

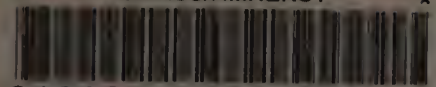


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Amherst

**A detailed study of the external morphology
of a species of *Leuctra* ; and, A taxonomic
study of certain of the New England stoneflies.**

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A DETAILED STUDY OF THE EXTERNAL MORPHOLOGY
OF A SPECIES OF LEUCTRA, AND A TAXONOMIC STUDY
OF CERTAIN OF THE NEW ENGLAND STONEFLIES

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A DETAILED STUDY OF THE EXTERNAL MORPHOLOGY OF A
SPECIES OF LEUCTRA, AND A TAXONOMIC STUDY OF
CERTAIN OF THE NEW ENGLAND STONEFLIES.

by

John F. Hanson

Thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
Massachusetts State College
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INTRODUCTION

The purpose of this paper is to present an investigation of the external morphology of the genus Leuctra Stephens. This is one of the many genera of stoneflies that have long been awaiting thorough study. In order that this work might be more valuable, all species available for study have been examined in almost as great detail as Leuctra variabilis n. sp. which served as a basis for the study of the genus as a whole.

Because of the many primitive characters exhibited by stoneflies, their various structures have been studied from the phylogenetic point of view by several workers, especially by Crampton, Snodgrass, Tillyard, and Hoke. However, a detailed and complete study of the external morphology of a single species or genus has been carried out only for a few genera. Wu (1923) has published on the morphology of Nemoura; Helson (1934), on the anatomy of Stenoperla prasina (Newman); and Gouck has prepared an unpublished thesis on the external morphology of Pteronarcys californica (Newport). Yet no thorough study of the external morphology of Leuctra has been published.

Some of the generalizations that hitherto have been drawn in morphological work concerning the genus Leuctra do not appear valid. In the taxonomy of Leuctra, also, characters which are not even constant within a species have been used for species differentiation. Since

there are great variations among species and, in some characters, even within species, such errors may be attributed to lack of sufficient material rather than to carelessness of workers in this field.

The following data concerning the material which has been used in this study are included here in order that the reader may better understand the scope as well as the limitations of this work. Of the 23 species of Leuctra known in North America, L. sara Claassen, L. bilobata Claassen, L. crosbyi Claassen, L. claasseni Frison, forcipata Frison, purcellana Neave, biloba Claassen, glabra Claassen, and bradleyi Claassen have not been available for study. The ones that have been investigated are Leuctra bartletti n. sp. (88 males, 30 females), L. decepta Claassen (39 males, 31 females), L. duplicata Claassen (15 males, 24 females), L. grandis Banks (8 males, 12 females), L. hamula Claassen (6 males, 6 females), L. infuscata Claassen (1 female), L. occidentalis Banks (1 male, 2 females), L. sibleyi Claassen (1 male, 3 females), L. tenuis Pictet (5 males, 7 females), L. triloba Claassen (2 males), L. truncata Claassen (1 male, 1 female), and L. variabilis n. sp. (181 males, 197 females.)

The great range of species and abundant material of two of the forms has made possible the gaining of some conception of the evolution of Leuctra and related genera and the determination of the variations among species. The large series, especially of Leuctra variabilis n. sp.

and L. bartletti n. sp., has made possible the testing of these variable characters for species distinction; and has also facilitated the detailed study of the external morphology of the genus.

GENERAL APPEARANCE

The members of the genus Leuctra are small in size, varying in length from 6 to 12 mm., L. grandis Banks being the largest species. However, in the single species, L. grandis, the size varies almost enough to include the range for the whole genus.

Leuctra may be distinguished easily from its near relative, Nemoura, by the wings, which are rolled around the side of the body instead of lying flat on the abdomen, and by the fact that it has no marginal crossvein beyond the tip of the subcosta. Leuctra is distinguished from Perlomyia by the fact that its medial vein arises from radius separately from the radial sector, while in Perlomyia the medial vein and the radial sector arise from radius at a common point.

The sclerotization of the body is usually not so great in this genus as in Nemoura or Taeniopteryx. In L. bartletti, however, sclerotization is relatively heavy.

HEAD

The head of Leuctra, as of all other Plecoptera, is prognathous, but the labrum (lr) is barely visible from above, due to a downward bending of this structure. The head is less than one millimeter in width, widest at the compound eyes, and slightly wider than long (fig. 1). The antennae are widely separated and situated far forward on the head near the bases of the mandibles. Among the various species of Leuctra there are very few differences to be noted in structure of the head. The most pronounced of these is the variability of the epicranial suture. In Leuctra occidentalis Banks the latter is almost entirely absent, while in L. bartletti it may be almost complete. But, as was brought out by Miss Hoke (1924), the coronal suture (cs) is usually entirely or partially absent. There is an indication that the epicranial suture varies as much in Taeniopteryx and Nemoura as in Leuctra. According to Wu (1923), Nemoura vallicularia Wu has a complete epicranial suture. According to Miss Hoke, Nemoura has no epicranial suture at all. This structure apparently has too much variability to be of any phylogenetic significance. The reduced mentum and labial stipes, as well as the postoccipital and temporal sutures, also show variations among species.

Head Capsule

The demarked areas of the cranium are few. Since the coronal suture (cs) is usually not developed, (fig. 1) the parietal areas (par) consist of a single sclerite which is by far the largest sclerite of the head. The parietal region is separated from the frons (f) by the postfrontal sutures (pfsu), usually bounded in the rear by a postoccipital suture, and extends laterally to the parietal and postgenal region. The occiput is undemarked from the parietal sclerites. The postoccipital sclerite bordering the foramen magnum dorsally is a narrow collar-like structure whose ventro-lateral extensions form the postgenae. The sclerite in front of the postfrontal sutures, the frons, is continuous on each side with the genal area which is situated between the compound eye and the antenna. The ocular and antennal sclerites are very poorly demarked. In Leuctra the clypeo-labral (cls) and epistomal (es) sutures are present so the clypeus and labrum are well demarked. Continuous with the epistomal suture is the subgenal suture separating the small subgenal sclerite (sge) from the frons above.

The parietals are generally rugose, while the other head sclerites are not. In most species of Leuctra the coronal suture is absent entirely while the postfrontal sutures are still strongly demarked. The postfrontal sutures form, at their junction, either a very obtuse angle or a wide arc. Each extends to the lateral margin

of a lateral ocellus where it bends abruptly cephalad and is lost near the supratentorina (MacGillivray). Among all the species studied, except L. infuscata Claassen and L. occidentalis Banks, the postfrontal sutures are well demarcated. In these species these sutures are barely traceable and the coronal suture is lacking entirely. The coronal suture always seems to be absent in L. decepta, carolinensis, sibleyi, and duplicata. In L. grandis, hamula, and variabilis it sometimes is present but never extends more than half way across the parietals. In L. bartletti it is almost always present and in some cases practically divides the parietal area into two separate sclerites.

The postoccipital sclerite is not entirely visible from above, due to the abrupt constriction of the parietals caudally. It is separated from the parietals by a postoccipital suture, except in L. infuscata, where the suture has dropped out. As shown in figure 1, the postocciput widens laterally and then bends abruptly ventrad and extends to the posterior tentorial pits. The postoccipital suture drops out near the occipital condyle but a groove continues from it to the gular pit.

The frons bears the three ocelli and the supratentorina (sn) which are protuberances in front of the lateral ocelli into which fit the dorsal arms of the tentorium. The distance between the lateral ocelli is slightly greater than the distance from a lateral ocellus to the median

ocellus. The lateral ocelli are about three times their own diameter from the compound eyes and lie at the extreme posterior margin of the frons. The median ocellus lies slightly anterior to the center of the frons. In front of it are several irregularly disposed infoldings serving for muscle attachment.

The ocular sclerite is a very narrow ring of uniform width surrounding the large protuberant compound eye.

