THE MUSCULAR SYSTEM OF GRYLLUS ASSIMILIS FABR.

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A Thesis

Submitted in partial fulfilment of the requirements
for the Degree of Doctor of Philosophy
in McGill University

by

E. Melville DuPorte, B.S.A., M.Sc.

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INTRODUCTION.

This paper gives an account of the musculature of *Gryllus assimilis* Fabr., one of our common field crickets. It includes also a brief description of the internal skeletal structures inasmuch as a knowledge of these is necessary to understand the method of attachment of the muscles.

In his comprehensive study of the thorax of *G. domesticus* Voss ('05) describes the musculature of the veracervix, the thorax and the anterior segments of the abdomen. Berlese ('09) figures some of the thoracic muscles of *G. campestris*. The musculature of these two insects agrees very closely with that of the allied *G. assimilis*.

In naming the head muscles, including those of the neck, I have employed terms descriptive of their functions without reference to possible segmental homology. I have followed Voss and Berlese's system in naming the thoracic and abdominal muscles, and have not described these muscles in detail, owing to their general similarity to the muscles of *G. domesticus* as described by Voss ('05). The numbers used by Voss are inclosed in square brackets after the description of the muscles; the names which he used for the cervical muscles are also thus inclosed, Crampton's term *veracervix* being substituted for *microthorax*.

I have thought it best to avoid the use of Latin terms. The numbers used have no significance apart from their reference to the figures.

I. THE ENDOSKELTON.

(Figs. 1, 2 and 3).

THE HEAD (Fig. 2). The well developed tentorium consists of a central plate (T.C.) from which two pairs of processes are given off. The base of the central plate forms the ventral edge of the occipital foramen (F.O.) The central plate lies in a horizontal plane approximately parallel to that passing through the median lines of the pleura. A constriction near the base gives this plate a more or less urn-shaped outline. At each of its apical angles it bears a large triangular anterior plate (T. A.), the base of which is attached to the lower edge of the gena near the base of the mandible. Immediately behind these processes second and smaller pair arises from the central plate. These are the posterior processes (T. P.); they are columnar in form and run obliquely forward and upward, fusing with the epicranium near the base of the antennae. Between the two anterior processes, the central plate and the epicranium, three foramina are formed, an anterior one (F. A), through which the œsophagus passes from within the epicranium to the mouth, and two lateral foramina (F. L.) through which the crura cerebri and the adductor muscles of the mandibles pass.

Three tuberculate apodemes arise from the epicranium at the edge of the occipital foramen, a median dorsal process (A. M.) and two lateral processes (A. L.) These processes serve for the insertion of certain of the muscles which move the head.

THE VERACERVIX OR NECK. (Fig. 1, Cerv.) There are five paired and one unpaired sclerites which support the cervical membrane and on their inner surfaces serve as points of attachment for some of the neck muscles. These are the three intersternites (Fig. 1, i.st. γ, δ, ϵ) or ventral cervical sclerites, the second of which is median and unpaired; the large interpleurite (Fig. 1, i.p.) bearing an inward projecting process (ap. ip.) at its anterior end, and the two intertergites (Fig. 1, i.t. α & β) or dorsal sclerites. The form and arrangement of these sclerites may be readily seen by referring to Fig. 1. As will be shown later the interpleurite is the only one of much importance for the attachment of muscles.

THE PROTHORAX (Fig. 1, T_1). A lateral entosternite or furca (es) arises from each of the posterior ends of the inverted V-shaped furcasternite (Fs) and extends across the opening of the fore-leg. The flattened distal portion is closely appressed to the inner face of the epimeron and entopleurite. The small spina or median entosternite (es. m) is a flattened three-lobed plate arising from the posterior edge of the spinasternite (Ss). The greater portion of the pleuron is overgrown by the pronotum and lies on the inner side of this sclerite (see DuPorte, '19). The contiguous edges of the episternum (Ep) and epimeron (Em) are infolded to form a deep entopleurite (ep) which projects ventrally to form a ball and socket articulation with the outer angle of the coxa.

THE MESOTHORAX (Fig. 1, T_2). The median entosternite (esm) or spina is a three-lobed disk attached by a short stalk which projects inwards from the furcasternite between the bases of the lateral entosternite (es). The proximal section of the lateral entosternites is more or less cylindrical, while the distal section is expanded and folded to form a pocket into which fits a process from the entopleurite. The entopleurite (ep) is formed from the inflexed contiguous edges of the episternum and epimeron. Its dorsal extremity projects beyond the edges of the episternum and epimeron, forming the pleural wing process. At its ventral end it gives off a spur-shaped pleural process which fits into the pocket of the entosternite. The two are connected by a pair of short muscles, one originating from either side of the spur and inserted on the inner sides of the pocket. Thus a strong arch is formed above the leg opening. From this arch certain of the leg muscles originate.

A pair of intersegmental sclerites (in), probably the pretergite, lies transversely in the sutural membrane between the pronotum and mesonotum, the inner ends are attached to the anterior edge of the mesoscutum and the outer ends extend to the anterior edge of the base of the wing near the anterior piece of the first axillary. There is a large basalar sclerite (b.s.) and a small subalar plate (s.a.p.)

THE METATHORAX (Fig. 1, T_3). The endosclerites in this segment are similar to those of the mesothorax, except that there is no median entosternite. The intersegmental sclerite (in_2) comes in close contact with the posterior process at the lateral end of the meso-postscutellum. There are one large and

one small basalar sclerites (b.s.) and two subalar plates (s.a.p.), the anterior one elongated, the posterior smaller and broadly oval.

THE ABDOMEN (Figs. 1 and 3). Several small chitinous plates are imbedded in the pleural membrane of the abdomen. The parasternal plate (Fig. 1, ps.p.) situated immediately behind the base of the third coxa, is the largest of these sclerites. Judging by its musculature this plate is apparently a detached portion of the first and second abdominal sternites. In each segment from the third to the seventh there are three small linear pleural sclerites, one ($p.s_1$) near the anterior end, one ($p.s_2$) near the posterior end and the third ($p.s_3$) in the middle of the segment nearer the tergum than the two other pleural sclerites. In the third segment the third pleural sclerite is large and receives muscles from the second and third sternites.

From the anterior edges of the eighth and ninth tergites in the female, a flattened blade-like process (Fig. 3, PA_8, PA_9) projects forward. These processes serve as points of origin for certain of the muscles which move the ovipositor. The supra-genital plate bears a median knife-like process (Fig. 3, P.S.G.) which serves the same purpose.

A ventral (Fig. 3, v_1, v_2) and a dorsal process (d_1, d_2) are given off from the base of each gonapophysis; these serve as points of insertion for muscles of the ovipositor. On each side the two dorsal processes (d_1 and d_2) are closely interlocked. The ventral processes (v_1) of the dorsal pair of gonapophyses (G. D.) are connected by means of a transverse chitinous rod (Fig. 3, t.c.) which bears a flat, thin unpaired process (m) in the middle of its anterior face.

II. THE MUSCLES OF THE HEAD.

The muscles of the head may be divided into (a) the muscles of the mouthparts, (b) the muscles of the antennae, (c) the muscles of the pharynx and oesophagus, and (d) the cervical muscles, or those which control the movements of the head as a whole.

(*a*). *The Muscles of the Mouthparts.*

THE LABRUM.—The *Abductors of the Labrum* (Figs. 7 and 9, abd.lbr.) are a pair of contiguous muscles, straight with parallel

fibres, originating in the middle of the front immediately beneath the median ocellus and inserted by a short tendon into the base of the labrum, one on each side of the median line.

The *Adductors of the Labrum* (Figs. 7 and 8, ad. lbr.) Two three-headed muscles inserted by means of a small tendon, one in each of the basal angles of the labrum. The outermost head is attached to the front near the inner side of the antenna, the innermost near the median line adjacent to the origin of the abductor, and the middle head midway between these two. In some specimens only the outer and inner heads were present.

THE MANDIBLES are articulated with the epicranium by means of a ginglymus joint permitting motion in one plane only, consequently there are but two muscles, an adductor, and an abductor. The *Adductor of the Mandible* (Figs. 4, 5 and 6, ad. md.) is a pyramidal complex muscle and, owing to the fact that in the cricket the mandibles are strong crushing jaws, is the largest and strongest muscle in the head. Its base occupies the whole top of the head as far forward as the eyes and upper edge of the brain. It is inserted into the inner angle of the base of the mandible by means of a large tendon composed of three flat transparent laminæ (Fig. 4, t).

The Abductor of the Mandible (Fig. 4, abd. md.) is smaller and has its origin in the epicranium beneath and behind the eye. It is inserted into the outer angle of the mandible by means of a long flat tendon.

THE MAXILLAE. Owing to the segmented structure of the maxilla, its muscles are more numerous and complicated than those of the labrum and mandible. The *Abductor of the Maxilla* (Figs. 12 and 14, abd. mx.) is a thick triangular muscle originating in the gena and postgena near the origin of the abductor of the mandible. It is inserted by means of a long narrow three-faced tendon into the inner angle of the second segment of the cardo. The hinge on which the maxilla turns lies mesad of the insertion of the tendon along the upper edge of the proximal segment of the cardo (i. e., the edge near the letter C_1 in Fig. 14). The opening of the maxillae therefore causes a pushing upwards of the outer portions of their bases (the outer edge of C_2). Conversely the upward pull given to this portion of the maxillae by the contraction of the abductors causes them to open.

There are two *Adductors of the Maxilla* which both take their origin in the lower surface of the central plate of the

tentorium. The *First Adductor* (Figs. 13 and 14, ad. mx.) is inserted into the first segment of the cardo at its junction with the second segment near the insertion of the abductor. The *Second Adductor* (Figs. 12 and 14, ad.$_2$ mx.) is also inserted into the cardo but at the outer angle of the second segment near the suture between the cardo and the stipes.

The *Flexor of the Maxilla* (Figs. 13, 14 and 16, fl.mx.) is a strong compound muscle which also originates from the lower face of the central tentorial plate. It is inserted into a flat elongated apodemal surface (Fig. 15, ap.st.) along the inner edge of the outer wall of the stipes. This muscle and the two adductors working together are capable of exerting considerable force in the closing of the maxillae.

The *Flexor of the Lacinia* (Fig. 14, fl.lac.) lies wholly within the stipes. It originates by a broad head near the outer angle of the base of the stipes, runs diagonally across the stipes and is inserted by a short flat tendon into the inner angle of the base of the lacinia.

The *Flexor of the Galea* (Fig. 15, fl.g.) is a smaller muscle having its origin in the outer integument of the stipes opposite the palpus and its insertion in the inner angle of the base of the galea.

Within the stipes there are two muscles which move the palpus. They both originate in the outer integument near the apodeme into which the flexor of the stipes is inserted. The proximal muscle is the *Extensor of the Palpus* (Fig. 15, ext.p.) and is inserted in the lateral edge of the base of the palpus. The second muscle, inserted at the opposite side of the base of the palpus is the *Flexor of the Palpus* (Fig. 15, fl.p.). Within each of the first three segments of the palpus there are an extensor and a flexor of the palpal segment. The *extensor* (Fig. 15, ext.p.s.) arises at the outer side of the base of the segment and the *flexor* (fl.p.s.) at the inner side. They are inserted respectively into the outer and inner sides of the base of the next distal segment.

THE LABIUM. The *Retractor of the Labium* (Figs. 16 and 17, r.lb.) is a long flat muscle with its plane at right angles to that of the labium. It originates in the base of the central plate of the tentorium near the inner angle of the postgena, and is inserted into the side of the ligula near the base of the paraglossa.

The *Abductor of the Labium* (Figs. 16 and 17, abd.lb.) is a straight parallel-fibered muscle. It originates from a small tubercle on the basal edge of the tentorium and is inserted at the outer angle of the distal edge of the mentum.

The *Adductor of the Labium* (Figs. 16 and 17, ad.lb.). The two adductors are contiguous at their origin near the middle of the base of the submentum, but diverge in their course. They are inserted by means of small semicircular tendons into the base of the ligula not far from the middle line.

