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THE MUSCULATURE OF THE LABRUM, LABIUM AND PHARYNGEAL
REGIONS OF ADULT AND IMMATURE COLEOPTERA

By
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Thesis submitted to the Faculty of the Graduate School
of the University of Maryland in partial
fulfillment of the requirements for the
degree of Doctor of Philosophy

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REGIONS OF ADULT AND IMMATURE COLEOPTERA

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	Page
Introduction	1
I. General discussion of the musculature	3
II. Muscle arrangement in Coleoptera	11
III. Caraboidea	11
Carabidae	11
Cicindelidae	11
Dytiscidae	11
IV. Gyrinoidea	13
Gyrinidae	13
V. Staphylinoidea	13
Silphidae	13
Staphylinidae	13
VI. Hydrophiloidea	15
Hydrophilidae	15
VII. Cucujoidea	16
Tenebrionidae	16
Coccinellidae	16
VIII. Byrrhoidea	18
Byrrhidae	18

	Page
IX. Dascilloidea	18
Nosodendridae	18
Heteroceridae	18
X. Dryopoidea	19
Dryopidae	19
Ptilodactylidae	19
XI. Cantharoidea	20
Cantharidae	20
Lycidae	20
Lampyridae	21
XII. Elateroidea	21
Elateridae	21
Buprestidae	21
Cebrionidae	22
XIII. Scaraboidea	23
Scarabaeidae	23
Lucanidae	23
XIV. Cleroidea	25
Dermestidae	25
Cleridae	25
Ostomatidae	25
XV. Meloidea	26
Meloidae	26
XVI. Mordelloidea	27
Mordellidae	27
XVII. Cerambycoidea	28
Cerambycidae	28
Cerambycinae	28
Prioninae	28

	Page
XVIII. Bostrichoidea	29
XIX. Bostrichidae	29
XX. Chrysomeloidea	30
Chrysomelidae	30
Donaciidae	30
Galerucidae	30
XX. Platystomoidea	31
Platystomidae	31
XXI. Curculionidae	32
Curculionidae	32
Scolytidae	33
Brentidae	33
XXII. Lymexyloidea	34
Lymexylidae	34
XXIII. Summary	35
XXIV. Literature consulted	40

Abbreviations used on the figures

Explanation of the plates

INTRODUCTION

This is a comparative study of the muscle arrangement in certain regions of the insect head and stomodaeum. A preliminary study was made in Orthoptera, Dermaptera, Hymenoptera and Neuroptera (adults and larvae), and this was followed by a similar, but more inclusive study of representatives of adult and immature stages of the order Coleoptera.

Several species of orthopteroid insects were dissected to determine the muscular arrangement in the generalized form of insect. The other orders are included in this work to observe similarities with and variations from the generalized type of muscle systems in Orthoptera, of which Periplaneta americana L. is chosen as the generalized form.

In order to observe carefully the places of origin and insertion of the labral, labial, hypopharyngeal and pharyngeal muscles, it is necessary to remove the maxillae, mandibles and the corresponding muscles. The maxillary, mandibular and antennal muscles are not included in this study.

This particular work evolved from an interest as to how chewing insects actually accomplish the feat of getting the food into the true mouth, which, of course, is located in the posterior region of the cibarium. Much is known as to how these insects procure and chew their food, but the hypopharynx, though tongue-like in position, could not be very efficient in accomplishing that which the vertebrate tongue does. In many insects the hypopharynx, for all practical purposes, can be considered to be absent; these insects also ingest food and thrive, so the hypopharynx alone can not be responsible for the act of placing the food in the mouth, from which point it can be swallowed.

It is hoped that the facts of the arrangement of muscles and certain anatomical observations herein presented will contribute to a better understanding of the means of ingestion of food by insects. Another object in this study was to homologize muscles in the several orders and in families in Coleoptera.

It is difficult, and often impossible, to identify corresponding muscles on a functional basis. A muscle, for example, as found in one species is an adductor, while its homologue in another species is a retractor because of a slight change in the position of the point of insertion. For this reason, the general application of functional names to muscles is limited; a careful study of each species individually is necessary to ascertain muscle functions.

The Leng system of classification, as modified by Boving and Craighead (1930), has been followed. A genus was chosen for specific study from one family of each series selected. When possible, the immature stage of the same genus was used. The species of Coleoptera included in this study are not considered as representative, necessarily, of their respective families.

This work is presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School, Entomology Department, University of Maryland. The study was carried on under the direct supervision of R. E. Snodgrass of the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, in his capacity as Lecturer and consultant of the Entomology Department of the University of Maryland.

The writer is sincerely grateful to R. E. Snodgrass for his guidance and encouragement throughout this entire study, and also to Dr. Ernest N. Cory, Head of the Entomology Department, University of Maryland, for his helpful criticisms. The help of the U. S. National Museum is appreciated for the loan of certain immature stages of Coleoptera for study, and also the kindness of several specialists in the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for their invaluable assistance in the identification of certain insects.

1. GENERAL DISCUSSION OF THE MUSCULATURE

Among the orthopteroid insects there is apparently, with minor variations, a general plan of muscle arrangement. The American cockroach, Periplaneta americana L., has been selected as a representative of Orthoptera exhibiting the generalized plan of musculature. The muscles included in this consideration are numbered for convenience of study, and their homologies in other species and orders have been studied.

These muscles are considered as occurring in definite pairs unless indicated as otherwise. The muscles in the dorsal region of the head inserted on the stomodaeum posterior to the paired nerve (frontal connective), which connects the frontal ganglion with the brain, are considered as belonging properly to the frons; those muscles that are anterior to this nerve belong to the clypeal region proper.

1. Compressor muscle of the labrum (fig. 1).—An asymmetrical muscle which arises in the posterior region of the dorsal wall of the labrum, inserted along the lateral margin of the ventral wall of the labrum.

2. Dilator muscle group of the labrum (fig. 1).--A transverse band of fibers arising on the inner surface on one side of the ventral wall of the labrum, and extending transversely to be attached on the opposite side.

3. Ventral (posterior) muscle of the labrum (fig. 2).--Arises in the posterior region of the frons adjacent to the inner margin of the antennal rim and is inserted laterally at the base of the labrum on the torus.

4. Dorsal (anterior) muscle of the labrum. (fig. 2).--Arises rather centrally in the posterior region of the frons and is inserted centrally on the posterior, dorsal margin of the labrum.

5, 6 and 7. Dorsal dilator muscles of the cibarium (fig. 2).--Arise in the clypeal region slightly laterally, and, with the exception of muscle 7, are inserted in the anterior region of the dorsal wall of the cibarium. Muscle 7 is inserted on the dorsal wall of the cibarium, mid-region, between the transverse muscles of this area.

8. Dorsal dilator muscle of the cibarium (fig. 1).--Arises centrally in the anterior clypeal region; it surrounds muscle 4 and extends ventrad to become inserted in the anterior region of the dorsal surface of the cibarium. This muscle was found only in Periplaneta americana L.

9. Dorsal dilator muscle of the anterior region of the pharynx (fig. 1).--Arises on the frons anterior to muscle 11 and is inserted on the dorsal wall of the pharynx immediately behind the frontal ganglion connective.

10. Muscle of hypopharyngeal bar Y (fig. 2, 10).--A branched muscle: branch (a) arises on the frons immediately laterad of muscle 11; branch (b) arises laterally in the anterior region of the frons. Both

branches are inserted on the dorsal end of sclerotized bar Y, branch (b) laterally.--(fig. 1).

11. Dorsal dilator muscle of the pharynx (fig. 2).--Arises on the frons immediately laterad of muscle 4 and is inserted slightly laterally on the dorsal wall of the pharynx.

12. Compressor muscle group of the cibarium (fig. 2).--Arise on one side of the dorsal wall of the cibarium, central region, and extend transversely across the surface to be attached on the opposite side.

13. Compressor muscles of the anterior region of the cibarium (fig. 1).--Arise laterally on the dorsal wall of the cibarium in the anterior region of muscle group 12; they extend diagonally anteriorly to become inserted on the dorsal surface of the cibarium mesad of muscle 5.

14. Hypopharyngeal muscle of the mandible (fig. 2).--Arises on the lateral wall of the mandible and is inserted on the distal end of sclerite X (fig. 2, X). This muscle was found only in Orthoptera; it is, of course, common in apterygote insects and lower arthropods.

15. Anterior dorsal dilator muscle of the salivarium (fig. 2).--Arises on sclerite X adjacent to muscle 16 and is inserted laterally on the ventral wall of the hypopharynx.

16. Dorsal salivary cup muscle (fig. 2).--Arises on the inner surface of sclerite X and is inserted, rather centrally, on the dorsal surface of the salivary cup.

17. Anterior salivary cup muscle (fig. 2).--Arises laterally on the ventral wall of the labium adjacent to the palpal base and is inserted laterally in the anterior region of the salivary cup anterior to muscle 18.

18. Latero-ventral salivary cup muscle (fig. 2).--Arises laterally at the base of the prementum near the dorsal surface and is inserted laterally in the anterior region of the salivary cup.

19. Muscle of the hypopharynx (fig. 2).--Arises on the tentorial bridge immediately dorsad of muscle 20 and is inserted laterally at the base of the hypopharynx.

20. Dorsal (anterior) muscle of the labium (fig. 2).--Arises on the tentorial bridge immediately dorsad of muscle 21 and is inserted laterally in the anterior region of the dorsal wall of the labium.

21. Ventral (posterior) muscle of the labium (fig. 2).--Arises laterally on the tentorial bridge at the posterior end of the anterior tentorial arm and is inserted laterally at the base of the prementum.

22. Muscle of the prementum (fig. 3).--Arises centrally in the posterior region of the submentum and is inserted slightly laterally at the base of the prementum.

23. Depressor muscle of the labial palpi (fig. 3).--Arises centrally on the dorsal wall of the labium, at the base of the glossa and is inserted on the dorsal base of the palpus.

24. Levator muscle of the labial palpi (fig. 3).--Arises laterally at the base of the prementum and is inserted posteriorly on the base of the labial palpus.

25. Muscle of the labial palpus (fig. 3).--Arises laterally on prementum, inserted basally and somewhat dorsally on second palpal segment.

26. Muscle of the labial palpus (fig. 3).--Arises in middle region of ventral (posterior) wall of first palpal segment, inserted ventrally (posteriorly) in middle region of the base of third segment.

27. Muscle of the labial palpus (fig. 3).--Arises anteriorly at base of the first palpal segment, inserted on the third segment basally on the anterior margin.

28. Flexor muscle of the glossa (fig. 3).--Arises centrally at the base of the prementum and is inserted on the ventral wall of the labium at the base of the glossa.

29. Flexor muscle of the paraglossa (fig. 3).--Arises on the ventral wall of the labium at the base of the paraglossa.

30. Ventral dilator muscle of the pharynx (fig. 2).--Arises on the tentorium, inserted centrally on the pharyngeal region immediately ventrad of the cibarium.

31. Lateral dilator muscles of the pharynx (fig. 2).--Arise laterally on dorsal head region adjacent to inner margin of compound eye posterior to muscle 10A, inserted laterally on the pharynx ventrad to muscle 11.

32. Dorsal appressor muscle group of the cibarium (fig. 1).--Arise on dorsal pharyngeal surface posterior to frontal ganglion and extend anteriorly beneath muscle 12 to be inserted on dorsal wall of the cibarium adjacent anterior limits of muscle 12. These muscles are found in a well developed state in the forms included in this work only in Orthoptera, Dermaptera and Neuroptera.

Two other Orthoptera were studied, the cricket, Gryllus assimilis Fab., and the grasshopper, Melanoplus differentialis (Thos.). In the latter, there were no essential changes in the musculature. In Gryllus, the muscle arrangement is practically the same as that found in Periplaneta except for a few minor variations; muscle 2 is absent, muscle 3 is branched, and muscle 10 is not branched.

As a representative of Dermaptera, Anisolabis maritima Gene was chosen (fig. 5). Muscles 20, 21 and 22 are essentially the same as those in Periplaneta except that muscle 20 arises posterior to muscle 21. Muscle 19, instead of arising on the tentorial structure, as it does in the cockroach, arises centrally in the middle region of the mentum; this is an unusual origin for this muscle, as it usually arises at some point on the posterior tentorial structure. The insertion of this muscle does not vary, however. Muscles 28 and 23 are absent. The muscles of the labrum, cibarium and hypopharynx are similar to those of Periplaneta.

In Neuroptera, Corydalus cornutus L. adult and larval stages were studied. In the adult form (fig. 9), the salivary muscles are similar to those of Periplaneta; however, muscle 15 is absent. The full complement of labial muscles is present. Muscle 19 arises laterally in the posterior region of the gula and is inserted at the base of the hypopharynx, but not on the sides of the salivary cup as is the case in Periplaneta. In addition to the usual compressor muscle of the labrum there is another muscle which arises immediately posterior to muscle 1 and is inserted in the anterior region of the cibarium on the dorsal wall; this is probably only a division of muscle 1. Muscles 3 and 4 of the labrum are of the general form and arrangement. Muscle 5 is represented by a single pair of muscles; while muscle 6 consists of two pairs. Muscle 7 also is made up of two groups of muscles on each side of the dorsum of the cibarium. Muscle 29 is an additional dorsal dilator muscle of the cibarium, which arises laterally in the posterior region of the Clypeal area; this muscle is not present in Periplaneta. Muscle 9 arises laterad of muscle 10 instead of mesad which is the usual way.

In the larval stage of Corydalis cornutus L. (figs. 10, 11, 12), the muscles vary little from those of the adult, with a few exceptions and variations. Of the salivary muscles, muscle 17 is absent. Muscles 6 and 7 are represented by only a single pair of muscle groups. The ventral wall of the cibarium is furnished with well developed transverse, longitudinal and diagonal muscle groups (figs 12, 33). These muscles were observed only in Neuroptera.