The antennal sclerite (asc) is also a very narrow ring. It widens gradually from the narrow caudal extremity reaching its greatest width just anterior to the lateral antennifer (af). There are two antennifers, one lateral and one mesal, the mesal being slightly anterior to the lateral.

The subgena (sge) is a tiny elongate sclerite lying between the antennal sclerite and the base of the mandible (fig. 3).

The clypeus (cl), lying between the frons and the labrum, is a transverse area very slightly produced on its anterior margin except in L. infuscata. The epistomal suture arches slightly into the frons.

The tentorium (tm), although not literally external, is a part of the skeleton and will therefore be considered here. It consists of anterior, ventral, and dorsal paired arms and the corporotentorium (ct) in the center of the head where the arms meet (fig. 4). This structure serves to support all parts of the head.

The body and all the branches of the tentorium are lamellar. Both the anterior and posterior arms broaden at their points of attachment but the posterior arms are by far the broader. The dorsal arms become constricted near their apices and then form peltate expansions which abut against the frons. Since they are outgrowths of the anterior arms, the dorsal arms are not attached to the frons but merely fit into slight cavities, called supratentorina by MacGillivray.

Head Appendages

Antennae: The antennae are about the length of the body (fig. 7). They are composed of 30 to 40 segments, and are filiform. The scape (s) is a short segment, about twice as thick as the pedicel and about equal to it in length. The first segment of the filament is almost twice as long as the pedicel. From the second segment of the filament (which is shorter than the first) to near the end of the filament, the length of the segments gradually increases.

Labrum: The labrum (lr), though not a true appendage, is moveable and functions as one of the mouth-parts. It is a flat transverse quadrangular sclerite which may be slightly produced or even emarginate occasionally on its anterior margin. Curiously enough the tormae are asymmetrical (fig. 11).

Mandibles: The mandibles (md) are well developed and asymmetrical. At their bases, near the attachments of the flexor tendons, are opposable areas bearing many ridges, apparently for grinding food. This area (mo) is concave on the left, and convex on the right, mandible. The right mandible bears a large tooth near this surface and two at the apex of the mandible in the incisor region. The left mandible bears three large teeth and a tiny one between the second and third large teeth. Several setae are borne on the mandible near the attachment of the extensor tendon (ex). The condyle, which articulates with the cranium in the post-genal region, and the ginglymus, which articulates with a lateral point of the clypeus, are seen in figure 8. There is little or no variation of mandibles among the species studied.

Maxillae: The maxillae (fig. 5, 10) articulate near the invaginations of the posterior arms of the tentorium by the cardo. The cardo is mesad of the stipes and is subdivided into basicardo (bc) and disticardo (dc). The cardo-process of the maxilla of Eusthenia described by Crampton (1923) is present but difficult to see in Leuctra. The stipes (s), which is the largest sclerite of the maxilla, is continuous with the lacinia (la). It is mostly ventral but extends laterally and projects slightly on to the dorsal surface. The parastipes (ps), which is not to be confused with the subgalea of Coleoptera, is a narrow sclerite extending the length of the stipes along

its mesal edge. The lacinia (la) is broad at the base and tapers to two sharp points directed mesad at the apex. The mesal surface is flat, and along the dorsal edge of this flat area is a fringe of long spines. The distigalea (dg) is the same length as the lacinia, is also curved mesad, but ends bluntly and is not so well sclerotized although well demarked. It bears a group of sense papillae on the lateral surface at the apex. The basigalea (bg), although not shown as such by Miss Hoke (1924), is a distinct sclerite. It is very difficult to see and is most easily visible in L. grandis. According to Crampton, the palpus (mp) is five-segmented. Thus there is no palpifer, but the basal sclerite is the first segment of the maxillary palpus. This segment is the smallest segment of the palpus. It is thickest on the dorsal side and does not form a complete ring, being unsclerotized on the mesal side. The second segment is about as long as the distigalea while each of the succeeding three segments are nearly twice as long. A few specimens of L. variabilis have been found with a 4-segmented palpus and one with a 3-segmented palpus. Such variations are probably abnormalities that have no significance. Like the mandible, the maxilla presents no differences that can be regarded as species characters.

Hypopharynx: The hypopharynx consists only of the lingua (lg). It is a very thinly sclerotized process which is slightly bilobed at the tip. Only two pairs of sclerites can be discerned in it. Two slender sclerites

arise almost from a common point at the region where the hypopharynx joins the labium. These extend distally and laterally along the hypopharynx until they become indistinguishable from the slightly sclerotized distal portion. They correspond to the basal plates or bars (bpl) described by Snodgrass (1935) and according to him serve for the insertion of the retractor muscles of the hypopharynx. At the base of the hypopharynx on the upper surface are two sclerites, the suspensoria (sus), articulating with the bases of the mandibles (fig. 13).

Labium: The labium (fig. 12), which closes the mouth ventrally, is equivalent to the two fused maxillae. Its enormous submentum (sm) forms the greater part of the ventral side of the head. In L. variabilis the submentum has somewhat the form of an isosceles trapezoid. In L. grandis, and in L. bartletti, however, the lateral margins tend to be more nearly parallel. The mentum (mn) which, together with the submentum, forms the postmentum, is usually a very small triangular, indistinct sclerite partly fused with the labial stipes. In L. bartletti the mentum is larger than in other species and extends the width of the labiostipes. Each labiostipes (lbi) is about as long as broad. The glossae (gl) are fused for a short distance at the base. They are slightly longer and much narrower than the paraglossae (pgl). Both glossae and paraglossae bear sense papillae at their apices. The labial palpi (lp) are short and 3-segmented. In L. variabilis they extend

beyond the paraglossae and the segments are about as broad as long. In L. grandis Banks and in L. bartletti they are much broader than long, especially the second segment, which is at least twice as broad as long. In the latter two species the palpi do not usually extend beyond the paraglossae. Miss Hoke says concerning her work, "Each palpiger is distinct in the species studied with one exception. In the nymph of Perla it is not separated by a distinct suture." This observation may not be correct, however, since in no species of Leuctra have I been able to find a suture demarking a palpiger, and in checking this character I have not been able to find such a suture in Taeniopteryx, Capnia, or Allocaenia.

CERVIX

Since the origin of the cervix is not definitely established, it is discussed briefly and separately from both head and thorax. The cervix is a membranous neck region bearing two lateral, and one ventral sclerite. No dorsal sclerite is present. The protruding lateral cervical sclerites (lc) articulate with the occipital condyle, or cephalinger, by means of a narrow extension. The ventral cervical sclerite (vc) of Leuctra is an unpaired transversely oval intersternite probably formed by a thickening in the neck membrane.

THORAX

The thorax of stoneflies, especially the prothorax, has been studied somewhat thoroughly by many workers, but not sufficiently for an understanding of the evolution of species within the Nemouridae. In this present study, variations have been observed, particularly in the sternal region and in the wings, which seem to be of significance in indicating the phylogeny of Nemoura and Perlomyia. These will be discussed in a later part of this paper after a consideration of the abdominal structures which offer additional evidence of the relationships of the species of Nemouridae.

The prothorax of Leuctra, like that of all other stoneflies, retains the primitive apterygotan condition of the pleura, while the notum consists of a single plate forming the pronotum. The meso- and meta-thoraces are quite similar to each other in most details. The mesothorax is the largest of the three segments, while the prothorax is the smallest. About the only variation in proportions is to be noted in L. bartletti and occidentalis in which the segments are longer than in other species. The pterothoracic segments are always longer than broad.

Prothorax

Notum: The prothoracic tergum consists only of

the large eunotum or pronotum (pn) which is usually rectangular, but sometimes widens posteriorly. In most species it is transverse (fig. 16), but in L. bartletti and L. occidentalis it is longer than broad. It bends laterally downward over the pleura and extends anteriorly over the cervix. Near the anterior margin of the pronotum is a suture demarcating the narrow precosta (Snodgrass). At the posterior border is a similar suture. There is also a thickening on the sagittal line. The lateral portions of the disc bear a few irregular embossings, as in most Plecoptera.

