DIVISION OF ENTOMOLOGY

BULLETIN NO. 1
PART 3

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

Leaf-Hoppers and their Natural Enemies

(PT. III. STYLOPIDÆ)

BY R. C. L. PERKINS

HONOLULU, H. T.
AUGUST 8, 1905

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LETTER OF TRANSMITTAL

Honolulu, T. H., July 14th, 1905.

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

Gentlemen:

I, herewith, submit for publication the third part of the Bulletin on "Leaf-Hoppers and Their Natural Enemies."

Yours obediently,

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

GENERAL REMARKS ON THE STYLOPIDAE.

The Stylopidae or Strepsiptera are minute insects of great interest on account of their anomalous structure and their remarkable parasitic habits. Even now, though they are common insects, their structures have been very imperfectly examined, and the most diverse opinions have been expressd as to their natural affinities. Sir Sydney Saunders, who monographed the group in 1872, divided them into two groups on account of their habits, viz: the Hymenopterobiae parasitic on bees, wasps, and ants, and Homopterobiae parasitic on Homoptera. The latter group was made to contain Westwood's genus *Colacina*, parasitic on a leaf-hopper from Borneo, and I believe never yet characterized. Since that time, Mr. Edward Saunders, in 1892, discovered the long known genus *Elenchus*, the host of which had been the subject of various erroneous conjectures, to be parasitic on a small leaf-hopper of the genus *Liburnia*. Two years ago Mr. Koebele bred this same insect in quantities from *Liburnia* in the State of Ohio, and subsequently in California, while in Australia we found the same to be very common in every locality which we investigated, and to attack not only *Liburnia*, but several other genera of Delphacid leaf-hoppers. Finally, Mr. Koebele, after my return to Hawaii, when he proceeded to Fiji, at once discovered *Elenchus* there in numbers, attacking various Delphacids, and we had previously found the females and male puparia in leaf-hoppers sent from those islands for our inspection. Otherwise outside Europe, a species of this genus had been collected in numbers in Mauritius by Templeton some seventy years ago. Nor is it only the Homopterous Rhynchota that are attacked, for Sharp has recorded a case of a Stylopid attacking a Pentatomid bug of the genus *Chrysocoris* from East Asia, and I had the pleasure of examining this interesting specimen, when I was last in Cambridge. We failed to find any Australian Pentatomid stylopized, though we examined considerable numbers, but as owing to pressure of other matters we were unable to make any really extensive search, it is quite probable that such will be found there. At least not only are many Fulgoridae and Jassidae affected with these parasites at all points investigated, from Sydney in New

South Wales to Cairns in Northern Queensland, but so too are the Aculeate Hymenoptera, both the Vespidae (Polistes, etc.) and many Fossores, such as the common, house-frequenting *Pelopoeus* of the Sphegidae, the Bembecidae, Stizidae, and no doubt many others.

It is but rarely that any of the male Stylopidae are met with on the wing, and consequently they appear to be rarely well represented in collections of Coleoptera; but they are so easily bred and in reality so common everywhere that our want of knowledge of their habits and structure is astonishing, when we consider how remarkable these are. On account of their larger size, the Stylopidae that are parasitic on bees and wasps, are in some ways more suitable for study than those on Homoptera. My experience of the bee parasites has been far more extensive than with the Rhynchotal ones, as I have found them everywhere in England, very abundant in bees in California, common in Arizona, and Mexico, casually noticed them at Washington and rather commonly in *Halictus* at Montreal. To their occurrence in Australia, I have already referred. In spite of this, it is doubtful whether any museum in the world possesses a collection of even a few hundred specimens of these parasites, such as would adequately illustrate the various subfamilies, genera, and species.

With regard to the species parasitic in bees such as *Andrena*, in order to obtain the male parasites freely, I have found it necessary to note one fact in countries, which have a cool winter. It is known that sometimes in the case of *Andrena*, and probably generally, the male *Stylops*, like the bee it infests, is fully developed, even in midwinter, and only awaits the emergence of its host in the spring to issue from its body. Therefore the first appearance of the bees in the spring should be watched for, and their first appearance in the morning, since the *Stylops* will often emerge at the very moment that the bee first comes from its burrow into the sunlight. Later on the majority of the bees bear only female parasites, or the empty puparia of males. Notable exceptions are indeed known to these facts but nevertheless they are generally true of the genus Stylops itself, when parasitic on the spring species of *Andrena* in colder countries, and it is these species that are chiefly affected. On the other hand, fossorial Hymenoptera and wasps may retain the male puparia of *Xenos* and its allies unhatched for days and even weeks after capture, and in the case of the Fossores it is sometimes difficult to keep the hosts alive till the parasites

emerge. With the parasites of Jassid leaf-hoppers, emergence from the puparia sometimes does not take place for a week or more after capture, but these leaf-hoppers are more easily kept alive in captivity than most of the Fossorial Hymenoptera.

EFFECT OF ATTACK OF STYLOPIDAE ON THEIR HOSTS.

The external and internal effects of stylopization on the hosts have been studied by various hymenopterists in the case of the typical genus *Stylops*, but they still require much closer further examination. In 1891 I showed that males of certain species of bees bearing the females of *Stylops* were apparently perfectly capable of reproduction. I have fully verified these observations subsequently. Piffard has recorded the fact of a stylopized male bee copulating, and I have myself since noticed similar cases, but in this respect the most remarkable case observed by me was that of the male of a leaf-hopper, a large species of *Tettigonia* bearing two great male puparia and two mature female parasites, which was in copula with a female carrying three or four parasites. Female bees of the genus *Halictus* infested with *Stylops* hibernate like healthy individuals. On the other hand, Theobald examining other species of *Andrena* came to a conclusion almost opposite to my own, which may have been due to the fact that the species investigated by us were different. I suspect however that it was largely due to two causes: (1) that he chiefly examined bees containing, or that had contained, male *Stylops*, the effect of which is much more severe on the host than is the female parasite; (2) he examined material in alcohol, and it is quite possible that, in the process of pickling, the contents of the *vesiculae seminales* were lost, as I have shown this may happen on contact with water, or possibly by the pressure of other parts on contraction in the alcohol. All my specimens were freshly caught ones, dissected under anaesthetics, and only after the whole genital system had been removed entire, glands, ducts and armature, were the bees placed in alcohol for the examination of other organs. It is obviously perfectly impossible that, in the species to which my paper refers, the germ cells were destroyed in the larva of the bee as Theobald says we should expect to be the case.