The *Adductor of the Paraglossa* (Fig. 17, ad.pgl.) originates from the base of the ligula near the median line, and runs diagonally to the base of the distal segment of the paraglossa.

The *Adductor of the Glossa* (Fig. 17, ad.gl.) originates in the ligula and is inserted into the lateral side of the base of the glossa.

The musculature of the labial palpi is similar to that of the maxillary palpi, but the flexor and extensor arise from a narrow elongate, median apodeme (Figs. 6 and 17, ap.lb.) which is given off at the point where the labium and hypopharynx unite, and projects backward as far as the mentum.

THE HYPOPHARYNX. The *Depressors of the Hypopharynx* (Fig. 6, dep.hyp.) are two muscles which originate from the lower side of the central plate of the tentorium and are inserted into the upper integument of the base of the hypopharynx near the point at which the pharynx narrows into the oesophagus. The depression of the hypopharynx at this point assists in enlarging the oesophageal canal.

The *Elevator of the Hypopharynx* (Fig. 6, el.hyp.) originates in the face in front of the median ocellus, and is inserted on the outer surface of the hypopharynx near the entrance to the oesophagus. This muscle pulls the base of the hypopharynx up against the roof of the pharynx, closing the entrance to the oesophagus.

The *Compressor of the Hypopharynx* (Fig. 6, c.hyp.) originates with its fellow of the opposite side from the median line of the lower side of the hypopharynx at its junction with the labium. The two muscles diverge, running obliquely backwards and upwards, and are inserted into the outer angles of the upper side of the base of the hypopharynx in front of the oesophagus. By compressing the hypopharynx these muscles enlarge the pharyngeal opening.

The *Retractor of the Hypopharynx* (Fig. 6, r.hyp.) is a long flat muscle having its head contiguous to that of the retractor of the labium. It runs parallel to this muscle and is inserted into the side of the hypopharynx near the junction between this organ and the labium.

THE EPIPHARYNX. There is a single median epipharyngeal muscle (Fig. 9, eph.m.) which has the form of a truncated cone. Its points of attachment are the inner sides of the labium and epipharynx.

(*b*). *Muscles of the Antennæ.*

There are three muscles within the head which bring about the movements of the antenna as a whole. (Fig. 5, m.ant.)

The *Extensor of the Antenna* (Fig. 11, ext.ant.) originates from the dorsal side of the lateral angle of the anterior tentorial plate and is inserted into the lateral side of the base of the first antennal joint.

The *Flexor of the Antenna* (Fig. 11, fl.ant.) This muscle has its origin near the apical angle of the central tentorial plate in the angle formed by the anterior and posterior plates. It is inserted at the inner side of the basal margin of the first antennal segment.

The *Depressor of the Antenna* (Fig. 11, dep.ant.) has a very broad head attached to the dorsal side of the anterior arm of the tentorium and extending from the epicranium to the attachment of the anterior plate to the central plate. It tapers rapidly and is inserted into the ventral side of the basal segment of the antenna.

Within each antennal segment there is a *flexor* (Fig. 10, fl.a.s.) and an *extensor* (ext.a.s.) similar to those described in the palpi.

(*c*). *Muscles of the Pharynx and Oesophagus.*

The circular or constrictor muscles are well developed in the oesophagus. In addition to these there are several muscles originating in the wall of the head or the tentorium which function as dilators and suspensors of the pharynx and oesophagus.

The *Precerebral Dorsal Dilators* (Figs. 5 and 6, pr.d.) There are usually three paired dilator muscles lying in front of the brain. The *first* (pr.d.$_1$) has its origin in the clypeus and is

inserted into the roof of the pharynx at a short distance from the median line. The *second* (pr.d.$_2$) originates in the front above the clypeus and is inserted into the pharynx behind the first. The *third dilator* (pr.d.$_3$) is inserted into the roof of the oesophagus just in front of the brain. Its origin is in the epicranium in front and to one side of the median ocellus. A fourth muscle is sometimes present.

The *Post-cerebral Dorsal Dilator* (Fig. 6, pst.d.) originates in the epicranium immediately in front of the adductor of the mandible and is inserted into the oesophagus just behind the brain and a short distance from the dorsal median line.

The *Lateral Dilator* (Fig. 5, l.d.) arises in the epicranium at the inner side of the compound eye and is inserted into the lateral median line of the oesophagus beneath the brain.

The *Ventral Dilators* (Fig. 6, v.d.) are two rows of small muscles which originate from the upper surface of the central plate of the tentorium and are inserted into the lower wall of the oesophagus a short distance on each side of the median line.

(*d*). *Cervical Muscles.*

(Figs. 18 and 19.)

The muscles which control the movements of the head may be classified as depressors, elevators, retractors and rotators of the head.

LONGITUDINAL MUSCLES.

(a) Sternal.

1. *The Inner Depressors of the Head* originate from the enlarged basal portions of the pro-entosternites and are inserted into the middle of the hind edge of the central tentorial plate. [137, 5th sternal muscle of the veracervix].

2. *The Outer Depressors of the Head* originate immediately laterad of the preceding, and are inserted into the dorsal surface of the central tentorial plate. [136, 4th sternal muscle of the veracervix].

3. *The Short Depressor of the Head,* origin, pro-entosternite, insertion, into the cervical membrane just beneath the ventral angle of the interpleurite. [135, 3rd sternal muscle of the veracervix].

(b) Dorsal.

4. *The Elevator of the Head.* A strong double intersegmental muscle. One head originates from the first intersegmental sclerite (Fig. 1, in.), the other from the posterior edge of the pronotum near the median line. The two are inserted by a common elongated tendon into the lateral apodeme (Fig. 2, AL.) of the dorsal border of the occipital foramen. [139, 140, 1st and 2nd tergal muscles of the veracervix].

(c) Pleural.

5. *The Retractor of the Head.* Origin, anterior edge of the pro-episternum; insertion, lateral side base of head. [138, Fifth (a) sternal muscle of the veracervix].

PLEURAL MUSCLES.

(a) Noto-pleural.

6. *The First Rotator of the Head.* Origin, anterior edge of the pro-episternum; insertion (1) median apodeme (Fig. 1, A. M.) of the dorsal border of the occipital foramen, and (2) anterior edge of the first intertergite. [141, 142, first and second external rotators of the head].

7. *The Second Rotator of the Head* originates from the anterior edge of the pronotum near the median line and is inserted into the postero-dorsal edge of the interpleurite near the dorsal angle. [143, the intersegmental muscle of the veracervix].

8. *The Third Rotator of the Head,* originates from the pronotum just in front of the distal end of the pleuron and is inserted into the ventral edge of the interpleurite. [144, second intersegmental muscle of the veracervix].

9, 10. *The Fourth and Fifth Rotators of the Head.* Both originate from the interpleurite and are inserted into the median apodeme (Fig. 1, A. M.) of the dorsal border of the occipital foramen. [146, 147, second and third dorsoventral muscles of the veracervix].

11. *The Sixth Rotator of the Head.* From the apodeme of the interpleurite to the lateral apodeme of the foraminal border. [148, fourth dorsoventral muscle of the veracervix].

12. *The Seventh Rotator of the Head.* Origin, apodeme of interpleurite; insertion, neck membrane behind the first intertergite. [145, first dorsoventral muscle of the veracervix].

(b) Sterno-pleural.

13. *The Cruciate Rotators of the Head,* originate from the anterior edge of the procoxae and are inserted into the narrow anterior portion of the interpleurite of the opposite sides. [134, the second sternal muscle of the veracervix].

Voss, ('05), regarding the cervical interpleurite as a sternal sclerite, describes 13 as a longitudinal sternal muscle, and 6 to 12 as dorsoventral muscles. I have followed Crampton ('17) in regarding the interpleurite as a pleural sclerite, in which case these muscles are sterno-pleural and noto-pleural respectively.

The several rotators working in pairs function as elevators and depressors.

III. MUSCLES OF THE THORAX.

A. The Prothorax.

LONGITUDINAL MUSCLES.

(a) Sternal.

XIII. *The First Prosternal Muscle* (Fig. 21) is a flat unpaired median muscle which originates in the posterior edge of the median entosternite spira of the prothorax, and is inserted into the anterior edge of the spira of the mesothorax. A retractor of the thorax. [102].

14, 14a. *The Second Prosternal* (Figs. 20 and 21). From the median entosternite, into the anterior side of the base of the coxa. A weak extensor of the coxa. [103].

15. *The Third Prosternal* (Fig. 20). From the prothoracic spira obliquely backwards into the distal section of the meso-furca. [104].

16. *The Fourth Prosternal* (Fig. 20). Origin, base of pro-thoracic furca; insertion, mesothoracic furca near 15. [105].

17. *The Sixth Prosternal* (Fig. 20). Origin, furca near 16; insertion, mesothoracic spira. [107].

18. *The Seventh Prosternal* (Fig. 20). From the spira into the base of the furca. [108].

The Longitudinal Prosternal muscles are retractors pulling the prosternite and mesosternite together and bending the head and prothorax downwards. The Longitudinal Pronotals are the antagonist muscles of the prosternals.

(b) Dorsal.

XIX. *The First Pronotal Muscle* (Fig. 20). From the posterior edge of the pronotum near the median line, into the inflexed posterior border of the neck membrane. [109].

19, 20. *The Third Pronotals* (Figs. 20, 21). From the first intersegmental sclerite into the median ridge of the pronotum. [111, 110]

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

21. *The Prothoracic Intersegmental Muscle.* From the base of the furca into the outer angle of the first intersegmental sclerite. Rotator of the thorax. [112].

(b) Noto-subcoxal.

22. *The First Dorsoventral Muscle of the Prothorax* (Fig. 20). From the pronotum immediately behind the distal end of the epimeron into the trochantin by a long flat tendon. A strong conical muscle. An extensor of the coxa.* [113].

(c) Noto-coxal.

23, 23a. *The Second Dorsoventral* (Fig. 20). Origin, in the pronotum immediately above the distal end of the pleuron usually with two (sometimes three) adjacent heads; insertion into the posterior edge of the coxa by a long thin tendon. A flexor of the coxa. [114].

24, 24a. *The Sixth Lateral* (Fig. 21). From the posterior side of the pronotum into the latero-caudal edge of the coxa by a broad tendon. Two heads—24 is a stout-bellied muscle while 24a is quite slender. Flexor of the coxa. [121].

(d) Noto-trochanteric.

25, 25a–25e are the six heads of a complex muscle inserted by a common tendon into the inner angle of the base of the trochanter. Together they form the extensor of the femur. The origins of the various heads are noted in their proper places below.

* When the coxa is pulled backwards it moves upwards towards the sternum. A forward pull moves it also downwards away from the body. I have designated the muscles which bring about these motions as *flexors* and *extensors* respectively, reserving the terms *adductor* and *abductor* for those muscles which pull the coxae inwards towards each other and outwards away from each other.

25b. *The Sixth (a) Lateral* (Fig. 21) originates from the lateral anterior edge of the pronotum. This muscle takes a sharp bend, passing between the pronotum and the pleuron, and enters the coxal cavity on the posterior side of the entosternite. [122].

25d. *The Eighth Dorsoventral* (Figs. 20, 21) originates in the dorso-lateral portion of the pronotum just behind the posterior edge of the epimeron. [117].

PLEURAL MUSCLES.

(a) Pleuro-pedal.

25. *The Fourth Lateral* (Fig. 20). Origin, the distal anterior edge of the inner face of the episternum. [119].

25a. *The Fifth Dorsoventral* (Figs. 20, 21) originates from the inner face of the epimeron. [115].

25c. This is a short muscle originating in the epimeron, near the ventral end, quite close to the leg. At its point of attachment it is pressed closely between the epimeron and the distal blade of the entosternite.

25e. This also is a very short muscle originating in the outer face of the entopleurite opposite the origin of 25c. (Not figured).

26. *The Fourth Lateral* (Fig. 21). Origin, from the episternum, by a curved head bending round the distal end of the entopleurite; insertion, by tendon into the latero-anterior edge of the coxa. Extensor of the coxa. [118].

27. *The Fifth Lateral* (Fig. 21). From the inner face of the episternum near its attachment to the ventral edge of the pronotum, into the lateral angle of the trochantin. [?120].

