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ANATOMY OF THE ADULTS OF *LOXAGROTIS ALBICOSTA*

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Introduction

LEPIDOPTERA are divided into the major suborders Monotrysia and Ditrysia (Borner, 1939). The vast majority of Lepidoptera belong to the Ditrysia. The Noctuidae, which is the largest family in the order, is probably the most destructive (Metcalf, et al., 1962). It includes *Loxagrotis albicosta* (Smith), the western bean cutworm, originally a pest of field beans, which has become a relatively serious pest of corn in southwestern and central Nebraska (Hagen and Roselle, 1972). Adults emerge from early July to late August, and eggs, which are deposited on the upper sides of corn leaves, hatch in approximately 1 week. The newly emerged larvae feed on pollen of the developing tassels or after tassel emergence will feed on the silks. There are 5 larval instars, with the 4th and 5th instars feeding on the developing kernels until larval maturity. Mature larvae enter the soil and overwinter as prepupae in earthen cells and pupate during late May (Hagen, 1962). Although the life history of *L. albicosta* is known, other aspects of its biology have not been reported. This study is an attempt to present details of the external structure of *L. albicosta.* No extensive treatment of noctuid anatomy is available; however, there does exist an enormous body of knowledge concerning structural details in the various species of Lepidoptera. But that knowledge is for the most part weakly coordinated. Basic studies of this nature should be the prerequisite to investigations in the diverse areas of entomology.

MATERIAL AND METHODS

Adults of *L. albicosta* were collected from black-light traps during the summers of 1971 and 1972 in York and Hamilton Counties, Nebraska. Adults were anesthetized with CO_2, dissected under physiological saline and stained with Wright's blood stain. For studies of the exoskeleton, specimens were treated with hot, 10% KOH to dissociate soft tissues and facilitate removal of setae. Adults were stored in a mixture of glycerol-formalin (10 ml glycerol/90 ml 5% formalin).

For histological studies, dissected tissues were fixed in Duboscq and Brasil's fluid (Galigher and Kozloff, 1964) dehydrated through 100% ethanol, cleared in a 100% ethanol benzene mixture and pure benzene preparatory to paraffin infiltration. Paraffin infiltration was accomplished by passing the specimens through benzene-paraffin mixtures and pure filtered paraffin (m.p. 56-57° C) prior to embedding. Serial sections were cut at 4-6 μm on a rotary microtome, stained regressively with standard alum hematoxylin and counterstained with "Triosin" (Galigher and Kozloff, 1964).

Line illustrations were made using a stereomicroscope (M5, Wild-Heerbrug Instruments, Inc.) fitted with a camera lucida.

1. INTEGUMENT AND ASSOCIATED MUSCULATURE

HEAD

Integumental studies of adult Lepidoptera have been presented by numerous investigators (Madden, 1944; DuPorte, 1946, 1956; Freeman, 1947; Short, 1951; Ehrlich, 1958a, 1958b, 1960; Smith, 1965; Callahan, 1969; Matsuda, 1970). Studies of the musculature have been limited to specific areas of the body. The muscles of the lepidopteran head were studied by Eassa (1963) and Hanneman (1965), the furcopleural muscles were described by Chadwick (1959), and Forbes (1939) presented a detailed study of the muscles of the male genitalia. Ehrlich and Ehrlich (1962, 1963) studied the musculature of representative members of the Papilionoidea, and the musculature of the monarch butterfly, *Danaus plexippus* (L.) was presented by Ehrlich and Davidson (1961) as part of an internal anatomy study. Bharadwaj *et al.* (1974) detailed the cervical and thoracic musculature of *Manduca sexta* (Johannson) and *Spodoptera eridania* (Cramer). Relatively few studies have been conducted on both the integument and musculature of Lepidoptera. Nuesch (1953) limited the study of sclerites and muscles of *Telea polyphemus* Cr. to the thoracic region. Treat (1959) studied the metathoracic sclerites and muscles of the glassy cutworm, *Crymodes devastator* (Brace) in relation to the tympanic organ. Thus, no comprehensive work is available on the integument and musculature of adult Lepidoptera. This section is an attempt to describe the sclerites and musculature of *L. albicosta* as a single functional unit.

The head sclerites of *L. albicosta* are modified from the generalized insectan plan. The clypeal region of the lepidopteran head is reduced, whereas the frontal region is exaggerated in width. This rugose and heavily sclerotized frontoclypeal sclerite of *L. albicosta* is not clearly delimited into a frons and clypeus because of the absence of an epistomal suture (Figs. 1 and 2). However, the clypeal region may be determined by the origins of the cibarial dilator muscles of the sucking pump (Snodgrass, 1947). Studies of the muscles of the head indicate that the clypeus extends from immediately anterior to the antennal bases to the depression on the anterior aspect of the frontoclypeal protuberance (Fig. 2). The U-shaped labrum is hidden beneath the protruding edge of the clypeal base (Figs. 1 and 2). Laterally, the labrum bears setose pilifers and medially the labrum is extended into a small lobe which is considered to be the epipharynx (Snodgrass, 1935; Callahan, 1969). The frontoclypeal sclerite is delimited laterally by the laterofacial suture (DuPorte, 1956) which extends posterodorsad from the base of the anterior tentorial pit to the antennal base (Figs. 1 and 2). Internally, the laterofacial suture is present as a thin ridge which strengthens the sclerotic plates and braces the anterior tentorial arms (DuPorte, 1946). Between the laterofacial suture and the expansive compound eye is a small, thin sclerite, the paraocular sclerite (Fig. 1, 2 and 4) (Michener, 1952) or ocular sclerite (Callahan, 1969). Appressed to the inner surface of each compound eye is the ocular diaphragm (Ferris, 1940a). The vestigial mandibles form an anterior extension of the paraocular sclerite which extends ventrad as a sharp, external ridge and forms a prominent angular structure (Fig. 1). The paraocular sclerite is limited on the meson by the occipital area (Fig. 2).

The vertex is separated from the frontoclypeal sclerite by the transfrontal suture which extends from the anteromesal edges of each antennal socket (Fig. 2). The vertex bears 2 ocelli with each ocellus situated at the posterolateral angle of the vertex (Fig. 2). In KOH-treated specimens, the ocelli appear to be on darkened elevations. Posteriorly, a depression occurs in the vertex which forms a slight internal ridge. This depression may be the posterior boundary between the vertex and the occiput (Fig. 2).

The posterior surface of the head (Fig. 3) contains the occiput and postocciput which are separated by the postoccipital suture. Laterally, the occiput is separated from the postgenae by temporal sutures. The postocciput and the postgenae comprise the occipital arch (Snodgrass, 1935). Numerous cervical muscles attach to the internal ridge of the postoccipital suture. The postoccipital suture extends around the occipital foramen which is divided into dorsal and ventral openings (Fig. 3). Mesially, the postoccipital bridge is a thickened, flap-like structure which articulates with the proximal portion of the cervical sclerite. The floor of the ventral occipital foramen is delimited by the hypostomal bridge which is a lateral extension of the hypostomal sclerite (Fig. 3). The hypostomal sclerite is situated lateral to the median labial sclerite and separated from it by the hypostomal suture (Fig. 4).

The siphoning mouthparts are composed primarily of well-developed galeae of the maxillae and the labial palpi. The paired galeae are elongate and situated at the anterior portion of the triangular labial sclerite (Fig. 4) and articulate with the reduced maxillary sclerites. Each galea is semicircular in section with an inflected median portion (Fig. 5). The galeae are joined by dorsal and ventral interlocking mechanisms. The dorsal mechanism consists of stiff, overlapping bristles, whereas the ventral mechanism consists of bifid hooks. The bifid hooks are composed of short, dorsal hooks and longer ventral hooks. The ventral hooks of the left galea fit between the dorsal and ventral hooks of the right galea. Between the dorsal and ventral interlocking mechanism is the food canal (Fig. 5). The galea is divided into a broad proximal base and a long, coilable distal portion. The proboscis, which appears annulated, is basically composed of exocuticular ribs. These ribs were described in detail by Eastham and Eassa (1955) for the cabbage butterfly, *Pieris brassicae* L. The region of the so-called knee-bend is the fixed point of the proboscis during feeding (Eastham and Eassa, 1955). In *L. albicosta*, the area of the knee-bend contains an extra set of muscles, the secondary oblique muscles, which have the origin and insertion on the median wall of the galea and on the longitudinal septum. A slight inflection separates the proximal and distal sclerites of each galea (Fig. 8). Internally, this inflection is manifested as an apodeme for muscle attachment. A single trachea (Fig. 5) extends into each galea and traverses the entire length of the proboscis. Septa arise from the trachea and divide the galeal hemocoel into 3 areas of unequal size (Fig. 5). The lateral septum extends from the mediolateral region of the trachea to the inner portion of the galea. The dorsal septum extends obliquely to the dorsolateral wall of the galea, and the ventral septum extends to the ventral wall of the galea. The dorsal and ventral septae enclose the primary oblique muscles and the galeal nerve. The tip of the proboscis bears numerous rod-like sensors and curved spines (Callahan, 1969). In some species, the curved spines are more prominent on the dorsal surface of the proboscis and could pierce the skin of soft fruits (Eastham and Eassa, 1955).

The remaining maxillary structures include the weakly developed stipites. Laterally, the tubular lateral part of the stipes, which is continuous with the galea and the head cavity, contains a valvular device formed by the inflection of the hypostomal sclerite. The mesial, flat portion of the stipes forms an apodeme on which the tentorial muscles of the stipes are inserted. The cardo (Fig. 4) is reduced to a small, irregular sclerite which is situated posterior to the stipes and lateral to the base of the labial palpus. Each maxillary palpus is composed of a triangular proximal segment and a smaller distal segment.

The reduced labial sclerite (Fig. 4) is triangular and bears a median carina between the galeal bases. The base of the labial sclerite contains 2 external circular areas (Fig. 4) to which palpal muscles attach. Labial palpi, which are composed of broad, crescent-shaped basal segments, long middle segments, and small distal segments, articulate on the posterior portion of the labial sclerite (Fig. 4). Numerous setae completely clothe the labial palpi. In their normal position, the labial palpi are extended anterolaterally to the galeae.

Antennae of *L. albicosta* articulate with the vertex; their sockets are bounded posteriorly by the frontoclypeal sclerite and laterally by the paraocular sclerite. Each antenna (Figs. 1 and 2) consists of a large, proximal scape which bears the pedicel, and the remainder of the antenna, the flagellum, is divided into subsegments. If bent backward, the antennae extend to approximately the 2nd abdominal segment.

HEAD MUSCLES

Insectan muscles have been designated by letters (Nuesch, 1953), numbers (Ehrlich and Ehrlich, 1962, 1963), function (Eassa, 1963), and attachment points (Youssef, 1971). Muscle nomenclature for *L. albicosta* is modified after the systems of Hanneman (1965) and Youssef(1971) in which the first name, the origin, is hyphenated with the name of the insertion, and the prefix "inter-" designates muscles which originate and insert on the same sclerite. For the sake of brevity, muscles are numbered in the illustrations with corresponding numbers in the text.

Utilization of attachments in muscle homology is difficult because of shifts in attachment and increase in muscle numbers by secondary splits (Matsuda, 1965). In addition to attachment, muscle homology should be based on innervation, function, and developmental studies. Because of the difficulties inherent in such a comprehensive approach to muscle homology, the musculature of *L. albicosta* is not homologized with that of other species.

Stipital Muscles

The stipital muscles function in closing the aperture between the stipes and the head cavity.

1. Paraocular-stipital muscle (Fig. 6)
    Origin: paraocular sclerite, lateral to internal ridge of clypeus and ocular diaphragm
    Insertion: stipital apodeme at base of stipes
    This broad, trapezoidal muscle, which is the first seen in lateral view after removal of the compound eye, is situated lateral to the anterior arm of the tentorium.
2. Tentorial-stipital muscle (Figs. 6 and 7)
    Origin: ventral aspect of anterior arm of tentorium
    Insertion: posterior aspect of stipital apodeme
    A trapezoidal muscle situated lateral to the paraocular-stipital muscle (no. 1).
3. Ventral tentorial-stipital muscle (Fig. 7)
    Origin: anteroventral area of anterior arm of tentorium
    Insertion: median aspect of stipital apodeme
    A short, rectangular muscle with a broad origin.

Galeal Muscles

4. Tentorial-galeal muscle (Fig. 8)
    Origin: Anteroventral arm of tentorium
    Insertion: galeal base between galea and stipes
    This muscle apparently provides for dorsal galeal extension thus opening the cibarium.
5. Anterior intergaleal muscle (Fig. 8)
    Origin: galeal base
    Insertion: anterior surface of galea

ANTENNAL MUSCLES

Insectan antennae are moved by extrinsic muscles which generally originate on the dorsal tentorium and insert on the base of the scape (Snodgrass, 1962). Imms (1939) divided arthropodan antennae into segmented and annulated types based on the presence or absence of intrinsic muscles in the flagellar segments. Segmented antennae have intrinsic muscles in each antennal segment and are characteristic of the Myriapoda, Diplura, and Collembola, whereas annulated antennae, which lack intrinsic muscles, are found in Thysanura and Pterygota. Four extrinsic antennal muscles are present in *L. albicosta*.

6. Lateral apodemal-scapeal muscle (Figs. 6 and 10)
   Origin: lateral apodemal plate of tentorium
   Insertion: posterolateral aspect of scapeal base
   This muscle is the most lateral of the 4 antennal muscles.
7. Median apodemal-scapeal muscle (Figs. 6 and 10)
   Origin: median apodemal plate of tentorium
   Insertion: lateral aspect of scapeal base
8. Posterior tentorial-scapeal muscle (Figs. 6 and 10)
   Origin: dorsal aspect of posterior portion of tentorium
   Insertion: anterior aspect of scapeal base
9. Median apodemal-scapeal muscle (Figs. 6 and 10)
   Origin: median apodemal plate of tentorium
   Insertion: median aspect of scapeal base

Cibarial Dilator Muscles

10. Posterior frontoclypeal-cibarial muscle (Fig. 8)
    Origin: posterolateral aspect of frontoclypeal sclerite, anterior to antennal base
    Insertion: lateral aspect of cibarial roof
11. Frontoclypeal-cibarial muscle (Fig. 10)
    Origin: anterior to antennal base of frontoclypeal sclerite
    Insertion: posterior aspect of cibarium
    This long slender muscle is the most posterior muscle of the cibarial dilator complex.
12. Lateral antennal-cibarial muscle (Fig. 10)
    Origin: lateral to frontoclypeal-cibarial muscle (no. 11)
    Insertion: posterior aspect of cibarium
    This muscle is the most median of the cibarial dilator muscle complex.
13. Frontoclypeal-cibarial muscle (Fig. 8)
    Origin: anterior aspect of frontoclypeal sclerite
    Insertion: anterior aspect of cibarial wall
    This is a short, flat muscle.
14. Anterior frontoclypeal-cibarial muscle (Fig. 8)

Origin: anterior aspect of frontoclypeal sclerite
Insertion: anteroventral aspect of cibarium

Cibarial Compressor Muscles

The cibarial compressor muscles, which are composed of circular and transverse muscles, originate on the hypopharyngeal ridge.

15. Dorsal interhypopharyngeal muscle (Figs. 8 and 9)
    This circular muscle extends dorsolateral from the ventral hypopharyngeal ridge and is situated ventral to the dorsal oblique muscles.
16. Ventral interhypopharyngeal muscle (Fig. 9)
    This muscle is situated beneath the dorsal interhypopharyngeal muscle (no. 15).
17. Anterior interhypopharyngeal muscle (Fig. 8)
    A small, transverse muscle situated between the frontoclypeal-cibarial muscle (no. 13 and the anterior frontoclypeal-cibarial muscle (no. 14).
18. Lateral hypopharyngeal-cibarial muscle (Fig. 10)
    Origin: hypopharyngeal ridge of cibarium
    Insertion: anterolateral extension of cibarial-pharyngeal pump floor
    This muscle extends obliquely from its origin and curves around the posterior frontoclypeal-cibarial muscle (no. 10), the frontoclypeal-cibarial muscle (no. 11), and the lateral antennal-cibarial muscle (no. 12).
19. Transverse interhypopharyngeal-cibarial muscle (Fig. 10)
    Origin: medial to lateral hypopharyngeal-cibarial muscle (no. 18).
    Insertion: posterolateral angle of cibarial-pharyngeal pump
    The origin and insertion are closely associated with muscle no. 18.

Salivary Dilator Muscle

20. Hypopharyngeal-salivary muscle (Fig. 9)
    Origin: median aspect of hypopharyngeal ridge
    Insertion: dorsal aspect of salivary duct

CERVIX AND PROTHORAX

The cervix, as in other insects, is the membranous intersegmental region between the head and prothorax (Fig. 11). In *L. albicosta,* the cervix contains a small sclerite which is composed of a straight anterior arm and a curved ventral arm. These arms articulate with the occipital condyle and a small, anterior extension of the precoxale, the presternum (Fig. 12). Dorsomesially, the presternum is delimited by the basisternum (Fig. 15) and furcasternal suture.

On the ventral surface of the anterior cervical arm is a small lobe, the cervical organ (Ehrlich, 1958b) which bears numerous, small setae (Fig. 11).

The pronotal sclerites (Figs. 11, 12, and 14) consist of dorsal and lateral plates. The dorsal plates are composed of the anterior and posterior dorsal plates. Anteriorly, the expanded posterior plate joins the anterior dorsal plate (Fig. 14). Posteriorly, the long, narrow posterior dorsal plate is inflected and joins the thin extensions of the mesothoracic prescutum (Fig. 14). Two large lateral plates of the pronotum articulate with the dorsal plates. Ventrally, the lateral plates are delimited by the proepimeron (Figs. 11, 12, and 13). The proepisternum and proepimeron are joined at the pleural suture. Internally, the pleural suture is inflected and forms the pleural ridge (Fig. 13). The lateral margins of the proepimeron bear a lightly sclerotized area, the furcal lamella, which originates on the mediolateral aspect of the proepimeron and continues internally to the furca. A large internal space is delimited by the posterior furca, the epimeron, and the episternum.

The prothoracic sternum is composed of 2 narrow posterior extensions of the precoxale, the probasisternum and the profurcasternum. Internally, the small, thin basisternum is a slight internal ridge. The furcasternum is inflected on the meson and is marked externally by the elongate furcal pit. Laterally, the furcal arms bear 2 extensions, a ventral extension which articulates with the trochantin, and a dorsal extension which is directed cephalad. Anterolaterally, the furca is continuous with the proepisternum. The prothoracic coxa, which is the remnant of the coxopleurite, articulates with the trochantin at a single point. The fixed portion of the trochantin arises from the ventral aspect of the epimeron (Figs 12 and 13). On the dorsolateral margins of the prothorax are large plates termed the patagia by Crampton (1914) (Figs. 12 and 14) which are located immediately posterior to the head. Each patagium extends from the meson to the lateral margin of the prothorax. Between the parapatagium and the lateral plate of the pronotum on each side is a broad membrane which joins the patagium to the lateral plate of the pronotum. The parapatagia, as described by Schultz (1914), are narrow, lightly sclerotized areas posterior to the dorsal plates of the pronotum which extend lateroventrally into the membranous area posterior to the episternum (Figs. 11, 12, and 14). Posterolaterally from the parapatagia are the conspicuous mesothoracic spiracles (Fig. 11).

CERVICAL MUSCLES

21. Furcal-postoccipital muscle (Fig. 16)
    Origin: dorsal aspect of furca
    Insertion: dorsolateral angle of postocciput
    A long, slender muscle which extends obliquely dorsad from the origin to the insertion.
22. Prescutal-postoccipital muscle (Fig. 16)
    Origin: lateroventral surface of prescutum of mesonotum.
    Insertion: postocciput
    This muscle extends anteriorly from the prescutum beneath the mesophragmal-episternal muscle (no. 40) and the lateral plate of the pronotum.
23. Lateral prescutal-postoccipital muscle (Fig. 16)
    Origin: lateral to prescutal-postoccipital muscle (no. 22)
    Insertion: postocciput
    This is a long, thin muscle which is parallel to muscle No. 22.
24. Pronotal-postoccipital muscle (Fig. 16)
    Origin: posterior surface of pronotal plate
    Insertion: lateral surface of postocciput
    This is the most median of the muscles which insert on the postocciput.
25. Anterior phragmal-postoccipital muscle (Fig. 16)
    Origin: anterior surface of anterior phragma
    Insertion: postocciput
    A small, slender muscle which is inserted dorsal and medial to the pronotal-postoccipital muscle (no. 24)
26. Cervical-lateral postoccipital muscle (Fig. 16)
    Origin: dorsal anterior arm of cervical sclerite

Insertion: lateral surface of postocciput

27. Episternal-postoccipital muscle (Fig. 17)
    Origin: ventrolateral wall of episternum
    Insertion: dorsolateral angle of postocciput
    This long, slender muscle inserts by a long tendon.
28. Anterior cervical-postoccipital muscle (Fig. 17)
    Origin: lateral surface of anterior arm of cervical sclerite
    Insertion: lateral to cervical-median postoccipital muscle (no. 29)
29. Cervical-median postoccipital muscle (Fig. 17)
    Origin: anterior arm of cervical sclerite
    Insertion: median, internal surface of postocciput
    This is a large, broad muscle which extends mesad and dorsad from origin to insertion.

PROTHORACIC MUSCLES

30. Episternal-coxal muscle (Fig. 16)
    Origin: posterolateral margin of episternum
    Insertion: inner, lateral surface of coxa
31. Lateral pronotal-coxal muscle (Fig. 16)
    Origin: lateroventral surface of lateral plate of pronotum
    Insertion: anterodorsal surface and anterior articulation of coxa
    This is a long, large muscle which passes ventrad from origin to insertion.
32. Ventral pronotal-coxal muscle (Fig. 16)
    Origin: ventral surface of dorsal plate of pronotum
    Insertion: dorsal, inner surface of coxa
    This muscle is situated beneath the episternal-coxal muscle (no. 30).
33. Lateral furcal-coxal muscle (Fig. 16)
    Origin: lateral, apical surface of furca
    Insertion: anterodorsal surface of coxa
    A transverse, rectangular muscle which extends mesad from origin to insertion.
34. Furcal-prescutal muscle (Fig. 16)
    Origin: lateral arm of furca
    Insertion: median surface of mesothoracic prescutum
35. Posterior episternal-pronotal muscle (Fig. 17)

Origin: posterolateral surface of episternum
Insertion: elongate dorsomedian plate of pronotum
This is an elongate, slender muscle.

36. Anterior episternal-pronotal muscle (Fig. 17)
    Origin: anterior to posterior episternal-pronotal muscle (no. 35)
    Insertion: posterior, median surface of lateral plate of pronotum
37. Lateral furcalsternal-coxal muscle (Fig. 16)
    Origin: inflected surface of furcasternum
    Insertion: posterolateral surface of upper 1/3 of prothoracic coxa
38. Median furcasternal-coxal muscle (Fig. 16)
    Origin: posteromedial to lateral furcasternal-coxal muscle (no. 37) on furcasternum
    Insertion: medial to muscle no. 37 on coxa
39. Ventral furcal-coxal muscle (Figs. 16 and 17)
    Origin: ventrolateral surface of raised furca ventral to lateral furcal-coxal muscle (no. 33)
    Insertion: dorsal to insertion of muscle no. 33
40. Mesophragmal-episternal muscle (Fig. 16)
    Origin: anteromedian surface of mesothoracic phragma
    Insertion: posterior surface of apodeme formed at juncture of lateral plate with episternum
41. Mesophragmal-pronotal muscle (Fig. 16)
    Origin: anterolateral surface of mesothoracic prescutum
    Insertion: anterior surface of median dorsal plate of pronotum
42. Ventral mesophragmal-pronotal muscle (Fig. 16)
    Origin: ventrolateral to mesophragmal-pronotal muscle (no. 41)
    Insertion: anterior to muscle no. 41 on lateromedian surface of anterior dorsal plate
43. Dorsal furcal-cervical muscle (Fig. 17)
    Origin: dorsal to furcal-cervical muscle (no. 46)
    Insertion: lateral surface of cervical sclerite
44. Mesophragmal-dorsal plate muscle (Fig. 16)
    Origin: lateral to ventral mesophragmal-pronotal muscle (no. 42)
    Insertion: posteromedian aspect of pronotal dorsal plate
45. Median mesophragmal-dorsal plate muscle (Fig. 16)
    Origin: median to mesophragmal-dorsal plate

muscle (no. 44)
Insertion: obliquely on anterior surface of pronotal dorsal plate
This slender muscle is closely associated with muscle no. 44.

46. Furcal-cervical muscle (Fig. 17)
Origin: lateral furcal arms
Insertion: posterior surface of ventral arm of cervical sclerite

47. Precoxal-coxal muscle (Fig. 17)
Origin: anteromedian surface of inflected precoxa
Insertion: lateral surface of coxa

48. Dorsal furcal-coxal muscle (Fig. 17)
Origin: anterodorsal surface of furcal base
Insertion: dorsolateral surface of coxa

49. Ventral furcal-coxal muscle (Fig. 17)
Origin: ventral to dorsal furcal-coxal muscle (no. 48) on anteroventral aspect of furcal base
Insertion: ventral to muscle no. 48

50. Profurcal-mesofurcal muscle (Fig. 16)
Origin: dorsal and ventral surfaces of dorsal furcal projection
Insertion: anterior surface of mesothoracic furca
This muscle is long and tapered at origin and insertion.

Coxal-Trochanteral Muscles

51. Proepisternal-trochanteral muscle (Fig. 18)
Origin: posteroventral aspect of proepisternum and dorsomedian aspect of coxa; angle between posterior aspect of trochanter and lower angle of proepisternum; posterolateral aspect of coxa
Insertion: membrane of posterior projection of trochanter
This muscle has 3 origins and inserts by a large tendon.

52. Femoral-trochanteral muscle (Fig. 18)
Origin: dorsolateral aspect of trochanter
Insertion: apical projection of femur
This large, broad muscle fills the entire trochanteral space.

53. Dorsal coxal-trochanteral muscle (Fig. 18)
Origin: anterodorsal aspect of coxa

Insertion: median articulation of trochanter
This muscle inserts by a large, flat tendon.

MESOTHORAX

The pleural and sternal sclerites of the pterothorax are interpreted based on the terminologies of Shepard (1930), Snodgrass (1935), and Ferris (1940b). The largest sclerite of the mesonotum is the dome-shaped mesoscutum (Figs. 19 and 20). Overlying the anterolateral angles of the mesoscutum are the large, flattened tegulae. Each tegula attaches by a broad membrane to the basal arm of the subtegula. The tegula hooks by a small, ventral projection to the humeral plate of the mesothoracic wing. Anteriorly, the mesoscutum is delimited by the prescutal (=transverse) suture which is hidden behind the posterior inflection of the dorsal plate of the pronotum. The prescutal suture extends from the base of the inflection to the pleuron and delimits a thin, irregular sclerite, the prescutum. Within the inflection of the pronotal dorsal plate, the prescutal suture delimits the anterior mesothoracic phragma. The mesoscutum bears incomplete anterolateral, V-shaped notches with the base of each "V" directed posteromesad. Anterior to the notches, the mesoscutum is extended as long projections which are closely associated with the prescutum. Posterior to the notches, the mesoscutum is extended as a flattened plate, the suralare (Sharplin, 1963a) or anterior notal wing process, which is the anterior margin of the notal emargination associated with the wing base (Fig. 20) and articulates with the 1st axillary sclerite of the wing. Posterior to the suralare an anteriorly directed projection of the notal emargination, the adnotale (Figs. 20 and 23) (Shepard, 1930), articulates with the wing base. The posterior wing process is absent and a long, slender 4th axillary sclerite articulates with the 3rd axillary sclerite (Fig. 23).

Posterior to the 4th axillary sclerite is the small adanal pad (Figs. 20 and 23). The distal aspect of the adanal pad articulates with the 4th axillary sclerite. Posteriorly, the mesoscutum is separated from the smaller mesoscutellum by the scutoscutellar suture which extends anterodorsad from the area of the axillary cord, but does not form a complete suture across the dorsum (Figs. 20 and 22). Internally, the scutoscutellar suture is a pronounced ridge. The lateral membranous area between the mesoscutellum and the wing base is thickened at the posterior boundary and forms the annulate axillary cord (Figs. 20 and 22) which joins the anal area of the wing (Fig. 23). The axillary cord is covered with long, thin setae. Extending laterally on the posteroventral aspect of the mesoscutellum is a transverse ridge which separates the mesoscutellum from the postnotum (Fig. 20). Dorsally, the thin postnotum extends internally into the mesoscutellum. The postnotum articulates laterally with the posteroventral edge of the mesoscutum which lies in a lateral fold beneath the mesoscutellum. The postnotum extends laterally as an irregular sclerite, the phragmal process (Ehrlich, 1958b), which bears dorsal and ventral arms (Fig. 22). The dorsal arms protrude anteriorly beneath the process of the postalar portion or the mesoepimeron, and the ventral arm extends mesad beneath the posterior mesothoracic phragma (Fig. 22). The mesothoracic phragma contains irregular, internal ridges which function as muscle attachment points. However, the inner, distal portions of the posterior mesothoracic phragma are smooth and bear 2 small semicircular ridges.

The pleural suture, which is important in the identification of sclerites, extends ventrad from the pleural wing process (Fig. 21) to the small, triangular sclerite, the epicoxal piece, situated between the meron and the eucoxa. Jordan (1902) and Snodgrass (1909) called this sclerite the trochantin, but Shepard (1930), Madden (1944), and Callahan (1969) called it the epicoxal piece. According to Shepard (1930), the epicoxal piece is the exposed part of the basicoxite anterior to the pleural articulation of the coxa. Michener (1952) simply referred to this sclerite as the basicoxite. The pleural suture divides the pleuron into a presutural episternum and a postsutural epimeron (Fig. 21). Each episternum is composed of an anepisternum, preepisternum, and katepisternum. The trapezoidal katepisternum is delineated from the dorsal anepisternum by the transverse anespisternal suture. Anteriorly, the elongate preepisternum is delimited from the katepisternum by the preepisternal suture (Fig. 21). The preepisternum extends anteroventrad and is the most anterior sclerite of the mesopleuron. The V-shaped epimeron is situated dorsal to the meron of the coxa and forms the anterior limit of the membranous areas of the mesopleuron. A convex, oval sclerite, the mesopreepimeron, is interposed between the episternum (=katepisternum and anepisternum) and the epimeron. The dorsal arm of the epimeron is a narrow exextension which with the associated membrane overlaps the anepisternum and internally forms a broad, flat plate for muscle attachment (Fig. 21). The epimeron extends to the pleural wing process which serves as a fulcrum for the wing. Anterior to the pleural wing process is the long, hooked subtegula which is situated dorsal to the anepisternum. The basal arm of the subtegula joins the dorsoanterior aspect of the basalare and anterior portion of the pleural wing process. Nuesch (1953) and Ehrlich (1958a) described the subtegula as the tegular arm. According to Sharplin (1963a), the tegular arm is restricted to the tergopleural apodeme, whereas the subtegula is the prescutal apodeme. In *L. albicosta*, the prescutal and tergopleural apodemes are fused.