In the case of stylopized leaf-hoppers, I should judge that the effects are a good deal the same as in stylopized bees, from such observations as we were able to make on the former. (1) The

male parasite injures the host more than the female, causing generally a considerable and often large distortion of the body .(2) Both male and female hoppers will copulate though very badly parasitized. (3) Death usually follows after the emergence of a male Stylopid, sometimes immediately, sometimes in a few hours, but sometimes not for some days in the case of especially robust hoppers, as also is the case with some wasps. (4) The much more fatal effect of the male parasite is not altogether due to the fact that the puparium is much larger (as to its protruded portion) than the mature female, and also usually more chitinized on its hidden segments, but it is largely due to the fact that, when the mature Stylopid emerges, the cap of the puparium being burst open and often altogether removed, a great opening extending far into the interior of the body of the host freely admits both light and air to the *viscera,* and this clearly produces most injurious and often rapidly fatal results. Possibly too it may be that the male parsite, so far more highly developed than the female, requires for its perfection to draw more heavily for nutriment on its host. Again in the case of leaf-hoppers, at least at certain seasons, no sooner does the male parasite emerge, than a fungous disease at once starts its attack in the opening thus made, the results of which are absolutely deadly. Sometimes, but much more rarely, one will find the fungus has developed at the point of protrusion of the female parasite. This fungus disease seems to be a constant concomitant of Stylopid attack on leaf-hoppers, both in America, Australia and Fiji. I have dealt with this question of the effect of the parasite at some length, because strenuous efforts were made to introduce *Elenchus* into these islands (it is to be feared unsuccessfully so far) for economic reasons, and it would be essential in my opinion to bring both the parasites and the concomitant fungus above mentioned to secure the best results. As, in Fiji, *Elenchus* attacks a species of *Perkinsiella* closely allied to our sugar-cane leaf-hopper, it could probably be much more easily imported from those islands than elsewhere.

THE GENERA *HALICTOPHAGUS* AND *ELENCHUS.*

The genus *Halictophagus.*

The literature accessible to me that deals with this genus is deficient, and I do not know whether this parasitic insect has been actually bred from the bee genus *Halictus* or whether its assignment to these common bees is altogether based on con-

jecture, as it was when Westwood wrote his "Introduction." On examination of the Australian Stylopidae that infest Jassids, it is evident that these are so extremely close to *Halictophagus* as figured by Westwood that I have left one of these species in that genus and have made a new subgenus for the reception of another. I incline to believe that *Halictophagus*, which appears to be very little known, and hardly noticed since J. C. Dale captured the type of the genus in 1832, and again took it in the same county (Dorset) in England in 1840, is really a Jassid parasite, and could be easily bred in numbers by any one who would investigate some of the Jassids in that country, *Agallia*, *Tettigonia*, or some such common form, being likely to prove its hosts. I am further led to believe its connection with *Halictus* is entirely suppositions because Mr. C. W. Dale, the son of the above named entomologist, writing 60 years after the type was obtained, says "*Halictophagus* is supposed to be a parasite of *Halictus*, *Elenchus* of *Prosopis*." We know the latter assignment of host and parasite to be incorrect, and probably the former is also. The Australian species of *Halictophagus* and of which males are known are confined to Jassids, but females of a quite distinct species found on large Fulgorids are in my opinion also allied, and belong to the same group.

The genus *Elenchus*.

So far as our observations have gone, these being confined to a single species, *Elenchus* attacks only Delphacid leafhoppers, and of these only such as feed on Graminaceous plants, not those found on shrubs or trees. I see no reason, after the examination of dry and alcoholic material and specimens preserved in balsam, to specifically separate the Australian examples from the American (the latter from Ohio and California) nor either of these from the Vitian. Again I refer all these to the British *Elenchus tenuicornis*. Other species of *Elenchus* have been described from Mauritius and Britain, but whether these are all distinct, I feel some doubts. Dried specimens of these insects become more or less distorted or shrivelled, so that examples of one species though taken together often exhibit apparent differences from these causes. Mounted in balsam, slight differences in position often give a very different appearance to various structures, e. g., the antennae, genitalia, etc. Next to fresh specimens those preserved in alcohol are most suitable for study. Throughout Koebele's notes this species is referred to under the name *Colacina* Westw. on the

authority of Mr. E. A. Schwartz but I cannot think that *Colacina* and *Elenchus* are identical. At any rate this is true *Elenchus,* and it does not seem likely that Westwood would have so forgotten this genus, which he knew well in 1840, as to make a new one for the same insect years afterwards. Mr. Koebele found in Ohio, at the same time as *Elenchus,* that a Jassid (*Agallia*) was also affected by a Stylopid parasite. On a slide are some mutilated specimens in balsam of the male parasites, which he found stuck to the glass in the tubes in which these *Agallia* were kept alive. I cannot see any difference whatever between these males and the *Elenchus* bred from Liburnia, but on examination of the dead *Agallia,* I find female Stylopids of a character so utterly different from that of *Elenchus,* that I imagine a *Liburnia* must have been accidentally included, from which the males in question emerged. Moreover the larvae from these females are different from those of *Elenchus.* I think it probable that the male of these females will prove to be a *Halictophagus,* but Mr. Koebele's well known accuracy and his opinion that the males sent came from *Agallia,* make further investigation necessary. By this I mean it is necessary to investigate *Agallia,* to prove whether it is at any time attacked by *Elenchus.* That these female Stylopids found in *Agallia* do not belong to that genus needs no investigation, and there is no possibility of their belonging to the males supposed to have been bred from the same leaf-hoppers; indeed there is no reason to doubt that they belong to the Halictophaginae.

THE LARVAE OF STYLOPIDAE.

The larvae of Stylopidae when they emerge from the brood-chamber of the female are often called triungulins, but very inappropriately so, since they entirely lack the very structures for which the name triungulin has been applied to the first instar of larval *Meloe* and other beetles. The larvae of Stylopids parasitic on Homoptera are much smaller and more difficult to study than are some of the wasp-parasites, and I have therefore figured in ventral view a larva of one of the latter (which is allied to Xenos) for comparison. This larva (Pl. IV, 5) when highly magnified is like *Lepisma* in general appearance and otherwise is chiefly remarkable for the great pigmented eye-spots around the lenses, and the structure of the elongate legs. The first two pairs of these terminate in the rounded pad noticed by writers on larval Stylops, but the hinder pair bear in place of this a long fine spine or seta, from which, near the extremity, there arises a finer and strongly curved one.

The young larva of *Elenchus* (Pl. IV, 3 and 4) in general resembles this, the legs being long, the eye spots large, and the pair of apical abdominal setae very long. All the legs however terminate in a long curved spine or seta, the two anterior pairs not differing much from the posterior. The ventral surface is much depressed, the dorsal convex. Each abdominal segment has a minute seta at the side, and on either side close to the middle line is an additional row of setae.

