*
Garrett, J. B., La. Crop Pest Comm. Baton Rouge, La. *C.*
Gerhard, Wm. J., Field Mus. Nat. Hist., Chicago, Ill. *C.*
Gibson, Arthur, Central Experiment Farms, Ottawa, Can. *C.*
Gifford, W. M., Box 1308, Honolulu, T. H. *C.*
Glasgow, Hugh, Univ. of Ill., Urbana, Ill. *Dec., '11.*
Glasgow, R. D., Univ. of Ill., Urbana, Ill. *Dec., '11.*
Goodwin, Wm. H., Ohio Agr. Exper. Sta., Wooster, O. *Dec., '08.*
Gorham, Prof. F. P., Brown University, Providence, R. I. *C.*
Gossard, H. A., Ohio Agr. Exper. Sta., Wooster, O. *C.*
Graef, E. L., 58 Court St., Brooklyn, N. Y. *C.*
Graenicher, Dr. S., 116 Harmon St., Milwaukee, Wis. *C.*
Green, F. V., Nyack, N. Y., *Aug., '07.*
Griffin, D. B., Winooski, Vt. *C.*
Grosbeck, J. A., American Mus. Nat. Hist., New York, N. Y. *C.*
Guthrie, Prof. J. E., Iowa State College, Ames, Ia. *C*
Haimbach, F., 150 Sumac St., Wissahickon, Philadelphia, Pa. *C.*
Hambleton, J. C., Ohio State University, Columbus, O. *Dec., '07.*
Hammar, A. G., Bureau of Entomology, Washington, D. C. *Dec., '07.*
Hansen, Rev. James, St. John's University, Collegeville, Minn. *C*
Harned, Prof. R. W., Miss. Agr. College, Agricultural College, Miss. *Dec., '07.*
Harrington, W. H., P. O. Department, Ottawa, Que., Can. *C.*
Hart, Charles A., Ill. State Lab. Nat. Hist., Urbana, Ill. *C.*
Hartman, Miss F. T., Geological Hall, Albany, N. Y. *C.*
Hartzell, F. Z., 321 W. Main St., Fredonia, N. Y. *Aug., '07.*
Haseman, Dr. L., Univ. of Missouri, Columbia, Mo. *C.*
Hayhurst, Prof. P., Univ. of Arkansas, Fayetteville, Ark. *C.*
Headlee, Prof. T. J., State Agr. College, Manhattan, Kans. *C.*
Healy, J. L., 1531 Estes Ave., Rogers Park, Chicago, Ill. *C.*
Hebard, Morgan, Chestnut Hill, Philadelphia, Pa. *C.*
Heidemann, O., Bureau of Entomology, Washington, D. C. *C.*
Herrick, Prof. Glenn W., Cornell University, Ithaca, N. Y. *C.*
Hertzog, P. H., Hightstown, N. J. *Dec., '08.*
Hewitt, Dr. Chas. G., Dominion Entomologist, Ottawa, Can. *Dec., '09.*
Hilton, Dr. W. A., Univ. of Minnesota, Minneapolis, Minn. *Dec., '08.*
Hinds, Prof. W. E., Ala. Polytech. Inst., Auburn, Ala. *C.*

Hine, Prof. J. S., Ohio State University, Columbus, O. *C.*
Hodgekiss, H. E., State Agr. Exper. Sta., Geneva, N. Y. *C.*
Hood, J. D., Biol. Survey, U. S. Dept. Agr., Washington, D. C. *C.*
Hooker, Charles W., Amherst, Mass. *C.*
Hooker, W. A., Office of Exper. Stations, Washington, D. C. *C.*
Hornig, H., 144 N. 53d St., Philadelphia, Pa. *C.*
Houghton, Prof. C. O., State Agr. College, Newark, Del. *C.*
Houser, J. S., Ohio Agr. Exper. Sta., Wooster, O. *C.*
Howard, Dr. C. T., 1735 East Ave., Rochester, N. Y. *C.*
*Howard, Chas. W., Univ. of Minnesota, St. Paul, Minn. *Aug., '07.*
Huard, Rev. V. A., 2 Port Dauphin St., Quebec, Can. *C.*
Hungate, Prof. J. W., State Normal School, Cheney, Wash. *Dec., '09.*
Hunter, W. D., Bureau of Entomology, Dallas, Tex. *C.*
Hyslop, J. A., Bureau of Entomology, Pullman, Wash. *Dec., '08.*