On either side of the pleural wing process are small sclerites, the epipleurites (Snodgrass, 1935) which are composed of a small, anterior basalare and a larger, posterior subalare (Fig. 21). The irregular basalare articulates with pleural wing process by a small, pointed projection which fits into a depression on the pleural wing process. The eippleurites are attachment sites for the wing muscles.

The thin, posterior arm of the mesoepimeron extends posterodorsad and broadens at the articulation with the lateral portion of the phragmal process. Internally, the epimerites join on the meson and form a V-shaped internal postalar brace.

The thin, elongate spina (Fig. 15) joins the venters of the prothorax and mesothorax. According to Shepard (1930), the Sphingoidea are morphologically similar to the Noctuoidea, with the greatest differences occurring in the shape of the spinasternum which differs between allied genera or groups of genera. The spinasternum of *L. albicosta*, which supports the membranous area of the venter, is an inverted "V" with the posterior arms joining the median sclerite of the mesothoracic venter, the triangular mesobasisternum (Fig. 15). Anterolaterally, the basisternum joins the preepisternum. A narrow, membranous area separates the mesoeucoxa from the mesobasisternum (Fig. 15), and internally, the mesobasisternum is an elongate, median ridge. This line of inflection is the discrimen (Michener, 1952). At the posterior aspect of the mesobasisternum is the mesofurcasternum and the furcasternal pit. The furcasternum is invaginated and bears 2 lateral arms, the furca, which are directed slightly anteriad.

The pteralia (Fig. 23) of the mesothoracic wing consist of the humeral plate, axillaries, and median plates. Situated on the anterior margin of the mesothoracic wing is the enlarged humeral plate which articulates with the costal vein. Proximally, the humeral plate articulates with the basal process of the subcosta. The large 1st axillary sclerite is the anterior hinge of the wing base which articulates with the adnotale and the 2nd axillary sclerite. Anteriorly, the 1st axillary sclerite articulates with the proximal portion of the basal process of the subcosta. According to Sharplin (1963b), the 1st axillary sclerite of higher Lepidoptera is proportionately larger in relation to the wing base than in the primitive Lepidoptera. The 2nd axillary sclerite (Fig. 23) articulates distally with the proximal median plate and is closely associated with the radial vein. The pivotal sclerite of the wing base, the 2nd axillary sclerite, articulates with the pleural wing process. Articulating with the elongate 4th axillary sclerite (Fig. 23) is the posterior 3rd axillary sclerite which functions in wing flexion Distally, the 3rd axillary sclerite articulates with the basoplica which bears the anal veins. Median plates, which are divided into proximal and distal plates, are situated at an angle between the 2nd axillary sclerite and the humeral plate. The posterior surface of the proximal median plate articulates with the 3rd axillary sclerite; the distal plate is situated at the base of the mediocubital veins.

According to Woodworth (1906), the wing venation of Lepidoptera is characterized by the absence of numerous cross-veins. The generalized wing venation of the Frenatae was illustrated by Borror and DeLong (1971), and the terminology used to describe the wing venation of *L. albicosta* is that of Comstock and Needham (1897). The anterior, longitudinal vein of the mesothoracic wing is the marginal costa (Fig. 24). According to Snodgrass (1935), the costal tracheal vein may be part of the subcostal trachea. Distally, the 2nd longitudinal vein, the subcosta, is not bifurcate as in the generalized wing plan of Snodgrass (1935). The 3rd longitudinal vein, the radius, divides into a single anterior vein, R_1, and the posterior arm of the fork divides several times into the R_2, R_3, R_4, and R_5 veins (Fig. 24). An accessory cell is formed by the radial and r-m cross-veins. The anterior branch of the median vein, M_1, is connected to the R_5 vein by the oblique r-m,cross-vein. The longitudinal median vein is lost and is visible distally as the M_1, M_2, and M_3 veins, and the cross-vein between the bases of M_1 and M_2 are atrophied. The longitudinal cubitus is the largest vein of the mesothoracic wing. This vein bifurcates distally into an anterior Cu_1 and a posterior Cu_2. Situated beneath the cubitus is the single 2A vein. The 1st anal vein is atrophied.

According to Braun (1919), the frenulum, which joins the mesothoracic and metathoracic wings, is a true lepidopteran character, having developed independently in widely separate species. In males of *L. albicosta*, a small lobe (Fig. 24) of the mesothoracic wing holds the frenulum, whereas in females, the frenulum is held by long setae situated at the base of the mesothoracic cubital vein.

MESOTHORACIC MUSCLES

Muscles of the meso- and metathorax of *L. albicosta* are grouped according to the modified classification of Snodgrass (1935) and Nuesch (1953).

Dorsolongitudinal Muscles

The dorsolongitudinal muscles extend between parts of the mesotergum.

54. Scutal-phragmal muscle (Fig. 27)
    Origin: posterodorsal median aspect of mesoscutum anterior to scutoscutellar suture
    Insertion: phragmal process

Muscle numbers 55 through 59 are similar in width and length and extend anteroposteriorly through the mesothoracic dorsum.

55. Mesoscutal-mesopostnotal muscle (Fig. 28)
    Origin: anterodorsal wall of mesoscutum
    Insertion: posterior wall of mesopostnotum
56. Ventral mesoscutal-mesopostnotal muscle (Figs. 27 and 28)
    Origin: ventral to mesoscutal-mesopostnotal muscle (no. 55) between postnotum and anterior phragma
    Insertion: ventral to muscle no. 55
57. Mesoscutal-mesophragmal muscle (Figs. 25 and 28)
    Origin: ventral to ventral mesoscutal-mesopostnotal muscle (no. 56)
    Insertion: ventral to muscle no. 56
58. Ventral mesoscutal-mesophragmal muscle (Figs. 25 and 28)
    Origin: ventral to mesoscutal-mesophragmal muscle (no. 57)
    Insertion: ventral to muscle no. 57
59. Mesointerphragmal muscle (Figs. 25 and 28)

Origin: anterior phragma
Insertion: posterior phragma
This muscle is situated on the anterior phragma of the mesoscutum ventral to the ventral mesoscutal-mesophragmal muscle (no. 58)

VENTROLONGITUDINAL MUSCLES

The ventrolongitudinal muscles extend between parts of the mesosternum. Although there is only one muscle of this group in the mesothorax, the profurcal-mesofurcal muscle (no. 50) also extends into the sternum of the mesothorax from the prothoracic sternum.

60. Furcal-basicostal muscle (Fig. 27)
Origin: ventral aspect of furcal arms
Insertion: basicostal inflection

DORSOVENTRAL MUSCLES

The dorsoventral muscles extend from the tergites to the sternites or to the legs.

61. Scutal-mesomeral muscle (Fig. 26)
Origin: posterior aspect of scutum mesiolaterally to notal incision
Insertion: posteroventral aspect of mesomeron

62. Scutal-mesofurcal muscle (Fig. 27)
Origin: anterolateral aspect of scutum
Insertion: mesofurca
This elongate muscle has an extensive origin.

63. Mesoscutal-basisternal muscle (Fig. 27)
Origin: dorsolateral aspect of mesoscutum
Insertion: anterior projecting arms of mesobasisternum

64. Posterior mesoscutal-mesobasisternal muscle (Fig. 27)
Origin: posterior to mesoscutual-basisternal muscle (no. 63)
Insertion: median wall of inflected mesobasisternum

PLEURODORSAL MUSCLES

The pleurodorsal muscles extend from the wing bases to the pleurites.

65. Anepisternal-axillary muscle (Fig. 25)
    Origin: posterior aspect of pleural ridge
    Insertion: anterior aspect of 3rd axillary sclerite

66. Ventral anepisternal-axillary muscle (Fig. 25)
    Origin: ventral to anepisternal-axillary muscle (no. 65) on posterior surface of pleural ridge
    Insertion: ventral to muscle no. 65 on third axillary sclerite
    According to Snodgrass (1935), the axillary muscles are present in all winged species.

67. Lateral anepisternal-axillary muscle (Figs. 25 and 26)
    Origin: lateral aspect of anepisternum
    Insertion: anterior aspect of 3rd axillary sclerite.
    A long, longitudinal muscle which tapers from origin to insertion.

68. Anepisternal-scutal muscle (Fig. 27)
    Origin: posteromedian aspect of anepisternum
    Insertion: anterolateral inflection of scutum

PLEUROVENTRAL MUSCLES

The pleuroventral muscles extend from the pleurites to the sternites or to the legs.

69. Meral-subalary muscle (Fig. 25)
    Origin: ventrolateral aspect of mesomeron
    Insertion: ventrolateral aspect of subalare

70. Posterior anepisternal-eucoxal muscle (Fig. 25)
    Origin: posteroventral aspect of anepisternum
    Insertion: median aspect of eucoxa
    This short, posterior muscle has a broad origin and tapers ventrad toward the insertion.

71. Median anepisternal-eucoxal muscle (Fig. 25)
    Origin: dorsomedian aspect of anepisternum
    Insertion: dorsomedian and ventromedian aspect of eucoxa
    This relatively large uniform muscle has 2 points of insertion.

72. Anepisternal-apodemal muscle (Fig. 26)
    Origin: posterior aspect of anepisternum anterior to base of pleural wing process; lateromedian aspect of scutum

Insertion: small, triangular sclerite on membrane at coxal-trochanteral articulation
This large muscle has 2 origins and inserts by a long, flat apodemal plate.

73. Pleural-mesofurcal muscle (Fig. 25)
Origin: pleural ridge
Insertion: anterior aspect of mesofurca
This flat, fan-shaped muscle inserts by a long, oblique tendon.

PLEURAL MUSCLES

The pleural muscles extend within the pleurites.

74. Epimeral-subalary muscle (Fig. 25)
Origin: anterodorsal arm of flattened epimeral plate
Insertion: posterior aspect of subalare

75. Anepisternal-preepisternal muscle (Fig. 25)
Origin: anterodorsal aspect of anepisternum
Insertion: lateral ridge of preepisternum

76. Dorsal anepisternal-preepisternal muscle (Fig. 26)
Origin: median aspect of anepisternum
Insertion: anterior aspect of preepisternum

77. Intersubtegular muscle (Fig. 25)
Origin: anterior arm of subtegula
Insertion: basal arm of subtegula

STERNOCOXAL MUSCLES

The sternocoxal muscles extend from the sternites or furcae or to the legs.

78. Basisternal-eucoxal muscle (Fig. 27)
Origin: obliquely on posterodorsal aspect of inflected basisternum
Insertion: ventromedian aspect of eucoxa

79. Spinal-apodemal muscle (Fig. 27)
Origin: median carina of spina
Insertion: inner aspect of sclerotic plate of anepisternal-apodemal muscle (no. 72)

COXOTROCHANTERAL MUSCLES

The coxotrochanteral muscles extend from the coxae to the trochanters.

80. Eucoxal-trochanteral muscle (Fig. 25)
    Origin: anterodorsal aspect of eucoxa
    Insertion: small sclerite of trochanter
    This fan-shaped muscle has 2 insertions.
81. Posterior eucoxal-trochanteral muscle (Figs. 25 and 26)
    Origin: posteroventral ridge of eucoxa
    Insertion: trochanter, anterior to posterior articulation
82. Eucoxal-apodemal muscle (Fig. 27)
    Origin: anteroventral aspect of eucoxal ridge
    Insertion: median aspect of sclerotic apodeme of anepisternal-apodeme muscle (no. 72)

METATHORAX

The metathoracic dorsum is composed of 2 triangular sclerites, the anterior metascutum and the posterolateral metascutellum (Fig. 29). Projecting from the anterolateral aspect of the metascutum is the pleural wing process (Fig. 29) which is the anterior pivotal point of the metathoracic wing. Situated at the posterolateral aspect of the metascutum is the long, slender posterior notal wing process, the adanale (Figs. 29 and 33) which extends lateral to the suralare. Posteriorly, the short narrow metascutellum articulates with the small, membranous alula of each metathoracic wing. Alulae (Fig. 33) of *L. albicosta* are continuous with the posterior angles of the metathoracic wing bases and extend as the axillary cord of the metathoracic wings.

The posterior aspect of the metascutellum is closely associated with the anterior aspect of the large, bulbous countertympanic cavities (Fig. 31). The hemispherical countertympanic cavities are joined on the meson by a common septum and the septal projection as described by Callahan (1969) in the countertympanic cavity of *H. zea* is absent. The dorsum of the countertympanic cavity is formed by the lateral arms of the T-shaped anteromedian sclerite. Ventrally, the opening of the countertympanic cavity bears an irregular sclerite (Fig. 31) which extends anteriad toward the mesothoracic postnotum and is a site for muscle attachment. The posterior wall of the countertympanic cavity is composed of the countertympanic membrane (Fig. 31).

The most anterior sclerite of the pleuron is the elongate metepisternum (Fig. 29). Dorsally, the episternum bears a small pad, the basalare, which is situated anteriorly to the articulation point of the metathoracic pleural wing process. In turn, the basalare bears a small sclerite which extends medially and is a site of thoracic muscle attachment. Also, the basalare covers the mesothoracic spiracular opening. According to Shepard (1930), the basalare pad is unique to Lepidoptera and may function as a metathoracic wing support. Separating the epimeron from the episternum is the pleural suture (Fig. 29). The posterior apex of the triangular epimeron is invaginated dorsally and forms the tympanal membrane (Fig. 29). The tympanum is present in a few groups of the Frenatae and is absent in the Jugatae, Richards (1933) described 3 basic types of tympana. The Noctuoidea have the tympana situated in the metathorax, whereas Geometroidea, Drepanoidea and many Pyralidoidea bear the tympana on the 1st abdominal segment, and the Uranoidea have the tympana on the 2nd abdominal segment. The epaulette or nodular sclerite (Fig. 29), which consists of approximately 4 lobes, is situated in the membrane dorsal to the invaginated epimeron. Internally, the invaginated epimeron joins the postcoxal bridge which functions as an internal brace (Fig. 31). The epimeron delimits the ventral epimeral pocket IV (Fig. 31) (Treat, 1959) which is the largest of the 4 pockets present. Dorsal to epimeral pocket IV are the postnotal pockets. Postnotal pocket III and epimeral pocket IV have a common anterior opening (Fig. 31). Ventral to the alula, the postnotal pocket II is situated beneath postnotal pocket I (Fig. 31).

Between the elongate eucoxa and the dorsally situated episternum is a small posterior epicoxal piece. According to Shepard (1930), the epicoxal piece is usually present in the metathorax if it is present in the mesothorax. The ventral portion of the eucoxa articulates with the metathoracic trochanter (Fig. 32). The basicostal suture separates the eucoxa from the meron (Fig. 29).

Ventrally, the thin basisternum (Fig. 32) is situated anterior to the eucoxa with the median portion of the basisternum inflected. Internally, this inflection is visible as a large, flat plate for muscle attachment. The posterior sclerite of the sternum is the postcoxal bridge (Figs. 31 and 32) or postcoxale which joins the epimeron with the furcasternum (Fig. 32).

The venation and axillary sclerites of the metathoracic wing of Lepidoptera are reduced (Sharplin, 1963b). The anterior projection of the 1st axillary sclerite articulates with the anterior notal wing process (Fig. 33). The mesal portion of the 1st axillary sclerite is flattened and articulates on the meson with the scutum. The 2nd axillary sclerite articulates with the posteromedian portion of the 1st axillary sclerite. Articulating with the anterolateral aspect of the 1st axillary sclerite is the subcostal base. The metathoracic humeral plate bears the frenulum. The 3rd axillary sclerite articulates posteriorly with the thin, elongate postnotal wing process and anteriorly with the proximal median plate. Laterally, the 3rd axillary sclerite articulates with the anal veins. The characteristics of the metathoracic wing are the fusion of the subcostal and R_1 veins, the presence of the radial sector and the general reduction of the radial and M_2 veins. The small, rudimentary M_2 vein is situated at the periphery of the metathoracic wing (Fig. 34). In the anal region, vein 3A (Fig. 34) is present in the metathoracic wing but is absent in the mesothoracic wing (Fig. 24).

METATHORACIC MUSCLES

DORSOLONGITUDINAL MUSCLES

83. Scutal-epimeral pocket IV muscle (Figs. 37 and 38)
    Origin: anterolateral aspect of metascutum
    Insertion: anteromedian wall of epimeral pocket IV
84. Prescutal-metascutellar muscle (Figs. 37 and 38)
    Origin: anterolateral aspect of prescutum
    Insertion: dorsolateral angle of anterior projection of metascutellum
85. Prescutal-metapostnotal muscle (Figs. 37 and 38)
    Origin: anteromedian aspect of prescutum
    Insertion: median carina of metapostnotum beneath countertympanic cavity.

VENTROLONGITUDINAL MUSCLES

86. Interfurcal Muscle (Fig. 37)
    Origin: posteroventral aspect of mesothoracic furca
    Insertion: anteromedian aspect of metathoracic furca

87. Posterior mesofurcal-abdominal muscle (Fig. 37)
    Origin: posterior to interfurcal muscle (no. 86)
    Insertion: fused sterna 1 and 2 of 1st abdominal segment

DORSOVENTRAL MUSCLES

88. Scutal-trochanteral muscle (Fig. 36)
    Origin: anteroventral aspect of metascutum
    Insertion: elongate tendonous plate of trochanter
89. Posterior scutal-meral muscle (Fig. 36)
    Origin: posterior to scutal-trochanteral muscle (no. 40)
    Insertion: ventromedian aspect of metameron
90. Furcal-tendonal muscle (Fig. 37)
    Origin: lateral aspect of dorsal projection of furcal arm
    Insertion: ventral median sclerotic plate of scutal-trochanteral muscle (no. 88)

PLEURODORSAL MUSCLES

91. Wing process-axillary muscle (Fig. 35)
    Origin: posterior aspect of wing process
    Insertion: broad, flat plate of 3rd axillary sclerite
    This broad, flat muscle inserts by a long tendon on the center of the plate.
92. Posterior episternal-axillary muscle (Fig. 35)
    Origin: posterolateral aspect of metepisternum at inflection of pleural suture
    Insertion: broad, flat plate of 3rd axillary sclerite
93. Anterior episternal-axillary muscle (Fig. 35)
    Origin: anterodorsal aspect of metepisternum ventral to basalare
    Insertion: ventral to wing process-axillary muscle (no. 91)
94. Ventral episternal-axillary muscle (Figs. 35 and 36)
    Origin: posteroventral aspect of metepisternum posterior to median, dorsoventral ridge; on anterior portion of metepimeron
    Insertion: ventral aspect of 3rd axillary sclerite

This muscle has 2 origins and inserts by a large tendon on the axillary sclerite

95. Dorsal scutal-episternal muscle (Fig. 37)
    Origin: dorsal aspect of anterior notal wing process
    Insertion: anteroventral aspect of metepisternum
    This long, slender muscle is situated anterior to the posterior scutal-meral muscle (no. 89).

96. Metascutal-prepectal muscle (Fig. 37)
    Origin: anterolateral aspect of metascutum
    Insertion: prepectus median to scutal-trochanteral muscle (no. 88).

The presence of pleurodorsal or furcopleural muscles in the lepidopteran pterothorax has caused some confusion. Chadwick (1959) stated that furcopleural muscles, which are unique to the Lepidoptera, arise from the mesothoracic pleural ridge and the sternal arms. The mesofurcal-basalary muscle (no. 100) extends from the mesothoracic furca into the metathorax. This is perhaps due to the posterior shift of the mesothoracic furcopleural muscle.

97. Meral-subalar muscle (Fig. 35)
    Origin: ventral aspect of metameron
    Insertion: ventral aspect of subalare

98. Basalar-eucoxal muscle (Figs. 35 and 36)
    Origin: basal, median aspect of basalare
    Insertion: posteromedian aspect of eucoxa

99. Episternal-eucoxal muscle (Fig. 35)
    Origin: anterior margin of episternum lateral to prepectus
    Insertion: median aspect of eucoxa anterior to basalar-eucoxal muscle (no. 98)

100. Mesofurcal-basalar muscle (Fig. 37)
    Origin: posterior groove of mesothoracic furca
    Insertion: anteromedian aspect of basalar-eucoxal muscle (no. 98)

101. Pleural ridge-furcal muscle (Fig. 37)
    Origin: posterior aspect of pleural ridge
    Insertion: dorsal arm of furca
    This muscle inserts by a long, slender tendon.

102. Basalar-prepectal muscle (Fig. 35)
    Origin: median aspect of prepectus
    Insertion: posterodorsal wall of basalare
    This small, slender muscle inserts by a long tendon.

STERNOCOXAL MUSCLES

103. Furcal-trochanteral muscle (Fig. 37)
    Origin: dorsal aspect of ventral median plate of furca
    Insertion: anteromedian aspect of trochanter
104. Furcasternal-metameral muscle (Fig. 37)
    Origin: lateral aspect of furcasternal base
    Insertion: ventrolateral aspect of metameron

COXOTROCHANTERAL MUSCLE

105. Eucoxal-trochanteral muscle (Fig. 36)
    Origin: anterodorsal aspect of eucoxa
    Insertion: trochanter
    This large muscle inserts by a large tendon.

APPENDAGES

The prothoracic coxa (Fig. 39), which is the shortest of the coxae, is broad proximally and tapers distally at the articulation with the rounded dorsal portion of the trochanter. At the juncture of the femur with the trochanter, the proximal portion of the femur is produced into a small projection. The long, slender femur is devoid of setae and articulates distally with the tibia which bears a characteristic posterior epiphysis and 4 large spurs. The enlarged tibial spur, the epiphysis, has migrated toward the tibial base (Michener, 1952) and is appressed to the posterior aspect of each tibia. Each tarsal segment bears numerous setae. The 1st tarsal segment is the longest of the tarsomeres which terminate at the pretarsus. The pretarsus is composed of a pair of moveable ungues or claws which articulate with the median unguifer (Fig. 42), and the inner dorsal surface of each bears a smaller hook. Medially, the pretarsus bears a terminal, flattened arolium which is supported by the arched arcus (Dashman, 1953). The ungues articulate with the unguifer which is small and lobe-like. On the sides of the unguitractor plate are paired pulvilli which bear branched lateral projections (Fig. 42). An extremely long, median seta is present in the membrane between the arolium and the planta. The pretarsal anatomy of the 3 legs is similar.

The meso- and metathoracic coxae were described in the thoracic section. The meso- and metathoracic femora (Figs. 40 and 41) are narrow and elongate. The trochanters of the meso- and metathoracic legs are ankylosed to the proximal portion of each femur. The mesothoracic tibiae (Fig. 40) each bear 2 large distal spurs, whereas the metathoracic tibiae (Fig. 41) bear 2 median and 2 distal spurs.

APPENDICULAR MUSCLES

The muscles of the pro-, meso-, and metathoracic legs, with the exception of the prothoracic coxal muscles, are essentially similar. Unlike the meso- and metathoracic coxae, the prothoracic coxa is not fused to the thoracic pleuron. The descriptions which follow are the generalized plans of the pro-, meso- and metathoracic legs.

FEMORAL MUSCLES

106. Lateral femoral-tibial muscle (Fig. 43)
    Origin: anterolateral and posterior aspects of upper 2/3 of coxa
    Insertion: anterolateral portion of tibia
    This large, broad muscle extends obliquely ventrad and forms a chevron-like pattern and occupies the entire lateral aspect of the femur.
107. Femoral-pretarsal muscle (Fig. 43 and 44)
    Origin: dorsal 1/3 of femur
    Insertion: pretarsus
    This small, ovate muscle, which is situated ventral to the lateral femoral-tibial muscle (no. 106), inserts by an extremely long tendon.
108. Ventral femoral-tibial muscle (Fig. 43)
    Origin: anterior and posterior aspects of femur
    Insertion: depression of posterolateral aspect of tibia
109. Dorsal femoral-tibial muscle (Fig. 43)
    Origin: mediodistal femoral wall
    Insertion: posteromedian angle of tibia

TIBIAL MUSCLES

110. Dorsal tibial-tarsal muscle (Fig. 44)

Origin: posterodorsal aspect of tibia
Insertion: tarsal apodeme
This short muscle is situated in the proximal portion of the tibia. The apodeme branches and inserts on the lateral and median aspects of the tibia, and a middle apodeme attaches on the proximal posterior aspect of the tarsal depression.

111. Posterior tibial-apodemal muscle (Fig. 44)
Origin: posterior aspect of the tibial wall, ventral to dorsal tibial-tarsal muscle (no. 110)
Insertion: apodemal base of muscle no. 110
This small muscle extends toward the apodeme of muscle no. 110

112. Median tibial-tarsal muscle (Fig. 44)
Origin: median aspect of tibia
Insertion: anterior to ventral tibial-tarsal muscle (no. 113)
This is a short, broad muscle which is situated distally in the tibia.

113. Ventral tibial-tarsal muscle (Fig. 44)
Origin: posteroventral and lateral aspects of tibia
Insertion: posteroventral aspect of tarsus at level of small, membranous tarsal projection

TARSAL MUSCLES

Intrinsic tarsal muscles are absent in insects (Levereault, 1935). A long tendon of the femoral-pretarsal muscle (no. 107) extends through the tarsus and attaches to the ungitractor plate.

ABDOMEN

PREGENITAL SEGMENTS

Because of the incorporation of the terminal abdominal segments into the external genitalia, the typical 10 abdominal segments in *L. albicosta* are reduced to 8 abdominal segments in males and 7 abdominal segments in females. All pregenital abdominal segments of *L. albicosta* are discrete with the exception of the fused sterna 1 and 2 (Fig. 45). Abdominal tergum 1 is reduced and bears a lateral sclerotic groove which joins with the posterolateral margin of the metascutellum (Figs. 45 and 46). This groove has been termed the laterotergal groove (Michener, 1952), the tergal groove (Ehrlich, 1958b), and the tergo-pleural groove (Callahan, 1969). Because the groove of *L. albicosta* is part of the tergum and is not associated with the pleuron, the term laterotergal is used. Arising from the dorsolateral surface of the fused abdominal sterna 1 and 2 is the small pleural bar (Fig. 46) which is situated immediately ventral to the 1st abdominal spiracle. The 2nd abdominal tergum of *L. albicosta* does not extend ventrolaterally into the pleural region as reported by Callahan (1969) for *H. zea*. The anterior aspect of each tergite is produced into an internal antecosta which is marked externally by the antecostal suture. Sterna have the same general structure as the terga, and the sternum bears a precostal sclerite, the acrosternite. Abdominal spiracles occur in the pleural region of the 1st 7 abdominal segments.

ABDOMINAL MUSCLES

The pregenital abdominal muscles are limited to the dorsolongitudinal, ventrolongitudinal, and pleural muscles. Because of the similarities of the pregenital muscles, a description of a typical abdominal segment will illustrate the pregenital muscles.

114. Interabdominal muscle (Fig. 37)
    Origin: antecosta of 2nd abdominal segment
    Insertion: anterior aspect of 1st abdominal segment
    This large muscle nearly occupies the entire dorsum of the abdomen.
115. Abdominal segment 2-epimeral pocket II muscle (Fig. 37)
    Origin: median aspect of antecosta of 2nd abdominal segment
    Insertion: posterolateral aspect of epimeral pocket II at angle with juncture of metathoracic hood
    A small, slender muscle which is situated above the tympanic cavity ventral to interabdominal muscle (no. 114).
116. Laterotergal groove-abdominal sterna 1,2 muscle (Fig. 37)
    Origin: ventral projection of laterotergal groove
    Insertion: anterior aspect of fused 1st and 2nd

abdominal sterna

117. Ventral laterotergal groove-abdominal 1,2 muscle (Fig. 37)
 Origin: ventral to laterotergal groove-abdominal 1, 2 muscle (no. 116)
 Insertion: ventral to muscle no. 116

DORSOLONGITUDINAL MUSCLES

118. Tergal-acrotergal muscle (Fig. 47)
 Origin: median aspect of tergum
 Insertion: posterior acrotergite
119. Interantecostal muscle (Fig. 47)
 Origin: abdominal antecosta 1
 Insertion: abdominal antecosta 2

ABDOMINAL MUSCLES OF STERNA 1, 2, and 3

120. Median antecostal-sternal 1, 2 muscle (Fig. 48)
 Origin: acrosternite of segment 3
 Insertion: inner, posterior aspect of sterna 1, 2
 This short, stout muscle is the most median of the abdominal muscles of sterna 1, 2.
121. Mediolateral antecostal-sternal 1,2 muscle (Fig. 48)
 Origin: lateral to antecostal-sternal 1, 2 muscle (no. 120)
 Insertion: lateral to muscle no. 120
 This muscle, which is larger than the antecostal-sternal 1, 2 muscle (no. 120), extends obliquely in abdominal segment A_{1-2}. In abdominal segments A_{3-7}, this muscle extends anteroposteriad.
122. Lateral antecostal-sternal 1, 2 muscle (Fig. 48)
 Origin: lateral aspect of sterna 1, 2
 Insertion: acrosternite of abdominal segment 3
 This muscle extends obliquely in abdominal segment A_{1-2} and anteroposteriad in abdominal segments A_{3-7}.
123. Antecostal 3-intersegmental 1, 2 muscle (Fig. 48)
 Origin: antecosta of abdominal segment 3 at lateral angle of sternum
 Insertion: intersegmental membrane of abdominal segment 1, 2

ABDOMINAL PLEURAL MUSCLES

124. Tergal-sternal muscle (Fig. 49)
    Origin: mediolateral aspect of 3rd abdominal tergum
    Insertion: 3rd abdominal sternum
125. Tergal-antecostal 4 muscle (Fig. 49)
    Origin: anterolateral aspect of 3rd abdominal tergum
    Insertion: antecosta of abdominal segment 4

MALE GENITALIA

The terminology applied to the external male genitalia is confused because of the lack of knowledge or exact homologies in all groups of insects (McDunnough, 1911; Klots, 1970). The terminology used in this study is that of Snodgrass (1935) and Klots (1970). The male genitalia of *L. albicosta* consist of phallic and periphallic organs. The phallic organ is the median intromittent structure located medially on the venter of the 9th abdominal segment (Figs. 50 and 51). The periphallic organs are moveable lobes which function as copulatory clasping organs (Figs. 51 and 52). The genital complex consists of the 8th, 9th, and 10th abdomminal segments. Abdominal segment 8 functions as a retractable base for the copulatory apparatus, and no accessory genital lobes are present on abdominal segment 8. The 9th abdominal segment is not divided into distinct tergite and sternite. The dorsal sclerite of the 9th abdominal segment, the tegumen, forms a roof-like structure over the anal tube (Fig. 52). At the lateral portions of the tegumen, a pair of small sclerites, the pedunculi, join the tegumen with the 9th sternite. According to Callahan (1969), a small sclerite intervenes between the 9th tegumen and the vinculum in *H. zea*. Klots (1970) described the pedunculi as processes which arise from the ventral edges of the tegumen that articulate with the dorsal surface of the vinculum. Part of the 9th sternum forms the vinculum (Fig. 52) which is U-shaped with a long, dorsal arm and a short, anterior arm. The anterior arms meet on the meson and form a deep cleft in the anterior sclerite, the saccus (Figs. 51 and 52). The uncus, which is an appendage of the 10th abdominal tergite (Ogata *et al.*, 1957) is modified into a long, curved, rod-like structure which arises from the mid-dorsal surface immediately posterior to the tegumen. The caudal portion of the uncus is extremely spinous. According to Pierce (1967), the probable function of the uncus is to grasp the female during copulation. Situated ventral to the tegumen and uncus is the anal tube (Fig. 50). On the median portion of the anal tube, posteroventral to the base of the uncus is a small sclerite, the scaphium (Figs. 51 and 52). The subscaphia (Figs. 51 and 52) are the paired ventral sclerotic arms of the anal tube. Ogata *et al.* (1957) retained the term scaphium to include the uncus and socii based on the assumption that they are a single morphological unit. The socii are soft lobes lateral to the uncus in the Geometridae and are not present in *L. albicosta*. Indeed, the division of the uncus and socii when present is difficult to discern in some species (Ogata *et al.*, 1957). Thus, nothing is gained morphologically by combining uncus and socii into the scaphium.