In the Australian subgenus *Bruesia* the larva (Pl. IV, 1 and 2) is larger than that of *Elenchus,* generally more parallel-sided, but both it and *Elenchus* are subject to considerable variation in shape according to the retraction or otherwise of the body segmnets. It also appears to differ from *Elenchus* in the arrangement of the setae of the ventral surface, but the claws of the legs are of a somewhat similar character, and unlike those of Xenos and the other hymenopterous parasites.

Newport's figure of the larva of *Stylops* reproduced in The Cambridge Natural History, if it be correct, would show that genus to be utterly unlike any of those here considered, no trace of the great eye spots being shown and the many jointed feet are utterly foreign to the species I have examined. Indeed I should not have recognized it as a Stylopid larva at all after my recent study of these.

THE PUPARIA OF STYLOPIDAE.

The puparium of a male Stylopid, that is to say the exserted portion, generally bears a great resemblance to the adult female except for the fact that it is rounded instead of flattened. In many cases the tubercles or depressions with which the apex is furnished closely resemble those in the female. As the male Stylopid becomes mature its head can be seen within the exserted apex of the somewhat transparent puparium, and this fact, combined with the great similarity between this part of the puparium and the exserted end of the female, would have satisfied me that in the latter it was the head end exserted, and not the tail as Meinert supposed, even if it had not been conclusively settled by the position of the ganglia in *Xenos*. Saunders has figured the adult *Elenchus* escaping from the puparium ventral side upwards—we have frequently watched the same insect issuing in this manner—and remarks that *Xenos* does the same, but that *Stylops* and *Hylecthrus* are said to emerge in reversed position. The puparia of all the Stylopids examined by us, on the emergence of the mature insect, split open by the

regular dehiscence of an apical cap. The pupa itself, as it approaches maturity, is more or less visible through the shell. It appears to me of a decidedly Coleopterous type, and when the mature insect emerges the pupal skin is shed as the most delicate of pellicles.

SOME RELATIONS OF PARASITE AND HOST.

In the case of *Xenos* parasitic on wasps of the genus *Polistes*, Hubbard noted the marked hostility of the host towards the parasite. Brues did not observe this with his specimens, and suggests that this was due to the fact that no females of the *Xenos* were present in the wasps that he studied, and consequently that the males of the parasite did not approach these for the purpose of pairing. This is very probably the true explanation of the difference in the wasps' behaviour in the two cases, in confirmation of which one may cite the old and often quoted observation of J. C. Dale: "Putting two bees (*Andrena labialis*) under a glass in the sun two Stylops were produced: the bees seemed uneasy and went up towards them, but evidently with caution, as if to fight; and moving their antennae towards them, retreated. I once thought the bee attempted to seize it; but the oddest thing was to see the Stylops get on the body of the bee and ride about, the latter using every effort to throw his rider." This certainly seems to point to the conclusion arrived at by Brues, the *Andrena* in question probably bearing a female specimen of the parasite. In the case of leaf-hoppers, we did not notice any sign of disturbance on the part of the host at the presence of the male parasites, nor did we ever see copulation take place, though we often had many male and female *Elenchus* in the same jar. It will probably prove that the remarkable mandibles of many male Stylopids are for the purpose of holding on to the host during the pairing of the sexes. In general it would appear that these organs are less remarkable in the parasites that attack leaf-hoppers, than in those that occur in bees and wasps, in fact in some of the former class they are small and of very simple form.

In the case of *Polistes* there is, according to Brues, a well-marked tendency for all the parasites in one wasp to develop the same sex. This is also notably the case with some of the Stylopids affecting the Fossorial Hymenoptera, but with those attacking leaf-hoppers it is often quite otherwise, and it is of the commonest occurrence to find male and female parasites in the same individual hopper.

It is perhaps worthy of notice that the male puparia of the species of *Halictophagus* parasitic on Jassids, pierce the dorsum or even the venter of the abdomen of these leaf-hoppers, but the head of the female is always, or nearly always, thrust through the pleura. On the contrary in *Elenchus* and *Deinelenchus,* parasitic on Fulgorids, the male puparium (as well as the head of the female parasite) is exserted from the pleural region only.

In the case of the *Halictophaginae* we found only mature leaf-hoppers to contain mature female parasites and puparia; but in the case of *Elenchus tenuicornis* the nymph or adult Delphacids will alike produce mature parasites of either sex.

CLASSIFICATION.

The differences between the various forms here considered are so great, that if the Stylopidae are considered as a family of Coleoptera, they must represent three sub-families; or if these parasites be treated as a separate Order, Strepsiptera, they might even form three families. The marked differences in the head, legs, and thoracic sclerites being probably sufficient to warrant the higher division. They may be distinguished as follows:

1.	Tarsi 4-jointed	Stylopinae.
2.	Tarsi 3-jointed	Halictophaginae
3.	Tarsi 2-jointed	Elenchinae

As personally I consider the Stylopidae to be a Coleopterous family, the divisions here are treated as sub-families.

The first of these divisions is capable of further subdivision, of a character in my opinion more than merely generic, but it is not necessary to enter into these minor distinctions here. The family will, naturally, be placed next to the Mordellidae (incl. Rhipiphoridae).

The measurements and descriptions of the female Stylopidae are made from the head, as it appears when the animal is imbedded in its host; for the variation in the length of the exserted portion in different individuals is very small.

Female Elenchinae are (so far as the species collected by us are concerned) easily distinguished from Halictophaginae by the absence of the median apical plate and other apical structures, and the presence of discal areas in front of the brood-chamber opening.

LIST OF SPECIES OF STYLOPIDAE HERE CONSIDERED.

STYLOPINAE.

Gen.? sp. nov. near Xenos.

HALICTOPHAGINAE.

Halictophagus.
H. schwarzii,, sp. nov.
H. americanus, sp. nov.
subg. Bruesia, subg. nov.
B. australensis, sp. nov.
B. phacodes, sp. nov.
B. stenodes, sp. nov.
Megalechthrus, gen. nov.
M. tryoni, sp. nov.

ELENCHINAE.

Elenchus.
E. tenuicornis, Curt.
Deinelenchus, gen. nov.
D. australensis, sp. nov.

GENERAL STRUCTURE OF STYLOPIDAE.

As the position of Stylopidae as a whole amongst the Insecta has been a cause of much discussion and disagreement, so the character of various structures has also been diversely interpreted. There is no question that the mouth-parts are of an abnormal character, and difficult to study, but that there should have been differences of opinion as to the thoracic sclerites and their appendages is not so easily understood. Even in the minute *Elenchus*, by far the most difficult of the Stylopidae to dissect, the prothorax and mesothorax can easily be separated entire, each in the form of a complete ring, exhibiting notal, pleural, and sternal portions, well marked, the former sclerite bearing the front legs, the meso-thoracic, in addition to the middle pair of legs, having the ladle-shaped elytra attached to the sides.