(b) Noto-pleural.

XXVIII. *The Dorsoventral Muscle* (not figured), is a very short, but strong muscle binding the pleuron closely to the pronotum.

(c) Sterno-pleural.

XXIX. *The Furca-entopleural Muscle* (not figured), also very short, binds the distal portion of the furca to the entopleurite. [132].

STERNAL MUSCLES.

(a) Sterno-pedal.

28. *The First Pedal Muscle of the Prothorax* (Fig. 21). From the base of the furca into the anterior border of the coxa. Extensor of coxa. [127].

29. *The Second Pedal Muscle* (Fig. 20). From the furca near its base into the posterior border of the coxa. Flexor of the coxa. [128].

30. *The Third Pedal Muscle* (Fig. 21). From the furca above the leg cavity into the meso-caudal edge of the coxa. An adductor and flexor of the coxa. [129].

31. *The Seventh Pedal Muscle* (Fig. 21). From the spira into the posterior border of the coxa. Probably a weak flexor or rotator, but of little functional importance. [131].

B. The Mesothorax.

LONGITUDINAL MUSCLES.

(a) Sternal.

32. *The Second Mesosternal Muscle* (Fig. 21). Homologue of 14. [66].

33. *The Third Mesosternal* (Fig. 20). Homologue of 15. [67].

34. *The Fourth Prosternal* (Fig. 20). Homologue of 16. [68].

(b) Dorsal.

35. *The First Mesonotal Muscle* (Fig. 21). A broad flat muscle near the dorsal median line originating from the ento-tergite of the metathorax and inserted into the anterior border of the mesoscutum. This and the next are retractors of the thorax drawing the meso- and meta-tergites together. [69].

36. *The Second Mesonotal* (Fig. 20). Similar to 35 in origin, but inserted into the first intersegmental sclerite. Lies on the inner (ventral) side of 35. [70].

XXXVI. *The Third Mesonotal* (Fig. 21). An oblique muscle running from the second intersegmental sclerite to the mesoscutellum. [71].

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

37. *The Mesothoracic Intersegmental Muscle* (Fig. 20). Homologue of 21. [73].

45. *The Seventh Dorsoventral Muscle of the Mesothorax* (Fig. 21 B). Origin, precoxale; insertion anterior notal wing process. Present only in the male and long winged female. Elevator of the tegmen. [78].

(b) Noto-coxal.

38, 38a. *The First and Sixth Dorsoventrals* (Fig. 20). Origin, by two heads from the lateral side of the anterior border of the mesoscutum; insertion by a common tendon into the anterior border of the coxa. The inner belly (38) is broad and stout with parallel fibres, the outer (38a) is slender and conical. The tendon is broad at its base, narrowing into a long linear process. The insertion of 38 is at the broad base of the tendon, that of 38a at the apex of the narrow process (cf. the homologous muscle 59, 59a, Fig. 31). Because of their insertion by a common tendon I have described this muscle and the two following as single muscles. Extensor of the coxa; indirect elevator of the tegmen. [74, 77].

39, 39a. *The Third and Fourth Dorsoventrals* (Fig. 20). The inner head (39) originates in the scutum, not very far from the median line, the outer (39a) near the postero-lateral edge of the scutum above the posterior notal wing process. The tendon, inserted into the posterior side of the coxa, is bilobed, one lobe being broad and short and the other narrow spatulate. 39, a broad, parallel-fibred belly, is attached to the broader lobe, while 39a, a narrow conical belly, is attached to the elongated lobe (cf. 60, 60a, Fig. 30). Voss describes the homologous metathoracic muscles, but states that these muscles are absent in the mesothorax of *Gryllus domesticus*. On the other hand, I have been unable to find his second dorsoventral muscle either in the mesothorax or metathorax of *G. assimilis*. Flexor of the coxa.

(c) Noto-trochanteric.

40, (40a). *The Fifth Dorsoventral and the Third Lateral* (Fig. 20). 40 arises in the mesoscutum just laterad of the origin of 39; 40a is a pleuro-pedal muscle originating in the

mesothoracic basalar sclerite. The two bellies enter the coxal cavity where they unite in a common broad flat tendon by which they are inserted into the upper anterior edge of the trochanter. Extensors of the femur; 40a is also an elevator of the tegmen. [76, 81].

PLEURAL MUSCLES.

(a) Pleuro-pedal.

41. *The First (and Second) Lateral Muscle of the Mesothorax* (Fig. 21). From the trochantin by tendon into the basalar sclerite. Usually biceps or digastric. Elevator of the tegmen, also elevator of the coxa. [79, 80].

40a. *The Third Lateral.* See above. [81].

42. *The Fourth Lateral* (Fig. 21). From the upper edge of the mesoepisternum, by tendon into the latero-anterior side of the coxa. Extensor of the coxa. [82].

43. *The Fifth Lateral* (Fig. 22). From the episternum near its middle, into (1) the anterior edge of the coxa, (2) the trochantin, and (3) the precoxale. Extensor of the coxa. [83].

44. *The Sixth Lateral* (Fig. 21). From the postero-lateral edge of the coxa into the subalar plate. Depressor of the tegmen. Flexor of the coxa. [84].

45. (See Tergo-sternals above).

46. (See Sterno-pleurals below).

(b) Noto-pleural.

47. *The Eleventh Lateral Muscle* (Fig. 21). From the anterior side of the pleural wing process into the first intersegmental sclerite. Probably an elevator of the tegmen. [88].

48. *The Twelfth Lateral Muscle* (Fig. 21). From the posterior side of the pleural wing process into a wing axillary just above the subalar plate. A short strong muscle. Depressor of the tegmen. [89].

49. *The Ninth Lateral Muscle* (Fig. 21). From the posterior face of the entopleurite ventrad of the origin of 48, into the posterior notal wing process. A depressor of the tegmen. [86].

(c) Sterno-pleural.

51. *The Lateral Adductor of the Mesothorax* (Fig. 20). From the median entosternite into a small pleural intersegmental sclerite behind the second spiracle. [101].

46. *The Fourteenth Lateral Muscle* (Fig. 21 B). From the precoxale into the basalar sclerite by the same tendon as 38. Found only in the male. Elevator of the tegmen. [91].

LI. *The Furca-entopleural Muscle* (not figured). From the inner sides of the entosternal pocket into the ventral process of the entopleurite. Binds the two processes together. [100].

STERNAL MUSCLES.

Sterno-pedal.

52. *The First Pedal Muscle of the Mesothorax* (Fig. 21). Origin, by three heads from (1) the base of the entosternite, (2 and 3), the sternum immediately in front of the entosternite; insertion into the anterior edge of the coxa. Extensor of the coxa. [93].

LII. *The Seventh Pedal Muscle* (Fig. 21). From the median entosternite, into the posterior edge of the coxa. Flexor of the coxa. [99].

53. *The Second Pedal Muscle* (Fig. 20). From the lateral entosternite above the inner angle of the leg into the posterior edge of the leg adjacent to the insertion of 39. Flexor of the coxa. [94].

54. *The Third Pedal Muscle* (Fig. 21). From the posterior edge of the entosternal pocket into the meso-caudal side of the edge of the coxa. Flexor and adductor of the coxa. [95].

55. *The Fifth Pedal Muscle* (Fig. 21). From the posterior edge of the distal end of the entosternite into the postero-lateral border of the coxa. Adductor of the coxa. [97].

LV. *The Fourth Pedal Muscle*, (Fig. 21 B). From the entosternite near the origin of 54, into the trochanter by the same tendon as 40. Extensor of the femur. [96].

C. The Metathorax.

LONGITUDINAL MUSCLES.

(a) Sternal.

LVI. *The First Metasternal Muscle* (Figs. 20 and 32). Originates from the posterior side of the base of the entosternite near the median line and runs backwards above the first four abdominal sternites. It has three insertions into the lateral end of the anterior edge of the third, fourth and fifth sternites respectively. A ventral retractor of the abdomen. [34].

THE MUSCLES OF THE LEGS.
(Plate V.)

The various muscles of the coxa as well as the large extensors of the femur which originate in the thorax have already been described. The following muscles lie entirely within the leg segments.

(a) Coxo-trochanteric Muscles.

The First Intracoxal Extensor of the Femur (Figs. 23 and 25, 1 ext. fem.) is a stout muscle with slightly converging fibres. It originates from the anterior side of the basal border of the coxa and is inserted into the trochanter just in front of the insertion of the large noto-trochanteric extensors.

The Second Intracoxal Extensor of the Femur (Figs. 23 and 25, 2 ext. fem.) is a conical muscle originating from the ventral edge of the base of the coxa and inserted by the same tendon as the noto-trochanteric extensors into the ventral edge of the trochanter.

The Third Intracoxal Extensor of the Femur (Figs. 23 and 26, 3 ext. fem.) originates from the posterior face of the coxa and is inserted into the trochanter behind the insertion of the noto-trochanteric extensor.

The First Flexor of the Femur (Figs. 23 and 26, 1 fl. fem.) originates in the dorsal edge of the coxa, and in the first and second legs, is inserted by a tendon into the dorsal edge of the base of the trochanter. In the hind legs it is inserted into the base of the femur at the dorsal edge of the femoral opening.

The Second Flexor of the Femur (Figs. 24 and 26, 2 fl. fem.) is similar to the first in its insertion. In the pro- and mesothoracic legs this flexor is a simple conical muscle, originating from the ventral side of the basal end of the coxa and running diagonally across the coxa. In the metathoracic leg the second flexor is a more powerful multiceps muscle. One head originates from the posterior face of the coxa, one from the ventral edge of the anterior face, and three from the basal edge of the anterior face.

(b) Trochantero-femoral Muscles.

The Fourth Extensor of the Femur (Fig. 25, 4 ext. fem.) is a small muscle originating from the ventral side of the base of the trochanter and inserted into the ventral side of the base of the femur.

64. *The Fifth Lateral* (cf. Fig. 22). The Homologue of 43. The precoxale is not developed as a separate sclerite in the metathorax, so this muscle has but two insertions, into the trochantin and the coxa. [52].

65. *The Sixth Lateral* (Fig. 21). Homologue of 44. This muscle is inserted quite distinctly into the coxa and not into the epimeron as is the case in *G. domesticus* (Voss). Depressor of the wing. [53].

(b) Noto-pleural.

66. *The Seventh Lateral* (Fig. 21). Origin, from the epimeron, a short distance dorsad of its middle; insertion, into the posterior subalar plate. Depressor of the wing. [54].

67. *The Twelfth Lateral* (Fig. 21). The homologue of 48 q. v.

68. *The Eleventh Lateral* (Fig. 21). From the anterior side of the pleural wing process into the anterior angle of the base of the wing, just in front of the anterior notal wing process. Elevator of the wing. , [58].

(c) Sterno-pleural.

LXVIII. *The Furca-entopleural Muscle of the Metathorax* (Not figured). Homologue of LI, q. v.

STERNAL MUSCLES.

Sterno-pedal.

69. *The First Pedal Muscle of the Metathorax* (Fig. 20). From the anterior side of the base of the entosternite into the inner anterior edge of the coxa. Adductor and extensor of the coxa. [60].

70. *The Second Pedal Muscle* (Fig. 20). Homologue of 53, q. v. [61].

71. *The Third Pedal Muscle* (Fig. 21). Homologue of 54. [62].

72. *The Fifth Pedal Muscle* (Fig. 21). Homologue of 55. [64].

LXXII. *The Fourth Pedal Muscle* (Not figured, cf. Fig. 21B, LV). Homologue of LV.

THE MUSCLES OF THE LEGS.

(Plate V.)

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(b) Trochantero-femoral Muscles.

The Fourth Extensor of the Femur (Fig. 25, 4 ext. fem.) is a small muscle originating from the ventral side of the base of the trochanter and inserted into the ventral side of the base of the femur.

The Anterior Flexor of the Femur (Fig. 26, ant. fl.) is a broad flat muscle with parallel fibres. It originates from the basal edge of the anterior face of the trochanter and is inserted into the anterior face of the femur. These two muscles are not present in the small trochanter of the hind legs.

(c) Femoro-tibial Muscles.