The phallic organs of *L. albicosta* include an aedeagus, an eversible endophallic tube, and a phallobase. The heavily sclerotized tubular aedeagus bears a prominent ventral, spatulate tooth (Figs. 50 and 51). Anterodorsally, the blunt aedeagus receives the ejaculatory duct. The juncture of the ejaculatory duct with the endophallus is the primary gonopore (Snodgrass, 1935). The aedeagus extends anteroventrally as a bulbous extension, the caecum (Fig. 50). Within the aedeagus, the endophallic tube is extremely convoluted and when fully extended is much longer than the aedeagus (Fig. 50). The distal portion of the everted endophallus bears a single ventral cornutus. The numbers of cornuti vary among different Noctuidae. For example, there are 3 to 4 cornuti in *H. zea* as reported by Callahan and Cascio (1963). Cornuti, according to Callahan and Chapin (1960) are absent in *Peridroma saucia* (Hbu.) but *Pseudaletia unipuncta* (Haw.) bears 11 to 13 heavily sclerotized cornuti. Drecktrah and Brindley (1967) described a single cornutus in the European corn borer, *Ostrinia nubilalis* (Hubner). According to Klots (1970), the cornutus penetrates the bursa copulatrix of the female during copulation. The juncture of the phallobase and the aedeagus is marked by the attachment of the diaphragma which extends from the anal tube to the base of the valvae. The diaphragma is derived from the 9th and 10th intersegmental membranes and portions of the 11th segment (Klots, 1970). The diaphragma, which surrounds the aedeagus, is folded and forms an eversible cone, the anellus (Fig. 51). The juncture of the anellus with the aedeagus is the zone (Fig. 50). The inner membrane, the manica, is attached to the base of the aedeagus.

The diaphragma is divided into 3 functional regions: the dorsal fultura superior, central anellus, and the ventral fultura inferior. Two sclerites are found in the diaphragma of *L. albicosta* a thin, dorsal, transverse transtilla, and a broad ventral shield-like juxta (Fig. 51). Actually, the transtilla of *L. albicosta* is part of the dorsoproximal region of the valva. The juxta is situated ventral to the aedeagal base and articulates with the posterolateral margins of the valvae beneath the peniculus (Fig. 51) (Pierce, 1967). The peniculus is clothed with dense setae. Sibutani *et al.* (1954), in an attempt to provide homologies for the regions of the valvae in Rhopalocera, Geometridae, and Phalaenidae (=Noctuidae), recognized 6 distinct regions: sacculus, costa, valvula, harpe, ampulla, and cucullus and a broad membranous region, the anellifer. The sacculus of *L. albicosta* is the heavily sclerotized ventroproximal portion of the valva (Fig. 52). The sacculus of *L. albicosta* is situated between the juxta and the vinculum. As the shifting of the juxta from the vinculum increases, the binary sacculi become more developed as in the Arctiidae and Phalaenidae (Okagaki *et al.*, 1955). The membranous anellifer is continuous with the dorsal portion of the sacculus which forms a deep indentation on the ental surface of the valva. The costa (Fig. 51) is the dorsoproximal region of the valva. Dorsally, the apical portion of the valva bears numerous, long setae (Fig. 51) and this region is the cucullus. Ventral to the cucullus is the semimembranous valvula (Fig. 51). The ental region of the valva contains a heavily sclerotized projection, the harpe, which is connected to the sacculus by an elongate arm. The area dorsal to the harpe is the ampulla (Fig. 51).

ABDOMINAL TERGAL MUSCLES OF SEGMENTS 7 AND 8

126. Antecostal 7-tergal 7, 8 muscle (Fig. 47)
    Origin: antecosta of 7th abdominal segment
    Insertion: elevated membrane of 7th and 8th abdominal segment
127. Intertergal 8 muscle (Fig. 47)
    Origin: inner, median aspect of 8th abdominal segment
    Insertion: ventrolateral aspect of 8th abdominal tergum
128. Ventral antecostal 7-tergal 8 muscle (Fig. 47)
    Origin: membrane between 7th and 8th segments

ventral to antecostal 7-tergal 7, 8 muscle (no. 126)
Insertion: membranous floor of 8th tergum

129. Median antecostal 7-uncal muscle (Fig. 47)
Origin: median to ventral antecostal 7-tergal 8 muscle (no. 128)
Insertion: anterior aspect of base of uncus

130. Antecostal 8-membranal 8 muscle (Fig. 47)
Origin: obliquely on antecosta of abdominal tergum 8
Insertion: inner membrane of abdominal tergum 8

131. Saccal-aedeagal muscle (Fig. 53)
Origin: anterior aspect of saccus
Insertion: dorsomedian aspect of aedeagel attachment to vas deferens

132. Tegumenal 9-aedeagal muscle (Fig. 53)
Origin: dorsolateral aspect of 9th pleurite at juncture with 9th tegumen
Insertion: anterior base of aedeagus

133. Saccal-juxtal muscle (Fig. 53)
Origin: lateral, inner aspect of base of saccus
Insertion: anterolateral aspect of juxta

134. Tergal 9-valval muscle (Fig. 53)
Origin: anteromedian aspect of laterally expanded 9th tegumen
Insertion: projection of dorsal aspect of vulva lateral to articulation point of clasper with vinculum
The insertion is not on the penicillus or peniculus as described by Forbes (1939).

135. Pleural 9-valval muscle (Fig. 53)
Origin: flat, plate-like anterior extension of 9th pleurite
Insertion: lateral to tergal 9-valval muscle (no. 134).

136. Tergal 9-uncal muscle (Fig. 53)
Origin: anterior base of 9th tergite
Insertion: base of uncus
This muscle extends dorsad and ventrad along the entire anterior wall of tergite 9.

137. Harpal-valval muscle (Fig. 53)
Origin: base of clasper
Insertion: dorsal sclerotization of valval base
This large, fan-like muscle occupies the entire basal aspect of the valva.

MALE GENITALIC MUSCLES OF THE 8TH ABDOMINAL STERNITE

138. Posterior antecostal 8-saccal muscle (Fig. 53)
    Origin: posterior aspect of antecosta of 8th abdominal segment
    Insertion: posterior aspect of saccus at "V" of base
139. Median antecostal 8-saccal muscle (Fig. 53)
    Origin: base of saccus
    Insertion: anterior projection of the saccus
    This broad muscle occupies the base of the saccus.
140. Lateral antecostal-tergal 9 muscle (Fig. 53)
    Origin: antecosta of abdominal sternite 8
    Insertion: anterolateral aspect of abdominal tergite 9

FEMALE GENITALIA

L.albicosta is classified in the suborder Ditrysia which is characterized by 2 widely separated genital openings in females (Busck, 1932; Hinton, 1946). The ovipore is closely associated with the anus, and the ostium bursae, which is covered by dense, short, setae, is located ventrally in the membrane between the 7th and 8th abdominal sternites (Fig. 55). According to Snodgrass (1935), the ostium bursae, which is the opening to the bursa copulatrix, is equivalent to the vulva in species having the genital opening on the 8th abdominal segment. The ovipositor is composed of the fused 9th and 10th abdominal segments, the papillae anales (Figs. 54 and 55). In addition, a long posteriorly-directed apophyses arise from the anteroventral surface of the papillae anales. These apophyses serve as attachment sites for the retractor muscles of the female genitalia. The 8th abdominal segment is a roof-like structure over the 9th and 10th abdominal segments (Figs. 54 and 55). The venter of the 8th abdominal segment opens posterior to the ostium bursae. Surrounding the the ostium bursae are sclerotized plates, the sterigmata, which have also been termed the genital plates (Pierce, 1967). The sterigma of *L. albicosta* is distinct and consists of a small, dorsal sclerite, the lamella postvaginalis, and a ventrally situated, transverse sclerite, the lamella antevaginalis which joins the 2 ventral halves of the 8th abdominal segment.

FEMALE GENITALIC MUSCLES

141. Antecostal 7-apophysial muscle (Fig. 56)
    Origin: dorsal aspect of antecosta of 7th abdominal segment
    Insertion: apex of posterior apophyses of papillae anales
142. Antecostal 7-antecostal 8 muscle (Fig. 56)
    Origin: antecosta of 7th abdominal segment
    Insertion: antecostal membrane of 8th abdominal segment
    This long muscle extends dorsad and obliquely to the antecostal 7-apophyseal muscle (no. 141).
143. Antecostal 7-lateral antecostal 8 muscle (Fig. 56)
    Origin: lateral to antecostal 7-antecostal 8 muscle (no. 142)
    Insertion: lateral to muscles no. 141 and 142.
144. Tergal-papilla analis muscle (Fig. 56)
    Origin: posterior aspect of 8th abdominal tergum
    Insertion: anterodorsal aspect of posterior apophyses of papillae anales posterior to antecostal 7-apophyseal muscle (no. 141)
145. Lateral antecostal 8-ventral antecostal 8 muscle (Fig. 56)
    Origin: lateral aspect of antecosta of 8th abdominal segment
    Insertion: sternite of antecosta of 8th abdominal segment
146. Antecostal 8-papilla analis muscle (Fig. 56)
    Origin: lateral aspect of antecosta of 8th abdominal segment
    Insertion: inner, lateral aspect of the base of the papillae anales
147. Antecostal 8-papilla analis muscle (Fig. 56)
    Origin: lateral aspect of antecosta of 8th abdominal segment
    Insertion: lateral wall posterior to papillae anales
148. Sternal 8-papilla analis muscle (Fig. 56)
    Origin: posterior aspect of 8th abdominal sternite
    Insertion: posterior to lateral wall of papillae anales
    An extremely small, oblique muscle which is situated ventral to the antecostal 8-papillae analeal muscle (no. 147).

149. Antecostal 8-tergal 7 muscle (Fig. 56)
    Origin: membrane between 7th and 8th abdominal segments, posterior to antecosta of 8th abdominal segment
    Insertion: dorsal to posterior aspect of 7th abdominal segment

150. Antecostal 8-pleural 7 muscle (Fig. 56)
    Origin: antecostal membrane of 8th abdominal segment
    Insertion: lateral wall of 7th abdominal segment
    This muscle is the most lateral of the female genitalic muscles and has an extensive origin and insertion.

151. Antecostal 8-dorsal laterotergal muscle (Fig. 56)
    Origin: antecostal membrane of 8th abdominal segment
    Insertion: posteromedian aspect of 7th abdominal segment

152. Antecostal 8-ventral laterotergal muscle (Fig. 56)
    Origin: lateral to antecostal 8-dorsal laterotergal muscle (no. 151)
    Insertion: lateroventral aspect of 7th abdominal segment

153. Pleural 8-papilla analis muscle (Fig. 56)
    Origin: posterodorsal aspect of posterior apophyses of papillae anales
    Insertion: posterolateral aspect of 8th abdominal segment

2. INTERNAL STRUCTURES

DIGESTIVE SYSTEM

The digestive system of adult Lepidoptera differs from the basic insectan plan. Although a peritrophic membrane, proventriculus, and gastric caecum are absent, a well-developed sucking pump, a large crop, and numerous rectal glands are present in the digestive system of adult Lepidoptera (Snodgrass, 1935).

The digestive system of the Noctuoidea has received little attention. For example, Mortimer (1965) described the alimentary canal of the ditrysian noctuid, *Plusia gamma* L., and Chauthani and Callahan (1967) described the alimentary canal of the larval, pupal, and adult *H. zea.* The stomodaeum of *L. albicosta* is divided into functional mouth, cibarial-pharyngeal pump, esophagus, crop, intermediate chamber, and esophageal valve. At the juncture of the galea and the head capsule, the lumen of the long, coiled proboscis opens proximally into the functional mouth. However, the true mouth, which is situated between the labum and the hypopharynx in the ventral wall of the head in the generalized condition, is absent in the Lepidoptera (Snodgrass, 1935). The posterior aspect of the cibarial-pharyngeal pump has 4 muscles (Figs. 8, 9, and 10) which dilate the anterior aspect of the pharynx (Eastham and Eassa, 1955; Eassa, 1963). Thus, the posterior aspect of the cibarial-pharyngeal pump *L. albicosta* is composed of the pharynx. The cibarial-pharyngeal pump of *L. albicosta* is a large, bulbous structure with dilator and compressor muscles. This pump is composed of a thin, membranous roof and a heavily sclerotized floor which extends latero-dorsally to the roof (Fig. 57). Anterolaterally, the floor extends dorsad as crescentic arms which approach each other on the meson. Posterior to the functional mouth, on the anteroventral floor of the cibarial-pharyngeal pump are a pair of small papillae (Figs. 57 and 59). The anterolateral angle of the floor of the pump bears the hypostomal ridge (Fig. 9) on which are located the sphincter muscles of the pump. Arising from the posterior aspect of the cibarial-pharyngeal pump, the small, cylindrical esophagus is situated dorsal to the salivary duct (Fig. 57). The esophagus extends posteriad between the tritocerebrum and the subesophageal gauglion through the cervix, pro-, meso-, and metathorax into the anteroventral portion of the abdomen. In the ventral portion of the fused 1st and 2nd abdominal sternites, the esophagus extends dorsad and joins the crop (Figs. 58 and 61), and both join the posteriorly situated intermediate chamber. When full, the large, membranous crop functions as a food reservoir and according to Imms (1957) is a dilation of the posterior portion of the esophagus. The intermediate chamber was described by Mortimer (1964) for *P. gamma*, but was not described by Chauthani and Callahan (1967) for *H. zea*. The elliptical intermediate chamber of *L. albicosta* does not bear internal bristles as described by Mortimer (1965) for *P. gamma*. The esophagus extends slightly into the mesenteron with the chitinous intima of the esophagus produced into elongate protrusions which form the well-developed esophageal valve (Fig. 60). Because of the presence of the esophageal valve in the intermediate chamber, this region is perhaps similar to the proventriculus found in the Diptera (Snodgrass, 1935; Imms, 1957). The crop has sphincter muscles situated at the opening to the intermediate chamber (Fig. 61).

The mesenteron of *L. albicosta* is divided into anterior and posterior regions. The anterior region consists of 2 large, dorsoventrally flattened lobes which meet on the meson (Fig. 58). Posteriorly, the mesenteron is smaller, more uniform in diameter and longer than the anterior region. Malpighian tubules open ventrally into the proctodaeum by a common stem (Fig. 63) which projects into the lumen of the proctodaeum as long valves (Fig. 63). Sphincter muscles are located at the base of each common stem of the Malpighian tubule (Fig. 64). Distally, the common stem divides into anterior and posterior branches with the anterior branch redividing forming a total of 6 Malpighian tubules (Fig. 58) which is the common number in Lepidoptera (Snodgrass, 1935). Anterior to the common stem of the Malpighian tubules in the ventricular valve (Fig. 65) formed by the posterior projection of the mesenteron. The proctodeum consists of the anterior intestine, rectal sac, and rectum. The long, slender anterior intestine (Fig. 58) bears numerous longitudinal folds. At the juncture with the rectum and the rectal sac, the anterior intestine increases slightly in diameter. The rectal sac is extremely thin and both the rectum and rectal sac bear numerous rectal glands (Figs. 58 and 66).

The salivary glands of *L. albicosta* are extremely long and convoluted. The salivary duct opens ventral to the functional mouth and dorsal to the labium (Fig. 57). The common salivary duct extends to the area of the occipital foramen where it bifurcates and the 2 salivary ducts continue for a relatively short distance before joining the large, convoluted fluted duct (Fig. 59). The fluted ducts extend posteriorly through the thoracic region, curve anteriorly, and join the salivary glands (Fig. 59). At the juncture with the salivary duct and fluted duct is a marked constriction. The walls of the salivary duct are uniform in diameter and extend posteriad into the abdomen.

RESPIRATORY SYSTEM

Ehrlich and Davidson (1961) described the internal anatomy of *D. plexippus* but did not study the respiratory system. The structure of the spiracular regulatory apparatus was described in great detail by Beckel (1956) for the larva, pupa, and adult of *Hyalophora cecropia* L., and Tonapi (1959) described the spiracular mechanism in the adult *Corcyra cephalonica* Staint. Kennedy (1922) homologized the tracheal branches of insects utilizing the respiratory system of Zygoptera as the basic plan.

The primitive number of tracheal invaginations is 17 with embryological evidence indicating that 14 invaginations are situated on the following: 2nd maxillary segment, the 3 thoracic segments, and the 1st 10 abdominal segments (Snodgrass, 1935). However, the basic pattern of the tracheal system contains spiracles between the pro- and mesothoracic segments, between the meso- and metathoracic segments, and on the 1st 8 abdominal segments (Kennedy, 1922; Snodgrass, 1935). Various modifications from this generalized plan exist. Davies (1927) reported a pair of prothoracic spiracles in the collembolan, *Sminthuris viridis* L., but Snodgrass (1935) stated that spiracles of *S. viridis* are actually situated in the region of the 2nd maxillary segment and are perhaps similar to the embryonic 2nd maxillary spiracle of the honeybee *Apis mellifera* L. The tracheal system of adult *L. albicosta* contains 2 thoracic and 7 abdominal pairs of spiracles.

The mesothoracic spiracles of *L. albicosta* are situated in the intersegmental membrane just posterior to each parapatagium (Fig. 11). The metathoracic spiracles are not visible superficially and are hidden in the intersegmental membrane between the meso- and metathorax on the posterior portion of the mesothorax. According to Snodgrass (1935), the apparent pleural position of the thoracic spiracles is due to the dorsal extension of the subcoxal plates on each side of the spiracles. Abdominal spiracles (Figs. 45 and 46) are situated on the anterior abdominal segments just ventral to the lateral portion of the tergum. The 1st abdominal spiracles are covered by a small, elongate lobe, the hood (Treat, 1959). The occlusor apparatus of *L. albicosta* is internal as opposed to those spiracles with an external closing apparatus. Externally, the spiracle is surrounded by an ovate peritreme (Fig. 67) and extending to the midline from the peritreme are elongate processes with numerous, fine projections which function as a guarding mechanism. The opening leads into a relatively small atrium or vestibule. The closing apparatus of the mesothoracic and abdominal spiracles is similar. The apparatus consists of a sclerotized bow (Fig. 67) and a band which encircle the opposite sides of the atrial opening. An elongate closing rod or lever (Fig. 67) is associated with the band. Krancher (1881) stated that 2 occlusor muscles are present in lepidopterous larvae and only 1 in adult Lepidoptera. However, 2 occlusor muscles are associated with the spiracular closing apparatus of adult *L. albicosta*. Each occlusor muscle (Fig. 67) extends from the bow to the lever and muscle contraction causes the lever to press the band against the bow closing the atrium. There appears to be no antagonistic response between the 2 occlusor muscles. The atrium is opened by an elastic band which attaches from the lever to the tergum (Figs. 67 and 68) (Beckel, 1956).

MESOTHORACIC TRACHEAL TRUNKS

The mesothoracic spiracle gives rise to numerous trunks which tracheate the head, prothorax, and mesothorax. The principal tracheae of the head are branches from the dorsal (Figs. 69 and 71, A) and ventral (B) anterior head trunks. The dorsal anterior head trunks (A) branch into 2 pairs of tracheal trunks which enter the occipital foramen and tracheate the compound eye and the brain. The ventral anterior head trunk (B) extends to the floor of the head and divides into a large ventral anterior trachea (Fig. 71, E) which extends into the galea, a small cibarial-pharyngeal trachea which extends directly anterior and tracheates the muscles of the cibarial-pharyngeal pump (Fig. 71), and at the base of the trunk of the cibarial-pharyngeal trachea is the antennal trachea (C) which extends dorsad into the antenna just lateral to the antennal muscles.

Near the spiracular mesothoracic atrium, the spiracular tracheal trunk bears a short anterior dorsal trachea (Fig.

69, C) from which small ventral branches tracheate the dorsal muscles of the prothorax. The ventral anterior body (D) divides into the leg trachea (H) which extends into the prothoracic leg, and the anterior lateral trachea (E) which extends toward the meson and forms a sac-like structure about the aorta, esophagus and salivary duct and glands. A long, slender median ventral trachea (I) extends from the venter of the anterior lateral trunk (E) and tracheates the median muscles of the prothorax. Posterior to the ventral anterior body trunk (D), the large ventral posterior lateral trunk (Fig. 70, C) gives rise to 3 main tracheal branches; an anterior ventral trachea (D) which tracheates the median muscles of the mesothoracic leg, a lateral ganglionic trachea (E) which supplies the pterothoracic ganglion, and a median longitudinal posterior trachea (G) which joins by means of an air-sac to the longitudinal branch associated with the pterothoracic ganglion (Fig. 72). Dorsal to the ventral posterior lateral trunk (Fig. 70, C) is the smaller dorsal posterior lateral trunk (F) which bifurcates and sends branches to the longitudinal muscles of the mesothorax and to the median longitudinal muscles of the metathorax. The pleural trunk (A) is the mesothoracic leg trunk (B) which extends posteriorly into the dorsal aspect of the mesoscutum and ventrally into the mesothoracic leg.

METATHORACIC TRACHEAL TRUNKS

The metathoracic spiracle does not have an occlusor mechanism. The atrial opening is not fully exposed externally. The posterior aspect of the spiracle is covered by the anterior margin of the metepisternum. This rudimentary condition of the metathoracic spiracle is relatively common among pterygote insects and is perhaps secondarily acquired (Snodgrass, 1935). The tracheal trunks of the metathorax are the largest of those found in the 3 thoracic regions. Three lateral longitudinal trunks (Fig. 72, C, H, and M) extend anteriad. The ventral longitudinal trunk (M) extends anteriad for a short distance, curves toward the venter and tracheates the muscles of the mesothoracic coxa. The anterior dorsal longitudinal trunk (H), which arises just medially to the lateral longitudinal trunk (C), has numerous small air-sacs throughout its entire length. A small dorsal trachea (N), which branches to the dorsal longitudinal muscles of the mesothorax, arises from the dorsal aspect of (H). The median ventral longitudinal trunk (I) extends anteriad and joins the mesothoracic longitudinal trunk by a large air-sac. Along the length of the median ventral longitudinal trunk (I) are are numerous small air-sacs which tracheate the longitudinal thoracic muscles. The most unusual tracheal trunk is the long median leg trunk (D) which extends medially and bifurcates into anterior (E) and posterior (F) median leg trunks. The posterior median leg trunk (F) is joined by the anterior ventral longitudinal connective (G) to the longitudinal trunk of abdominal spiracle 1 situated at the ventral aspect of the mesopostnotum. At the level of the bifurcation of the median leg trunk (D) from the spiracular trunk, the pleural leg trunk (A) extends laterad and divides into the dorsal pleural trachea (O) which tracheates the metathoracic wing base and a long ventral pleural trunk (P) which tracheates the mesothoracic leg. The short posterior median trunk (B) extends toward the dorsum and tracheates the dorsal muscles of the metathorax.

ABDOMINAL TRACHEAL TRUNKS

Abdominal tracheae of *L. albicosta* are divided into 3 distinct types, the 1st abdominal spiracle, abdominal spiracles 2 through 6, and the 7th abdominal spiracle. The tracheal trunks of the 1st abdominal segment are the largest of those found in the abdomen. An anterior ventral longitudinal connective (Fig. 73, H) extends ventrad and passes beneath the mesopostnotum and joins the posterior median leg trunk (Fig. 72, F) of the mesothoracic spiracle. The dorsal longitudinal trunk (Fig. 73, G) extends anterolaterally and tracheates the lateral muscles of the metathorax. Above the dorsal longitudinal trunk (G) is the large lateral trunk (F) which forms a large air-sac ventral to the countertympanic cavity. A dorsal tergal trunk (E) extends dorsad and tracheates the dorsal muscles of abdominal segments 1 and 2 and the dorsal aorta. The posterior trunks of the 1st abdominal spiracle are the posterior median trunk (I) and the posterior ventral longitudinal trunk (J). The posterior median trunk (I) forms a large air-sac just posterior to the lateral trunk (F). The posterior ventral longitudinal trunk (F), which extends ventrad and tracheates the lateral and ventral mesothoracic muscles, connects with the 2nd longitudinal abdominal trunk (K).

Abdominal spiracles 2 through 6 are each connected by a large longitudinal connective trunk (Fig. 74, A). The lateral branched (K) of the spiracular atrium are small air-sacs which send fine branches to the fat bodies. These air-sacs are most numerous in the dorsal aspect of the atrium. The 2 dorsal lateral trunks (B) have a common stem and extend dorsad to the dorsal muscles, dorsal aorta, and internal organs present at that particular abdominal level. A large median dorsal trunk (C) also tracheates the internal organs. There are no dorsal connectives. The ventral trunks contain 5 main branches (D, E, F, G, and H). Each trunk tracheates the lateral muscles, fat bodies and sends branches medially which tracheate internal organs. A large ventral trunk (H) bifurcates into anterior and posterior ventral trunks. The anterior ventral trunk (Fig. 75, I) extends ventrad and divides into small tracheae. The posterior ventral trunk (J), which joins the posterior ventral trunk of the opposite side, forms the ventral commissure. The ventral trunk (J), which tracheates the ventral nerve cord, is divided into a large anterior ventral trunk (D) and a smaller posterior ventral trunk (E). The anterior tracheal trunk joins with the ventral trunk of the opposite side and forms the anterior ventral commissure (H). The posterior ventral trunk (E) also forms the posterior ventral commissure (I), but is smaller in diameter than the anterior ventral commissure. The anterior ventral trunk (D) gives off several branches, a ganglionic trunk which extends obliquely and tracheates the abdominal ganglion, a longitudinal connective (F) which joins the anterior ventral trunk (D) with the posterior ventral trunk (E) and a small series of dorsal branches (G) which tracheate the fat bodies.

The 7th abdominal spiracle is associated primarily with the genitalia, and because the main trunks which tracheate the male and female genitalia are similar, only the male is described. The main differences in the 7th abdominal trunks as opposed to the trunks of the 2nd through 6th abdominal segments involve the loss and modification of the posterior longitudinal trunk (Fig. 76, H) into a posterior dorsal (E), ventral posterior (G), and the median posterior trunk (F). The posterior longitudinal trunk (F and G) divides and tracheates the external genitalia (A, B, and C). The median posterior trunk (F) sends branches to the rectum and to the external genitalic muscles. The ventral median trunk (L) bifurcates at the base and sends branches to the inner aspects of abdominal segments 9 and 10 and to the reproductive organs situated in the 9th and 10th abdominal segments. The large ventral trunk (K) does not form a commissure but tracheates the ventral internal organs. The dorsal lateral trunks (D) and the ventral lateral trunks (I) have small lateral expanded tracheae which send numerous branches to the fat bodies.

NERVOUS SYSTEM

The study of the nervous system of adult Lepidoptera has been limited to a few species. Nuesch (1957) described the nervous system of *T. polyphemus* as part of a thoracic study. Ehrlich and Davidson (1961) studied the nervous system as part of a comprehensive work on the internal anatomy of *D. plexippus.* Beckel (1956) presented a study of the larval, pupal, and adult nervous systems associated with the spiracular regulatory apparatus of *H. cecropia.* Parts of the nervous system associated with the male reproductive system of *H. cecropia* were presented by Libby (1961). Schmitt (1961) reviewed the literature on insect nervous systems and made an attempt to homologize nerves in selected species. Studies of the noctuid nervous system include the works of Chauthani and Callahan (1967) on the nervous system of *H. zea.* The supraesophageal ganglia of *P. litura* were described by Srivastava (1969), and Mathur (1969) expanded the study of *P. litura* to the entire nervous system. The central nervous systems of the majority of Lepidoptera are divided into brain, subesophageal ganglion, and ventral nerve cord which contains 2 thoracic and 4 abdominal ganglia. The abdominal ganglia are situated in abdominal segments 2 through 6 (Imms, 1957).

The brain of *L. albicosta* is characteristic of the type found in families of Macrofrenatae with the exception of the Drepanidae and Cymatophoridae (Weber, 1933). The macrofrenate families have lateral, projecting optic lobes and a large deutocerebrum. The protocerebrum of *L. albicosta* is large and occupies a dorsal position in the head cavity (Fig. 77). The posterodorsal surface of the protocerebrum gives rise to 2 small ocellar nerves which innervate the dorsal ocelli (Fig. 77). The lateral aspect of the protocerebrum gives rise to a large, broad optic nerve which innervates the expansive compound eyes. Ventral to the protocerebrum, the deutocerebrum projects anteriad and gives rise to the antennal nerve. Srivastava (1969) described the antennal nerve of *P. litura* as a single nerve, whereas Mathur (1969) described the same as dividing into fine branches at the flagellar base.