In Hymenoptera, Sphecius speciosus (Dru.) adults were selected for study (figs. 13, 14, 15, 16). This species possesses muscles which are massive and somewhat complicated in arrangement. It is not easy to homologize these muscles with those of Periplaneta; however, certain of them can be considered homologous. Muscle 27 arises basally on the ventral wall of the prementum and is inserted on the ventral wall of the prementum at the base of the paraglossa. There is only one labial palpal muscle present, 24, and it is similar to that found in Periplaneta. The salivary cup muscles consist of muscle 16, which arises on the inner surface of sclerite X and is inserted laterally on the salivary cup, and muscle 17 which arises immediately posterior to muscle 24 on the ventral wall of the prementum and is inserted laterally in the anterior region of the salivary cup. Muscle 19 arises in the posterior region of the head and is inserted in the posterior region of the salivary cup immediately ventrad and caudad of muscle 16. Muscle 21 takes its origin on the inner side of the base of the anterior tentorial arm and is inserted centrally at the base of the prementum. Muscle 20A arises on the anterior tentorial arm slightly above muscle 21 and is inserted on the base of the cardo proximally so it probably belongs to the maxilla and not to the labium. Muscle 3 of the labrum arises and is inserted in the

usual manner. The dorsal dilator muscles of the cibarium are powerful and specialized. Muscle 5 arises centrally in the anterior region of the dorsal wall of the cibarium; it probably corresponds to muscle 5 of Periplaneta. Muscle 6 arises laterally in the anterior region of the clypeus adjacent to the clypeal suture and is inserted laterally on the dorsal wall of the mid-region of the cibarium. Muscle 7 is posterior to muscle 6 in origin and insertion. Muscle 12 is similar to that of Periplaneta. Muscle 35 arises centrally on the dorsal surface of the modified bar Y and extends slightly diagonally, anteriorly to become inserted on the dorsal wall of the cibarium, anterior region. These are compressor muscles of this region and may be homologous with muscle 13 in the cockroach. The two modified sclerites, bars Y, support the sides of the cibarium and stomodaeum; they are united by a continuous sclerotized area which strengthens the wall of the stomodaeum. A muscle is inserted laterally on the distal end of the bar Y; this muscle extends laterally and anteriorly to its point of origin in the posterior region of the frons adjacent to the inner margin of the compound eye. Muscle 11 consists of a compact group of fibers and probably is a homologue of muscle 11 in orthopteroid forms. Muscle 30 is especially large and powerful; it arises on a sclerotized central projection from the anterior (dorsal) surface of the tentorial bridge by means of a tendon; it is inserted centrally on the ventral surface of the continuous sclerotized area which supports the stomodaeum. This is a dilator muscle of the stomodaeum. It was thought upon first examination, that muscle 36 was homologous with muscle 10 of Periplaneta; this, however, is not the case because the small frontal ganglion, with its connectives, lies

posterior to this muscle, the function of which is not certain. In the honeybee, Apis mellifica L., there is a muscle, 10, which undoubtedly is homologous with that found in Periplaneta; it consists of an anterior and a posterior branch inserted on the distal end of bar Y, which is posterior to the frontal connective nerve.

II. MUSCLE ARRANGEMENT IN COLEOPTERA

The muscles in the adult and immature Coleoptera, included in this work are numbered as in Periplaneta americana L. and are considered as homologous with those of the same designation in the orthopteroid forms unless they are indicated as being otherwise.

Certain muscles appear generally and consistently throughout the adult and immature stages in the order; however, there are specialized muscles found in certain species, and also generalized muscles which are greatly modified in size, shape, origin and insertion. By considering the muscles of each series separately, it is easier to interpret homologies and the probable function of the various muscles.

III. CARABOIDEA

In this series, adult Harpalus caliginosus F., Carabidae (figs. 17, 18, 19), Tetracha carolina (L.), Cicindelidae and Laccophilus sp., Dytiscidae were selected for study. The labral muscles are absent in the three genera studied. In Harpalus, the muscles of the cibarium, and dorsal and lateral pharyngeal regions are similar to those found in Periplaneta americana L. Bar Y is attached to a sub-pharyngeal brace. Muscle 31 is not considered, necessarily, as a homologue of 31 in Periplaneta or in any of the species of Coleoptera since it varies greatly in size, form and position; the function, however, of dilating the

pharyngeal walls is the same, so for convenience, it will be referred to by this number. The place of origin of the labial and hypopharyngeal muscles is unusual; in the anterior region of the gula, caudad of the posterior tentorial pits, there is a central invagination or apodeme (fig. 18, PTN), which is fin-like and of considerable size, on which muscles 19, 20 and 37 arise and not on the tentorial structure as is the usual manner. Muscle 20 is inserted centrally on a projection which extends inward from the ventral labial wall in the basal region; it possibly does the same work as 20 in Periplaneta. Muscle 36 was found only in this species; it probably in some way supplements the action of the other labial muscles.

In Tetracha, only muscles 20, 21 and 22 are present and they arise centrally in the posterior gula region. Muscles 5, 6 and 7 are similar to those of Harpalus. Muscle 12 is more strongly developed. Muscle 11 is a very powerful one. The tormae of the labrum extend posteriorly and then bend sharply ventrad to form a rigid, lateral support on each side of the mouth; this rigid brace is continuous with the ventral head structure. Bar Y projects from the posterior, dorsal region of this tormae modification, and muscle 10 is inserted on the distal end.

In Laccophilus, muscle 21 originates in the posterior gular area. Muscle 19 is single, broad and thin, and arises by means of a bifurcate tendon high on each anterior tentorial arm. Muscle group 12 is well developed. Muscles 5, 6 and 7 are essentially the same as those in Harpalus.

For the larval forms in this series, Amara sp. and Galerita sp. were studied. In Amara (figs. 20, 21, 22), muscle 24 is strong and 20 and 21 are large. Muscles 5, 6 and 7 are well developed. The pharynx is small; muscle 11 is absent. Bar Y extends posteriorly along the

sides of the cibarium and is connected with the one on the opposite side by a long, subpharyngeal sclerotized area. In Galerita, muscles 20 and 21 are similar to those in Amara. The dorsal dilator muscles of the cibarium, 5, 6 and 7, are grouped together to form a massive unit of muscle fibers. Muscle 10 is similar to that of Amara.

IV. GYRINOIDEA

The adults studied in this series are Dineutes discolor Aube' and D. vittatus (Germ.). In D. discolor (figs. 23, 24, 25), the labral muscles are absent. Muscles 5, 6, 7, 9, 10 and 12 are similar to those in Harpalus. Muscle 11 is absent. Bar Y is also continuous with a subpharyngeal support. There is an apodeme originating in the anterior gular region essentially the same as the one in Harpalus; however, only muscles 20 and 21 arise on this. Muscle 19 arises by means of a T-shaped tendon, the lateral arms of which originate on the walls of the gular suture. The musculature of D. vittatus is practically the same as that in discolor.

The larvae used for study are Dineutes sp. (figs. 26, 27, 28). Muscles 5, 6, 7 and 10 are similar to those of Amara sp.; however, they are proportionately much more massive. Muscle 11 is present and muscle 12 is either absent or so poorly developed that it is not noticeable. The labial muscles are essentially the same as those of Amara, with some variation as to shape. Muscle 22 is present in Dineutes.

V. STAPHYLINOIDEA

The adults studied in this series are Silpha americana L., Silphidae (figs. 29, 30, 31) and Creophilus villosus Crav. In Silpha, the labral muscles appear; muscles 1 and 3, the latter being inserted on the labrum by means of a long, thin tendon. The dorsal dilator muscles

of the cibarium, 5, 6, 7 and 12, and those of the pharynx, 9, 11 and 10 of the hypopharynx, are massive and undoubtedly furnish the power for a strong and efficient sucking mechanism. The musculature of the labium is essentially the same as that found in Periplaneta, excepting, of course, the salivary muscles which are not found in Coleoptera; muscles 19, 20, 21, 22 and 24 are present. The preoral cavity is provided with a sizeable, narrow lobe which extends downward from the cibarial wall and also with a sub-oral grooved shelf which originates in the posterior, dorsal region of the labium and which receives the cibarial lobe in somewhat of a semi-piston and cylinder relationship, possibly to facilitate sucking operations.

In Creophilus, the labial muscles are the same in number and arrangement as in Silpha; they, however, arise slightly more posteriorly on the lateral gular sutures. The labral muscles are similar also except that 3 arises on the anterior surface of the distal end of the anterior tentorial arm at the junction of the arm and the head wall. The muscles of the cibarial and pharyngeal regions are practically the same as those found in Silpha.

Silpha americana L., Silphidae, (figs. 32, 33, 34) and a specimen of the Staphylinae of the Staphylinidae are the two larval forms used for study. The muscles in Silpha are very well developed. Muscle 1 is absent; muscle 3 is strong. Muscles 5, 6 and 7 have become grouped together in a large mass. Muscle 12 is strong as are 9, 11 and 10, which is multi-branched. Muscle 37 is an additional dorsal dilator muscle of the pharynx which possibly belongs to the muscle 11 group. The labium is, of course, a good example of the prementum with two divisions, 1 and 2. Muscles 19, 20, 21 and 22 are all present, well

developed, and take their origin on the tentorial structure (figs. 33, 34). In the specimen of Staphylinae muscle 22 is inserted on the prementum at the base in the same plane as 20 and 21. The prementum is not divided into two parts as in Silpha. The cibarial, pharyngeal, and hypopharyngeal muscles are much the same as those of Silpha, with a few variations. The labral muscles are absent; however, a tendon arises on the anterior tentorial arm, dorsal region, and extends anteriorly to be inserted basally and laterally on the nasale very similar to the manner of muscle 3 in the adult Creophilus villosus Grav.

VI. HYDROPHILOIDEA

Sphaeridium scaraboides Linn. (figs. 35-37) Hydrophilidae is the adult species which was studied. The muscles, though well developed, are reduced in number. Muscle 1 possibly corresponds with 1 in Periplaneta; however, the insertion has become changed from the ventral wall of the labrum to a sclerotized, mesal extension of the torma, which is continuous with the dorsal wall of the anterior region of the cibarium. Muscle 3 arises on the distal end of the dorsal branch of the anterior tentorial arm and is inserted in the usual way. The dorsal dilator muscles of the cibarium, 5, 6 and 7, are absent. The anterior tentorial arms are joined together by a suboesophageal brace; there is a lateral dilator muscle of the pharynx which arises on this brace. Muscles 20 and 21 both take their origin in the anterior area of the postmental region.

Sphaeridium bipustulatum Fabr. (figs. 38-40), and Hydrous triangularis (Say) are the larvae which were studied from the family Hydrophilidae. In Sphaeridium, the labral muscles are absent; muscle 6 is long and 7 forms a compact linear group. Muscles 9, 10 and 11 are well developed. Bar Y is continuous with the subpharyngeal sclerotized area. Muscle

39 arises laterally from the posterior region of this area and is inserted at the base of the maxilla as are muscles 40 and 41, which, however, arise on a median apodeme in the posterior gular region. There is a small labial muscle, probably 21, which arises at the base of the postmentum adjacent to posterior tentorial pits and is inserted centrally and basally on the prementum.

In Hydrous, there are five pairs of powerful muscles which arise on the true anterior tentorial arm and are inserted at the base of the maxilla. There is a muscle present, which probably is 21, and another inserted on the dorsal region of the labrum which may be 20. Muscles 6, 7, 9, 10, 11 and 12 are similar to those in Sphaeridium; they are, however, much more massive. The ventral muscles of the pharynx are large and complicated in arrangement.

VII. CUCUJOIDEA

In this series, Scotobates calcaratus (Fab.), Tenebrionidae and Epilachna corrupta Muls., Coccinellidae adults were used for study. In Scotobates (figs. 41-43) the labral, cibarial, pharyngeal and hypopharyngeal muscles are present and well developed. Bar Y is connected with the anterior, distal edge of the anterior tentorial arm by means of a flat, sclerotized band. Muscle 21 may be homologous with that of Periplaneta, however, the origin is in the anterior region of the postmentum and not on the tentorium. Muscle 20 arises in the usual manner, but it is inserted centrally on the inner side of the anterior labial wall; this also could easily be interpreted as being muscle 19.

In Epilachna, there is only one labial muscle; it corresponds with 21 in Scotobates. The muscles of the labrum, cibarium and pharynx

are essentially the same as those in Scotobates, with a slight variation in arrangement. Muscle 10 lies laterad of 3; 9 and 11 are very powerful.

In Hippodamia convergens Guer., the musculature is practically the same as in Epilachna. Muscle 12 is very well developed.

Scotobates calcaratus (Fab.), Tenebrionidae, Hippodamia convergens Guer., Coccinellidae, and Synchroa puncta Newm. larvae were studied. In Scotobates (figs. 44-46), the muscles are well developed; 1, 12 and 11 are absent; and 5, 6 and 7 have become grouped together. Muscle 10 has numerous subdivisions. There is a large heavily sclerotized, median, cuspidate sclerite on the dorsal surface of the hypopharynx. An arm extends posteriorly and ventrally from each side of the posterior region of this sclerite to become joined to a heavily sclerotized intralabial brace, the lateral limits of which are the sides of the posterior hypopharyngeal region. Muscle 21 arises and is inserted in the usual manner; 20, however, arises in the posterior, lateral region of the submentum just anterior to the posterior end of the anterior tentorial arm, and 22 is a broad, powerful muscle.

In Hippodamia, there is only one pair of labial muscles, 21. Muscle 3 is absent; the tormae are slender and rod-like and extend posteriorly to become united with bar Y. Muscles 9 and 11 are especially powerful.

In Synchroa, the musculature is similar to that of Scotobates; however, muscle 12 is present and 10 is not branched so much.

VIII. BYRRHOIDEA

Only larval forms were available for study in the family Byrrhidae, Byrrhus sp. In Byrrhus (figs. 47-49), the labral muscles are absent. Muscles 5, 6 and 7 are reduced in size and are grouped together. Muscle 9 is small; however, muscle 10 consists of two large branches. The labial muscles are somewhat confusing; muscles 20 and 21 correspond with those of the generalized plan, and considering the prementum as being divided into two parts, muscle 22 is consistent. Muscle 22A is to be accounted for; it could be a second muscle of the prementum inserted at the base of prementum 1; 22 arises on the tentorial bridge and not on the postmentum as it does in the generalized form.

IX. DASCILLOIDEA

From this series, adult and immature stages of Nosodendron californicum Horn, Nosodendridae, and Heterocerus sp., Heteroceridae larvae were studied. In the adult Nosodendron (figs. 50-52), of the labral muscles, only 3 is present. The other cibarial, pharyngeal and hypopharyngeal muscles are well developed. Muscle 10 is especially massive. Bar Y is somewhat modified; it forms a strong, lateral support to the mouth and is continuous with a broad, thin, sclerotized structure which extends ventrally and posteriorly to become united with the ventral head wall. Of the labial muscles, 20 and 21 are present; the latter being large; both arise in the gular area posterior to the submentum; the mentum completely covers the prementum in this species.

In the larval Nosodendron (figs. 53-55), the labral muscles are absent, as is also 12. Muscles 6, 7, 9, 10 and 11 are all massive and are collected, more or less, in the region of the posterior area of

the cibarium. Bar Y is large and forms a strong support on the sides of the mouth opening and extends ventrally on the sides of the posterior hypopharyngeal region. The full complement of labial muscles is present.