The Extensor of the Tibia (Figs. 23 and 25, ext. tib.) In the large leaping hind leg this muscle originates from the entire dorsal two-thirds of the inner surface of the femur. It is a pseudo-penniform muscle sending short oblique fibres into the long spatulate tendon by which it is inserted into the dorsal edge of the base of the tibia.

In the first and second legs (Fig. 25, ext. tib.) the extensor is much weaker. The tendon is shorter and the fibres originate chiefly from the basal end of the femur, though some spring from near or beyond the middle of the segment.

The Flexor of the Tibia (Figs. 23 and 25, fl. tib.) originates by two heads from (1) the ventral side of the base of the trochanter and (2) the proximal end of the ventral side of the femur. It is a conical muscle and is inserted into the ventral proximal edge of the tibia by means of a long linear tendon.

(c) Tibio-tarsal Muscles.

The First Extensor of the Tarsus (Fig. 23, 1 ext. tar.) is very similar to the extensor of the tibia in the hind leg. It lies in the ventral half of the tibia, and is inserted into the proximal end of the first tarsal segment.

The Second Extensor of the Tarsus (Fig. 23, 2 ext. tar.) originates from the dorsal side of the tibia near the femoro-tibial articulation. It is a short conical muscle and is inserted by a long filamentous tendon, running through the greater part of the tibia and tarsus, into the ventral edge of the third tarsal segment.

The second tarsal segment, projecting as it does backwards and forwards beneath the first and third, limits the flexing of the tarsal segments, so that this muscle extends the entire tarsus outwards in a straight line with the tibia.

The Flexor of the Tarsus (Fig. 23, fl. tar.) originates in the dorsal face of the tibia a short distance from the articulation with the femur. It is inserted by a flat tendon into the first tarsal segment.

(d) Tarsal Muscles.

The Extensor of the Second and Third Tarsal Segments (Fig. 23, ext. tar.$_2$) lies in the dorsal side of the first tarsal segment. It originates in the proximal end of the segment and is inserted into the dorsal proximal edge of the second segment. When this last is extended it pulls the third segment with it so that the two segments move together.

The Extensor of the Claws (Fig. 23, ext. ung.) originates from the proximal end of the dorsal side of the third tarsal segment and is inserted into the base of the claws by means of a tendon, which forms a bridge between them on the dorsal side.

The Flexor of the Claws (Figs. 23 and 27, fl. ung.) originates on the ventral side of the third segment opposite the origin of the extensor. Connected with the base of the claws on the ventral side is a prominent apodeme (Fig. 27, ap. ung.) at the end of which the flexor is inserted by a long narrow tendon.

IV. MUSCLES OF THE ABDOMEN.

(Plate VI, Figs. 32–36.)

A. First Abdominal Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

73. *The First Ventral Muscle* (Fig. 32). From near the antero-lateral edge of the first sternite, into the anterior edge of the second sternite. [26].

74. *The Second Ventral* (Fig. 32). From the lateral side of the first sternite into the inner angle of the parasternal plate. [27].

(b) Tergal.

75. *The First Dorsal Muscle* (Fig. 32). Two straight flat muscles lying in the tergum near the median line. They originate from the posterior edge of the tergite and are inserted into the anterior edge of the second tergite. [28].

76. *The Second Dorsals* (Fig. 32). Origin contiguous to that of 75; inserted into the lateral end of the anterior edge of the second tergite. [29].

The longitudinal muscles are retractor muscles of the abdomen.

DORSOVENTRAL MUSCLES.

Tergo-sternal.

77. *The Second Dorsoventral* (Fig. 32). From the lateral edge of the tergite near the posterior end, into the lateral angle of the parasternal plate. [31].

PLEURAL MUSCLES.

Sterno-pleural.

78. *The Dilator of the Spiracle* (Fig. 32). From the lateral end of the anterior edge of the parasternal plate into the closing lever or process of the stigmatal bow. [32, Lateral stigmatal muscle α].

79. *The Second Dilator of the Spiracle* (Fig. 32) originates with 78 from the parasternal plate and is inserted into the pleural membrane just behind the spiracle. Present only in the first and second abdominal segments. [32, Lateral stigmatal muscle β).

B. The Second Abdominal Segment.

TRANSVERSE MUSCLES.

Sternal.

80. *The Ventral Transverse Muscle* (Fig. 32). From the middle of the parasternal plate of one side across the anterior end of the second sternite into the parasternal plate of the other side. [17].

LONGITUDINAL MUSCLES.

(a) Sternal.

81. *The First Ventral Muscle* (Fig. 32). From behind the anterior margin of the second sternite into the anterior margin of the third sternite. [13].

82. *The Second Ventral Muscle* (Fig. 32). From the mesal edge of the parasternal plate, into the anterior edge of the third sternite. [14].

(b) Tergal.

83. *The First Dorsal Muscles* (Fig. 32). Homologous with 75 and similarly arranged.

84. *The Second Dorsal Muscles* (Fig. 32). Homologous with 76, but originate near the transverse medial line and not in the anterior margin of the second tergite.

DORSOVENTRAL MUSCLES.

Tergo-sternal.

85. *The First Dorsoventral Muscle* (Fig. 32). From the anterior end of the lateral edge of the tergite into the parasternal plate immediately behind the insertion of the tergosternal of the first segment. [30].

As stated before, the musculature of the parasternal plate indicates that this sclerite is composed of detached portions of the first and second sternites. Muscles 56, LVII, 74, 77, 78 and 79 appear to belong to the first sternite, while the others belong to the second. Voss, however, described 85 as an intersegmental muscle, a mistake no doubt due to the fact that the anterior tergosternals not being developed in any other segment in *G. domesticus*, he failed to trace the homology.

86. *The Second Dorsoventral* (Fig. 32). A straight parallel-fibred muscle originating from the posterior end of the lateral edge of the tergite and inserted into the corresponding region of the sternite. [18].

PLEURAL MUSCLES.

(a) Noto-pleural.

87. *The Fourth Lateral Muscle* (Fig. 32). From the postero-lateral angle of the tergite into the posterior pleural sclerite of the second segment. [22].

88. *The Fifth Lateral Muscle* (Fig. 32). Origin as in 87; insertion into the first pleural sclerite of the third segment. [23].

(b) Sterno-pleural.

89. *The First Lateral Muscle* (Fig. 32). From the parasternal plate into the pleural membrane in front of the spiracle. Voss regards this as the first and second laterals. The large third pleural sclerite (ps_3) of the third segment probably results from the fusion and enlargement of the sclerites of the second and third segments, in which case 92 is probably the homologue of the second lateral of the succeeding segments and I have thus regarded it. [19, 20].

90, 91. *The Dilators of the Spiracles* (Fig. 32). Homologues of 78 and 79, and similarly placed. [25, lateral stigmatal α and β].

92. *The Second Lateral* (Fig. 32). From the parasternal plate into the antero-ventral edge of the third pleural sclerite of the third segment. [24, sixth lateral parastigmatal].

93. *The Third Lateral* (Fig. 32). From the parasternite into the second pleural sclerite of the second segment.

C. The Third to Sixth Segments of the Female; Third to Eighth of the Male.

TRANSVERSE MUSCLES.

Sternal.

94. *The Transverse Ventral Muscle* (Fig. 32) lies entirely within the sternum across the anterior end. Its points of attachment are near the latero-anterior angles of the sternite.

LONGITUDINAL MUSCLES.

(a) Sternal.

95. *The First Ventral Muscle* (Fig. 32). A short muscle having its origin near the transverse median line and lying not far from the longitudinal median line of the sternite. It is inserted into the anterior border of the segment behind the one in which it lies. [1].

96. *The Second Ventral Muscle* (Fig. 32) lies in the lateral side of the sternum and extends from the anterior border of one segment to the anterior border of the next segment behind. [2].

(b) Dorsal.

83, 84. *The First and Second Dorsals.* (See above).

DORSOVENTRAL MUSCLES.

Tergo-sternal.

97. *The First Dorsoventral Muscle* (Fig. 32) stretches across the pleural membrane from the antero-lateral angle of the tergite to the corresponding region of the sternite. Homologue of 85.

98. *The Dorsoventral Sternal* (Fig. 32). Homologue of 77 and 86. Similar to 97, but lying in the posterior end of the segment. [5].

PLEURAL MUSCLES.

(a) Noto-pleural.

99. *The Fourth Lateral Muscle.* Homologue of 87, q. v. [9].
100. *The Fifth Lateral.* Homologue of 88, q. v. [10].

(b) Sterno-pleural.

The sternopleural muscles (101 to 105) all originate from the lateral border of the sternite in succession from the anterior to the posterior end of the sclerite. They are inserted into the pleural sclerites or into the spiracle, as follows:

101. *The First Lateral,* into the first pleural sclerite. [6].
102. *The Second Lateral,* into the third pleural sclerite. [7].
103. *The Dilator of the Spiracle,* into the process of the bow of the spiracle. [11].
104. *The Third Lateral,* into the second pleural sclerite. [8].
105. *The Third (a) Lateral,* with 104 into the second pleural sclerite.

Functions of the Foregoing Abdominal Muscles. The longitudinal muscles are retractors of the abdomen. The ventral and dorsal working together telescope the segments. The ventral bend the body downwards, while the dorsal act as their antagonist muscles, bending the body upwards. The tergosternals and laterals are expiratory muscles, and pull the sternum and tergum together. Those of either side working alone may act as rotators of the abdomen.

THE EXTREMITY OF THE ABDOMEN.

In both sexes ten dorsal segments, including the suranal plate (Figs. 3, 33, 35, P. S.) can be readily distinguished. On the ventral side, however, there are only eight in the female and nine in the male, including the subgenital plate. A study of the musculature as described below will show, apart from other evidence, that in the female the supra-genital plate, lying above the ovipositor is the sternite of the ninth segment, and in both sexes the podical plates (P. P.) are the divided halves of the tenth sternite.

D. The Seventh Abdominal Segment of the Female.

LONGITUDINAL MUSCLES.

Sternal.

106. *The Retractor of the Vagina* (Fig. 33) is a flat parallel-fibred muscle originating from the antero-lateral angle of the seventh sternite and inserted into the dorsal side of the vagina at its junction with the oviduct. A suspensor and retractor of the vagina. The muscle probably helps to force the egg out by elongating the vagina, thus reducing its lumen and exerting pressure on the egg.

107. *The Adductor of the Subgenital Plate* (Figs. 33 and 34). A rectus muscle having its origin adjacent to and immediately in front of 106. It is inserted into the lateral end of the anterior border of the eighth sternite or subgenital plate. Homologous with the second sternals.

The other muscles are similar to those of the preceding segments.

E. The Eighth Segment in the Female.

LONGITUDINAL MUSCLES.

(Fig. 34.)

There are no longitudinal muscles in the eighth sternites. The tergal muscles occupy the entire tergum except the median line, and all extend from the anterior to the posterior border, showing no differentiation between the first and second dorsals.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

108. *The Abductor of the Subgenital Plate* (Fig. 34) originates from the lateral end of the anterior process of the eighth tergite, runs obliquely ventrad, and is inserted into the antero-lateral angle of the subgenital plate.

(b) Noto-gonapophysal.

109. *The First Depressor of the Ovipositor* (Fig. 33) is a large, strong, conical muscle originating from the inner face of the anterior process of the eighth tergite and running obliquely ventrad to be inserted into the ventral process of the ventral gonapophysis.

F. The Ninth Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

110. *The Second Ventral* (Fig. 35). A rectus muscle from the anterior lateral angle of the subgenital plate, the ninth sternite, into the ventral edge of the podical plate or tenth tergite. This muscle apparently enlarges the anal opening. Found in the male only.

(b) Tergal.

Similar to the eighth segment.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

111. *The Indirect Elevator of the Ovipositor* (Fig. 34). A straight muscle from the anterior edge of the ninth tergite into the supragenital plate or ninth sternite.

(b) Noto-gonapophysal.

112. *The Second Depressor of the Ovipositor* (Figs. 33 and 34), is a strong muscle originating from the entotergite of the ninth segment. It is inserted into (1) the ventral process of the dorsal gonapophysis and (2) the median process of the transverse beam connecting the ventral processes of the two dorsal gonapophyses.