Pleuron: Close to the lateral cervical sclerite and under the edge of the pronotum lies the eupleuron (Crampton, 1926) which is elongated posteriorly and ventrally (fig. 14). The ventral prolongation is the precoxale, which is not joined to the basisternum in Leuctra. It is only partly separated from the episternum (eps). The episternum is separated from the tiny sclerite known as the epimeron (epm) by the pleural suture.

The eutrochantin (etn) lying below the eupleuron is of the same general shape but much smaller than the eupleuron. It diverges from the eupleuron anteriorly and extends ventrally to articulate with the anterior margin of the prothoracic coxa. Like the eupleuron, it is divided by the pleural suture into a tiny posterior and a large anterior sclerite. Posterior to the eutrochantin is a chitinization in the membrane, the postcoxale, which in Leuctra does not form a complete postcoxal bridge.

Sternum: Immediately behind the ventral cervical sclerite is the presternum (fig. 15) which in this genus is still attached to the basisternum, while in Capnia, Allo-capnia and in the closely related Perlomyia, the presternum has been constricted off from the basisternum (bs). The prothoracic basisternum is a subtriangular sclerite extending to the furcasternum (fs), which lies between the coxae. In L. bartletti and L. occidentalis the furcasternum is undivided; in L. hamula and L. sibleyi it is still undivided but is deeply constricted along the sagittal line; while in L. grandis and L. variabilis it is divided into two distinct parts. The postfurcasternum (pfs) is a transversely oval sclerotization behind the furcasternum which also is usually completely divided into two parts. The spinasternum (ss), which may be the last segment of the prothorax, is a slender sclerite taking the shape of a wide arc.

Pterothorax

Terga: Meso- and meta-terga are practically identical, so they can be described together. The anterior-most sclerite of the wing-bearing plate is the prescutum (prc), which is divided along the sagittal line and is sunken anteriorly. The prealar bridge (pa) is adjacent to the prescutum laterally and is also sunken anteriorly. The scutum (sct), the largest sclerite of the tergum, is roughly hexagonal. At the anterior lateral angle of the scutum

is a tiny projection called the anterior notal process (anp) which supports the first axillary sclerite. The posterior notal process (pnp), which is many times as large as the anterior notal process, serves for the attachment of the third axillary sclerite of the wing. It is demarked by two converging grooves which extend to near the posterior margin of the scutellum. The posterior margin of the scutum rolls downward to meet the postscutellum, which is a distinct, well-developed sclerite in all Plecoptera and Embiids. The scutellum (scl) is demarked from the scutum only by a U-shaped suture. Anteriorly it is not separated from the scutum by a suture. The postscutellum (pscl) bears various grooves and raised areas which need not be described here.

Pleura: The meso- and meta-thoracic pleura are very much alike. They are more highly evolved than the prothoracic pleura, which retain the apterygotan condition. The pleural suture is more oblique than in the prothorax. The epimeron tapers anteriorly to a point at the posterior basalare. There is no postalar bridge between the epimeron and postscutellum as there is in Perla and Taeniopteryx. The episternum is the largest of the pleural sclerites and is divided into an anepisternum (aes) and a katepisternum (kes), with which the slender trochantin is continuous. The anepisternum bears the anterior and posterior basalares.

The wing has no articulation with the anterior basalare (ab) but has two with the posterior basalare (pb).

The humeral plate at the base of the costal vein articulates with the anterior portion of the posterior basalare while the third axillary sclerite of the wing articulates with the posterior basalare at its posterior edge. The prealar bridge mentioned previously in connection with the discussion of the tergum, unites with the anterior border of the anepisternum and offers support to the tergum. The lateropleurite which is not demarked from the episternum, and the laterosternite which is not demarked from the basisternum, are separated from each other by a suture (fig. 14). There is no postcoxal bridge.

Mesothoracic sternum: Immediately behind the prothoracic spinasternum lies the mesothoracic presternum, a small oval sclerite which is sometimes almost indistinguishable. The basisternum which is the largest sternal sclerite of the thorax is much larger than the prothoracic basisternum, as a result of which the coxae are more widely separated than those of the prothorax. It articulates anteriorly with the tips of the prothoracic spinasternum. The furcasternum and spinasternum are fused into a subtriangular area which is also fused to the basisternum. Extending posterolaterally from the furcal pits are sclerotized projections which support the coxae but do not articulate with them. On each side of the transversely elongate spinasternum are small oval sclerites corresponding to the divided postfurcasternum. In L. occidentalis these are united with the spinasternum.

Metathoracic sternum: The metathoracic sternum is quite similar to that of the mesothorax with the exception that it bears no spinasternum and the furcasternum is much more elongate transversely.

Articulation of the Wings

The axillary sclerites of the fore and hind wings are practically identical. The anteriormost axillary sclerite is the humeral plate (hp), which is extremely difficult to make out except in L. bartletti. Since it passes under the larger tegula (tg) to meet the basalare of the anepisternum, it is only partly visible from above. There are three axillaries. The first is closely approximated to the edge of the scutum and articulates with the base of the subcostal vein by a long neck (fig. 16), which probably is supported by the anterior notal process (anp). The second axillary has four articulatory points; it hinges to the outer margin of the first axillary, to the posterior basalare, to the base of the radial vein, and to the anterior end of the third axillary. The third axillary also articulates with the posterior notal process and with the base of the anal veins. Muscles which run to the anepisternum are attached to an enlargement near its center. The median plate (m) lying distal to the second and third axillary is a poorly delimited sclerite which plays a part in the folding of the wing.

Wing Venation

The wing venation is perhaps more stable in Leuctra than would be expected in a stonefly. A study of a large series shows very few digressions in number of branches, and in position and number of crossveins. In one case, however, a specimen of L. bartletti had the media of both fore wings fused with the radial sector for a short distance. On the basis of generic characters in use at the present time, an entirely new genus would have to be created for this one specimen -- all of which indicates that great caution should be exercised in describing a new species of stonefly from a single specimen.

Wing venation is of little or no use in specific determinations. However, it is possible to differentiate two different groups or subgenera of Leuctra on the basis of wing venation; but as will be seen later these differences may be correlated with other major differences which also easily distinguish them.

The subcosta joins the radius at its base, and ends on the costa at a point slightly beyond the center of the wing. The radial sector branches only once, almost directly below the tip of Sc. M is unbranched and arises from the radius a short distance before Rs does. According to Needham and Claassen (1925), M is branched, but their interpretation seems to be incorrect. Due to the shortening of the crossvein between M and Cu_{1a} (fig. 20), Cu_{1a}

often appears to be a branch of M. But figures 21 and 22 show other conditions indicating that M is simple. Thus, in one specimen of L. decepta, shown in figure 22, (and in one specimen of L. bartletti), Cu_{1a} is not connected to M by a crossvein, but in these and in all other specimens and species of Leuctra examined the vein in question is attached to Cu. In view of these facts, and the fact that media in the hind wing of Leuctra is always unbranched, it is reasonable to assume that media is also unbranched in the fore wing, and Cu₁ therefore must be the vein which is branched.

In L. bartletti the dichotomy occurs beyond the middle of the wing, and not proximal to it, as in other species. Cu₂ and the first anal vein are unbranched. The second anal has a long anterior branch and a very short posterior one.

The crossveins are few in Leuctra and do not occur beyond the cord. There is only one costal crossvein (humeral), one radial, and one radial-medial. The number of supplementary medial-cubital crossveins varies from 4 to 6 and there are no crossveins beyond m-cu. The number of intercubitals varies from 9 to 13. The number of intercubitals beyond the last m-cu crossvein is often used as a supplementary species character but is valueless for this purpose, as there are all sorts of intergradations between specimens.

The hind wing differs from the fore wing particularly in having an anal fan and only one m-cu and one inter-

cubital crossvein. Also r joins Rs before the dichotomy, while in the fore wing it joins R₂. In the L. occidentalis, bradleyi, infuscata, and bartletti group, m-cu always joins Cu_{1a}, but in all other species m-cu joins Cu₁ before its dichotomy.