Chauthani and Callahan (1967) reported that the antennal nerve of *H. zea* divides into 2 small and 2 large nerves. Histological examination of the antennal nerve of *L. albicosta* revealed only a single nerve which bifurcates in the pedicel and extends into the flagellum. A small dorsal tegumentary nerve (Fig. 77) extends anterodorsad to the vertex. The tritocerebrum gives rise to the short frontolabral nerve which bifurcates into the frontal ganglionic connective and the labral nerve. The frontal ganglionic connective passes laterad to the dorsoventral cibarial muscles and joins the frontal ganglion. The smaller labral nerve extends anteriad and bifurcates just posterior to the cibarial-pharyngeal pump. The dorsal branch of the labral nerve extends to the muscles of the cibarium, and the posterior branch innervates the muscles of the labrum. The tritocerebrum is broadly joined to the ventral subesophageal ganglion. The subesophageal ganglion gives rise to a large, anteroventral maxillary nerve (Fig. 77) which extends into the galea. A small nerve branches from the maxillary nerve and extends to the lateral muscles of the head. The posteroventral region of the subesophageal ganglion gives rise to the labral and cervical nerves. The small, anteroventral labial nerve innervates the labium and its muscles. Chauthani and Callahan (1967) described and illustrated the labial nerve as the prothoracic leg nerve. The cervical nerve extends posteriad and innervates the cervical and prothoracic muscles. This cervical nerve is perhaps similar to the S_2 nerve in the noctuid, *P. litura*, as described by Mathur (1969). The cervical nerve was not described by Chauthani and Callahan (1967) for *H. zea* although nerve I_2 of *H. zea* is perhaps similar to the S_2 nerve of *P. litura*. Because of the reduction of the mandibles, the mandibular nerve is absent. The esophageal sympathetic or stomatogastric nervous system is associated directly with the brain by the frontal ganglionic connectives which extend from the tritocerebrum to the frontal ganglion. A small nerve extends anteriad from the frontal ganglion and bifurcates above the cibarial-pharyngeal pump. The branches from this nerve innervate the muscles to the clypeus and the labrum. Situated at the posterior aspect of the head of *L. albicosta* are the retrocerebral glands which approximate the lateral distal type of Cazal (1948b). Posteriorly from the frontal ganglion, the median recurrent nerve extends between the deutocerebrum and tritocerebrum. A single nerve extends laterad from the recurrent nerve to each corpus cardiacum which is joined to the protocerebrum by 2 small nerves, the corpus cardiacum external and corpus cardiacum internal

(Cazal, 1948 a, b). The corpora cardiaca are joined to the paired non-nervous corpora allata. Corpora cardiaca have been variously named by previous investigators. In general texts such as Imms (1957), the corpus cardiacum was termed the esophageal or pharyngeal ganglion. Snodgrass (1935) synonomized the occipital ganglion as the pharyngeal, esophageal, or hypocerebral ganglion. Cazal (1948b) revised the terminology to include the pharyngeal, aortic, angeien ganglion, and corpus cardiacum. The hypocerebral ganglion could not be detected in *L. albicosta*, and Cazal (1948b) illustrated a similar condition in *Aporia* sp. The recurrent nerve extends posteriad as the stomatogastric nerve which bifurcates just anterior to the mesenteron and branches extend on both sides of the mesenteron. A thin nerve, which Caza (1948a) called the posterior nerve, extends from each corpus allatum into the thorax and abdomen.

The main thoracic nerves are designated by upper case letters and nerve branches by their respective lower case letters and numbers. The fused pair of ventral nerve connectives extend from the subesophageal ganglion into the anterior aspect of the mesothorax where the connectives join the prothoracic ganglion. Because of the anterior position of the prothoracic ganglion in the mesothorax, the single, main prothoracic nerve (Fig. 79, A) extends anterlaterad and gives rise to 2 main branches, the dorsal (a_1) and ventral (a_2) branches. The dorsal branch (a_1) bifurcates and innervates the posterior muscles of the cervix and the anterior muscles of the prothorax. The ventral branch (a_2) divides further into 3 branches a_3, a_4, and a_5. Nerve a_3 extends anteroventrad and innervates the ventral muscles of the prothoracic coxa and femur, respectively. The prothoracic ganglion of *L. albicosta* is joined to the fused mesothoracic, metathoracic, and 1st abdominal ganglia by longitudinal connectives which pass around the spina. Most investigators have referred to the fused ganglia as the pterothoracic ganglion. Several important nerves arise from the longitudinal connectives, or anterior ganglionic connectives (Schmitt, 1961). The median nerves are composed of 2 main stems B and C. Stem B extends anterodorsad and gives rise to 3 branches b_1, b_2, b_3. Nerve b_1 is long and innervates the anterodorsal prothoracic muscles, whereas nerve b_2 is shorter and innervates the posterior prothoracic muscles. According to Chauthani and Callahan (1967), the mesothoracic wing nerve of *H. zea* arises from the prothoracic ganglion. However, the mesothoracic wing nerve (b_3) of *L. albicosta* arises from the pterothoracic ganglion. The large nerve b_3 curves dorsolaterally around the longitudinal muscles of the mesothorax, passes beneath the basalare, and divides into 3 branches. The small anterior branch turns anteriad and innervates the intersubtegular muscle (no. 77). The median nerve bifurcates at the basal process of the subcosta sending one branch into the costal vein, and the other branch into the subcostal vein. The posterior branch of b_3 bifurcates and innervates the radial, median-cubital, and anal veins (Fig. 80). The nerve trunk C is divided into 3 main trunks c_1, c_2, and c_3 (Fig. 79). Nerve c_1 extends anteriad and innervates the occlusor muscles of the mesothoracic spiracle. Branch c_2 turns beneath the longitudinal mesointerphragmal muscle (no. 59), innervates the aorta, and continues dorsad to the mesonotum. The majority of the longitudinal muscles of the mesothorax are innervated by c_3. Arising dorsolaterally from the posterior aspect of the pterothoracic ganglion, nerve D bifurcates, and one branch innervates the scutal-epimeral IV (no. 83) and precutal-metascutellal (no. 84) muscles; the other nerve extends laterad and innervates the metathoracic anterior episternal-axillary muscle (no. 93). The origin of nerve E is ventrolateral to nerve D. Posterior to the base of nerve E, a small nerve innervates the metathoracic interfurcal muscle (no. 86). Dorsally, nerve E continues as the metathoracic wing nerve. Treat (1959), in a description of the metathoracic muscles of the noctuid *C. devastator*, illustrated a nerve Nl_c which is perhaps similar to nerve E of *L. albicosta*, and nerve Nl of *C. devastator* may be similar to the combined nerves D and E of *L. albicosta*. Nerve E, which supplies the metathoracic wing (Fig. 80), has fewer branches than the mesothoracic wing nerve b_3. Nerve E bifurcates ventral to the 1st axillary sclerite, and the anterior branch innervates the costal, subcostal, and cubital veins (Fig. 81). The posterior branch of nerve E innervates the anal vein. On the ventral surface of the pterothoracic ganglion (Fig. 79) are several nerves. A small, thin nerve F extends obliquely to the anterior aspect of the mesobasisternal carina and innervates the mesoscutal-basisternal (no. 63) and posterior mesoscutal-mesobasisternal (no. 64) muscles. The posterior portion of the mesobasisternal carina is innervated by nerve G which arises posterior to nerve F. Arising posterior to nerve G, nerve H innervates the median muscles of the mesothoracic and metathoracic legs. A small branch arises from nerve H and innervates the spinal-apodemal muscle (no. 79) of the mesothorax. From the middle of the pterothoracic ganglion, the lateral nerve I innervates the superficial muscles of the mesothorax. Situated at the posterior portion of the pterothoracic ganglion, the posterior nerve trunk J branches into smaller nerves which innervate the lateral anepisternal-axillary muscle (no. 67). Nerve J continues ventrad and innervates the metathoracic leg muscles. The fused longitudinal connective extends posteriad through the metathorax and nerves K and L are given off at the level of the metafurca. The anterior nerve K extends laterad and bifurcates into a dorsal branch which follows the 1st abdominal tracheal trunk and innervates the occlusor muscles of the 1st abdominal spiracle (Fig. 73). The ventral branch of the anterior nerve (K) and the posterior nerve (L) innervate the interabdominal (no. 114), abdominal 2-mesoepimeral (no. 115), laterotergal groove-abdominal 1, 2 (no. 116), and ventral laterotergal groove-abdominal 1, 2 (no. 117) muscles (Fig. 79).

Because of the cephalization of the nervous system, the terminology applied to the nerves of the abdominal ganglia is based on the innervated body segments (Snodgrass, 1935; Libby, 1961). The abdominal segments have a basic plan of organization which is modified due to shifts in origin and attachment of muscles (Libby, 1961; Matsuda, 1965). The only modification is the fusion of the 1st and 2nd abdominal sternites. Thus, the basic plan of the abdominal segments is not greatly modified. Abdominal ganglia 3, 4, and 5 have similar nerve patterns which contain median, lateral, and ventral nerves (Fig. 82). The 4th abdominal segment of *L. albicosta* is described as a typical abdominal segment. The median nerve (I) extends posteriad and, at the level of the 4th abdominal ganglion, bifurcates and fuses with the lateral nerve (J) which joins the posterior lateral nerve (H) of the 3rd abdominal ganglion (A). The lateral nerve (J) passes dorsal to the ventral longitudinal muscles and innervates the lateral tergosternal muscles and the spiracular occlusor muscles. Nerve (H) passes to the transverse ventral muscles and to the fat bodies. The terminal abdominal ganglion (D), which is a composite of the 6th, 7th, and 8th abdominal ganglia, is situated in the posterior portion of abdominal segment 6 and innervates the 6th, 7th, and 8th abdominal segments, the rectum, and the genitalic muscles. According to Libby (1961), the 5th abdominal ventral nerve (N) joins with the lateral nerve (P) which arises slightly anterior to the body of the terminal ganglion.

The most conspicuous nerve of the terminal ganglion

(Fig. 83, A) is the large composite 9th, 10th, and 11th nerve (B) which is primarily associated with the reproductive system. Because the main nerve branches of the terminal ganglion are similar in males and females, only the innervation of the male reproductive system is discussed. Nerve B gives rise to 2 median nerves D and I which turn beneath the main trunk of the 9th, 10th, and 11th nerves and extend laterad. Nerve D bifurcates into a lateral nerve (E) and a ventral nerve (F) which extends ventrad around the genitalic muscles and bifurcates into a ventral branch (M) and a lateral dorsal nerve (G). Nerve G joins the dorsal nerve (E) and forms a single nerve H which innervates the apical aspect of the rectum. Nerve I innervates the posterior aspect of the ejaculatory duct. The main trunk J extends posteriad and gives off nerves K and L. Nerve L bifurcates and innervates the external genitalia and the posterior antecostal 8-saccal muscle (no. 138). Nerve K sends branches which innervate the saccal-aedeagal (no. 131), the saccal-juxtal (no. 133), the tergal 9-valval (no. 134), and the pleural 9-valval (no. 135) muscles. The 8th abdominal nerves are small and situated medially to the composite nerve (Fig. 82, G). Nerve 8 extends posterodorsad and sends numerous branches which innervate the dorsal muscles of the 8th abdominal segment.

REPRODUCTIVE SYSTEM

MALE

The male reproductive system of *L. albicosta* (Fig. 84) consists of a dorsal, globular testis encased in a yellow peritoneal sheath. The testes are fused into a single median organ secured by tracheal branches, fat bodies, and other abdominal strucutres. From the ventral aspect of the testis, the paired seminal vesicles divide into anterior and posterior sacs. A short connection is present between the anterior and posterior sacs. A short connection is present between the anterior and posterior enlargements of the seminal vesicles. Vasa deferentia arise from the posterior aspect of each seminal vesicle and attach to the paired ejaculatory duct. The apical portion of the vas deferens constricts abruptly at the juncture of the thin, elongate accessory gland. Posteriorly, the paired ejaculatory ducts fuse and join the single median ejaculatory duct which was divided by Callahan

(1958) into an anterior primary segment (=distal segment of Drecktrah and Brindley, 1967) and a posterior cuticular segment of Drecktrah and Brindley, 1967). The short primary segment of *L. albicosta* is relatively undifferentiated, whereas the cuticular segment gradually widens posteriorly and at the juncture with the aedeagus is laterally flattened. The division between the primary and cuticular segments is marked by a pronounced constriction. The primary segment produces the spermatophore precursors, and the cuticular segment enters the posterodorsal, apical caecum of the aedeagus.

FEMALE

The female reproductive system consists of paired ovaries, lateral oviducts, median oviduct, accessory glands, spermatheca, and bursa copulatrix. Each ovary of *L. albicosta* consists of 4 polytrophic ovarioles, which is the typical number in Lepidoptera (Imms, 1957). Each ovariole is divided into an anterior germarium, posterior vitellarium, and pedicel (Fig. 85). The germarial region of mature ovarioles is extremely small compared with the vitellaria which constitutes the major area of the ovariole. Terminal filaments were not discernible in *L albicosta* and were not found by Callahan and Chapin (1960) in the noctuids *P. unipuncta* and *P. saucia*. Drecktrah and Brindley (1967) reported that terminal filaments were absent in *O. nubilalis*. However, Williams (1947) described short terminal filaments in the psychid, *Fumea casta* Pallas. Fatzinger (1970) described terminal filaments in the pyralid, *Dicoryctria abietella* (Denis and Schiffermuller). Thus, terminal filaments may be absent in the Noctuidae but present in other lepidopteran families. Posteriorly, each ovariole is joined to the lateral oviduct by an extremely short pedicel which enters the expanded calyx. Lateral oviducts join the posterior median oviduct which opens into the vagina through the true gonopore. The external opening of the vagina is the ovipore. The seminal duct joins the ventrolateral aspect of the anterior vagina. The seminal duct extends laterad and gradually becomes smaller in diameter and more convoluted distally. The seminal duct extends anterodorsad and joins the apical or free portion of the cervix bursae on its venter. The bursa copulatrix is divided into the corpus bursae and the cervix bursae. The dorsal, U-shaped cervix bursae extends ventrad and receives the ductus bursae. The ostium bursae opens on the ventral aspect of the ductus bursae. The ductus bursae turns slightly to the lateral, tergal margin of abdominal segment 1 and joins the expanded corpus bursae which bears numerous internal folds. The corpus of the spermatophore is situated anteriorly in the bursa copulatrix with the shoehorn-shaped frenulum situated posteriorly. Dorsolateral to the seminal duct, the convoluted spermathecal duct, which opens into the vagina, is divided into lower and upper convoluted loops and a tubular middle region. The upper convoluted loop joins the bilobed supermatheca. The utriculus, which is the larger spermathecal lobe, is curved anteriorly and the smaller spermathecal lobe, the lagena is appressed to the lateral aspect of the utriculus. The tublar spermathecal gland extends from the apical portion of the utriculus through the abdominal cavity. The accessory gland complex arises from the posterodorsal aspect of the vagina. Proximally, the vestibule receives the short reservoir duct of the accessory gland. Distally, a pair of ducts joins the C-shaped accessory gland reservoirs which are closely associated with the rectal base. The apical portion of each accessory gland reservoir bears the extremely elongate accessory gland.

CIRCULATORY SYSTEM

Gerould (1938) described the structure of the dorsal aorta and heart of the silkworm, Bombyx mori (L.). The dorsal vessel of *D. plexippus* was briefly described by Ehrlich and Davidson (1961). Hessel (1966,1969) presented a comparative work on the structure and the phylogenetic significance of the dorsal vessel of Lepidoptera. However, the work of Gerould (1938) is the only comprehensive work on the dorsal vessel of adult Lepidoptera. This section is an attempt to provide information on the circulatory system of adult *L. albicosta*.

The circulatory system of *L. albicosta* is composed of a dorsal vessel which circulates hemolymph from the posterior abdominal region anteriorly into the head (Fig. 86). The posterior portion of the dorsal vessel is the heart, which extends from the mid-portion to the 8th abdominal segment in males and the 7th abdominal segment in females. The heart is closed posteriorly and in the 8th abdominal segment of males the heart is extremely small. At the level of abdominal segment 2, the dorsal heart passes ventrad between the posterior aspect of the countertympanic cavity and the metathoracic air-sac. The aorta extends anteriad beneath the metathoracic postnotum and ascends dorsad just posterior to the scutoscutellar suture. At this level, the aorta is flattened laterally and forms a transverse chamber which is typical of the Noctuoidea (Hessel, 1969) (Fig. 87). The ostium of the dorsal chamber opens into the mesothoracic accessory diaphragm. A thin, membranous base attaches the diaphragm to the mesothoracic tergum. In addition, long, slender muscle fibers extend to the tergum. The aorta leaves the dorsal chamber and extends anteroventrad through the mesothorax, prothorax, and passes into the head dorsal to the esophagus. In the head, the aorta is situated between the circumesophageal connectives and terminates as an expanded sac. Lateral branches, which were also described by Hessel (1969), arise from the sac and extend to the compound eyes and antennae. The external openings of the dorsal vessel are undifferentiated (Fig. 88) and do not form thickened anterior lips in *L. albicosta* as reported by Hessel (1966, 1969), Abdominal ostia (Figs. 88 and 89) are situated dorsally, whereas the 3rd thoracic ostium is situated ventrally (Fig. 90). Ostia were not detected anterior to the descending aorta. Internally, the wall of the aorta in the region of the 3rd thoracic segment is inflected laterally and forms an auricular valve which prevents the backflow of hemolymph (Wigglesworth, 1972).

The dorsal diaphragm of *L. albicosta* is composed of only delicate alary muscles (Fig. 86) which spread fan-like beneath the heart and attach laterally to the antecosta of each abdominal segment. Alary muscles are located in abdominal segment 3 through 8 in males and 3 through 7 in females. The dorsal space between the heart and the integument is the dorsal or pericardial sinus. Dorsal muscular extensions attach the heart to the abdominal terga. These muscular extensions or trabeculae were not numerous in the ostial region as reported by Hessel (1969) but were evenly distributed along the dorsum of the heart. Numerous tracheae supply the posterior portion of the heart in abdominal segment 8 in the male and abdominal segment 7 in the female. Small tracheal branches tracheate the heart along the dorsal surface in the pericardial sinus.

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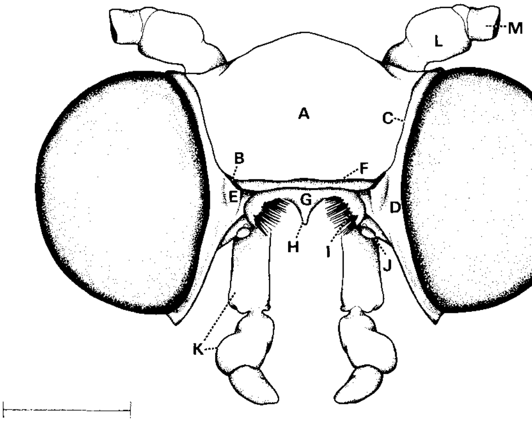

Fig. 1. Anterior aspect of head. Galea and flagellar segments removed. A, frontoclypeal sclerite; B, anterior tentorial pit; C, laterofacial suture; D, ocular (=paraocular) sclerite; E, rudimentary mandible; F, clypeolabral suture; G, labrum; H, epipharynx; I, pilifer; J, maxillary palpus, K, labial palpus; L, scape; M, pedicel.
(Scale line = 1.0 mm)

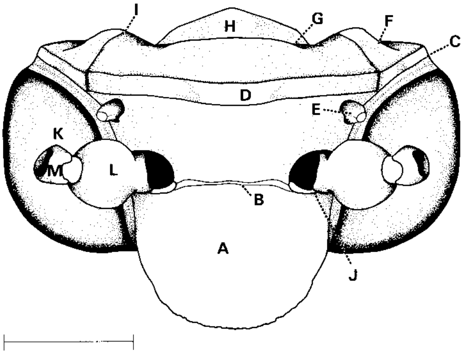

Fig. 2. Dorsal aspect of head. Flagellar segments removed. A, frontoclypeal sclerite; B, transfrontal suture; C, laterofacial suture; D, vertex; E, ocellus; F, occipital area; G, postoccipital suture; H, postocciput; I, temporal suture; J, antennifer; K, compound eye; L, scape; M, pedicel.
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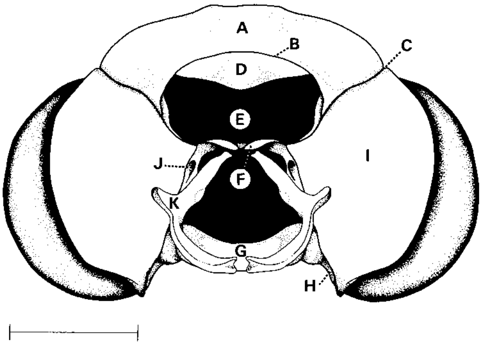

Fig. 3. Posterior aspect of head and cervical sclerites. A, occiput; B, postoccipital suture; C, temporal suture; D, postocciput; E, occipital foramen; F, occipital condyle; G, hypostomal bridge; H, hypostomal area; I, postgena; J, posterior tentorial pit; K, cervical sclerite
(Scale line = 1.0 mm)

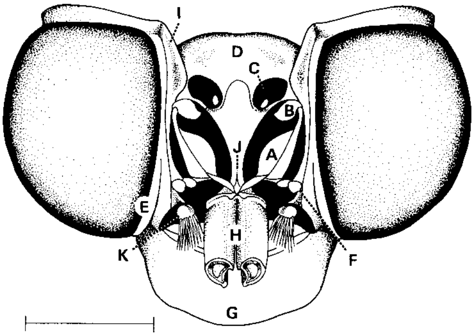

Fig. 4. Ventral aspect of head. Distal portion of galea removed. A, stipes; B, cardo; C, attachment point of labial palpus; D, labial sclerite; E, paraocular sclerite; F, maxillary palpus; G, frontoclypeal sclerite; H, galeae (Base only); I, Hypostomal area; J, labial carina; K, pilifer.
(Scale line = 1.0 mm)

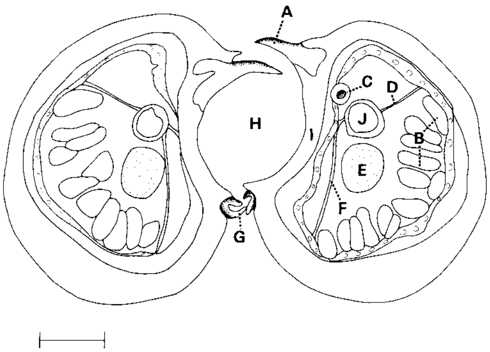

Fig. 5. Transverse section of galea.
A, dorsal bristle; B, primary oblique muscles; C, gland cell; D, dorsal septum; E, galeal nerve; F, septum; G, ventral hook; H, food canal; I, inner galeal wall; J, ventral anterior trachea.
(Scale line = 0.05 mm)

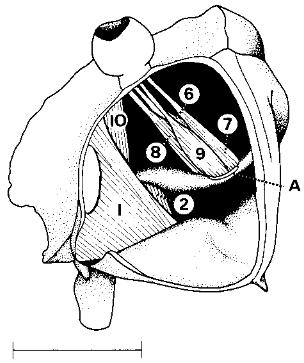

Fig. 6. Left lateral aspect of head muscles. Compound eye removed. A, lateral plate of tentorium; 1, paraocular-stipital m.; 2, tentorial-stipital m.; 6, lateral apodemal-scapeal m.;7, median apodemal-scapeal m.; 8, posterior tentorial-scapeal m.; 10, posterior frontoclypeal-cibarial m.
(Scale line = 1.0 mm)

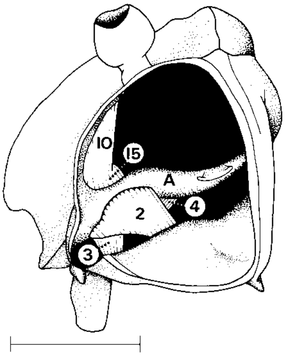

Fig. 7. Left lateral aspect of head muscles. Superficial muscles removed. A, tentorium; 2, tentorial-stipital m.; 3, ventral tentorial-stipital m.; 4, tentorial-galeal m.; 10, posterior frontoclypeal-cibarial m.; 15, dorsal interhypopharyngeal m. (Scale line = 1.0 mm)

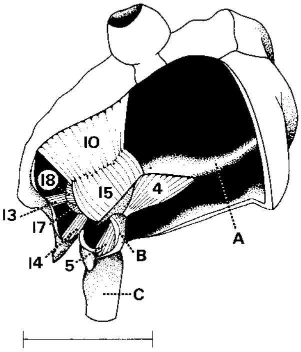

Fig. 8. Median aspect of cibarial and galeal muscles. A, tentorium; B, proximal sclerite of galea; C, distal sclerite of galea; 4, tentorial-galeal m.; 5, anterior intergaleal m.; 10, posterior frontoclypeal-cibarial m.; 13, frontoclypeal-cibarial m.; 14, anterior frontoclypeal-cibarial m.; 15, dorsal interhypopharyngeal m.; 17, anterior interhypopharyngeal m.; 18, lateral hypopharyngeal-cibarial m. (Scale line = 1.0 mm)

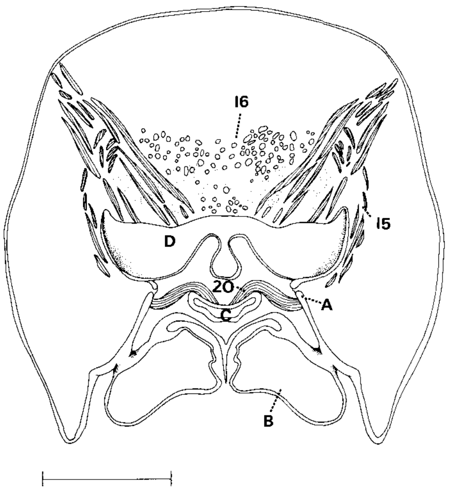

Fig. 9. Transverse section of the head. A, hypopharyngeal ridge; B, galeal base; C, salivary duct; D, cibarial-pharyngeal pump; 15, dorsal interhypopharyngeal m.; 16, ventral interhypopharyngeal m.; 20, hypopharyngeal-salivery m. (Scale line = 0.35 mm)

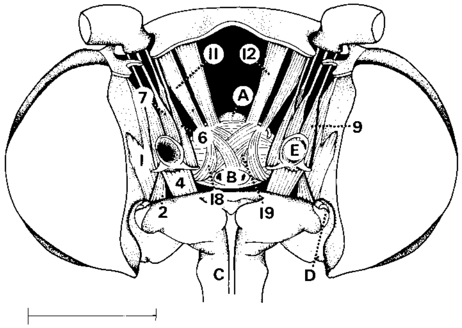

Fig. 10. Posterior aspect of head and muscles. Posterior head sclerites removed. A, frontal ganglion; C, galea; D, tubular stipes; E, tentorium; 1, paraocular-stipital m.; 2, tentorial-stipital m.; 4, tentorial-galeal m.; 6, lateral apodemal-scapial m.; 7, median apodemal-scapial m.; 9, median apodemal-scapial m.; 11, frontoclypeal-cibarial m.; 12, lateral antennal-cibarial m.; 18, lateral hypopharyngeal-cibarial m.; 19, transverse interhypopharyngeal-cibarial m. (Scale line = 1.0 mm)

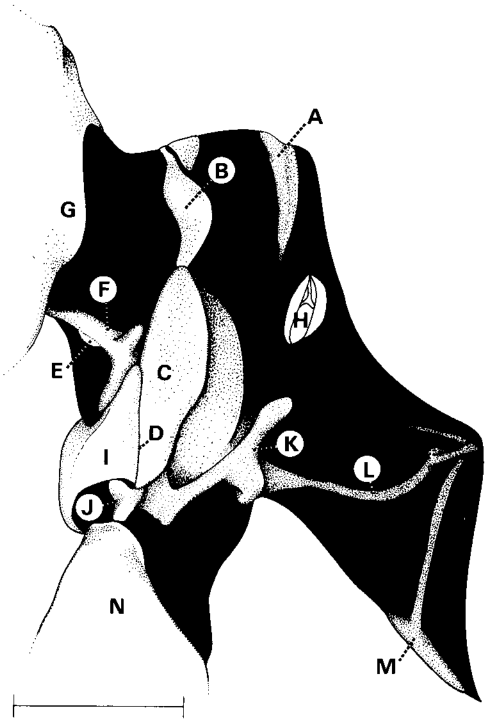

Fig. 11. Lateral aspect of cervix and prothorax.
A, parapatagium; B, lateral plate of pronotum; C, proepimeron, D, pleural suture; E, cervical organ; F, cervical sclerite; G, posterior aspect of head; H, mesothoracic spiracle; I, proepisternum; J, trochantin; K, furca; L, spina; M, spinasternum; N, coxa.
(Scale line = 1.0 mm)

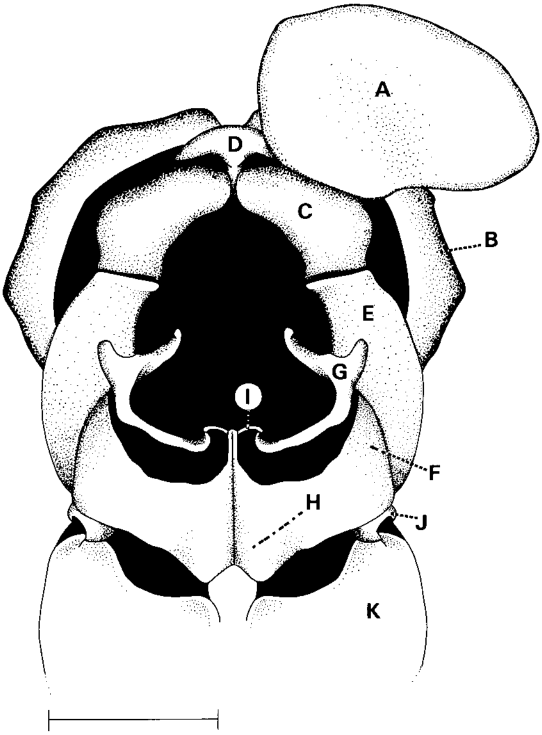

Fig. 12. Anterior aspect of cervical sclerite and prothorax. Right patagium removed. A, patagium; B, parapatagium; C, lateral plate of pronotum; D, dorsal plate of pronotum; E, proepimeron; F, proepisternum; G, cervical sclerite; H, precoxale; I, presternum; J, trochantin; K, coxa.
(Scale line = 1.0 mm)

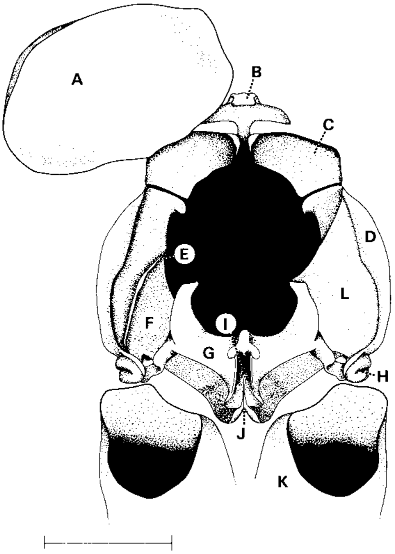

Fig. 13. Posterior aspect of prothorax. Right patagium removed. Left furcal lamella removed to show ental aspect. A, patagium; B, dorsal plate of pronotum; C, lateral plate of pronotum; D, proepimeron; E, pleural ridge; F, precoxale; G, furca; H, trochantin; I, furcasternal pit; J, furcasternal suture; K, coxa; L, furcal lamella.