In Heterocerus, the labral, cibarial, pharyngeal and hypopharyngeal muscles are similar to those of Nosodendron; 10 is trifurcate. Muscle 20 arises at the posterior end of the anterior tentorial arms and is inserted on the dorsal wall of the labium, at what is probably the base of the hypopharynx. Muscle 20 arises centrally in the posterior region of the postmentum, and is inserted centrally at the base of prementum 1. Muscle 22 originates on a transverse bar that connects the anterior tentorial arms and is inserted laterally in the posterior region of prementum 2.

X. DRYOPOIDEA

Helichus fastigiatus (Say), Dryopidae (figs. 56-68) is the adult form selected for study from this series. The musculature, in this species, is of the generalized plan, with some modification. Muscle 12 is absent as are 9 and 5. Bar Y is very weakly sclerotized. The labial muscles consist of two pairs, 20 and 21.

The larvae considered from the family Ptilodactylidae are Ptilodactyla serricollis (Say), (figs. 56-61). Of the labral, pharyngeal and hypopharyngeal muscles only 3, 6, 7 and 10 are present, but they are strong. The labial muscles consist of 21, which arises on the base of the submentum between the posterior ends of the anterior tentorial arms, and of 20, which originates centrally at the inner base of the anterior tentorial arms.

XI. CANTHAROIDEA

Adults from two families in this series were studied, Chauliognathus pennsylvanicus DeG., Cantharidae and Plateros timidus Lec., Lycidae.

In Chauliognathus (figs. 62-64), the muscles are very well developed; those of the labrum, cibarium, pharynx and hypopharynx are massive. Muscle 1 is large and powerful, as are 5, 6, 7, 9, 10 and 11. The transverse group 12 is absent. Bar Y is continuous with the greatly modified tentorial structure which forms a strong support to withstand the action of the powerful muscles of this region; it unites the dorsal and ventral head walls rigidly. One side of the structure is joined with the other by means of a subpharyngeal sclerotized area; the posterior (ventral) ends are continuous with the ventral head wall. The epipharyngeal region of the labrum and the posterior, dorsal, labial region are equipped with a lobe and a grooved receptacle respectively, similar to that already described in the adult Silpha americana L., but in Chauliognathus it is more definitely associated with the epipharyngeal area. The labial muscles are much the same as those of the generalized form and are not nearly so powerful, proportionately, as are those of the dorsal head regions. Each lateral, posterior margin of the labium is furnished with a slender, sclerotized, resilient bar which abuts against the anterior, external face of the rigid tentorial structure and probably assists the labium in returning to its normal resting position after contractions of the labial muscles have disturbed its position.

In Plateros, there is only one pair of labial muscles, 21; these arise on the posterior ends of the anterior tentorial arms and are inserted centrally on the base of the prementum. Muscle 24 is present.

The rigid tentorial structure which was found in Chauliognathus is absent in Plateros. The labral, cibarial, pharyngeal and hypopharyngeal muscles are all essentially the same as in Chauliognathus.

Chauliognathus pennsylvanicus DeG., Cantharidae and Photuris sp. Lampyridae are the larval forms studied.

In Chauliognathus (figs. 65-67), muscle 5 does the same work as 5 in the generalized form, so it is considered homologous, though it is greatly modified in origin and somewhat in its insertion. Muscles 6 and 7 form a compact, linear group as do those which make up 11. There is a heavy tentorial modification present, but it is less extensive than that of the adult; it is continuous with the subpharyngeal plate. Bar Y extends from the dorsal region of the structure. There is a heavily sclerotized, postoral, subpharyngeal support which joins the head on each side laterad of the mouth. The labial muscles are similar to those of the adult, and the posterior lateral sclerotized bar, which was described in the adult form, is also present in the larvae.

In Photuris sp., Lampyridae, the musculature is similar to that of Chauliognathus; the muscles, however, are less well developed.

XII. ELATEROIDEA

Neotrichophorus carolinensis (Schfr.), Elateridae and Chrysobothris femorata (Oliver), Buprestidae were the adult forms selected for study.

In Neotrichophorus (figs. 68-70), the full complement of labral muscles is present, 1, 3 and 4. Upon first examination it was thought that only 3 was present, however, it was later determined that 3 and 4 are so closely appressed as to appear as one. Muscle 4 is inserted laterally on the posterior, dorsal rim of the labrum; while 3 is inserted ventrally and laterally as is the usual manner. This is the only species in the order Coleoptera examined in this work, which exhibited any indi-

cation of an anterior (dorsal) labral muscle. Another elaterid adult, Monocrepidius nicholsi (Notman) was examined, but only 3 is present; this, however, is unique in taking its origin laterally in the anterior clypeal region (fig. 74, 3). This condition has been observed only in Monocrepidius nicholsi (Notman). The figures of the cibarial, pharyngeal, and hypopharyngeal muscles are self-explanatory. Bar Y more or less parallels the lateral margins of the cibarium and is joined to the bar on the opposite side by a subpharyngeal, supporting area on which rather strong, ventral dilator muscles, 30, of the pharynx, are inserted. The labial and hypopharyngeal muscles are of generalized form, though 21 is apparently absent unless 22 has been misinterpreted as 21, in which case, of course, 22 would be absent.

In Chrysobothris, the labial and palpal muscles are similar to those in Neotrichophorus, though 22 is absent. The labral muscles are also similar, excepting that 4 is absent; 3 arises in the mid-frontal region on the inner (mesal) surface of the suture which separates the inner margin of the compound eye from the frons. The cibarial, pharyngeal, and hypopharyngeal muscles are essentially the same, but all are poorly developed.

Parallelostethus attenuatus (Say), (figs. 71-73), Alaus sp., Elateridae and Cebric antennatus Schfr., Cebrionidae are the larvae studied in this series.

In Parallelostethus, the labral muscles are absent. The cibarial, pharyngeal and hypopharyngeal muscles are powerful, but otherwise similar to the condition found in the adult Neotrichophorus as is also bar Y. The labial muscles, except for being long and thin, are of the generalized plan. The extra length is made possible by a posterior, spur-like extension of the anterior tentorial arm; muscles 20 and 21

arise on the inner surface on the posterior tip of this spur-like extension.

In the specimen of Alaus sp. studied, the musculature is essentially the same as that in Paralleostethus.

In the cembrionid larva, Cebrio, the muscles are found to be practically the same as those in the two elaterid larvae studied.

XIII. SCARABOIDEA

The adults of Popillia japonica Newman and Macroductylus sub-spinosus (Fab.), Scarabaeidae and Lucanus placidus Say, Lucanidae were selected for study in this series.

In Popillia (figs. 75-77), of the labral muscles, only 2 is present. The cibarial, pharyngeal and hypopharyngeal muscles are similar to those of the generalized plan except that 11 is absent. Muscle group 13 may or may not be homologous with 13 in Periplaneta; they are well developed, diagonal muscles inserted on the anterior dorsal wall of the cibarium and apparently have the same function. Muscle band 12 is wide, but not long and is confined to the posterior dorsal region of the cibarium. There is only one labial muscle, 38, present (figs. 43, 38); it is a single unit of fibers arising centrally in the middle region of the labium and extending slightly anteriorly and dorsally to become inserted centrally on the dorsal labial surface. The function, probably, is to assist in moving the hypopharyngeal region in some manner. Muscle 24 arises on an intralabral torus-like process extending mesad from the latero-ventral base of the labium; this structure extends in a hoop form dorsally and is joined to the process on the opposite side of the labium. The tendonous insertion end of one of the maxillary muscles enters the

intralabral region extending through the hoop-like structure, just mentioned, and becomes inserted on the maxilla, but it has no effect on the movement of the labium.

In Macroductylus, muscle 38 is absent; a muscle probably corresponding to 21 arises rather centrally in the anterior region of the postmentum and is inserted ventrally on the base of the prementum. The cibarial, pharyngeal and hypopharyngeal muscles are similar to those in Popillia, 13, however, is absent as is also 3.

In Lucanus, muscle 38 is absent; muscle 21 is similar to that in Macroductylus. Muscle 3 is absent. Muscle 10 is large and branched because of the fact that bar Y has a wide, thin, multi-branched, distal end, and 10, of course, is inserted on these distal branches. There is a muscle group which possibly is homologous with 13 in Popillia; however, these muscle fibers are arranged on the dorsal wall of the cibarium more longitudinally than diagonally which is the case in Popillia. The cibarial muscles are all rather slender; the oesophagus is small, considering the size of the insect.

Popillia japonica Newman and Cotinis nitida (L.), Scarabaeidae are the larvae studied in this series.

In Popillia (figs. 78-80), muscle 3 of the labrum is strong, and muscle 10 is massive. All the cibarial muscles are absent. The pharyngeal muscles 9 and the hypopharyngeal muscles 10 are present, but 9 is so weak as to be almost thread-like. Muscle group 12 is poorly developed. There is a large, heavily sclerotized, cuspidate sclerite on the dorsal surface, posterior region, of the labium. The labium is furnished with rather well developed muscles, 20, 21 and 22.

In Cotinis, the labial and labral muscles are similar to those in Popillia as is also muscle 10. There is one pair, probably 7, of weak muscles inserted on the dorsum of the cibarium just anterior to the frontal connective nerves. A weak pair of dorsal pharyngeal muscles, probably 9, are present.

XIV. CLEROIDEA

Dermestes caninus Germ., Dermestidae and Enoclerus spinolae Lec., Cleridae are the adults forms studied in this series.

In Dermestes (figs. 81-83), the labral, cibarial, pharyngeal and hypopharyngeal muscles are well developed. Muscles 1 and 5 are absent and 10 is branched, as in the generalized form. Bar Y is rather heavy and is continuous ventrally with a sclerotized subpharyngeal rod which connects the bar Y of one side with that of the other. In the labium, a muscle is present which could be considered as either 22 or as 21; it arises centrally in the anterior region of the submentum and is inserted centrally on the base of the prementum. The muscle 20 in the figure may, in reality, be homologous with 19; it is difficult to say; however, it arises on the inner surface of the posterior end of the anterior tentorial arm and is inserted centrally on the dorsal, labial wall in the anterior region, by means of a tendon.

In Enoclerus, the musculature is similar to that in Dermestes, with some variations, of course. There is one more pair of ventral muscles of the labium present.

For the larval stages, Dermestes caninus Germ., Dermestidae and Tenebriodes sp., Ostomatidae were chosen for study.

In Dermestes (figs. 84-86), the labial muscles are absent, as is also group 5, 11, and 12; the other cibarial, pharyngeal and hypopharyngeal muscles are present and well developed. 110 is massive and branched. Bar Y is heavily sclerotized and forms a rigid, lateral support to the dorsal, cibarial region and the mouth. As was the case in the adult Dermestes, the labial muscles are difficult to homologize with those of the generalized form; the selection of their numerical designations is influenced by their points of insertion.

In Tenebriodes sp., muscle 3 is present. The cibarial, pharyngeal, hypopharyngeal, and labial muscles are similar to those of Dermestes; however, muscle 21 arises on the tentorial structure and not on the submentum as is the case in Dermestes.

XV. MELOIDEA

Macrobasis immaculata (Say), Meloidea (figs. 87-89) is the adult studied in this series. The labral muscles, 1 and 3, are present and well developed. Muscles 5 and 11, of the cibarium and pharynx respectively, are absent, the others are strong. The proximal (ventral) region of bar Y supports the ventral pharyngeal wall and the sides of the mouth. In the labium, muscle 24 takes its origin in the intralabial sclerotized bar which terminates laterally in a broad, lateral, hypopharyngeal sclerite (fig. 88). Muscle 19 arises in the usual area and is inserted centrally on a short, apodeme process by means of a tendon.

The larva studied is Zonabris phalerata Pall. (figs. 90-92). The muscles are well developed in this species; 1 and 5 are absent. 20 arises in the posterior region of the submentum; 21 originates centrally in the anterior region. Bar Y is continuous with a long, sclerotized, subpharyngeal structure which joins the two bars together

in the posterior region of the ventral wall of the cibarium.

XVI. MORDELLOIDEA

Mordella quadripunctata (Say), Mordellidae (fig. 93-95) is the adult form used for study in this series. The muscles are all powerful and well developed. The cibarial, pharyngeal and hypopharyngeal muscles are of the generalized form. Bar Y is weakly sclerotized. Muscle 22 could be 21 with the origin moved anteriorly from the tentorial structure, rather than 22, though it is difficult to interpret a condition like this. 30 and 31 are present, the latter being very massive. There is a sclerotized, subpharyngeal rod which lies immediately under the mouth opening; it terminates laterally in the integument of the posterior, dorsal, hypopharyngeal area.

The larvae studied are of the same species as the adult (figs. 96-98). The musculature is well developed and unusual, as the figures clearly indicate. Muscles 3, 10 and 11 arise on a large, thin, sclerotized appodeme which extends ventrally from the center of the middle region of the frons. Muscle 3 is inserted on the distal end of a modified tormus which originates on the ventral, labral wall and extends laterally and dorsally. Muscles 6 and 7 are thin and very long; 10 is divided into three branches, and 11 originates on the ventral margin of the posterior region of this appodeme. The labial muscles do not require special comment as the figures are self-explanatory. There is a rigid, heavily sclerotized subpharyngeal, intralabial structure present. The cross-piece, which lies beneath the anterior region of the pharynx, terminates in the lateral, integumental wall of the posterior labial or hypopharyngeal region.

XVII. CERAMBYCOIDEA

The adults studied in this series are Cyllene robiniae (Forst.), Cerambycidae, Cerambycinae, and Prionus pocularis Dalm., Prioninae.

In Cyllene (figs. 99-101), the muscles are well developed and are of the generalized plan. Muscle 10 is especially massive. The dorsal wall of the cibarium is decidedly dome-shaped and appears to be able to accommodate the suboral lobe. Muscle 20 is inserted laterally on the prementum near the dorsal surface. In the posterior, lateral region of the subhypopharyngeal area, the integument of one side is joined with that of the opposite by a sclerotized intralabial rod. The anterior tentorial arm is broad, but thin. The suboral lobe is probably the hypopharynx; a muscle which is interpreted as being 19 is inserted centrally at its base.

In Prionus, muscle 1 is absent and 10 is branched, otherwise the labral, cibarial, pharyngeal and hypopharyngeal muscles are similar to those in Cyllene. The labial muscles are similar also, excepting that 22 apparently is absent and 21 is present since it arises on the tentorial structure.