Illingworth, J. F., 115 Linn St., Ithaca, N. Y. *Dec., '11.*
Jackson, Prof. C. F., New Hamps. Agr. College, Durham, N. H. *Aug., '07*
Jenne, E. L., Bureau of Entomology, Washington, D. C. *C.*
Jennings, H. R., Parkville, Mo. *Dec., '10.*
Jensen, Jesse O., Eagle Bend, Minn. *Dec., '08.*
Jobbins-Pomeroy, A. W., Nat. Hist. Bldg., Urbana, Ill. *Dec., '11.*
Johannsen, Prof. O. A., Maine Agr. Exper. Sta., Orono, Me. *C.*
Johnson, Prof. C. E., Univ. of Minnesota, Minneapolis, Minn. *C.*
Johnson, Fred., Bureau of Entomology, Washington, D. C. *C.*
Johnson Prof. S. A., Colorado Agr. College, Fort Collins, Colo. *C.*
Johnston, F. A., Truck Exper. Sta., Norfolk, Va. *Dec., '08.*
Jones, C. R., 317 Edward St., Fort Collins, Colo. *C.*
Jones, F. M., 802 Washington St., Wilmington, Del. *C.*
Kayser, Wm., 26 E. Auglaize St., Wapakoneta, O. *C.*
Kearfott, W. D., Montclair, N. J. *C.*
Keith, Edw. D., 220 Sacket St., Providence, R. I. *C.*
Keller, G. J., 191 Avon Ave., Newark, N. J. *C.*
Kelly, E. O. G., U. S. Entom. Lab., Wellington, Kans. *C.*
Kincaid, Prof. T., Univ. of Washington, Seattle, Wash. *C.*
King, Vernon, Entom. Lab., Wellington, Kans. *Dec., '11.*
Knab, F., U. S. Nat. Museum, Washington, D. C. *C.*
Knaus, W., 512 S. Main St., McPherson, Kans. *C.*
Knight, Harry, H. 45 East Ave., Ithaca, N. Y. *Dec., '11.*
Kohlsaat, J. E. C., 1739 Eastern Ave., Cincinnati, O. *C.*
Kotinsky, Jacob, Board of Agr. and Forestry, Honolulu, T. H. *C.*
Kribs, H. G., Chestnut Hill, Philadelphia, Pa. *Dec., '08.*
Kraus, E. J., Bureau of Entomology, Corvallis, Ore. *C.*
Kuhns, D. B., Ter. Division of Entomology, Honolulu, T. H. *Dec., '08.*
Lacey, H., Kerrville, Tex. *C.*
Lagai, Dr. G., care of Kny-Scheerer Co., 404 W. 27th St., New York, N. Y. *C.*
Lang, Jos. N., 1433 59th Ave., Cicero, Ill. *C.*

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* Life Member.

Laurent, P., 31 E. Mt. Airy Ave., Philadelphia, Pa. *C.*
Lawford, J. M., 718 N. Howard St., Baltimore, Md. *C.*
Leonard, M. D., R. F. D. No. 2, Ithaca, N. Y. *Dec., '10.*
Lewis, A. C., 332 State Capitol, Atlanta, Ga. *Dec., '09.*
Liljeblad, E., 1018 Roscoe St., Chicago, Ill. *C.*
Lloyd, J. T., College of Agriculture, Ithaca, N. Y. *C.*
Lochhead, Prof. W., MacDonald College, MacDonald College, Que., Can. *C.*
Loding, H. P., 911 Palmetto St., Mobile, Ala. *June, '08.*
Lowe, Edward G., 80 E. 55th St., New York, N. Y. *C.*
Lutz, Dr. F. E., American Mus. Nat. Hist., New York, N. Y. *C.*
McCann, Miss Sue D., 137 E. High St., Lexington, Ky. *Dec., '08.*
McConnell, Prof. W. R., Penn. State College, State College, Pa. *Dec., '10.*
McCracken, Miss M. I., Stanford University, Cal. *Aug., '07.*
McDaniel, Miss Eugenia Inez, East Lansing, Mich. *Dec., '10.*
McElhose, H., 20 West St., Ilion, N. Y. *C.*
McIndoo, N. E., Bureau of Entomology, Washington, D. C. *Dec., '11.*
