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VOLUME XXXIX

THE EXTERNAL MORPHOLOGY OF THE LAST-  
INSTAR NYMPH OF *MAGICICADA SEPTENDECIM* (L.)  
(HEMIPTERA: HOMOPTERA)<sup>1</sup>

BY GRACE LI-EN LEW<sup>2</sup>

TABLE OF CONTENTS

	Page
	PAGE
Introduction .....	102
Review of Literature .....	102
Taxonomic Status .....	107
General Appearance .....	108
Head .....	108
Sutures of the Cranium or Head Capsule .....	108
Areas of the Head Capsule .....	111
Tentorium .....	112
Head Appendages .....	113
Cervix or Neck .....	116
Thorax .....	116
Thoracic Terga .....	116
Thoracic Pleura .....	118
Thoracic Sterna .....	121
Legs .....	122
Abdomen .....	126
Pregenital Abdominal Segments .....	126
Male Terminalia .....	128
Female Terminalia .....	129
Measurements of Nymphal Parts .....	130
Appendix I. ....	131
Appendix II. ....	141
Literature Cited .....	148
Acknowledgments .....	148
Plate Abbreviations .....	155
Index .....	180

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<sup>1</sup> Revised from a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at the University of Massachusetts.

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## ENTOMOLOGICA AMERICANA

### INTRODUCTION

The almost complete lack of keys by which the immature stages of cicadas can be distinguished, is concurrent with a sparcity of morphological work done on these nymphs. This paper is intended to provide a detailed morphological study of the last-instar nymph of our common, economic species, *Magicicada septendecim* (L.), that may serve as a foundation for comparative morphological studies which may in turn reveal some taxonomic characters.

### REVIEW OF LITERATURE

This review summarizes the available information that is useful in studying the external anatomy of the last-instar nymph of *Magicicada septendecim* (L.). Snodgrass' interpretations of some parts of the body of this last-instar nymph (as discussed and figured in his various publications on insect morphology) have been used as a basis for the present study, because his works are widely accepted and easily available. This review also includes several papers on the adult *M. septendecim* (L.) and on related species which proved helpful in arriving at the interpretations here presented.

In order to offer the reader a clearer picture of the structures discussed, each term used by other authors is supplemented with its synonymous equivalent used in the text of this thesis. The terms adopted in the text will be written in italics, while those used by other authors will be placed in quotation marks.

*Measurements:* Marlatt's (1907) measurements of the last-instar nymph of *M. septendecim* (L.) are within the ranges given in the present paper, except for the body length (27 mm.—35 mm.). It is possible that the preserved specimens studied by the present writer had assumed a curled-up posture and hence appeared shorter than the living (?) specimens studied by Marlatt. (For a detailed analysis of Marlatt, 1907, see Appendix I.).

*The Head.* Muir (1926) made a very detailed study of the head of the last-instar nymph of *Melampsalta* sp. discussing all the cranial sclerites, sutures, apodemes, and tentorial parts. He coined the terms *genal suture*, *maxillary suture*, and *labial suture*... (His interpretation which was very different from Snodgrass (1927a) is discussed in Appendix II).

Muir's statement that the floor of the pump is membranous and separable from a sclerotic, supporting plate is confirmed by Evans (1938) but not by other authors including the present writer. His other statement that an apodeme from the genal suture forms a

support for the anterior portion of the pump floor, and an apodeme from the "frontal" (*epistomal*) suture forms the posterior support, has not been verified by anyone. The structure labelled "maxillary apodeme" is apparently a composite of the *hypopharyngeal wing* and the *maxillary apodeme* of the present writer. Muir was the first to describe the continuity of the posterior lamina of the genal apodeme with the mesal surface of the maxillary stipes and with the anterior lamina of the maxillary apodeme.

In Snodgrass' (1927a) study of the head of *M. septendecim* (L.) are presented seven beautiful figures of the last-instar nymph. Besides identifying the true *frons*, naming the facial sclerites and mouth parts, he presented the hypopharyngeal parts in total and showed clearly their relationship with the pump, the ridge *j* (*epistomal ridge*), the *salivary syringe*, as well as the nature of the *mouth cleft* and *functional mouth*. He also demonstrated the connection of the *protractor arm* of the *mandibular stylet base* with the *lorum*, the connections of *a* with the *median lobe* of the *hypopharynx*, the position of the *stylet bases* in the pouch, and the shape of the *maxillary stylet base* and its relation with its imaginal counterpart.

Snodgrass has left the homologies of the *lorum* and *maxillary plates* undecided in this (1927) paper, and the *maxillary suture* unlabelled. The *labial fold*, *labial invagination*, *maxillary apodeme*, and the chaetotaxy of the head were not figured.

Spooner (1938) figured the head of the last-instar nymph of *Tibicen sayi* (Sm. and Grab.) (anterior, dorsal, lateral, and caudal views). The suture demarking the postclypeus from the frons (median portion of the *epistomal suture*) was shown as continuous with the *genal sutures*, and not with the sutures separating the postclypeus from the lora (ventral portions of *epistomal suture*). (This is in disagreement with Snodgrass' interpretation of these sutures in *M. septendecim* L.). His interpretation of the *lorum* ("paraclypeus") as a part of the clypeus is discussed in Appendix II; otherwise his terminology agrees with Snodgrass'. The posterior margin of his maxillary plate extends dorsad behind the eye, and the region posterior to this is not shown.

Evans (1940) in his study of the morphology of *Tettigarcta tomentosa* White, figured and discussed certain parts of the last-instar nymph of this species. His terminology of the cranial sclerites and the tentorium agreed with that used for *M. septendecim* (L.) by Snodgrass, as also did his statement that the mandibular stylets are attached to the turned-in margin of the lorum.

The posterior tentorial arm terminates at the tip of the hypopharyngeal wing.

*The thorax.* Marlatt's (1907) figures of the prothoracic legs of the fifth-instar nymph agree with those of the last-instar nymph studied in this paper.

Hansen (1900c, 1901) made the statement that in the adult cicada the very oblique articulation between the fore-trochantin and fore-femur enables the latter to move in a "see-saw movement," which view was confirmed by Myers (1928). Although this condition is not observed in the nymph of *M. septendecim* (L.) by the present writer, it deserves further investigation if live specimens become available. In a later (1902a & b) paper, Hansen described the positions of thoracic spiracles in adult cicadas which correspond with those of the nymph.

Crampton's (1909) figures of the mesopleuron and metapleuron of an adult cicada did not show any precoxale or postcoxale.

Taylor (1918) discussed and figured the thorax of adult *Tibicen linnei* (Sm. & Grab.) (as *Cicada tibicen* Germar). The pronotum, pro-episternum, and pro-pleural suture were very similar to those of the last-instar nymph of *M. septendecim* (L.) studied in this paper (see "Thoracic Terga," "Thoracic Pleura"). The pro-episternum is connected with a precoxale, and the pro-epimeron with a postcoxale. The pronotum, however, does not encroach as far ventrad as it does in the nymph of *M. septendecim* (L.), and the pro-epimeron is continuous dorsad of the coxal cavity. (Compare with Plate VI, Figs. 23, 24).

In the mesothorax the precoxale, he stated, is "definitely fused" with the katepisternum and with the sternum, while the postcoxale "connects katepimeron with sternum," and a ridge corresponding in position to the nymphal infracoxal arc was figured. In the metathorax, the precoxale is "fused with the episternum" but the postcoxale is "indistinct," and no ridge was shown on the mesal edge of the coxal cavities.

In Crampton's (1926) figure of the prothorax of an adult cicada the lateral edges of the pronotum, encroaching ventrad to the rim of the coxal cavity, seems to be continuous with the precoxale and postcoxale and there is no pro-episternum nor pro-epimeron labelled.

Snodgrass (1927b) gave a ventral view of the thorax of the last-instar nymph of *M. septendecim* (L.) to demonstrate the continuation of the pleura around the coxal cavities. This figure and

the accompanying text gave no information about the propleuron nor the exact demarcation between adjacent sterna. A ventral view of the adult thorax showed "the subcoxal rings persisting as chitinous ridges on edges of sterna." Two other figures, one of the mesopleuron and another of the metapleuron, gave identification of the pleural parts but not of the legs.

Snodgrass (1930) presented the fore-leg with its chaetotaxy in two anterior views showing the tarsus extended, as well as bent at right angles to the tibia. These views did not reveal the complete femoral comb.

Myers (1928) stated that the pronotal sutures of cicadas are secondary internal ridges developed for muscle attachments. His (1929) posterior view of the fore-femur (without setae) of the last-instar nymph of *M. septendecim* (L.) agrees with that of the present writer.

Evans' (1941) dorsal view of the inner surface of the thoracic sterna and adjacent parts confirmed Snodgrass' interpretation that each pleuron is continuous around the coxal cavity, and showed a pleural apodeme from each pleural ridge and a large bifurcate furca upon each sternum. There was a definite line of demarcation extending clear across the body between adjacent thoracic segments but there was none between the metasternum and the first abdominal sternum. The pro-pleural sclerites were not mentioned.

An anterior view of the fore-leg showed the various segments clearly (quite different from that of *M. septendecim* L.) but did not reveal the comb completely.

In Kramer (1950) who includes the external morphology of the adult *M. septendecim* (L.) the pronotum is shown undivided and the pro-epimeron and pro-pleural suture correspond in size and in position to that shown by Taylor (1918). However, Kramer states that the pro-epimeron is "completely covered" by the pronotum. This condition differed from that of the nymph studied by the present writer (see text). Precoxales and postcoxales joining the pleura to the sterna were figured and described in all three thoracic segments.

*The abdomen.* In Crampton's (1922) figure and discussion of the adult male genitalia of *Melampsalta calliope* Walker, the "surgonopods" (ventral claspers) were described as belonging to the tenth abdominal segment. This information aided the present writer in identifying the tenth abdominal segment in the nymph of *M. septendecim* (L.).

Kershaw and Muir (1922) were of the opinion that the male and female genital processes are homologous to each other. They maintain that the anal segment actually is composed of the fused tenth and eleventh segments; that the ninth abdominal sternite is absent in male Homoptera; and that the ventral claspers of the adult cicada, homologous with the third gonapophyses of the male nymph, belong "to the segment behind the eighth abdominal sternite."

The three pairs of female gonapophyses of the cicada nymph, stated as being "the same" as those of the *Cercopidae*, and illustrated with the last instar female nymph of *Philaenus leucophthalmus* (Linn.), agree in their position, origin, and homology with those of the last instar nymph of *M. septendecim* (L.) of Snodgrass (1933).

Myers (1928) described the metapleuron and the first two abdominal segments of the ultimate female nymph of *Melampsalta leptomera* Myers (Fig. 22, same as 1929: Fig. 71). These sclerites, their demarcations and their spiracles closely resemble those of the *M. septendecim* (L.) nymph in the present paper. The protrusile area labelled "ac" is much larger than *h* of *M. septendecim* (L.), and is said to be more swollen in the male nymph (which condition is not observed in *M. septendecim* (L.)).

A region labelled "a" (ventrad of "ac") is designated as the site where the adult male develops the "tymbal." By comparison with the same region of the adult male (Fig. 67: *M. sericea* (Walk.)) it is clear that "a" is the site of future "tympanum" or "mirror," and the label "tymbal" must have been a typographical error.

The "'pleural' spiracle covers" (apparently homologous with Heymon's *Tergitwülste*) which are present in most cicada nymphs are mentioned and figured (illustrated with *M. leptomera* Myers). Myers also summarized the dispute about the presence of abdominal pleura, citing Hansen (1902a, b) versus Heymon's (1899) and stating Comstock's (1920) and Imms' (1925) opinions.

Snodgrass (1933) showed a side view (Fig. 30D) of the junction of the thorax and the abdomen in the last-instar nymph of *M. septendecim* (L.) in which the various segments were labelled; but there was no mention of the areas designated as *tm* and *h* in the present paper, nor of the exact ventral and anterior limits of the first tergite. Fig. 30B of the same region in an adult female (which identified the positions of *tm* and *h*) was helpful to the present writer in her interpretations.

Two other figures showed the female terminalia in ventral



view. These beautiful figures were fully labelled and showed all the structure of the female terminalia except those that were hidden from view (ventral region of the ninth segment, dorsal aspect of the tenth, eleventh segments). In the accompanying text Snodgrass presented an original interpretation of the homologies of the genital parts of the female last-instar nymph, which is adopted by the present writer. She is, however, not clear whether Snodgrass meant the second gonapophyses to be a pair of separate structures. On the specimens studied in this paper these are represented by a single tube-like structure bearing a median line.

In Evans' (1941) figure 6 (which included the meso- and meta-pleura, the wing pads and abdominal segments one to four), his terminology agreed with Snodgrass' (1927b, 1933), except he applied the term "meron" (homologous with the *meron* in the present paper) to an area not labelled by Snodgrass. This figure does not show any demarcation between the first and second segments, but only a protrusile area below the second abdominal spiracle and a curved line above the first abdominal spiracle.

Fennah (1945b), in disagreement with Kershaw and Muir's (1922) interpretation of the origin of the homopterous genitalia, stated that the ninth abdominal sternite is present in the male nymph and that the genital processes "emerge in the conjunctival membrane between the ninth and tenth segments." In his figure of the fourth instar male nymph of *Peregrinus maidis* (Ashm.) the ninth segment is a wide ring and the tenth segment is terminal.

The three pairs of gonapophyses ("first, second and third valvulae") of the fifth instar female nymph of *Peregrinus maidis* (Ashm.) are very similar in position and origin to those of the female last-instar nymph of *M. septendecim* (L.) shown by Snodgrass, (1933).

Kramer (1950) figured the ventral claspers of adult male *M. septendecim* (L.) as belonging to the tenth segment, and thus confirmed Crampton's (1922) view.

#### TAXONOMIC STATUS

Since the completion of the present study several papers by Moore and Alexander have shown that the taxonomic situation with regard to the Periodical Cicada is more complex than had previously been realized. The present morphological study attempted to restrict its material to the seventeen year form which is now thought to be composite. The nature of the criteria used

to establish the several species considered formerly to be *M. septendecim* indicates that the morphological material presented in the present paper will be almost completely applicable to the entire "Complex." In addition the fluid nature of the current taxonomic situation and the impossibility of ascertaining from dead, dissected material whether more than one of the Moore and Alexander units are involved has led the author to retain the use of the name *septendecim* in the traditional sense in the entire discussion.

#### GENERAL APPEARANCE

The last-instar nymph of *M. septendecim* (L.) has a body length of 23 mm. to 28.5 mm. in the male, and 26 mm. to 30 mm. in the female. It is fairly stout, with red eyes, seven-segmented antennae, and a six-toothed comb on each fore-femur. The general body color is brown in preserved and live specimens, with two large black patches on the pronotum. (For measurements of body parts, see appended table.)

#### HEAD

Figs. 1-21.

The head of the last-instar nymph of *M. septendecim* (L.) is opisthognathous. It is roughly conical in shape, with the high, bulging postclypeus protruding in front, the enormous compound eyes protruding at the dorso-lateral angles near the posterior margin, and the antennae, just anterior to the latter. The labium, enclosing the mouth stylets, hangs ventrally from the cervical membrane. The flat, triangular dorsal surface of the head has a width (across the eyes) roughly one and one half times its length (from posterior margin of head to tip of postclypeus). The areas posterior to the maxillary suture and ventral to the eyes are of weakly sclerotized membrane; the rest of the head is well sclerotized.

In this paper, Snodgrass' recent terminology (1935, 1944, 1950) has been adopted tentatively, for the most part.

#### SUTURES OF THE CRANIUM OR HEAD CAPSULE

Figs. 1-3; 5, 8, 12.

The sutures of the cranium of the last-instar nymph of *M.*

*septendecim* (L.) are: the *epicranial*, *epistomal*, *clypeal*, *genal* (Snodgrass, 1927a), and *maxillary* (Muir, 1926) *sutures*, as well as a *labial fold* ("labial suture" of Muir, 1926).

The *Epicranial Suture* is of the usual Y-shape. This suture is often represented by a narrow cleft in the specimens collected above ground just before the last molt (Fig. 1), and is represented by a pale line in the cuticle in the last-instar nymph of younger age.

The *coronal suture* (crs) (Figs. 1, 6) runs along the median dorsal line of the head. It forks into the frontal sutures at a point just posterior to the site of the imaginal median ocellus. (Although ocelli are not present on the last-instar nymph, the two lateral and one median ocellus (oc) of the imago can be seen through the translucent nymphal skin.)

The *frontal sutures* (fs) (Figs. 1, 2, 5), being the anterior portions of the line of ecdysis, may end behind or below the antennal sockets. In the exuviae the split may extend anteriorly to meet the epistomal suture.

The **EPISTOMAL SUTURE** (es) (Figs. 1-3, 5) is an unbroken arch across the head capsule and demarks the postclypeus posteriorly from the frons and the lora. The median portion is merely an impressed line. The internal expression of each lateral portion is a crescent-shaped apodeme (Figs. 11, 18, 19: esap), starting a little distance above the antennal socket, widening and then tapering to a low ridge at the ventral margin of the post-clypeus. Dorsal to this point, the *epistomal apodeme* can be separated into a clypeal and a loral lamina. But at this point the apodeme, reduced to a low ridge, fuses with the thickened rim of the trough-shaped floor of the mouth pump, extending a short distance into the latter as a thickened area (Fig. 21). No such wide area of apodemal tissue occurs between the pump and the head capsule, as there is in the adult.

The **CLYPEAL SUTURE** (cs) (Figs. 2, 3, 5, 21) is an impressed arch that at each end, meets the epistomal suture at right angles. Internally it has a thickening at each end which is fused onto the rim of the pump floor at a point just anterior to the junction of the latter with the epistomal ridge.

The **GENAL SUTURE** (gs) (Figs. 2, 3, 5, 12) is a deep groove with its lower portion parallel to and caudad of the epistomal suture on each side of the head; its upper portion, extending cephalad, meets the latter at a very acute angle just antero-dorsad of the antennal socket. This suture is formed by the apposition of a posterior extension of the lorum and an anterior extension of the maxillary

plate. These two laminae are fused along their mesal portions to form an internal apodeme (Fig. 12: gap) about half the width of the lorum. A thickened band (Fig. 12: band) extends all the way along the inner edge of this apodeme and is continuous with the lateral arm of the funnel-shaped base of the mandibular stylet (Fig. 12: mdsb) which is also joined to the postero-ventral angle of the lorum. The posterior lamina of the genal apodeme is adherent to the base of the mandibular stylet (Fig. 14). and is continuous with the anterior and mesal surfaces of the ventral lobe, or stipes (b), of the maxillary plate.

The MAXILLARY "SUTURE" (ms) (Figs. 2, 6, 8) has its lower portion parallel to and caudad of the genal suture and its upper portion bends cephalad just ventrad of the eye where it ends without meeting the genal suture. Its upper one-third is but a faint, impressed line. Its middle one-third is a shallow groove formed at the junction of the weakly sclerotized membrane and the posterior edge of the maxillary plate. Its ventral one-third is a slit which terminates as it meets the "keel" of the hypopharyngeal wing-plate near the posterior margin of the maxillary stipes (b). The two lips of this slit are not fused (either in the nymph or in the adult); the weakly sclerotized membrane mentioned above is joined to the posterior lip, then extends underneath the stipes (Fig. 7: lbmb) to join the dorsal margin of the median lobe of the hypopharynx (Fig. 4: p). This slit (Fig. 8: slms) marks the invagination which forms the *maxillary apodeme* (Fig. 8: mxap). This apodeme consists of two laminae which can be separated without KOH treatment: the posterior lamina is joined to the "keel" of the hypopharyngeal wing-plate; the anterior one is continuous with the membrane of the stylet pouch, discussed under a separate paragraph.

The LABIAL FOLD (ls) (Figs. 2, 5), a crease of fairly constant position, extends ventrad from a point near the posterior margin of the eye, and has two ventral branches; one extending caudad of the labium demarks the labial membrane from the prosternum, the other extending cephalad of the labium disappears as it approaches the maxillary suture. The dorsal portion of the labial fold is marked by an invagination of constant position labelled *d* in this paper (homologous with the structure labelled *d* by Snodgrass, 1927a, and *dl* by Muir, 1926). In the last-instar nymphs studied in this paper, this structure *d* lies directly over an imaginal structure, which is a composite of an unidentified membranous invagination, and an occipital condyle connected with the posterior tentorial arm (Figs. 9, 10).

## VOLUME XXXIX

### AREAS OF THE HEAD CAPSULE

Figs. 1-8, 12, 18-20.

The principal areas of the cranium are: *vertex*, *frons*, *postclypeus*, *anteclypeus*, a pair of *lora* and a pair of *maxillary plates*.

The VERTEX (vx) or EPICRANIUM (Figs. 1, 2, 6) comprises the dorsal region of the head capsule on both sides of the coronal suture including the sites of the imaginal lateral ocelli and the ovoid compound eyes of the nymph. It is demarked anteriorly by the frontal sutures, laterally by the upper portions of the maxillary sutures, and posteriorly by the cervical membrane.

The COMPOUND EYES (e) (Figs. 1-3, 5, 6) ovoid and very large, protrude hemispherically from the postero-lateral angles of the head. They are red in color in fresh specimens (Marlatt, 1907) and brown-black in preserved specimens.

The FRONS (fr) (Figs. 1, 2, 5) is a triangular sclerite delimited posteriorly by the frontal sutures, and anteriorly by the epistomal suture. It includes the regions around the antennal sockets and the site of the imaginal median ocellus.

The POSTCLYPEUS (pclp) (Figs. 1-3, 5), the anterior-most region of the head, is delimited posteriorly by the epistomal suture and ventrally by the clypeal suture. It is very large and cone-shaped, with nine or more rows of pale, long setae (s).

The ANTECLYPEUS (aclp) (Figs. 2-5, 19, 20), delimited dorsally by the clypeal suture, is about one-half as wide and one-half as high as the postclypeus. It is shaped like a half-open book, with the bound edge placed anteriorly, and with its posterior edges free. An "epipharyngeal" or inner surface is tightly apposed onto the median, conical lobe of the hypopharynx (Figs. 19, 20: acep; Fig. 18: mh) and the ventral lobes of the lora (Figs. 19, 20: acepl; Fig. 18: a,a) when the sclerites are held in their natural position. After treatment with KOH the clypeal and loral surfaces can be separated easily, showing that they are distinct structures (Figs. 5, 18, 20).

The LORUM (lr) (Figs. 2, 3, 5, 12, 18), delimited by the epistomal and genal sutures on each side of the head, is roughly rectangular in shape, narrowing dorsally. It is intimately connected with the hypopharynx. (see Hypopharynx). The lower, mesal portion of the lorum is apposed onto the "epipharyngeal" surface of the anteclypeus (Fig. 18: area mesal to dotted line).

The MAXILLARY PLATE (mxp) (Figs. 2, 5, 7, 8, 18), delimited by the maxillary suture and the labial fold, is a bow-shaped sclerite. The maxillary *stipes* (b) is the ventral lobe of this plate, which is sclerotized on its anterior, lateral and posterior surfaces. The

maxillary *galea* (*c*), a soft, slender projection, hangs from the ventral end of the stipes. The mesal surfaces of the stipes and galeae are continuous anteriorly with the sclerotized posterior lamina of the maxillary apodeme. When held in natural position, the stipes lies laterad of the median hypopharyngeal lobe (*mh*); the galea fills the space between the anteclypeus and the labium, and with its fellow holds the mouth stylets in place from their lateral sides just as they enter the labial groove.

The very weakly sclerotized area posterior to the maxillary suture (Figs. 2, 5, 6) soon merges into the cervical membrane (*cvmb*). The labium is hung from the membrane (*lbmb*) between the two ventral branches of the labial fold.

## TENTORIUM

## Figs. 9-11

As the last-instar nymphs studied in this paper were apparently collected just before the last molt, the imaginal structures can be seen immediately under the nymphal skin. However, the fact that the tentorial structures of these specimens are probably distinct from the imaginal tentorium is suggested by the fact that remnants of the nymphal tentorium are found in several of the exuviae studied by the writer.

The tentorium of the last-instar nymph is “ $\pi$ ” shaped, consisting of the corporotentorium and three pairs of arms.

The CORPOROTENTORIUM or BODY OF TENTORIUM (Fig. 11: *ct*) is the middle portion of a weakly sclerotized, deflexed bar, in the median posterior region of the head.

The POSTERIOR ARMS (Fig. 11: *pat*) are the lateral portions of this bar, each lying upon the short dorsal edge of the hypopharyngeal “wing” (*hw*) of the same side of the head. Its lateral end terminates on the tip of the latter, and in the vicinity of the invagination (*d*) of the labial fold. In nymphs, just before the final molt, this invagination (*d*) lies immediately over the imaginal structure which is a composite of an unidentified membranous invagination (Fig. 9: *ocmb*) and an apparent occipital condyle (Figs. 9, 10: *occ*). In adult specimens studied, this composite structure has a definite sclerotic connective (*con*) with the posterior tentorial arm (*pat*) and with the tip of the hypopharyngeal wing (*hw*). The author is unable to ascertain whether this complex structure is in any way related to the original posterior tentorial pit. But in the nymphs just before the final molt, there is no connection at all

between the posterior tentorial arm and the exoskeleton. Whether this is due to the fact that some internal cranial structures have lost their external connections just prior to the last molt is a question that can be answered only when some last-instar nymphs of a younger age are available for study.

The ANTERIOR ARMS (Fig. 11: aat), about 4 and one-half times as long as the posterior arms, are weakly sclerotized, fragile structures. Each arises at the junction of the corporotentorium with the posterior arm, and extending cephalad fuses onto the head capsule at a point on the genal apodeme just ventrad of the antennal base. No conspicuous external pit is found at this point.

The DORSAL ARMS (Fig. 11: dat), about  $\frac{3}{8}$  as long as the anterior arms, branch off from the latter near their distal ends. In nymphs just before their last molt, these dorsal arms are apparently attached to the imaginal cranium. But in one slightly younger nymph, these arms are very lightly attached to the vertex (of the nymphal cranium) at a point marked by an external depression anterolaterad of the site of the lateral ocellus. They can be identified by the antennal muscles attached to them.

#### HEAD APPENDAGES

Figs. 1-7, 12-21

The movable parts of the head are the following: *antennae*, *labrum*, a pair of *mandibular stylets*, a pair of *maxillary stylets*, *hypopharynx*, and *labium*.

The ANTENNAE (ant) (Fig. 13) are sub-filiform, tapering distally, and have the specific characteristic of being 7-segmented. The third and first segments are the longest. The second segment is slightly bent mesally, giving the antenna an elbowed appearance.

The LABRUM (lm) or upper lip, is a small, slender sclerite arising from the ventral edge of the inner surface of the anteclypeus and projecting forward from the latter at an angle (Figs. 2-5). A groove is present along its inner surface (Fig. 4).

The MANDIBULAR STYLETS (mds), comprising the whole of the embryonic mandibles (Snodgrass, 1938), are long, setiform structures each with a funnel-shaped *base* (Figs. 5, 12: mdsb). The base has two arms extending dorsally. The *protractoral*, or lateral, *arm* is continuous with the sclerotized band (Fig. 12: band) of the genal apodeme mentioned above. Thus the base is attached to the posteroventral angle of the lorum, while it lies mesad of the stipes (b). Snodgrass (personal communication), has pointed out that it is an unsolved problem how the nymph can move its mandibular

stylet while the protractor arm is thus attached. The *retractor*, or mesal, *arm* (rmds), which is two thirds as long as the funnel, projects dorsad into the head and ends in a tendon.

The MAXILLARY STYLETS (mxs), which are the *laciniae* of the embryonic maxillae (Snodgrass, 1938), resemble the mandibular stylets in structure but have more elongate bases (Figs. 5, 14, 16, 17: mxsb). The *retractor*, or anterolateral, *arm* (rmxs) is hog-ear shaped and shorter than the length of the funnel. A *lever* ( $lvr_2$ ) or sclerotized bar, that bears the protractor muscles, is connected by membrane with the posteromesal side of the stylet base, and has its ectal end fused onto the maxillary apodeme (mxap). The maxillary stylet base lies mesad and caudad of the mandibular base.

The HYPOPHARYNX consists of a *median lobe* (mh; p), the *floor* of the *sucking pump* (fpmp), and two lateral plates commonly called *hypopharyngeal wing-plates* (hw) by homopterists.

The *median lobe* (Figs. 4, 18, 21: mh, p) is funnel-shaped, open posteriorly; it encloses the salivary pump (syr) and has the opening of the salivary duct at its tip (Figs. 18, 21: syro). Upon its anterior wall is a thickened, spoon-shaped area bearing a groove (Fig. 18: fgr) to form a food meatus. Its posterior wall is thin and flat. According to Snodgrass (1938) the anterior wall is homologous with the *lingua* (mh) and the posterior wall is homologous with a pair of fused *sublingual plates* (p).