In the larval Cyllene robiniae (Forst.), Cerambyciane (figs. 102-104), the muscles are powerful and in the dorsal head region are usually multi-branched or subdivided. The labral muscles are absent; muscles 5, 6 and 7 occur in groups, 10 consists of two main branches each of which is subdivided into several units. Muscle group 12 is strong; immediately beneath this group the dorsal wall of the posterior region of the cibarium and the anterior pharyngeal region invaginates to form a pouch, which when viewed laterally is somewhat obovate. This pouch or lobe extends down into the region of the mouth opening. There is

a median muscle beneath the muscle group 12 (fig. 103, 42), which arises centrally in the posterior region of the pouch and is inserted centrally in the anterior region of the same. Muscle 11 is inserted on the posterior, dorsal region of the pouch and 7 in the anterior, dorsal region. By the combined action of muscles 7, 11, 12 and 42, it would seem that the lobe, formed by the ventral wall of the pouch, could pull food into the mouth from the shelf-like hypopharynx which lies immediately anterior to it. In the ventral head region muscles 19, 20, 21, 30 and 31 are well developed, but conform closely enough to the generalized form so as not to warrant special mention.

XVIII. BOSTRICHODEA

Apatides fortis (Lec.), Bostrichidae, both adult and immature forms, are used for study in this series.

In the adult Apatides (figs. 105-107), the epipharynx is large, long and cone-like; muscle 1 is elongate and is inserted laterally near the tip of the epipharynx. The epipharynx is supported laterally by a slender sclerotized rod arising dorsally on a torma-like process which extends mesad from the side of the labrum, anterior to the base of the normal torma. Muscle 3 is inserted on the distal end of the torma which is more elongate than usual. The cibarial, pharyngeal and hypopharyngeal muscles are strong. 7 apparently has a branch, 7A, the point of origin of which has migrated anteriorly to the posterior surface of epistomal suture. The labial muscles are well developed; 21 could be 22, since it takes its origin laterally in the posterior region of the submentum.

The larval Apatides (figs. 108-110), exhibited the first labral compressor muscles, 1, observed in immature Coleoptera. Muscle 3 is inserted on the distal end of an elongate torma, 10 is branched and

30 and 31 are powerful as are also 3 and 10. In the labium 20 and 21 lie so close together that they appear to be one muscle. Muscle 43 is unusual; it was observed only in this instance. It arises laterally in the anterior region of the submentum and extends dorsally almost vertically to become inserted laterally at the base of the labium near the dorsal surface.

XIX. CHRYSOMELOIDEA

Leptinotarsa decemlineata (Say), Chrysomelidae, Donicia distincta Lec., Donaciidae and Galerucella xanthomelaena (Schr.), Galerucidae are the adult specimens studied in this series.

In Leptinotarsa (figs. 111-113), the muscles of the dorsal head region are well developed. Muscle 10 is branched, the anterior, 10A, arises laterally in the anterior frontal area on the posterior surface of the epistomal suture. The labial muscles are strong, especially 20. There is an unusual tendous structure, arising broadly, centrally and basally from the ventral labial wall, which extends anteriorly to be inserted centrally on the dorsal wall of the labium in the anterior region; it is definitely not muscular. A contraction of muscle 20 would pull on the labium at the point of insertion and this tendon, which joins the anterior dorsal labial surface with that of the posterior ventral, probably retracts the anterior labial area. There is a strongly sclerotized intralabial brace in the posterior region of the labium which terminates laterally in the integument.

In Donacia, muscle 1 is absent; the anterior branch, 10A, arises as it does in Leptinotarsa. The cibarial, pharyngeal, hypopharyngeal and labial muscles are apparently homologous with those found in Leptinotarsa.

For the larvae in this series, Leptinotarsa decemlineata (Say) and Typophorus viridicyaneus (Cr.), Chrysomelidae were selected for study.

In Leptinotarsa (figs. 114-116), the muscles are very well developed. Muscle 1 is present; the cibarial and pharyngeal muscles are long because of the space between the dorsal wall of the stomodaeum and the head; 10 is subdivided into many units. Muscle 30 is especially massive, 20, 21 and 22 are strong. 22 is inserted on the ventral wall of the labrum in an area in which the division of the prementum is indistinct; however, muscles 20 and 21 are inserted on the base of the prementum 1 so 22 is inserted on the base of the second division of the prementum even though the suture is indistinct.

In Typophorus, the musculature is similar to that of Leptinotarsa, except that muscle 1 is absent.

XX. PLATYSTOMOIDEA

Euparius marmoreus (Oliv.), Platystomidae, (figs. 117-119) is the adult form studied in this series. The labral muscles are absent; the cibarial, pharyngeal and hypopharyngeal muscles are not well developed. Bar Y is modified into a flat plate. There is a heavily sclerotized subpharyngeal rod that supports the ventral region of the mouth and also strengthens the posterior, lateral labial walls in which region the ends of the rod terminate. The labial muscles are well developed. 20 is an unusual muscle in this species; it arises laterally in the posterior gular area as a thickened, powerful group of muscle fibers which soon converge to become inserted on the end of a thin tendon, in the anterior gular region, which extends anteriorly and is inserted somewhat laterally in the dorsal region of the posterior, labial area.

In the larva of this species (figs. 120-122), muscle 3 of the labrum is present. Those muscles present are well developed; 10 is massive and 9 and 11, though usually present, are absent in this species. Bar Y is large; it supports the mouth opening laterally and is continuous with a heavily sclerotized, suboral lobe that is joined, on each side, by a heavily sclerotized bar which terminates in the integumental wall of the posterior, dorsal, lateral region of the labium. In the labium, 21 arises on the tentorium, at the base of the tentorial arm, and is inserted centrally on the base of the prementum; muscle 22 is interpreted as being divided into two branches, each arising laterally in the anterior region of the submentum and each being inserted laterally at the base of the prementum.

XXI. CURCULIONIDAE

From this series Pantomorus godmani (Crotch), Curculionidae and Dendrocton valens Lec., Scolytidae adults were selected for study.

In Pantomorus (figs. 123-125), the muscles are reduced in number and are poorly developed. The labial muscles are absent and, of the cibarial muscles, a row of weak muscles inserted through the transverse group 12 are present and since they do insert through 12 are all probably divisions of 7. Muscle 10 is weak also and bar Y has practically disappeared; it is very lightly sclerotized at any rate. There is a large, soft, suboral lobe that extends anteriorly into the cibarium in a tongue-like manner. The labium is furnished with only one pair of muscles which probably correspond with 22 in the generalized form.

In Dendroctonus, the musculature is similar to that of Pantomorus, with a few minor variations.

Pantomorus leucoloma Boh. and Listroderes obliquus Klug., Curculionidae and Eupsalis minuta Brury, Brentidae are the larval species studied.

In Pantomorus (figs. 126-128), muscles 3 and 10 are very well developed; the cibarial and pharyngeal muscles are rather weak. The pharyngeal muscles are probably homologous with 11; they are inserted dorsally on the wall of the pharynx posterior to the frontal connective. Bar Y is continuous with a broad, lateral and ventral sclerotized plate which passes beneath the anterior region of the pharynx to become joined with Y of the other side. From the posterior, dorsal margin of the labrum arises a median, flat, sclerotized posterior extension which is of a resilient nature. When muscle 3 is retracted the labrum is depressed and the sclerotized dorsal extension abuts against the posterior, inner surface of the epistomal suture. When muscle 3 is relaxed, the resiliency of the extended process pushes the labrum back into its normal position, thus doing the work of a dorsal muscle. There is a heavily sclerotized, intralabial rod present which terminates laterally on the posterior, lateral walls of the labium and which is joined to the dorsal labial wall adjacent to the mouth opening. The labial muscles conform with those of the generalized form in origin and insertion.

In Listroderes, the muscles are essentially the same as those in Pantomorus. The posterior, dorsal margin of the labrum is furnished with the median posterior extension also. Muscle 20 is inserted laterally on the labium on the dorsal surface.

In Dendroctonus, the musculature is similar to that of Pantomorus, with a few minor variations.

Pantomorus leucoloma Boh. and Listroderes obliquus Klug., Curculionidae and Eupsalis minuta Drury are the larval species studied.

In Pantomorus (Figs. 126-128), muscles 3 and 10 are very well developed; the cibarial and pharyngeal muscles are rather weak. The pharyngeal muscles are probably homologous with 11; they are inserted dorsally on the wall of the pharynx posterior to the frontal connective. Bar Y is continuous with a broad, lateral and ventral sclerotized plate which passes beneath the anterior region of the pharynx to become joined with Y of the other side. From the posterior, dorsal margin of the labrum arises a median, flat, sclerotized posterior extension which is of a resilient nature. When muscle 3 is retracted the labrum is depressed and the sclerotized dorsal extension abuts against the posterior, inner surface of the epistomal suture. When muscle 3 is relaxed, the resiliency of the extended process pushes the labrum back into its normal position, thus doing the work of a dorsal muscle. There is a heavily sclerotized, intralabial rod present which terminates laterally on the posterior, lateral walls of the labium and which is joined to the dorsal labial wall adjacent to the mouth opening. The labial muscles conform with those of the generalized form in origin and insertion.

In Listroderes, the muscles are essentially the same as those in Pantomorus. The posterior, dorsal margin of the labrum is furnished with the median posterior extension also. Muscle 20 is inserted laterally on the labium on the dorsal surface.

The muscles in Eupsalis are similar to those of Pantomorus. Muscle 20 is inserted as in the case of Listoderes. Muscle 9 is present.

XXII. LYMEXYLOIDEA

Hylecoetus lugubris Say, Lymexylidae, adults and larvae were selected for study in this series.

The muscles of the labrum in the adult (figs. 129-131), are represented only by number 3. The pharyngeal muscles 9 and 11 occur in groups of two. 10 lies between the two branches of 9. A small, longitudinal band of muscles occurs which may, or may not, be homologous with 13 of the general plan; they arise centrally, adjacent to the anterior margin of 12 and are inserted centrally and dorsally on the cibarium a short distance anterior to the origin. Bar Y is rather large and furnishes a strong support to the sides of the mouth and posterior, lateral cibarial region. Muscle 31 is long and powerful; the only labial muscle present is 22.

In the larvae of Hylecoetus (figs. 132-134) the labral muscles are absent; muscle 10 and its branch 10A are especially massive, while the cibarial and pharyngeal muscles are comparatively long and slender. Muscle 10A arises centrally, by means of a tendon, in the posterior region of the frons. The posterior, lateral, labial region is furnished with a heavily sclerotized intralabial brace, the ends of which terminate in the integumental wall; externally there is a heavily sclerotized U-shaped area, which extends over the dorsal surface of the posterior, labial region and is continuous laterally, with the ends of the intralabial brace. The labial muscles present an unusual plan

of arrangement. The prementum is elongate and possesses a small median sclerite in the anterior region. Muscle 22, which is short and very broad, arises centrally along the posterior margin of the tentorial bridge and is inserted along the base of the prementum. Muscle 21 arises centrally on the posterior margin of the tentorial bridge and is inserted rather centrally on the posterior edge of the median, premental sclerite. Muscle 20 arises laterally on the inner surface of the posterior end of the anterior tentorial arm and is inserted laterally in the anterior region of the median sclerite of the prementum.

XXIII. SUMMARY

A general plan of muscle arrangement can be recognized in orthopteroid insects, and the same plan is found in representatives of other orders. It is possible to discover apparent homologies among muscles on the basis of origin, insertion and probable function, though all these factors may vary considerably among the different species. There are certain muscles that are evidently homologous with those of the generalized plan, but because of some variation or modification in origin or insertion, it is difficult to identify them. On the other hand, some muscles are aberrant and cannot be reconciled with any plan.

Some unusual muscles and structures and relationships between muscles and skeletal parts were encountered in this study.

In Periplaneta americana L., Orthoptera, muscle 1 (fig. 2) is asymmetrical and 2 (fig. 2) and 8 (figs. 1, 1A) were observed only in this species.

The dilator muscle of the salivarium, 15 (fig. 1), occurs in Orthoptera, but is not found in Dermaptera, Hymenoptera or Neuroptera.

The hypopharyngeal muscle 19 in Anisolabis maritima Gene, Dermaptera (figs. 5-7) arises centrally in the midregion of the mentum and not on the tentorial structure as is the usual manner.

Muscle groups 33 (fig. 11) in Corydalus cornutus L., Neuroptera (larva), are especially well developed. In both the adults and larvae of this species, the prementum is divided into three sclerites.

Muscles 35 and 36 were observed only in Sphecius speciosus (Dru.), Hymenoptera, (adult). Muscle 10, of the generalized plan, is absent in this species; this is the only case in which this condition was observed.

In Harpalus caliginosus F., Carabidae, (adult), muscle 37 (fig. 19) is an additional labial muscle that is not found in the other insects included in this work. It is in this species, also, that the post-tentorial apodeme (fig. 19, PTN) occurs; all the labial muscles arise on this structure, as also does the hypopharyngeal muscle 19. A similar apodeme is found in Dineutes discolor Aube, Gyrinidae (adult), (fig. 23, PTN); muscle 19 does not originate on it, however.

The prementum is divided into two sclerites in the coleopterous larvae of: Silpha americana L., Silphidae; Byrrhus sp., Byrrhidae; Nosodendron californicum Horn, Nosodendridae; Hylecoetus lugubris Say, Lymexylidae and Leptinotarsa decimlineata (Say), Chrysomelidae. Muscle 22, of the prementum, occurs in all of these larvae.

Muscle 3 arises on the distal end of the anterior tentorial arm, in Sphaeridium scaraboides L., Hydrophilidae (adult)(fig. 37), instead of on the head wall as is the usual manner. In Sphaeridium bipustulatum Fabr., (larva)(fig. 39), muscle 39 arises on the posterior, lateral margin

of the subpharyngeal supporting area and is inserted on the base of the cardo; this muscle was not observed in other insects.

It was found that in Scotobates calcaratus (Fab.), Tenebrionidae (adult)(fig. 41, AT), the anterior tentorial arm is connected with bar Y by means of a thin, flat, sclerotized band.

A heavily sclerotized, intralabial brace or rod (fig. 46), which terminates laterally in the integument of the posterior, lateral, labial region, is to be found in Coleoptera in: Cyllene robiniae (Forst.), Cerambycidae, (adult); Macrobasis immaculata (Say), Meloidae, (adult); Leptinotarsa decimlineata (Say), Chrysomelidae, (adult); Scotobates calcaratus (Fabr.), Tenebrionidae, (larva); Mordella quadripunctata (Say), Mordellidae, (larva); Pantomorus leucoloma, Curculionidae, (larva); Hylecoetus lugubris Say, Lymexylidae, (larva).