The mouth parts of *Elenchus* and its other characters have been elaborately discussed by Eaton, but the figure given by him is an unfortunate one, owing to the position in which it was drawn; for of the part which he considers the *ligula*, the extremity approximate to the labium is not visible at all. Nev-

ertheless, had I examined no other Stylopid than *Elenchus*, I might possibly have agreed with his interpretation of the mouth parts, but the examination of a species of a genus allied to *Xenos*, and more especially a close study of the head of a species of the subgenus *Bruesia* (hereafter described) and of a species of *Halictophagus*, leads me to favor a different interpretation. The delicate transverse band on the under side of the head I agree in considering labium, the two-jointed organ on either side of it being probably the labial palpi. The part called ligula by Eaton requires close study being in many Stylopidae bent at an angle, to form two planes; when the upper part is seen in full surface view, the lower part meeting it at a strong angle slopes very strongly backwards from the point of meeting. This structure might be called an epistome, but it is possible that the lower part is really the labrum or upper lip, the position of which it occupies. Between the apex of the lip and the labium approximated to it, is the closed, or obsolescent oral aperture. The so-called mandibles are probably rightly so called. Adopting Eaton's interpretation the oral aperture of *Elenchus* is bounded by and in fact leads into the frontal process, but this seems to me certainly erroneous. According to the view here suggested by me, the mouth parts of the Stylopidae are not so extremely remarkable. The difficulty of studying the insect is not only due to the small size and delicate structure, but also to the fact that the sides of the face within the eyes have sharp protuberant edges, so that this part is more or less deeply excavated, the other structures being partly or wholly immersed, and further obscured by the mandibles and palpi. In *Bruesia australensis* however, and *Halictophagus schwarzii*, the face is much more open, and after dissecting off the mandibles and palpi the parts can be studied with comparative ease. It was therefore found advisable to carefully examine these before coming to any decision as to the mouth-parts of *Elenchus*. In Pl. I, fig. 1, is a diagrammatic view of the front of the head, simplified from what is actually seen in *Bruesia* and *Halictophagus*, as I interpret it, actual figures of these being given on the same plate, fig. 2 and 5. The parts indicated by the letters b and d together represent what I have already called epistome, of which however, the lower portion (d) may be labral; e is the labium, and the closed, or at least obsolescent, oral opening is the slit between d and e. For the rest, the other parts are sufficiently explained in the description of the figures, but special attention must be called to the foramen (c) at or near the junction of b and d. This exists in *Elenchus*, *Halic-*

tophagus, *Bruesia* and in the species examined of a genus allied to *Xenos*, in fact in all the male Stylopids considered in this paper, and as it furnishes an easy means of identifying homologous parts of the face, it is of great importance.

If we now consider the parts of the face in *Elenchus* as compared with *Bruesia* the most striking difference noticed at once is the fact that the part immediately above the *foramen* (which corresponds to b in the diagrammatic figure) appears to end above in a free edge and not to be sutured to the frontal process. It is this edge that Eaton considers the apex of the *ligula*, and the cavity between it and the frontal process as the oral opening. I believe however that this edge is not the real extremity of this plate but is due only to a sharp bend therein. We are therefore left with two alternatives: if we consider with Eaton that there is a great *ligula*, then in *Bruesia* and *Halictophagus schwarzii* the apex of the ligula is not free, but continuous with the frontal process, and not even divided therefrom by a distinct suture; or if we adopt the interpretation that I favor, we shall consider the same part as epistome, or epistome and labrum, though in some genera its basal (upper) margin is deeply imbedded in the excavated front of the head. A strong immersion of the clypeus beneath the level of the front, or of labrum beneath the clypeus, is by no means unfamiliar in other orders of mandibulate insects. In a species of a genus allied to *Xenos*, the head of which is figured on Plate I, fig. 4, it will be seen that the epistomal portion lies entirely immersed beneath the prominent edges of the sides of the face. As to the division of the lower part of the face into epistome and labrum, both in a dry specimen of *Bruesia* and in one mounted in balsam, I think I can detect faint sutures, marking off a labrum from the epistome, and I suspect that the foramen always marks the division between these.

THE THORACIC SEGMENTS.

The pro- and meso-thorax appear to be always small and ring-like, and one or both of these are immersed in the posterior concavity of the head (Pl. I, fig. 3), and on superficial examination may even appear to be part of this.

In some figures of Stylopidae the top of the head is represented as much more solid than it really is, the pronotum probably having been considered as part of the vertex. The meta thorax differs greatly in the arrangements of its parts in different genera. In *Elenchus* (Pl. II, fig. 11) the posterior of the four

anterior lobes, which may be called the scutellum, is semilunar, and extremely small compared with the great triangular anterior lobe, not penetrating forwards between the lateral lobes. The post-scutellum also is unusually short.

In *Halictophagus* and *Bruesia,* (Pl. II, fig. 9) the scutellum is triangular, but much smaller than the anterior lobe, penetrating somewhat between the lateral lobes, the post-scutellum being very elongate. In a genus allied to *Xenos* there is a great triangular scutellum, produced far forwards between the lateral lobes and longer than the anterior lobe (Pl. II, fig. 10). It is clear that the structure of the thorax will prove of great use in the classification of Stylopidae. The great differences between the tarsi of the several subfamilies are shown in Pl. II, figs. 6, 7 and 8, and also the wings of *Elenchus, Bruesia* and ? *Halictophagus* on the same plate (figs. 1, 2, 3), so that it is not necessary to refer further to these.

DESCRIPTIONS OF GENERA AND SPECIES.

Bruesia n. subg. (of *Halictophagus*).

Head very deeply concave behind, seen from above consisting only of a narrow rim supporting the eyes, and produced considerably in front of these to form the tip of the blunt and wide frontal projection, at the sides of which the antennae are inserted. That which appears to be the top of the head on superficial inspection, is in reality the dorsum of the pro- and mesothorax, which in their natural position are deeply immersed within the posterior concavity of the head, which they more or less fill up. Antennae with the two basal joints simple, the following excessively short, being produced laterally into an elongate and thin lamina, the first and fifth (or last) of these laminae being larger than the others and capable of enclosing them in a fan-like fashion. Mandibles very short compared with those of other Stylopids, their tips not reaching one another, simply pointed. Labial palpi very large, the second joint foliaceous half as wide as long, pilose, subacuminate at the apex. Scutellar portion of metanotum moderately large, penetrating somewhat between the lateral lobes of its anterior portion, triangular, and very different from the small semilunar scutellum of *Elenchus*; the post scutellum very elongate, twice as long as wide, or appearing still longer in dry specimens, covering several of the basal abdominal segments. Elytra clavate or ladle-shaped in well-preserved specimens. Wings smoky hyaline,

neuration black, very distinct. Tibiae dilated apically, and grooved or hollowed above for the partial reception of the three-jointed tarsi, when these are drawn up.