The two *hypopharyngeal wing-plates* (hw) are sail-shaped and strongly sclerotized. Each projects from the point, where its ventral tip is fused onto the lateral surface of the median lobe, dorsally into the head cavity at right angles with the sucking pump (fpmp). Each is joined to the posterior lamina of the maxillary apodeme along the keel-like projection (hwk) on its lateral margin.

The hypopharynx is connected with the lorum on each side in the following ways: The floor of the pump posterior to the mouth cleft is continuous with the lorum laterally (Fig. 18). A bridge-like structure (a) extends between the lower end of the lorum and the lateral surface of the median lobe (Figs. 5, 18). And a sheet of membrane (lrmb) extends from the posterior margin of the lorum to the posterior surface of the median lobe and the mesal margin of the hypopharyngeal wing (Figs. 4, 12, 15). According to Snodgrass (1938, 1944, 1950) the lora are morphologically part of the hypopharynx.

The SUCKING PUMP (pmp) (Figs. 7, 18-21), shaped like a covered trough, extends from the "epipharyngeal" surface of the



anteclypeus posterodorsad across the lower portion of the head cavity. Its *floor* (fpmp) is trough-shaped and strongly sclerotized, with a thickening along its median line.<sup>3</sup> Its *roof* (rpmp) is soft, deflexed, nesting in the concavity of the floor, and is fused onto the latter along its thickened rim. A row of tendons (tdd) for attachment of dilator muscles occurs along the median line of the roof. The pump leads into the small bulb-like pharynx (ph) posteriorly and into the functional mouth (mth) anteriorly.

The ACTUAL MOUTH (mthc) is the wide cleft visible on either side of the head, extending between the "epipharyngeal" surface of the anteclypeus and the anterior edge of the lorum and upward to the junction of the clypeal and epistomal sutures (Fig. 5: mthc). The cleft opens into the sucking pump through a slit across the full depth of the pump floor (Fig. 21: mc; Figs. 18, 20: mcl). This mouth cleft is never open when the above parts are held rigidly apposed in their normal positions, but can only be seen when these parts are treated with KOH.

The FUNCTIONAL MOUTH (mth) is the narrow tube formed by the closure of the "epipharyngeal" groove of the anteclypeus (Fig. 20: fgr) upon the hypopharyngeal groove (Fig. 18: fgr). This tube leads from the food channel in the maxillary stylets to the lumen of the sucking pump.

The LABIUM (lb) (Figs. 2, 3, 5, 6) is 3-segmented; the distal segment is the longest and has a slight immargination at its tip. A definite suture occurs on the posterior surface of the second segment, and a faint indication of one appears on the distal segment (Fig. 6). According to Crampton (1921) the three segments represent respectively the mentum, the fused labial palpigers, and the fused labial palpi. Along the anterior labial surface is a groove with a line of strong sclerotization at its bottom (Fig. 3: lbgr), the dorsal extension of which projects into the head cavity as a hard

<sup>3</sup> Muir (1926) stated that the floor of the pump in the last-instar nymph of *Melampsalta* sp. is membranous and separable from a sclerotic, supporting plate; he further states that an apodeme from the genal suture forms a support for the anterior portion of the pump floor, and an apodeme from the "frontal" (*epistomal*) suture forms the posterior support. The present writer was unable to find these features in the last-instar nymph of *M. septendecim* (L.). She does not know if this is due to specific differences or whether it is possible that adult and nymphal pump floors coexisting in the ultimate nymph might have been mistaken as two layers of the nymphal floor.

## ENTOMOLOGICA AMERICANA

rod (Fig. 6: rlbgr). The labium is suspended from the hypostomal membrane (lbmb).

The **STYLET POUCHES**, or "invaginations of the ventral head wall that contain the bases of the stylets" (Snodgrass, 1927a), are situated on each side of the head between the pump floor and the maxillary plate. Dorsally each pouch terminates at the dorsal margins of the stylet bases, which it encloses like fingers in a glove. Ventrally, each pouch can be conceived of as consisting of two walls: The mesal wall (Fig. 15) consists of the hypopharyngeal wing and a sheet of membrane (lrmb) that extends from the mesal margin of the hypopharyngeal wing and from the median lobe of the hypopharynx to the posteroventral margin of the lorum. The lateral wall (Fig. 14) consists of a sheet of membrane which is continuous with the posterior lamina of the genal apodeme (gapp), with the mesal surface of the stipes and galea, and with the anterior lamina of the maxillary apodeme (mxapa) and which is fused onto the dorsal margin of the hypopharyngeal wing. The stylet pouch is open ventrally, where the stylets extrude from the head.

The relationship of the mouthparts is as follows: At the point where the stylets issue from the head capsule they are held in place laterally and posteriorly by the maxillary stipes and galeae, and anteriorly by the epipharyngeal groove of the labrum. At the tip of the median hypopharyngeal lobe the maxillary stylets become interlocked to form the food channel and the salivary channel which are continuous respectively with the functional mouth and the opening of the salivary duct. The mandibular stylets are locked onto the maxillary stylets laterally. The four interlocked stylets then enter the labial groove and lie in it along their full length.

### CERVIX OR NECK

The cervix, a narrow, membranous region between head and prothorax, bears no sclerites.

### THORAX

Figs. 22-33.

### THORACIC TERGA

Figs. 22-29.

**PRONOTUM** ( $t_1$ ) — The prothoracic tergum is a single, rectangular plate, about twice as wide as long, its deflexed lateral margins

encroaching far down over the propleura. Along its mid-dorsal line is the line of ecdysis (ec) which extends the full length of the thoracic terga. Two pairs of sutures occur on the pronotum. The mesal pair (X, X), meeting on the ecdysial line near its midpoint, diverge to extend cephalo-laterad to the anterior margin of the pronotum. Each of the lateral pair (Y, Y) extends from a point about midway between the anterior and posterior margin of the pronotum to the anterior margin where it meets suture X. A small area of the pronotum here bends downward, and the joined sutures are continuous ventrally with the *pleural suture* (Fig. 23: ps). The internal ridges of the pronotal and propleural sutures are discussed later under PROPLEURON.

These sutures, X, X; Y, Y, correspond in their positions to the grooves on the pronotum of the adults of *Cicada tibicen* described by Taylor (1918) and hence to those of *Melampsalta cingulata* and *M. muta* discussed by Myers (1928). Taylor named PRESCUTUM (Figs. 22, 24, 25: pre?) the triangular area bounded by the mesal pair of sutures (X, X), SCUTUM (sc?) the area between these sutures and a straight posterior groove (not present in the nymph), and SCUTELLUM (sct?) the posterior strip. Myers, however, held the view that these "deep grooves are associated with muscle insertions" and "they are purely secondary structures having no connections with the typical wing-bearing segments." In support of his view, he referred to Crampton's (1918) statement in regard to *Dissosteira*: that the pronotal intralobes marked off by sulci are "purely secondary structures", having been "incorrectly designated as the 'prescutum', 'scutum' . . ." etc. Snodgrass (1935) expressed the same opinion in a general statement regarding the pronotal sutures of pterygote insects. In Kramer's (1950) study of the adult of *M. septendecim* (L.), the pronotum is shown undivided.

Crampton (1926) pointed out in reference to the thorax, that "the general character of the parts shown in Fig. 69 (*Cicada*) is extremely suggestive of the parts in the Orthopteron shown in Fig. 68 (*Tettix*), and it would appear that the pronotum may grow down over the pleuron in certain Hemiptera (Fig. 73) in a fashion remarkably like that occurring in the Orthoptera."

Further studies of related forms, as well as of earlier nymphal instars of *Magicicada septendecim* (L.) will be necessary before either Taylor's views or Myers' views can be applied to the last-instar nymph of this species.

MESONOTUM ( $t_2$ )—The mesothoracic tergum is a single undivided sclerite about one and a half times as long as the pronotum.

No sutures corresponding to those of the adult notum are present, but only a pair of dimple-like depressions for muscle attachments. On each side a *wing-case* (Figs. 22, 24: *wc*), whose dorsal wall is continuous with the mesonotum, extends caudad nearly to the posterior margin of the second abdominal tergite ( $ta_2$ ) and laterad to the level of the metathoracic meron. The ventral wall of the wing case arises in an oblique line, from the membranous area above the mesopleuron. The folds of the imaginal wings seen through the translucent nymphal skin are fairly constant in pattern.

**METANOTUM** ( $t_3$ )—The metathoracic tergum is an undivided sclerite about half as long as the pronotum, with no sutures, only a pair of dimple-like depressions for muscle attachments. The *wing-cases* (Fig. 24: *wc*) are partially hidden under those of the mesothorax and extend to the posterior margin of the second abdominal tergite ( $ta_2$ ).

The adjacent thoracic terga are joined to each other by a narrow strip of secondary-intersegmental membrane. A thin *flange* (*fl*) is present along the posterior margin of each tergum, which may serve to protect the soft membrane when the tergal sclerites are pulled apart as the insect bends.

#### THORACIC PLEURA

Figs. 23–31.

In the nymph each pleuron forms a complete ring around the coxal cavity. This condition suggests, according to Snodgrass (1927b), "that each pleuron represents a basal or subcoxal segment of a leg." The smooth, sclerotized upper portion of the pleuron is divided by a *pleural suture* into an *episternum* and an *epimeron* homologous with those of the adult; the lower portion is a wrinkled, poorly sclerotized band which persists in the adult "as chitinous ridges on edges of sterna" (Snodgrass, 1927b). Three regions are designated for this lower portion of the pleural ring: the *pre-coxale* or *precoxal bridge*, the *infracoxal arc*, and the *post-coxale* or *postcoxal bridge* (Snodgrass, 1935); these are located respectively: cephalad, mesad and caudad of the coxal cavity, being undemarked from each other and recognizable only by their relative positions. Adjacent pleura are delimited from each other by a suture between their upper sclerotized portions and by a fold between their lower poorly sclerotized areas (Fig. 30).

**PROPLEURON** (Figs. 23–29)—The upper parts of the prothoracic pleuron are much reduced.

Due to the lack of available information concerning the homologies of the propleuron of this species, only a tentative discussion is given here. The coining of new terms is deliberately avoided in order not to create unnecessary synonyms for future workers to contend with.

The internal ridges of the pronotum and propleuron (Figs. 22, 23, 26-29), a brief mention of which it is hoped might furnish points of interest to future workers, are as follows: The pronotal suture  $X$  has an internal ridge  $XR$  which extends from a point about midway on the ecdysial cleft to the anterior margin of the pronotum, which margin it follows very closely for a short distance before joining the ridge  $YR$ .  $YR$ , the internal ridge of suture  $Y$ , extends from a point about half way between the anterior and posterior edges of the pronotum, obliquely to the anterior margin of the pronotum where it joins  $XR$ . The bases of these crescent-shaped ridges unite first, forming externally the suture  $XY$ ; further on, their free edges unite. A tendon (td) almost as long as  $YR$  marks this latter junction. The pronotum bends ventrad in the vicinity of  $XY$ .

$Ep_1R$  and  $Em_1R$ , the short internal ridges of the sutures  $Ep_1S$  and  $Em_1S$ , extend respectively mesad and laterad from the tendon-marked junction.  $Ep_1R$  and  $Ep_1S$  probably demarked the dorsal margin of the episternum ( $ep_1$ ) which, according to Taylor (1918), is homologous with the proepisternum of *Cicada tibicen*. No information is available concerning the homologies of  $Em_1R$  and  $Em_1S$ ; they may be either the dorsal demarcation of the anterior portion of the epimeron ( $em_1$ ) or purely secondary structures.

The PLEURAL RIDGE (Figs. 26, 27, 29:  $pr_1$ ) is interpreted here as the short but very high ridge ventrad of the junction of  $Ep_1R$ . Its ventral end protrudes within the body beyond the termination of the pleural suture and has a double ball-and-socket structure which fits onto its counterpart on the basicosta at the anterior apex of the meron (Fig. 28). This enlarged ventral end of the ridge is apparently the *pleural coxal process* ( $pcp_1$ ).

The PLEURAL SUTURE (Fig. 23:  $ps_1$ ), the external suture of the pleural ridge, is very short, situated anterior to the coxal cavity. It lies at the bottom of a deep groove formed by the infolding of the episternum and epimeron in its vicinity. This suture is interpreted here as the pleural suture because of the position of the pleural coxal process mentioned above. It also corresponds in position to the pleural suture on the adults of *M. septendecim* (L.) (Kramer, 1950) and of *Cicada tibicen* (Taylor, 1918).

The EPISTERNUM ( $ep_1$ ) is probably the tiny triangular sclerite immediately mesal to the pleural suture, its probable dorsal demarcation being the suture  $Ep_1S$ . This interpretation is in agreement with Taylor (1918).

The EPIMERON ( $em_1, em'_1$ ) appears to be cut into two pieces by the downward encroachment of the pronotum. Snodgrass (1927b) shows these as continuous with each other ventrad of the pronotal edge, in a figure illustrating the subcoxal origin of the pleuron (in which the specific parts of the propleuron are unlabelled). On the specimens examined, only a narrow strip of very weakly, if at all, sclerotized membrane connects these two areas (Figs. 23, 24). The small, triangular anterior piece ( $em_1$ ) whose probable dorsal demarcation is the suture  $Em_1S$ , is interpreted as the anterior portion of the epimeron as it lies immediately laterad of the pleural suture (Figs. 23, 27, 29). The larger posterior piece (Figs. 24, 25:  $em'_1$ ), bounded anteriorly by the lateral margin of the pronotum, and the membrane of the coxal cavity, is interpreted as the posterior portion of the epimeron, since it lies immediately cephalad of the *peritreme* ( $pm_1$ ) of the *mesothoracic spiracle* ( $sp_2$ ) (See Myers, 1928).

The TROCHANTIN ( $tn_1$ ) is in its normal position: its lower end articulating with the basicoxite, its upper end joined onto the episternum near the pleural suture (Fig. 23).

The PRECOXALE ( $pcx_1$ ) is a narrow, poorly sclerotized strip "extending downward from the episternum anterior to the coxa and the trochantin" (Snodgrass, 1935) and separated from the cervical membrane by a deep fold.

The POSTCOXALE ( $poc_1$ ) is a wider, poorly sclerotized band extending ventrad from the posterior portion of the epimeron ( $em'_1$ ).

The INFRACOXAL ARC ( $ica_1$ ) is a wide band of poorly sclerotized area lying mesad of the coxal cavity and separated from the sternum by a deep fold (Figs. 30, 31).

MESOPLEURON (Figs. 24, 25, 30, 31) The sclerites of the mesothoracic pleuron are considerably larger than those of the propleuron and are quite different in shape.

A PLEURAL SUTURE ( $ps_2$ ) extends obliquely from the pleural coxal articulation to a point near the base of the wing case, dividing the pleuron into two parts, the episternum and the epimeron.

The EPISTERNUM ( $ep_2$ ) is a roughly pear-shaped sclerite lying immediately anterior to the pleural suture. It is undivided.

The EPIMERON ( $em_2$ ) lies immediately posterior to the pleural suture, and is almost twice as large as the episternum. A faint

suture,  $z$ , represented internally by a fold extends posteriorly from the pleural suture half way across the epimeron. This suture  $z$  is possibly homologous with the suture between the anepisternum and katepisternum in the adults of various species (Taylor, 1918; Crampton and Hasey, 1915; Myers, 1928; Kramer, 1950; and other authors).

An area of wrinkled, weakly sclerotized membrane (Fig. 25:  $amb_2$ ) lies dorsad of the epimeron under the wing case, in the region in which the alar sclerites of the adult develop.

The TROCHANTIN ( $tn_2$ ) is considerably broader than the prothoracic one, and its entire dorsal margin is joined to the episternum, its lower end articulating with the basicoxite in the usual manner.

The PRECOXALE ( $pcx_2$ ) is broader than the prothoracic one. The INFRACOXAL ARC ( $ica_2$ ) and the POSTCOXALE ( $poc_2$ ) are similar to those of the prothorax.

METAPLEURON (Figs. 25, 30, 31). The metathoracic pleuron is very similar to the mesopleuron, except for its slightly larger size and the absence of suture  $z$ .

## THORACIC STERNA

## Figs. 30-33

The thoracic sterna are poorly sclerotized areas and are not divided into sclerites. They are demarked from the adjacent, protrusile subcoxal rings by folds of more or less constant position. The sternal parts are named here according to Snodgrass 1927b).

PROSTERNUM ( $st_1$ )—The prothoracic sternum is a protrusile, roughly rectangular-shaped, undivided area between the prothoracic infracoxal arcs ( $ica_1, ica_1$ ) bounded anteriorly by the cervical membrane, and demarked posteriorly from the mesothoracic sternum by a shallow fold. Internally it bears a pair of *furcae* (Fig. 31:  $f_1$ ) on its posterior portion: without visible external pits.

MESOSTERNUM ( $st_2$ )—The mesothoracic sternum is an undivided, roughly triangular area with a long posterior region and it is larger than the prosternum. It is bounded laterally by the posterior portions of the prothoracic infracoxal arcs ( $ica_1, ica_1$ ), the mesothoracic precoxales ( $pcx_2, pcx_2$ ) and infracoxal arcs ( $ica_2, ica_2$ ). A central, ellipse-shaped area is protrusile and slightly more sclerotized than the surrounding, recessed area which bears many folds or wrinkles which allow flexibility. In the posterior, recessed region a pair of furcate *furcae* is present internally (Figs. 31, 32:  $f_2$ ): their position is marked externally by a transverse *furcal pit* Fig. 30, ( $fp_2$ ).

## ENTOMOLOGICA AMERICANA

**METASTERNUM** ( $st_3$ )—The metathoracic sternum is an undivided, kite-shaped area with a long posterior end, and it is about the same size as the mesosternum. It is bounded laterally by the mesothoracic postcoxales ( $poc_2$ ,  $poc_2$ ), the metathoracic precoxales ( $pcx_3$ ,  $pcx_3$ ) and the anterior portions of infracoxal arcs ( $ica_3$ ,  $ica_3$ ). Posteriorly it is adjacent to the *first abdominal sternite* ( $sa_1$ ) which is wedged between the posterior portions of the metathoracic pleural rings. A central ellipse-shaped area resembles that of the mesosternum mentioned above. A single median bifurcate *furca* is present internally in the posterior, recessed region (Figs. 31, 33:  $f_3$ ): its position is marked externally by a longitudinally elongate *furcal pit* Fig. 30, ( $fp_3$ ).

### LEGS

#### Figs. 34–40

The mesothoracic and metathoracic legs are not highly specialized, but the prothoracic legs are greatly developed and specialized in conjunction with the fossorial habits of the insect.

Eight surfaces of the leg are generally easily recognized: *dorsal*, *postero-dorsal*, *posterior*, *postero-ventral*, *ventral*, *antero-ventral*, *anterior*, and *antero-dorsal*. In cicadas, however, the great amount of specialization in structure and position in the prothoracic legs may lead to confusion as to homologies of leg surfaces. The above terminology shall therefore be discussed and concisely defined before proceeding further.

Since the articulatory points are perhaps as fundamental and as conservative as any leg structures, they might well serve as the primary landmarks. According to Snodgrass (1935): “the coxo-trochanteral hinge is always dicondylic with an anteroposterior axis”; the trochantero-femoral articulations if present, are “usually dorsal and ventral”; the femoro-tibial articulations are anterior and posterior. Grimshaw (1905) explains that “the *ventral* surfaces of the femur and tibia are those which would come into apposition if the leg were entirely closed.” On the coxa, the dorsal surface is that which is continuous with the dorsal surface of the femur and which offers a full, surface view of the pleuro-coxal articulation. The prearticulate portion of the basicoxite is situated on the dorsal and anterior surfaces of all the legs. On the tarsus the ventral surface is that on which the pretarsal unguitactor is situated. Those surfaces which Marlatt (1907) labelled as the “inner face” and “outer face” of the fore-leg of the cicada nymph are, therefore, the anterior and posterior surfaces respectively.



PROTHORACIC LEG (Figs. 34–38)—The COXA or basal leg segment is long and subcylindrical. Setae occur on the coxa in a band along the posterior surface, in a wider band on the anterodorsal surface, in a row along its distal margin, and all over its ventral surface. A narrow *basicoxite* (bcx) (Snodgrass, 1935) is marked off by a *basicostal* suture (bes) which suture is confluent with the coxal margin on the ventral side. The *meron* (me) or post-articulate part of the basicoxite is not enlarged. Both a pleural and a trochantinal articulation are present (Figs. 23, 28). The well developed coxal corium, widest on the posterior side, allows considerable freedom of movement in abduction and adduction. The longer axis of the *coxal cavity* (Fig. 30: CC<sub>1</sub>) is at an acute angle to the insect's mid-plane. The bases of the coxae are not contiguous.

The TROCHANTER (tr) is horn-shaped. Scattered setae are densest along the ventral surface. Its broad proximal end is articulated to the coxa by an anterior and a posterior point each consisting of a curved process interlocking with a similar one from the coxa. Movement through more than 90 degrees is allowed on this hinge due to the deeply emarginate dorsal rim of the coxa and the overlapping of the ventral coxal rim over the trochanter. Its dorsal surface being but a narrow strip, the trochanter is joined onto the femur in an extremely oblique fashion. A dorso-ventral hinge consisting of a dorsal condyle and a ventral point of apposition, allows slight movement of the femur in a plane perpendicular to that of the trochanter.

The FEMUR (fe). Because Myers (1929) found taxonomic characters in the armature of the prothoracic femur that served to distinguish all the known species of cicada nymphs in New Zealand, and because Marlatt (1907) recognized specific characters in this armature in the nymph of *M. septendecim* (L.), the femur will be discussed in detail. This largest segment of the fore-leg is nearly as wide as long and compressedly flattened. The armature on its ventral side consists of the following: (1) a comb whose base is about two-fifths the length of the ventral femoral margin and which has six teeth of gradually decreasing length, the distal one being the shortest and widest; (2) a spur midway on the ventral femoral margin which is about twice as wide at its base as the approximating comb-tooth and whose distal margin forms about a sixty-degree angle with the latter; (3) a proximal bifid spur, about three times as long and twice as wide at its base as the middle spur. The ventral margin between the two spurs (which is nearly a straight line) is

slightly shorter than the basal width of the large spur. The specimens studied were collected after the last-instar nymphs had emerged from the ground, therefore the tips of the comb-teeth and spurs have been worn off. Setae occur in two irregular rows near the mid-lines of the anterior and posterior surfaces, in two rows along the dorsal surface, in two rows along the proximal surface of the large spur, and are irregularly scattered between the spurs.

The TIBIA (tb) is scythe-shaped and compressedly flattened, nearly as long (including spur) as the femur and about one fifth as wide as long. Its distal end beyond the tarsal articulation is produced into a bifid spur. Three notches are present on its thin ventral edge. Setae occur in a row along its antero-dorsal surface. It is articulated to the femur by a dicondylic hinge consisting of an anterior and a posterior condyle, which allows the tibia to move in a range of more than 90 degrees, with its flexor surface against that of the femur in a scissors-like fashion.

The BASITARSUS (bt) is a ring-like segment, widest on its ventral side. Although it is not joined to the tibia by definite articulatory points, the extent of the articular corium is such that movement is restricted nearly to one plane. By motion at the joint the tarsus may be laid back against the anterior surface of the tibia, or may be extended beyond the tibial spurs. In the last-instar nymph the tarsus is held at the former position until the insect emerges from the soil (Marlatt, 1907; Myers, 1929).

The DISTITARSUS (dt), the second and distal segment of the tarsus, is cylindrical and nearly as long as the distance between tibial joints. It is closely joined to the basitarsus.

The PRETARSUS (pt) (Figs. 36-38), consists of two subequal claws or *ungues* (un) fused at their bases (ub). A subrectangular *unguitractor* consisting of a wide distal lobe (utd) and a narrow basal lobe (utb), both ornamented with oval callosities, is connected by membrane-like tissue (utm) with the notched ventro-basal region of the fused claws. On its proximal end is attached an *unguitractoral tendon* (utt).

MESOTHORACIC LEG (Fig. 39)—The COXA, considerably shorter than that of the prothorax, is longest on its dorsal side, much shorter ventrally, and joined obliquely onto the coxal cavity. It is ovoid in cross section, being most curved on its ventral side. Setae occur on the coxa in a broad band between the trochantinal and trochanteral articulations and all over the ventral surface. Dorsally, a narrow *basicoxite* (bcx) with a slightly enlarged *meron* (me) is marked off by a *basicostal suture* (bcs). A pleural and a trochan-

tinal articulation allow abduction and adduction of the coxa. The longer axis of the *coxal cavity* (Fig. 30:  $cc_2$ ) is almost at a right angle to the insect's mid-plane. The bases of the coxae are closer to each other than are the prothoracic ones, but are not contiguous.

The TROCHANTER (tr) is roughly boat-shaped, and shorter than that of the prothorax. Setae occur in several irregular rows over the upper posterior surface and the ventral surface, and are scattered all over the anterior surface. Its articulations with the adjacent segments and its range of movement are similar to those of the prothorax.

The FEMUR (fe) is a roughly rectangular, compressedly flattened segment, about 3 and one-half times as long as wide. Setae are distributed as follows: two bands of several rows each bordering the mid-line of the anterior surface, the ventral band being spine-like, short, and stiff; several irregular rows along the mid-line of the posterior surface; some on the dorsal surface. The longest setae are on the postero-ventral and antero-ventral surfaces.

The TIBIA (tb) is cylindrical and approximately 8 times as long as wide. Three spurs are borne on the anterior side of the distal margin, the dorsal-most spur being the stoutest. Spine-like setae occur in one or two irregular rows along the mid-line of the posterior surface. Long setae occur in several irregular rows over the tibia, the ventral and dorsal ones being longest and most closely spaced. The tibia is articulated with the femur by a dicondylic hinge which allows movement through almost a semi-circle.

The BASITARSUS (bt) is ring-like, its ventral side being twice as long as its dorsal side. It is articulated to the tibia by membrane and can move in somewhat less than a semi-circle.

The DISTITARSUS (dt) is long and cylindrical and closely joined to the basitarsus. Numerous, scattered setae are sparsest on its postero-ventral and antero-ventral surfaces.

The PRETARSUS (pt) resembles that of the prothoracic leg except that it has one seta on the dorsal surface, and two setae on the ventral surface of the fused bases of the claws.

METATHORACIC LEG (Fig. 40)—The hind leg resembles the middle leg in all respects except the following. The longer axis of the *coxal cavity* of the hind leg (Fig. 30:  $cc_3$ ) lies at a right angle to the insect's mid-plane, and the coxal bases, though not contiguous, are closer together. The femur (fe), approximately four times as long as wide, and the tibia (tb), approximately nine times as long as wide, are slightly longer. The setae on the ventral surface of the tibia are slightly longer and denser; the spine-like setae are slightly

## ENTOMOLOGICA AMERICANA

stouter on the femur, and are absent on the tibia. Several spines of the imaginal tibia can be seen through the nymphal skin on the dorsal surface and along the distal margin of the tibia.

### ABDOMEN

Figs. 41-48.

The abdomen of the last-instar nymph of *M. septendecim* (L.) is broadly joined onto the thorax and consists of eleven segments in both sexes. The abdominal parts are less strongly sclerotized than the thoracic terga but more so than the thoracic sterna.

### PREGENITAL ABDOMINAL SEGMENTS

Figs. 41, 42.

In the female the pregenital segments are seven in number. Each segment consists of a tergite and a sternite, which sclerites are transversely rectangular. A *flange* (fl) which covers the intersegmental membrane is present along the posterior edge of each of the first six tergites. The abdominal spiracles are oval, non-operculate and much smaller than the thoracic ones.

The main part of the first tergite ( $ta_1$ ), as demarked by the extent of the flange, does not extend as far laterally as the succeeding tergites. Lateral to the main part of the first tergite is a clear, trapezoidal, raised area (tm) which corresponds to a similar area in the male, discussed later.

The spiracles ( $spa_1$ ) of the first abdominal segment are larger than the succeeding ones and lie in the lateral membranous areas on either side of the body near the posterior margin of the metapimeron (Figs. 25, 41, 42). Their positions indicate the anterior limit of the lateral portions of the first abdominal tergite while the posterior limit is partially demarked by a groove superposing upon its imaginal counterpart.

The second tergite ( $ta_2$ ), slightly shorter than the succeeding tergites, bears on each of its lateral ends a hemispherical protrusion (h) underneath which lies the auditory capsule of the imago. Myers (1928) stated that these auditory capsules on *Melampsalta* are located on the "ventro-lateral portion of the second abdominal tergite (paratergite, Vogel)". Snodgrass (1933) wrote that those on adult *Magacicada septendecim* are "located at the ventral lateral angles of the second segment where the tergum and the sternum are confluent," and again referred to them as being borne on "the

posterior sclerite of the second sternum". On the newly molted imagos of this species studied here, a distinct line marking a high internal ridge cuts across the segment just dorso-laterad of the auditory capsule, and a similar but smaller ridge extends just cephalad of the capsule. (No such ridges are present on the succeeding segments.) On the mature nymphs, the protrusions are located at the level of the terga of the succeeding segments but are surrounded by membranous areas bearing no mark to delimit them from the second tergite or sternite.