Legs

The legs differ from one another very little except in size. The prothoracic legs are slightly shorter than the mesothoracic legs, which in turn are considerably shorter than the metathoracic legs. The tibia of the metathoracic leg is exactly as long as the tibia and tarsus of the mesothoracic leg.

The relative size of the parts of the legs does not vary in different segments of the thorax. The tibia is as long as the femur and trochanter together. The tarsus is one half as long as the tibia. The first tarsomere is at least as long as the other two combined. The middle tarsomere is reduced.

The fore coxa differs from the others in that it has no meron on its posterior proximal surface. It has what Snodgrass calls the basicoxite, set off by a basicostal suture.

The pretarsus is an interesting structure occurring beyond the distal tarsomere. It is very similar to that of Taeniopteryx nivalis Fitch discussed by Holway (unpublished

thesis). The long curved claws or ungues (un) are separated by a large membranous arolium. They articulate with the dorsal rim of the distitarsus (3d ta) by a projection as shown in figure 25. Just above this articulation is another projection which acts as a stop when the claws are relaxed. On the arolium (ar) is a broad, dorsal, deflected sclerite, the orbicula (or). There is no demarked planta at the distal end of the unguitractor (ut). The long seta-like structures which, according to Holway, are the basipulvilli (bp), seem in Leuctra to arise from a membranous area of the unguitractor. Each is joined to the unguitractor by a rod, laterally. This junction probably acts as an articulatory point for independent motion of these setae.

ABDOMEN

The abdomen of Plecoptera is generally considered to consist of eleven segments, although interpretations as to the segmental distribution of the terminalia vary. The abdomen has been most thoroughly studied by Crampton (1918, 1929) and Snodgrass (1936).

Pregenital Segments

In the male of Leuctra variabilis all pregenital sternites are completely sclerotized and unmodified, while the seventh and eighth tergites are partly membranous. A broad median prolongation (fig. 33) extends from the middle of the seventh tergite almost to the posterior border of the segment. This prolongation is usually truncate at the tip but is sometimes rounded or trilobed and may bear sharp lateral projections (fig. 30c) as well. The eighth tergite is mostly membranous.

In the female the sternites do not extend to the dorsopleural line as they do in the male and the tergum of the first seven segments is usually not sclerotized except for small laterotergal areas. Both sexes have the full number of abdominal spiracles (8 pairs), situated in the anterior, laterotergal region of each of the first eight abdominal segments.

Male Terminalia

Both Crampton (1918) and Snodgrass (1936) have indicated that our knowledge concerning the homologies of male genitalic parts of Plecoptera is meager, and further study of various genera and species of stoneflies is necessary before we can determine the various stages in the evolution of the group. The fact that the mating appendages of male Plecoptera are secondary outgrowths and not modifications of true styli complicates the interpretation of parts. As a result of this confusion in homologizing parts, workers have offered different interpretations of the terminal abdominal segments of Leuctra as well as of other Plecoptera.

Snodgrass (1936) considers both the subanal lobes (fig. 32) and titillators (tit) to be prolongations of the tenth sternum. Crampton (1918), on the other hand, indicates that the titillators may be homologous with the paraprocts (processes of the eleventh sternite), while Snodgrass would denote as the paraprocts, the undifferentiated membranous region surrounding the anus. Crampton believes the supra-anal plate (supra-anal process of Mosely, rose-shaped process of Morton) to be the epiproct (eleventh tergite). Since the views of Crampton as to homologies of the parts of the postgenital segments seem more plausible than others, they are adopted here.

The description of the terminalia of Leuctra

variabilis n. sp. is given here as representative, in general, of most species of the genus. The tergal region of the ninth segment is largely membranous but bears a rectangular sclerite called the sensomacula (sma). The ninth sternite is the largest sternite of the abdomen. A median lobe, called the ventral lobe (fig. 26) in taxonomic work is situated at one-third of the distance from base to apex of the sternite. The latter is membranous posterior to the lobe. The membranous area is produced posteriorly into a narrow median process. The median subanal lobes are probably processes of the sternal plate (tenth sternite). In lateral view they taper gradually to a blunt apex (fig. 29); in dorsal or ventral view they are wide only at their bases where the genital opening is situated. The supra-anal plate or process (fig. 33) which is interpreted as the epiproct arises from a broad sclerotized area which is probably part of the tenth tergite.

The sternum of the eleventh segment is probably represented by the sclerites from which the titillators arise. The titillators (tit) are slender processes embracing the subanal lobes. They are slightly shorter than the subanal lobes and curve dorsalward (fig. 29). At the base of the titillator is a tiny sclerite which, apparently, has previously been figured only as a continuation of the titillator sclerite. The two distinct sclerites (t', t''), above mentioned, can best be seen in fig. 32 in which the tenth and eleventh abdominal segments are depicted as though

flattened out, but in fig. 29 they are shown in their normal position. The cerci (ce) which are thought to be appendages of the eleventh segment are one-segmented and only thinly sclerotized.

Female Terminalia

Practically the only specialization of the terminalia of the female is in the variations of the eighth abdominal sternite or subgenital plate. The subgenital plate of all species of Leuctra except of the genotype, L. geniculata Stephens, is bilobed (fig. 27). It generally covers the anterior fourth of the ninth sternite, and therefore also covers the gonotreme which is situated between the eighth and ninth sternites. The gonotreme is the external opening of the internal sexual organs and in the female is also called the vulva.

The epiproct, paraprocts, and cerci are borne terminally on the abdomen in a membranous area behind the tenth segment. In this genus the tenth segment is not prolonged to cover the epiproct (fig. 31) as it is in Pteronarcys. The cerci are similar to those of the male, and the paraprocts are simple subtriangular lobes beneath the cerci.

EVIDENCES OF PHYLOGENETIC RELATIONSHIPS OF
LEUCTRA AND PERLOMYIA

The heads of the various species of Leuctra and Perlomyia furnish no characters which are of value for indicating phylogenetic tendencies in these two genera. But many variable characters which show phylogenetic relationships among the species are found in the thorax (especially in the sternal region) and in the terminalia, and by using these characters the genus Leuctra may be divided easily into two very distinct subgenera. Leuctra occidentalis Banks, L. bradleyi Claassen, L. glabra Claassen, L. forcipata Frison, L. claasseni Frison, L. purcellana Neave, and L. bartletti n. sp. belong to the group for which the subgeneric name Paraleuctra is here proposed. Leuctra tenuis Pictet, L. grandis Banks, L. biloba Claassen, L. carolinensis Clsn., L. decepta Clsn., L. duplicata Clsn., L. hamula Clsn., L. sibleyi Clsn., L. triloba Clsn., L. truncata Clsn., and L. variabilis n. sp. fall in the typical subgenus Leuctra. It is also proposed here that the genus Perlomyia be relegated to subgeneric rank within the genus Leuctra on account of its close relation to Paraleuctra.

Characters in the thorax that bring out the relationships of species of the subgenera Perlomyia, Paraleuctra, and Leuctra are found in the general shape of the thoracic segments, in the shape of the prothoracic presternum, in the furcasternum, in the extent of fusion

of the laterosternite and lateropleurite of the meso- and metathoraces, and in the venation of the hind wing. The thoracic segments of Perlomyia and of Paraleuctra are much more elongate than those of the subgenus Leuctra. Thus, the pronotum in Perlomyia and Paraleuctra is always elongate, while in Leuctra it is almost always transverse. In Perlomyia and Paraleuctra the furcasternum always consists of a single sclerite which is united with the posterior end of the basisternum, while almost all the members of the subgenus Leuctra have a furcasternum consisting of two distinct sclerites which are not united with the basisternum. In neither Leuctra nor Paraleuctra is there a postcoxal bridge (fig. 14) in the prothorax, but in Perlomyia a slightly sclerotized strip extends from the postcoxal sclerite to the furcasternum making a nearly complete postcoxal bridge. In Leuctra the meso- and metathoracic laterosternite and lateropleurite are not completely joined anteriorly (fig. 15), and the suture between them extends posteriorly to the base of the trochantin. However, in Perlomyia and Paraleuctra the laterosternite and lateropleurite are completely joined anteriorly, and posteriorly the suture is beginning to disappear; i.e., the latter does not extend to the base of the trochantin. The position of m-cu in the hind wing also relates Paraleuctra very definitely with Perlomyia. In both of these subgenera m-cu always joins Cu_{1a}, while in the subgenus Leuctra, m-cu always joins Cu₁ before its dichotomy into

Cul_a and Cul_b. Also, the anal fan of Perlomyia and Paraleuctra is slightly larger than that of the subgenus Leuctra.