In Nosodendron californicum Horn, Nosodendridae, (adults and larvae) (figs. 50-55), bar Y is greatly modified and enlarged (more so in the adult) and is continuous with the tentorial structure. In the adult, the mentum covers the prementum.

In Chauliognathus pennsylvanicus DeG., Cantharidae (adults and larvae) (figs. 62-67), the tentorial structure is greatly modified (more so in the adult); a sclerotized, resilient bar is present in the integument of the posterior lateral margin of the labium.

Only in Neotrichophorus carolinensis (Schfr.), Elateridae (adult) (figs. 68-70), of the Coleoptera studied, were both the dorsal (anterior) and ventral (posterior) muscles found to be present. Monocrepidius nicholsi (Notman) (adult), muscle 3 (fig. 74) arises laterally on the anterior region of the Clypeus; this is an unusual point of origin for this muscle. In the larval Parallelotethus attenuatus (Say) (figs. 71-73),

there is a posterior extension of the anterior tentorial arms which provides the points of origin for the long, labial muscles.

In Popillia japonica Newman, Scarabaeidae (adult) (figs. 75-77), the labial muscles are absent and muscle 38 is to be found only in this species.

The palpal muscle 24, in Macrobasis immaculata (Say), Meloidae (adult), arises on the intralabial brace.

In the larvae of Mordella quadripunctata (Say), Mordellidae (fig. 97), there is a thin apodeme that arises medianly in the posterior region of the frons and extends deeply into the head cavity; all the labral, cibarial and dorsal pharyngeal muscles arise on this apodeme, as also does muscle 10.

There is an unusual lobe which extends ventrally from the dorsal, cibarial wall into the mouth region of the larval Cyllene robiniae (Forst), Cerambycidae (figs. 102, 104); the lobe is furnished with muscle 42 and probably assists in some manner in ingestion.

The epipharynx is large and unusual in structure in the adult Apatides fortis (Lec.), Bostrichidae (fig. 106, EP). In the larva of this species, muscle 43 (fig. 108) is unusual in that it is not found in the other insects studied in this work.

In the adult chrysomelid, Leptinotarsa decimlineata (Say) (figs. 111, 112), branch 10A arises on the posterior surface of the epistomal suture. In this species, the ventral labial wall, posterior region, is connected with the anterior, dorsal wall by means of an intralabial, tendonous structure.

Muscle 20 in Euparius marmoreus (Oliv.), Platystomidae, (adult) (figs. 118, 119), arises laterally in the posterior region of the head, posterior to the tentorium and is inserted on the labium by means of a very long tendon.

In the larval Pantomorus leucoloma Boh., Curculionidae (figs. 126, 127), the resilient, median process which extends posteriorly from the dorsal labral margin abuts against the epistomal suture when muscle 3 is contracted and probably assists in returning the labrum to its resting position when 3 relaxes.

Further investigations are necessary to determine the nature of the complete act of the ingestion of food by insects. The facts presented in this paper indicate, however, that the cibarial, pharyngeal and hypopharyngeal muscles, which are powerfully developed in many species, play an important part in ingestion. The action of these muscles is undoubtedly supplemented by that of the labial muscles, to a varied degree, depending on the species.

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ABBREVIATIONS USED ON THE FIGURES

ANT, antenna

AT, anterior tentorial arm

AF, antennal fossa

CD, cardo

CIB, cibarium

CL, clypeus

CS, coronal suture

E, compound eye

EP, epipharynx

ES, epistomal suture

EC, frontal connective nerve

FGN, frontal ganglion

FR, frons

FS, frontal suture

GL, glossa

GU, gula

HY, hypopharynx

LB, labium

LBP, labial palpus

LIG, ligula

LM, labrum

M, true mouth opening

MD, mandible
MT, mentum
MX, maxilla
MP, maxillary palpus
NA, nasale
O, ocellus
OE, oesophagus
PGL, paraglossa
PH, pharynx
PMT, prementum
PSMT, postmentum
PT, posterior tentorial pits
PTN, posttentorial structure
SC, salivary cup
SD, salivary duct
SMT, submentum
ST, stomodaeum
T, torus
TB, tentorial bridge
TN, tentorium
Y, hypopharyngeal bar Y

EXPLANATION OF PLATES

Plate 1

1. Periplaneta americana L., Orthoptera, sagittal section of head slightly to the left of median plane.
- 1A. Same, diagrammatic detail of relation of muscle 8 to muscle 4.
2. Same, dorsal view of head with part of head wall removed to expose muscles.
3. Same, ventral view of labium and posterior head region with part of integument removed to expose muscles.
- 3A. Same, diagrammatic detail of relationship of muscles 25, 26 and 27 of labial palpus.

Plate 2

4. Anisolabis maritima Gene, Dermaptera, dorsal view of head with part of head wall removed to expose muscles.
5. Same, sagittal section of head slightly to the left of median plane.
6. Same, ventral view of head with part of integument removed to expose muscles.
7. Corydalis cornutus L., Neuroptera, (adult) dorsal view of part of head with integument removed to expose muscles.
8. Same, sagittal section of head slightly to the left of median plane.

- 9.. Same, ventral view of head with part of integument removed to expose muscles.

Plate 3

10. Corydalis cornutus L., Neuroptera, (larva) view of head with part of integument removed to expose muscles.
11. Same, ventral view of head with part of integument removed to expose muscles.
12. Same, sagittal view of head slightly to the left of median plane.
13. Sphacius speciosus (Dru.), Hymenoptera, (adult) lateral view of labium with part of intetument removed to expose muscles and also portion of anterior tentorial arm with points of muscle origin.
14. Same, sagittal section of anterior (dorsal) head region slightly to the left of median plane.
15. Same, dorsal view of anterior region of head with part of integument removed to expose muscles.
16. Same, ventral view of labium and tentorium with part of intetument removed to expose muscles.

Plate 4

17. Harpalus caliginosus F., Carabidae, (adult) dorsal view of head with part of integument removed to expose muscles.
18. Same, ventral view of labium with part of integument removed to expose muscles.
19. Same, sagittal section of head slightly to the left of median plane.

20. Amara sp., Carabidae, (larva) ventral view of labium with part of integument removed to expose muscles.
21. Same, dorsal view of head with part of integument removed to expose muscles.
22. Same, sagittal section slightly to the left of median plane.

Plate 5

23. Dineutes discolor Aube, Gyrinidae, (adult) sagittal section of head slightly to the left of median plane.
24. Same, dorsal view of head with part of integument removed to expose muscles.
25. Same, ventral view of labium with part of integument removed to expose muscles.
26. Dineutes sp., Gyrinidae, (larva) dorsal view of head with part of integument removed to expose muscles.
27. Same, ventral view of labium with part of integument removed to expose muscles.
28. Same, sagittal section of head slightly to the left of the median plane.

Plate 6

29. Silpha americana L., Silphidae, (adult) dorsal view of head with part of integument removed to expose muscles.
30. Same, ventral view of head with part of integument removed to expose muscles.
31. Same, sagittal section of head slightly to the left of median plane.

32. Silpha americana L., Silphidae (larva) dorsal view of head with part of integument removed to expose muscles.
33. Same, ventral view of labium with part of integument removed to expose muscles.
34. Same, sagittal section of head slightly to the left of median plane.

Plate 7

35. Sphaeridium scaraboides L., Hydrophilidae, (adult) dorsal view of head with part of integument removed to expose muscles.
36. Same, ventral view of head with part of integument removed to expose muscles.
37. Same, sagittal section of head slightly to the left of median plane.
38. Sphaeridium bipustulatum Fabr., Hydrophilidae (larva) dorsal view of head with part of integument removed to expose muscles.
39. Same, sagittal section of head slightly to the left of median plane.
40. Same, ventral view of labium with part of integument removed to expose muscles.
41. Scotobates calcaratus (Fab.), Tenebrionidae, (adult) modified sagittal section of head slightly to the left of median plane.

Plate 8

42. Scotobates calcaratus (Fab.), Tenebrionidae, (adult) ventral view of head with part of integument removed to expose muscles.
43. Same, dorsal view of head with part of integument removed to expose muscles.

44. Scotobates calcaratus (fab.), Tenebrionidae, (larva) dorsal view of head with part of integument removed to expose muscles.
45. Same, ventral view of anterior portion of head with part of integument removed to expose muscles.
46. Same, sagittal section of head slightly to the left of median plane.

Plate 9

47. Byrrhus sp., Byrrhidae, (larva) anterior portion of head with part of integument removed to expose muscles.
48. Same, sagittal section of head slightly to the left of median plane.
49. Same, ventral view of head with part of integument removed to expose muscles.
50. Nosodendron californicum Horn, Nosodendridae, (adult) ventral view of head with part of integument removed to expose muscles.
51. Same, dorsal view of head with part of integument removed to expose muscles.
52. Same, sagittal section of head slightly to the left of median plane.

Plate 10

53. Nosodendron californicum Horn, Nosodendridae (larva), dorsal view of head with part of integument removed to expose muscles.
54. Same, sagittal section of head slightly to the left of median plane.
55. Same, ventral view of head with part of integument removed to expose muscles.

56. Helichus fastigiatus (Say), Dryopidae (adult), dorsal view of head with part of integument removed to expose muscles.
57. Same, sagittal section of head slightly to the left of median plane.
58. Same, ventral view of head with part of integument removed to expose muscles.

Plate 11

59. Ptilodactyla serricollis (Say), Ptilodactylidae (larva), dorsal view of head with part of integument removed to expose muscles.
60. Same, ventral view of head with part of integument removed to expose muscles.
61. Same, sagittal section of head slightly to the left of the median plane.
62. Chauliognathus pennsylvanicus DeG., Cantharidae (adult), sagittal section of head slightly to the left of median plane.
63. Same, dorsal view of head with part of integument removed to expose muscles.
64. Same, ventral view of head with part of integument removed to expose muscles.

Plate 12

65. Chauliognathus pennsylvanicus DeG., Cantharidae (larva), dorsal view of head with part of integument removed to expose muscles.
66. Same, ventral view of head with part of integument removed to expose muscles.
67. Same, sagittal section of head slightly to the left of median plane.

68. Neotrichophorus carolinensis (Schfr.), Elateridae, (adult), sagittal section of head slightly to the left of median plane.
69. Same, ventral view of head with part of integument removed to expose muscles.
70. Same, dorsal view of head with part of integument removed to expose muscles.

Plate 13

71. Parallellostethus attenuatus (Say), Elateridae, (larva) dorsal view of head with part of integument removed to expose muscles.
72. Same, ventral view of head with part of integument removed to expose muscles.
73. Same, sagittal section of head slightly to the left of median plane.
74. Monocrepidius nicholsi (Notman), Elateridae, (adult) lateral view of labrum and clypeus with part of head wall removed to expose muscle.
75. Popillia japonica Newman, Scarabaeidae, (adult) dorsal view of head with part of integument removed to expose muscles.
76. Same, sagittal section of head slightly to the left of median plane.

Plate 14

77. Popillia japonica Newman, Scarabaeidae, (adult) ventral view of head with part of integument removed to expose muscles.
78. Popillia japonica Newman, Scarabaeidae, (larva) sagittal section of head slightly to the left of median plane.
79. Same, dorsal view of head with part of integument removed to expose muscles.

80. Same, ventral view of head with part of integument removed to expose muscles.
81. Dermestes caninus Germ., Dermestidae, (adult) sagittal section of head slightly to the left of median plane.
82. Same, dorsal view of head with part of integument removed to expose muscles.

Plate 15

83. Dermestes caninus Germ., Dermestidae, (adult), ventral view of head with part of integument removed to expose muscles.
84. Dermestes caninus Germ., Dermestidae, (larva), sagittal section of head slightly to the left of median plane.
85. Same, dorsal view of anterior portion of head with part of integument removed to expose muscles.
86. Same, ventral view of head with part of integument removed to expose muscles.
87. Macrobasis immaculata (Say), Meloidae, (adult), dorsal view of head with part of integument removed to expose muscle.
88. Same, sagittal section of head slightly to the left of median plane.

Plate 16

89. Macrobasis immaculata (Say), Meloidae, (adult), ventral view of head with part of integument removed to expose muscles.
90. Zonabris phalerata Pall., Meloidae, (larva), dorsal view of head with part of integument removed to expose muscles.
91. Same, sagittal section of head slightly to the left of median plane.
92. Same, ventral view of head with part of integument removed to expose muscles.

93. Mordella quadripunctata (Say), Mordellidae, (adult), sagittal section of head slightly to the left of median plane.
94. Same, dorsal view of head with part of the integument removed to expose muscles.

Plate 17

95. Mordella quadripunctata (Say), Mordellidae, (adult), ventral view of head with part of integument removed to expose muscles.
96. Mordella quadripunctata (Say), Mordellidae, (larva) dorsal view of head with part of integument removed to expose muscles.
97. Same, sagittal section of head slightly to the left of median plane.
98. Same, ventral view of head with part of integument removed to expose muscles.
99. Cyllene robiniae (Forst.), Cerambycidae, (adult), sagittal section of head slightly to the left of median plane.

Plate 18

100. Cyllene robiniae (Forst.), Cerambycidae, (adult), dorsal view of head with part of integument removed to expose muscles.
101. Same, ventral view of head with part of integument removed to expose muscles.
102. Cyllene robiniae (Forst.), Cerambycidae, (larva) dorsal view of head with part of integument removed to expose muscles.
103. Same, ventral view of head with part of integument removed to expose muscles.
104. Same, sagittal section of head slightly to the left of median plane.

Plate 19

- 105. Apatides fortis (Lec.), Bostrichidae, (adult), dorsal view of head with part of integument removed to expose muscles.
- 106. Same, sagittal section of head slightly to the left of median plane.
- 107. Same, ventral view of head with part of integument removed to expose muscles.
- 108. Apatides fortis (Lec.), Bostrichidae, (larva), sagittal section of head slightly to the left of median plane.
- 109. Same, dorsal view of head with part of integument removed to expose muscles.

Plate 20

- 110. Apatides fortis (Lec.), Bostrichidae, (larva), ventral view of portion of head with part of integument removed to expose muscles.
- 111. Leptinotarsa decimlineata (Say), Chrysomelidae (adult), dorsal view of head with part of integument removed to expose muscles.
- 112. Same, sagittal section of head slightly to the left of median plane.
- 113. Same, ventral view of portion of head with part of integument removed to expose muscles.
- 114. Leptinotarsa decimlineata (Say), Chrysomelidae, (larva), sagittal section of head slightly to the left of median plane.