The second pair of abdominal spiracles ( $spa_2$ ) lies transversely in a membranous area antero-mesad of the hemispherical protrusions mentioned above (Figs. 41, 42).

The third to seventh tergites ( $ta_3$  to  $ta_7$ ), several times as long as the sternites, are strongly arched, while the sternites are entirely ventral in position. The third and fourth tergites are the longest and the seventh tergite is the widest (Figs. 41, 42). At each lateral end of each tergite an area is marked off by a line of indentation: this area is largest on the third tergite and progressively smaller posteriorly. Heymen (1898) named these areas *Tergitwülste* stating that they appear to be formed partly of paratergite and partly of tergite, and that, present on the embryo, they persist through the nymphal to the adult stage. Hansen (1902 a & b) wrote of a sclerotized pleural region on the abdomen of adult cicadas but his view concerning this homology has not been confirmed by other authors (see Myers, 1928). The term *Tergitwülste* (tw) is adopted here merely to denote an otherwise nameless area, as the present writer is unable to confirm or dispute the various views.

The first sternite ( $sa_1$ ) is a triangular area wedged between the metathoracic postcoxales ( $poc_3$ ), demarked anteriorly by the metathoracic furcal pit ( $fp_3$ ) and posteriorly by a series of creases of constant position.

The second sternite ( $sa_2$ ) is as long as the succeeding ones and its antero-lateral regions are protrusile (Fig. 41).

The third to seventh sternites ( $sa_3$  to  $sa_7$ ) are approximately as wide as their corresponding tergites and lie directly opposite the latter. The fourth and fifth sternites are the longest (Fig. 41). On each lateral end of each sternite is a wrinkled, very poorly sclerotized area, continuous with the intersegmental membrane between the tergites.

The third to seventh pair of abdominal spiracles ( $spa_3$  to  $spa_7$ ) are ventral in position. They are small, oval openings lying ob-

liquely to the ventral median line (at progressively lesser angles posteriorly), near the anterior margin of the wrinkled area (Fig. 41) mentioned in the above paragraph.

The MALE pregenital segments are eight in number. They are similar to those of the female except that the male abdomen is smaller, and that the area marked (tm) on the first tergite is slightly larger. Immediately underneath the latter the striated tymbal of the adult can be seen through the translucent nymphal skin. Although Myers (1928) stated that the protrusion (h), enclosing the auditory capsule, is more swollen on the male than on the female nymphs, the present writer is unable to find any obvious sexual difference in the size of these organs.

#### MALE TERMINALIA

Figs. 43, 44, 47, 48.

The male terminalia includes the ninth, tenth, and eleventh abdominal segments. Genital processes are absent. The shovel-shaped ninth tergite ( $ta_9$ ) covers the dorsal portions of the tenth and eleventh segments as well as the anus (Figs. 43, 47, 48). Behind the unmodified eighth sternite ( $sa_8$ ) which lies over its imaginal counterpart, there is a narrow region including two pale, bulging and poorly sclerotized antero-lateral areas, and a bow-shaped, strongly sclerotized median posterior area bearing a mid-ventral suture (Figs. 43, 44). This region lies directly opposite the anterior portion of the ninth tergite, and represents at least in part the ninth sternite ( $sa_9$ ).<sup>4</sup>

The tenth segment ( $a_{10}$ ) is an undivided annulus, with a wide, glabrous, strongly sclerotized ventral portion, which forms a bulging cap over the imaginal ventral claspers (Crampton, 1922b, Kramer, 1950) of the tenth segment,<sup>5</sup> and a very poorly sclerotized mid-

<sup>4</sup> Gustafson's (1950) interpretation of abdominal sterna enlarges Snodgrass' (1935) idea.

<sup>5</sup> Brittain (1922) states, "the ninth tergite . . . roofs over the tenth tergite which bears a pair of hooked processes (surgonopods, Crampton 1922) and conceals the small ninth sternite . . . the hooked claspers which in this family are not parameres but processes of the tergum, probably homologous with the small blunt knobs on the corresponding tergum of *Ceresa*. It is interesting to note that in *Philaenus* there are a pair of hooked claspers homologous with and resembling in appearance those of the male Cicadidae, though this insect also possesses true parameres."

dorsal region (Figs. 43, 47, 48).

The eleventh or terminal segment ( $a_{11}$ ) of the abdomen is an undivided cap-shaped area, strongly sclerotized ventrally and poorly sclerotized posteriorly. The *anus* (*an*) is situated at the center of its posterior surface (Fig. 48).

FEMALE TERMINALIA  
Figs. 41, 42, 45, 46.

The female terminalia involves the eighth, ninth, tenth, and eleventh segments. The eighth tergite ( $ta_8$ ) though smaller than the preceding ones is unmodified. The ninth tergite ( $ta_9$ ), similar to that of the male, covers the dorsal regions of the tenth and eleventh segments and the anus (Figs. 41, 42).

According to Snodgrass (1933), the true eighth sternite ( $sa_8$ ) is a small spindle-shaped area immediately posterior to the seventh sternite. On this the gonopore (*gp*) is situated. The "*limb base plate*" of the *first gonopods* (Figs. 41, 45:  $lb_8$ ) is a smooth, incompletely divided plate lying posterior to the eighth sternite, and is homologous with the first valvifers of the adult. Lateral to this plate, on each side is a wrinkled area. The eighth pair of abdominal spiracles ( $spa_8$ ) lies almost lengthwise, near the anterior margins of these wrinkled areas. The *first gonapophyses* ( $gh_1$ ) are a pair of processes projecting posteriorly from the limb base plate and are homologous with the first valvulae of the adult; the tips of the latter are ensheathed by the nymphal gonapophyses.<sup>6</sup>

The *second gonopods* (Figs. 41, 42, 45, 46), belonging to the ninth segment and lying underneath the first gonapophyses, are slightly wider than the latter and are homologous with the second valvifers and third valvulae of the adult. "The true ventral region of the ninth segment" (Fig. 46:  $sa_9$ ) is the "clear, sclerotized area between the bases of these second gonopods" (Snodgrass, 1933). The *second gonapophyses* (Fig. 45:  $gh_2$ ) are represented by a tube-like process arising from the basal, mesal portion of the second gonopods<sup>7</sup> and lying hidden between the latter and the first

<sup>6</sup> Radio (1922) figured valve I attached to ninth pleuron, valve I and valve II attached to ninth sternum.

<sup>7</sup> Gustafson (1950) proposed that "gonopod" be dropped from further usage because the genital appendages of the insects are not modified pedal appendages, nor fragments nor secondary growths from the basal segment (coxite) of the leg.

ENTOMOLOGICA AMERICANA

gonapophyses. An unbroken suture extends along its mid-ventral and mid-dorsal lines, indicating either fusion or incomplete division. This process is homologous with the third valvulae of the adult, the tips of which it ensheathes.

The tenth segment ( $a_{10}$ ) resembles that of the male in being an undivided ring whose ventral width is almost equal to that of the limb base plates of the first gonopods, but is much narrower than that of the male; it is poorly sclerotized dorsally. The eleventh or terminal segment ( $a_{11}$ ) is like that of the male, and the *anus* (an) is terminal.

MEASUREMENTS OF NYMPHAL PARTS\*  
(in millimeters)

	Body Dimensions	
	Male	Female
Length of Body	23 – 28.5 (15)	26 – 30 (18)
W of Head	6.6 – 7.2 (12)	7.1 – 7.6 (13)
L of Pronotum	3.64 – 4.90 (12)	4.48 – 5.04 (11)
W of Pronotum	7.28 – 8.68 (12)	8.12 – 8.96 (11)
L of Mesonotum	3.92 – 5.53 (12)	4.34 – 6.30 (12)
L of Metanotum	0.84 – 1.40 (12)	1.12 – 1.68 (12)
	Forelegs	
L of Coxa	4.62 – 5.32 (12)	5.32 – 5.74 (9)
L of Trochanter	2.52 – 3.36 (12)	3.22 – 3.50 (9)
L of Femur (joint to tip of comb)	4.06 – 4.76 (12)	4.46 – 5.04 (9)
L of Femur (joint to joint)	3.71 – 4.34 (12)	4.06 – 4.62 (9)
W of Femur (including large spur)	4.34 – 4.76 (12)	4.48 – 5.04 (9)
L of Tibia (without spur)	2.66 – 3.08 (12)	2.66 – 3.50 (9)
L of Tibial spur	1.12 – 1.4 (12)	1.26 – 1.68 (9)
L of Tarsus without pretarsus	2.52 – 2.80 (12)	2.52 – 3.08 (9)
L of Pretarsus	0.35 – 0.42 (12)	0.42 (9)

\* Figures in parentheses indicate number of specimens measured.



VOLUME XXXIX

	Midlegs	
	Male	Female
L of Coxa	2.80 – 3.40(6)	3.08 – 3.50(5)
L of Trochanter	2.38 – 2.80(6)	2.52 – 2.94(5)
L of Femur	4.40 – 4.90(6)	4.76 – 5.60(5)
L of Tibia		
(without spurs)	5.60 – 6.61(6)	5.88 – 7.00(5)
L of Tarsus		
(without pretarsus)	2.38 – 2.66(6)	2.50 – 2.80(5)
	Hindlegs	
L of Coxa	2.80 – 3.30(6)	3.29 – 3.78(5)
L of Trochanter	2.10 – 2.52(6)	2.52 – 2.80(5)
L of Femur	4.90 – 5.05(6)	4.90 – 5.74(5)
L of Tibia		
(without spurs)	6.30 – 6.86(6)	6.02 – 7.28(5)
L of Tarsus		
(without pretarsus)	2.30 – 2.66(6)	2.52 – 2.80(5)

APPENDIX I

COMPARISON OF VARIOUS INTERPRETATIONS UPON THE HEAD OF THE  
CICADA AND RELATED HOMOPTERA

Below is a list of terms used in this paper, their abbreviations and the corresponding terms used by other authors in the field. (The latter are quoted with no interpretation attempted by this writer.) Each paper cited is indicated by a number, as follows:

1. Marlatt	1895	<i>M. septendecim</i> (L.), adult
2. Marlatt	1898	
	(1907)	<i>M. septendecim</i> (L.), adult
3. Meek	1903	<i>M. septendecim</i> (L.), adult
4. Muir and Kershaw	1911a	<i>Cicada</i> (sp. ?) and other Homoptera, adults.
5. Muir and Kershaw	1911b	<i>Pristhesancus papuensis</i> (Reduviidae), embryo
6a. Muir and Kershaw	1912	<i>Siphanta</i> (Flatidae), embryo
6b. Muir and Kershaw	1912	<i>Cicada</i> (sp. ?), nymph

ENTOMOLOGICA AMERICANA

7. Comstock	1920	<i>M. septendecim</i> (L.), adult (follows 1, 2, 3)
8. Crampton	1921	<i>Cicada</i> , adult.
9. Snodgrass	1921	<i>M. septendecim</i> (L.), adult and nymph
10. Imms	1925	Homoptera, adult
11. Muir	1926	<i>Melampsalta</i> , nymph
12. Snodgrass	1927a	<i>M. septendecim</i> (L.), adult and nymph
13. Myers	1928	<i>Cicadidae</i> , adults
14. Metcalf	1929	<i>M. septendecim</i> (L.), adult and Dog-day Cicada, adult
15. Muir	1929	Hemiptera
16. Crampton	1932	Homoptera: Jassid
17. Snodgrass	1935	<i>M. septendecim</i> (L.), adult
18. Snodgrass	1938	<i>M. septendecim</i> (L.), adult, <i>Cephisus siccifolius</i> Walker, nymph.
19. Spooner	1938	<i>Tibicen Sayi</i> , adult and nymph
20. Evans	1938	<i>Cicadidae</i>
21. Evans	1941	<i>T. tomentosa</i> White, adult and nymph
22. Ferris	1943	<i>Tartessus</i> , adult and nymph, Cercopid, adult, <i>Hemiodoecus fidelis</i> Evans, nymph
23. Butt	1943	Homoptera, adults
24. Snodgrass	1944	<i>M. septendecim</i> (L.), adult
25. Snodgrass	1947	<i>M. septendecim</i> (L.), adult and nymph
26. Snodgrass	1950	<i>M. septendecim</i> (L.), adult, <i>Tibicen</i> (sp. ?), adult, <i>Cephisus siccifolius</i> Walker
27. Du Porte	1946	<i>M. septendecim</i> (L.), nymph and <i>Philaenus</i> , adult
28. Kramer	1950	<i>M. septendecim</i> (L.), adult

coronal suture (crs)

crs (12, 20, 27) ; epicranial suture (3) ; epicranial stem, "visible in nymph, invisible in adult" (19) ; Y-shaped ridge internally (28).

**frontal suture (fs)**

fs (27), and present only in nymph (12); epicranial arms, seen in nymph at ecdysis, a fairly distinct Y-line occurs internally in adult (13), and internally "two somewhat divergent ridges" extending "anteriorly" from the median ridge (28) [present writer cannot find these in adult]; epicranial arms and extend behind antefrons in nymph, not visible in adult (19); "line of dehiscence" in nymph (11); epicranial suture (3), and fs of 20, fs of 12, epicranial suture, fs and es can all co-exist in Homoptera (20); post-frontal suture (22) fs and postfrontal s. homologous (27)

**epistomal suture (es)**

es—bounding pelp laterally and dorsally identified by anterior tentorial pit (17); extent not indicated (23); median portion in dotted line (16); frontoclypeal suture (12); and lower portions are clypeo-loral sutures (18); a strong apodemal ridge (28); frontoclypeal suture (23) and median portion (dotted) is continuous with gs, each lower portion is "a suture extending from each proximal corner of acp" shown as not continuous with "frontoclypeal suture" in nymph (19); median portion is "es" extends to in front of antennae, lower portion is "cs," esap is "apodeme of cs" (20); pharyngeal sulcus (lateral portions of es), (pharyngeal strut is portion of apodeme between esap and fpmp) (6b) fs fused (9, 11), "T-shaped" (3), and apodeme widens ventrally to form frontal plate which gives support to posterior half of pharyngeal floor (11), median portion is a transverse fold, lateral portions are frontal sutures, esap is frontal apodeme, following 11 (13).

transfrontal suture, and fronto-genal suture (extending to point dorsad of aat) (27).

**clypeal suture (cs)**

not labelled (12, 17, 26, 11, 20); dotted line (16, 19), definite (suture?) (28).

**genal suture (gs)**

mandibular suture-edges not cemented or joined by membrane (4); mandibular sulcus (6b).

genal suture—flange-like apodeme forms anterior support of pharyngeal floor (11, 13, 20), and is lateral limit of clypeus (19); gs. deep membranous fold, anterior part is membranous portion of nymphal mandibular plate, posterior part is suture between gena

and postgena (12); genal apodeme—bar mentioned as protractor apodeme (9); genal suture (Fulgorids: gs not a suture because “merely apposed,” “not joined”) (28).

**maxillary suture (ms)**

maxillary sulcus (6b); ms (20), except anteriorly only recognizable as crease (11); not labelled (21); traces indicate fusion of maxilla and postgena (19).

**maxillary apodeme (mxap)**

mxap (21), and formed by invagination at inner side, distal end of mxp (11, 13); appears to be apodemal process from mxp (28).

**labial fold (ls)**

labial suture (11), and “must be homologous with postoccipital suture” (20); “not found,” may be (a) line of attachment of lbmb to postgena, or (b) postoccipital suture of 18 (19).

**vertex (vx)**

vx—top of head with ocelli and antennae continuous laterally with mxp (12).

portion of vx (3, 9, 11); vx (28), and with lateral ocelli (7), and on both sides of ers (20), and delimited anteriorly by epicranial arms (19).

**frons (fr)**

cephalic part of epicranium bears 3 ocelli (3).

fr (19, 28), and with median ocellus (7), and between “eps” and “es” (20, 21); present in nymph, identified by epicranial arms and ocellus (12, 17, 18); figured, not named (1, 2).

fr—“median portion of the antennal segment,” although may be delimited by different sutures in different species (22, 25) [theory widely accepted].

“part of true fr” (13).

postfrons (fs and postfs homologous) (27).

**postclypeus, anteclypeus, and labrum (pclp, aclp, lm)**

pclp, aclp, lm (12, 17, 18, 16, 19, 20, 21, 23, 28).

fr (or fr and clypeus), may be clypeus (or clp and lm; or lm) third sclerite unnamed (11).

fr, clp, lm (9, 14) part of fr, clp, lm (13), fr, clp, lm and epipharynx (lm with "under surface grooved and closely fitted" onto epipharynx) [artifact?] (3), no projection from epipharyngeal surface visible externally (19).

antefrons and pelp, aclp, lm (27).

clp, lm, lm (1, 2).

clp, lm, epipharynx (4, 5, 7, 10).

### labium (lb)

lb (14, 20, 28), and suspended from cervical membrane (9, 12, 13, 17), and suspended from membrane posterior to mxp (12, 23); attached to head and floor of prothorax (21); 3 segmented and "attached to chitinized collar of prothorax" (3).

lb—mentum, palpigers, palpi (16).

lb—submentum, mentum, ligula (1, 2)

lb—submentum, mentum, palpigers with vestiges of palpi (7 quotes Leon and 1).

lb—entire fusion of second maxillae (5, 6).

lb—"no unanimity of opinion" (10).

### lorum and bridge (lr; a)

lr, a—part of hypopharynx (18, 23, 26, 27).

lr (10), and outer parts probably from clypeus, although narrow arm between lorum and hypopharynx probably from hypopharynx (28).

gena or part of gena (11), belongs to mandibular segment (12) lorum most of true genal area (13); lr or mandibular sclerite (situated below gena), gena is region below eye (3).

mandibular sclerite, base of mandibular seta (1, 2, 7).

"lateral development of clypeal region," "lies between pharyngeal and mandibular sulci and are formed by them" with no relation to mandibles (5, 6a).

paraclypeus—lateral free plates of clypeus (4); part of clypeus (Crampton, 1921) (19, 20, 22).

### maxillary plate (mxp) and stipes (b) and galea (c).

mxp, and stipes (homologous with maxillary lobe of flea, body of maxilla of thrips), and galea (small soft appendage at ventral tip) (24); mxp—upper part probably is gena, ventral lobes equal basal part of maxilla united with head (17); probably postgena, separated from vx in nymph, *b* and *c* from maxilla (12); dorsal portion mxp not named, and stipes (middle portion) and galea

## ENTOMOLOGICA AMERICANA

(ventral portion) (8); mxp—at least in part is gena and postgena plus portion of maxilla, *b* and *c* are maxillary process (19).

mxp—suspended from gena (no subgenal suture) (20); continuous with cranium merging into gena behind eye (23), mxp (21, 13), and that portion of the head to which it is fused (11); maxillary sclerite (3); “postero-lateral plate” (9).

base of maxillary seta (1, 2); mxp—developed “directly from the basal joint” of the second of appendages completely amalgamated with head capsule (5); mxp—cardo and stipes (6a, 7).

**tentorium**—same as author's (3, 4, 5, 6a, 12, 23, 28)

tentorium is segmental apodeme (11); not homologous with orthopteroid (15).

tentorium is tergal (20).

**corporotentorium** (ct)

ct (3, 11, 12, 13, 14?, 15, 19, 21, 23, 28).

**posterior tentorial arm** (pat)

pat—extends to posterior margin of mxp just above ends of lateral cervical sclerite (12); similar (13, 23, 28); reaches occipital wall of head at a process which looks like condyle (nymph), reaches head wall, no condyle-shaped structure shown (adult) (19); “tendonous strands” connecting ct with head wall (3).

pat—figured as terminating at tip of hw (20, 21).

pat—rests on “mxap” (hw and mxap?) to which “dat” are joined (11); arose from “posterior suture” (postoccipital suture?) connected to hw by ligamentous connections (nymph), by “highly chitinized” connection (adult) (15).

**posterior tentorial pit**

lost in cicadas (28) (present author agrees); none shown (3).

posterior tentorial pit—at base of “maxillary sulcus” [sic] (Fig. 11 showed invagination near but not directly connected with pat) (6b); definite connection between pat and head wall (11); invagination on labial suture (ls) possible (13); “doubtless on the postoccipital suture,” only difficult to find (20).

**anterior tentorial arm** (aat)

aat—(9, 23), and to suture behind pelp at the upper end of lr (Fig. 6 shows these on gs) (12); arise from base of gs (at bottom of

fold) (19); pit at junction of gs and es (28); seems to arise from gs (?) although anterior to antennal socket (21); from posterior end of "mandibular sulcus" (6b); termination same as 12, along line where the mandibular sclerite meets the fr (3); arises on es where it approaches cs at posterior apex of lr (20).

dat—arises near genal suture (11, 15); arises from genal apodeme near antafossa (13).

**dorsal tentorial arm (dat)**

dat—branches from aat close to origin (20); apex with antennal muscles (28); to vicinity of antennal socket (6b).

absent in adult and nymph (19); absent in *T. Sayi* (23).

not mentioned although shown in Fig. 4 (11).

**mandibular stylet (mds)**

mds (24, 25, 26, 3, 28), and protractor arm articulates with posterior margin of lr (23), and has forked base (21, 17); attached to posterior corner of lr (20); mdsb forked, one arm and lvr<sub>1</sub> [adult?] (19).

mandibular seta (4), and mdsb is sheath of seta (1, 2).

mds is whole of embryonic mandible (12, 14); "developed directly from the first pair of appendages behind the stomodeum of the embryo" (5, 10); Homopterous mouthparts develop in same manner as Heteroptera (6a, 10), mandibular seta in part of mandible (7—Heymons, 10); is skeptical of 5, 6a and 7 (9, 13).

**mandibular lever (lvr<sub>1</sub>) (only in adult)**

lvr<sub>1</sub> and protractor arm articulate with postero-lateral margin lr (18), and in external membranous groove between lr and mxp, articulates with dorsal end of lr (17); from invagination at upper end gs (19); at base of protractor arm (23); articulates with lr just behind a.t. pit (28); "quadrangular sclerite" with single hinges (3); articulates by "true ginglymus articulation" at posterior end mandibular suture (4).

**mandibular protractor arm (pmd) (and muscles)**

nymph: pmd formed by membranous separation of the entire posterior border of lr (12); attached on internal margin of lr (21); "articulated on oral margin between the clypeus and maxillae" (5); (mandibular pillar (lvr<sub>1</sub>?) with pmd attached (6b); rod of genal

suture attached to outer corner of mxsb (mdsb?) and extends to gena and apodeme (11); pmd—rod to gena and apodeme which support pharynx.

adult: pmd (23); inner surface of lr “thin apodemal inflection” along inner edge of lvr<sub>1</sub> (17); pmd and lvr<sub>1</sub> articulate with posterolateral margin lr (18); pmd is on arm of mdsb which is connected with lr (9); is from inner anterior margin lr (20); from lr to lvr<sub>1</sub>, and apodeme of stylet (28, 24, 25, 26); from lr and lower face to protractor arm (13); pmd is muscular base of seta (1, 2); pmd from maxillary sclerite [sic] (3).

**mandibular retractor** (rmd) (and muscles)

nymph: rmd muscle to head capsule (11), on one arm mdsb (19).

adult: rmd muscles: one between forks of mdsb, or on base (24, 25, 26, 23); one to tendon, or retractor arm (24, 25, 26, 23, 19), which is from vx, or epicranium (28, 9, 17), which is from three origins (3); rmd to head capsule (11), and from mdsb (13).

**maxillary stylet** (mxs)

mxs (21, 23, 24, 25, 26, 28), and is lacinia of embryonic maxilla (12, 18), detached lacinia and its base sunk into head capsule and forms cup-shaped base (8), is skeptical of 5, 6a, and Heymons (9); maxilla (14).

maxillary seta (13, 3, 1, 2) and probably palpifer (4), and mdsb is sheath of seta (1, 2), and “developed directly from the distal joint of the second pair of appendages” (5, 10); not palpus, may be palpiger or combination of lacinia and galea (6a, 10, 20); quotes Heymons and Muir (7).

**maxillary lever** (lvr<sub>2</sub>)

nymph: h (12), is crescent sclerite of Comstock, and is a thickening of the wall of mxap (11).

adult: lever sclerite (24), articulates with mxap not with mxp (28), to posterior edge mxp (23, 20), like lvr<sub>2</sub> of Heteroptera (adult?) (19); “crescent shaped sclerite” (3).

**maxillary protractor arm** (pmx) (and muscles)

setal muscles have little homologies with biting insects (12) [See discussion under lorum].



adult: One—from mxp to mxsb (28, 23, 17), but is from lr (3), but is to mxp and *b* (9). One—from mxp to lvr<sub>2</sub> (28, 23, 17), but is from lr (3); pmx? (25, 26), attached to walls of mxp (4); from lower part mxp to where? (13); bulbous expansion of seta (1, 2).

#### maxillary retractor arm (rmx) (and muscles)

nymph?: one from mxsb, one from arm of mxsb, both to epicranium (9); setal muscles have little homologies with biting insects (12).

adult: three, one from vx, or epicranium, to mxsb (28, 23, 24, 25, 26, 17); one from separate origin on vx, to mxsb (28, 23, 24, 25, 26, 17); one from tentorium to lvr<sub>2</sub> (28, 23, 24, 25, 26); rmx—from vx to where? (13).

#### hypopharynx

hypopharynx (7, 20) and joined broadly to lora (28); laterally margins of acp invaginate (membranous in cicadas) and “serve as support for salivary pump and for mesal margins of mds and mxs” (19); is part of pharynx (4).

#### lingua (mh)

mh—median lobe connected to lr by *a* (12), is small free apical lobe (18, 23, 24, 25, 26), conical lobe (17), median lobe of hypopharynx (9, 20).

hypopharynx (7, 10, 13) and is “outgrowth of inner surface of lb floor” (?) (3), and is “attached to upper base of lower lip” (1, 2).

#### sublingual plates (p)

sublingual sclerites, union forms cup to contain salivary syringe (18, 23, 24, 25, 26).

“salivary syringe apodeme” (20).

part of pharynx? (4).

#### salivary syringe, and canal (syr, canal)

syr (12, 18, 23, 24, 25, 26, 20), and homologous salivarum of Orthoptera, similar to Dipterous syr (17), and homologous with claustrum salivae (Hansen) of Diptera (5, 6a); salivary pump (9, 14), salivary injector (3).

salivary duct (10), salivary canal extends into interlocked setae (13).

parts of hypopharynx (4).

**hypopharyngeal wing plates (hw)**

hw—special development of Hemiptera (12, 18), is secondary structure (19).

hypopharyngeal apodeme (21), and not directly continuous with mxp as Muir said (20); hypopharyngeal lamellae (3); parts of hypopharynx (1, 2, 4).

hw—joined to mxap (28); part of “mxap” (?) not otherwise mentioned (11).

anterior tentorial arms [sic] (15).

**sucking pump (pmp), floor (fpmp) and roof (rpmp)**

cibarium (18, 23), and fpmp is dorsal wall of hypopharynx (12, 28), fpmp with mouth cleft, and rpmp is epipharyngeal surface of aelp (17); fpmp is loral lamella homologous with sitophore, and rpmp is clypeal lamella (24, 25, 26); sucking pump (21), and fpmp is a circular membranous plate joined to clypeal apodeme and lorum, two layers of floor separable (20).

pharynx (9, 14), and fpmp is lower trough of pharynx, rpmp is upper trough of pharynx (3), and fpmp has two layers.

sclerotized layer homologous with frontal plate of Orthoptera, “floor of pump” is membranous and separable from frontal plate (11); follows 11, “unable to achieve separation of floor from plate, but had no specimens near ecdysis” (13) [author: separation probable artifact]; cannot agree with 12 (15).

anterior part of pharynx, “fastened to the anterior part of clypeus by two chitinized pharyngeal struts” [*loral apodemes*], posterior to this point [posterior to *mouth cleft*] pharynx separates into epipharynx and hypopharynx (4).

rpmp is epipharynx (?), a “rather chitinous,” “keel-like structure projecting from . . . the roof of the mouth, attaching to the clypeus and labrum” and fitting tightly between *lora* (1, 2, Fig. 23, Id and I'd’).

**pharynx (ph)**

ph (12, 24); dorsal end of ph (3); supplementary ph (14).

**functional mouth (mth)**

food meatus (24); mouth (14); “pharyngeal canal,” strongly

chitinized (3); pharyngeal duct (10).