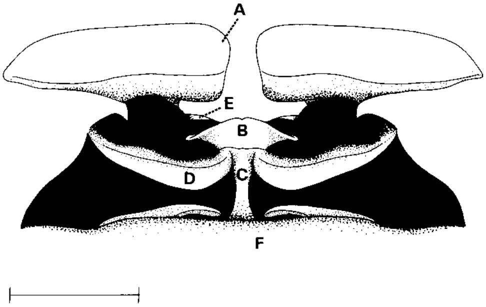

Fig. 14. Dorsal aspect of prothorax. A, patagium; B, anterior dorsal plate; C, posterior dorsal plate; D, parapatagium; E, lateral plate; F, mesothorax. (Scale line - 1.0 mm)

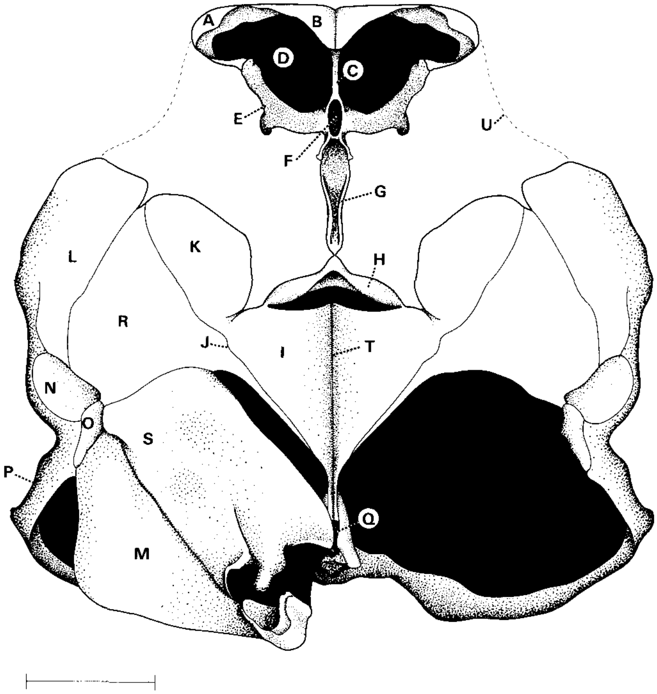

Fig. 15. Ventral aspect of prothorax and mesothorax. Prothoracic coxae and left mesothoracic coxa removed. A, episternum; B, precoxale; C, probasisternum; D, prothoracic coxal cavity; E, furca; F, furcasternum with pit; G, spina; H, spinasternum; I, mesobasisternum; J, precoxal suture; K, episternum (preepisternum); L, anepisternum; M, meron; N, preepimeron; O, epicoxal piece; P, epimeron; Q, furcasternal pit (mesothorax); R, katepisternum; S, eucoxa; T, discrimen; U, intersegmental membrane. (Scale line = 1.0 mm)

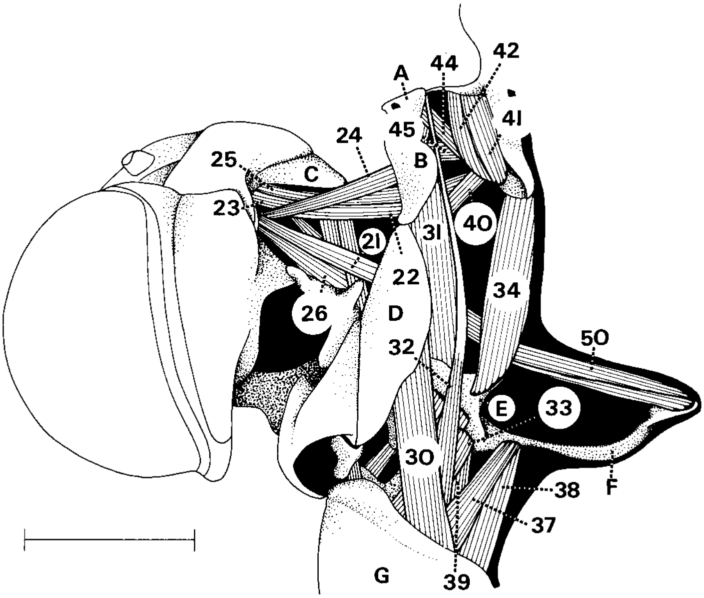

Fig. 16. Lateral aspect of the head and superficial muscles of the cervix and prothorax. A, lateral portion of dorsal plate; B, lateral plate; C, postocciput; D, episternum; E, furca; F, spina; G, prothoracic coxa; 21, pronotal-postoccipital m.; 22, prescutal-postoccipital m.; 23, lateral prescutal-postoccipital m.; 24, pronotal-postoccipital m.; 25, anterior pronotal-postoccipital m.; 26, lateral postoccipital-cervical m.; 30, episternal-coxal m.; 31, lateral pronotal-coxal m.; 32, ventral pronotal-coxal m.; 33, lateral furcal-coxal m.; 34, furcal-prescutal m.; 37, lateral furcasternal-coxal m.; 38, median furcasternal-coxal m.; 39, ventral furcal-coxal m.; 40, mesophragmal-episternal m.; 4], mesophragmal-pronotal m.; 42, ventral mesophragmal-pronotal m.; 44, mesophragmal-dorsal plate m.; 45, median meso-prescutal-dorsal plate m.; 50, profurcal-mesofurcal m.
(Scale line = 1.0 mm)

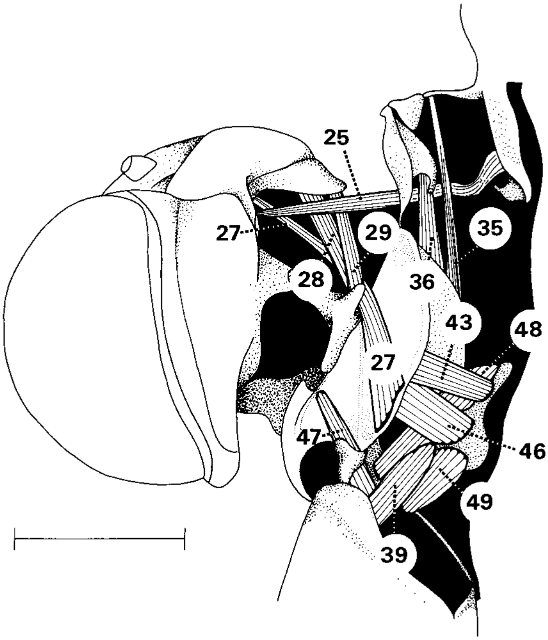

Fig. 17. Lateral aspect of the head and median muscles of the cervix and prothorax. 25, anterior pronotal-postoccipital m.; 27, episternal-postoccipital m.; 28, anterior cervical-postoccipital m.; 29, cervical-median postoccipital m.; 35, posterior episternal-pronotal m.; 36, anterior episternal-pronotal m.; 39, ventral furcal-coxal m.; 43, dorsal furcal-cervical m.; 46, furcal-cervical m.; 47, precoxal-coxal m.; 48, dorsal furcal-coxal m.; 49, ventral furcal-coxal m.
(Scale line = 1.0 mm)

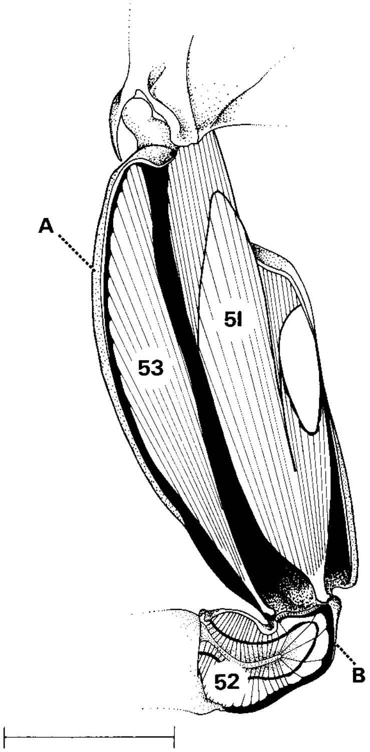

Fig. 18. Lateral aspect of prothoracic coxal and trochanteral muscles. A, coxa; B, trochanter; 51, proepisternal-trochanteral m.; 52, femoral-trochanteral m.; 53, dorsal coxal-trochanteral m.
(Scale line = 1.0 mm)

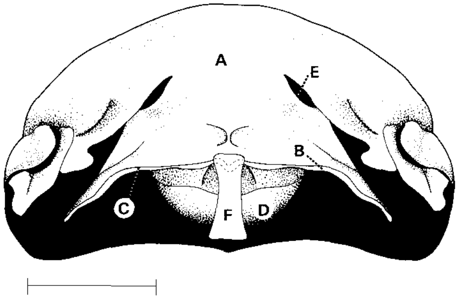

Fig. 19. Anterior aspect of the mesonotum. Tegula removed. (Broken lines indicate prescutal suture and prescutum.) A, mesoscutum; B, prescutum; C, transverse suture; D, anterior mesothoracic phragma; E, V-shaped notch; F, dorsal plate of pronotum. (Scale line = 1.0 mm)

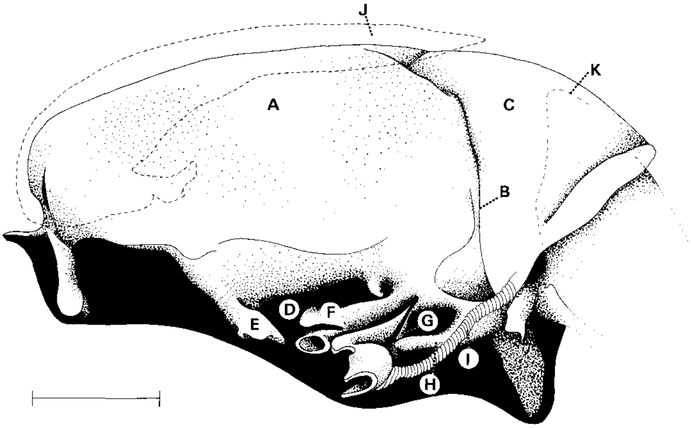

Fig. 20. Lateral aspect of the mesonotum. Mesothoracic wing and tegula removed. A, mesoscutum; B, scutoscutellar suture; C, mesoscutellum; D, notal emargination; E, suralare; F, adnotale; G, adanale, H, adanale pad; I, axillary cord; J, outline of tegula; K, outline of postnotum. (Scale line = 1.0 mm)

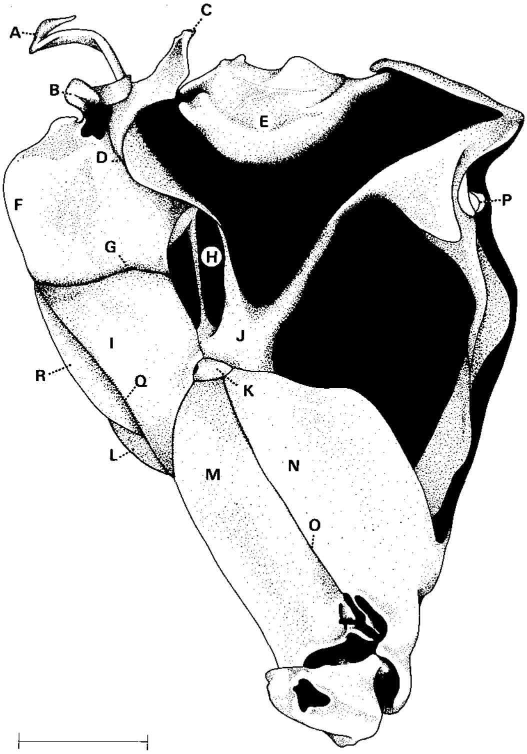

Fig. 21. Lateral aspect of the mesopleuron.
A, subtegula; B, basalare; C, pleural wing process; D, pleural suture; E, subalare; F, anepisternum; G, anepisternal suture; H, preepimeron (membrane removed); I, katepisternum; J, epimeron; K, epicoxal piece; L, basisternum, M, eucoxa; N, meron; O, basicostal suture; P, metathoracic spiracle; Q, preepisternal suture; R, preepisternum.
(Scale line = 1.0 mm)

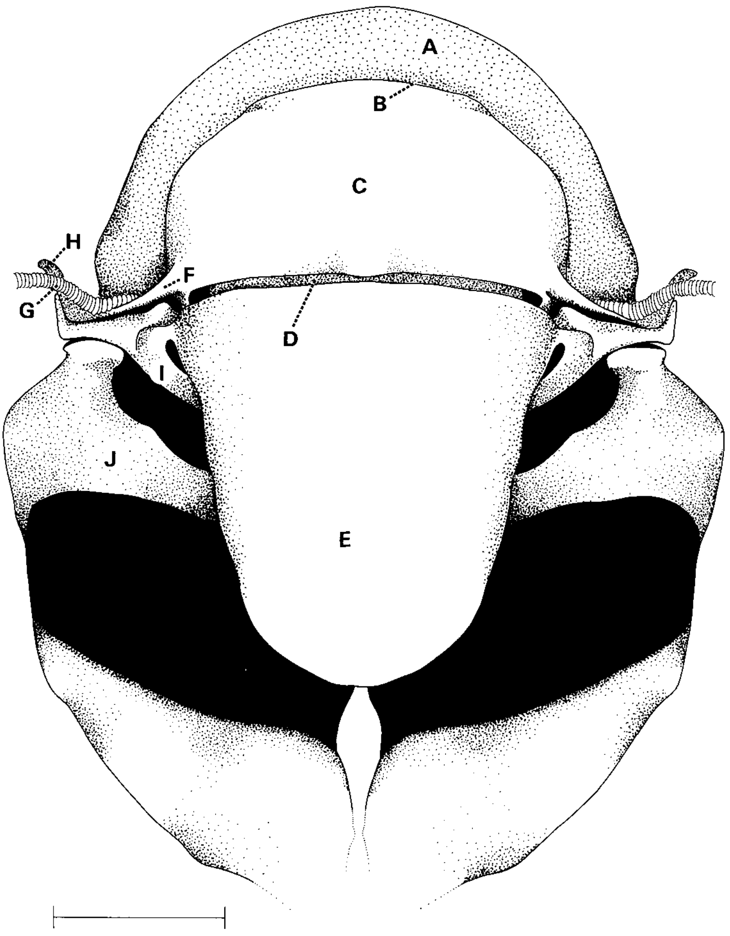

Fig. 22. Posterior aspect of the mesothorax.
A, scutum; B, scutoscutellar suture; C, scutellum; D, postnotum; E, posterior mesothoracic phragma; F, postalar plate; G, axillary cord; H, process of postalar; I, phragmal process; J, epimeron. (Scale line = 1.0 mm)

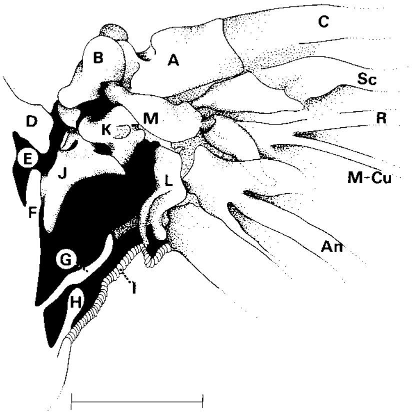

Fig. 23. Dorsal aspect of mesothoracic axillary region. A, humeral plate; B, basal process of subcosta; D, suralare; E, notal emargination; F, adnotale; G, adanale (4th axillary sclerite); H, pad of adanale; I, axillary cord; J, 1st axillary sclerite; K, 2nd axillary sclerite; L, 3rd axillary sclerite; M, proximal median plate; C, costal vein; Sc, subcostal vein; R, radial vein; M-Cu, median-cubital vein; An, anal vein.
(Scale line = 1.0 mm)

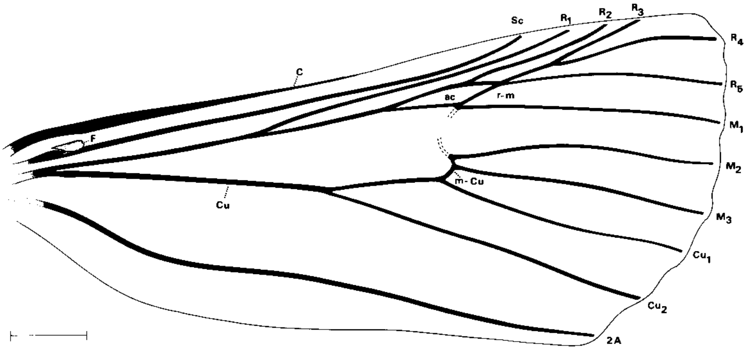

Fig. 24. Right mesothoracic wing. C, costal vein; Sc, subcostal vein; R, radial vein; Cu, cubital vein; A, anal vein; ac, accessory cell; r-m, radial-median cross-vein; m-cu, median-cubital cross-vein; F, catch.
(Scale line=2.0 mm)

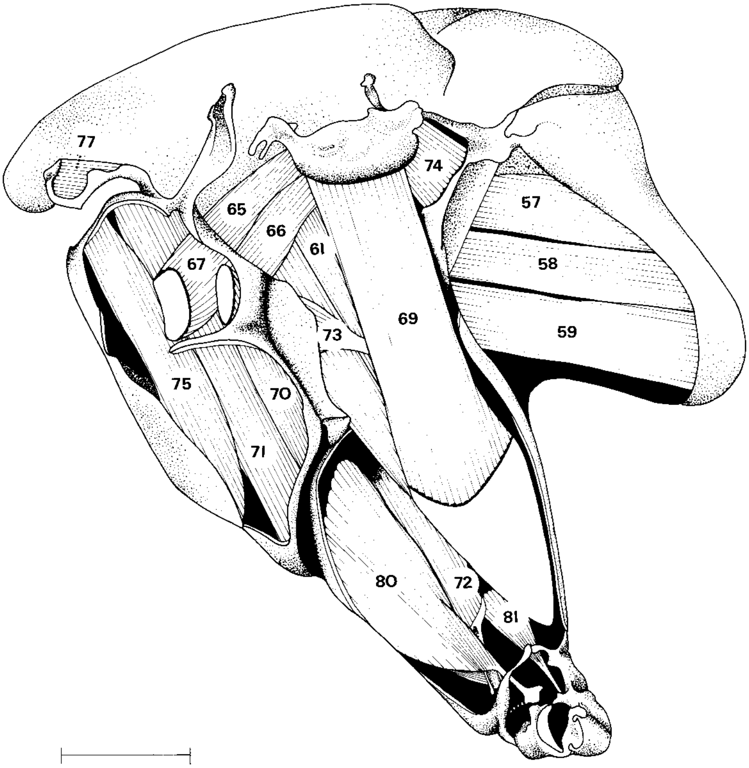

Fig. 25. Left lateral aspect of superficial mesothoracic muscles. Mesothoracic sclerites partially removed. 57, mesoscutal-mesophragmal m.; 58, ventral mesoscutal-mesophragmal m.; 59, mesointerphragmal m.; 61, scutal-mesomeral m.; 65, anepisternal-axillary m.; 66, ventral anepisternal-axillary m.; 67, lateral anepisternal-axillary muscle m.; 69, meral-subalary m.; 70, posterior anepisternal-eucoxal m.; 71, median anepisternal-eucoxal m.; 72, anepisternal-apodemal m.; 73, pleural-mesofurcal m.; 74, epimeral-subalary m.; 75, anepisternal-preepisternal m.; 77, intersubtegular m.; 80, eucoxal-trochanteral m.; 81, posterior eucoxal-trochanteral m.
(Scale line= 1.0 mm)

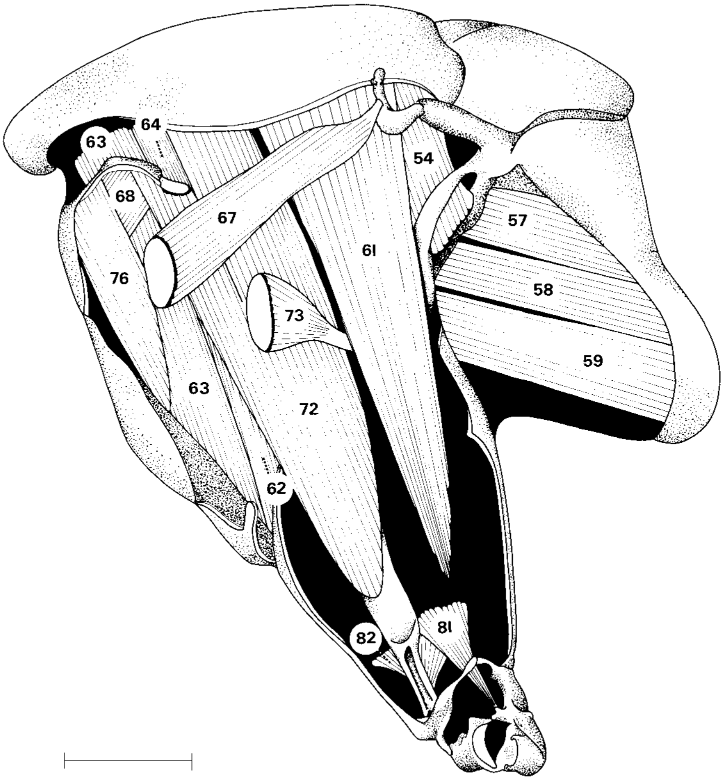

Fig. 26. Left lateral aspect of mesothoracic muscles. Superficial thoracic muscles removed. 54, scutal-phragmal m.; 57, mesoscutal-mesophragmal m.; 58, ventral mesoscutal-mesophragmal m.; 59, mesointerphragmal m.; 61, scutal-mesomeral m.; 62, scutal-furcal m.; 63, mesoscutal-basisternal m.; 64, posterior mesoscutal-mesobasisternal m.; 67, lateral anepisternal-axillary m.; 68, anepisternal-scutal m.; 72, anepisternal-apodemal m.; 73, pleural-mesofurcal m.; 76, dorsal anepisternal-preepisternal m.; 81, posterior eucoxal-trochanteral m.; 82, eucoxal-apodemal m.
(Scale line = 1.0 mm)

Fig. 27. Median aspect of mesothoracic muscles.
50, tendon of profurcal-mesofurcal m.; 54, scutal-phragmal m.; 55, mesoscutal-mesopostnotal m.; 56, ventral mesoscutal-mesopostnotal m.; 57, mesoscutal-mesophragmal m.; 58, ventral mesoscutal-mesophragmal m.; 59, mesointerphragmal m.; 60, furcal-basicostal m.; 62, scutal-furcal m.; 63, mesoscutal-basisternal m.; 64, posterior mesoscutal-mesobasisternal m.; 68, anepisternal-scutal m.; 73, tendon of pleural-mesofurcal m.; 78, basisternal-eucoxal m.; 79, spinal-apodemal m.; 82, eucoxal-apodemal m.
(Scale line = 1.0 mm)

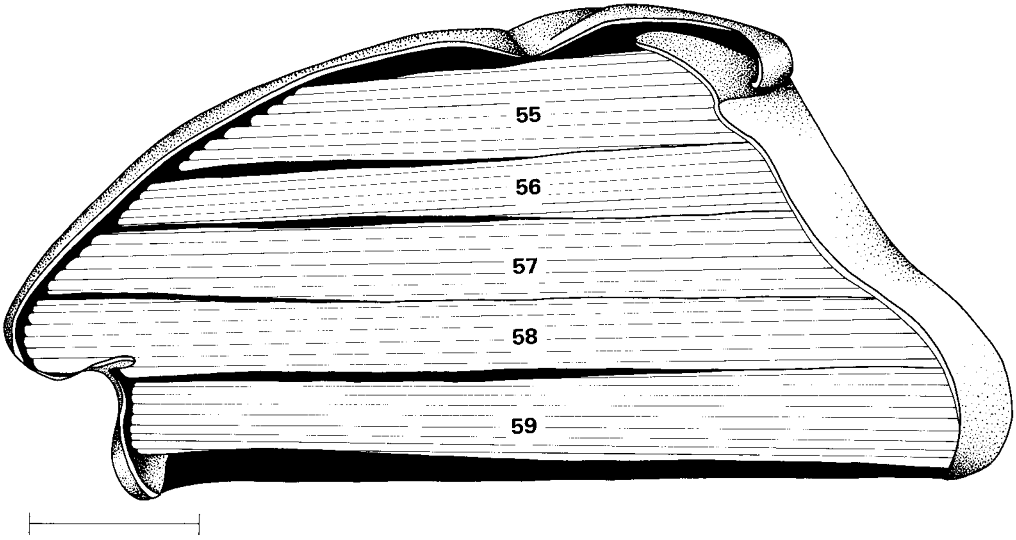

Fig. 28. Median aspect of longitudinal mesoscutal muscles. 55, mesoscutal-mesopostnotal m.; 56, ventral mesoscutal-mesopostnotal m.; 57, mesoscutal-mesophragmal m.; 58, ventral mesoscutal-mesophragmal m.; 59, mesointerphragmal m. (Scale line = 1.0 mm)

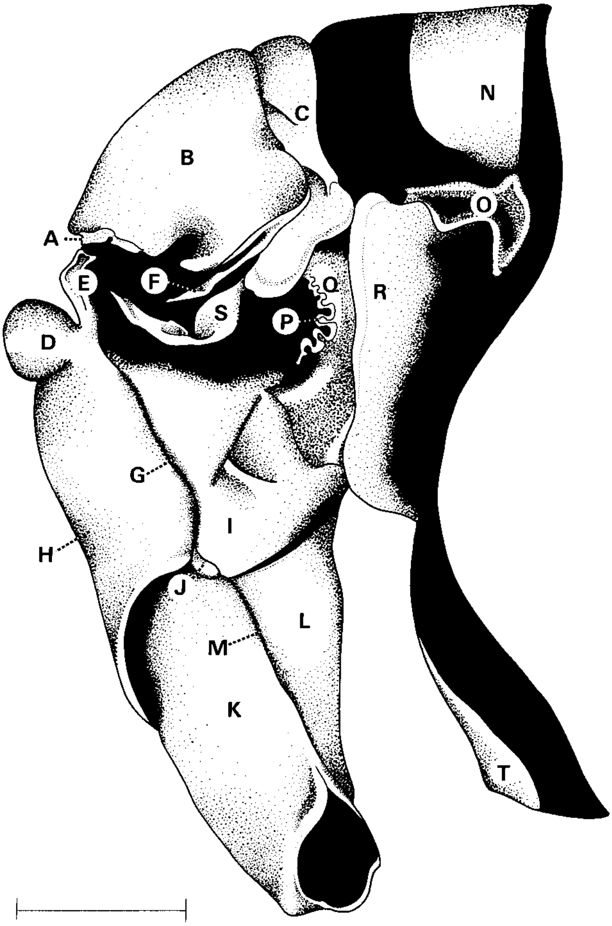

Fig. 29. Left lateral aspect of metathorax and 1st abdominal segment.
A, metasuralare; B, metascutum; C, metascutellum; D, basalare; E, pleural wing process; F, adanale; G, pleural suture; H, metepisternum; I, metepimeron; J, epicoxal piece; K, meteucoxa; L, metameron; M, basicostal suture; N, 1st abdominal tergum, O, laterotergal groove; P, epaulette; Q, tympanic membrane; R, hood; S, subalare; T, fusion of abdominal sterna 1 and 2.
(Scale line = 1.0 mm)

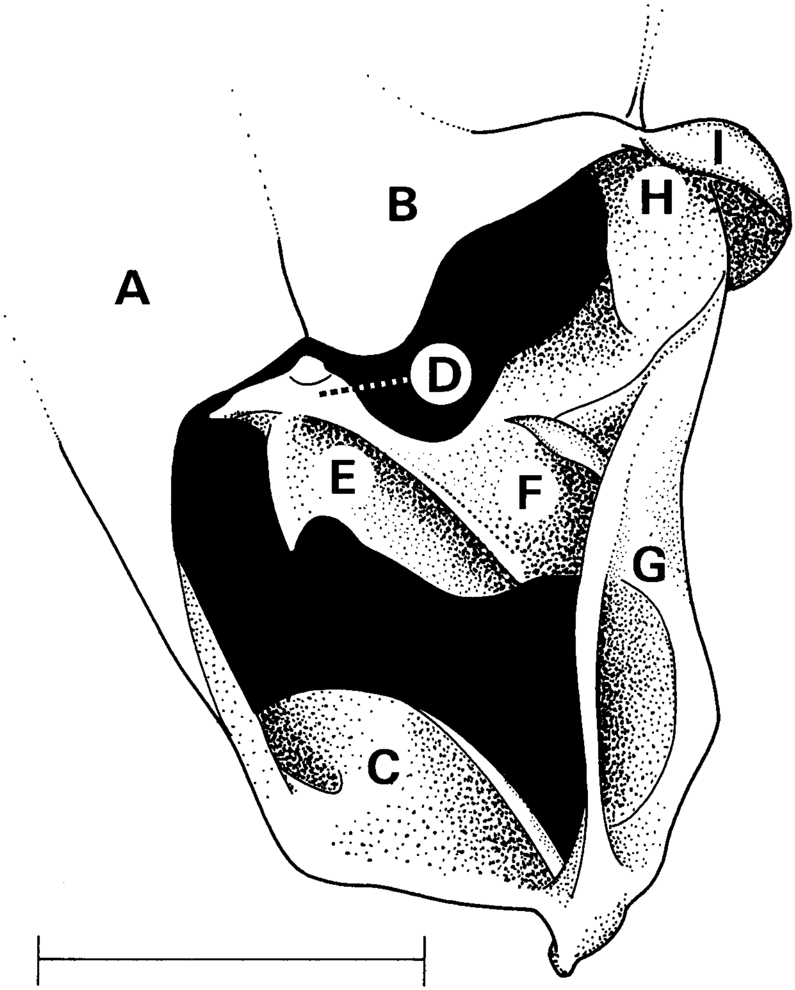

Fig. 30. Left lateral aspect of matathoracic coxa and furca. Femur removed.
A, episternum; B, epimeron; C, ventral median plate of furca; D, anterior furcal arm; E, median ridge of furca; F, posterior arm of furca; G, base of furca; H, postcoxal bridge; I, posterior tendon plate.
(Scale line = 1.0 mm)

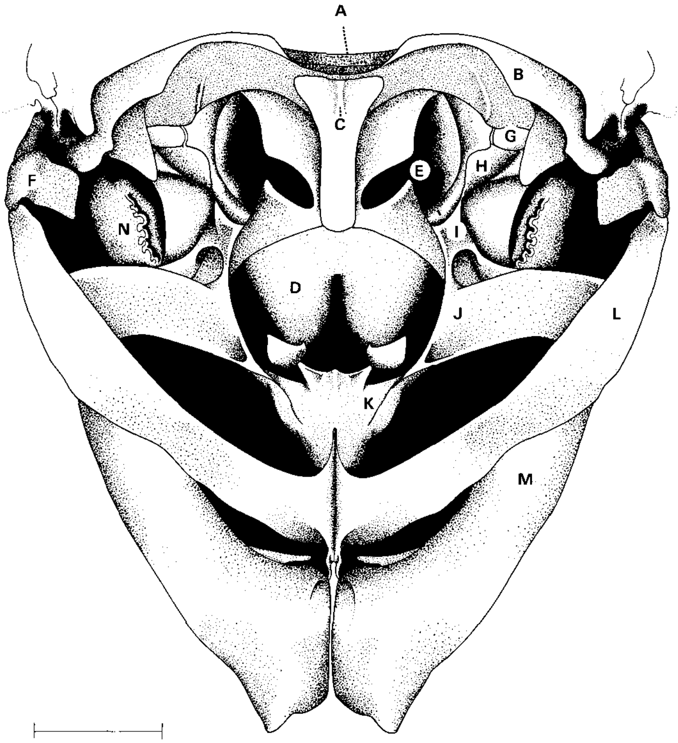

Fig. 31. Anterior aspect of metathorax and countertympanic cavities.
A, metascutellum; B, metascutum; C, median carina; D, countertympanic membrane; E, countertympanic pocket; F, basalare; G, postnotal pocket I; H, postnotal pocket II, I, postnotal pocket III; J, epimeral pocket IV; K, postcoxal bridge; L, episternum; M, eucoxa; N, epaulette.
(Scale line = 1.0 mm)