Again, every abdominal structure shows that Paraleuctra and Perlomyia are closely allied. But these two groups are so isolated from the subgenus Leuctra that it is impossible to homologize with certainty the accessory genital organs of the tenth and eleventh segments of the male. Perlomyia and Paraleuctra have no parts corresponding to the subanal lobes of the subgenus Leuctra. However, if the points of articulation are of any significance, the long subanal probes of Paraleuctra are homologous with the titillators or paraprocts of the subgenus Leuctra. Both articulate with the ventro-lateral end of the tenth tergite. In Perlomyia and Paraleuctra the probes articulate also with the cerci which are modified into sclerotized spined processes most probably used in copulation. Their articulations with the bases of the subanal probes insure coordination with the subanal probes in the copulatory movements. The subanal plate in Perlomyia and Paraleuctra does not have a membranous area posterior to the ventral lobe as Leuctra has, and the subanal plate is produced a much greater distance posteriorly in Perlomyia and in Paraleuctra than in Leuctra. The epiproct in Perlomyia and Paraleuctra is sclerotized and pointed dorsalward, while in the subgenus Leuctra the epiproct or supra-anal plate is a small membranous lobe. The tenth tergite

is large and well sclerotized in Paraleuctra and Perlomyia, but in Leuctra it is mostly membranous. In the female of Paraleuctra and Perlomyia there is a dorsal sclerotized plate on each abdominal segment, while the dorsum of each segment of the abdomen of Leuctra bears only the latero-tergal sclerites.

It is evident from the foregoing discussion that the species of the subgenus Paraleuctra are much more closely related to Perlomyia than they are to Leuctra. No features of the terminalia would indicate the probability of a direct relationship between Leuctra and Paraleuctra. Only on the basis of the nature of the presternum and the position of the crossvein between Cu₁ and Cu₂ of the hind wing is it possible to trace a line of evolution from Leuctra to Paraleuctra. Paraleuctra leads over to Perlomyia. The prothoracic presternum of Leuctra shows no trace of separation from the basisternum, while in Paraleuctra it is partially separated, and in Perlomyia it is completely separated from the basisternum. The crossvein between Cu₁ and Cu₂ in Leuctra joins Cu₁ before its dichotomy into Cu_{1a} and Cu_{1b}, while in Perlomyia it joins Cu_{1b} near its base, and in Perlomyia the crossvein joins Cu_{1b} farther from the base of the wing. From the above facts it is evident that the crossvein has migrated toward the apex of the wing.

In Paraleuctra and Perlomyia a few additional

characters indicate that Perlomyia is higher in the scale of evolution than is Paraleuctra. The fore wing is specialized, in that the bases of Rs and M have migrated to a common point on the Radius. The subanal probe in Paraleuctra is a simple projection, but that of Perlomyia has developed spines, grooves, and other irregularities on its sclerotized areas. The subanal plate is produced posteriorly much more in Perlomyia than in Paraleuctra. In Perlomyia solitaria Frison it is enormously produced to extend beyond all the other terminal abdominal structures.

There are several characters which show that Perlomyia, Paraleuctra, and Leuctra are very closely interrelated and must be placed within a single genus.

1. All have involute wings and no cross vein beyond the tip of the subcosta.
2. The second tarsal segment is short in all species.
3. Head structures are very similar.
4. A well developed presternum is always present.

Furthermore, the genus Leuctra is sharply separated from Nemoura on the structure of the mouthparts, which are subject to very little variation within either genus and are therefore an excellent criterion. Nemoura also lacks the prothoracic presternum, and has the wings flat upon the abdomen. The general shape of the body of Nemoura, too, is different from that of Leuctra. In all characters except the mouthparts, Taeniopteryx is as sharply distinguished from Leuctra as is Nemoura and in addition, differs in having the second tarsal segment as long as either of the other two.

Species Characters

A study of all the external structures of many species of Leuctra has shown that taxonomists have neglected no characters of value in specific distinctions within the genus. The main distinction between the species of the typical subgenus Leuctra lies, in the males, in the

characters of the processes arising on the sixth, seventh, and eighth abdominal tergites and in the shape of the titillators and subanal lobes. The shape of the supra-anal plate has been used extensively by Mosely in England and, to some extent, by Claassen in America, but it is very small, and because it is membranous easily becomes misshapen. In the males of Perlomyia and Paraleuctra variations in the shape of the cerci and the subanal probe furnish the chief specific characters. In the female sex, species are differentiated on the basis of the subgenital plate or eighth sternite. Species differ in the depth and width of the emargination of this plate, but differentiation of some species on female characters, I think, will prove to be impossible. In the Needham and Claassen monograph (1925) the drawings would seem to indicate that the females of each species are distinctly separable from all others, but a study of a large series of females of one species often shows a range of variations in the subgenital plate which intergrade with the average patterns of the subgenital plate of other species.

Several supplementary specific characters, that are misleading and not dependable, are in use. Body length, as previously mentioned, is too variable to be of value in specific distinctions. The number of intercubitals beyond m-cu has been used also as a supplementary character but is too variable for this purpose. The

distance between the lateral ocelli and the distance of either lateral ocellus from the compound eyes varies so slightly as a character for species distinction that it can be used^{only} with difficulty if at all.

New Species

In collecting material for study at least one new species has been discovered. There is a possibility that through a curious series of inaccuracies in the drawing given in the original description of L. forcipata the species described tentatively here as the new species, Leuctra (Paraleuctra) bartletti may prove to be Leuctra forcipata Frison. However, until it is possible to compare the present specimens with type material of L. forcipata, the validity of L. bartletti must remain in doubt.

Leuctra (Leuctra) variabilis n. sp.

Since Leuctra (Leuctra) variabilis n. sp. has been discussed in detail in the morphological section of this paper, it need not be described further here. It is most closely allied to L. carolinensis, L. triloba, and L. crosbyi Clsn., but differs from these in the process of the seventh abdominal tergite and in the terminalia. In L. variabilis the process of the seventh

tergite is usually truncate and in L. carolinensis the posterior border of this process is triangular. The rare specimens of L. variabilis that do have a trilobed process (fig. 30, a) can be distinguished from L. triloba by the absence of spines on the apices of their subanal lobes and from L. crosbyi by the shape of the process of the seventh abdominal tergite.

The female of L. variabilis differs from other females of Leuctra in that the lobes of the subgenital plate converge markedly near their apices (fig. 27).

Leuctra bartletti n. sp. ?

Leuctra (Paraleuctra) bartletti is most closely related to L. forcipata Frison and L. occidentalis Banks. It is practically identical with these species in all characters except the shape of the cerci and of the tenth abdominal tergite. It can be distinguished from L. occidentalis only by the shape of the cerci. The lower projection of the cerci in L. bartletti is as long as the upper one and bears a small pointed "tooth" on its mesal surface. In L. occidentalis the lower projection is shorter than the upper, and bears no "tooth". Also, the base of the cerci of L. occidentalis is more elongate than that of L. bartletti. If Frison's drawing is accurate, the hind margin of the tenth tergite of L. forcipata is very different from that of my specimens.

The teeth on the upper and lower prongs of the cerci are also much longer in L. bartletti than in L. fortipata.

Interesting Distributional Records

During the course of this study identifications of Leuctra from many regions of North America have been made. The known geographical range of most species has been extended and in several instances interesting information concerning duration of emergence periods has been obtained. In the following list, records which add new states or provinces to our previous knowledge of the range of distribution of a species are starred.