### stylet pouches

hw and anterior membrane meet at dorsal tip hw to form pouch (28); invaginations of ventral head wall between inner surface of mxp and outer surface of hw (17); lateral hypopharyngeal surfaces form walls of setal pouches (12); "maxillary stylet goes through the membrane ("hypodermis") at the base of the inner side" of mxp (4, 6b?); gs joins "mxap" to form pouch (11, 13).

## APPENDIX II

### NOTES ON THE HOMOLOGIES OF THE ADULT CICADAN HEAD

A resume of the various interpretations of the homologies of the adult cicadan head may be helpful to future workers in their interpretations of the nymphal cranium, since the nymphal and adult head capsules appear to be very similar and information on the former is very scarce. (See Appendix I.). Each term used by other authors (in quotation marks) is supplemented with its synonymous equivalent used in the text (*italics*).

(1) *Epicranial suture and frons*—there is a diversity of opinion regarding their presence and interpretation (Appendix I). Ferris' (1943) and Snodgrass' (1947) widely accepted theory (that the frons is an arbitrary apotome representing the median region of the antennal segment, bearing the median ocellus and the pharyngeal dilators) when applied to the cicadan head, confirms the validity of this identification (see text).

(2) The *postclypeus*, *anteclypeus* and *labrum* have been interpreted in several ways (Appendix I):

(a) "Postclypeus, anteclypeus, labrum" (Appendix I).

Snodgrass (1927) decided that the large striated plate was really the *postclypeus*, for the following reasons:

1.—The sucking pump, whose dilator muscles are "attached" on the striated facial plate is "a development more probably of the mouth cavity than of the true pharynx." (Quoted by Butt, 1943).

2.—"The fact that the uppermost facial plate lies before the frontal sutures would indicate that (the striated plate) belongs to the clypeus, and that it is no part of the true front."

3.—The *anterior tentorial roots* ("dorsal roots" of Muir, 1926) "just below the bases of the antennae in the groove bounding

the striated plate, identify this groove as the fronto-clypeal suture" (*epistomal suture* of Snodgrass, 1935).

He explained that the "preoral position" of the *anteclypeus* suggests that it is also a clypeal sclerite. Also he pointed out that Muir and Kershaw (1911a, 1911b) showed examples in Cercopids, Fulgorids, and Reduviids, as well as in the 21-day old embryo of *Pristhesancus*, where "this plate is not separated from the plate above it." "Its position relative to the mouth is not that of a labrum," contrary to Muir's suggestion; while the *labrum* lying outside of the mouth cavity has all the relations of the labrum to surrounding parts.

Muir (1929) could not accept Snodgrass' (1927) interpretation of the pump as being cibarial. But Crampton (1932): agreed with Snodgrass' (1927) homologies. Butt (1943) and Kramer (1950) also accepted this interpretation.

Spooner (1938) maintained that the homopterous clypeus always consists of at least two pieces (*post-clypeus*, *ante-clypeus*), and often four pieces (including two paraclypeal areas; see section 3). This clypeus is bounded posteriorly by the "fronto-clypeal suture" (homologous with the median portion of the *epistomal suture* between the antenna-fossae), and laterally by the *genal sutures*. Each paraclypeal lobe is separated from the postclypeus by a suture extending posteriorly from each proximo-lateral corner of the anteclypeus, which suture is not continuous with the "fronto-clypeal suture."

He pointed out the importance of the antennafossa as a landmark, as it is situated on the front just dorsad of the "fronto-clypeal suture," and the attachment of the mandible. In forms lacking the "fronto-clypeal suture," "a line drawn across the fronto-clypeal area just ventrad of the antennafossae will approximately separate the two areas."

Evans' (1938, 1941) interpretation was essentially similar to Spooner's, with the following differences: The clypeus often consisted of one single sclerite, although in the forms such as *Archilus flammens* Kby. and the cicadas the postclypeus and anteclypeus are separated by "a superficial suture" (*clypeal suture*). And the "epistomal suture" is not continuous with the *genal suture* in the cicada as Spooner had figured. His "epistomal suture" is apparently homologous with Spooner's "fronto-clypeal suture" and his "clypeal suture" homologous with Spooner's unnamed suture that delimits the paraclypeus mesally (homologous with the lateral portion of *epistomal suture* ventrad of antennafossae in the present paper).

(b) "Frons (or frons and clypeus), clypeus (or clypeus plus labrum, or labrum), third sclerite un-named"—Muir (1926). As Muir (1926) formed his second interpretation of the anterior tentorial pits (see under section 4b), he believed the *clypeal suture* to be the "epistomal suture" and the *epistomal suture* to be the fused "frontal sutures." The *postclypeus*, therefore, becomes the "frons or frons and clypeus." Muir also approved of Snodgrass' (1921) criterion of using the origin of "pharyngeal muscles" (*pump muscles*) as evidence for the homology of the "frons" (*postclypeus*). Of the *anteclypeus*, he was uncertain; and the *labrum* was not named.

(c) "Antefrons plus postclypeus, anteclypeus, labrum"—Du Porte (1946). Du Porte, after demonstrating that the anterior tentorial pit has most frequently migrated into the fronto-genal suture (from its primitive position at the junction of fronto-genal and fronto-clypeal sutures), identified that vertical portion of the *epistomal suture* dorsad of the tip of the *lorum* as the "fronto-genal suture." Since the angle ("a") between the clypeus and gena marks the primitive mandibular articulation (the *lorum* being a portion of the hypopharynx exposed after the displacement of the mandible), an imaginary line drawn from "a" to its fellow will be the dorsal demarcation of the "post-clypeus." Therefore, the *postclypeus* is a composite of "antefrons" and "postclypeus," the *frons* is "postfrons" and the median portion of the *epistomal suture* is the "transfrontal suture." (More evidence of his theory was offered with comparisons of the cercopid and cicadid heads with that of *Psocus*, which was in turn compared with the Orthoptera.)

(3) The *lorum* has been interpreted in the following ways:

(a) "Mandibular sclerite"—(*fide* Snodgrass 1921, was considered as "mandibular in origin" by Meeznikov (1866), Smith (1892), Heymons (1899), Berlese (1909), Bugnion and Popoff (1911). Marlatt (1895, 1907) interpreted the *lorum* as the base of the mandible. Muir and Kershaw (1911b, 1912), in their studies of the embryology of a homopteron and a heteropteron, observed that as the whole of the mandible develops into the mandibular stylet, the *lorum* cannot be part of the mandible.

(b) "Gena"—Muir (1926) asserted that this sclerite represented the gena or part of the gena. Snodgrass (1927) and Myers (1928) agreed to this interpretation. Later, in the work of Spooner (1938), Butt (1943) and Du Porte (1946) the gena is represented by the area below the eye and dorsal to the *lorum*.

(c) "Paraclypeus"—Muir and Kershaw (1911a) had called the *lora* the lateral plates of the clypeus. Later Spooner (1938) and

Evans (1938) arrived independently at the same idea that this sclerite is clypeal in origin.

Spooner (1938) notes that in *Otiocerus degeerii* Kby. (a Fulgorid used as a generalized form) which has no paraclypeus, the clypeus is delimited from the maxillary plate by a suture homologous with the genal suture of Muir (1926). He then presented a progressive series of eight Fulgorids: *Lamenia* sp. lacking any paraclypeus, *Amaloptera uhleri* Van D. showing the anteclypeus included in the postclypeus for a distance, and *Cyarda melichari* Van D., *Acanalonia latifrons* (Walk.), *Pelitropis rotatula* Van D., *Epiptera* sp. nymph, and *Bruchomorpha* sp. with completely delimited paraclypea of various shapes. "The study of this series," he concluded, "leaves little doubt that the paraclypeal areas are actually portions of the clypeal area cut off by the progressive development of a suture extending from each proximal corner of the anteclypeus."

However, Spooner wrote that in *O. degeerii* Kby., wing-like projections from the ventral ends of the genal sutures extend to the "pharyngeal pump" which they help to support. In forms with well developed paraclypeus, "the anteclypeus is marked off by a deeply invaginated suture on each side of the lateral portion of the epistomal suture. The invaginations along these sutures form a deep flange about the postclypeus, extending into the head, which serves for muscle attachment, and from the ventral margins of which there extend wing-like supports to the pharyngeal pump."

The present writer does not understand how Spooner's "deeply invaginated suture" (according to him a *more recent* structure phylogenetically than the genal suture), should have an apodeme that serves a *similar* function as the genal suture in species which *have* the genal sutures (such as his Fig. 16).

Evans' (1938) interpretation of the "paraclypeus" differed from Spooner's. He used *Hemiodoecus fedilis* Evans as a basic form (considering it the most primitive of all Homoptera). He maintained that the clypeal lobe may well be homologous with the antecoxal piece of certain mandibular insects such as the larva of *Corydalis* (Comstock, 1920), because of its position and the attachment of the mandible to its anterior recurved margins.

The clypeal lobes of *Hemiodoecus* and certain fulgorids, according to Evans, have developed into the lora of other groups. This development is "associated with the stress set up by the dilators of the pump and their backward migration on the clypeal plate, which resulted in the enlargement of the median clypeus and arching of

the clypeal suture, and the simultaneous backward movement of the clypeal suture and apodeme" (lateral portion of the *epistomal suture*).

Regarding the cicadas, however, he remarked: "The lorae or mandibular plates, are joined to the genae posteriorly, to the apodemes of the clypeal suture laterally, and to the circular membranous plate already described (*floor of the sucking pump*) medially; they have thus no apparent [sic] connection with the clypeus." He made no further comment upon the homology of the cicadan lorum.

Ferris (1943), in disagreement with Spooner (1938), pointed out that the paraclypeal lobes of Homoptera (illustrated with an adult cercopid) are identical with paraclypeal lobes of Crampton (1921), because of the position of the anterior tentorial arms, the suture extending to the cranial margin, and the attachment of the mandibles. Also he said Evans was in error in using *H. fidelis* Evans as a primitive form, as this species is "clearly a quite specialized form," because it has a much reduced clypeus and its head is fused with the thorax approaching Sternorrhynchous conditions.

(d) "Part of hypopharynx"—Snodgrass (1938, 1950) developed a new theory, which was accepted by Butt (1943) and Du Porte (1946), that the lora are "expanded lateral parts of the basal region of the hypopharynx on which the hypopharyngeal muscles of the mandibles take their origin."

Previously, Meek (1903), Muir (1926), Spooner (1938), and Evans (1938, 1941) had all described to a certain extent the connection between the floor of the sucking pump and the apodemes of the sutures which delimit the lora anteriorly (*epistomal suture*). But they failed to mention that in the cicada the posterior lamina of this apodeme is continuous with the anterior margin of the lorum.

Snodgrass gave this evidence:

(1) "The hypopharynx and the lora constitute an anatomically integral structure" (1950). His figures (1938, 1950) of the hypopharynx and lora of adult *M. septendecim* (L.) and nymph of *Cephus siccifolius* Walker, and his horizontal section through the head of *M. septendecim* (L.), showed that "the contiguous edges of the postclypeus and the lorum are inflected individually clear through the head," and that "the lower ends of the lora are directly continuous beneath the anteclypeus with the body of the hypopharynx." (Confirmed by present writer.)

Snodgrass (1938) further pointed out Heymon's (1899) statement that the homopterous lora "are derived from 'Bestandtheilen

des Mandibularsegmentes,' ' although Heymon's ascribed the cicadan lora to both the mandibular and antennal segments. The attachment of mandibular muscles "is presumptive evidence" that the lorum is derived from the mandibular somite, whereas "the anterior part of the hypopharynx is formed from the ventor of this somite." Hence, embryologically these sclerites have a common origin.

(2) The protractor muscles of the mandibular stylet arise on the interior surface of the lorum. "There is no precedent in insect anatomy for the origin of mandibular muscles on any part of the clypeus" (1938).

Snodgrass (1938) said that Spooner (1938) and Evans (1938) neglected to explain these two evidences in their theories of the clypeal origin of the lora. Snodgrass also believed that the fused condition of the lora with the postclypeus in the fulgorids, which these authors used as a generalized form, actually represented an advanced condition.

(3) A detailed comparison of the gnathal muscles (1938), together with a comparison of the hypopharyngeal parts, of the mandibulate insects (the roach) with those of the Homoptera (the cicada) revealed that the protractors of the mandibular stylet in the latter is homologous with the hypopharyngeal adductor of the mandible of the former. Therefore, Snodgrass concluded, the lorum is a lateral portion of the hypopharynx exposed after the reduction of the mandible. (See Appendix I.)

(e) Kramer (1950) stated that Snodgrass (1938) was in error in considering the loral areas of the Fulgoridae as representing a specialized condition. And "since the clypeus and sucking pump area of the Fulgoridae is a primitive one in comparison with other Auchenorrhyncha, it would support the contrary idea that the lorum is differentiated from the lateral areas of the clypeus."

Using *Scolops punjens* (Fulgoridae) as illustration, he concluded: "It seems likely that this narrow arm between the hypopharynx and the lorum has been differentiated from the hypopharynx, and has apparently expanded, in the other families to form the broader connective. Thus, it may well be that although the loral areas are derived mainly from the lateral regions of the clypeus, a part of the hypopharynx has formed a bridge with the present structure."

(4) The *tentorium*:

(a) Of the three interpretations of the tentorium, that given by Snodgrass (1927 to date) and most of the other writers (includ-



ing Muir and Kershaw, 1911a, 1911b, 1912) is presented under the TENTORIUM in the text.

(b) Muir's 1926 theory disagrees with Snodgrass (1927), but was accepted by Myers (1928). This theory was based on his study of the last-instar nymph of *Melampsalta* sp., compared with the normal mandibular head (not figured) and with *Mnemosyne bergi* (figured). The tentorium, he maintained, represents segmental apodemes arising from four pairs of invaginations.

His "anterior root" is the "invagination" (pit-like depression, see Plate 1, Figs. 2, 3) at the junction of the "frontal suture" (*epistomal suture*) and "epistomal suture" (*clypeal suture*) at which point internally the apodeme of the "frontal suture" "flattens out and joins the one from the opposite side, thus forming a plate which appears to be homologous to the frontal plate of the tentorium of some Orthoptera" (*pump floor?*).

The "dorsal arm" is Snodgrass' (1927) *anterior arm*. (See Appendix I.) Evans (1938) pointed out that the dorsal arms can have no connection with the posterior arm or with corporotentorium.

(c) Muir (1929) formulated a third theory in reference to Snodgrass' Point 18 (1928), which stated that a pair of hypopharyngeal apophyses of the Myriapods and Apterygota (which support the adductors of gnathal appendages, and which have retained their hypopharyngeal connections in Myriapods and most of the Apterygotes) have migrated to the epistomal sutures in all but some lower forms of Pterygotes, to become the anterior tentorial arms.

Consequently Muir (1929) concluded that the hemipterous tentorium is not homologous with the Orthopteroid tentorium, but has a more primitive origin, because "the large arms of the tentorium, which are so conspicuous, arise from the hypopharynx." The "anterior tentorial arms," from his description, seem to be the *hypopharyngeal wings*.

This theory has not been supported by anyone. Evans (1938) gave the following criticism, "It is . . . more probable that whilst the hypopharyngeal apodemes of *Heterojapyx*, as figured by Snodgrass (1928), are homologous with similar apodemes present in Hemiptera, and apodemes such as occur with the *Machilidae* (Snodgrass, 1928, Fig. 19), which arise from the margin of the head capsule just anterior to the epistomal suture, are homologous with the anterior arms of the tentorium of Pterygote insects, the two sets of apodemes are not homologous with each other."

(d) Evans (1938), using as support a suggestion made by Helsing and China (1937) that the paired dorsal pits on each segment of the thorax of *Hemiodoecus veitchi* "may be the ends of the thoracic apodemes similar to the frontal pits," maintained that the tentorium is a tergal structure (without proving the validity of the comparison drawn between thoracic and cranial structures).

The Orthopteroid origin of the Hemiptera, Evans (1938) stated, is suggested by a study of the head of *Hemiodoecus*; and the Hemiptera "possess, in common with the Orthoptera, sternal apophyses that arise from the hypopharynx, in addition to two pairs of tergal invaginations that give rise to the anterior and posterior arms of the tentorium." Therefore, he concluded, the tentorial arms which arise from pits on the epistomal suture, such as occur in *Hemiodoecus* "must be" the anterior arms and not dorsal arms. (See Ferris, Sec. 3c.)

(e) Spooner (1938) notes that Muir had neglected Snodgrass' (1928) implication that the tentorium of the Hemiptera is homologous with that of the mandibulate insects. Spooner maintained that Muir's "invagination of the hypopharynx," possibly the *hypopharyngeal wings*, are secondary in nature, and only "united with the tentorium proper during the evolution of the group."

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PLATE ABBREVIATIONS

**a** — bridge like structure between anterior, ventral end of lorum and the lateral surface of the median lobe of hypopharynx. **a<sub>10</sub>**, **a<sub>11</sub>** — tenth, eleventh abdominal segment. **aat** — anterior tentorial arm. **acepmb** — membranous portion of the “epipharyngeal” surface of anteclypeus, apposed onto the anterior surface of the maxillary stipes. **acep** — “epipharyngeal” surface of anteclypeus apposed onto the median lobe of hypopharynx. **aclp** — external surface of anteclypeus. **acepl** — “epipharyngeal” or inner surface of anteclypeus apposed onto the anterior surface of lorum and “a”. **aem<sub>2</sub>** — mesothoracic anepimeron. **amb** — membranous region ventral to the wing cases, where the alar sclerites develop in the adult. **amds** — imaginal mandibular stylet. **an** — anus. **ant** — antenna. **antf** — antennal socket. **apm<sub>ds</sub>** — protractor arm of imaginal mandibular stylet. **aps** — spot of apposition or fusion of the occipital condyle and the sclerotic connective in the adult head.

**b** — stipes of maxilla. **band** — thickened band along inner edge of genal apodeme connected with the protractor arm of the mandibular base. **bcs** — basicostal suture. **bcx** — basicoxite. **bt** — basitarsus.

## ENTOMOLOGICA AMERICANA

**c** — galea of maxilla. **cc<sub>1</sub>**, **cc<sub>2</sub>**, **cc<sub>3</sub>** — prothoracic, mesothoracic, metathoracic coxal cavity. **comb** — comb of prothoracic femur. **con** — sclerotic connective between the distal end of the posterior tentorial arm, the tip of the hypopharyngeal wing-plate and the occipital condyle, in the adult head. **cs** — clypeal suture. **crs** — coronal suture. **ct** — corporotentorium or body of tentorium. **cvmb** — cervical membrane continuous with lbmb (see: lbmb).

**d** — invagination on labial fold. **dat** — dorsal tentorial arm. **dt** — distitarsus.

**e** — compound eye. **ec** — line of ecdysis. **em<sub>1</sub>** — small, triangular anterior portion of proepimeron. **em<sub>1</sub>'** — large, posterior portion of proepimeron. **em<sub>2</sub>**, **em<sub>3</sub>** — mesoepimeron, metaepimeron. **em<sub>1</sub> r** — internal ridge of suture **em<sub>1</sub> s**. **em<sub>1</sub> s** — an unidentified suture in the dorsal region of the anterior portion of proepimeron. **ep<sub>1</sub>**, **ep<sub>2</sub>**, **ep<sub>3</sub>** — proepisternum, mesoepisternum, metaepisternum. **ep<sub>1</sub> r** — short internal ridge of suture **ep<sub>1</sub> s**. **ep<sub>1</sub> s** — an unidentified suture which probably demarks the dorsal margin of the proepisternum (**ep<sub>1</sub>**). **es** — epistomal suture. **esap** — apodeme of epistomal suture, composed of a clypeal and a loral lamina. **eucx** — eucoxa.

**f<sub>1</sub>**, **f<sub>2</sub>**, **f<sub>3</sub>** — furca of prosternum, of mesosternum, of metasternum. **fe** — femur. **fgr** — groove forming food meatus or functional mouth. **fl** — thin flange along posterior margin of each notum and each abdominal tergum. **fp<sub>2</sub>**, **fp<sub>3</sub>** — furcal pit of mesosternum, metasternum. **fpmp** — floor of sucking pump. **fr** — frons. **fs** — frontal suture.

**g<sub>2</sub>** — second gonopod. **gap** — apodeme of genal suture (two laminae fused). **gapp** — posterior lamina of genal apodeme. **ggr** — groove of genal suture. **gh<sub>1</sub>** — first gonapophysis. **gh<sub>2</sub>** — second gonapophysis. **gp** — gonopore. **gs** — genal suture.

**h** — a hemispherical protrusion on each side of the second abdominal tergite, underneath which lies the auditory capsule of the imago. **hw** — hypopharyngeal wing-plate. **hwk** — keel-like projection along the lateral edge of the hypopharyngeal wing-plate.

**ica<sub>1</sub>**, **ica<sub>2</sub>**, **ica<sub>3</sub>** — prothoracic, mesothoracic, metathoracic infracoxal arc. **ii** — ridge on lateral side of median lobe of hypopharynx. The mandibular and maxillary stylets glide upon its dorsal and lateral sides respectively.

**kem<sub>2</sub>** — mesothoracic katepimeron.

**lb<sub>1</sub>**, **lb<sub>2</sub>**, **lb<sub>3</sub>** — 1st, 2nd, and 3rd segment of labium. **lb<sub>8</sub>** — limb base plate of the first gonopod. **lbgr** — groove on anterior surface of labium. **lbmb** — the unbroken sheet of weakly sclerotized membrane posterior to the maxillary suture, by which membrane the labium is suspended from the hypostomal region of the head. **lcvs** — lateral cervical sclerite of the adult head. **lm** — labrum. **lr** — lorum. **lrmb** — a sheet of membrane extending from the lower, lateral margin of the lorum to the posterior surface of the median hypopharyngeal lobe and the mesal margin of the hypopharyngeal wing-plate. **ls** — labial fold. **lvr<sub>2</sub>** — lever of maxillary stylet which bears the protractoral muscles.

**mb** — membrane. **mc** — slit on floor of pump through which the actual mouth opens into the cavity of the pump. **mcl** — lips of this slit (**mc**). **mds** — mandibular stylet. **mdsb** — base of mandibular stylet. **me** — meron. **mh** — lingua or anterior wall of median lobe of hypopharynx. **ms** — maxillary “suture.” **mscl** — muscle. **mth** — functional mouth. **mthc** — actual mouth or mouth cleft; between “epipharyngeal” surface of anteclypeus and anterior surface of lorum. **mxap** — apodeme of maxillary suture. **mxapa** — anterior lamina of the maxillary apodeme, shown moved out of position posteriorly. **mxgr** — groove on the mesal surface of the maxillary stylet. **mxp** — maxillary plate. **mxs** — maxillary stylet. **mxsb** — base of maxillary stylet.

## ENTOMOLOGICA AMERICANA

**oc** — site of imaginal ocellus (seen through translucent nymphal skin). **occ** — an apparent occipital condyle of adult head. **occv** — occipital cavity. **ocmb** — mesal wall of an unidentified membranous invagination or sac, which is connected to the distal end of an apparent occipital condyle, in the adult head.

**p** — fused sublingual plates which form the posterior wall of the median lobe of hypopharynx. **pat** — posterior tentorial arm. **pclp** — postclypeus. **pcp<sub>1</sub>**, **pcp<sub>2</sub>**, **pcp<sub>3</sub>** — prothoracic, mesothoracic, metathoracic pleural coxal process. **pcx<sub>1</sub>**, **pcx<sub>2</sub>**, **pcx<sub>3</sub>** — prothoracic, mesothoracic, metathoracic precoxale. **ph** — pharynx, connected to posterior end of sucking pump. **pit** — funnel-shaped depression or pit at the spot where the epistomal suture meets the clypeal suture. This is supposed by Muir (1926) to be the anterior tentorial pit. **pm** — peritreme. **pmp** — sucking pump. **poc<sub>1</sub>**, **poc<sub>2</sub>**, **poc<sub>3</sub>** — prothoracic, mesothoracic, metathoracic postcoxale. **prc** ? — area on pronotum which might represent prescutum. **pr<sub>1</sub>**, **pr<sub>2</sub>**, **pr<sub>3</sub>** — prothoracic, mesothoracic, metathoracic pleural ridge. **ps<sub>1</sub>**, **ps<sub>2</sub>**, **ps<sub>3</sub>** — prothoracic, mesothoracic, metathoracic pleural suture. **pt** — pretarsus.

**rlbgr** — rod-like extension of the sclerotized floor of the labial groove. **rmds** — retractoral arm of mandibular stylet. **rmxs** — retractoral arm of maxillary stylet. **rpmp** — roof of sucking pump.

**s** — seta. **sa<sub>1</sub>**, **sa<sub>2</sub>**, **sa<sub>3</sub>**, etc. — 1st, 2nd, 3rd, etc., abdominal sternite. **sc** ? — areas on pronotum which might represent scutum. **sct** ? — area which might represent scutellum. **slms** — lower portion of maxillary "suture" which is an open slit. **sp<sub>2</sub>**, **sp<sub>3</sub>** — mesothoracic and metathoracic spiracle. **spa<sub>1</sub>**, **spa<sub>2</sub>**, **spa<sub>3</sub>**, etc. — 1st, 2nd, 3rd, etc. abdominal spiracle. **spr<sub>2</sub>**, **spr<sub>3</sub>**, — spur on **pr<sub>2</sub>**, **pr<sub>3</sub>**. **st<sub>1</sub>**, **st<sub>2</sub>**, **st<sub>3</sub>** — prosternum, mesoternum, metasternum. **syr** — salivary pump or syringe. **syro** — opening of salivary pump at tip of median lobe of hypopharynx.

VOLUME XXXIX

**t<sub>1</sub>** — pronotum or tergum of first thoracic segment. **t<sub>2</sub>** — mesonotum. **t<sub>3</sub>** — metanotum. **ta<sub>1</sub>, ta<sub>2</sub>, ta<sub>3</sub>**, etc. — 1st, 2nd, 3rd, etc. abdominal tergite. **tb** — tibia. **td** — tendon. **tdd** — tendons of cibarial dilators of the sucking pump. **tm** — a trapezoidal area on each side of the first abdominal tergite which, in the male nymph, supersedes the tymbal of the adult male. **tn<sub>1</sub>, tn<sub>2</sub>, tn<sub>3</sub>** — prothoracic, mesothoracic, metathoracic trochantin. **tr** — trochanter. **tw<sub>1</sub>, tw<sub>2</sub>, tw<sub>3</sub>**, etc. — 1st, 2nd, 3rd, etc. "Tergitwülste."

**ub** — fused base of unguis. **un** — unguis. **utb** — basal lobe of unguitractor. **utm** — an area of translucent tissue which joins utd to ub. **utt** — unguitractoral tendon.

**vx** — vertex.

**wc** — wing-case.

**x, x** — mesal pair of unnamed sutures on pronotum. **xr** — internal ridge of suture x. **xy** — the unnamed suture formed by the union of the bases of xr and yr.

**yr** — internal ridge of suture y. **y, y** — lateral pair of unnamed sutures on pronotum.

**z** — a faint, unidentified suture extending posteriorly from the mesopleural suture half way across the mesoepimeron.

PLATE 1, HEAD

Figures 1-3. *External views*: 1. Head capsule, dorsal view. 2. Head capsule, lateral view. 3. Head capsule, anterior view. Fig. 4. Median lobe of hypopharynx, anteclypeus and labrum, (with maxillary stipes and galeae removed), postero-ventral view.