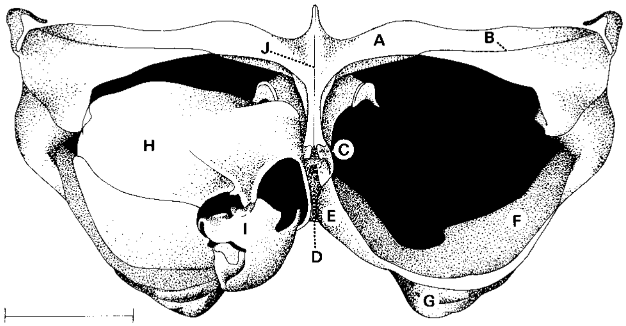

Fig. 32. Ventral aspect of metathorax. Left coxa removed. A, basisternum; B, marginal pleural suture; C, articulation of metacoxa; D, apophyseal pit; E, furcasternum; F, postcoxal bridge; G, posterior tendon plate; H, coxa; I, trochanter; J, discrimen. (Scale line = 1.0 mm)

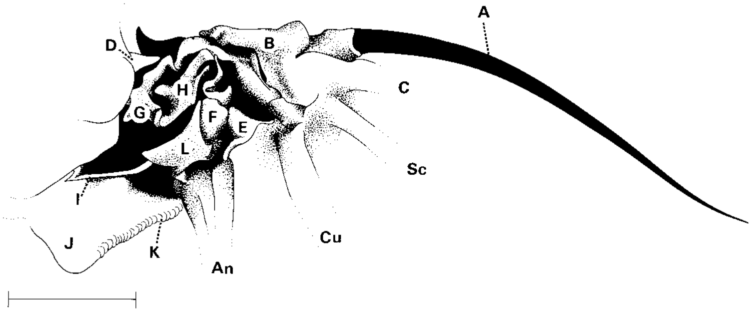

Fig. 33. Right metathoracic axillary region of male. A, frenulum; B, humeral plate; C, costal vein; D, suralare; E, distal median plate; F, proximal median plate; G, 1st axillary sclerite; H, 2nd axillary sclerite; I, adanale; J, alula; K, axillary cord; L, 3rd axillary sclerite; Sc, subcostal vein; Cu, cubital vein; An, anal vein.
(Scale line = 1.0 mm)

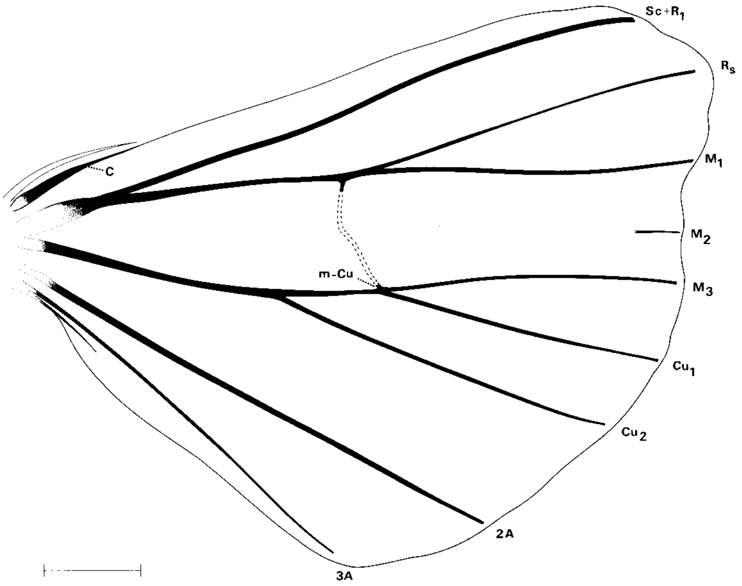

Fig. 34. Right metathoracic wing of male.
C, costal vein; Sc, subcostal vein; R, radial vein; Cu, cubital vein; A, anal vein; m-Cu, median-cubital cross-vein R_s, radial sector; M, median vein. (Scale line = 2.0 mm)

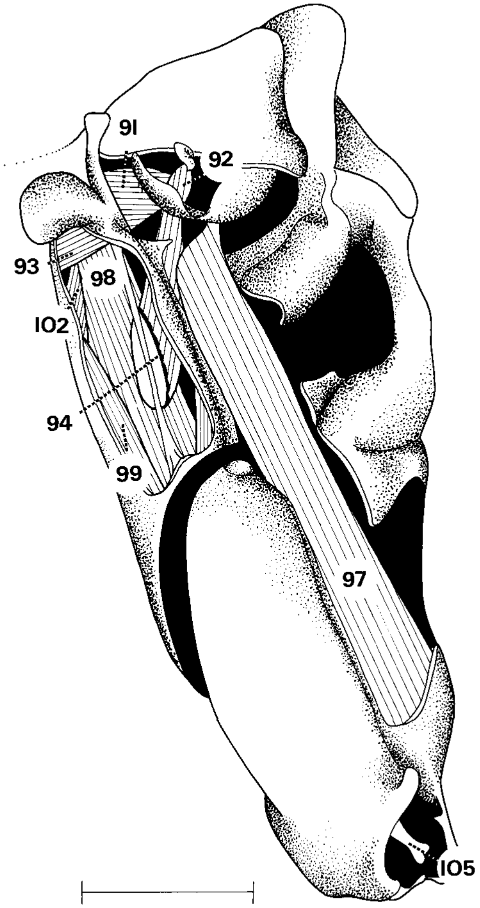

Fig. 35. Left lateral aspect of superficial metathoracic muscles. Metathoracic sclerites partially removed. 91, wing process-axillary m.; 92, posterior episternal-axillary m.; 93, anterior episternal-axillary m.; 94, ventral episternal-axillary m.; 97, meral-subalar m.; 98, basalar-eucoxal m., 99, episternal-eucoxal m.; 102 basalar-prepectal m.; 105, tendon of eucoxal-trochanteral m.
(Scale line = 1.0 mm)

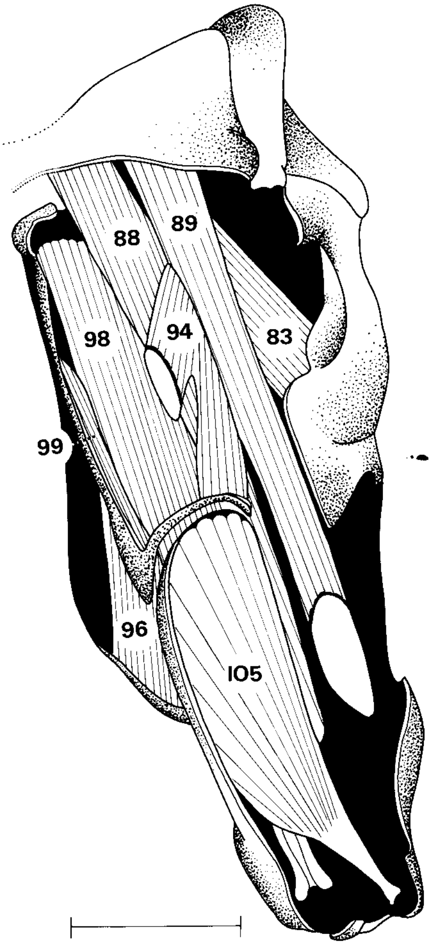

Fig. 36. Left lateral aspect of metathoracic muscles. Superficial muscles partially removed. 83, scutal-epimeral m.; 88, scutal-trochanteral m.; 89, posterior scutal-meral m.; 94, ventral episternal-axillary m.; 96, metascutal-prepectal m.; 98, basalar-eucoxal m.; 99, episternal-eucoxal m.; 105, eucoxal-trochanteral m. (Scale line = 1.0 mm)

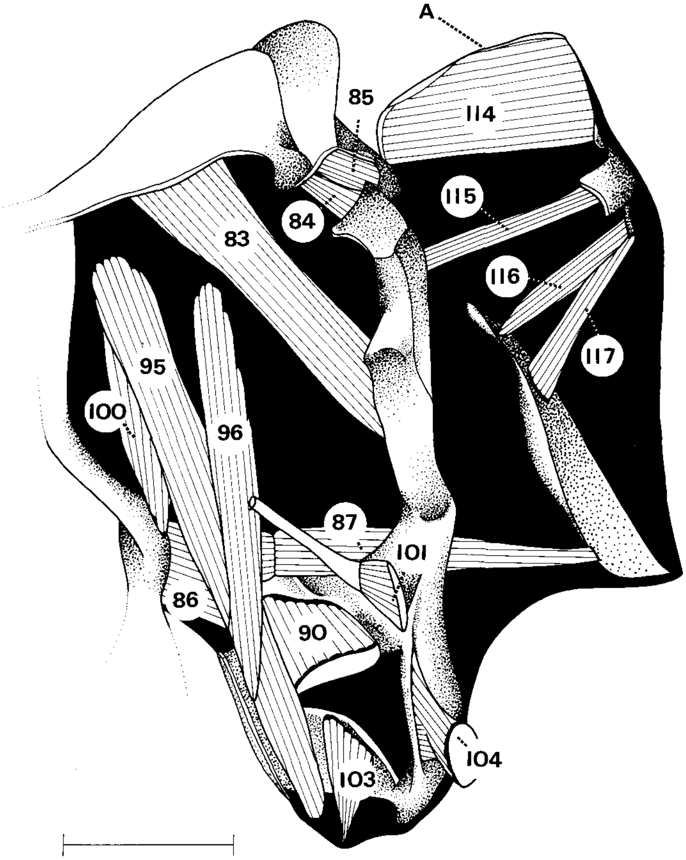

Fig. 37. Left lateral aspect of median metathoracic and 1st abdominal muscles.
A, 1st abdominal segment; 83, scutal-epimeral pocket IV m.; 84, prescutal-metascutellar m.; 85, pre scutal-metapostnotal m.; 86, interfurcal m.; 87, posterior mesofurcal-abdominal m.; 90, furcal-tendonal m.; 95, dorsal scutal-episternal m.; 96, metascutal-prepectal m.; 100, mesofurcal-basalar m.; 101 pleural ridge-furcal m.; 103, furcal-trochanteral m.; 104, furcasternal-metameral m.; 114, interabdominal m.; 115, abdominal segment 2-epimeral pocket II m.; 116, laterotergal groove-abdominal 1,2 m.; 117, ventral laterotergal groove-abdominal sternal 1,2 m.
(Scale line = 1.0 mm)

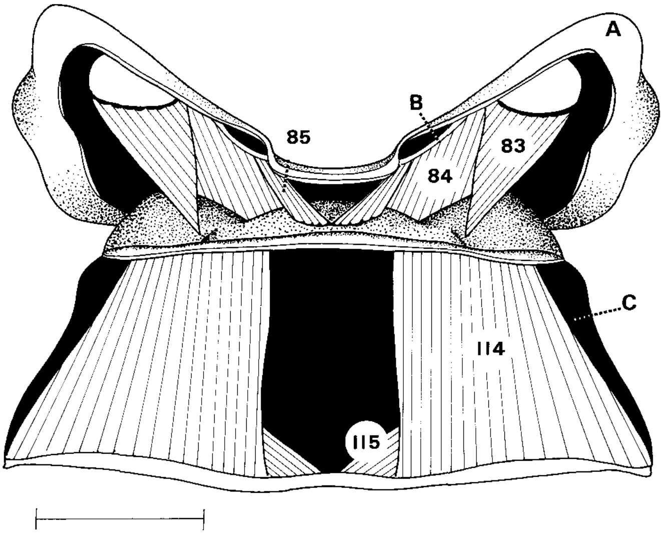

Fig. 38. Dorsal aspect of posterior metathoracic and 1st abdominal muscles.
A, scutum; B, prescutum; C, 1st abdominal segment; 83, scutal-epimeral m.; 84, prescutal-metascutellal m.; 85, prescutal-metapostnotal m.; 114, interabdominal m.; 115, abdominal segment 1,2-epimeral pocket 2 m.
(Scale line = 1.0 mm)

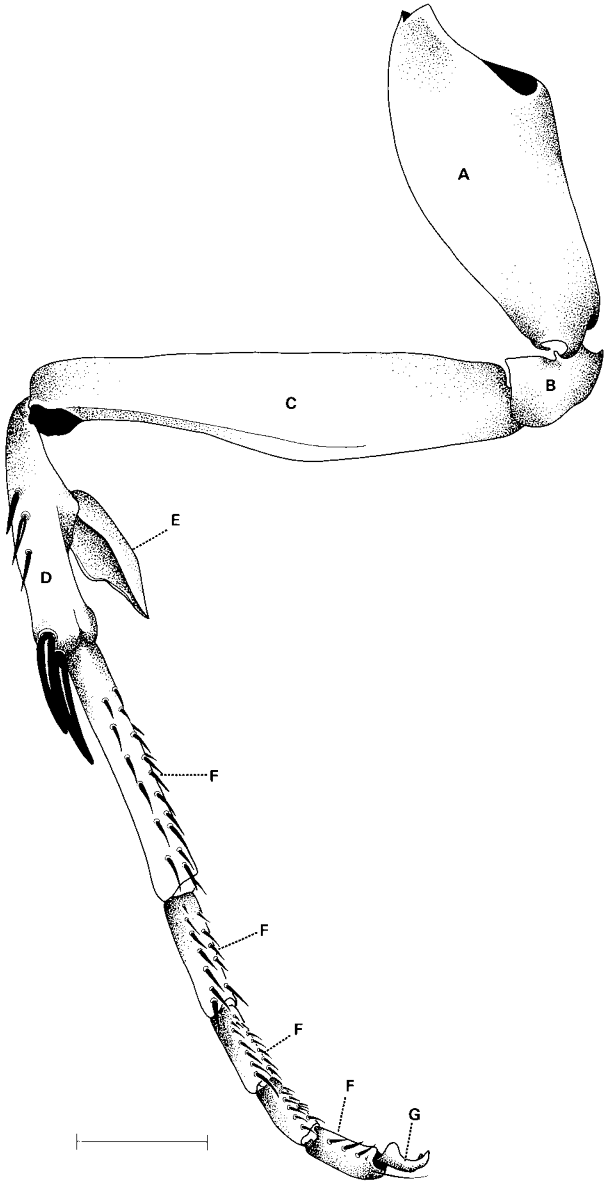

Fig. 39. Posterior aspect of left prothoracic leg.
A, coxa; B, trochanter; C, femur; D, tibia; E, epiphysis; F, tarsomeres; G, pretarsus.
(Scale line = 1.0 mm)

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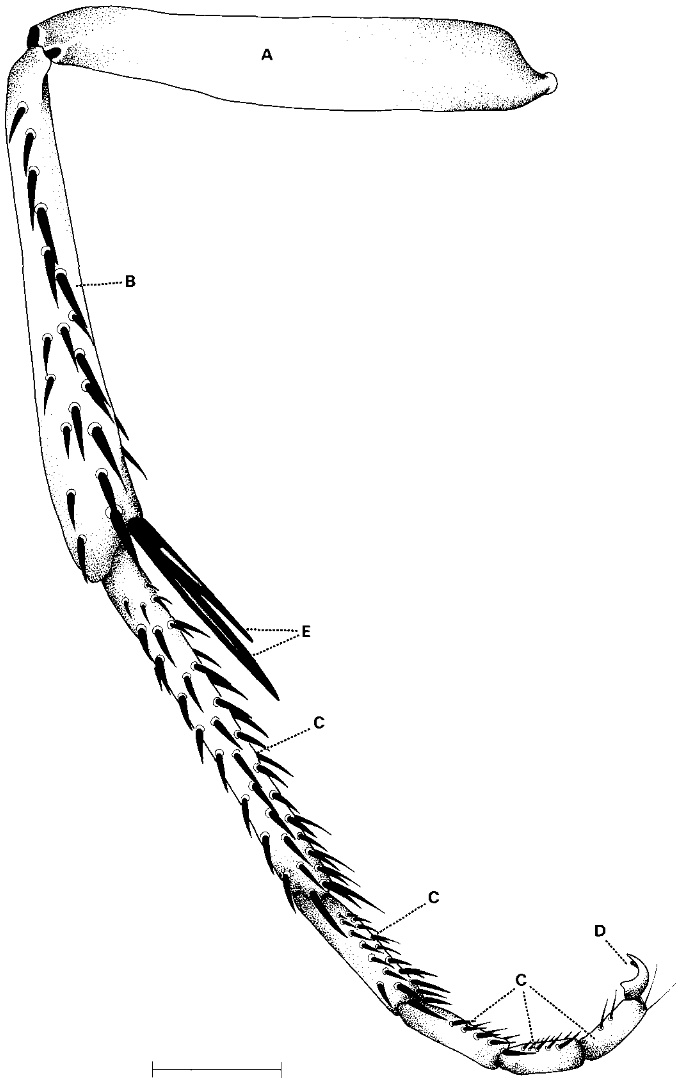


Fig. 40. Posterior aspect of left mesothoracic leg.
A, femur; B, tibia; C, tarsomeres, D, pretarsus;
E, spurs.
(Scale line = 1.0 mm)

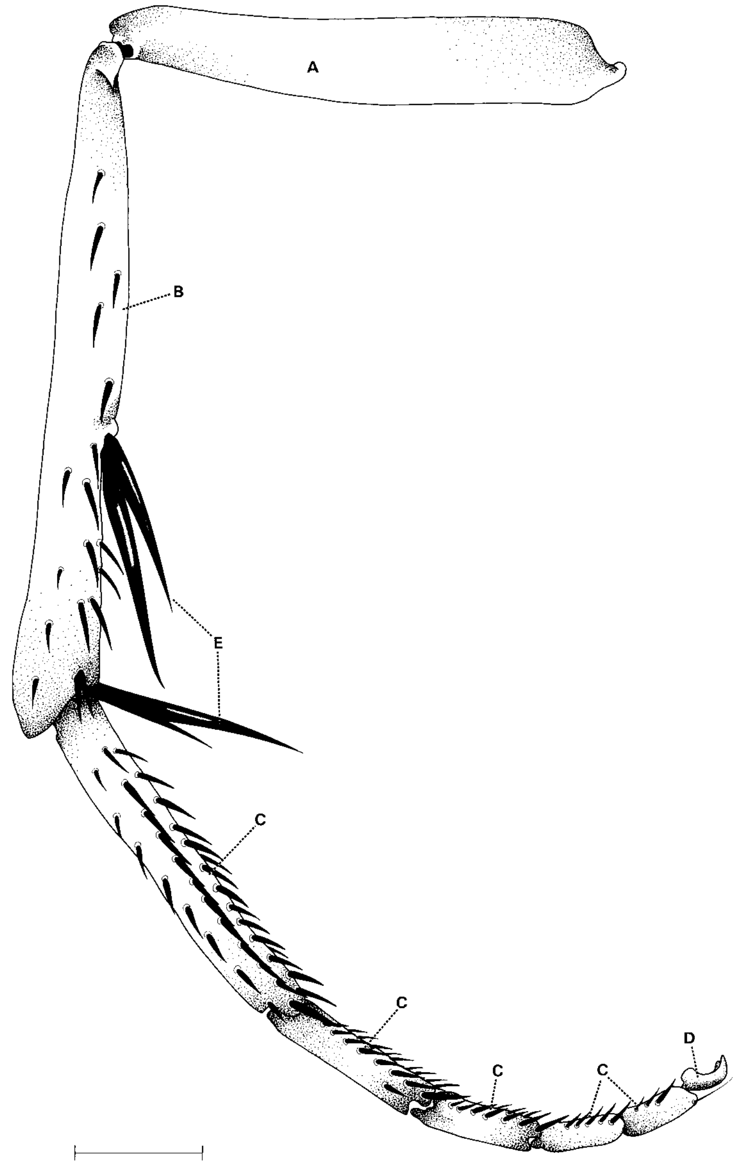


Fig. 41. Posterior aspect of left metathoracic leg.
A, femur; B, tibia; C, tarsomeres; D, pretarsus;
E, spurs.
(Scale line = 1.0 mm)

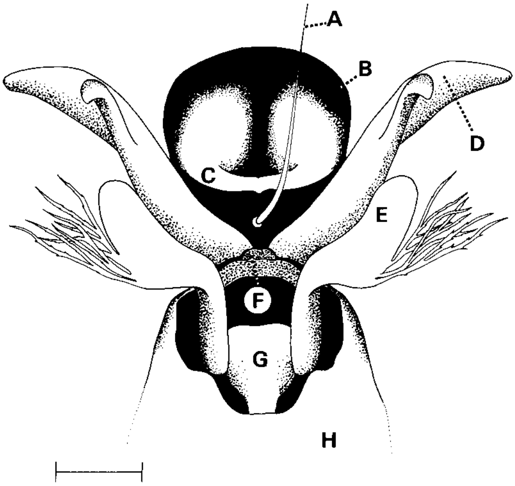
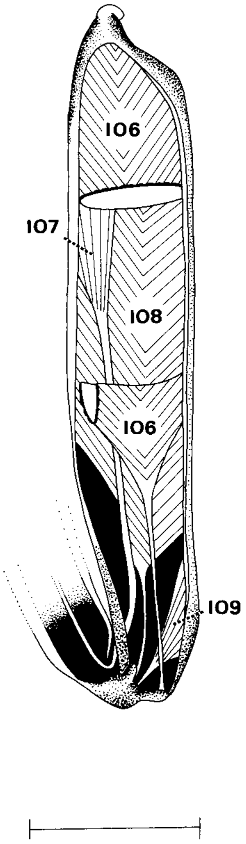


Fig. 42. Ventral aspect of metathoracic distitarsus and pretarsus.
A, median seta; B, arolium; C, arcus; D, ungues;
E, pulvilius; F, unguifer; G, unguitractor plate;
H, distitarsus.
(Scale line = 0.09 mm)



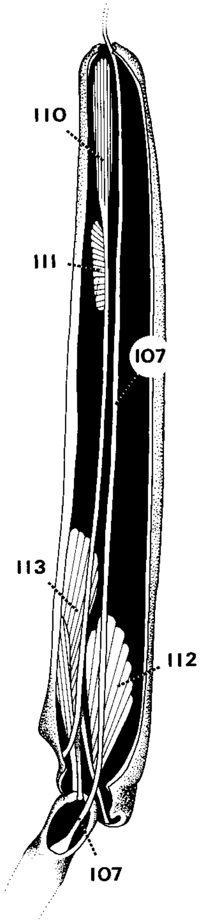


Fig. 43. Lateral aspect of prothoracic femoral muscles. 106, lateral femoral-tibial m.; 107, femoral- pretarsal m.; 108, ventral femoral-tibial m.; 109, femoral-tibial m.
(Scale line = 1.0 mm)

Fig. 44. Lateral aspect of prothoracic tibial muscles. 107, tendon of femoral-pretarsal m.; 110, dorsal tibial-tarsal m.; 111, posterior tibial-apodermal m.; 112, median tibial-tarsal m.; 113, ventral tibial-tarsal m.

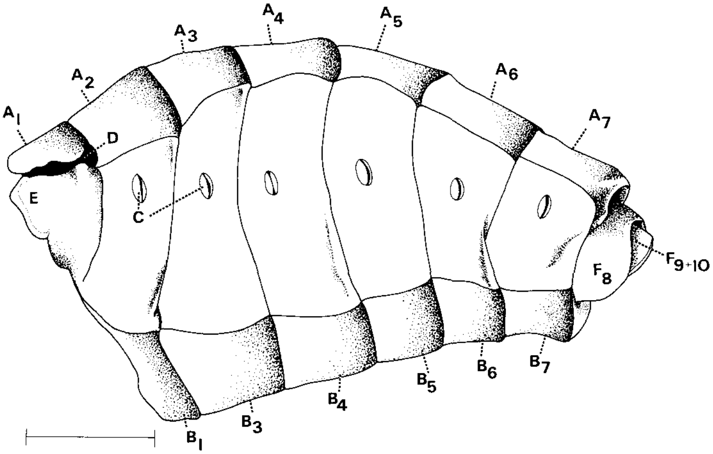


Fig. 45. Left lateral aspect of female abdomen. $A_{(1-7)}$, abdominal tergites 1 through 7; B_1 fused sternites 1 and 2; $B_{(3-7)}$, abdominal sternites 3 through 7; C, abdominal spiracles; D, laterotergal groove; E, hood; F_8 8th abdominal segment; $F_{(9+10)}$, papillae anales. (Scale line = 0.5 mm)

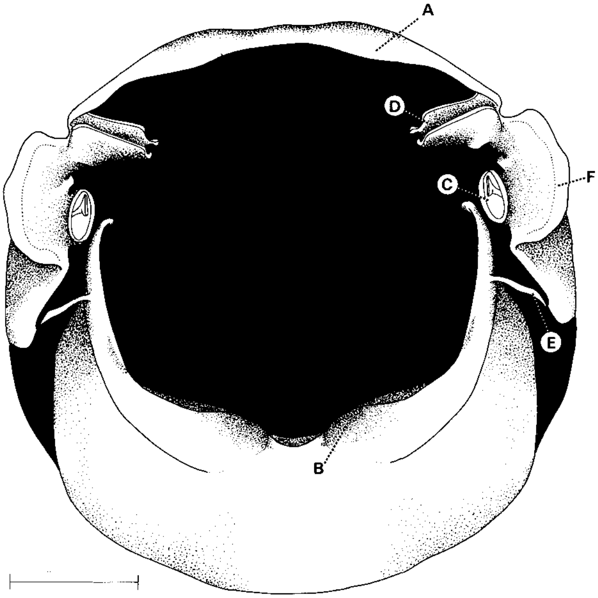


Fig. 46. Anterior aspect of 1st abdominal tergite and fused abdominal sternites 1 and 2. A, abdominal tergite 1; B, fused sternites 1 and 2; C, abdominal spiracle 1; D, laterotergal groove; E, pleural bar; F, hood. (Scale line = 1.0 mm)

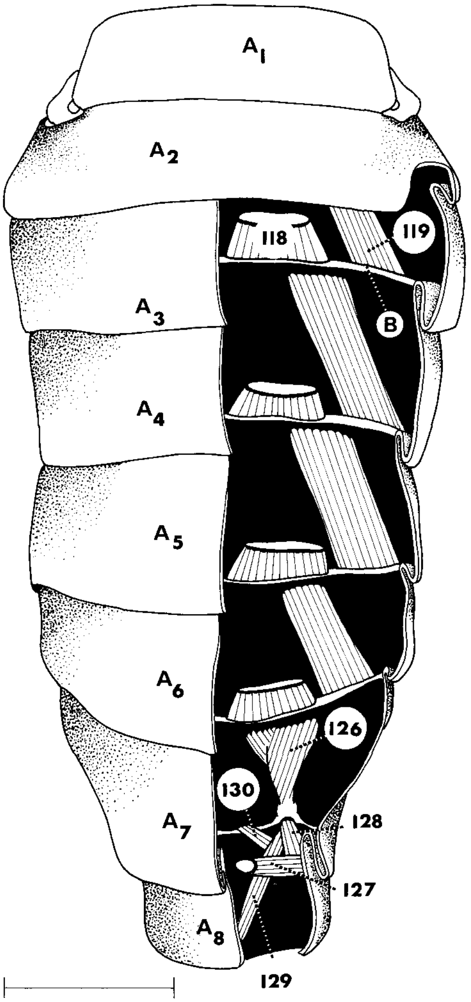


Fig. 47. Dorsal aspect of male abdominal muscles. Right tergites partially removed.
$A_{(1-8)}$, abdominal tergites; B, antecosta; 118, tergal-acrotergal m.; 119, interantecostal m.; 126, antecostal 7-tergal 7,8 m.; 127, median intertergal 8 m.; 128, ventral antecostal 7-tergal 8 m.; 129, median antecostal 7-uncal m.; 130, antecostal 8-membraneal 8 m.
(Scale line = 0.5 mm)

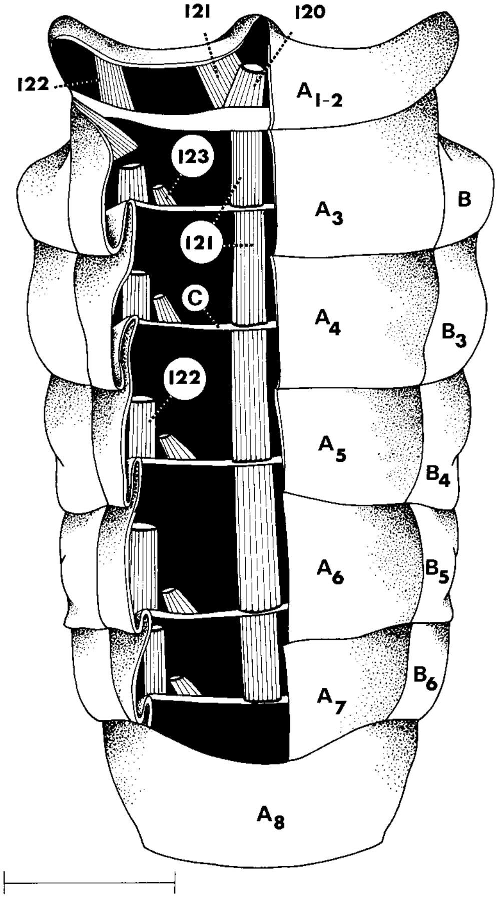


Fig. 48. Ventral aspect of male abdominal muscles. Right sternites partially removed.
$A_{(1-8)}$, abdominal sternites; $B_{(3-6)}$, abdominal pleurites; C, antecosta; 120, antecosta-sternal 1,2 m.; 121, mediolateral antecostal-sternal 1,2 m.; 122, lateral antecostal-sternal 1,2; 123 antecostal 3-intersegmental 1,2 m.
(Scale line = 0.5 mm)

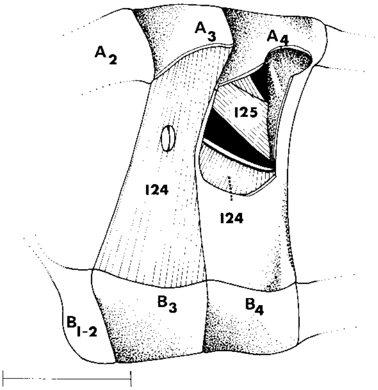


Fig. 49. Lateral aspect of abdominal muscles. Pleural membrane partially removed.
$A_{(2-4)}$, abdominal tergites 2 through 4; $B_{(1-2)}$, fused abdominal sternites 1 and 2; $B_{(3-4)}$, abdominal sternites 3 and 4; 124, tergal-sternal m.; 125, tergal-antecostal 4 m.
(Scale line = 0.5 mm)