113. *The Third Depressor of the Ovipositor* (Fig. 33), a stout, conical muscle, also originates from the inner face of the anterior process (entotergite) of the ninth tergite. It lies on the inner side of the second depressor and is inserted into the ventral process of the dorsal gonapophysis.

114. *The First Elevator of the Ovipositor* (Figs. 33 and 34), is a short broad muscle originating from the lateral anterior edge of the ninth tergite and inserted into the ventral face of the dorsal process of the dorsal gonapophysis.

STERNAL MUSCLES.

(a) Male Genital Muscles.

115. *The Suspensory Muscle of the Spermatophore Cup* (Figs. 35 and 36), a short muscle from the latero-anterior angle of the subgenital plate into the ventral valve of the spermatophore cup at its junction with the ductus ejaculatorius.

116. *The First Retractor of the Spermatophore Cup* (Figs. 35 and 36) originates from the anterior end of the ventral valve at its junction with the ductus, runs obliquely round the cup and is inserted into the lateral side of the dorsal valve at the posterior end where the chitinous plates are given off.

117. *The Second Retractor of the Spermatophore Cup* (Figs. 35 and 36) is similar to the first retractor in origin and insertion and lies between it and the cup.

118. *The Dilator of the Mouth of the Spermatophore Cup* (Figs. 35 and 36), a very short, straight muscle having its origin on the dorsal side of the dorsal valve and its insertion adjacent to that of the retractors.

119. *The Constrictor of the Spermatophore Cup* (Figs. 35 and 36) forms a muscular tunic covering the outer surface of the dorsal valve of the spermatophore cup. The action of this muscle and of the retractors forces the spermatophore out of the cup.

(b) Female Genital Muscles.

120. *The Protractor of the Ovipositor* (Fig. 33) is a short, stout muscle which originates from the process of the supragenital plate (P. S. G.) and is inserted into the inner face of the ventral process of the dorsal gonapophysis. Pulls the ovipositor backwards.

121. *The Lateral Abductor of the Gonapophyses* (Fig. 33) also originates from the supragenital process and is inserted into the dorsal process of the ventral gonapophysis. It pulls the two gonapophyses of one side apart from those of the other side, at the same time enlarging the genital orifice which lies between the bases of the ventral gonaphyses. It also elevates the ovipositor.

THE MECHANICS OF THE OVIPOSITOR.

The two plates on each side are enabled to work together (1) by a tongue and groove joint which runs along their entire length and (2) by the interlocking of the dorsal processes. (Fig. 3).

The ovipositor is a lever of the first order, the inner processes being the force arms, so that an upward or downward pull on these processes, respectively depresses or elevates the external plates. Similarly an inward pull (the transverse beam being the fulcrum in this case) separates the right and left plates externally.

G. The Tenth Segment.

LONGITUDINAL MUSCLES.

(a) Sternal.

122. *The Ventral Muscle* (Fig. 35) is a short flat muscle lying across the inner end of the pedical plate. Probably the homologue of the first ventral muscle of the anterior segments.

(b) Tergal.

123. *The Dorsal Muscle* (Fig. 35), a homologue of the first dorsals of the anterior segment lies near the median line of the suranal plate, stretching from the anterior to the posterior borders of the sclerite. This and the preceding pull the edges of the anus forward, probably aiding in the ejection of the faeces.

DORSOVENTRAL MUSCLES.

(a) Tergo-sternal.

124. *The First Dorsoventral* (Fig. 35). From the lateral side of the anterior edge of the suranal plate into the anterior edge of the podical plate near the insertion of the first ventral of the ninth segment. Pulls down the podical plate, enlarging the anal orifice.

125. *The Second Dorsoventral* (Fig. 35). From near the hinder end of the suranal plate into the podical plate a short distance in front of its hinder border. Closes the anal orifice by bringing the edges of the suranal and podical plates together.

(b) Noto-cercal.

126. *The Adductor of the Cercus* (Figs. 34 and 35). From the median line of the suranal plate into the inner side of the base of the cercus.

127. *The Depressor of the Cercus* (Figs. 34 and 35). From the anterior edge of the suranal plate into the ventral side of the base of the cercus.

128. *The Elevator of the Cercus* (Figs. 34 and 35) originates laterad of the origin of the depressor and is inserted into the dorsal edge of the cercus.

129. *The Abductor of the Cercus* (Figs. 34 and 35). From the anterior edge of the lateral portion of the suranal plate into the outer edge of the cercus.

V. THE MUSCLES OF THE SPIRACLES.

THE MESOTHORACIC SPIRACLE (Fig. 37) lies transversely in the pleural membrane behind the prothoracic leg. The anterior lip is composed of a broad ventral (a. $l._1$) and a narrow dorsal (a. $l._2$) sclerite. Two tracheal chambers open into the vestibule and between the two chambers there is a thickened chitinous septum (c. t.)

The First Occlusor of the Mesothoracic Spiracle (Fig. 37, $oc._1$ sp.) originates near the anterior margin of the episternum of the mesothorax and is inserted into the ventral anterior valve. It closes the orifice of the spiracle by pulling the anterior lip against the posterior.

The Second Occlusor of the Mesothoracic Spiracle (Fig. 37, $oc._2$ sp.) originates from the ventral sclerite of the anterior lip and is inserted into the anterior side of the chitinous septum between the two tracheal chambers. It closes the dorsal chamber by pulling its anterior and posterior walls together. There seems to be no mechanism for closing the ventral chamber apart from the first occlusor.

THE METATHORACIC SPIRACLE (Figs. 38 and 39) has a crescent shaped anterior lip (a. l.) and a somewhat sickle-shaped posterior lip (p. l.) with an expanded ventral end. There is but one tracheal chamber, the ventral wall of which has a chitinous thickening which serves for the insertion of an occlusor muscle.

The First Occlusor of the Metathoracic Spiracle (Fig. 38, $oc._1$ sp.) originates from the outer border of the posterior lip and is inserted into the anterior lip. It closes the spiracle by pulling the two valves together.

The Second Occlusor of the Metathoracic Spiracle (Fig. 39, $oc._2$ sp.) has the same origin as the first, but is inserted into the chitinous thickening of the wall of the tracheal chamber. It closes the chamber by pulling its walls together.

THE ABDOMINAL SPIRACLES (Figs. 40 and 41) have a triangular posterior valve and an arcuate anterior valve. Each valve bears a narrow ridge beset with minute chitinous projections. The ridge of the anterior segment is the "bow" of Landois, and bears near its ventral end an inward projecting process, the closing lever or peg.

The Occlusor of the Abdominal Spiracles (Figs. 40 and 41, oc. sp.) is a short muscle which takes its origin from the dorso-posterior edge of the triangular posterior valve. It is inserted into the process of the bow and closes the spiracle by pulling the bow down against the other lip.

The Dilator Muscle (Figs. 40 and 41, d. sp., Fig. 32, 103) originates from the lateral edge of the abdominal sternite and is inserted into the extreme ventral end of the closing lever.

VI. THE MUSCLES OF THE VISCERA.

The Constrictor Muscles of the Oesophagus and Crop form a muscular tunic composed of a single layer of circular muscles.

The Constrictor Muscles of the Proventriculus (Fig. 42, c. m.) form a very strong muscular coat consisting in its thickest part of as many as ten layers of circular muscles.

The Dilator Muscles of the Proventriculus (Fig. 42, d. m.) are situated within the cavity of each median tooth. The edges are attached at the bases of the outer barbated lobes near the partitions between the epithelial folds. The muscle folds on itself, the fold extending far within the cavity of the median tooth. The effect of the contraction of this peculiar muscle is to pull the epithelial folds outwards towards the muscular tunic, thus enlarging the lumen of the proventriculus.

The Constrictors of the Mesenteron form a single layer of circular muscles.

The Dilators of the Mesenteron are longitudinal muscles, several groups of which lie along this organ outside the circular muscles.

The Constrictors of the Rectum (Figs. 43 and 44, c. m.) are usually two layers thick.

The Dilators of the Rectum (Figs. 43 and 44, d. m.) There are six groups of dilator muscles in the rectum, which originate from the body wall as follows: The two dorsals from the anterior edge of the tenth tergite, one on each side of the median line; the two laterals from the lateral side of the anterior edge of the same sclerite, in front of the cerci; the two ventrals in the male from the latero-anterior processes of the eighth sternite, in the female from the base of the ventral gonapophyses in the angle between the ventral and dorsal processes. Each of these groups

enters the rectum, behind its middle, on the line where the primary epithelial folds are in contact with the muscular tunic. The muscles of each group then separate, running backwards and forwards along this line and extending from the anus to the junction of the colon and rectum.

The Suspensorium of the Crop and Gastric Caecum is a thin muscle originating from the anterior border of the pronotum near the median line. One branch enters the latero-dorsal wall of the crop near its middle and runs backwards towards the proventriculus; another branch is inserted at the apex of the caecum and divides into several smaller bundles which run backwards, forming the longitudinal muscles of the caecum.

The Alary Muscles of the Heart. There are ten of these delicate fan-shaped muscles, one in the mesothorax, one in the metathorax, and one in each of the eight anterior abdominal segments. They originate in the dorsal diaphragm near the median line beneath the heart, and are inserted near the lateral end of the anterior border of the several tergites.

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REFERENCE LETTERING.

A_1, A_2, etc.—Abdominal segments.
Abd.—Abductor muscle.
Ad.—Adductor Muscle.
A. L.—Lateral apodeme of the dorsal border of the occipital foramen.
a. l.—Anterior valve of the spiracle.
A. M.—Median dorsal apodeme of the base of the head.
a. n. p.—Anterior notal wing process.
ant.—Antenna.
ant. fl.—Anterior flexor of the femur.
ap.—Apodeme.
b. s.—Basalar sclerite.
C_1, C_2.—Cardo, first and second segments.
Cerv.—Veracervix or neck region.
c. hyp.—The compressor of the hypopharynx.
c. m.—Constrictor (circular) muscles of the digestive tract.
Cox.—Coxa.
Cs.—Cercus.
c. t.—Chitinous thickening of the tracheal wall.
d_1, d_2.—Internal dorsal processes of the dorsal and ventral gonapophyses respectively.
dep.—Depressor muscle.
d. m.—Dilator muscle.
d. sp.—Dilator of the spiracle.
el.—Elevator muscle.
Em.—Epimeron.
Ep.—Episternum.
ep.—Entopleurite.
Eph.—Epipharynx.
eph. m.—Epipharyngeal muslce.
es.—Lateral entosternite (furca).
es. m.—Median entosternite (spina).
ext.—Extensor muscle.
ext. a. s.—Extensor of the antennal segment.
ext. p. s.—Extensor of the palpal segment.
F. A.—Anterior foramen of head.
fem.—Femur.
F. L.—Lateral foramen of head.
fl.—Flexor muscle.
fl. a. s.—Flexor of the antennal segment.
fl. g.—Flexor of the galea.
fl. p.—Flexor of the palpus.
fl. p. s.—Flexor of the palpal segment.
F. O.—Occipital foramen.
Fs.—Furcasternite.
G.—Gena.
Gal.—Galea.
G. D.—Dorsal gonapophysis.
Gl.—Glossa.
G. V.—Ventral gonapophysis.
hyp.—Hypopharynx.
in_1. in_2.—Intersegmentalia.
i. p.—Interpleurite of the veracervix.
i. st.—Intersternites of the veracervix.
i. tg.—Intertergites of the veracervix.
Lac.—Lacinia.
Lb, lb.—Labium.
Lbr., lbr.—Labrum.
l. d.—Lateral dilator of the oesophagus.
m. ant.—Antennal muscles.
Md., md.—Mandible.
Mx., mx.—Maxilla.
Oc.—Ocellus.
oc.—Occlusor muscle.
Oes.—Oesophagus.
P. A_8. P. A_9—Anterior tergal processes (entotergites) of the eighth and ninth abdominal segments.
Pcx.—Precoxale.
P. G.—Postgena.
Pgl.—Paraglossa.
Ph.—Pharynx.
p. l.—Posterior valve of spiracle.
Pl. mb.—Pleural membrane.
p. n. p.—Posterior notal wing process.
P. P.—Podical plate.
p. p.—Pleural wing process.
pr. d.—Precerebral dilators of oesophagus and pharynx.
P. S.—Suranal plate.
p. s.—Pleural sclerites of abdomen.
Pscl.—Postscutellum.
P. S. G.—Process of the supragenital plate.
ps. p.—Parasternal plate.
pst. d.—Postcerebral dilators of the oesophagus.
r. hyp.—Retractor of the hypopharynx.
r. lb.—Retractor of the labium.
sa. p.—Subalar plate.
Sc.—Scutum.
Scl.—Scutellum.
sp.—Spiracle.
sp. c.—Spermatophore cup.
Ss.—Spinasternite.
st.—Stipes.
Stn.—Sternum.
t.—Tendon.
T. A.—Anterior arm of the tentorium.
tar.—Tarsus.
T. C.—Central plate of tentorium.
t. c.—Transverse chitinous beam connecting the ventral processes of the two dorsal gonapophyses.
tend.—Tendon.
Tg.—Tergite.
tib.—Tibia.
T. P.—Posterior arm of tentorium.
tr.—Trochantin.
Troc.—Trochanter.
ung.—Claws.
v_1, v_2—Internal ventral processes of the dorsal and ventral gonapophyses, respectively.
vag.—Vagina.
vd.—Ventral dilators of the oesophagus.
Vs.—Verasternite.