1. *Halictophagus* (*Bruesia*) *australensis*, sp. nov.

Black or blackish fuscous, the thorax paler, piceous or brownish, the lamellate joints of the antennae also paler, yellowish or sordid testaceous. Wings smoky hyaline, with slight but evident iridescence, the neuration strong, black. Apical abdominal segment with its genital process concave above and much produced, towards the base with an upright tongue-shaped, pilose organ; in lateral view the sides are slightly convergent to the apex, which is armed with a recurved hook, the tip of which is itself bent upwards; in front of the origin of this uncus the process has a small deep emargination. The apical ventral segment is triangular and produced at the apex. The abdomen is clothed with a very delicate cinereous pubescence. Expanse about 4 mm.

Female. Head yellow or brownish yellow, distinctly rounded at the sides, with a distinct anterior median area (or plate) marked out, and slightly produced; tuberculate on either side of this area in front. The opening of the brood-chamber is behind the middle of the exposed part of the head, the surface between this opening and the apex subconvex. Length about $1\frac{1}{3}$ mm.

(Plate I, figs. 3, 5 and 9; Plate II, figs. 1, 7, 9 and 12; Pl. III, fig. 8 and 9.)

Hab. Cairns, Queensland, parasitic on a very common and conspicuous species of *Tettigonia*, many parasitized examples being taken by us. (No. 2238).

2. *Halictophagus* (*Bruesia*) *phacodes*, sp. nov.

Female. Head broader than long, brown, more yellowish in front and darker behind the opening of the brood chamber, strongly rounded at the sides, the anterior median area defined and slightly produced, tuberculate on either side of this area in front; the surface slightly convex between the opening of the brood-chamber and the apex. Length about $\frac{1}{4}$ mm.

(Plate III, fig. 3).

Hab. Cairns, Queensland; one female specimen parasitic on a common green flat-headed Jassine of the genus *Hecalus*.

3. *Halictophagus* (*Bruesia*) *stenodes*, sp. nov.

Female. Head narrow, subelongate, sides not strongly rounded, more parallel-sided, piceous, shining, opening of the brood-chamber near the middle of the head, the surface slightly convex. Otherwise agreeing generally with the preceding. Length about $\frac{1}{4}$ mm.

(Plate III, fig. 2).

Hab. Cairns, Queensland. One female, parasitic on a small seed-like brown Jassine of the genus *Paradorydium*. I also took one bearing a male *puparium*.

? *Halictophagus* Curtis.

The species, which I provisionally assign to this genus, differs from the male of the subgenus *Bruesia* in that the five apical antennal joints are not all of thin laminate form throughout, but the basal ones of these are of more normal form, and the branches are less thinly laminate. The face, as far as I have been able to examine it, appears to be of simple form, the middle part not much separated from the lateral elements, nor deeply immersed beneath the latter, and the palpi to be much more slender than in *Bruesia*. The general form of the metathorax, tarsi, and genital segment is the same as in that subgenus.

The unique specimen described was originally mounted on a slide in balsam and much distorted, the prothorax and front legs being so displaced as to overlie and conceal the head, while one crumpled wing concealed the body. It was therefore removed from the balsam, cleaned, and relaxed, so far as was possible; the one wing was removed and the prothorax was put more or less into its proper place.

It is most probable htat this insect is not true *Halictophagus*, but possibly it may be included in *Bruesia*, when the latter ranks, as I have little doubt it will, as a good genus. In Westwood's figure of *Halictophagus*, the metathorax is very different, as also is the terminal abdominal segment, in which the Australian forms closely resemble one another. In the antennae however the present species is intermediate between *Halictophagus* and *Bruesia*. (See Westwood Int. Mod. Class. Ins. II, fig. 94, 10 and 14).

4. *Halictophagus? schwarzii*, sp. nov.

Black, clothed with extremely delicate sericeous pubescence,

which is cinereous in some parts; the extreme tip of the abdomen testaceous; metathorax more or less obscurely pale in some parts, at least along some of the sutures. Antennae blackish, third and fourth joint short, subtriangular, with one of the apical angles produced into a long branch, fifth and sixth joints shorter than the preceding, more ring-like, but produced into similar branches; seventh joint lamellate throughout. Wings subhyaline, slightly smoky and iridescent, the nervures very distinct, blackish. Expanse 3 mm.

(Plate I, fig. 2 and 7; Pl. II, fig. 2).

Hab. Mittagong, New South Wales, bred from a common Bythoscopine Jassid, *Agallia* or an allied genus, found on Melaleuca (Koebele 2356). I have named this after Mr. E. A. Schwartz, who was interested in the Stylopids discovered in Ohio by Mr. Koebele, and has often placed his knowledge at Mr. Koebele's service.

5. *Halictophagus* (?) *americanus,* sp. nov.

Female. Dark brown or piceous, suboblong, the anterior median area distinct in apical view, but generally hardly visible in surface view, owing to its position on the apex of the head, which is bent at an angle to the outer surface; tuberculate on either side of this area; the whole disc of the head deeply impressed so as to form a great cavity leading into the opening of the brood-chamber. Length about $\frac{1}{6}$ mm.

It is, I should think, almost impossible that this female can be congeneric with those I have assigned to the subgenus *Bruesia.* It would not be surprising to find that this is really the female of *Halictophagus* proper, though we have no proof that such is the case. As the parasite is so common in Ohio on the Jassid *Agallia 4-notata* it is to be hoped that the entomologists of that state will quickly decide his question.

(Plate III, fig. 6).

Hab. Columbus, Ohio; taken abundantly by Mr. Koebele, (No. 2191).

Megalechthrus, gen nov.

Female. Head ovate, moderately elongate, the opening of the brood-chamber near the middle or rather in front of it, the small anterior median area distinct, a little produced in front, and tuberculate on either side of this area in front. This large form appears to be allied to *Bruesia* and *Halictophagus*, but is

I think distinct generically from these, by its long, ovate form and great size.

Megalechthrus tryoni, sp. nov.

Female. Head ovate, moderately elongate, yellow or brownish yellow, shining when clean, but often dull from the excretion of its host, more strongly convex behind the orifice of the brood-chamber than in front of it.

Male puparium brown or pitchy, unicolorous or nearly so. Length about $\frac{2}{3}$ mm.

(Plate III, fig. 5.)