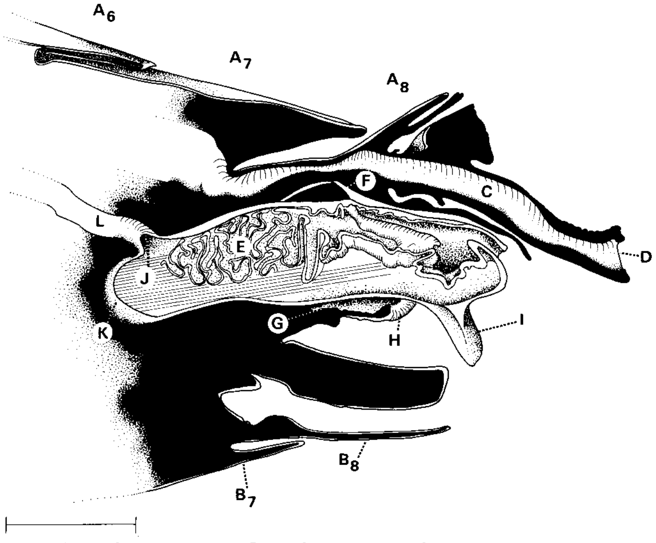


Fig. 50. Sagittal aspect of male genitalia.
$A_{(6-8)}$, abdominal tergites 6 through 8; $B_{(7-8)}$, abdominal sternites 7 and 8; C, anal tube; D, anus; E, endophallus; F, manica; G, zone; H, anellus; I, aedeagus; J, primary gonopore; K, caecum; L, ejaculatory duct.
(Scale line = 1.0 mm)

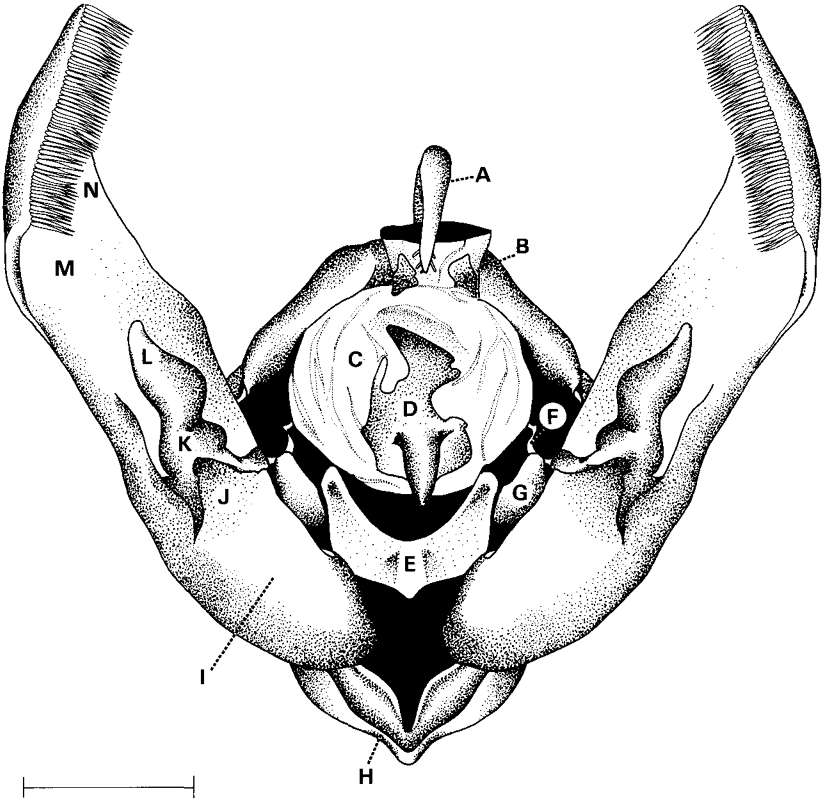


Fig. 51. Anterior aspect of male genitalia and accessory structures.
A, uncus; B, scaphium; C, anellus; D, aedeagus; E, juxta; F, transtilla; G, peniculus; H, saccus (of vinculum); I, costa; J, anellifer; K, harpe; L, ampulla; M, valvula; N, cucullus.
(Scale line = 1.0 mm)

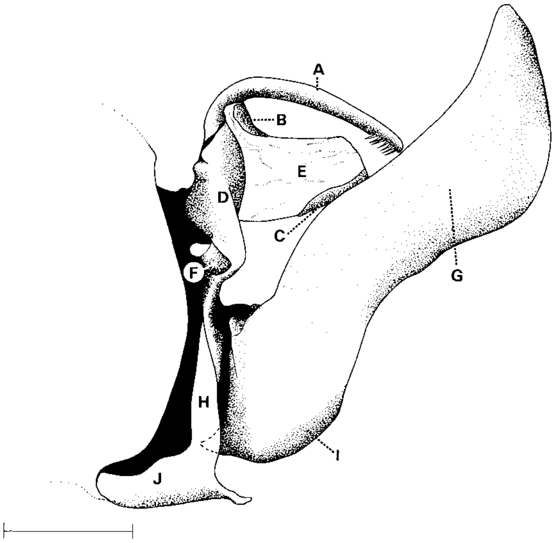


Fig. 52. Lateral aspect of male genitalia and accessory structures.
A, uncus; B, scaphium; C, subscaphium; D, tegumen; E, anal tube; F, 9th pleurite; G, valva; H, vinculum; I, sacculus; J, saccus (of vinculum).
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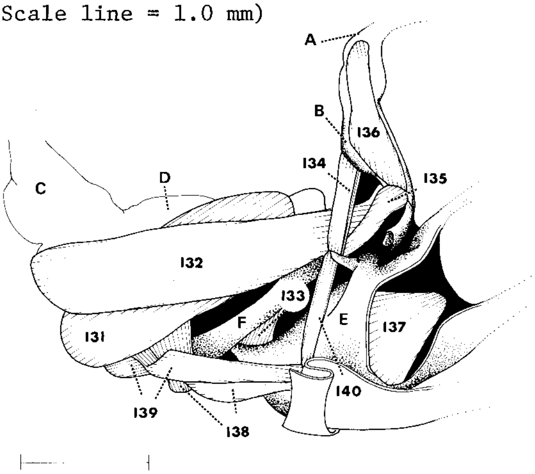

Fig. 53. Left lateral aspect of male genitalic muscles. Abdominal segments removed.
A, uncus; B, tegumen; C, ejaculatory duct; D, aedeagus; E, saccus; F, vinculum; 131, saccal-aedeagal m.; 132, tegumenal 9-aedeagal m.; 133, saccal-juxtal m.; 134, tergal 9-valval m.; 135, pleural 9-vulval m.; 136, tergal 9-uncal m.; 137, harpal-vulval m.; 138, posterior antecostal 8-saccal m.; 139, median antecostal 8-saccal m.; 140, lateral antecostal-tergal 9 m.
(Scale line = 1.0 mm)

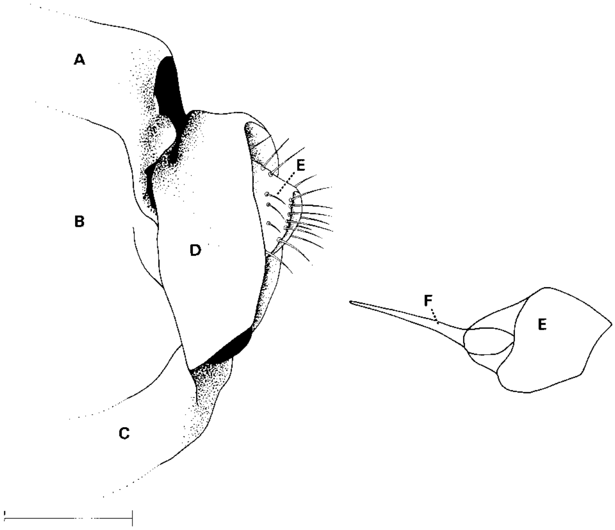

Fig. 54. Lateral aspect of female genitalia (Inset: lateral aspect of papillae anales).
A, 7th abdominal tergite; B, 7th abdominal pleurite; C, 7th abdominal sternite; D, 8th abdominal segment; E, papillae anales; F, posterior apophyses.
(Scale line = 1.0 mm)

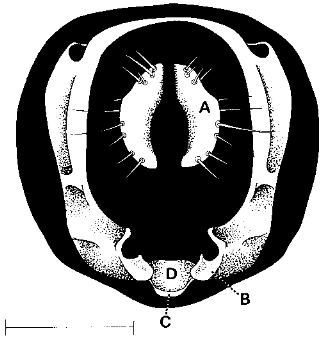

Fig. 55. Anterior aspect of female genitalia.
A, papilla analis; B, lamella postvaginalis; C, lamella antevaginalis; D, ostium bursae.
(Scale line = 1.0 mm)

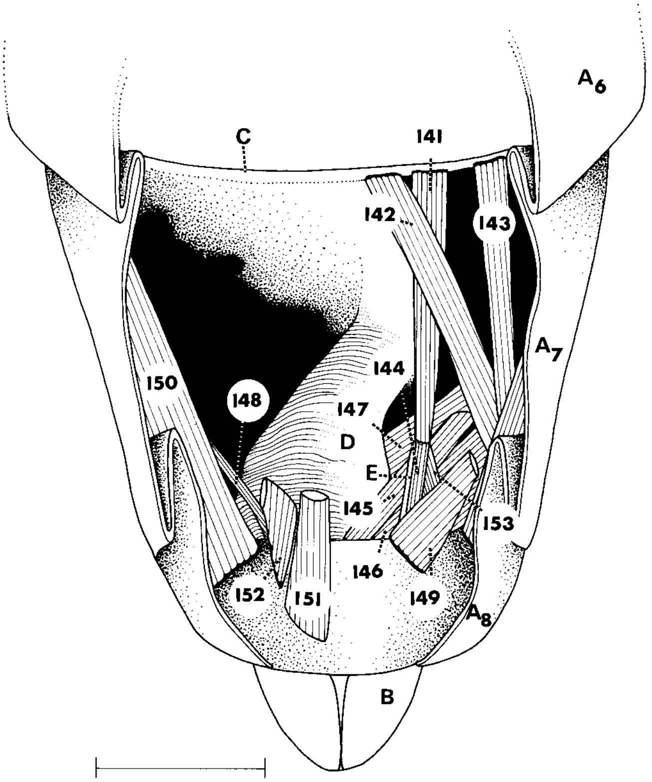

Fig. 56. Dorsal aspect of female genitalic muscles. Abdominal tergites and left superficial muscles removed. $A_{(6-8)}$, abdominal tergites 6 through 8; B, papilla analis; C, antecosta; D, proctodaeum; E, posterior apophysis; 141, antecostal 7-apophysial m.; 142, antecostal 7-antecostal 8 m.; 143, antecostal 7-lateral antecostal 8 m.; 144, tergal-papilla analis m.; 145, lateral antecostal 8-ventral antecostal 8 m.; 146, antecostal 8-papilla analis m.; 147, antecostal 8-papilla analis m.; 148, sternal 8-papilla analis m.; 149, antecostal 8-tergal 7 m.; 150, antecostal 8-pleural 7 m.; 151, antecostal 8-dorsal tergopleural m.; 152, antecostal 8-ventral tergopleural m.; 153, pleural 8-papilla analis m. (Scale line = 1.0 mm)

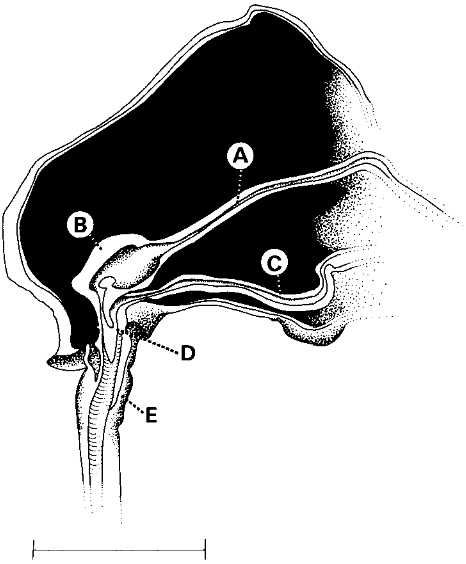

Fig. 57. Sagittal section of head and anterior digestive system.
A, esophagus; B, cibarial-pharyngeal pump; C, salivary duct; D, functional mouth; E, galea. (Scale line = 1.0 mm)

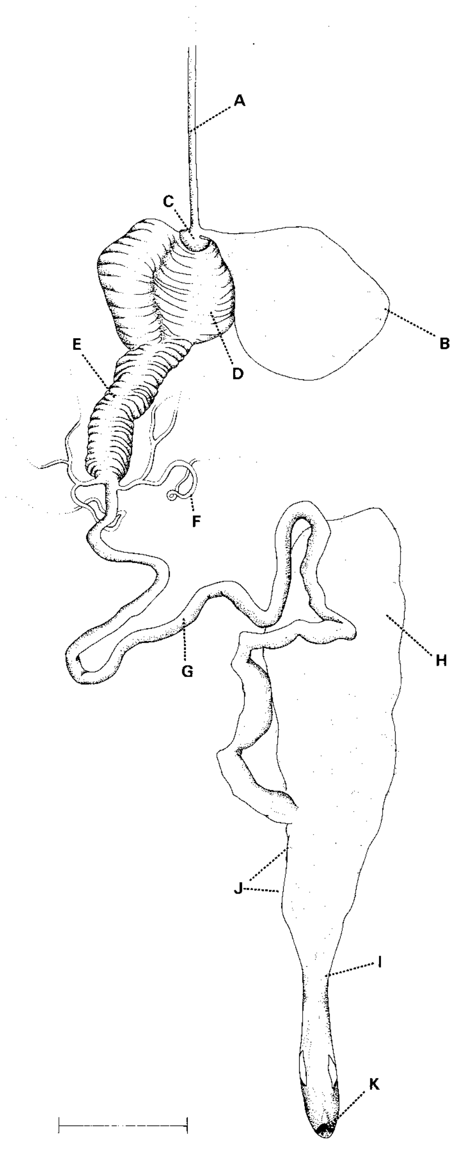

Fig. 58. Dorsal aspect of digestive system.
A, esophagus; B, crop; C, intermediate chamber; D, anterior mesenteron; E, posterior mesenteron; F, Malpighian tubule; G, anterior intestine; H, rectal sac; I, rectum; J, rectal glands; K, anus. (Scale line = 2.0 mm)

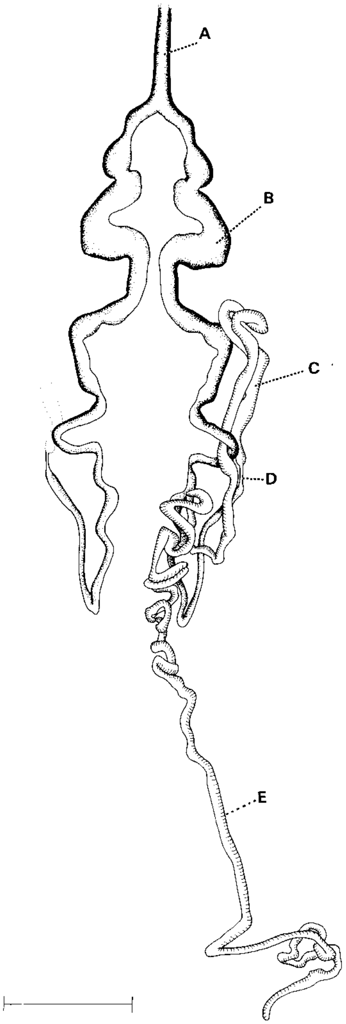

Fig. 59. Dorsal aspect of salivary glands and ducts. Left salivary gland removed.
A, common salivary duct; B, fluted duct; C, salivary duct; D, constriction; E, salivary gland.
(Scale line = 1.0 mm)

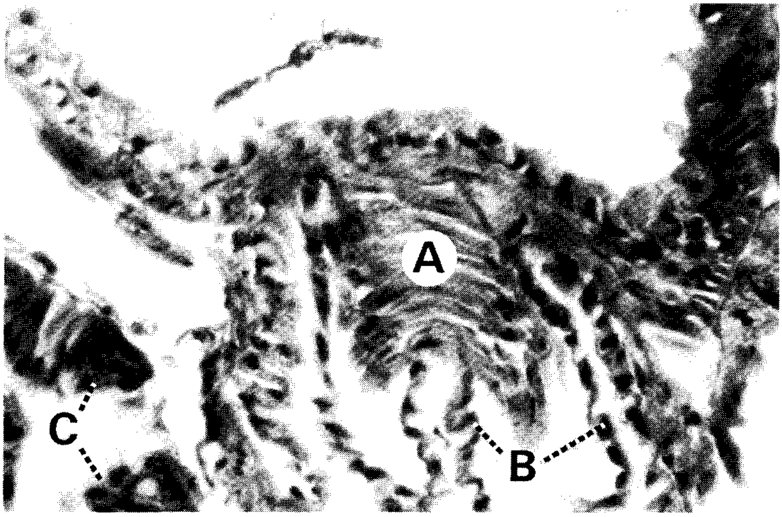

Fig. 60. Parasagittal section of juncture of the esophagus, crop, and mesenteron (350 X).
A, esophageal sphincter muscle; B, esophagus; C, mesenteron.

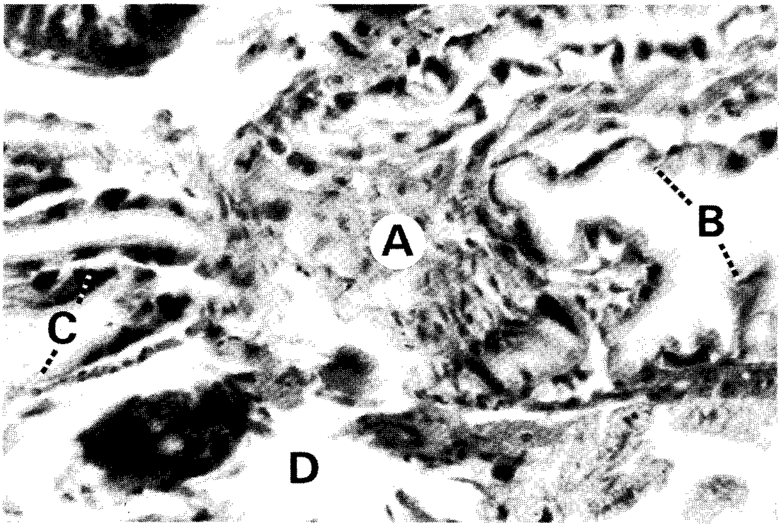

Fig. 61. Parasagittal section of juncture of esophagus, crop, and mesenteron (350X).
A, crop sphincter muscle; B, crop; C, esophagus; D, lumen of mesenteron.

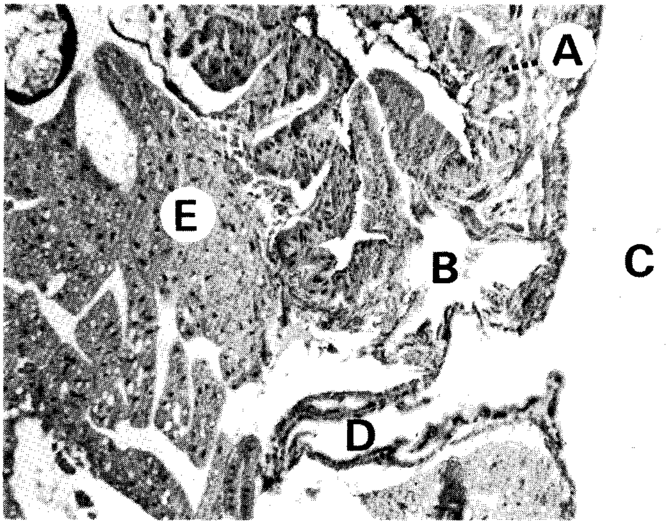

Fig. 62. Parasagittal section of juncture of esophagus, crop, and mesenteron (87 X).
A, mesenteron; B, intermediate chamber; C, lumen of crop; D, lumen of esophagus; E, fat bodies.

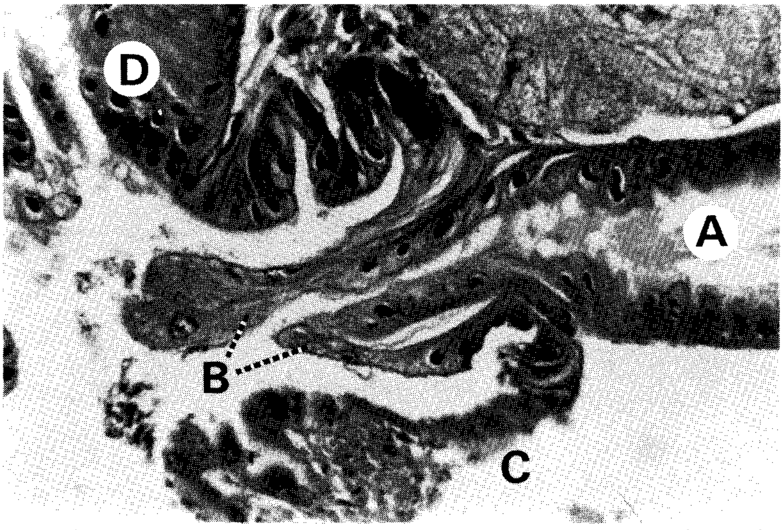

Fig. 63. Parasagittal section of Malpighian tubule (350 X).
A, lumen of Malpighian tubule; B, valves of Malpighian tubule; C, proctodaeum; D, mesenteron.

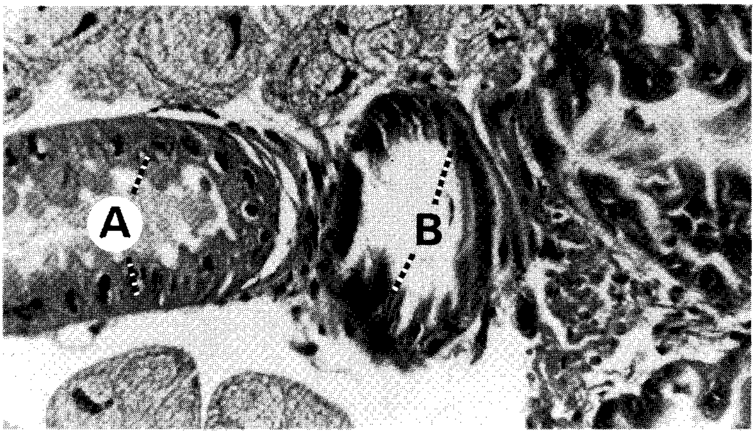

Fig. 64. Parasagittal section of Malpighian tubule (350 X). A, Malpighian tubule; B, sphincter muscle.

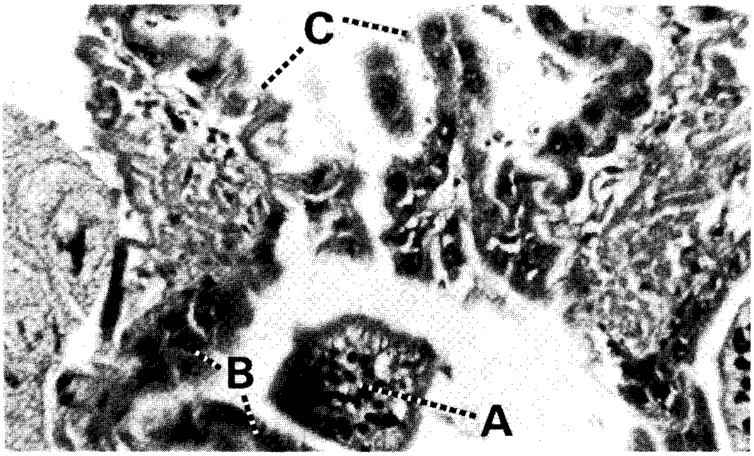

Fig. 65. Parasagittal section of ventricular valve (350 X). A, ventricular valve; B, mesenteron; C, proctodaeum.

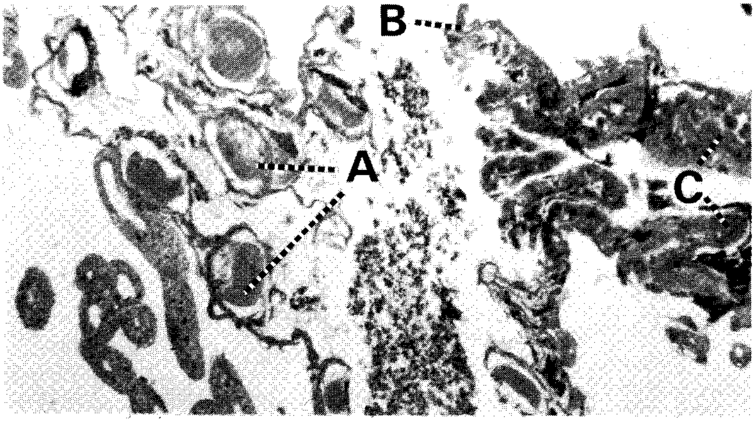

Fig. 66. Parasagittal section of rectum and rectal glands (87 X).
A, rectal glands; B, rectum; C, anterior intestine.

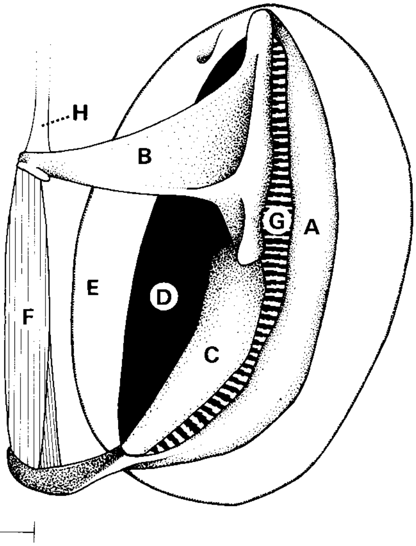

Fig. 67. Internal aspect of the 3rd abdominal spiracle.
A, bow; B, lever; C, band; D, atrial wall; E, peritreme; F, occlusor muscle; G, guarding hairs; H, elastic band.
(Scale line = 0.08 mm)

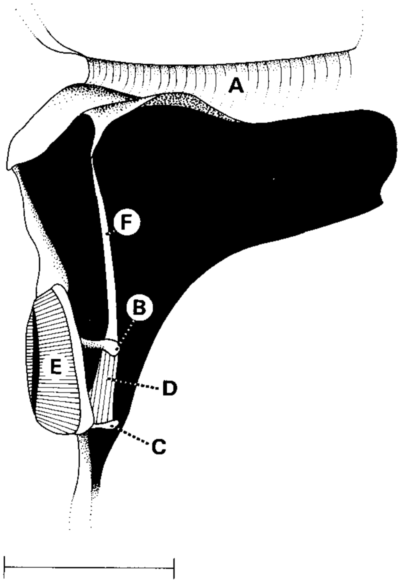

Fig. 68. Left lateral aspect of 1st abdominal spiracle.
Abdominal pleurite 1 removed.
A, laterotergal groove; B, lever; C, bow; D, occlusor muscle; E, guarding hairs, F, elastic band.
(Scale line = 1.0 mm)

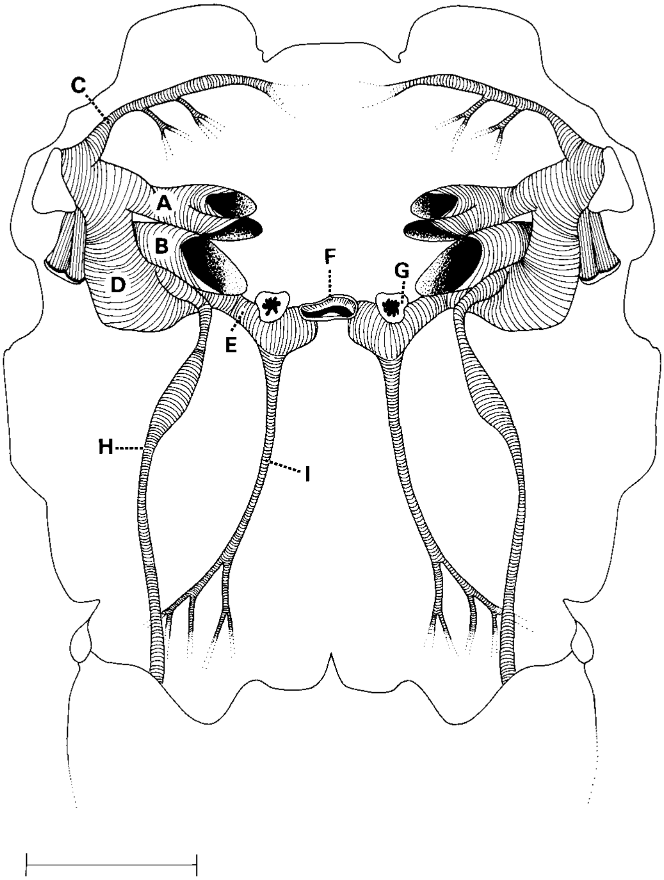

Fig. 69. Anterior aspect of the mesothoracic spiracles and tracheal trunks.
A, dorsal anterior head trunk; B, ventral anterior head trunk; C, anterior dorsal trachea; D, ventral anterior body trunk; E, anterior lateral trunk; F, esophagus; G, salivary duct; H, leg trachea; I, median ventral trachea.
(Scale line = 2.0 mm)

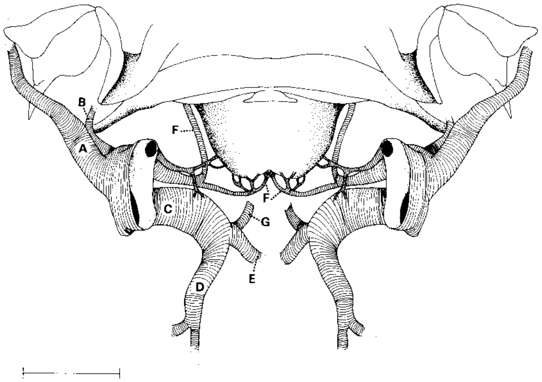

Fig. 70. Anterior aspect of the posterior mesothoracic tracheal trunks. Anterior tracheal trunk removed. A, pleural trunk; B, mesothoracic leg trunk; C, ventral posterior lateral trunk; D, anterior ventral trachea; E, ganglionic trachea; F, dorsal posterior lateral trunk; G, median longitudinal posterior trachea.
(Scale line = 2.0 mm)

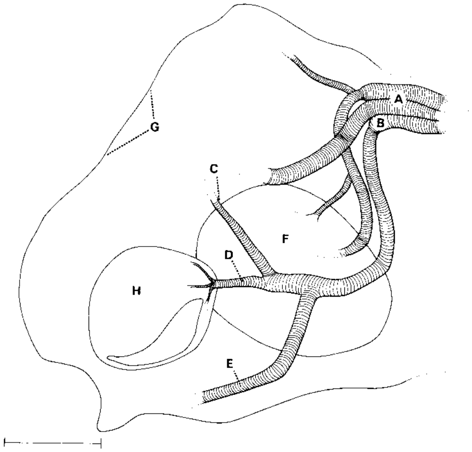

Fig. 71. Left lateral aspect of the right, dorsal and ventral tracheal trunks and head trachea.
A, dorsal anterior head trunks; B, ventral anterior head trunk; C, antennal trachea; D, cibarial-pharyngeal trachea; E, ventral anterior trachea; F, occular diaphragm; G, outline of head; H, cibarial-pharyngeal pump.
(Scale line = 2.0 mm)