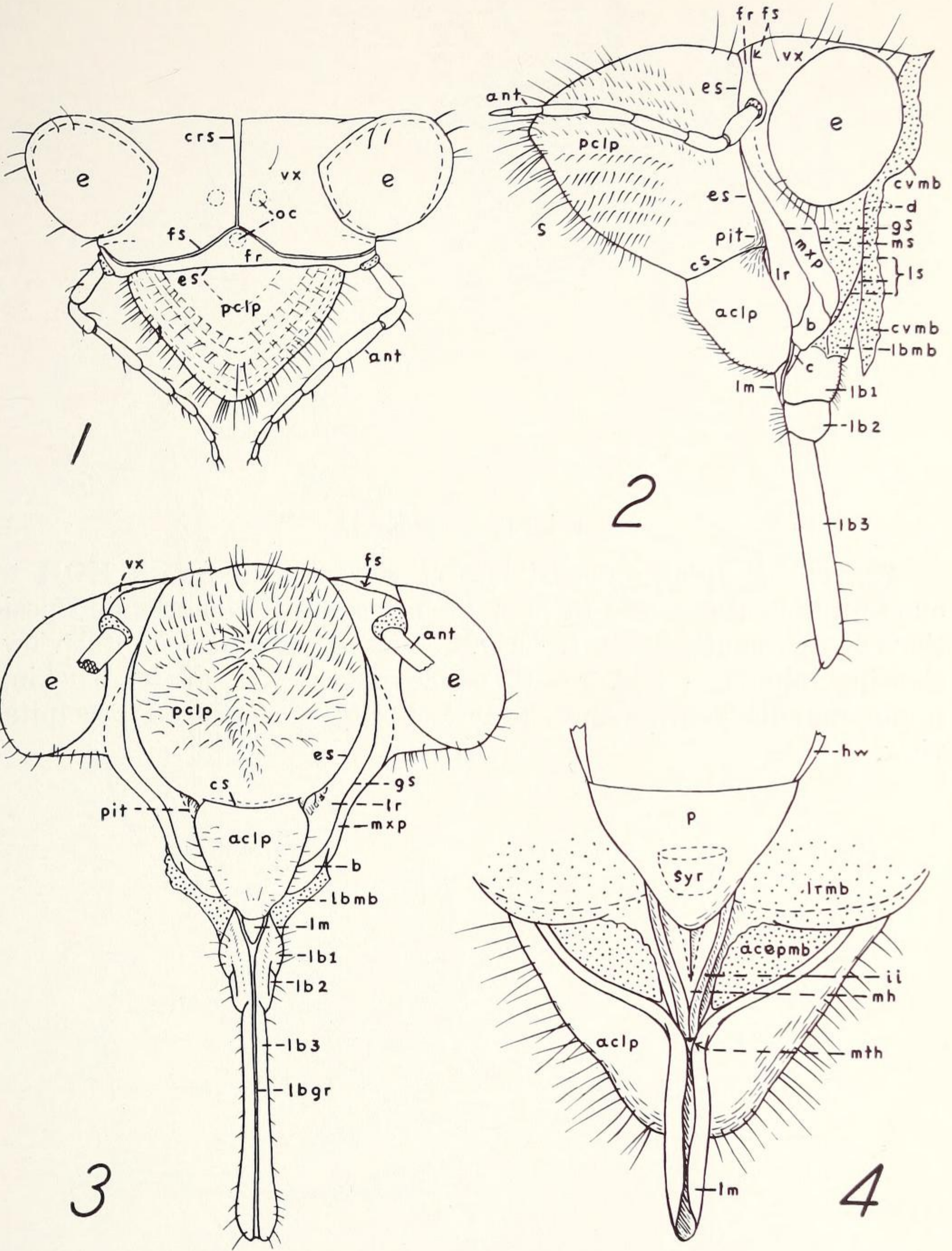


PLATE 2, HEAD

Figure 5. Head capsule, lateral view (treated with KOH to open up the sutures and to show the approximate lengths and positions of the mouth stylets). Fig. 6. Head capsule, occipital view, showing labium. Fig. 7. Hypopharyngeal wing-plates, sucking pump, maxillary stipes and galeae (with labium removed), occipital view.



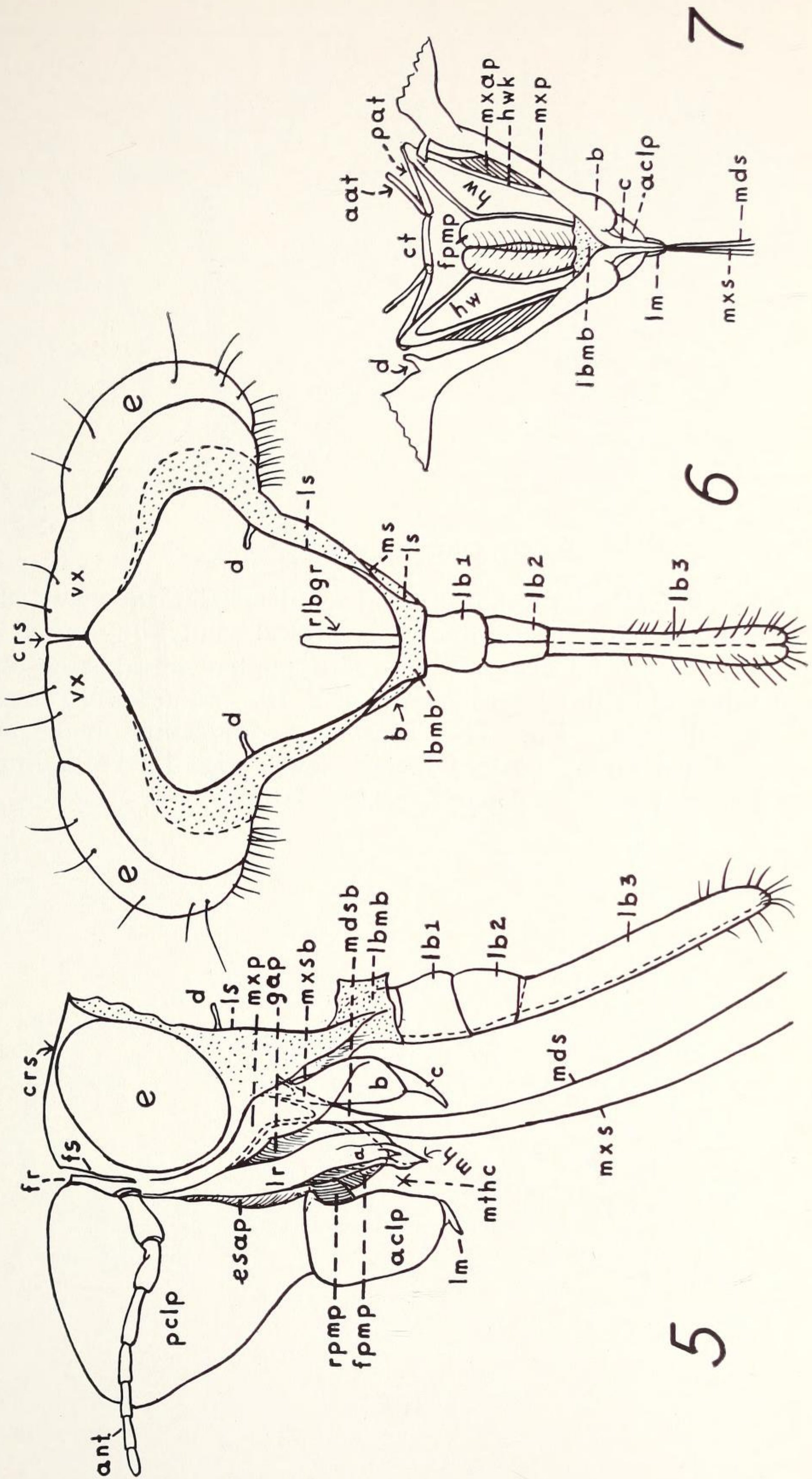
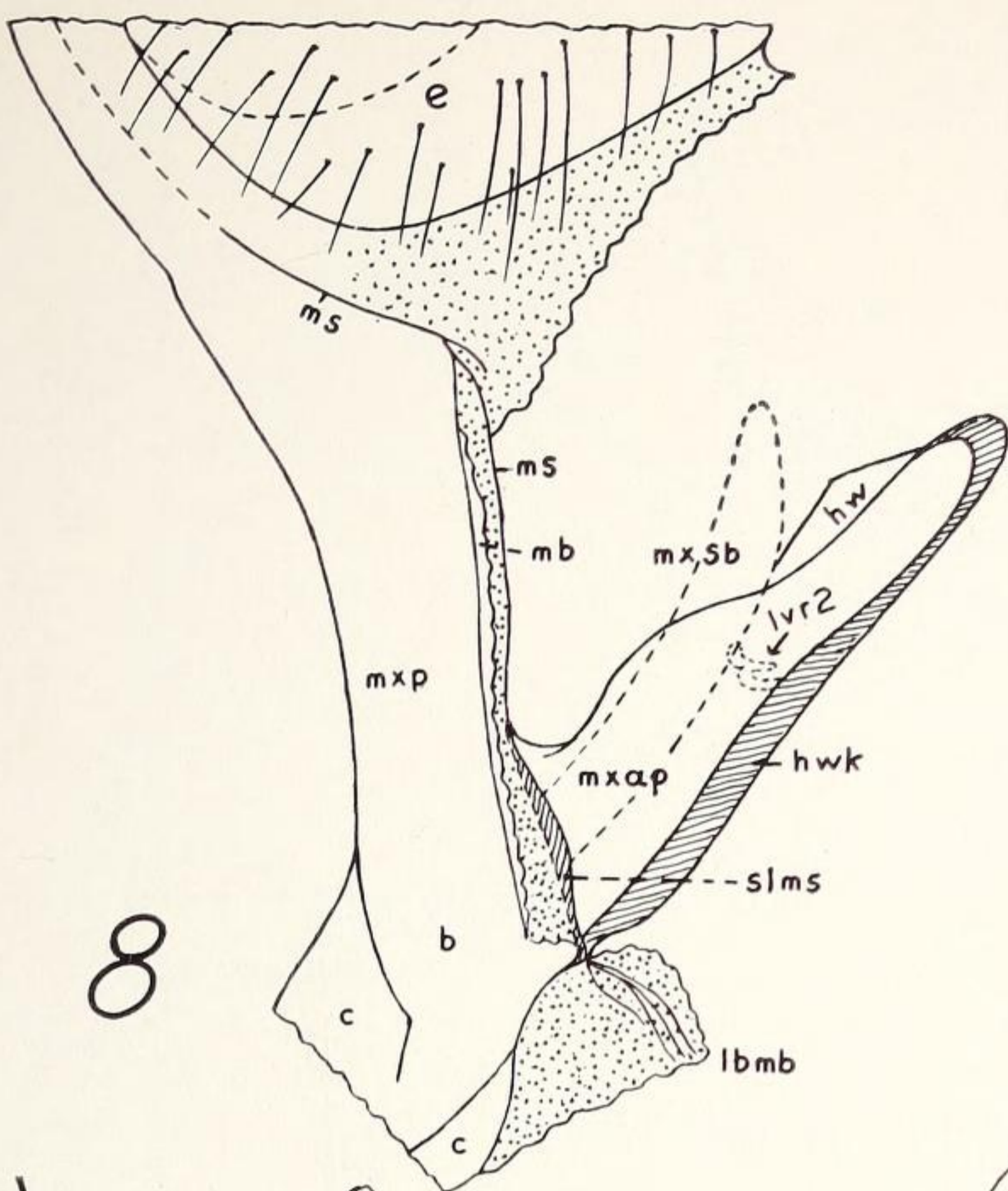
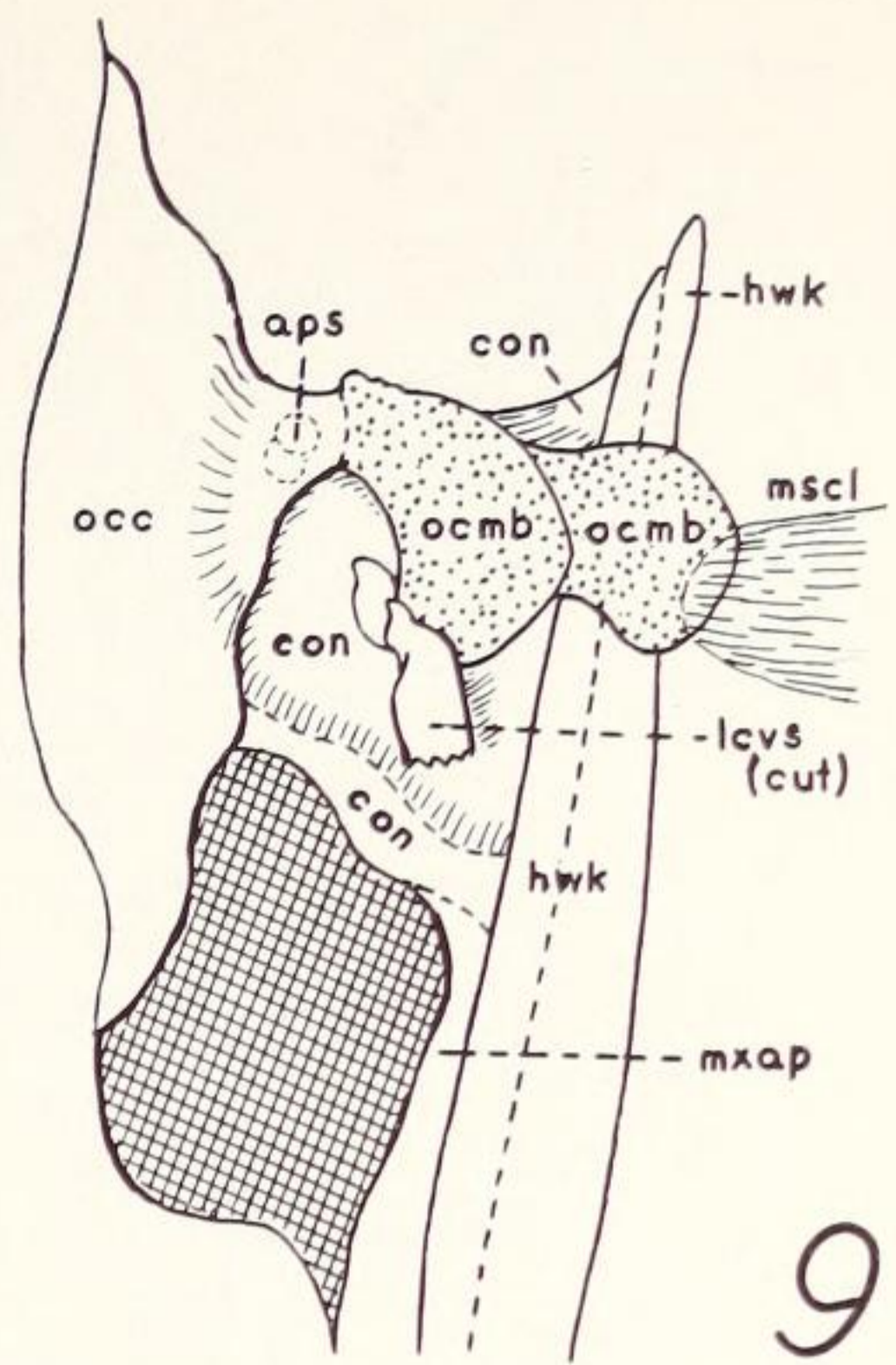


PLATE 3, HEAD

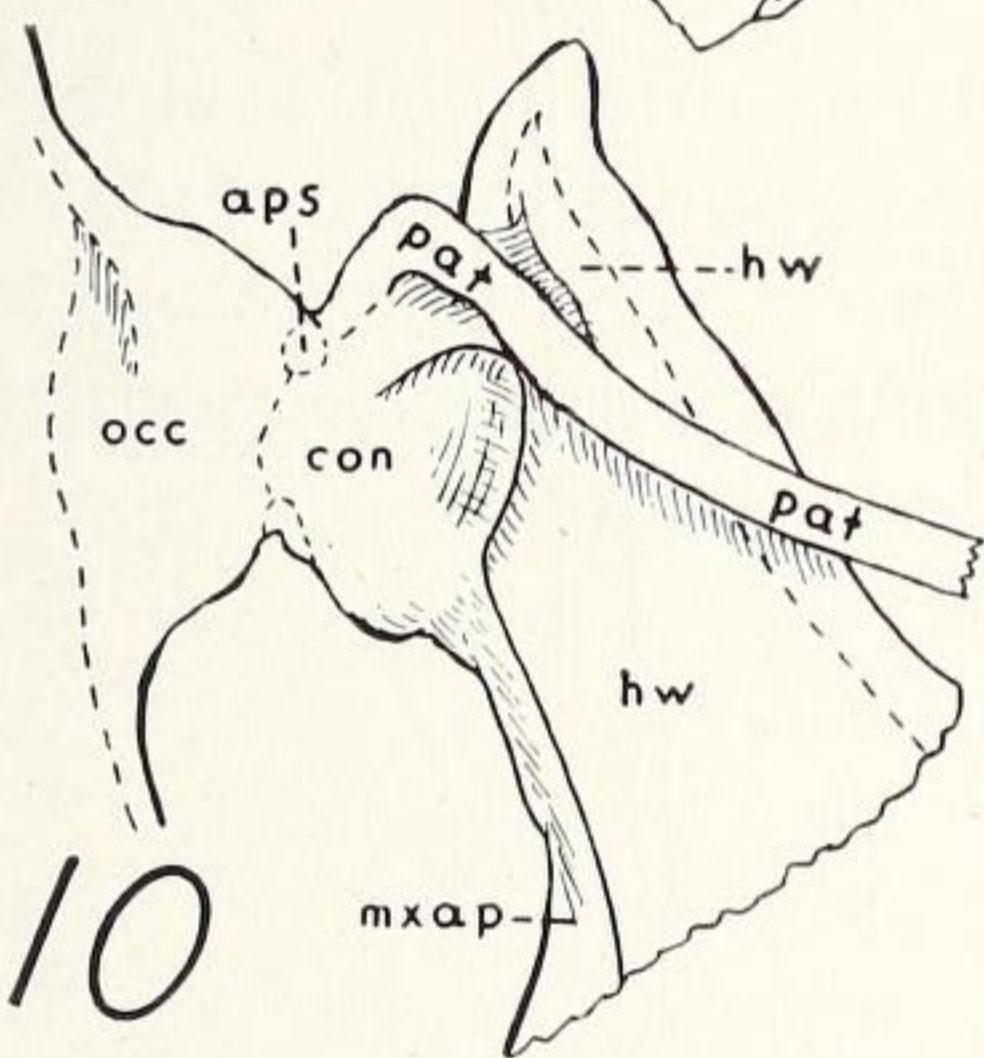
Figure 8. Maxillary suture and apodeme, lateral view. Fig. 9. The relationship of an apparent occipital condyle, terminal end of posterior tentorial arm, and tip of hypopharyngeal wing-plate, imago (sinistron side) lateral view. Fig. 10. Same as 9, (dextron side) mesal view. Fig. 11. Tentorium (showing comparative lengths of the arms) postero-dorsal view. Fig. 12. Mandibular stylet base and associated parts, postero-lateral view.



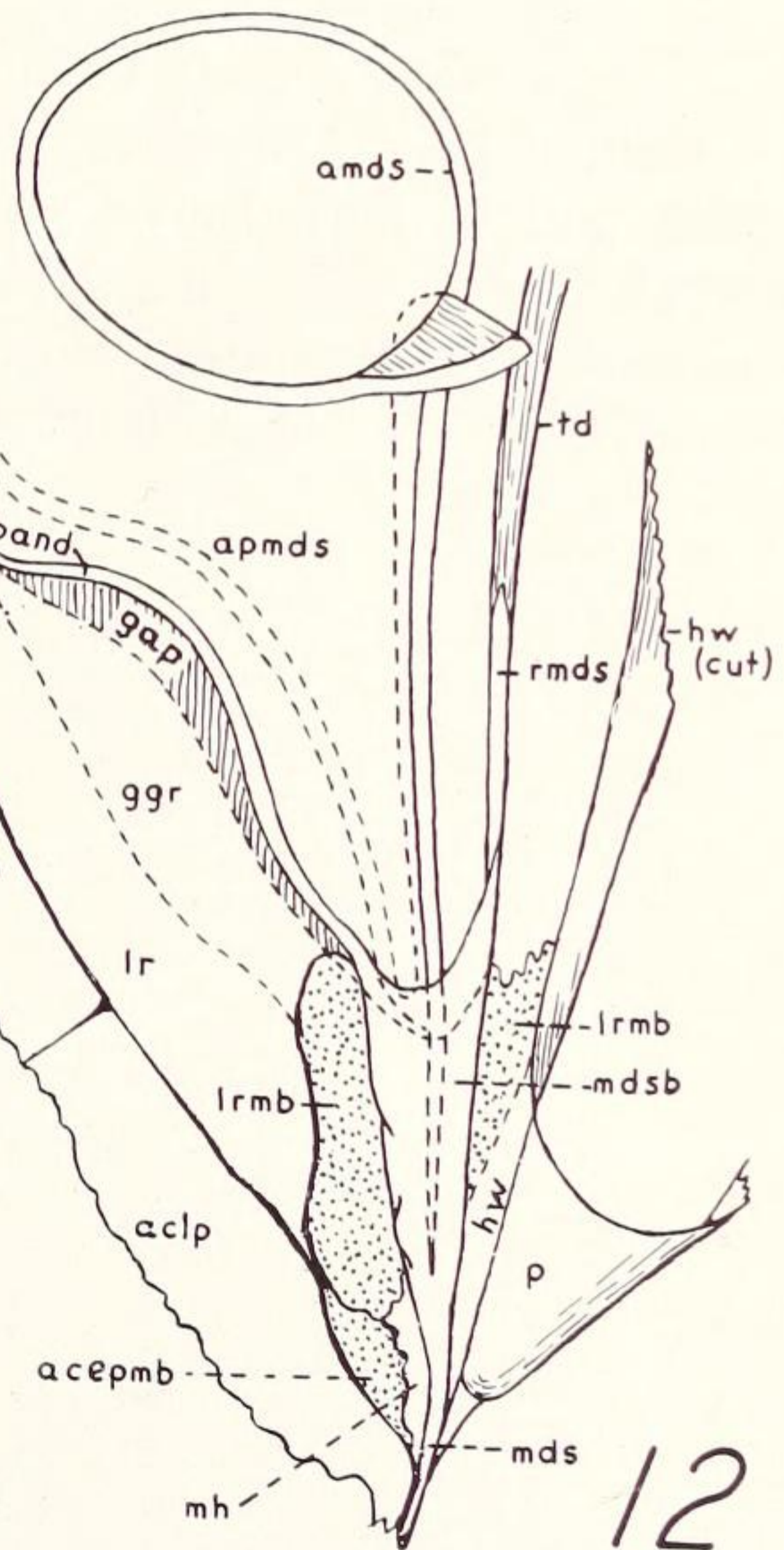
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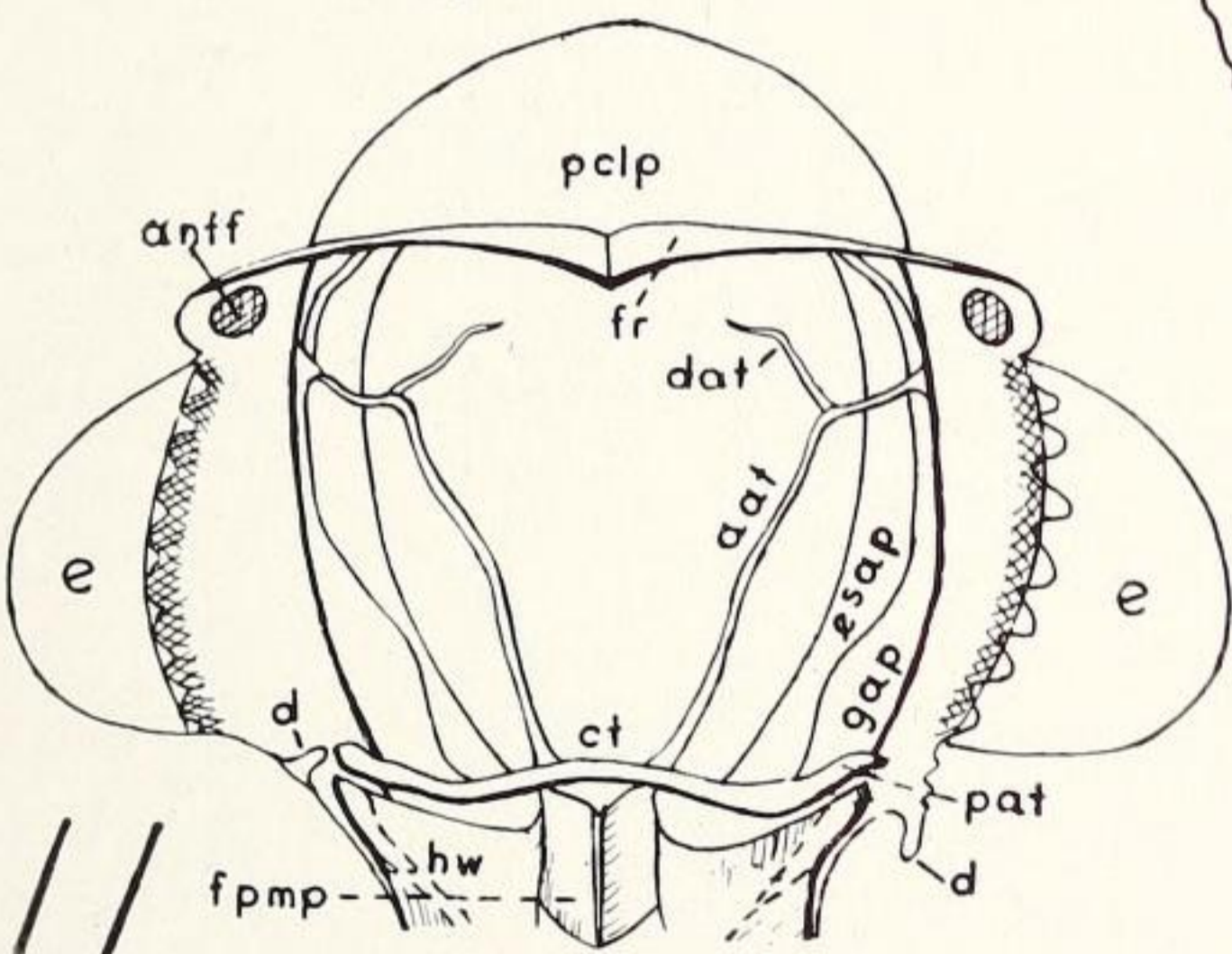
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PLATE 4, HEAD

Figure **13**. Antenna. Fig. **14**. Position of mouth stylets in stylet pouch, with lower portion of lateral pouch wall removed, lateral view. Fig. **15**. Mesal wall of stylet pouch, with stylets removed, lateral view. Fig. **16**. Maxillary stylet base, posterior view. Fig. **17**. Maxillary stylet base, mesal view.