EXPLANATION OF FIGURES.

PLATE I.

Fig. 1. Plan of part of the inner right side of the skeleton showing the endoskeletal structures and the attachment of the muscles. External sclerites are dotted, the internal sclerites and processes are shaded black, tendons are cross-hatched and the attachment of the muscles outlined with dotted lines.

PLATE II.

Fig. 2. Ventro-caudal view of the epicranium showing the tentorial plates.
Fig. 3. Inner view of the right half of the extremity of the female abdomen.
Fig. 4. The mandibles and their muscles. On the left side several layers of the adductor are removed to show the tendons, on the right side the adductor is cut across to show its thickness.
Fig. 5. Front view of the head with the labrum, clypeus and front removed to show the heads of the adductors of the mandibles, the anntenal muscles and the dilators of the oesophagus and pharynx.
Fig. 6. Longitudinal section through the head.
Fig. 7. The muscles of the labrum.
Fig. 8. Longitudinal section through the lateral side of the labrum, clypeus and part of the front.
Fig. 9. Same through the median line.
Fig. 10. Longitudinal section through the basal joints of the antenna.
Fig. 11. Portion of front of head showing the antennal muscles.

PLATE III.

Fig. 12. Head with the greater part of the epicranium and internal tissues removed to expose the muscles of the maxillae.
Fig. 13. Ventro-caudal view of the head with the labium and gular region removed.
Fig. 14. Muscles of the maxilla.
Fig. 15. External muscles of the maxilla.
Fig. 16. Caudal view of the head with the integument of the mentum and submentum removed exposing the labial and maxillary muscles.
Fig. 17. The muscles of the labium.
Fig. 18. The cervical muscles.
Fig. 19. External cervical muscles.

PLATE IV.

Fig. 20. The inner layer of thoracic muscles, right side.
Fig. 21. (A) The outer layer of thoracic muscle. (B)* The outer layer of the mesothoracic muscles of the male.

PLATE V.

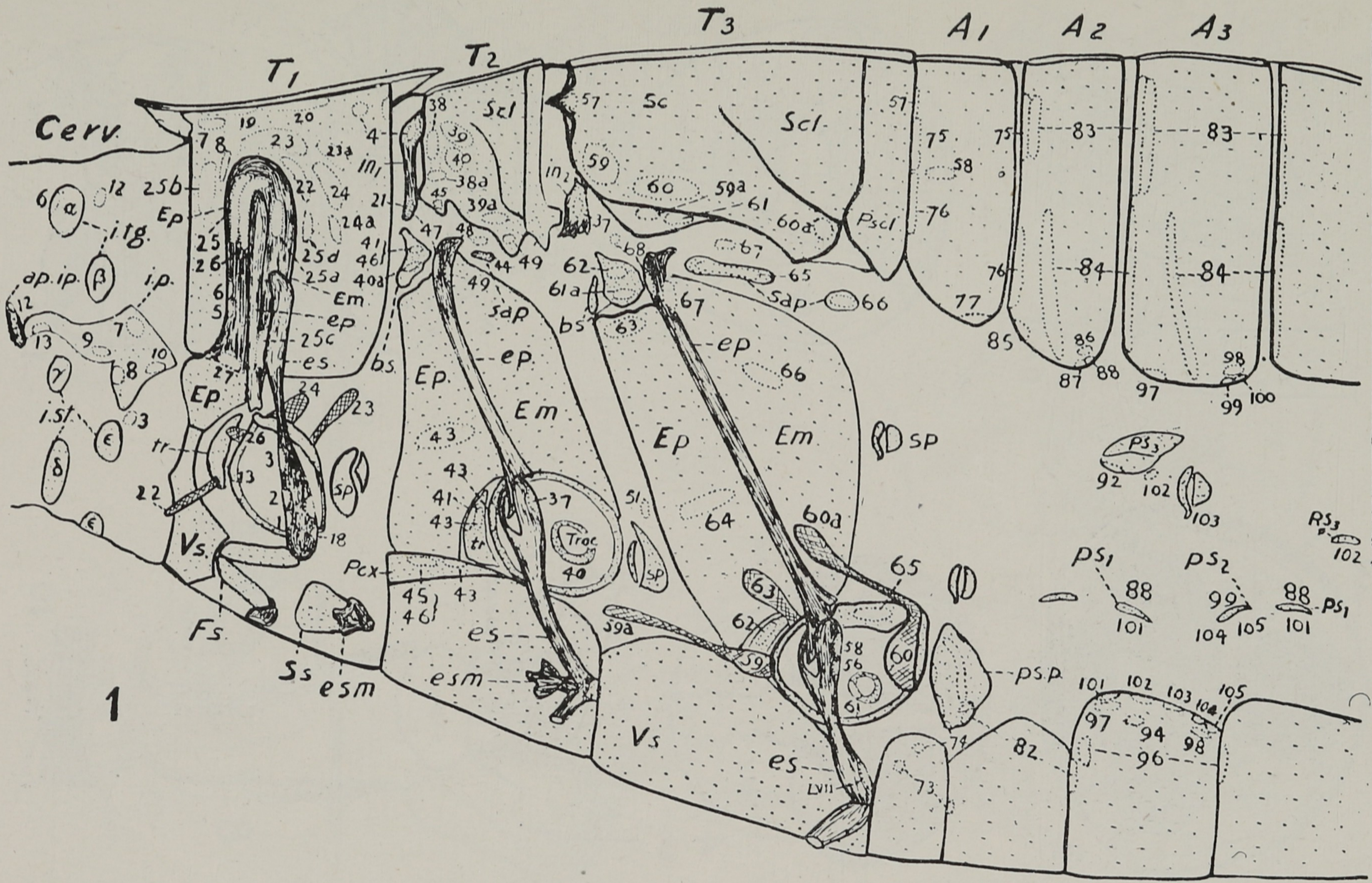
Fig. 22. The articulation of the mesothoracic leg with the episternum and the sternum showing the fifth lateral muscle of the mesothorax.
Fig. 23. Inner side of the anterior face of the right metathoracic leg.
Fig. 24. Anterior face of the coxa of metathoracic leg with the extensors of the femur removed to show the flexors.
Fig. 25. Anterior face of left mesothoracic leg.
Fig. 26. Posterior face of the coxa and trochanter of the same.
Fig. 27. Ventral view of the claws and their flexing apparatus.
Fig. 28. Enlarged metathoracic longitudinal dorsal muscle of longwinged female.
Fig. 29. The nototrochanteric extensor of the femur.
Fig. 30. The notocoxal flexor.
Fig. 31. The notocoxal extensor.

PLATE VI.

Fig. 32. The muscles of the first five abdominal segments. In segments 3 and 4 the dorsoventrals are removed to expose laterals.
Fig. 33. Muscles of the extremity of the female, inner layer.
Fig. 34. Same, outer layer.

PLATE VII.