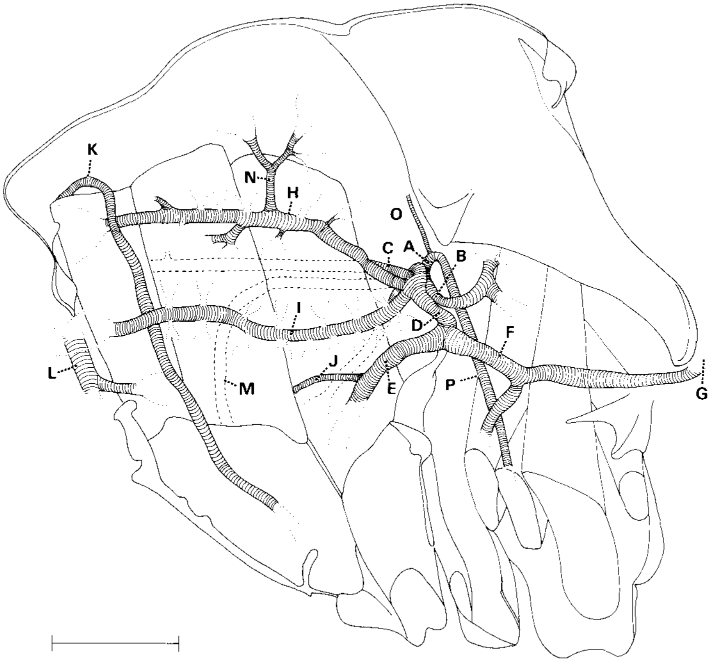

Fig. 72. Ental aspect of the right mesothoracic spiracle and associated tracheae. (Anterior to the right). A, pleural leg trunk; B, posterior median trunk; C, anterior lateral longitudinal trunk; D, median leg trunk; E, anterior median leg trunk; F, posterior median leg trunk; G, anterior ventral longitudinal connective; H, anterior median dorsal longitudinal trunk; I, median ventral longitudinal trunk; J, ventral lateral trunk; K, branch from mesothoracic spiracle; L, ventral posterior body trunk; M, ventral longitudinal trunk; N, dorsal trachea; O, dorsal pleural trachea; P, ventral pleural trunk.
(Scale line = 1.0 mm)

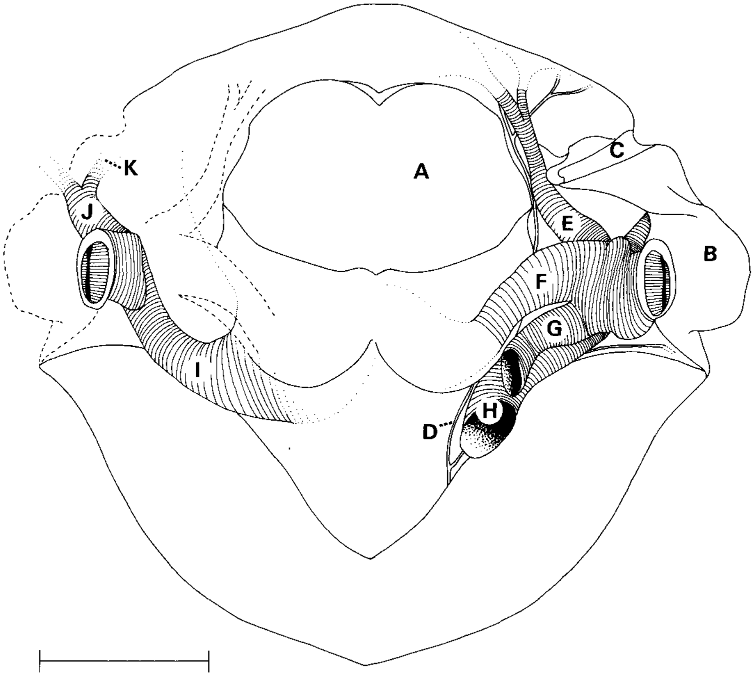

Fig. 73. Anterior aspect of 1st abdominal spiracle and anterior tracheal trunks. Right anterior tracheal trunks removed. Broken lines indicate the position of the anterior tracheal trunks.
A, countertympanic cavity; B, hood; C, laterotergal groove; D, nerve D; E, dorsal tergal Trunk; F, lateral trunk, G, dorsal longitudinal trunk; H, anterior ventral longitudinal connective; I, posterior median trunk; J, posterior ventral longitudinal trunk; K, longitudinal abdominal trunk.
(Scale line = 1.0 mm)

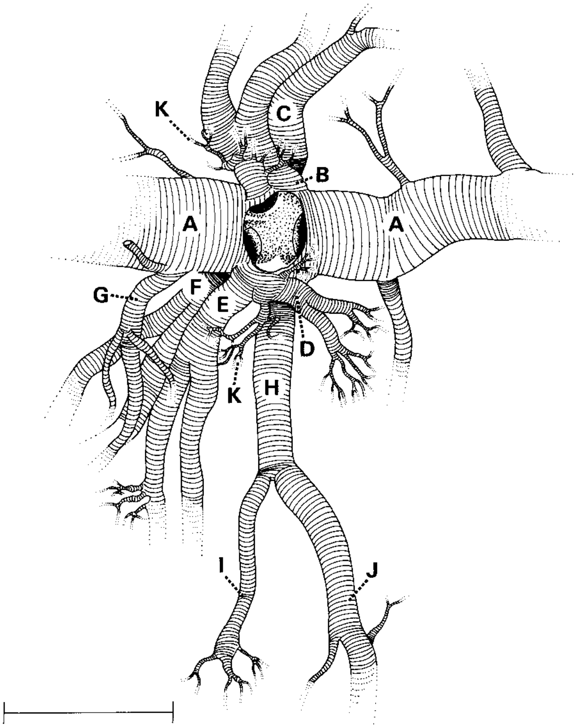

Fig. 74. Left lateral aspect of the 4th abdominal tracheal trunks. Occlusor apparatus removed. (Anterior to the right).
A, longitudinal connective trunk; B, dorsal lateral trunk; C, median dorsal trunk; D, lateral posterior trunk; E, lateral ventral trunk; F, median ventral trunk; G, anterior lateral ventral trunk; H, ventral trunk; I, anterior ventral trunk; J, posterior ventral trunk; K, lateral branch.
(Scale line = 1.0 mm)

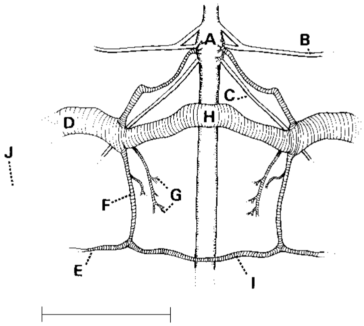

Fig. 75. Ventral aspect of the 4th abdominal tracheal trunks. A, 4th abdominal ganglion; B, 4th lateral ganglionic nerve; C, 4th ventral ganglionic nerve; D, anterior ventral trunk; E, posterior ventral trunk; F, longitudinal connective; G, small branches to fat bodies; H, anterior ventral commissure; I, posterior ventral commissure; J, posterior ventral trunk. (Scale line = 1.0 mm)

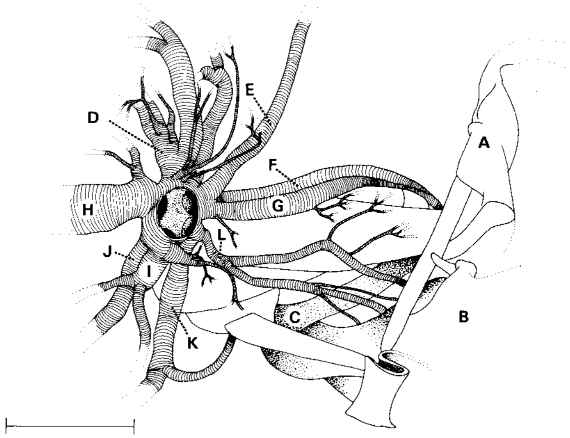

Fig. 76. Left lateral aspect of the 7th abdominal tracheal trunks and tracheae of the male genitalia. (Anterior to the right).

A, tegumen; B, valva; C, vinculum; D, dorsal lateral trunk; E, posterior dorsal trunk; F, median posterior trunk; G, ventral posterior trunk; H, posterior longitudinal trunk; I, ventral lateral trunk; J, median ventral trunk, K, ventral trunk; L, ventral median trunk.
(Scale line = 1.0 mm)

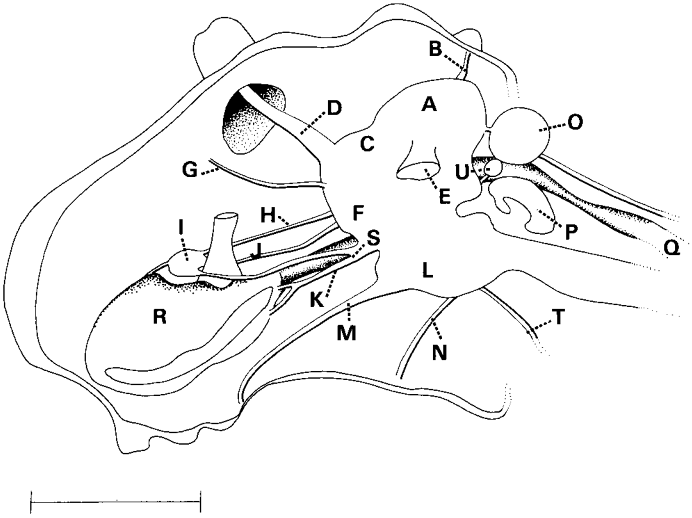

Fig. 77. Left lateral aspect of the nervous system of the head.

A, protocerebrum; B, ocellar nerve; C, deutocerebrum; D, antennal nerve; E, optic nerve; F, tritocerebrum; G, dorsal tegumentary nerve; H, frontal ganglionic connective; I, frontal ganglion; J, recurrent nerve; K, labral nerve; L, subesophageal ganglion; M, maxillary nerve; N, labial nerve; O, corpus allatum; P, posterior tentorial bridge; Q, esophagus; R, cibarial-pharyngeal pump; S, frontolabral nerve; T, cervical nerve; U, corpus cardiacum.

(Scale line = 1.0 mm)

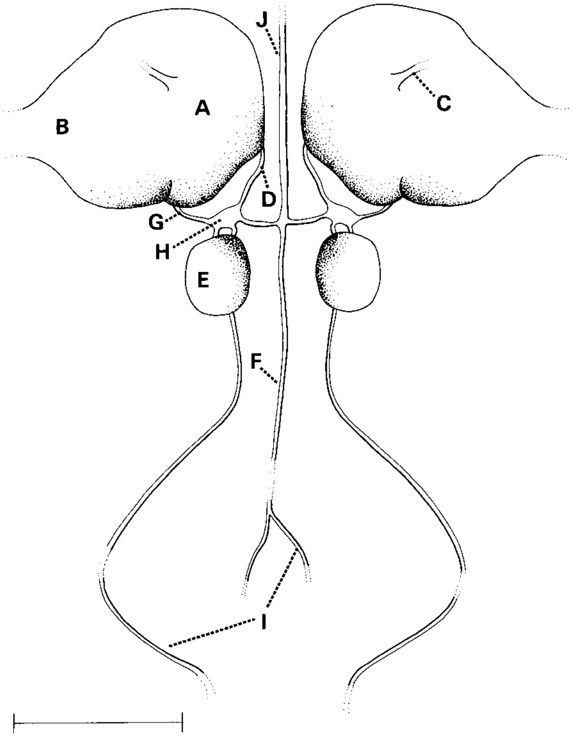

Fig. 78. Dorsal aspect of the protocerebrum and sympathetic nervous system.
A, protocerebrum; B, optic lobe; C, ocellar nerve; D, internal corpus cardiacum nerve; E, corpus allatum; F, stomatogastric nerve; G, external corpus cardiacum nerve; H, corpus cardiacum; I, nerves in abdomen; J, recurrent nerve.
(Scale line = 1.0 mm)

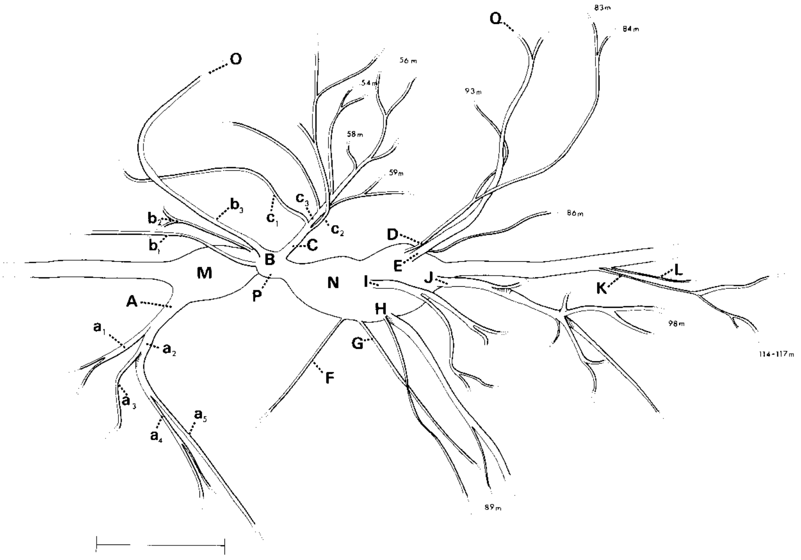

Fig. 79. Left lateral aspect of the prothoracic and pterothoracic ganglia and main nerve trunks.

A, nerve A from prothoracic ganglion; a_1, branch of nerve A to prothoracic muscles; a_2, branch of nerve A to prothoracic leg; a_3, branch of nerve A to prothoracic muscles; a_4, branch of nerve A to procoxal muscles; a_5, branch of nerve A to muscles of the prothoracic leg; B, nerve B from thoracic connective; b_1, nerve to cervical muscles; b_2, nerve to posterior prothoracic muscles; b_3, nerve to mesothoracic alary muscles; C, nerve C; c_1, nerve to cervical muscles; c_2, nerve to dorsal muscles; c_3, nerve to lateral anterior aspect of mesonotal muscles; D, nerve D from pterothoracic ganglion; E, nerve E; F, nerve F; G, nerve G; H, nerve H; I, nerve I; J, nerve J; K, nerve K; L, nerve L; M, prothoracic ganglion; N, pterothoracic ganglion; O, nerve to metathoracic alary muscles; P, thoracic connective; Q, nerve to metathoracic alary muscles. (Scale line = 1.0 mm)

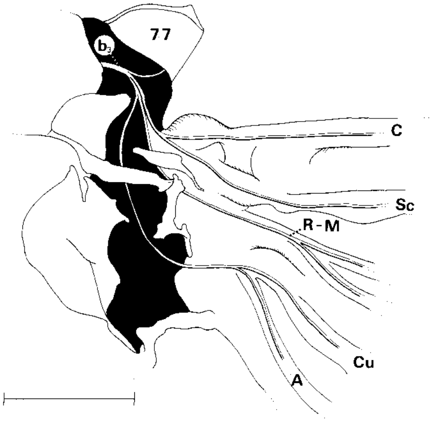

Fig. 80. Nerves of the left, ventral mesothoracic axillary region.
b_3, branch from nerve B; C, costal nerve; Sc, subcostal nerve; R-M, radial median nerve; Cu, cubital nerve; A, anal nerve.
(Scale line = 1.0 mm)

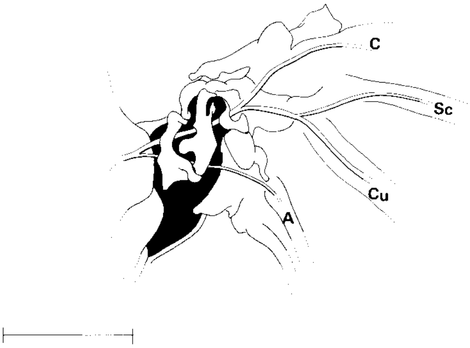

Fig. 81. Nerves of the right, dorsal metathoracic axillary region.
A, anal nerve; C, costal nerve; Cu, cubital nerve; Sc, subcostal nerve.
(Scale line = 1.0 mm)

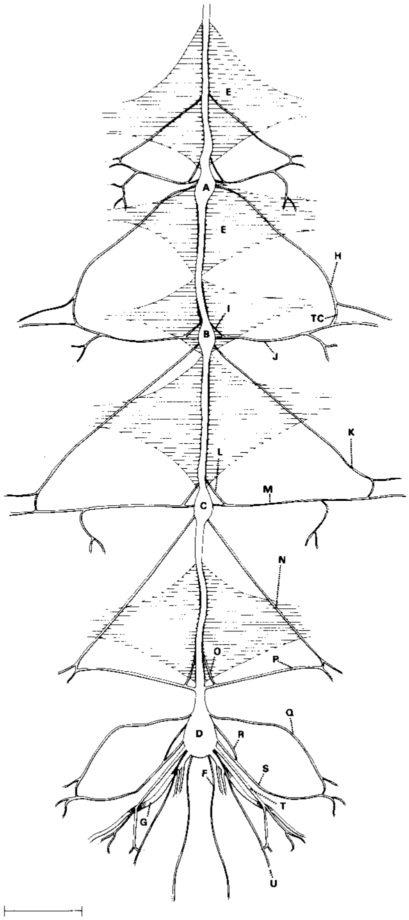

Fig. 82. Ventral aspect of abdominal ganglia and nerves. A, 3rd abdominal ganglion; B, 4th abdominal ganglion; C, 5th abdominal gangion; D, fused 6, 7, 8th abdominal ganglia; E, ventral diaphragmatic muscles; F, 8th abdominal n.; G, composite 9, 10, 11th abdominal n.; H, 3rd ventral ganglionic n.; I, 3rd median ganglionic n.; J, 4th lateral ganglionic n.; K, 4th ventral ganglionic n.; L, 4th median ganglionic n.; M, 5th lateral ganglionic n.; N, 5th ventral ganglionic n.; O, 5th lateral ganglionic n.; P, 6th lateral ganglionic n.; Q, 6th ventral ganglionic n.; R, 6th median ganglionic n.; S, 7th lateral ganglionic n.; T, 7th dorsal ganglionic n.; U, 7th median ganglionic n.; TC, transverse connective.
(Scale line = 1.0 mm)

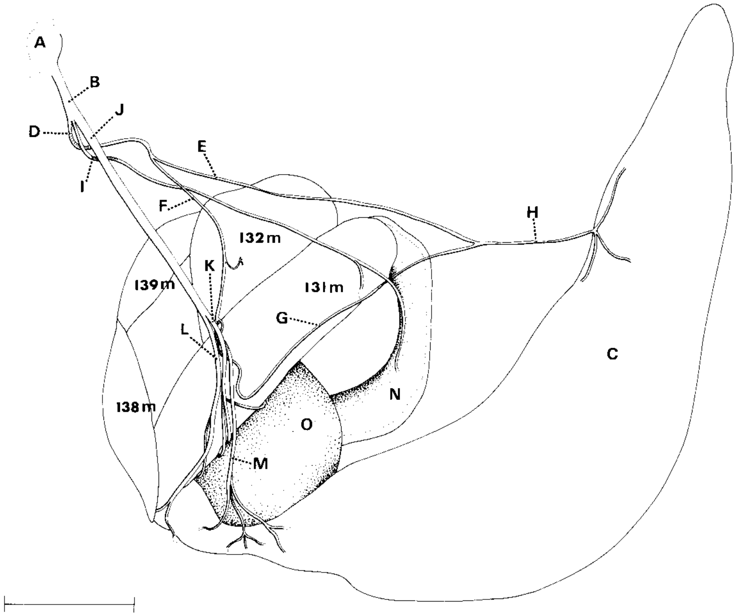

Fig. 83. Nerves of the terminal abdominal ganglion of the male.
A, composite 6th, 7th, and 8th abdominal ganglion; B, nerve 9, 10, 11; C, rectum; D, branch of the 9th, 10th, 11th nerve; E, lateral branch 1; F, ventral branch 1; G, ventral lateral branch 1; H, fusion of nerves G and E; I, branch 2 of the 9th, 10th, 11th nerve; J, main trunk of the 9th, 10th, 11th nerve; K , nerve branch to harpes; L, nerve branch to muscles of external genitalia; M, ventral branch 1; N, ejaculatory duct; O, aedeagus. (Scale line = 1.0 mm)

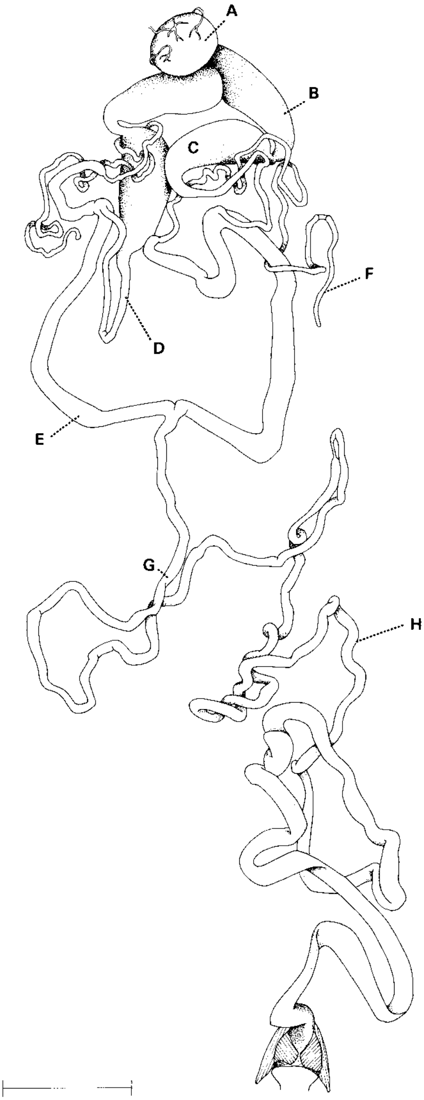

Fig. 84. Dorsal aspect of the male reproductive system. A, testis; B, anterior sac of seminal vesicle C, posterior sac of seminal vesicle; D, vas deferens; E, ejaculatory duct; F, accessory gland; G, primary duct; H, cuticular duct. (Scale line = 4.0 mm)

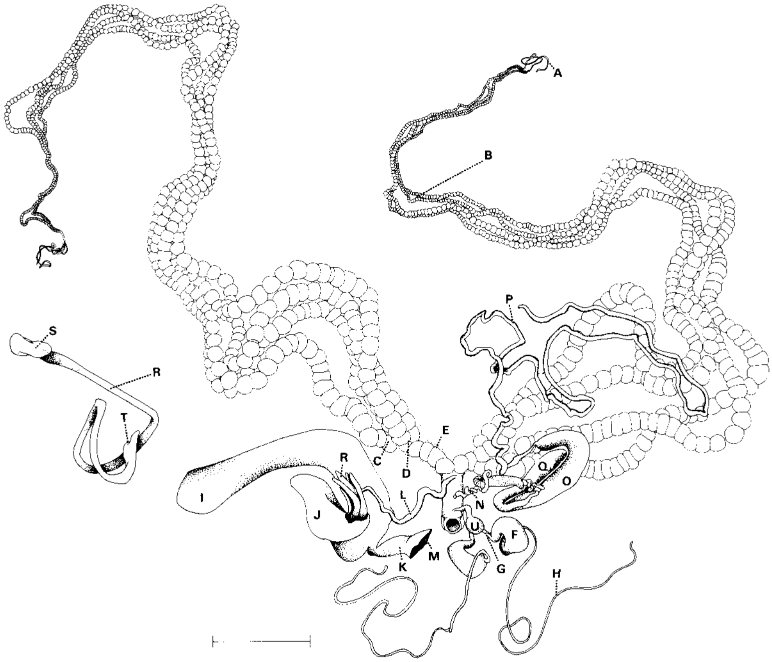

Fig. 85. Dorsal aspect of female reproductive system (Inset: spermatophore).
A, germarium; B, vitellarium, C, pedicel; D, calyx; E, lateral oviduct; F, accessory gland reservoir; G, accessory gland duct; H, accessory gland; I corpus bursae; J, cervix bursae; K, ductus bursae; L, seminal duct; M, ostium bursae; N, spermathecal duct; O, utriculus of the spermatheca; P, spermathecal gland; Q, lagena of spermatheca; R, spermatophore; S, corpus of spermatophore; T, frenulum of spermatophore; U, vestibule.
(Scale line = 4.0 mm)

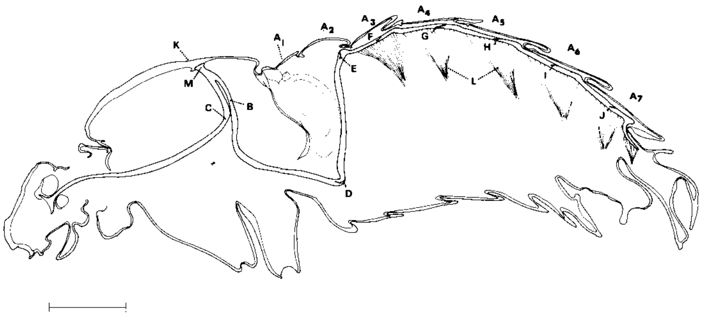

Fig. 86. Composite illustration of dorsal vessel, body wall, and right alary muscle of the male.
A_1-A_8, abdominal tergites; B, ascending aorta; C, descending aorta; D, metathoracic valve; E, 2nd abdominal valve; F, 3rd abdominal valve; G, 4th abdominal valve; H, 5th abdominal valve; I, 6th abdominal valve; J, 7th abdominal valve; K, scutoscutellar suture; L, alary muscles; M, transverse chamber.
(Scale line = 1.5 mm)

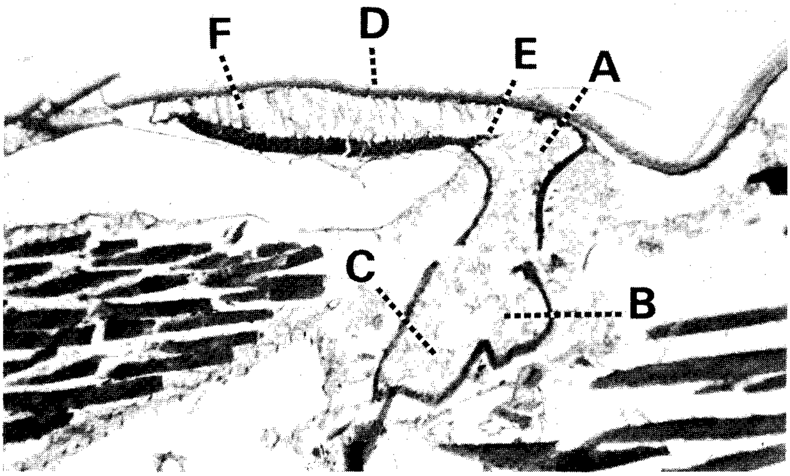

Fig. 87. Parasagittal section of dorsal chamber (87 x). A, dorsal chamber; B, ascending aorta; C, descending aorta; D, mesothoracic accessory diaphragm; E, ostium; F, muscle fibers.

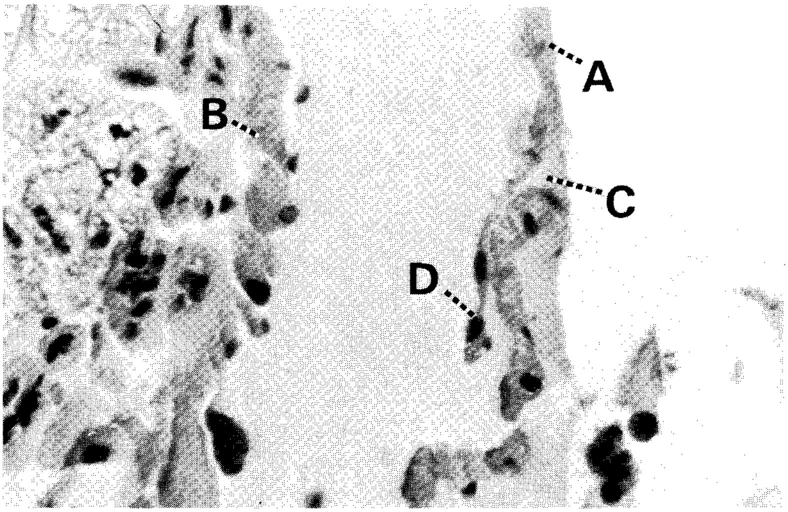

Fig. 88. Parasagittal section of dorsal vessel and 2nd abdominal ostium (350 X). A, dorsal wall of heart; B, ventral wall of heart; C, closed ostium; D, ostial valve.

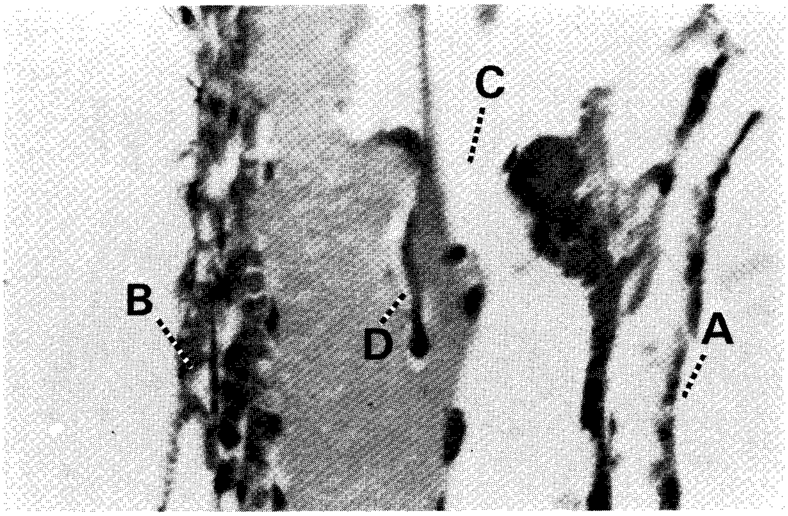

Fig. 89. Parasagittal section of dorsal vessel and 5th abdominal ostium (350 X).
A, dorsal wall of heart; B, ventral wall of heart; C, ostium (open); D, ostial valve.

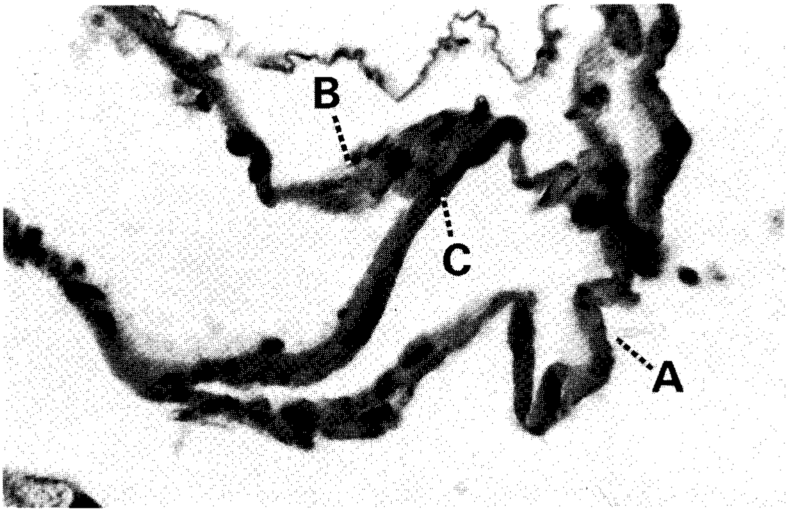

Fig. 90. Parasagittal section of dorsal vessel and metathoracic ostium (350 X).
A, dorsal wall of heart; B, ventral wall of heart; C, auricular valve.