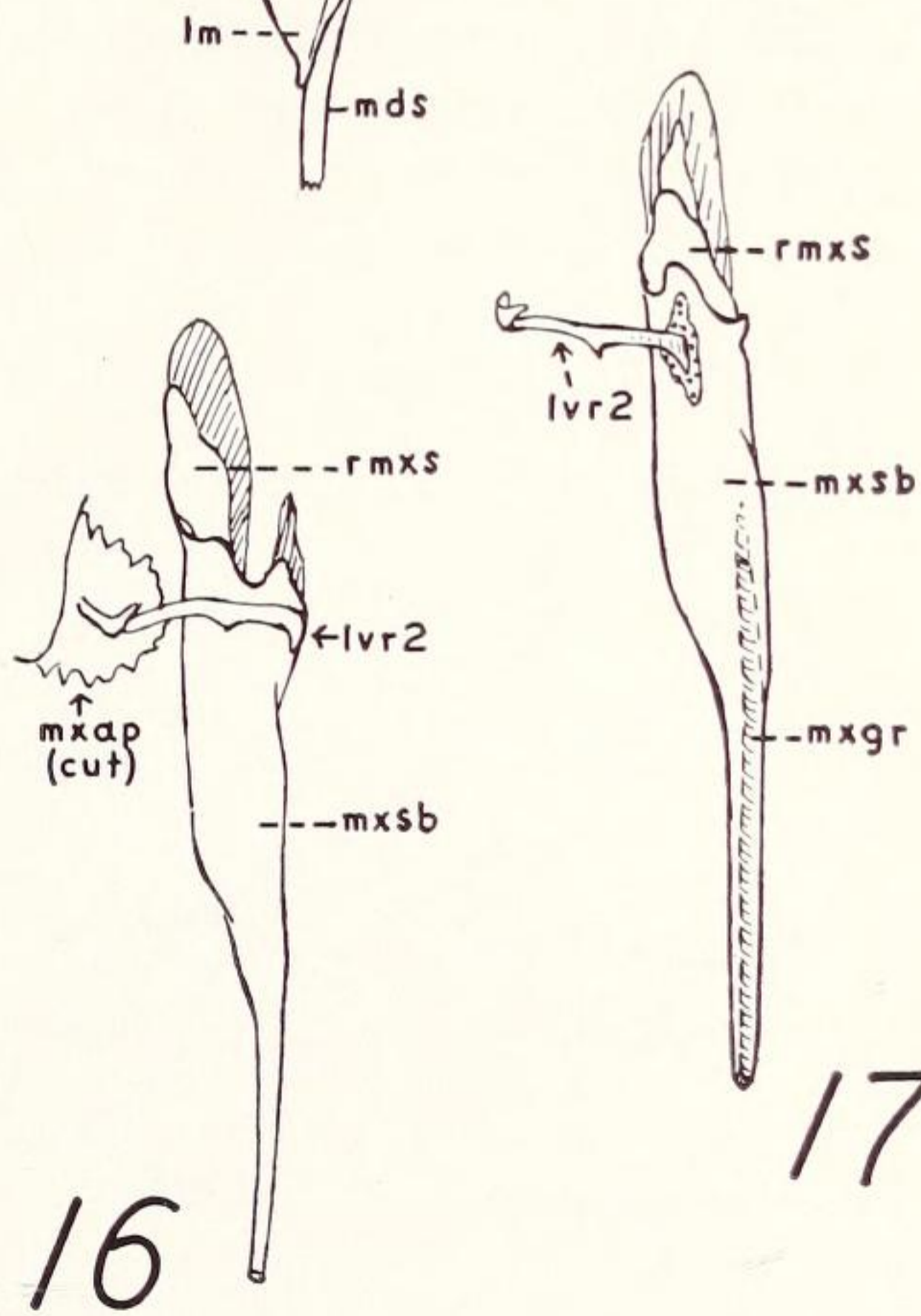
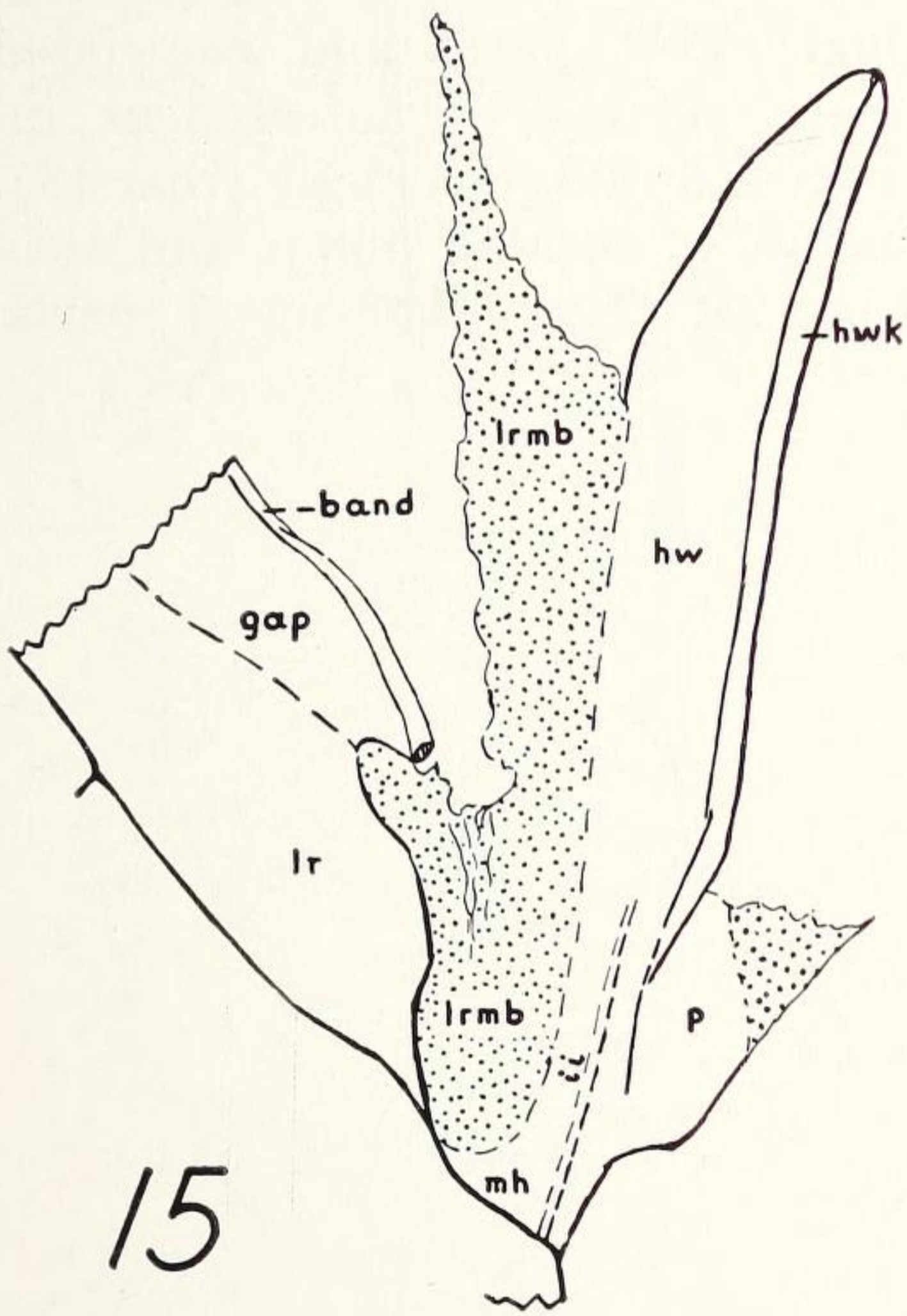
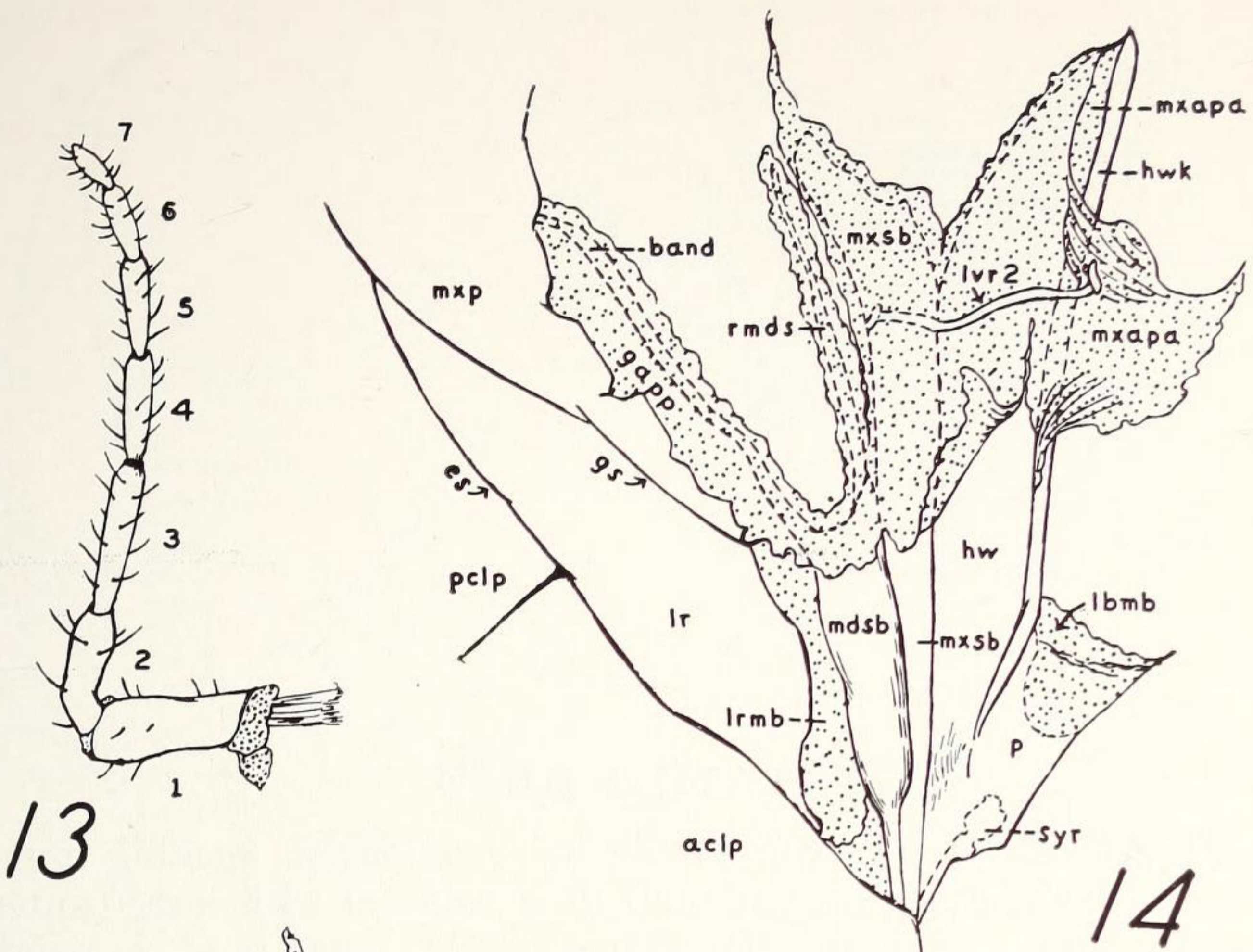


PLATE 5, HEAD

Figure **18**. Loral (or posterior) portion of sucking pump, median lobe of hypopharynx, and their relation with lora, (antero-dorsal view). Fig. **19**. Hypopharyngeal parts and associated cranial structures ("epipharyngeal" surface of anteclypeus included), antero-dorsal view. (seen from a different angle from 18). Fig. **20**. Clypeal (or anterior) portion of sucking pump, and associated parts, posterior view. Fig. **21**. Hypopharyngeal parts, lateral view.

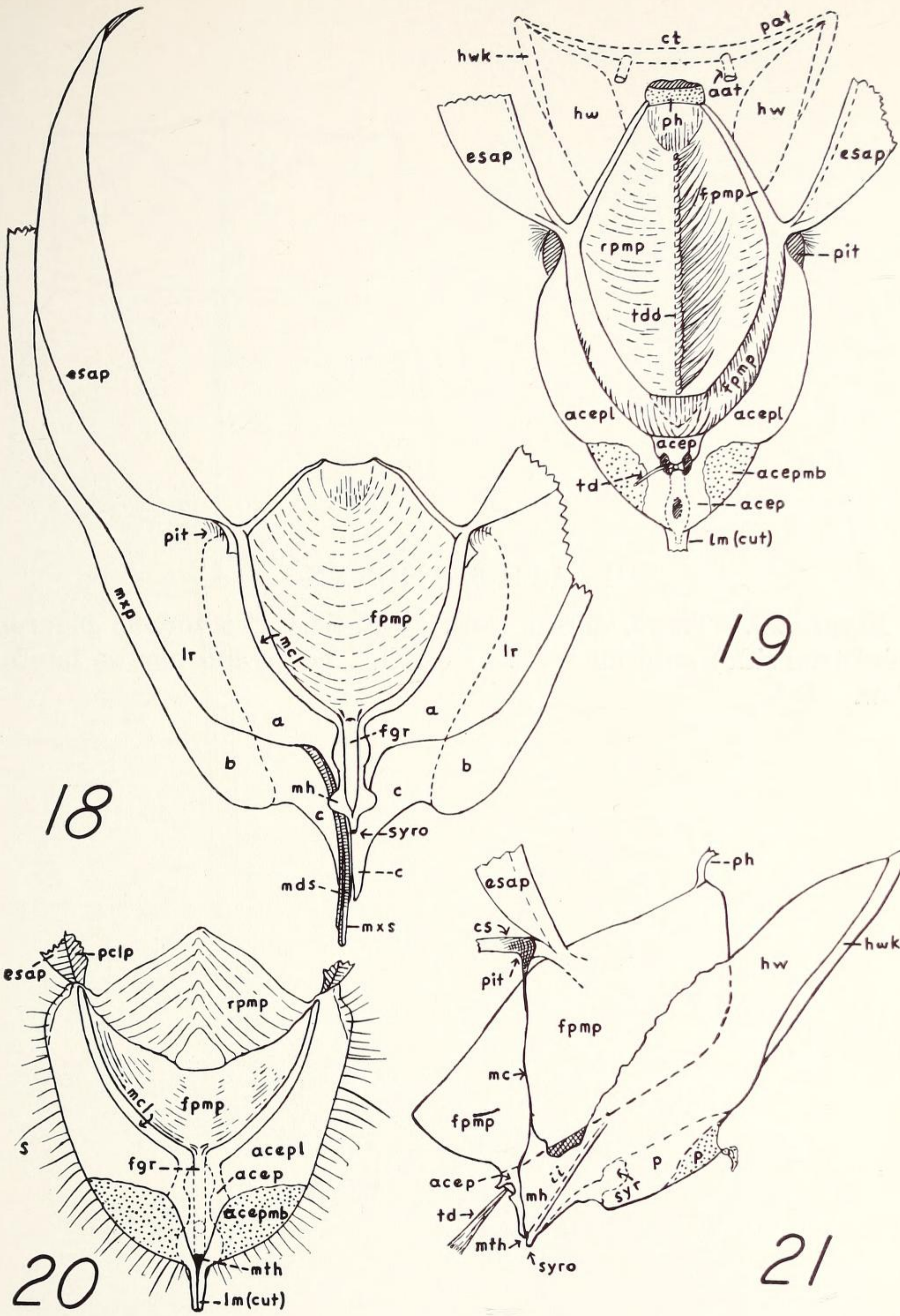
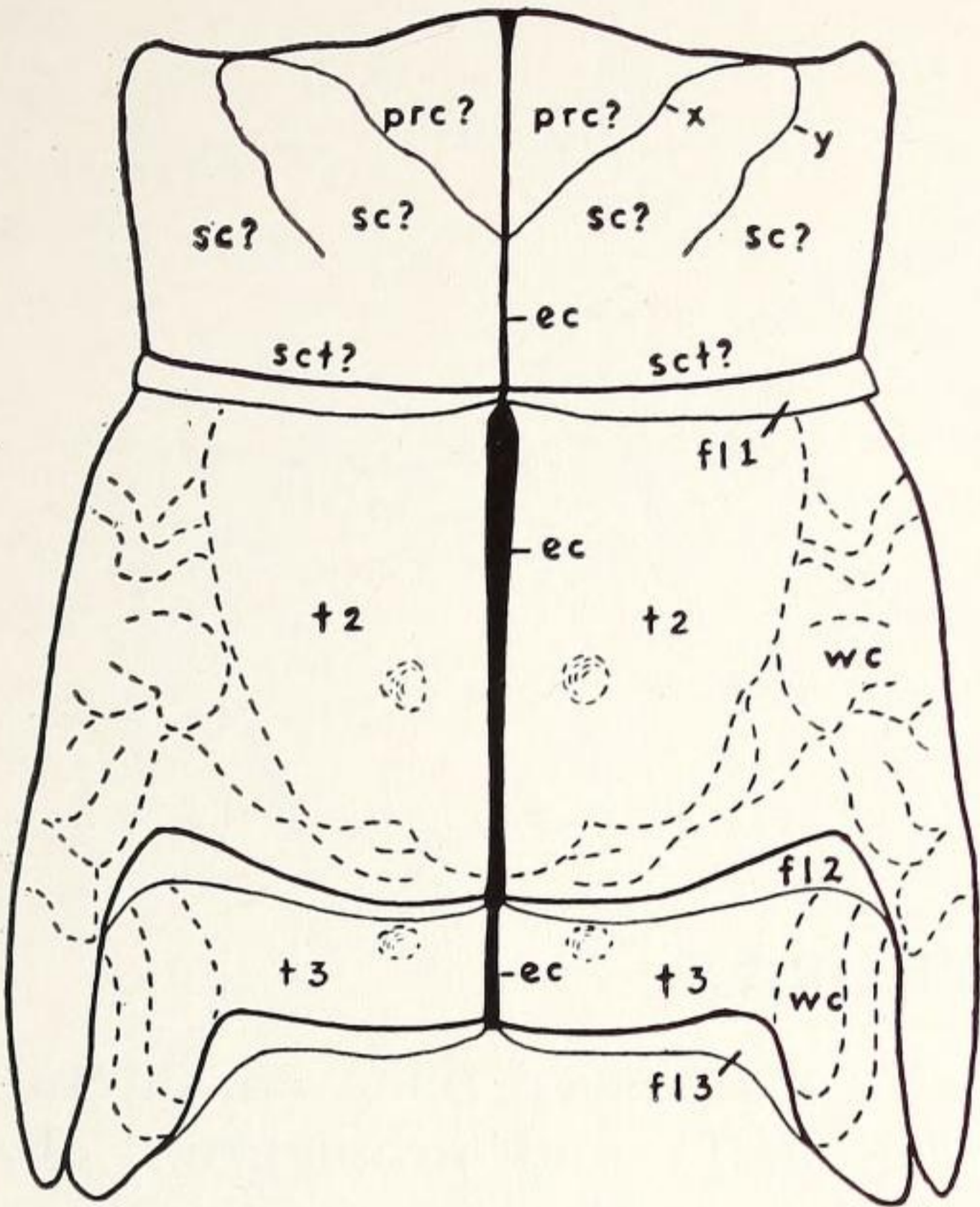


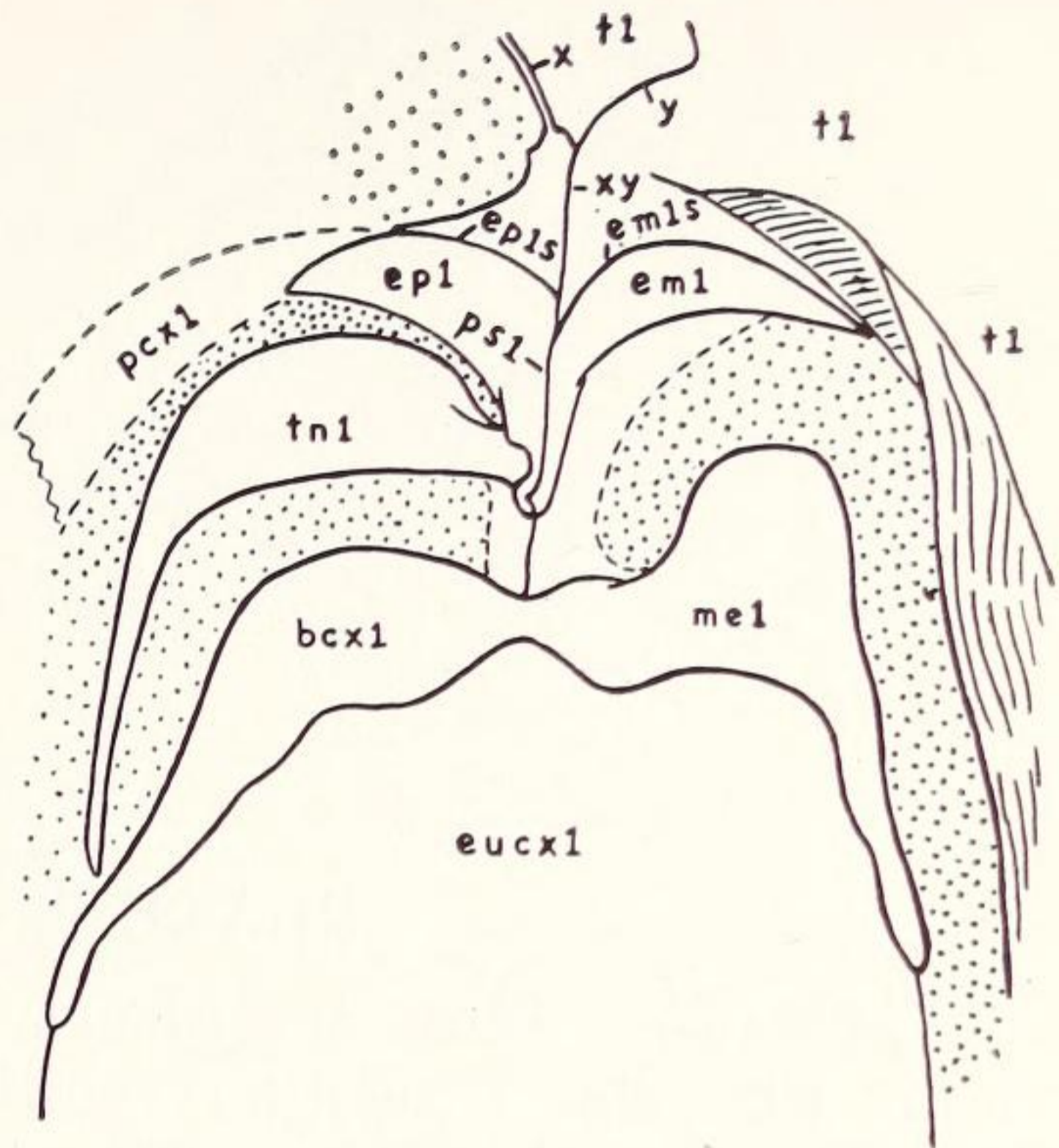
PLATE 6, THORAX

Figure **22**. Terga, dorsal view. Fig. **23**. Prothoracic pleuron (sinistron side) anterior view. Fig. **24**. Terga and pleura, lateral view.

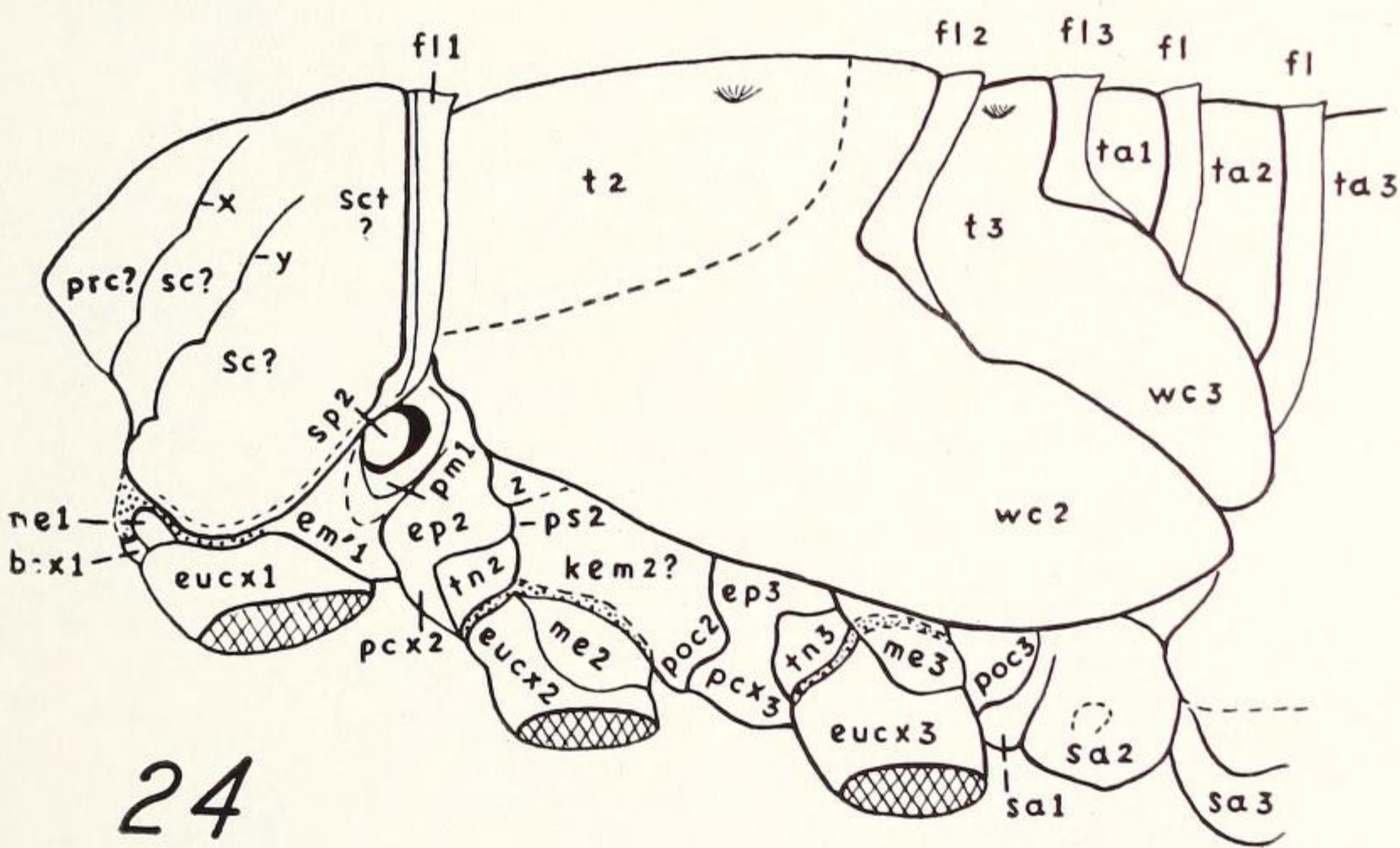




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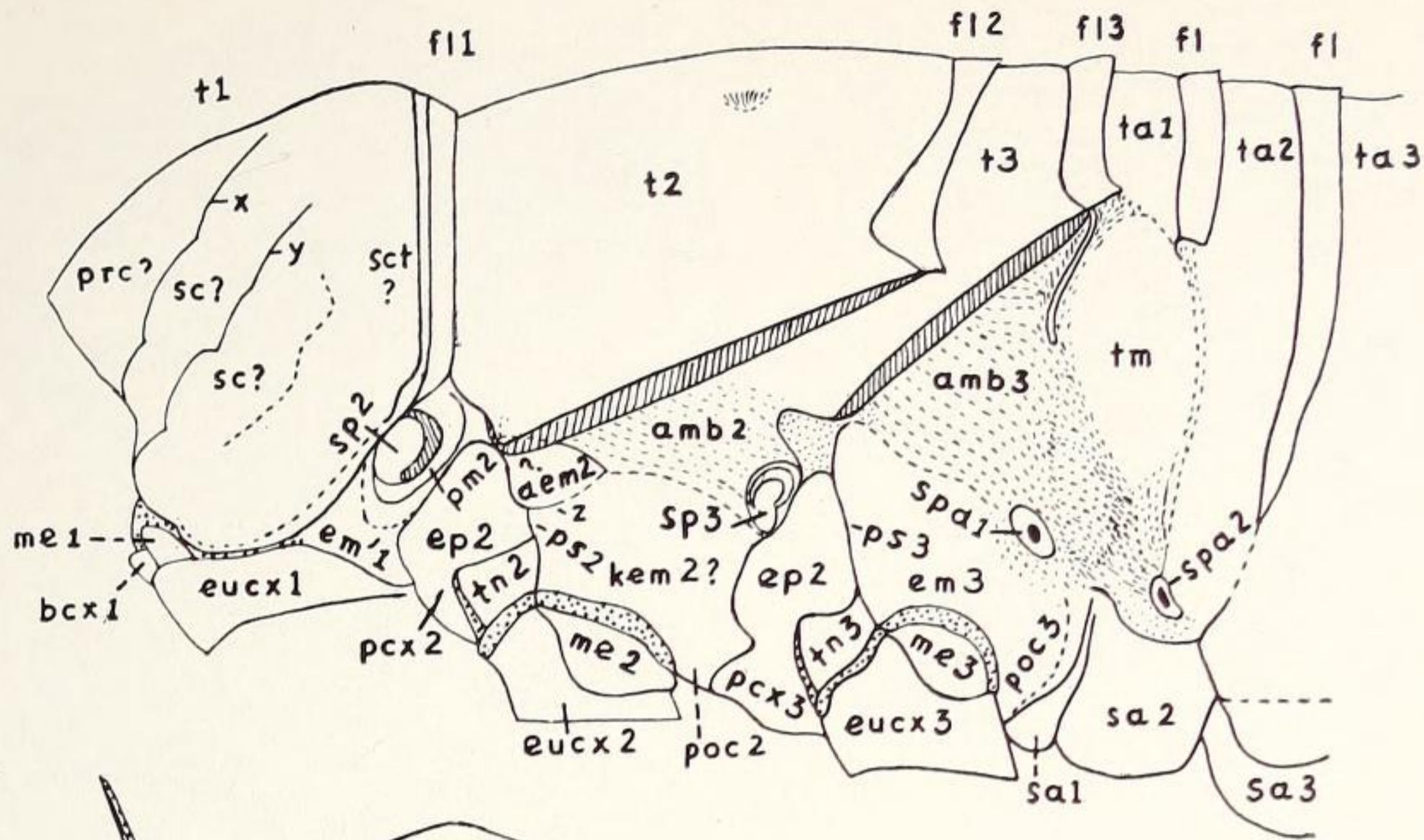
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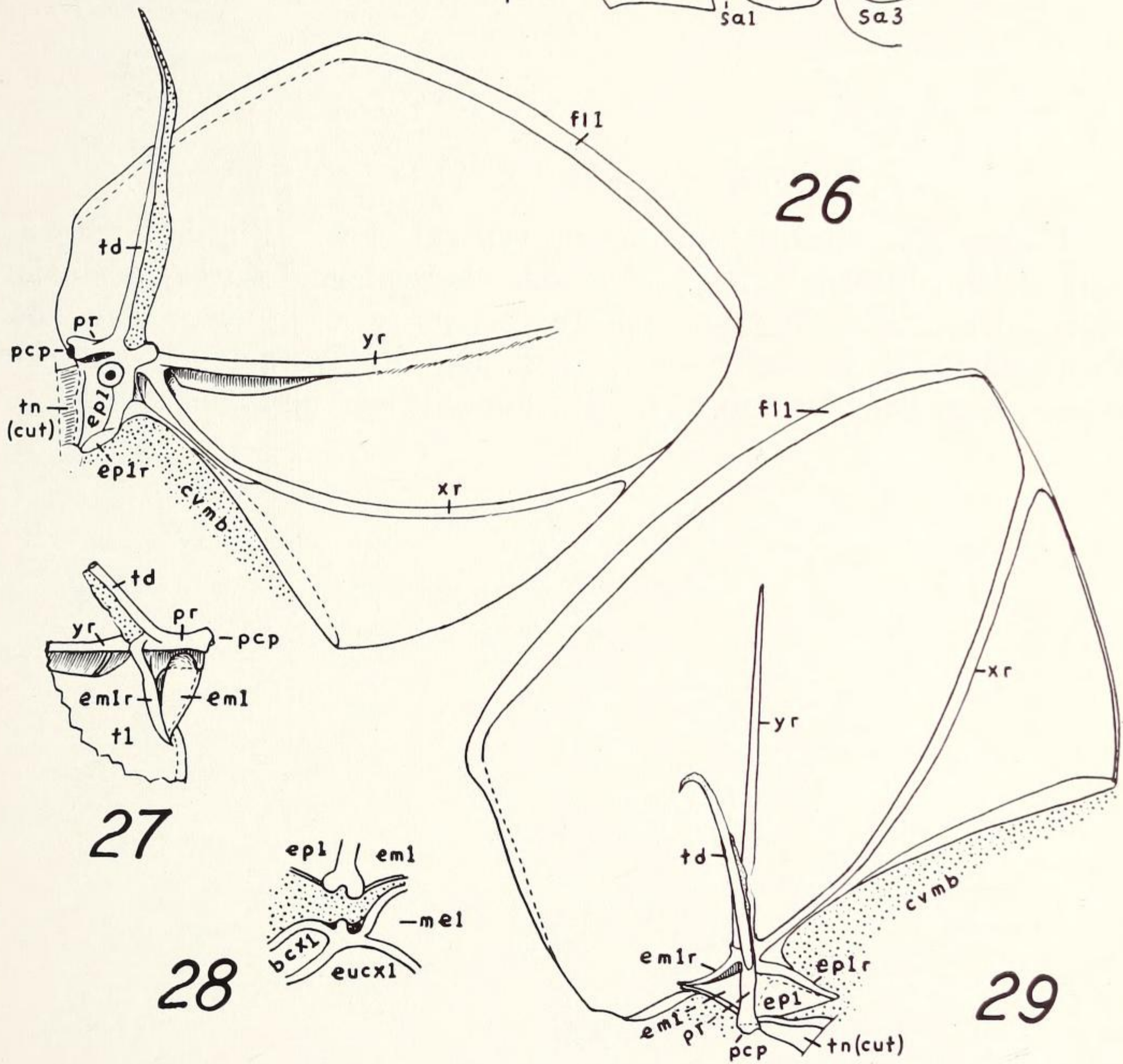
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PLATE 7, THORAX

Figure 25. Terga and pleura, with wing cases removed, lateral view. Fig. 26. Pronotum (sinistron half) and propleuron, oblique internal view. Fig. 27. Anterior portion of proepimeron (sinistron side), seen from a view point opposite to that of 26. Fig. 28. Pleural articulation of procoxa (dextron side) internal view. Fig. 29. Pronotum (dextron half) and propleuron, internal view.