Leuctra (Leuctra) decepta Claassen

- * CANADA. Height of land near Isabelle River, foot of Mt. Albert, Central Gaspé, August, 1937, 1 male, 3 females: Forillon, Gaspé, August, 1937, 1 female: Cape Gaspé, Gaspé, August 19, 1937, 1 male: Perce, Gaspé, August 22, 1937, 1 female (Alexander).
- * MAINE. Canyon Brook, Mt. Desert, June 23, 1935, 5 males, 4 females (Alexander).
- * NEW HAMPSHIRE. Randolph, 2 males.
- * VERMONT. Jacksonville, October 31, 1937, 1 female (Hanson).
- * MASSACHUSETTS. Paradise Trail, Sunderland, Massachusetts, October 11, 1937, 2 males; October 21, 1937, 3 females: Pelham, Massachusetts, May 21, 1938, 1 male (Hanson).

- NEW YORK. Sea Cliff, Long Island (Banks), 1 male, 1 female.
- * NEW JERSEY. Lucaston, April 18, 1902, 1 male (Banks).
- * PENNSYLVANIA. Pennsylvania Mts., 1860, 1 male (O. Sachen).
- * NORTH CAROLINA. Mt. Mitchell, altitude 6400 feet, "4-7
Sept.", 4 males: Smoky Mts., Bryson City, altitude 2000
feet, August 2, 1930, 1 female (Banks).
- * TENNESSEE. Newfound Gap, altitude 5000 feet, August 30,
20 males, 16 females; 2 males, 2 females (Banks).

Leuctra (Leuctra) duplicata Claassen

- * MAINE. Canyon Brook, Mt. Desert, June 23, 1935, 2 males,
1 female (Alexander).
- * NEW HAMPSHIRE. Hillsboro, June 15, 2 males, 4 females.
Randolph, 6 males, 9 females. Huntington Ravine, alti-
tude 4000 feet, August 15, 1935, 1 female (Alexander).
- * VERMONT. Jacksonville, June 20, 1937, 1 female (Hanson).
- MASSACHUSETTS. Holliston, May 31, 1 male (Banks).
Belchertown, May 21, 1938, 1 male: Pelham, May 21, 1938,
2 males, 1 female (Hanson).
- NEW YORK. Sport Island, Sacandaga River, June 6, 1 female;
June 22, 3 females: Woodworth Lake, Fulton County, May 30,
1909, 2 males, 3 females: Hamilton County (Adirondacks),
altitude 1500 feet, June 26, 1937, 2 males, 2 females
(Alexander).

Leuctra (Leuctra) grandis Banks

- * MASSACHUSETTS. Paradise Trail, Sunderland, June 3, 1937,
1 male, 1 female (Hanson).
- * NEW YORK. Gloversville, June 13, 1 female.
- NORTH CAROLINA. Black Mountains, 7 males, 10 females.

Leuctra (Leuctra) hamula Claassen

- * CANADA. Height of land near Isabelle River, foot of Mt.
Albert, Central Gaspé, August, 1937, 1 male: Cape
Gaspé, August 19, 1937 (Alexander).
- * VERMONT. Jacksonville, June 20, 1937, 3 males, 6 females
(Hanson).
- NEW YORK. Blue Mt. Lake, June 4, 1937, 1 male (Alexander).

Leuctra (Leuctra) sibleyi Claassen

- * MASSACHUSETTS. Pelham, May 21, 1938, 2 males, 7 females
(Hanson).
- NEW YORK. Ithaca, May 23, 1 male, 3 females.

Leuctra (Leuctra) tenuis Pictet

- * VERMONT. South Newfane, September, 1 male; July, 4 females
(Bryant).
- NEW YORK. Blue Mt. Lake, June 4, 1937, 1 male (Alexander).
- PENNSYLVANIA. Sulfur Springs, August, 1 male, 1 female
(Banks).

- * NORTH CAROLINA. Smokemont, altitude 200 feet, August 24, 1930, 2 males, 2 females, (Banks).

Leuctra (Leuctra) triloba Claassen

NORTH CAROLINA. Mt. Mitchell, altitude 6400 feet, "4-7 Sept." (Banks).

- * TENNESSEE. Newfound Gap, altitude 5000-5200 feet, September 1, 1930, 1 male.

Leuctra (Leuctra) truncata Claassen

- * CANADA. Cape Gaspe, Gaspe, August 19, 1937, 1 female:
Forillon, Gaspe, August, 1937, 1 male (Alexander).

Leuctra (Leuctra) variabilis n. sp.

Holotype, male, Paradise Trail, Sunderland, Massachusetts, November 24, 1937 (Hanson).

Allotopotype, female (Hanson).

Paratopotypes. October 3, 1937, 12 males, 15 females;
October 11, 1937, 37 males, 35 females; October 21, 1937, 26 males, 23 females; November 7, 1937, 8 males, 10 females; November 24, 1937, 4 males, 1 female (Hanson).
October 3, 1937, 14 males, 13 females; October 21, 1937, 2 males, 8 females (Bartlett).

Paratypes

MASSACHUSETTS. Dover, October 18, 1915 (Banks).

Sunderland, October 12, 1937, 6 males, 7 females;

November 6, 1937, 7 males, 4 females (Hanson).

VERMONT. Jacksonville, September 12, 1937, 57 males, 68 females; October 31, 1937, 3 males, 11 females (Hanson): August 3, 1937, 4 males, 2 females (Pratt).

Leuctra (Paraleuctra) bartletti n. sp.

Holotype, male, Paradise Trail, Sunderland, Massachusetts, March 31, 1937 (Hanson).

Allotopotype, female (Hanson).

Paratopotypes. March 30, 1937, 3 males, 1 female; March 31, 1937, 24 males, 2 females; April 11, 1937, 4 males (Hanson): April 11, 1937, 6 males, 1 female (Bartlett).

Paratypes. South Amherst, Massachusetts, March 31, 1937, 2 males; April 6, 1937, 18 males, 7 females; April 10, 1937, 9 males, 4 females; April 11, 1937, 4 males; April 18, 1937, 1 male; May 4, 1937, 5 males, 8 females (Hanson): April 10, 1937, 11 males, 4 females; April 18, 1937, 1 male, 3 females (Bartlett).

Leuctra (Paraleuctra) occidentalis Banks

COLORADO. Granite Peaks Camp, 1 female. Colorado University Camp, Nederland, altitude 10,000 feet, July 3,4, 1932, 1 male, 2 females.

Leuctra (Perlomyia) solitaria Frison

* CALIFORNIA. Santa Barbara, 1 male (Garman).

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ABBREVIATIONS

- 1 - first axillary sclerite
- 2 - second axillary sclerite
- 3 - third axillary sclerite

- A - anal vein
- ab - anterior basalare
- aes - anepisternum
- af - antennifer
- anp - anterior notal process
- ant - antenna
- ar - arolium
- asc - antennal sclerite
- ata - anterior tentorial arm

- bc - basicardo
- bg - basigalea
- bp - basipulvillus
- bpl - basal plate
- bs - basisternum

- C - Costa
- cdl - condyle
- ce - cercus
- cl - clypeus
- cls - clypeo-labral suture
- cs - coronal suture (stem of epicranial suture)
- ct - corporotentorium
- Cu - cubitus
- cx - coxa

- dc - disticardo
- dg - distigalea
- dta - dorsal tentorial arms

- e - compound eye
- ep - epiporct
- epm - epimeron
- eps - episternum
- es - epistomal suture
- etn - eutrochantin
- ex - extensor tendon

- f - frons
- fe - femur
- fl - filament
- fs - furcasternum
- fx - flexor tendon

- g - ginglymus

- ge - gena
- gl - glossa

- hc - hypocondyle
- hp - humeral plate

- kes - keskatepisternum

- la - lacinia
- lbi - labiostipes
- lc - lateral cervical sclerite
- lg - lingua
- li - labium
- lp - labial palpus
- lr - labrum
- lst - laterosternite
- lt - laterotergite
- ltp - pateropleurite