Hab. Cairns and I think noticed in other localities in Queensland. Unfortunately we did not breed the male, not having time to pay any particular attention to this parasite, though we frequently noticed Fulgorids of the genus *Platybrachys,* or its allies, to be affected by it. I have named the species after Mr. Henry Tryon the Government Entomologist of Queensland, whose wide general knowledge of the fauna of that State is so well-known to all.

Elenchus, Curt.

The characters of this genus have been elaborately drawn up by Eaton and it is not necessary to repeat these. I have already stated wherein I differ from him in the interpretation of the mouth parts. Briefly what he considers to be the ligula I consider to be epistome or epistome and labrum, the oral aperture of his description being merely a deep concavity beneath the frontal projection. Although what he considers to be the third and fourth antennal joints are unquestionably morphologically so, yet it appears that at the point of their divergence these may be connected by a thin submembranous portion and not perfectly free. Further he remarks that the wings are "well represented by previous authors," but Westwood's figure of these is quite unlike any specimen I have seen, in neuration, and the same remark applies to the metathoracic acutellum.

Elenchus tenuicornis, Kirb.

Female. Head brownish or pitchy, opening of the brood-chamber far behind the middle and very large, no anterior median area and tubercles defined, but with a faint round spot just in front of the brood-chamber orifice on each side of the middle line. Length $\frac{1}{6}$ mm.

Male. Apparent slenderness of the antennal joints varying much according to aspect and from shrinkage. Metathorax paler in some than other; in balsam specimens becoming much paler with age.

(Pl. I, fig. 6 and 8; Pl. II, fig. 3, 4, 5, 6, 11 and 12; Pl. III, fig. 4.)

Hab. Columbus, Ohio, and Alameda, California, or *Liburnia lutulenta* in abundance (Koebele). Everywhere abundant in Queensland on *Liburnia* and other Delphacids, and also in Fiji.

Deinclenchus, gen. nov.

Female. Head nearly circular, very wide, the anterior margin simply and widely rounded, with no defined anterior median area, and without evident tubercles in front. Between the opening of the brood-chamber and the anterior margin there are two distinct areas marked out by impressed lines, which run backwards to the brood-chamber orifice as deep grooves on either side of a smooth slightly raised tubercle. Opening of the brood-chamber bisecting the head in surface view.

This insect is much larger than *Elenchus* and seems to me evidently allied to that genus, by the absence of a definite anterior median area and the presence of those on the disc, between the anterior margin of the head and the orifice of the brood-chamber. Still it can hardly be generically identical.

Deinclenchus australensis, sp. nov.

*Female. Head brownish in front of and yellow behind the brood-chamber orifice. The discal areas between the latter and the apical margin somewhat fan-shaped, and themselves divided by very fine grooves. Sometimes in apical view of the head two round faint spots can be seen, but there is no definite median area, nor tubercles. Length and breadth each about $\frac{2}{3}$ mm.

Male puparium dark brown with a pale ring at the base of its protruded portion.

(Pl. II, fig. 7.)

Hab. Cairns and Brisbane, Queensland; on a Fulgorid (*Platybrachys* or allied genus). Koebele's No. 2254.

OBS. At various places during the six months that Mr. Koebele and myself were together in Australia, we found isolated individuals of leaf-hoppers, containing male puparia of Stylo-

* For characters of male see supplementary note, p. 108.

pids, which had already hatched, or from which we bred no imago. These would comprise some four or five species of Jassids not mentioned in the foregoing account, the common *Tettigonia albida*, a *Deltocephalus?* a *Phlepsius?* and one or more *Bythoscopines* being among these. No doubt the parasites attached to some of these will prove to be different from those here described, and yet many other new ones remain to be discovered.

SUPPLEMENTARY NOTE.

After completing the above account of the Stylopidae and sending it to press, it occurred to me that by sacrificing the few male puparia that we preserved, mature pupae of the two genera *Megalechthrus* and *Deinelenchus* (which are characterized on females) might be obtained in such condition as to allow some male characters to be determined. These puparia were therefore opened and the contents examined; most of them were empty, the male Stylopids having emerged, but in two cases I obtained very immature and dried up pupae of *Megalechthrus*. No details of structure could be made out sufficiently accurately from these, but I believe the rudiments of the antennae contained 7 joints, five being foliaceous, and this would confirm its position in the Halictophaginae.

From puparia of *Deinelenchus* I obtained no pupae, but in one was a mature dry male of *D. australensis*, amply confirming its position in the Elenchinae and the validity of the genus. I here add the generic characters of the male, and a specific description.

Deinelenchus (male char.)

Like *Elenchus* in most respects e. g. in the structure of the tarsi and antennae, but very much larger, and with the second antennal joint, seen from above, very short and transverse, the basal one elongate. Frontal process much blunter and less prominent than in *Elenchus*. As in that genus, the face is deeply excavated, but it is much more open, not triangular, but with the sharp edge of the front and sides forming a great semicircle, or rather more. The palpi are two-jointed sparsely pilose, the second joint narrower than the first and in the form of a curved blade. The large size and wide excavation of the face of this genus renders it much easier to examine structurally

than *Elenchus*, and the structure seems to me to greatly favor the interpretation of the mouth-parts, that I have adopted. The edge, which, in *Elenchus*, Eaton supposed to be the apex of the ligula, is in *Deinelenchus* easily seen to be no free edge at all, but is due to a bend perhaps augmented by a ridge in the part I have called epistome. The post-scutellum of the metathorax is longer than in *Elenchus*.

D. australensis.

Male. Piceous, perhaps blacker in mature specimens; the sides and scutellum of the metathorax pale, its anterior lobe and postscutellum dark. Legs with the femora pale, the tibiae dark, fuscous. Elytra for the most part blackish, the wings (not spread) apparently quite smoky, with a slight iridescence, the neuration black. Expanse probably about 4.5-5 mm.

Hab. Cairns, Queensland; extracted from a puparium in the abdomen of a female of a large Fulgorid of, or allied to, the genus *Platybrachys*.

BIBLIOGRAPHY.

An extensive bibliographic list is given by Brues and as his paper is cited below, it is not necessary to refer to the titles that are therein listed. I merely refer to one or two, which he has passed over.

Brues, C. T. "A contribution to our knowledge of the Stylopidae." Zool. Jahrb. Abth. Anat. XVIII, (1903) p. 241.

Dale, C. W. "Stylopidae" Ent. Mo. Mag. 1892, p. 50.

Eaton, A. E. "Notes on *Elenchus tenuicornis* Kby. with illustrations." loc. cit. p. 250.

Perkins, R. C. L. "Stylopized bees." loc. cit. p. 1.

Saunders, Edward. "*Elenchus tenuicornis* Kirby, parasitic on a Homopterous insect of the genus *Liburnia*." loc. cit. p. 249.