Mackenzie, G. P., 1921 Chestnut St., Philadelphia, Pa. *C.*
Mann, B. P., 1918 Sunderland Place, Washington, D. C. *C.*
Marshall, Dr. W. S., Univ. of Wisconsin, Madison, Wis. *C.*
Matausch, Ignaz, American Mus. Nat. Hist., New York, N. Y. *C.*
Matheson, Dr. R., Cornell University, Ithaca, N. Y. *C.*
Matthews, J. H., 3219 N. 13th St., Philadelphia, Pa. *C.*
Melander, Prof. A. L., Washington State College, Pullman, Wash. *C.*
Metcalf, Z. P., Division of Entomology, Raleigh, N. C. *Dec., '08.*
Miller, Mrs. E. R., 4180 E. 95th St., Cleveland, O. *C.*
Mitchell, Miss E. G., U. S. Nat. Museum, Washington, D. C. *C.*
Montgomery, Prof. T. H. Jr., Univ. of Pennsylvania, Philadelphia, Pa. *C.*
Moore, Dr. R. M., 74 S. Fitzhugh St., Rochester, N. Y. *C.*
Moore, W., College of Agr., Potchefstrom, Transvaal, S. Afr. *Dec., '08.*
Morgan, A. C., Bureau of Entomology, Washington, D. C. *C.*
Morgan, Miss Ann H., Mt. Holyoke College, South Hadley, Mass. *Dec., '08.*
Morgan, Prof. H. A., Univ. of Tennessee, Knoxville, Tenn. *C.*
Morrill, A. W., Arizona Agr. Exper. Station, Phoenix, Ariz. *C.*
Morris, Earl, Hall of Records, San Jose, Cal. *C.*
Morse, A. P., Wellesley College, Wellesley, Mass. *C.*
Mosher, Miss Edna, 740 Harrison St., Gary, Ind. *Dec., '08.*
Mosher, F. H., 17 Highland Ave., Melrose, Mass. *C.*
Moulton, Dudley, Room 11, Ferry Building, San Francisco, Cal. *C.*
Mueller, G. T. O., San Mateo, Cal. *C.*
Muir, F., Ha. Sug. Plan. A. Exper. Sta., Keeaumoku, Honolulu, T.H. *C.*
Myers, P. R., U. S. Nat. Museum, Washington, D. C. *C.*
Nason, Dr. Wm. A., Algonquin, Ill. *C.*
Nelson, Dr. J. A., Bureau of Entomology, Washington, D. C. *Dec., '07.*
Ness, H., Jonesboro, Ark. *C.*
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Newcomb, Dr. W. W., Venice, Cal. *C.*
Newcomer, E. J., 1015 Forest Court, Palo Alto, Cal. *C.*
Newell, Miss A. G., Smith College, Northampton, Mass. *Dec., '10.*
Newell, Prof. W., Texas Agr. College, College Station, Tex. *Dec., '07.*
O'Kane, W. C., New Hampshire Agr. Exper. Sta., Durham, N. H. *June, '08.*
Osborn, H. T., Bureau of Entomology, Washington, D. C. *Dec., '08.*
Osburn, Prof. R. C., Columbia University, New York, N. Y. *C.*
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Patch, Miss Edith M., Agr. Exper. Sta., Orono, Me. *C.*
Paxson, O. S., Devon, Chester Co., Pa. *C.*
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Peterson, Alvah, 1005 S. Second St., Champaign, Ill. *Dec., '11.*
Petrunkevitch, Dr. Alex., Yale University, New Haven, Conn. *Dec., '07.*
Pettit, Prof. R. H., Michigan Agr. College, East Lansing, Mich. *C.*
Phillips, E. E., Plainfield, N. J. *June, '10.*
Phillips, Prof. J. L., Blacksburg, Va. *C.*
Pierce, W. D., Bureau of Entomology, Dallas, Tex. *C.*
Plunkett, C. R., Ithaca, N. Y. *Dec., '10.*
Powell, P. B., Clinton, N. Y. *C.*
Price, W. J. Jr., Blacksburg, Va. *Dec., '08.*
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