- M - Media
- m - median plate
- m-cu - medial-cubital crossvein
- md - mandible
- me - meron
- mn - mentum
- mo - mola
- mp - maxillary palpus
- mx - maxilla

- o - ocellus
- occ - occiput
- ocs - ocular sclerite
- os - ocular suture
- or - orbicula

- p - pedicel
- pa - prealar bridge
- par - parietal sclerite
- pb - posterior basalare
- pc - precosta
- pfs - postfurcasternum
- pfsu - postfrontal suture (one arm of epicranial suture)
- pgl - paraglossa
- pn - pronotum
- pnp - posterior notal process
- po - postcoxale
- poc - postocciput
- pocs - postoccipital suture
- pp - paraproct
- prc - precoxale
- prs - presternum
- ps - parastipes
- psc - prescutum

pscl - postscutellum
pta - posterior tentorial arms
ptar - pretarsus

R - Radius
Rs - Radial Sector
r - radial crossvein
r-m - radial-medial crossvein

s - stipes
Sc - Subcosta
sa - supraanal plate
sb - subanal process
scl - scutellum
sct - scutum
sge - subgena
sgs - subgenal suture
sm - submentum
sma - sensomacula
sn - supratentorina
sp - spiracle
ss - spinasternum
st - sternite
sus - suspensoria

t - tergite
ta - tarsomere
tg - tegula
ti - tibia
tit - titillators
tm - tentorium
tn - trochantin
tp - tempora
tr - trochanter
ts - temporal suture

un - ungues
ut - unguitractor

vc - ventral cervical sclerite
vl - ventral lobe

EXPLANATION OF PLATES

All figures are of *Leuctra variabilis* except figures 19, 22, and 28.

Plate I.

- Fig. 1. Dorsal view of head.
- Fig. 2. Ventral view of head.
- Fig. 3. Lateral view of head.
- Fig. 4. Dorsal view of head showing the tentorium.
- Fig. 5. Dorsal view of maxilla.
- Fig. 6. Base of antenna.
- Fig. 7. Antenna.
- Fig. 8. Left mandible (dorsal).
- Fig. 9. Right mandible (dorsal).
- Fig. 10. Ventral view of maxilla.
- Fig. 11. Labrum.
- Fig. 12. Labium.
- Fig. 13. Hypopharynx.

Plate II.

- Fig. 14. Lateral view of thorax.
- Fig. 15. Ventral view of thorax.
- Fig. 16. Dorsal view of thorax.
- Fig. 17. Fore wing.
- Fig. 18. Hind wing.
- Fig. 19. Hind wing of *L. bartletti*.
- Fig. 20. Cubital field of fore wing.

Fig. 21. Cubital field of fore wing.

Fig. 22. Cubital field of fore wing of L. *decepta*.

Plate III.

Fig. 23. Mesothoracic leg.

Fig. 24. Ventral view of pretarsus.

Fig. 25. Lateral view of pretarsus.

Fig. 26. Ventral view of the male abdomen .

Fig. 27. Ventral view of the female abdomen.

Fig. 28. Lateral view of terminalia of L. *bartletti*.

Fig. 29. Lateral view of abdomen of male.

Fig. 30. Seventh tergite of male showing variations.

Fig. 31. Lateral view of female abdomen.

Fig. 32. Flattened view of male terminalia.

Fig. 33. Dorsal view of male abdomen.

PLATE I

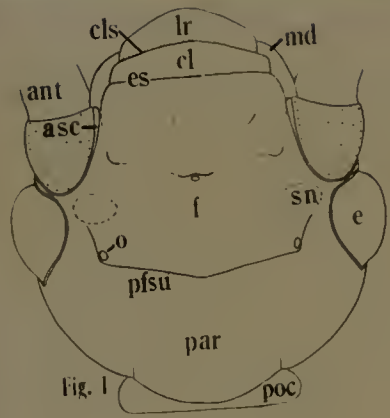


Fig. 1

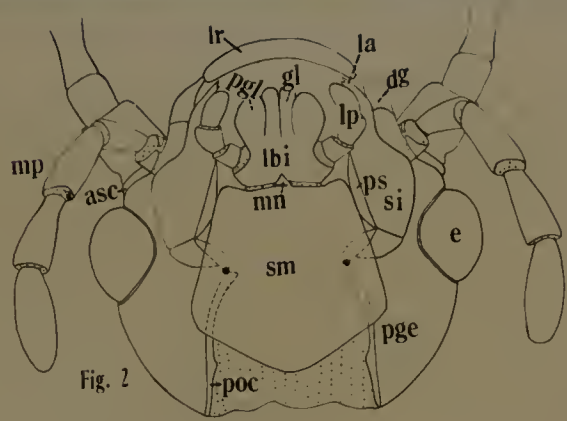


Fig. 2

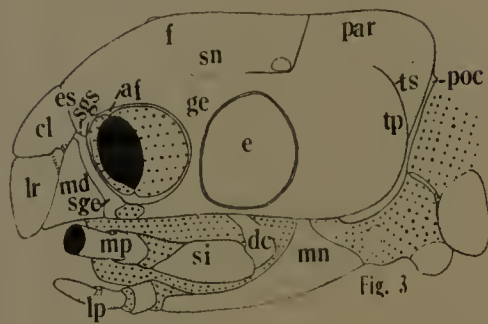


Fig. 3

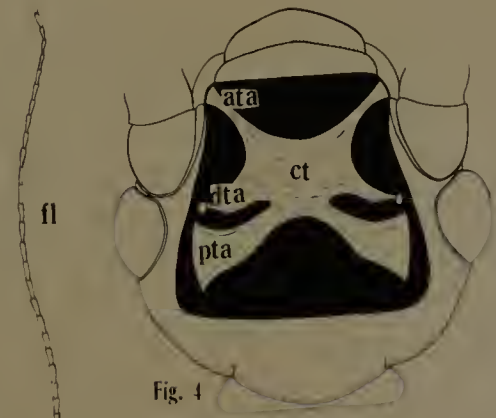


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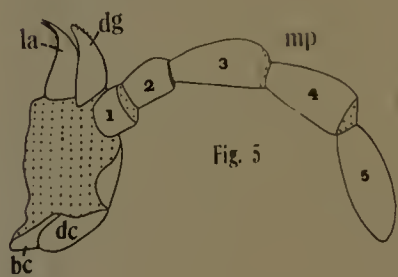