Id. "*Elenchus tenuicornis*, Kirby, and its host." loc. cit. p. 297.

Theobald, F. V. "Stylopized bees." loc. cit. p. 40.

DESCRIPTION OF PLATES.

I.

Fig. 1. Diagrammatic figure of head of Stylopid; a frontal process, b and d epistome or epistome and labrum, c foramen, e labium, f palpus, g mandible, h sides of face along inner orbits, i eye, j antenna.
" 2. Head of *Halictophagus schwarzii* front view.
" 3. Dorsal view of head and front part of thorax of *Bruesia australensis;* a pronotum, b. mesonotum.
" 4. Head of sp. nov., gen. ?, near Xenos; front view.
" 5. Head of *Bruesia australensis*, front view.
" 6. The same of *Elenchus tenuicornis.*
" 7. Antenna of *Halictophagus schwarzii.*
" 8. The same of *Elenchus tenuicornis.*
" 9. The same of *Bruesia australensis.*

II.

" 1. Wing of *Bruesia.*
" 2. The same of *Halictophagus schwarzii.*
" 3. The same of *Elenchus.*
" 4. Elytron of *Elenchus,* lateral view.
" 5. The same from above.
" 6. Tarsus of *Elenchus.*
" 7. The same of *Bruesia.*
" 8. The same of genus near *Xenos.*
" 9. Metanotun of *Bruesia.*
" 10. The same of genus near *Xenos.*
" 11. The same of *Elenchus.*
" 12. Terminal segment of *Bruesia.*
" 13. The same of *Elenchus.*

III.

" 1. Ventral view of abdomen of a Fulgorid (*Platybrachys* or allied genus) showing female parasites and male puparia.
" 2. Head of female of *Bruesia stenodes.*
" 3. The same of *Bruesia phaeodes.*
" 4. The same of *Elenchus tenuicornis.*
" 5. The same of *Megalechthrus tryoni.*
" 6. The same of *Halictophagus? americanus.*

" 7. The same of *Deinelenchus australensis.*
" 8. The same of *Bruesia australensis* removed and mounted in balsam.
" 9. The same not removed from the host.

IV.

" 1. Larva of *Bruesia australensis,* lateral view.
" 2. The same in dorsal aspect.
" 3. Larva of *Elenchus,* ventral view.
" 4. The same in dorsal aspect.
" 5. Ventral view of sp. nov. gen? allied to *Xenos.*

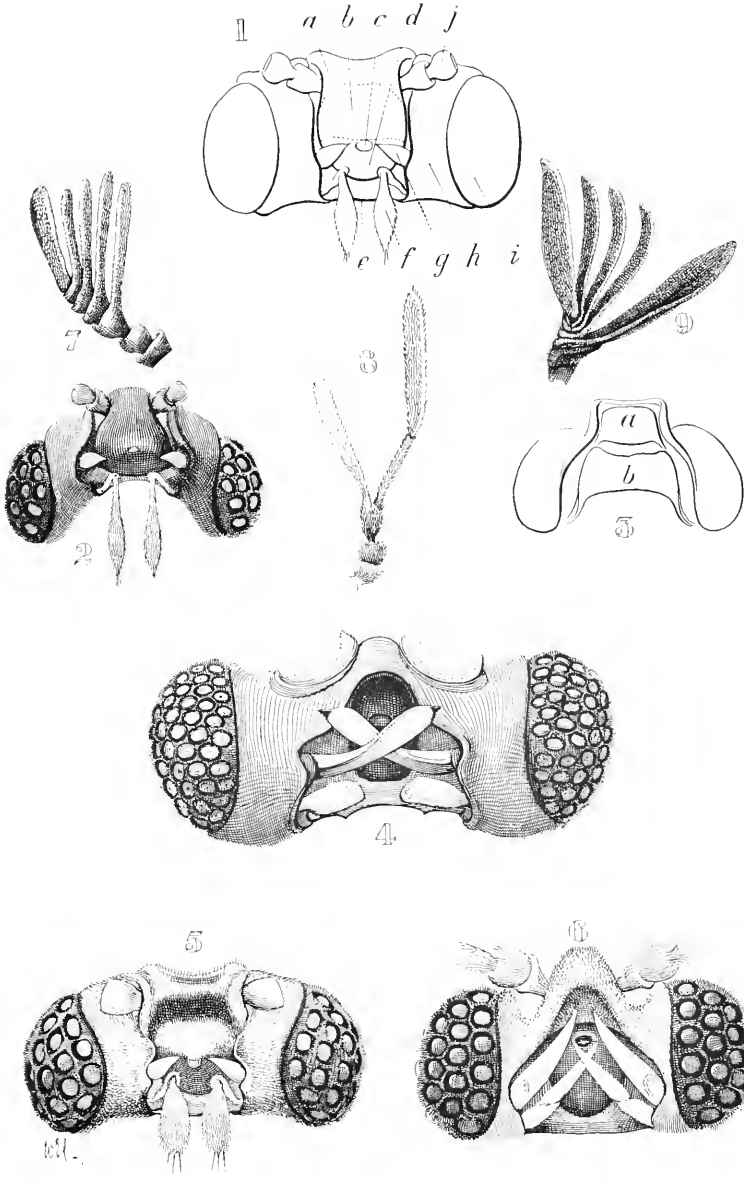
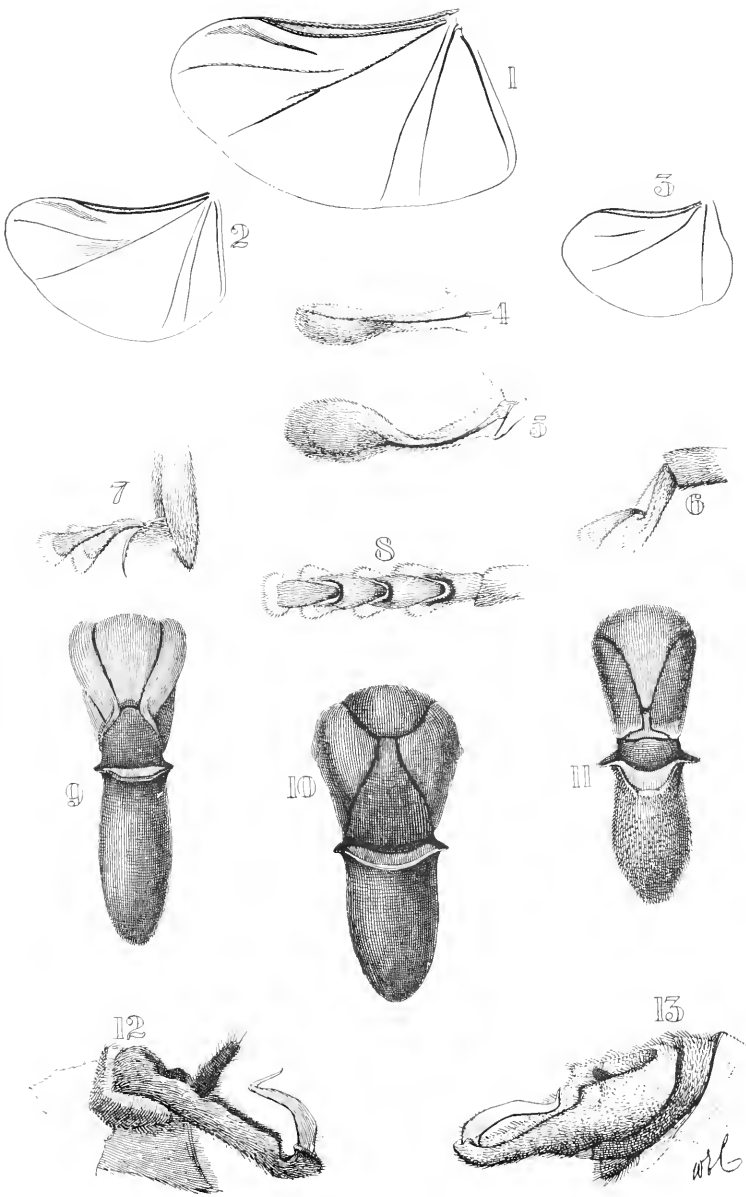