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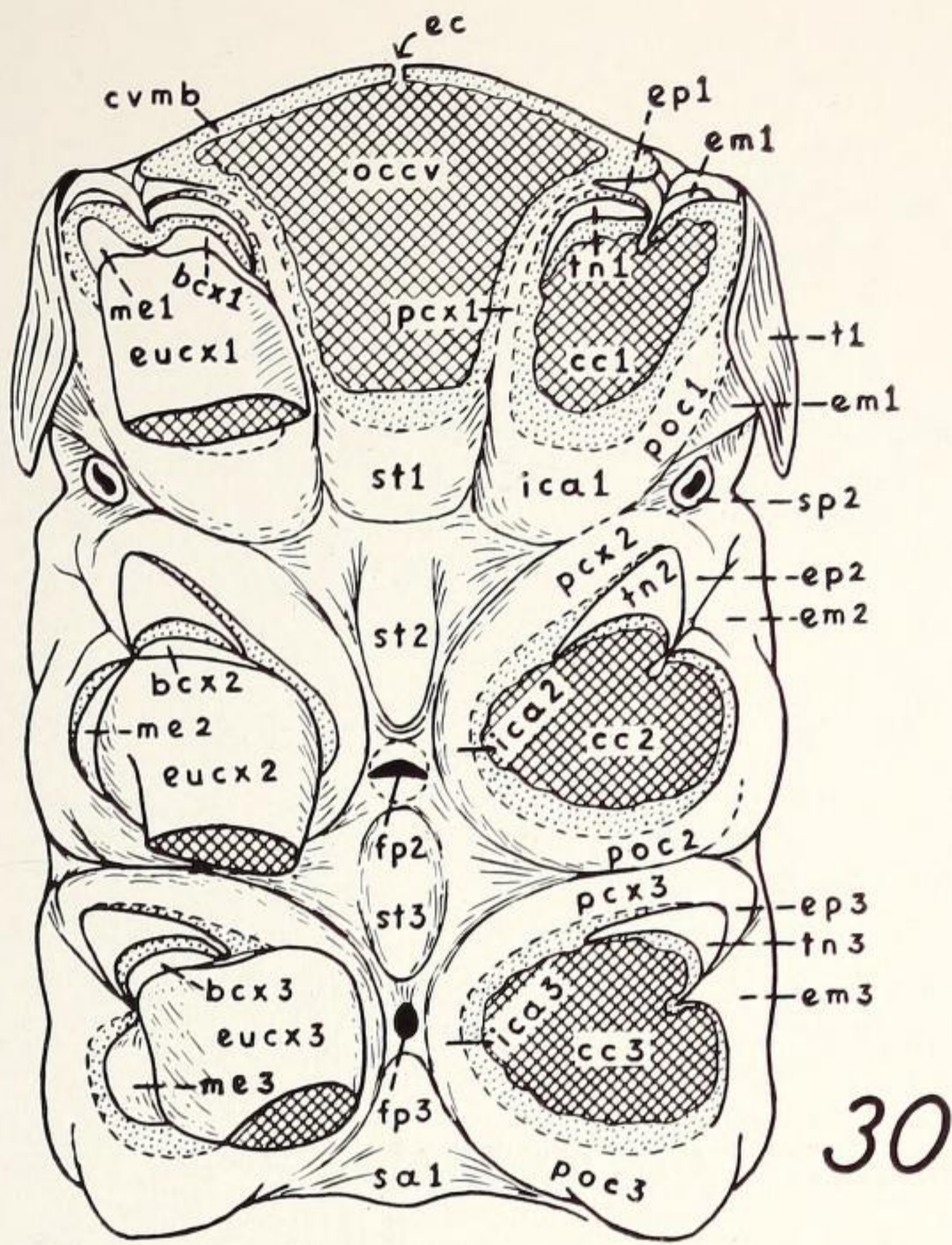
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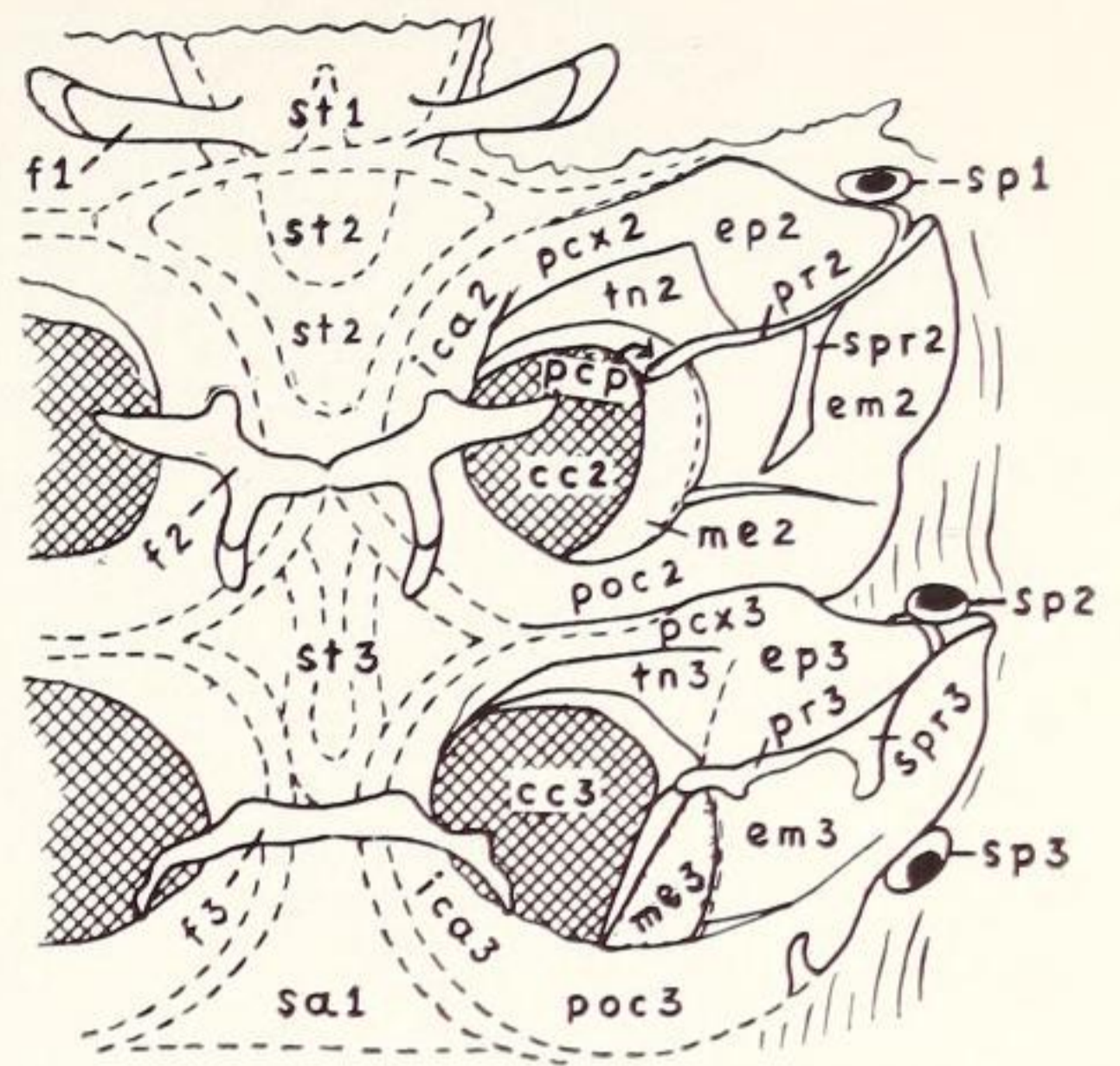
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PLATE 8, THORAX AND LEGS

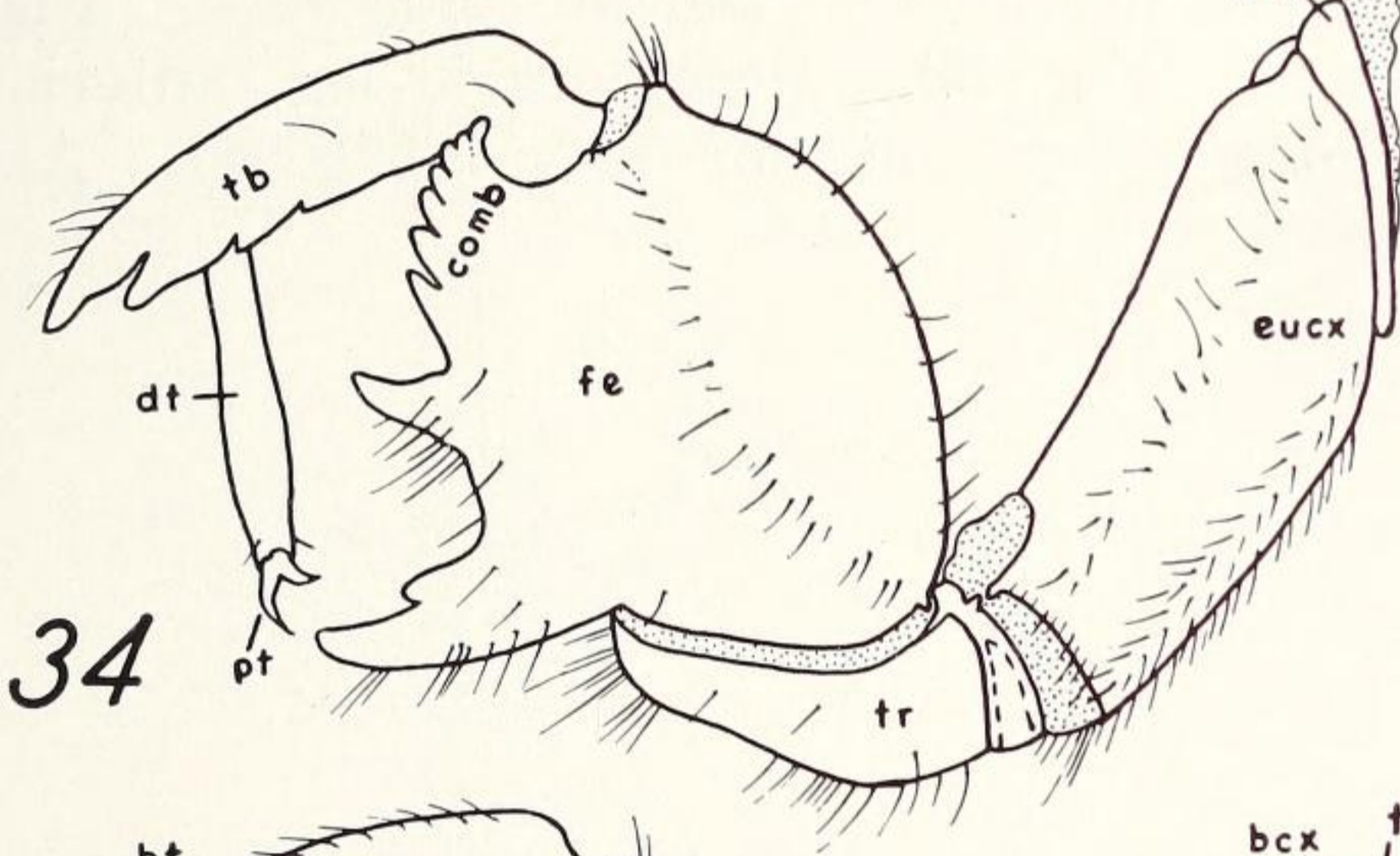
Figure 30. Sterna and pleura, ventral view. Fig. 31. Sterna and pleura, internal view. Fig. 32. Mesosternal furca, posterior view. Fig. 33. Metasternal furca, posterior view. Fig. 34. Prothoracic leg, posterior view. Fig. 35. Prothoracic leg, anterior view. Fig. 36. Pretarsus of prothoracic leg, posterior view.



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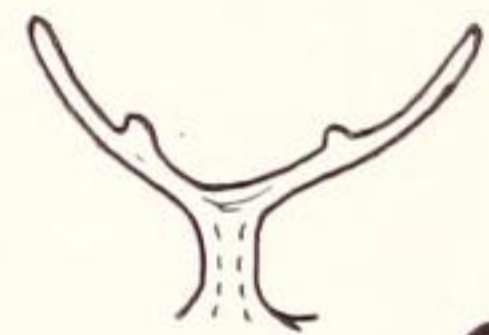
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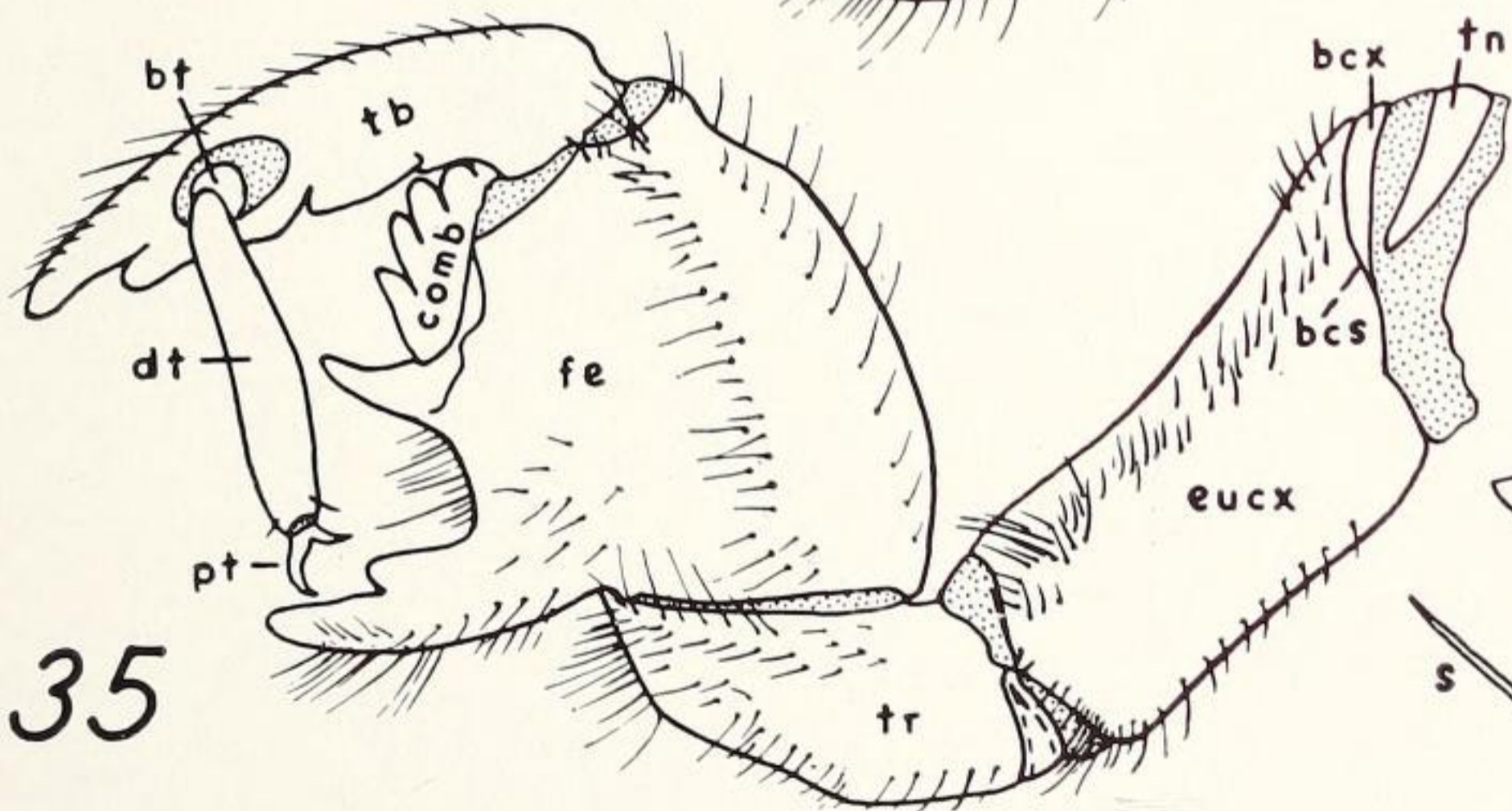
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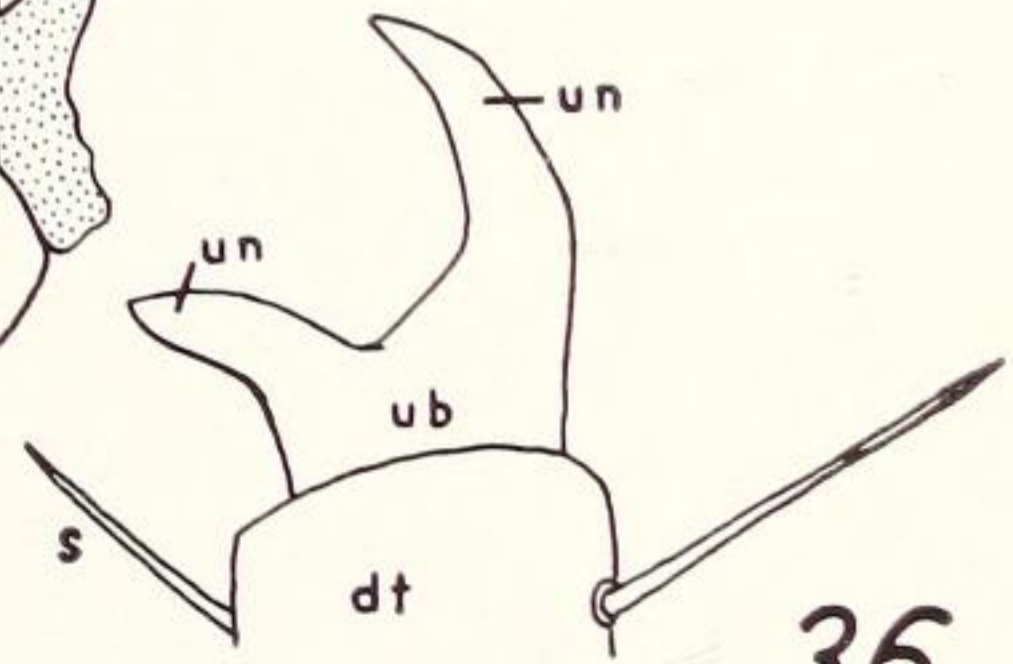
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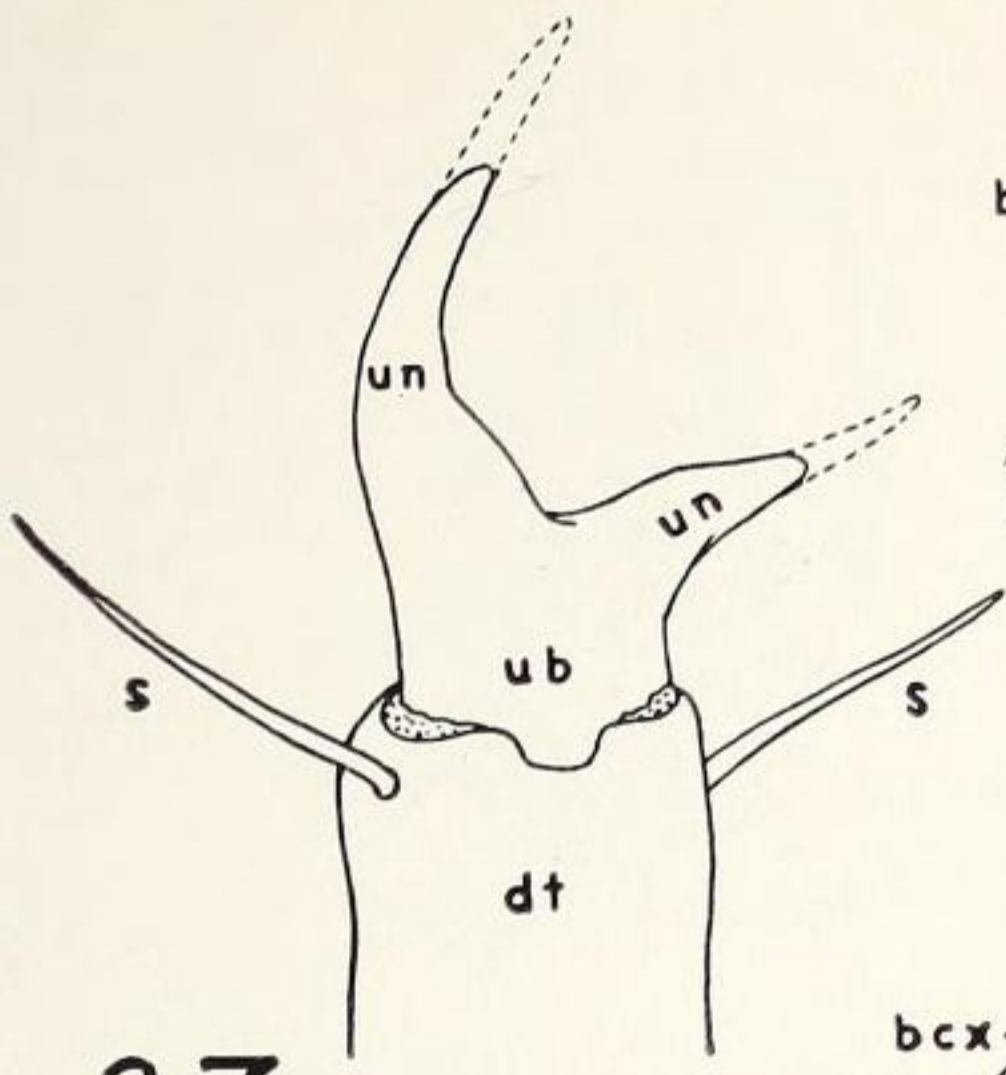
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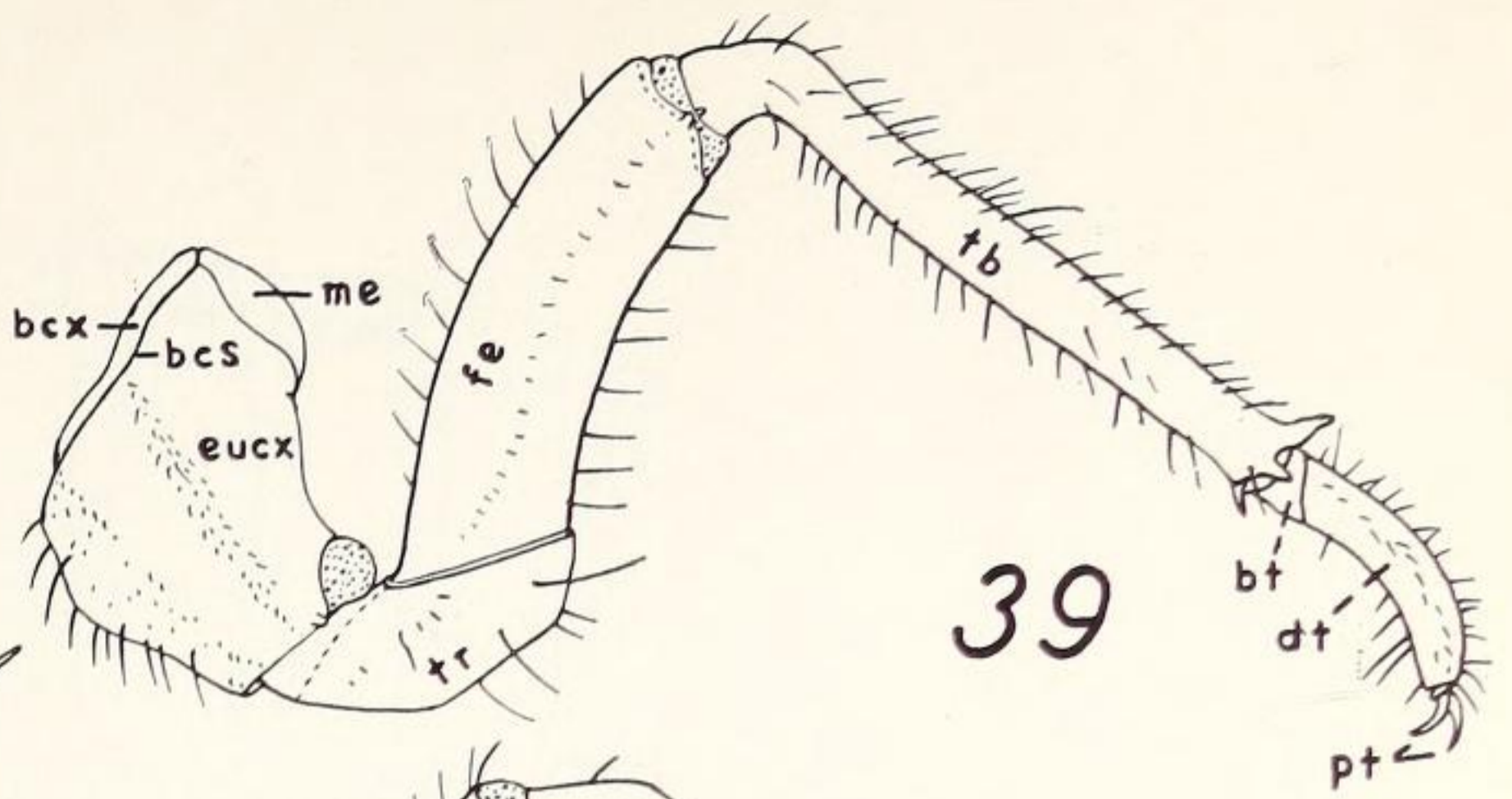
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PLATE 9, LEGS AND ABDOMEN

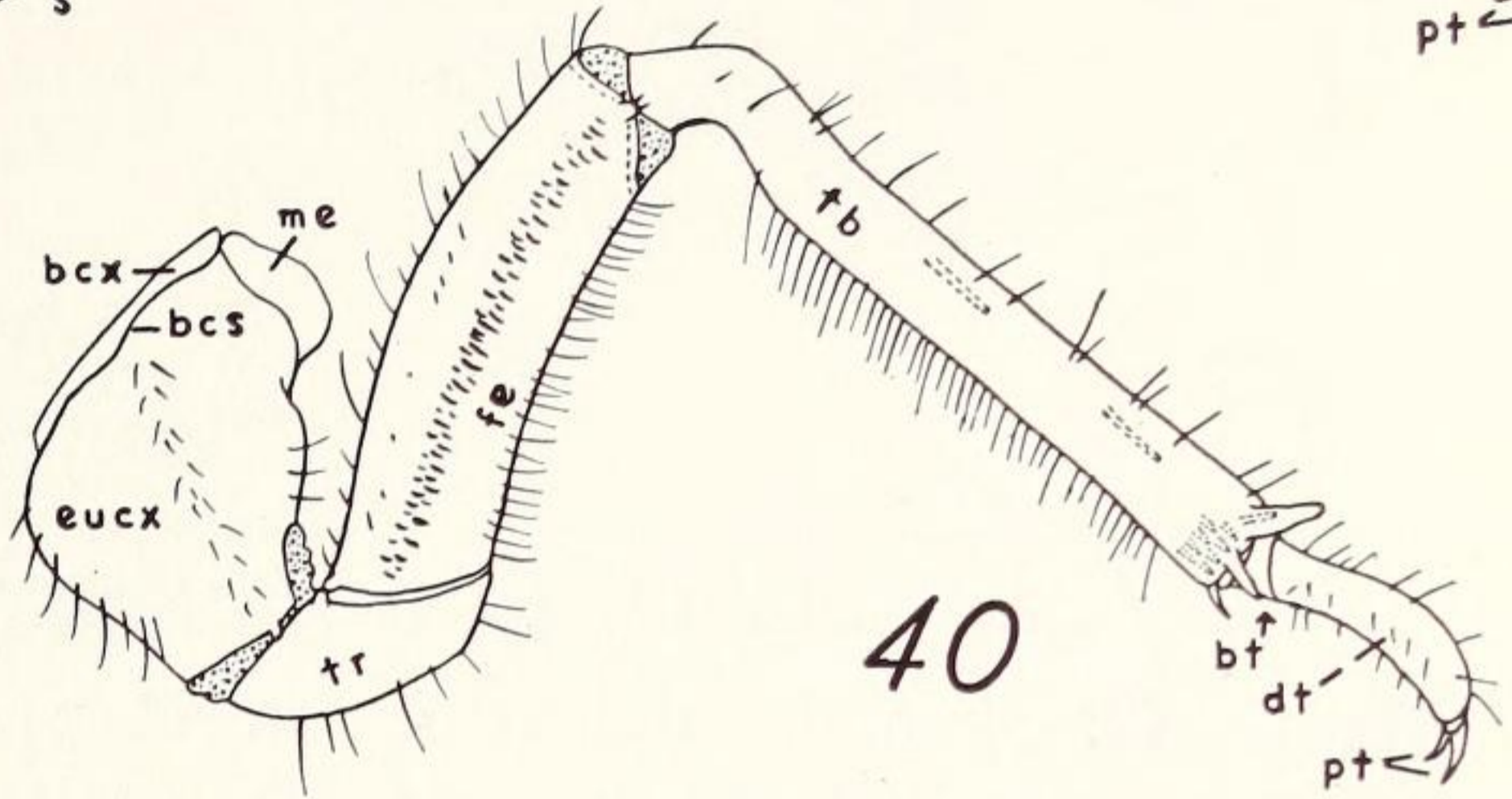
Figure **37**. Pretarsus of prothoracic leg, anterior view. Fig. **38**. Same as 37, enlarged. Fig. **39**. Mesothoracic leg, anterior view. Fig. **40**. Metathoracic leg, anterior view. Fig. **41**. Abdomen, female, ventral view.