Fig. 35. Muscles of the extremity of the male.
Fig. 36. Lateral view of the spermatophore cup and its muscles.
Fig. 37. Inner view of the mesothoracic spiracle.
Fig. 38. Inner view of the metathoracic spiracle.
Fig. 39. Same with the first occlusor removed.
Fig. 40. Inner view of an abdominal spiracle, open.
Fig. 41. Same, closed.
Fig. 42. Transverse section through one fold of the proventriculus.
Fig. 43. Transverse section of the rectum.
Fig. 44. External view of the rectum.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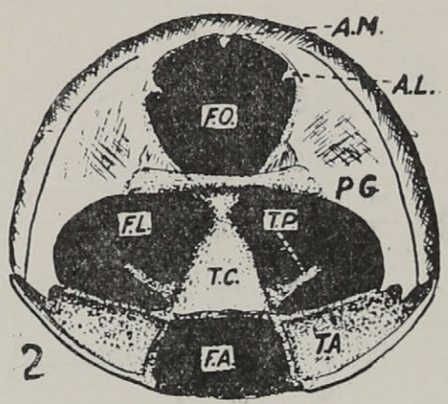
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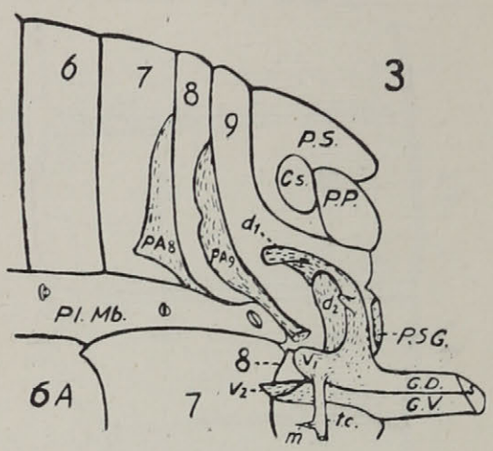
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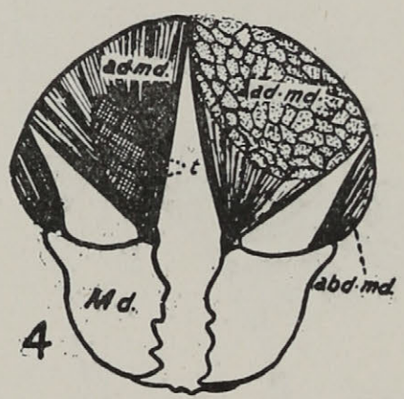
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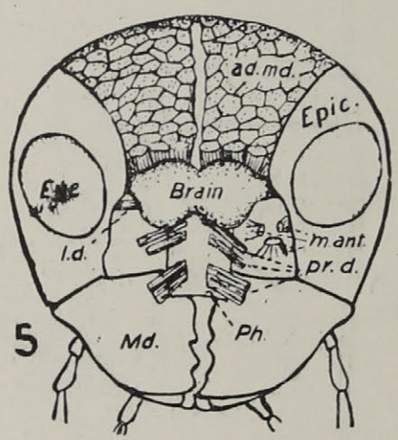
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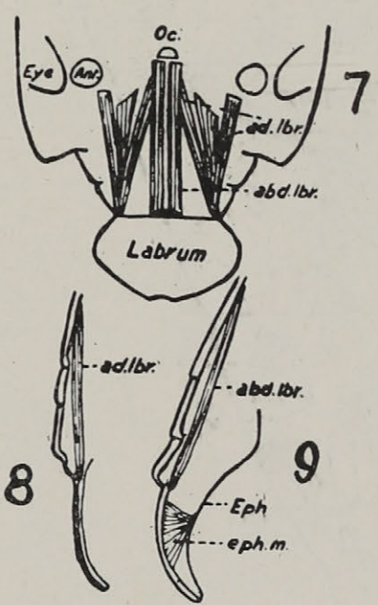
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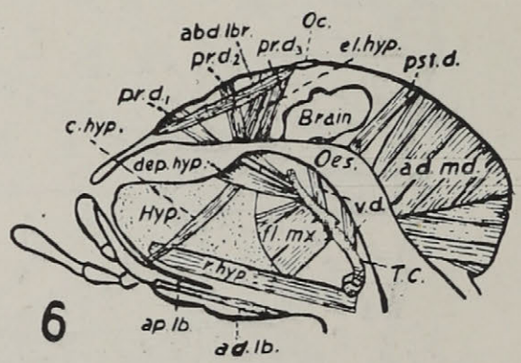
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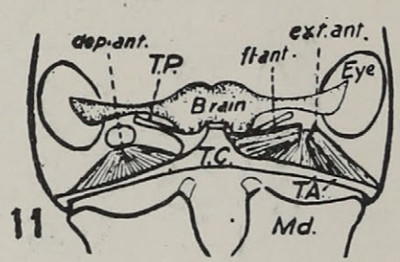
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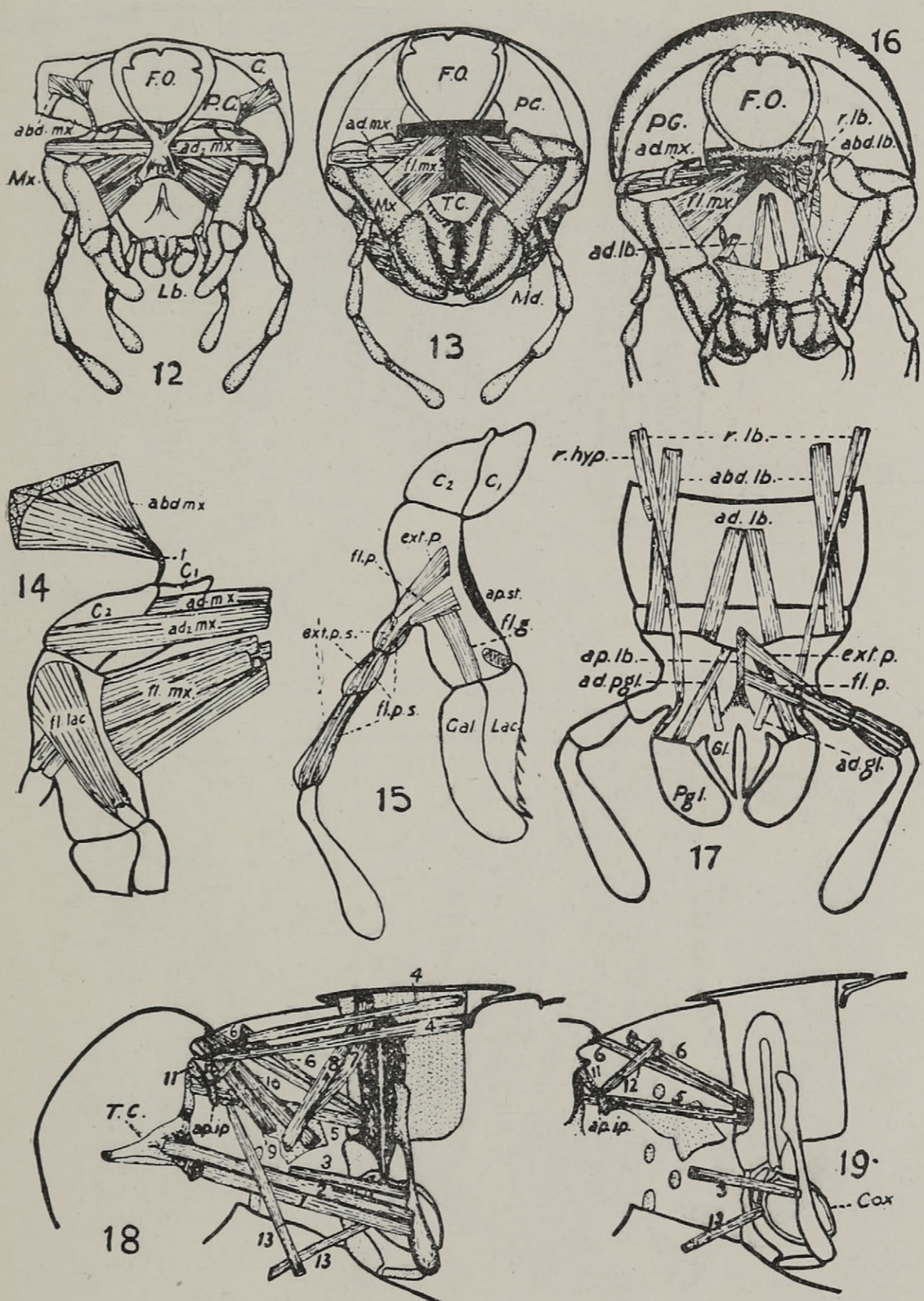
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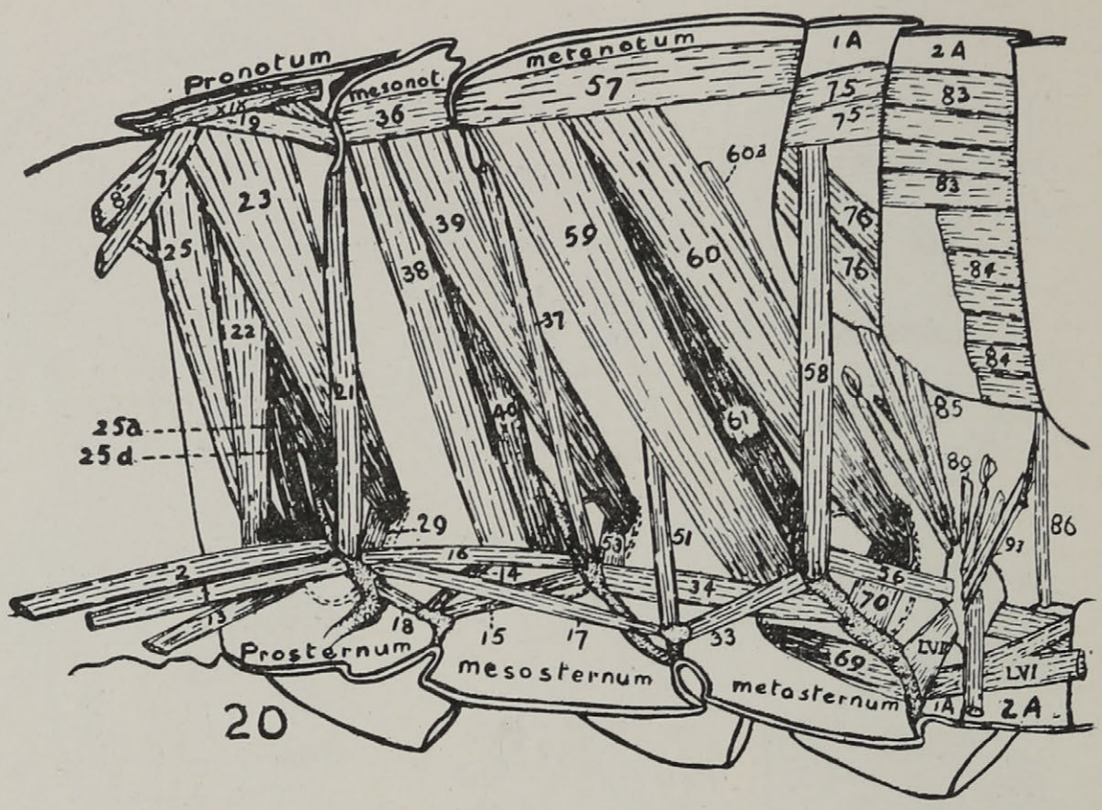

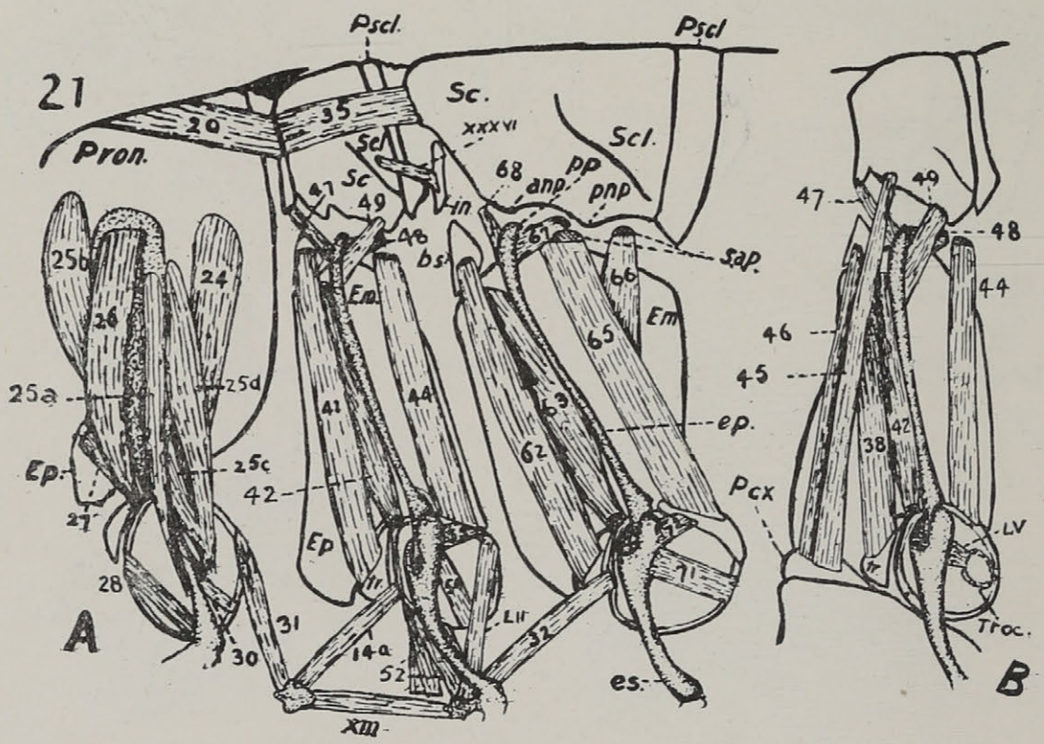

(NOTE—In Figure 21B for 38 read 41.)