Plate 21

- 115. Leptinotarsa decimlineata (Say), Chrysomelidae, (larva), dorsal view of head with part of integument removed to expose muscles.

116. Same, ventral view of head with part of integument removed to expose muscles.
117. Euparius marmoreus (Oliv.), Platystomidae, (adult), dorsal view of head with part of integument removed to expose muscles.
118. Same, sagittal section of head slightly to the left of median plane.
119. Same, ventral view of anterior portion of head with part of integument removed to expose muscles.
120. Euparius marmoreus (Oliv.), Platystomidae, (larva), dorsal view of head with part of integument removed to expose muscles.

Plate 22

121. Euparius marmoreus (Oliv.), Platystomidae, (larva), sagittal section of head slightly to the left of median plane.
122. Same, ventral view of head with part of integument removed to expose muscles.
123. Pantomorus godmani (Grotch), Curculionidae, (adult), sagittal section of head slightly to the left of median plane.
124. Same, dorsal view of head with part of integument removed to expose muscles.
125. Same, ventral view of anterior portion of head with part of integument removed to expose muscles.

Plate 23

126. Pantomorus leucoloma Boh., Curculionidae, (larva), dorsal view of anterior region of head with part of integument removed to expose muscles.
127. Same, sagittal section of head slightly to the left of median plane.

128. Same, ventral view of head with part of integument removed to expose muscles.
129. Hylecoetus lugubris Say, Lymexylidae, (adult), dorsal view of head with part of integument removed to expose muscles.

Plate 24

130. Hylecoetus lugubris Say, Lymexylidae, (adult), sagittal section of head slightly to the left of median plane.
131. Same, ventral view of head with part of integument removed to expose muscles.
132. Hylecoetus lugubris Say, Lymexylidae, (larva), sagittal section of head slightly to the left of median plane.
133. Same, dorsal view of anterior portion of head with part of integument removed to expose muscles.
134. Same, ventral view of head with part of integument removed to expose muscles.

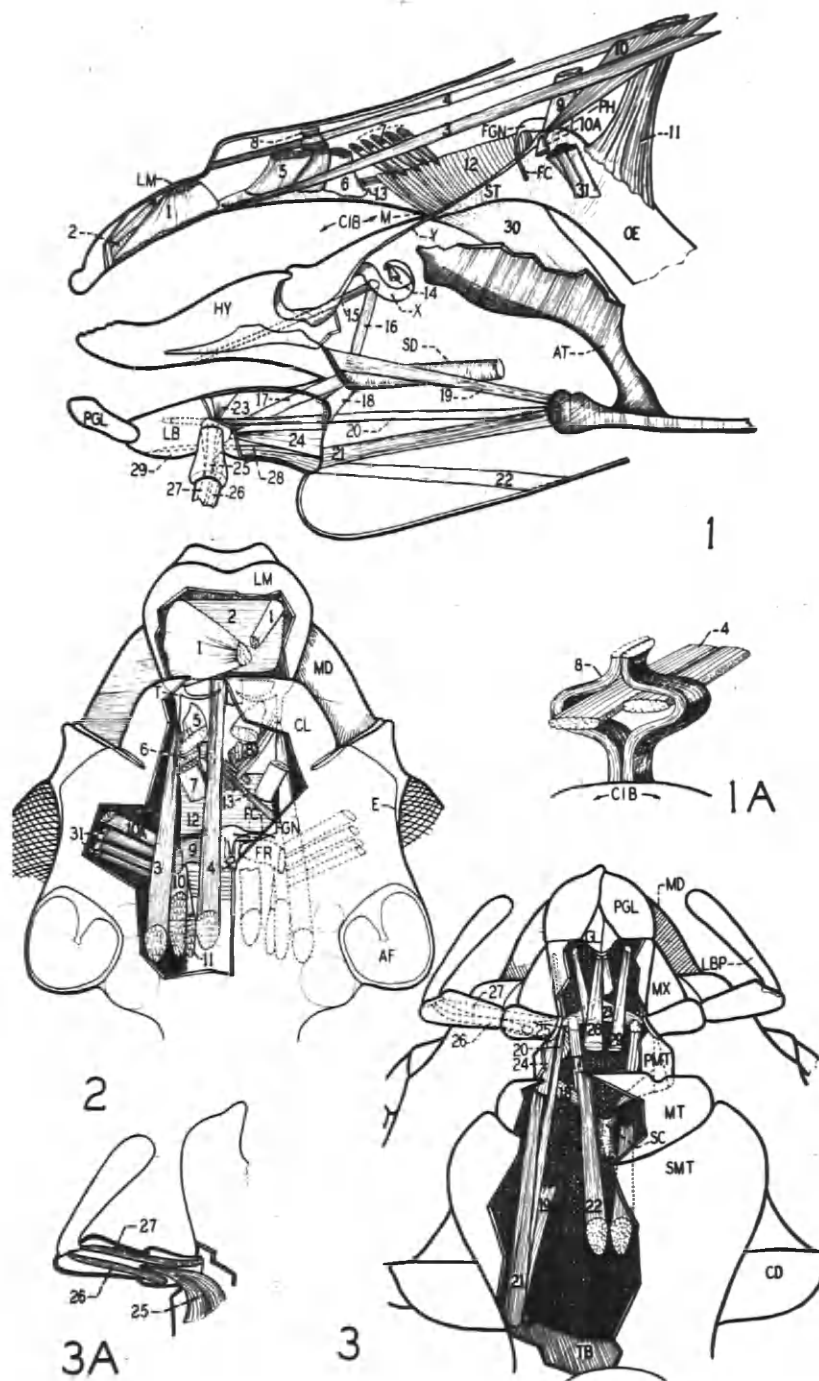


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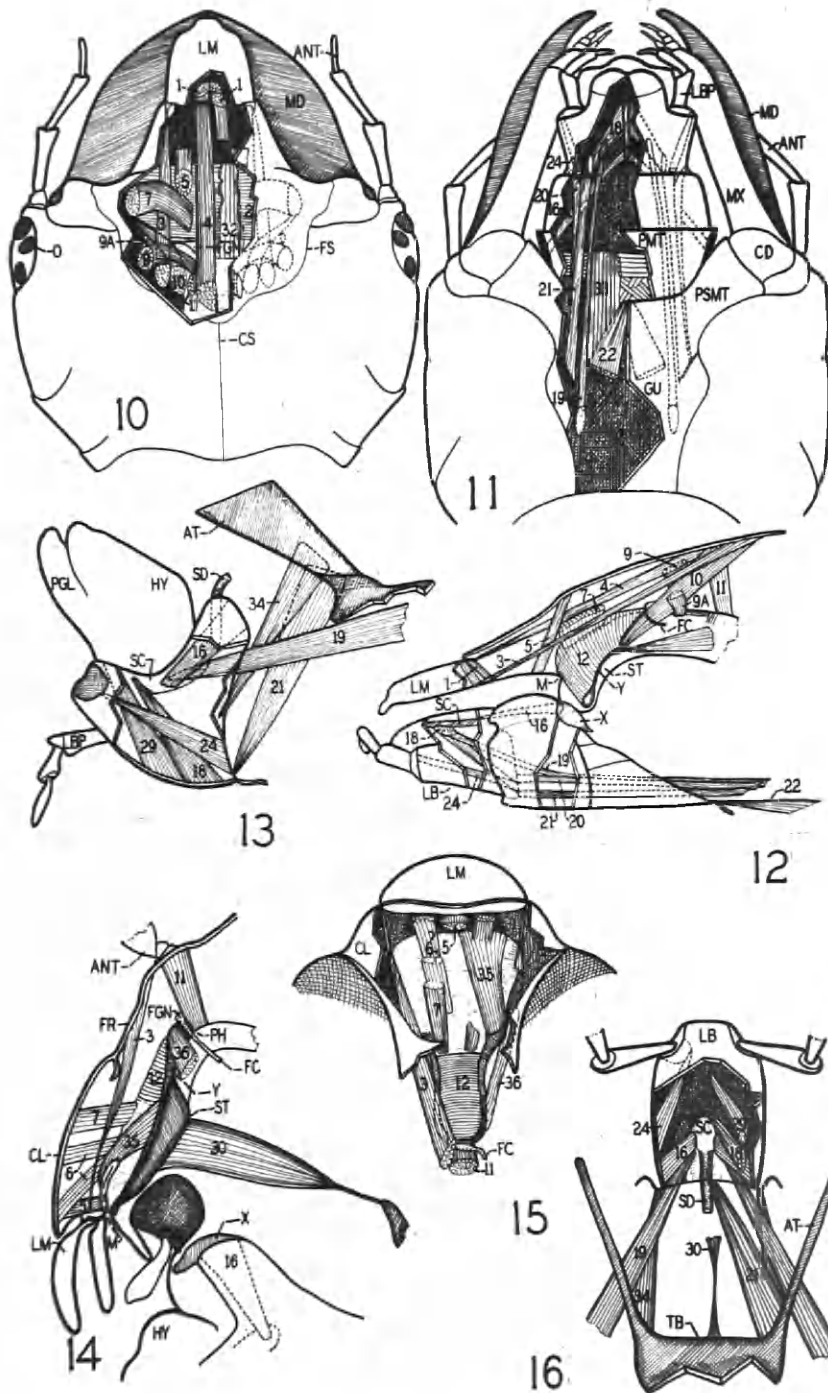
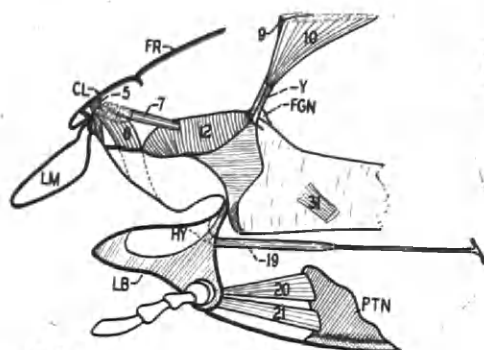
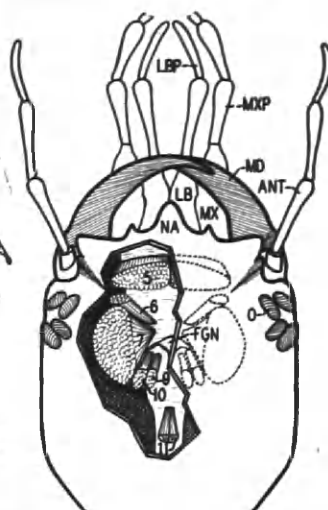