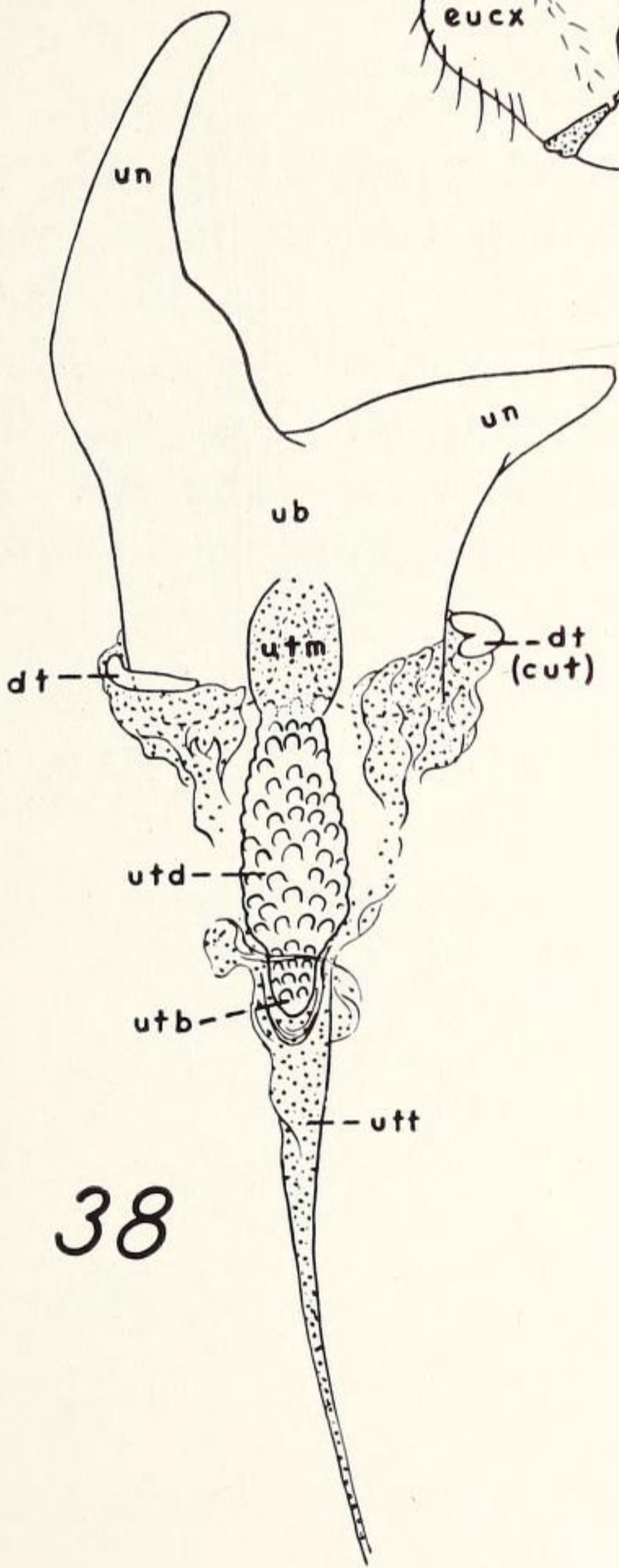
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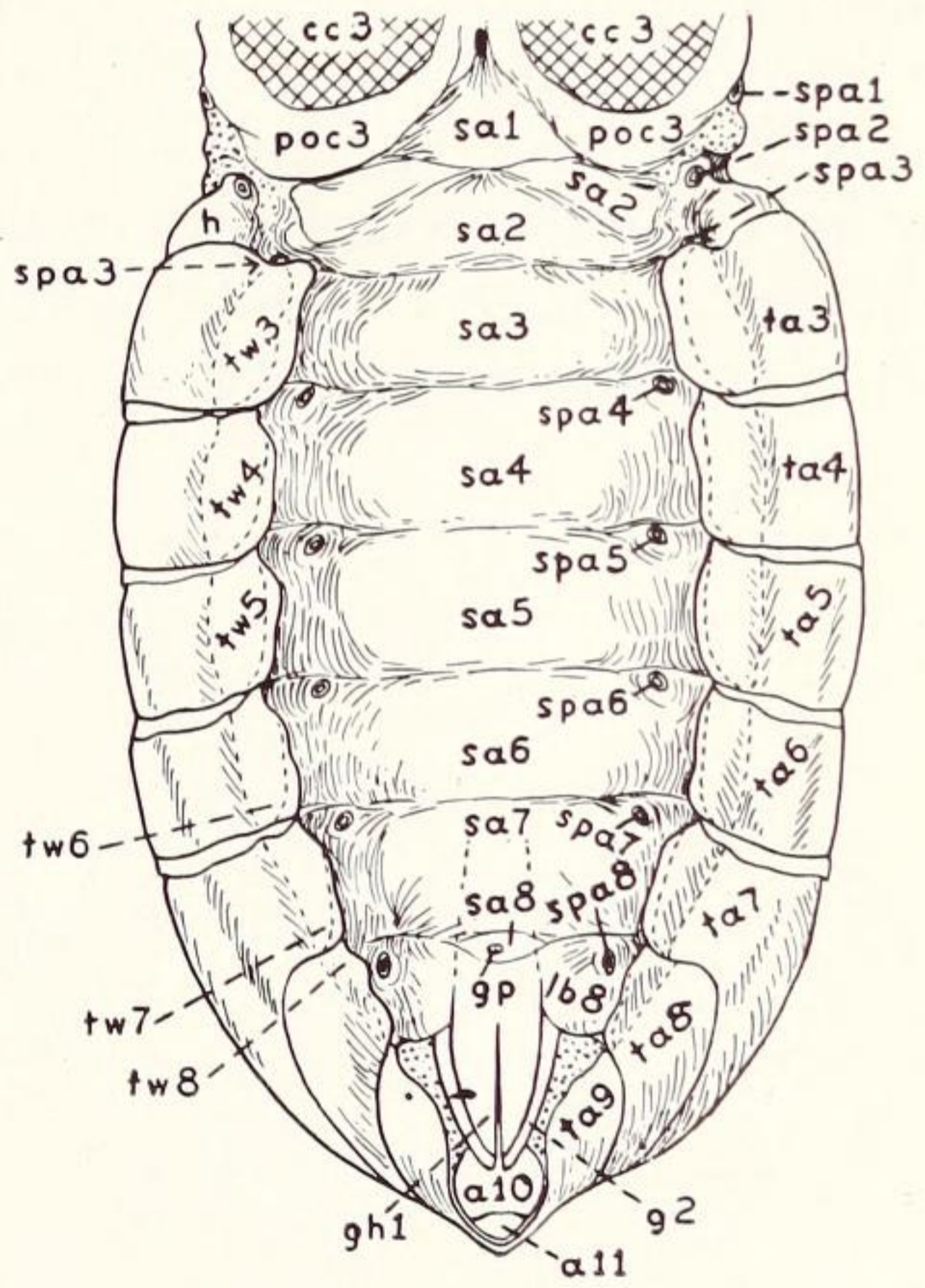
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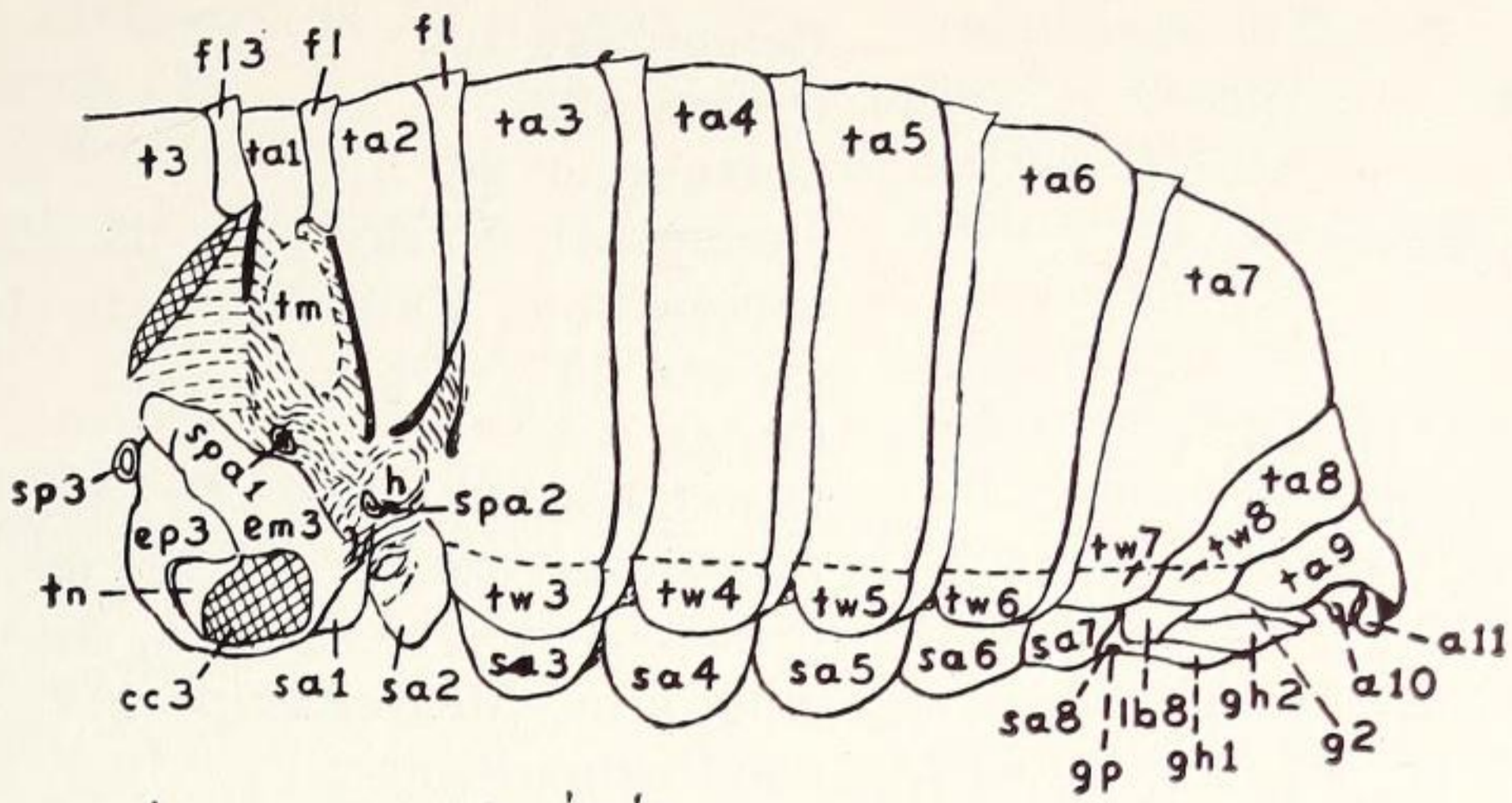


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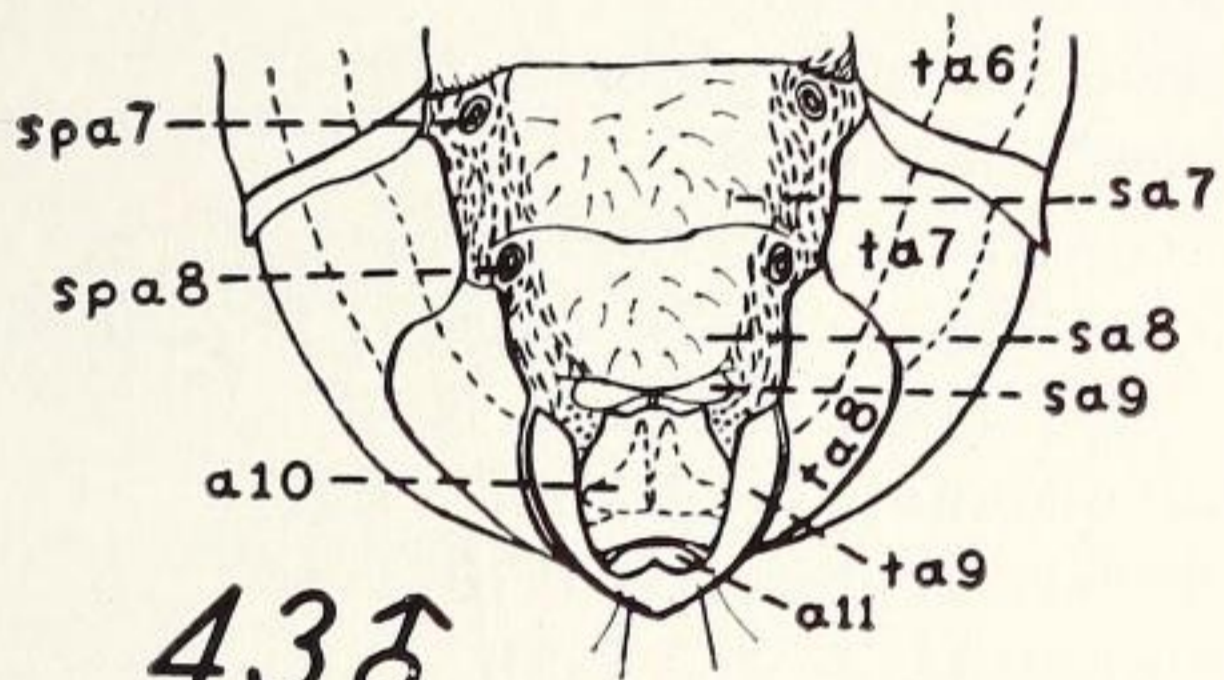
PLATE 10, ABDOMEN

Figure **42**. Female abdomen, lateral view. Fig. **43**. Male terminalia, ventral view. Fig. **44**. Ninth tergite, male, ventral view (tenth tergite moved slightly out of place). Fig. **45**. Female terminalia, with first gonapods removed, ventral view. Fig. **46**. Same as 45, with second gonapophyses removed. Fig. **47**. Tenth and eleventh segments, male postero-lateral view. Fig. **48**. Same as 47, terminal view (tenth segment moved slightly out of place).

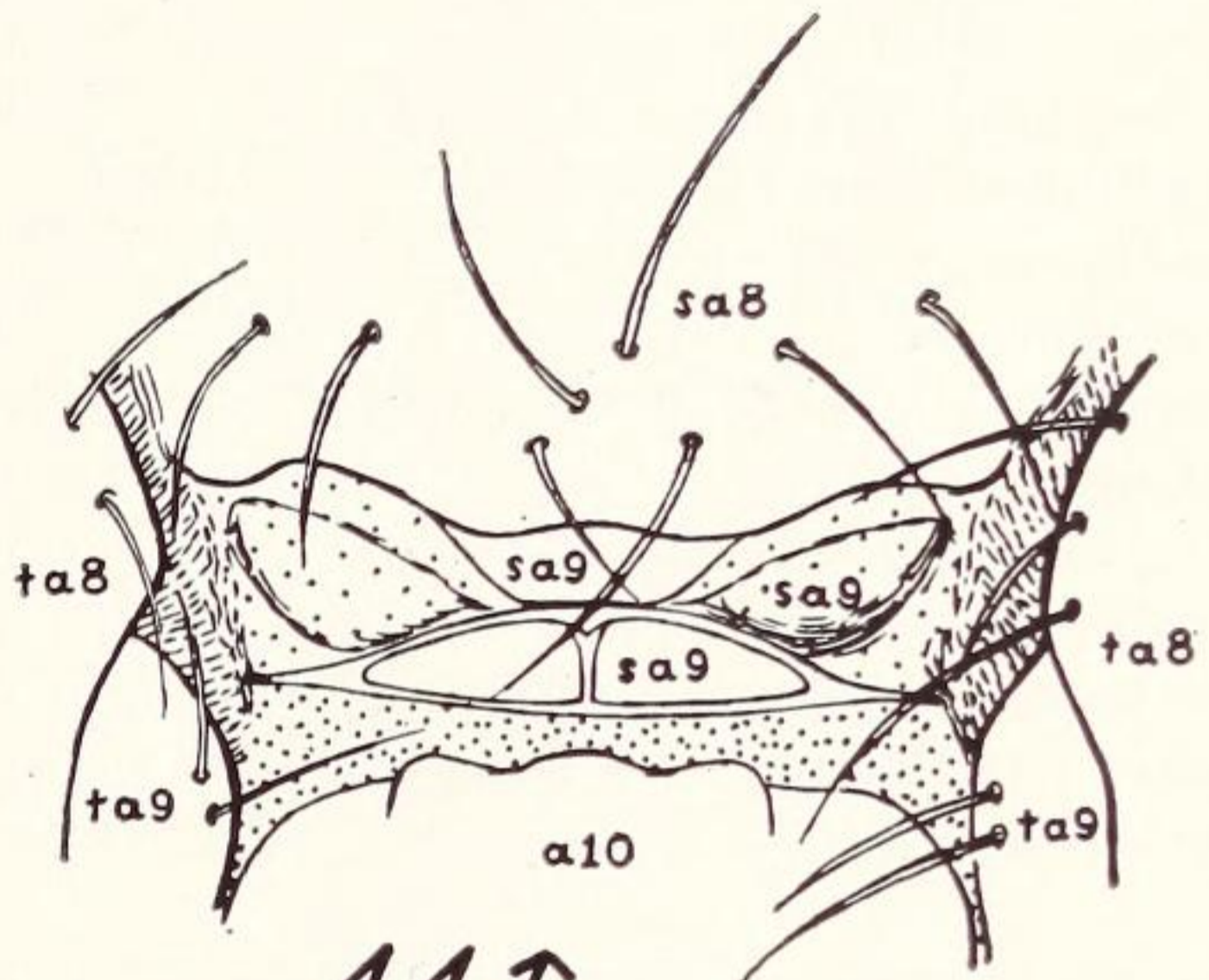




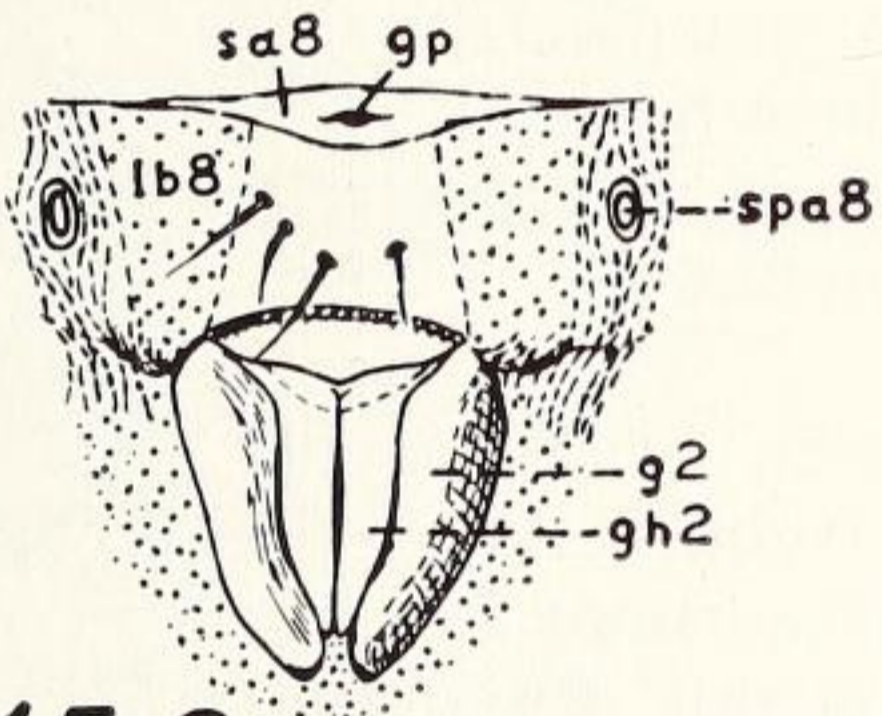
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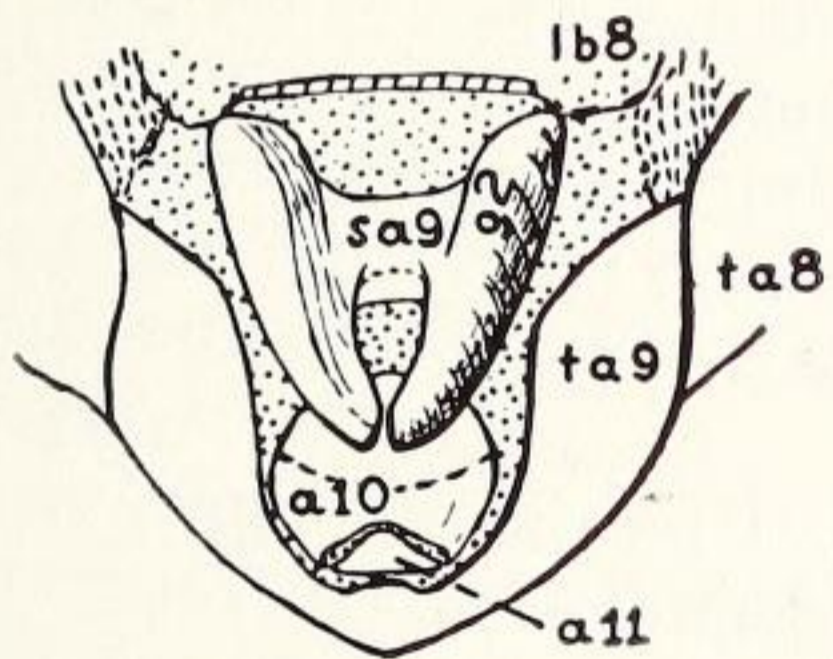
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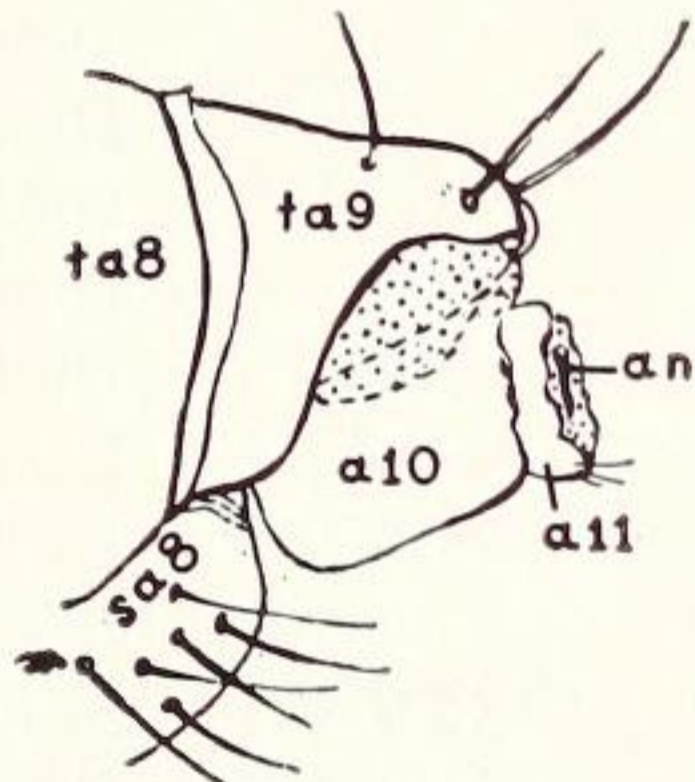
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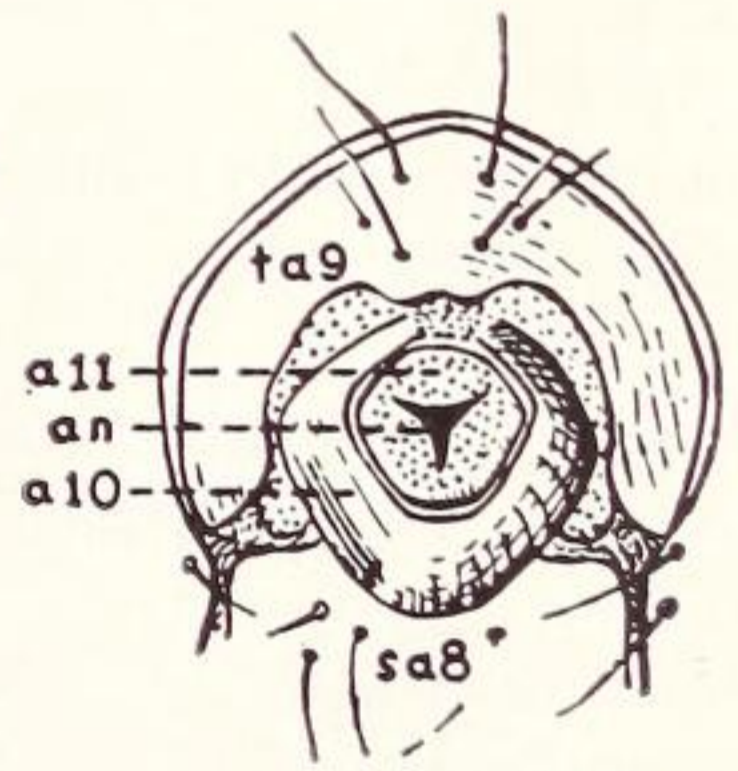
45♀



46♀



47♂



48♂