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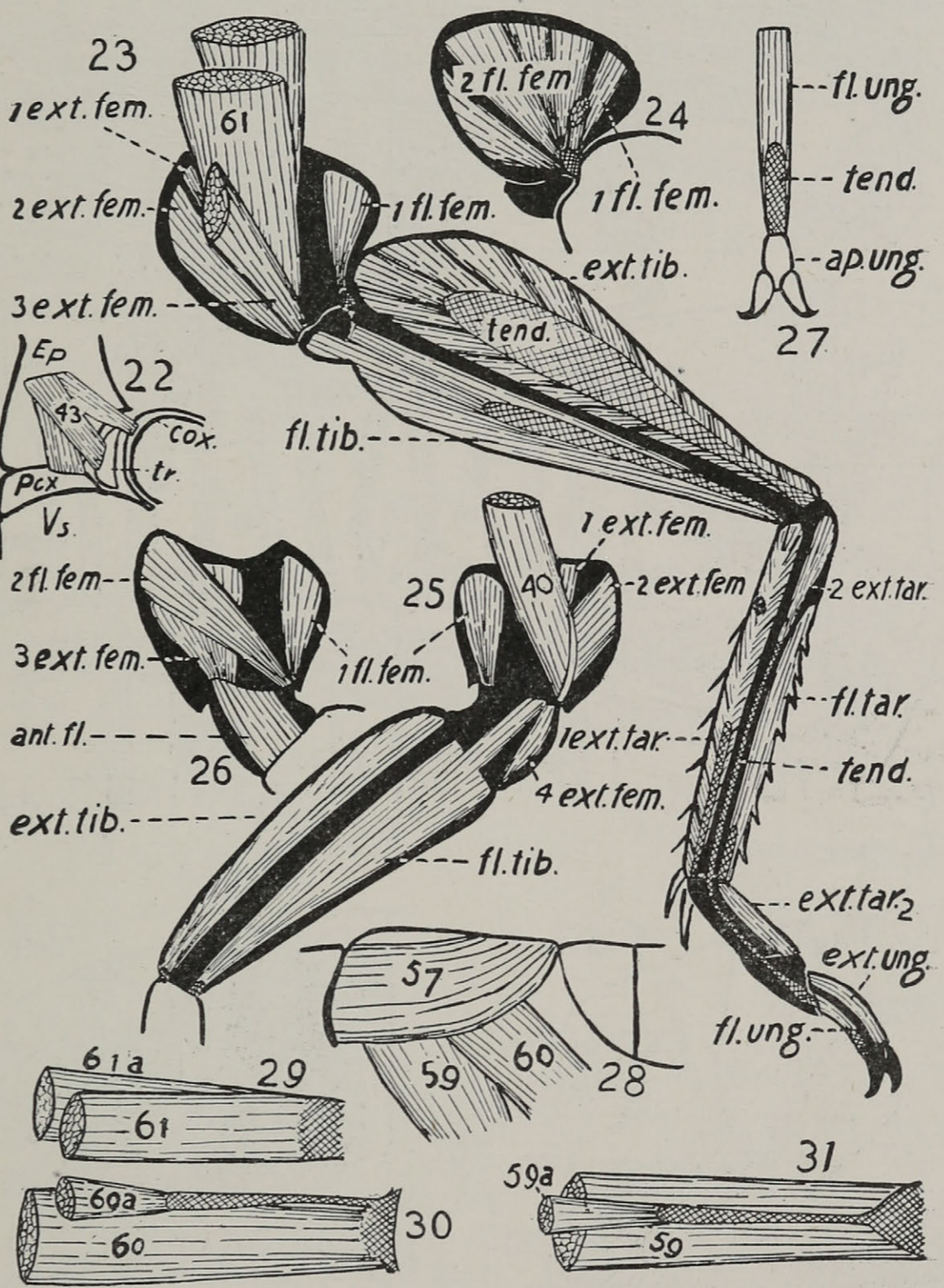
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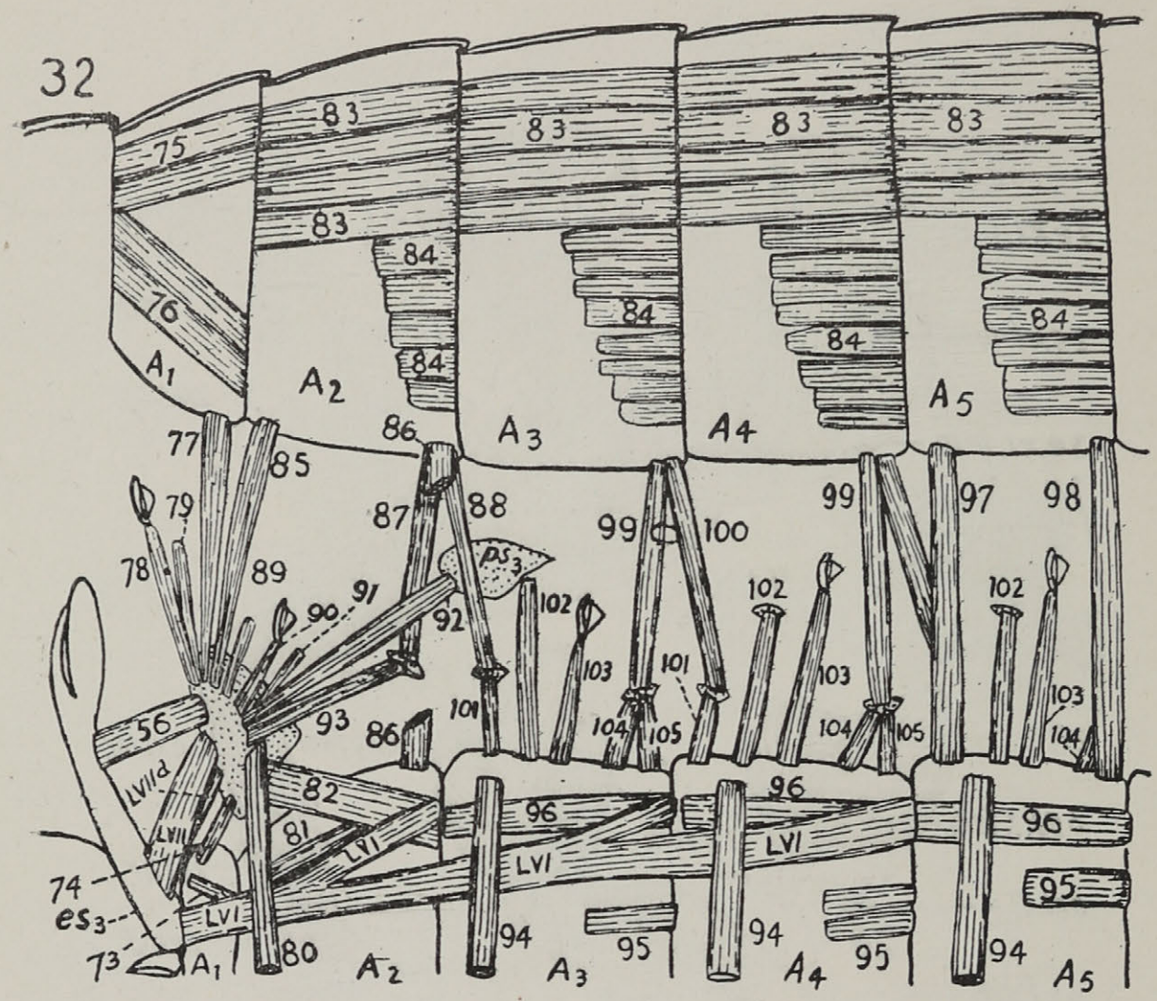
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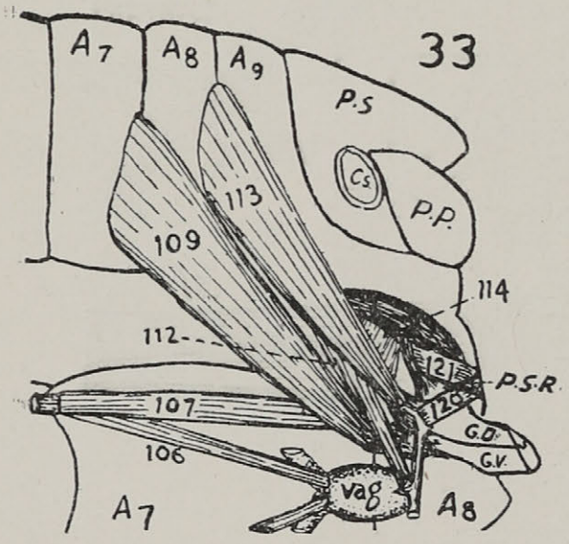
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P.S
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P.S.R.
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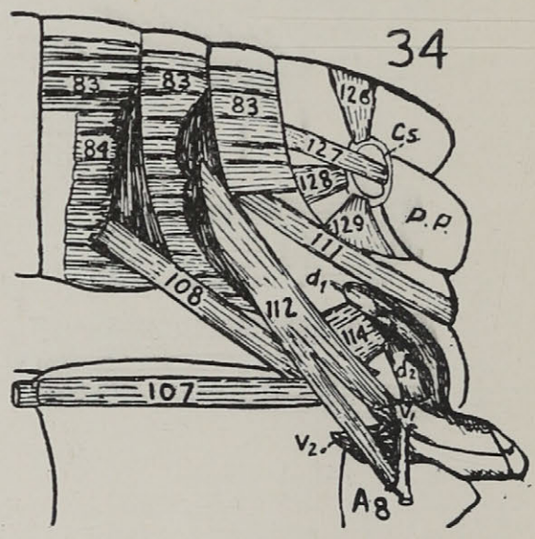
G.D.
G.V.
106
vag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d2
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V1
V2
A8

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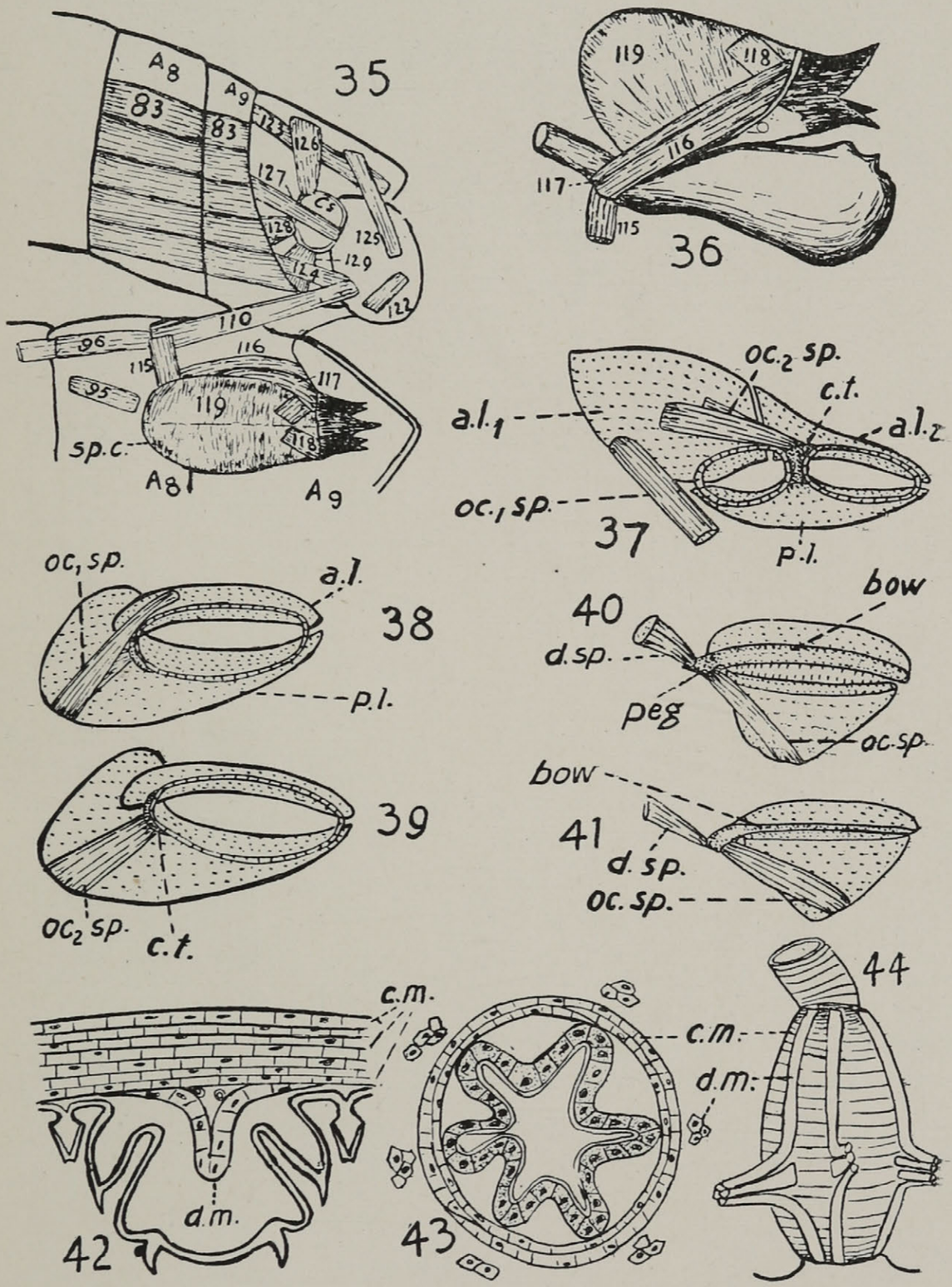
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118
sp.c.
A8
A9
36
119
118
116
117
115
37
oc.2 sp.
c.t.
a.l.1
a.l.2
oc.1 sp.
p.l.
38
oc.1 sp.
a.l.
p.l.
39
oc2 sp.
c.t.
40
bow
d.sp.
peg
oc.sp.
41
bow
d.sp.
oc.sp.
42
c.m.
d.m.
43
c.m.
d.m.
44

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