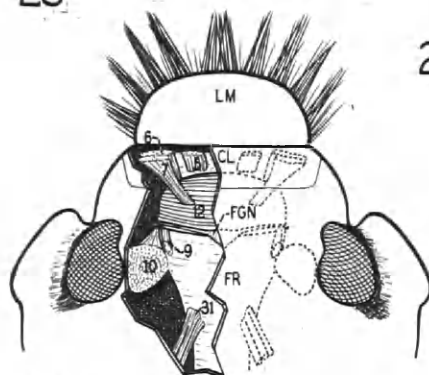
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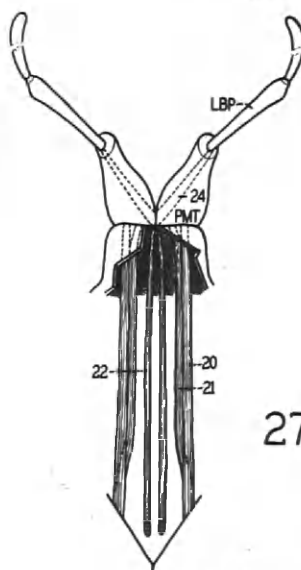
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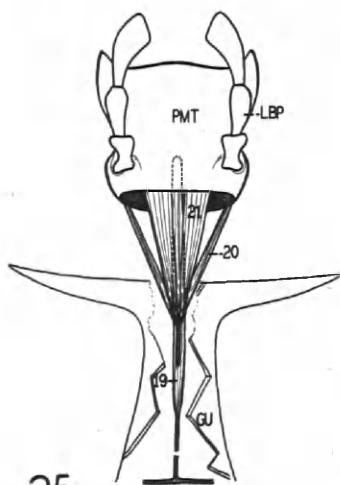
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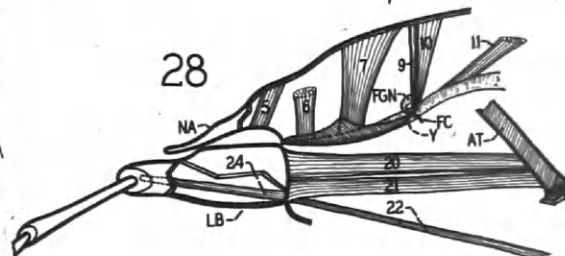
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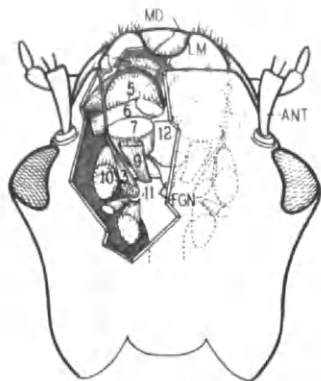
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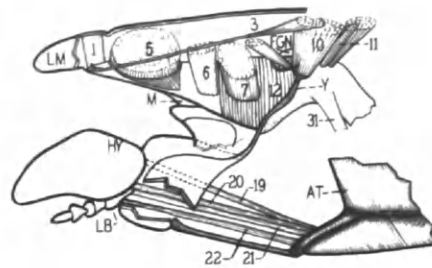
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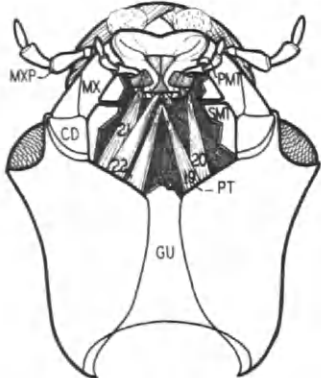
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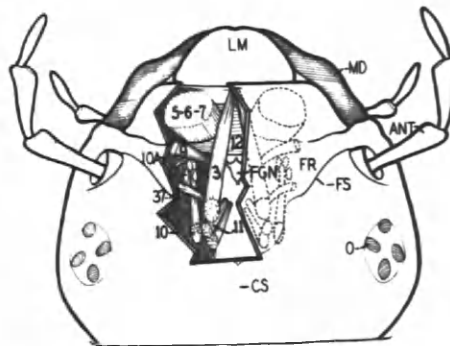
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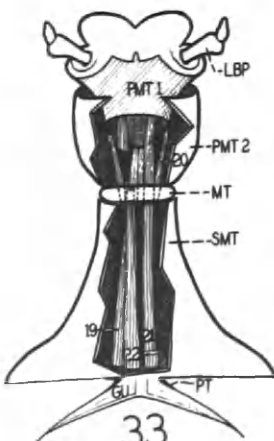
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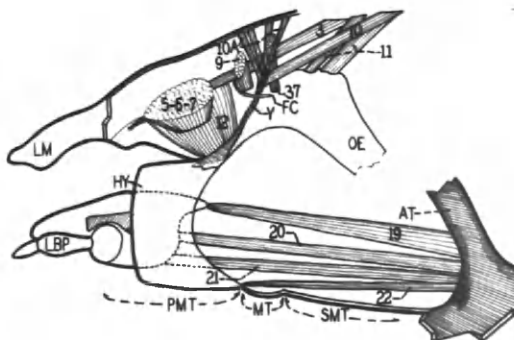
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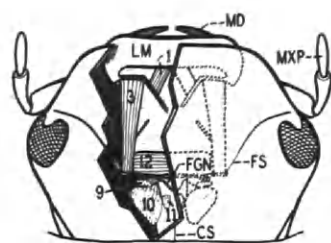
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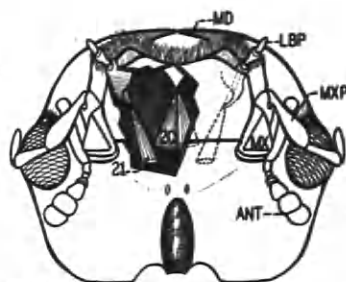
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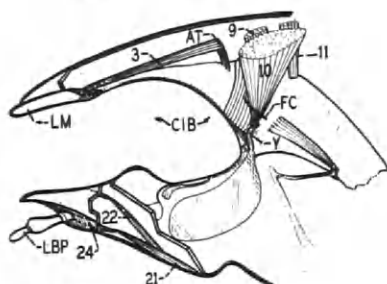
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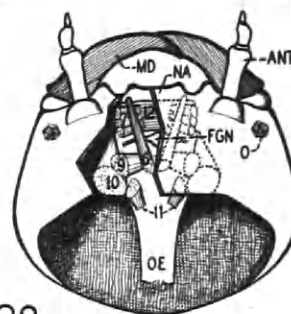
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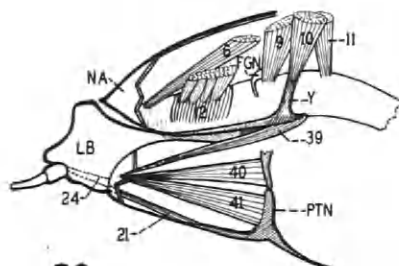
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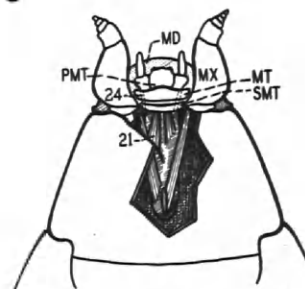
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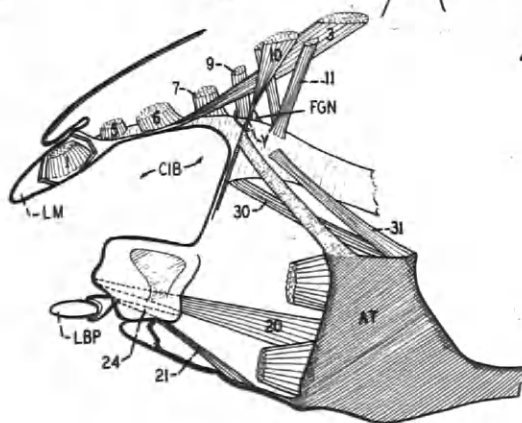
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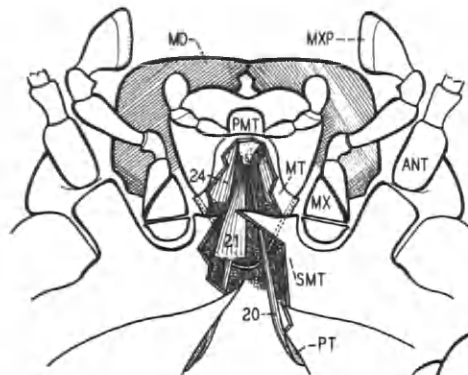
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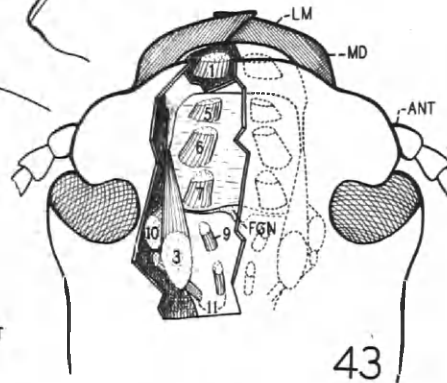
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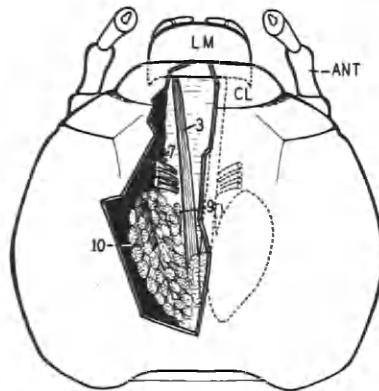
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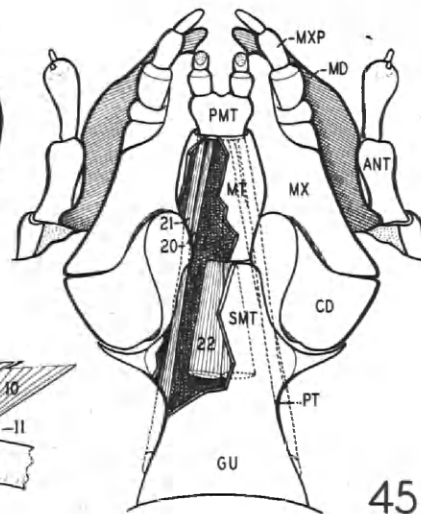
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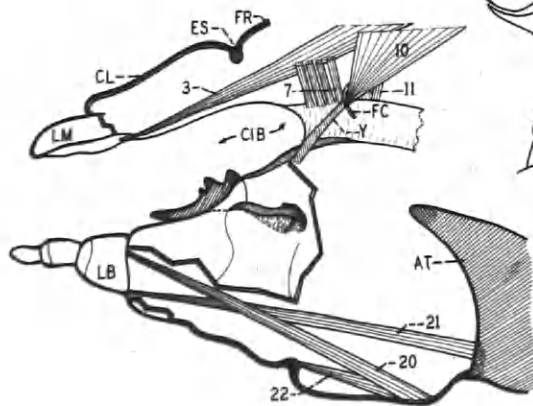
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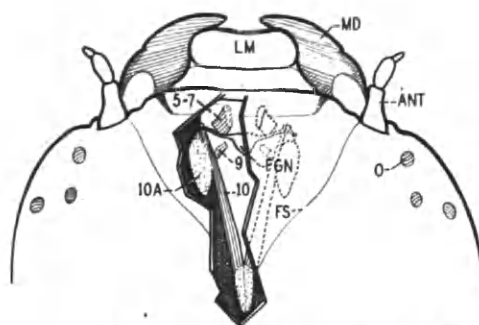
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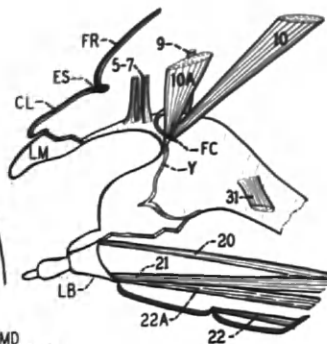
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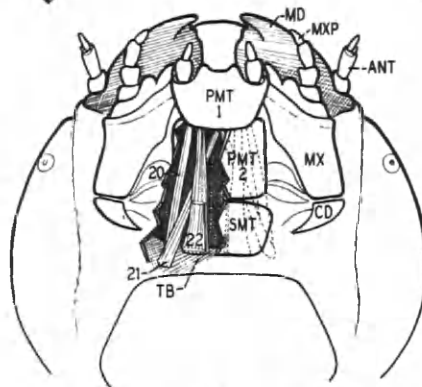
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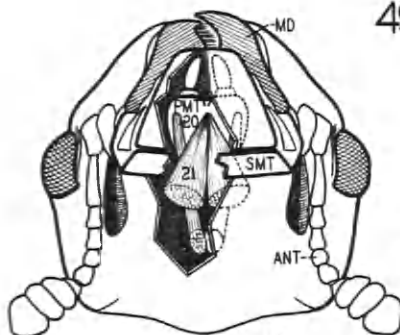
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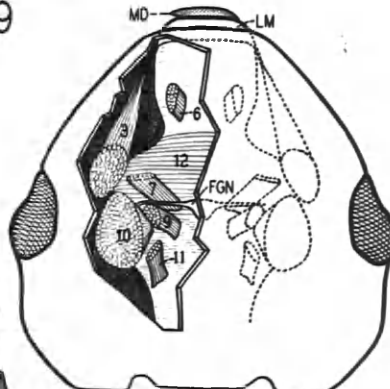
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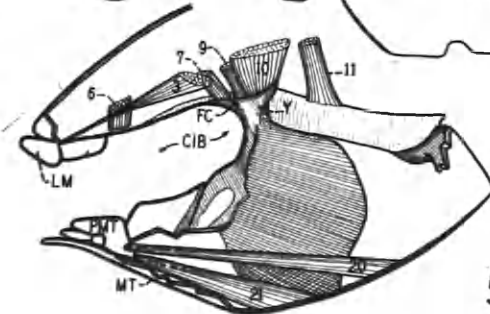
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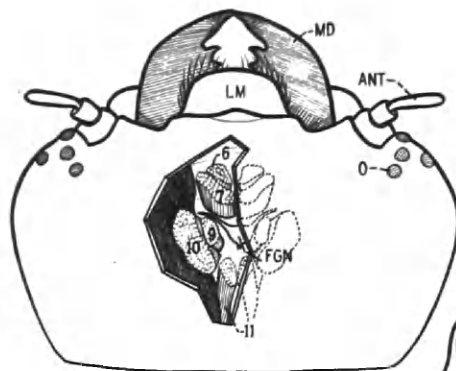
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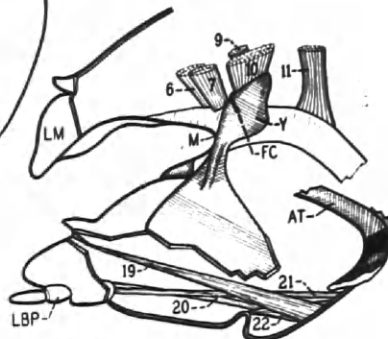
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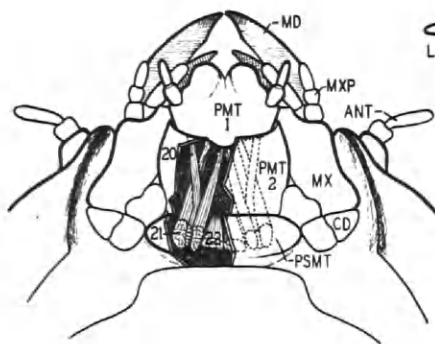
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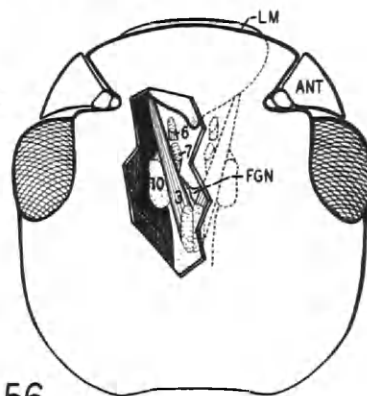
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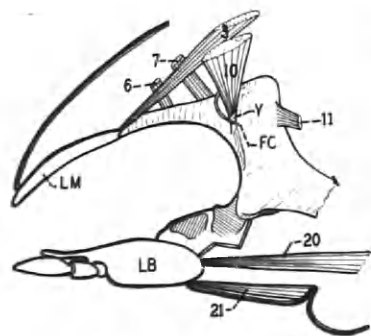
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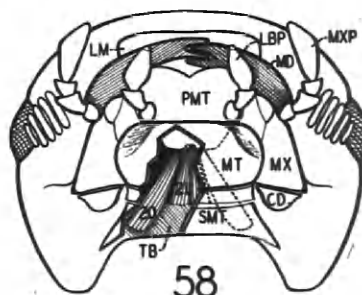
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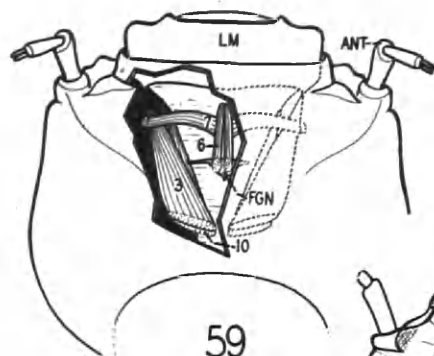
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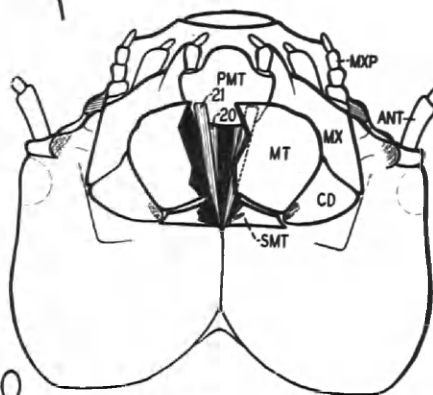
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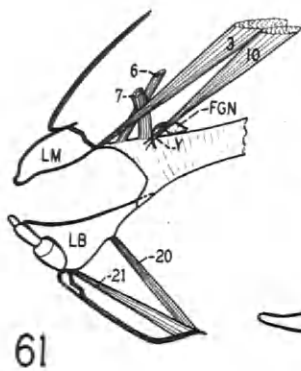
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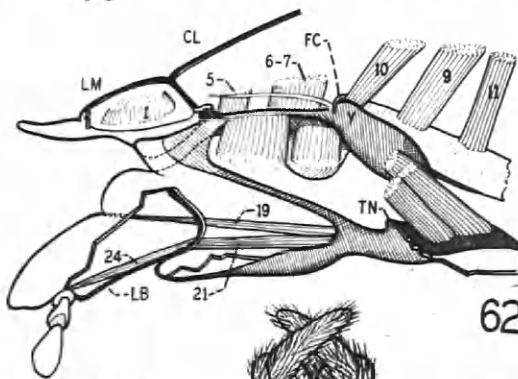
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60