Fig. 5



Fig. 6

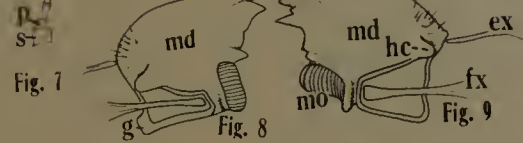


Fig. 7

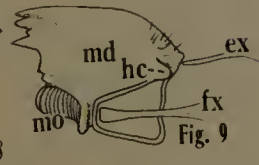


Fig. 9

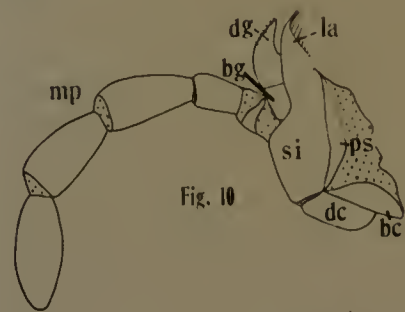


Fig. 10

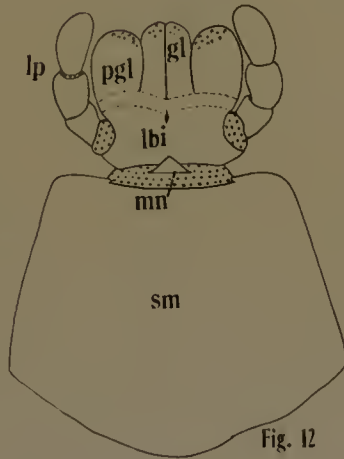


Fig. 12

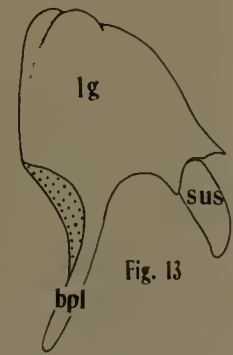


Fig. 13

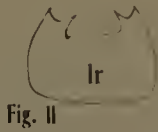


Fig. 11

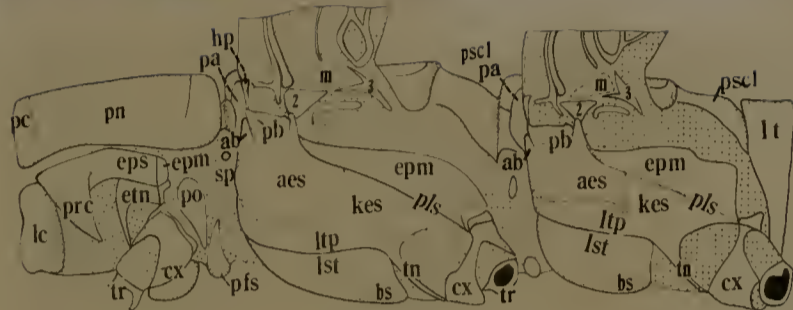


Fig. 14

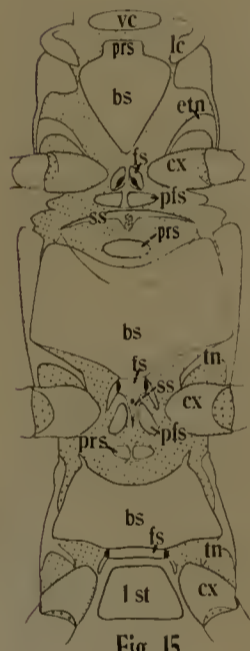


Fig. 15

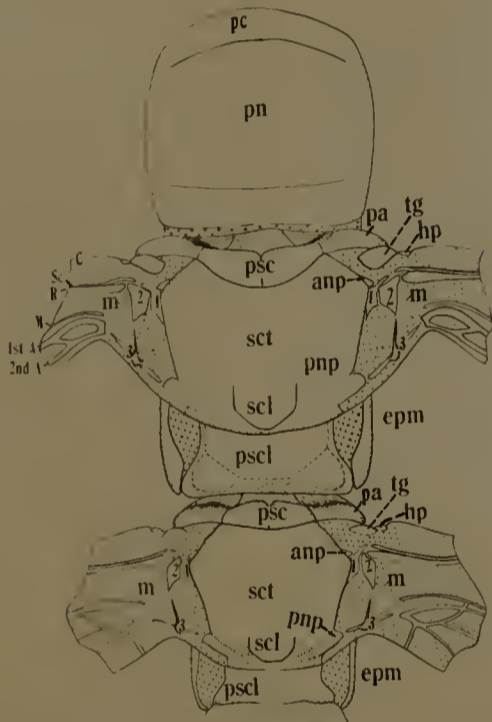


Fig. 16

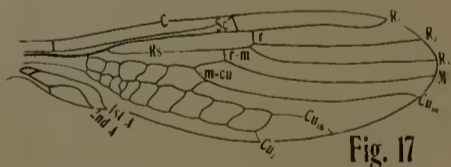


Fig. 17

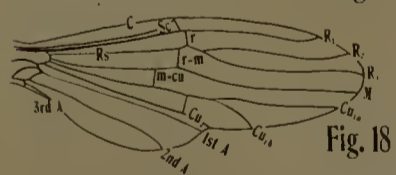


Fig. 18

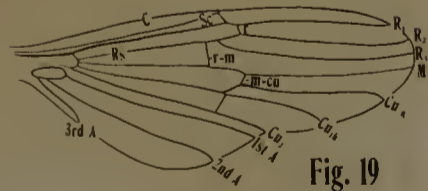


Fig. 19



Fig. 20

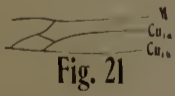


Fig. 21

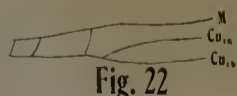


Fig. 22

PLATE III

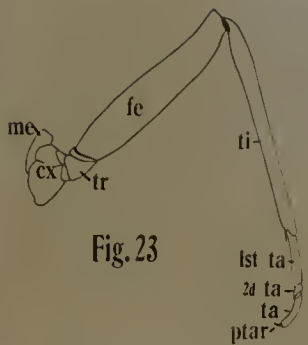


Fig. 23

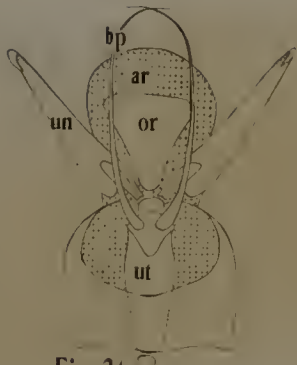


Fig. 24

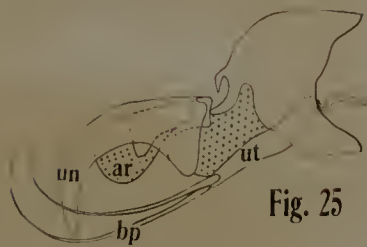


Fig. 25

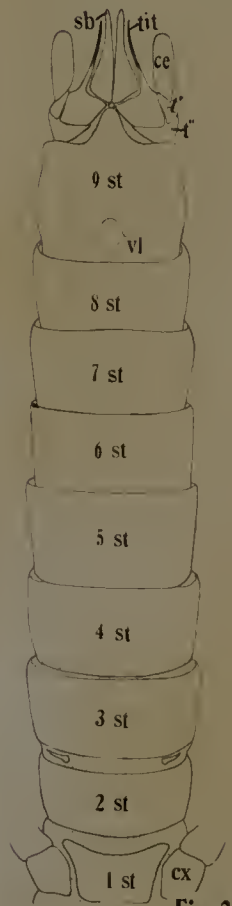


Fig. 26

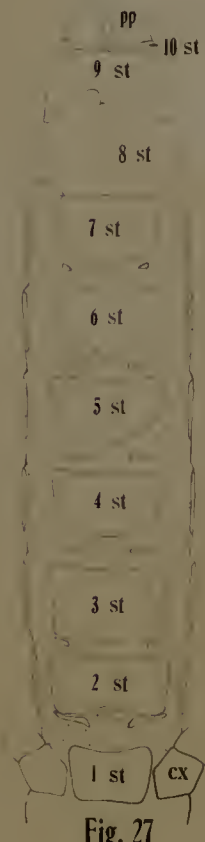


Fig. 27

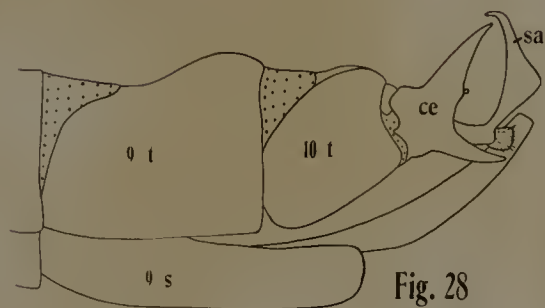


Fig. 28

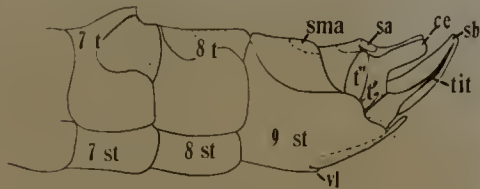


Fig. 29



Fig. 30



Fig. 31

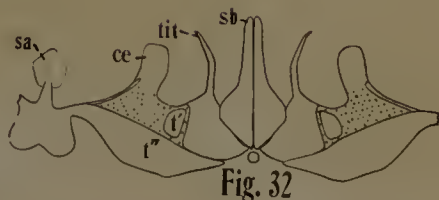


Fig. 32



Fig. 33

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Date