PLATE I.



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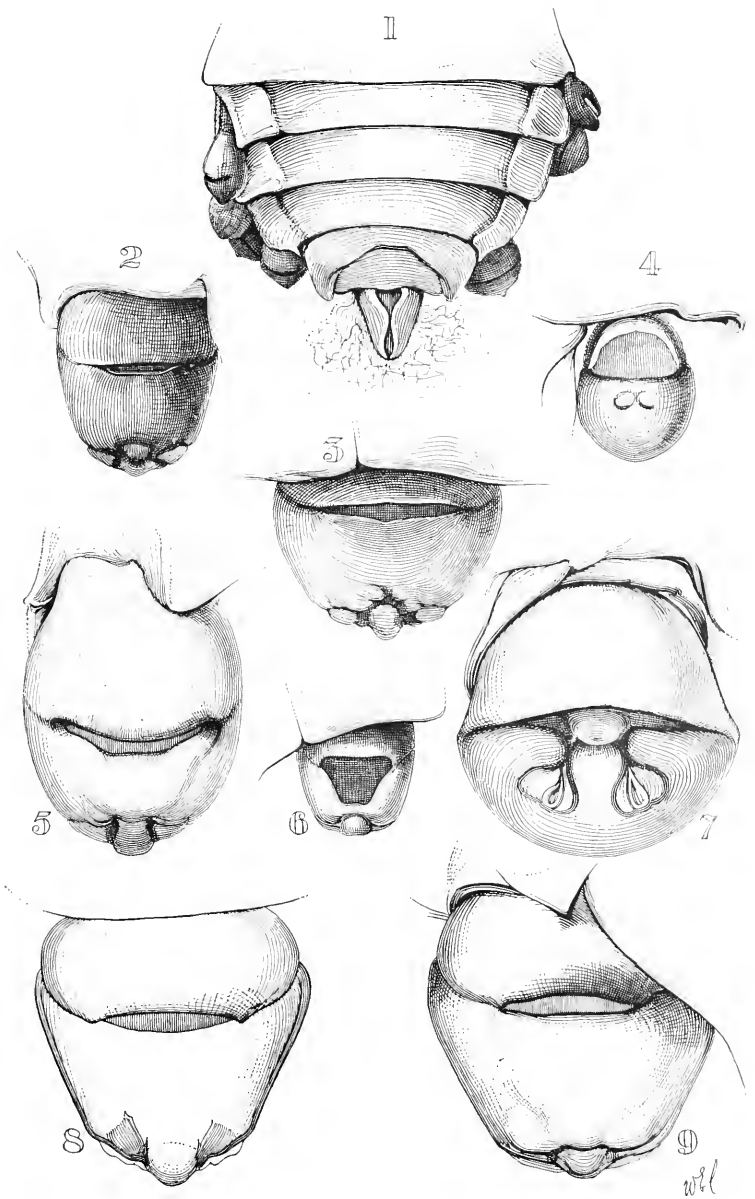

PLATE III.

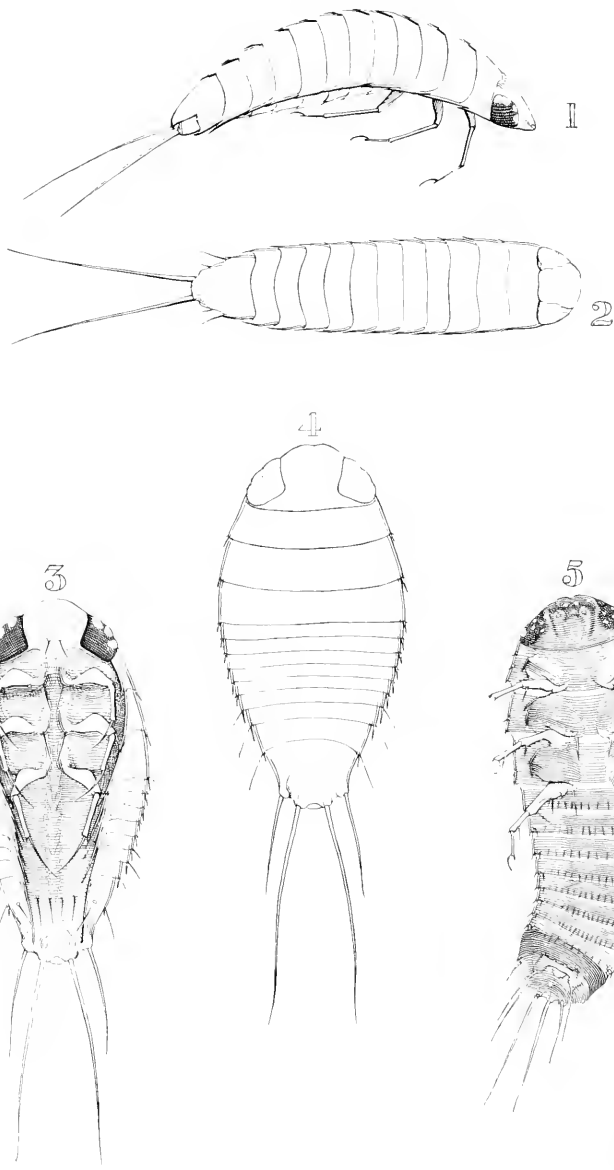

PLATE IV.