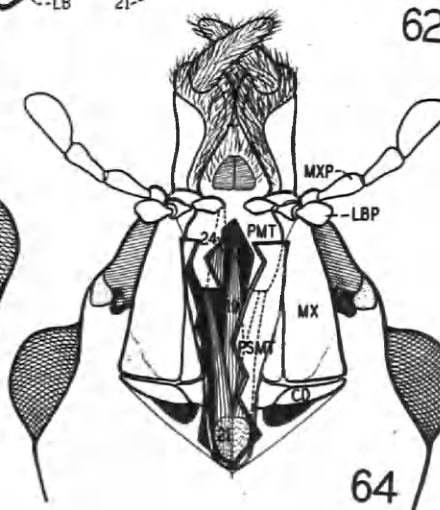
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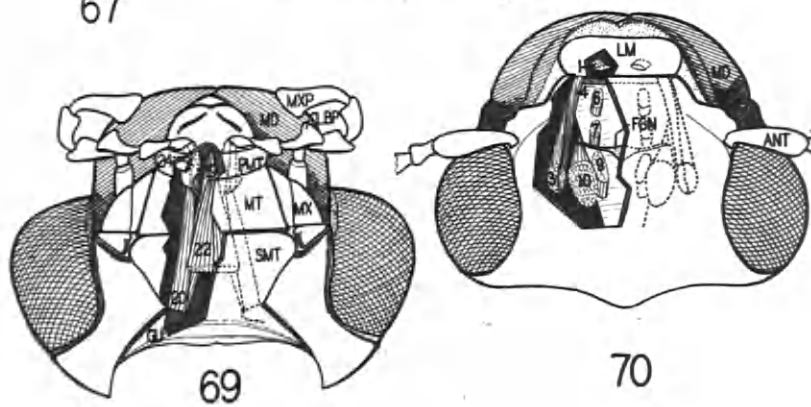
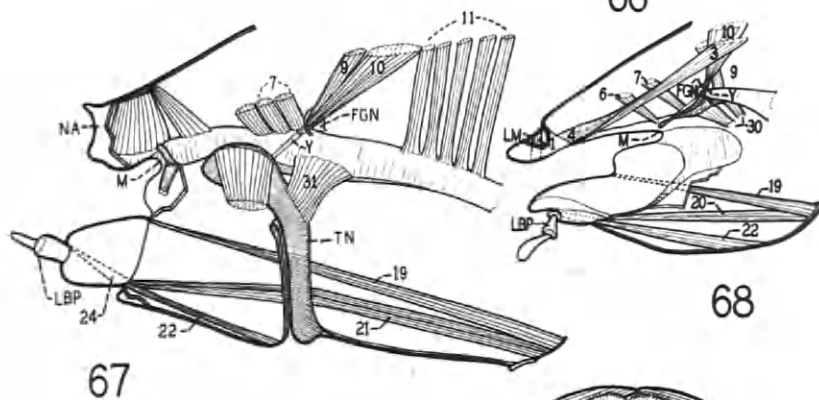
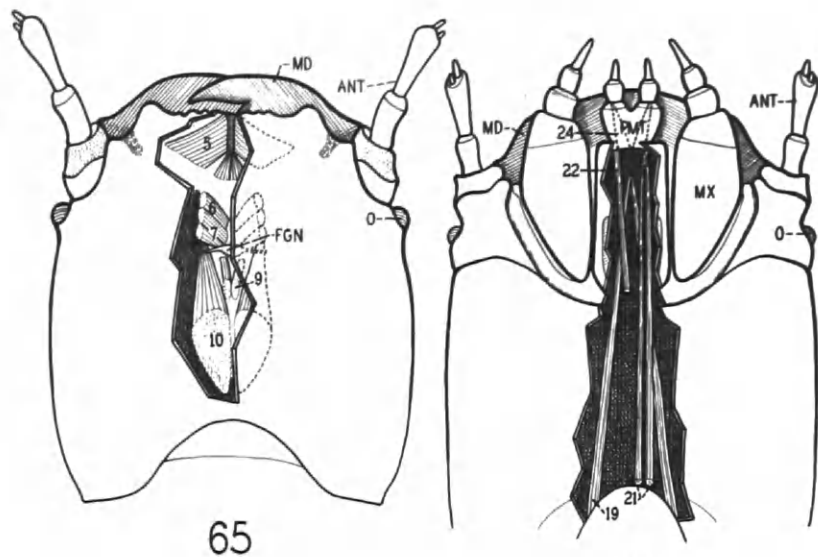
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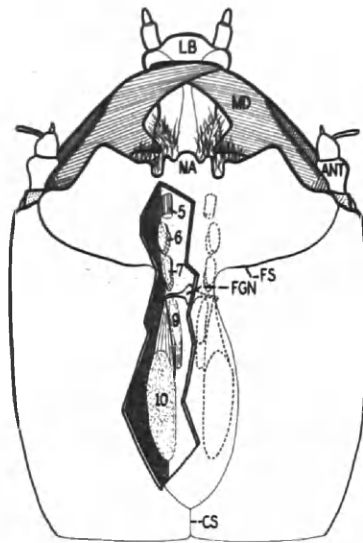


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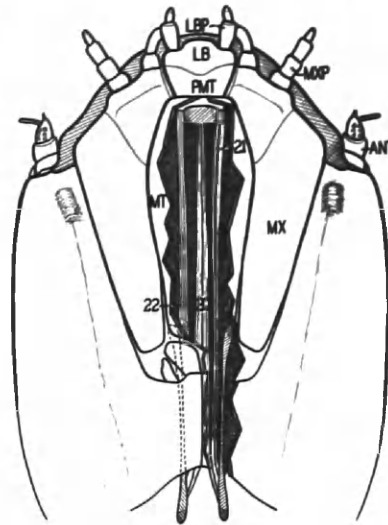


64

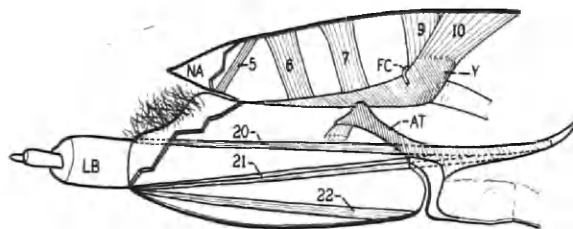




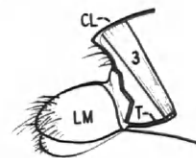
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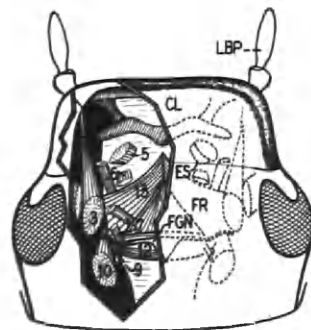
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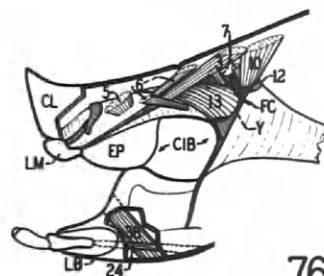
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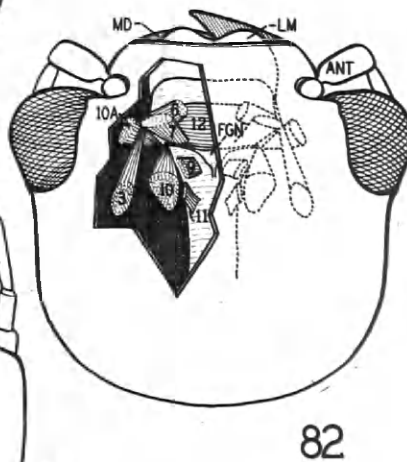
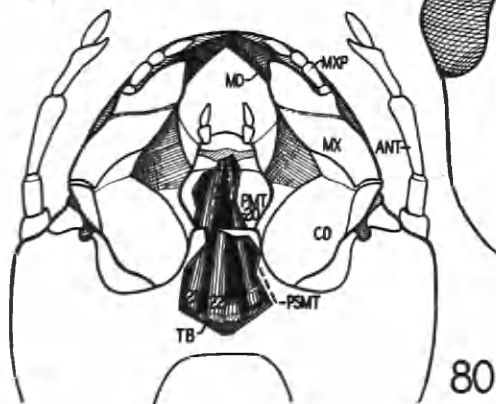
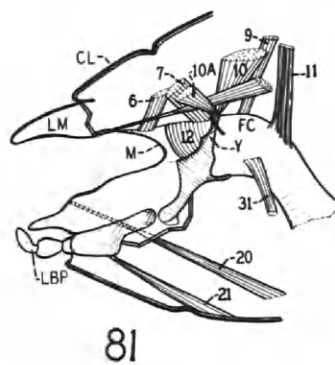
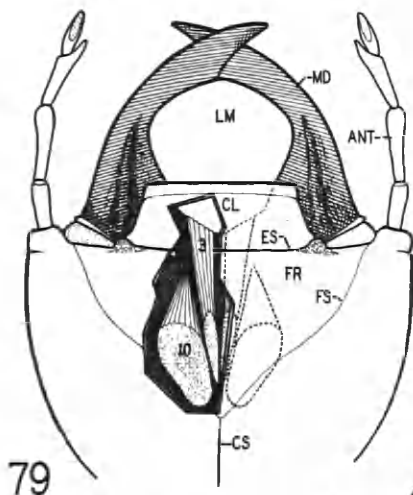
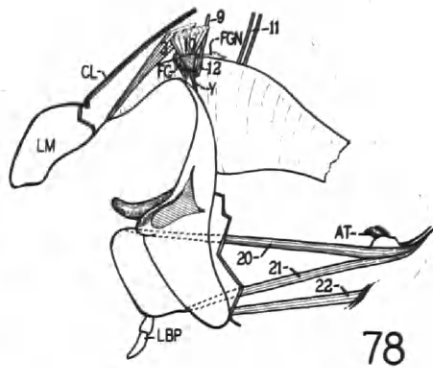
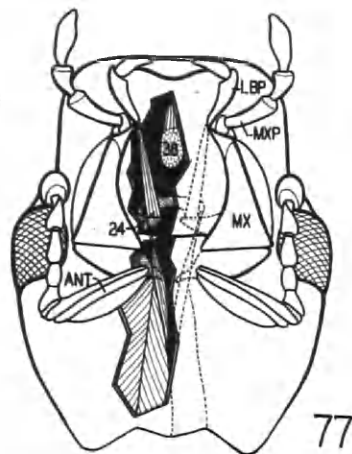
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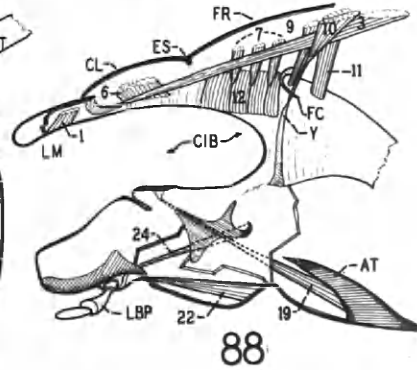
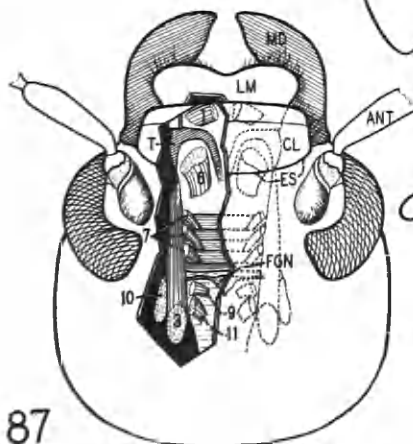
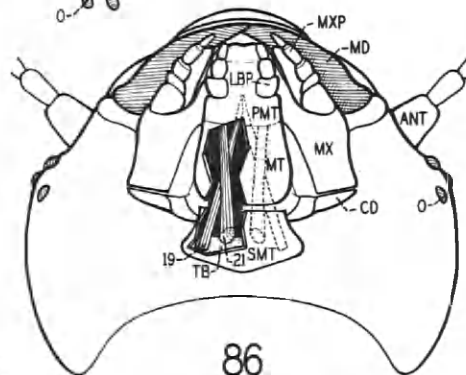
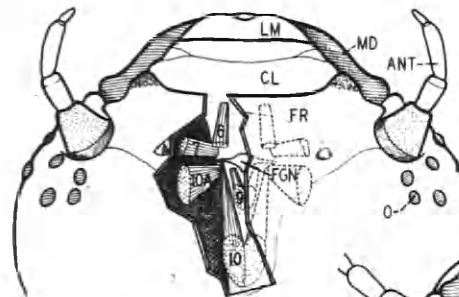
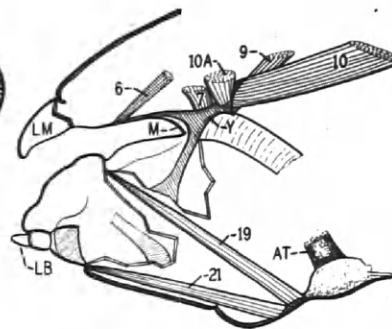
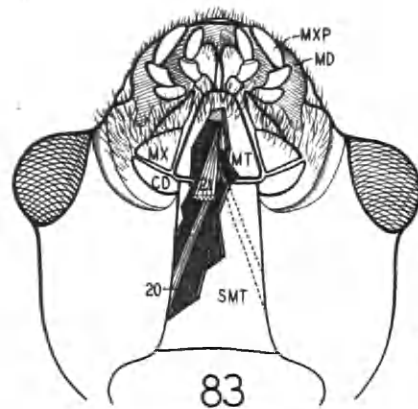


75



76





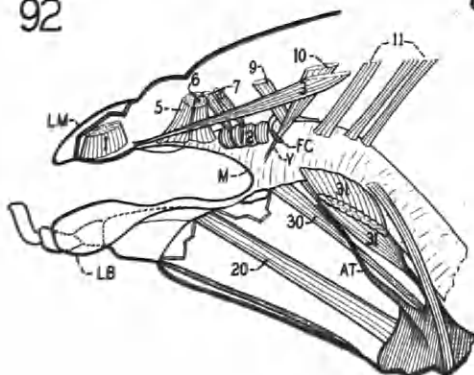
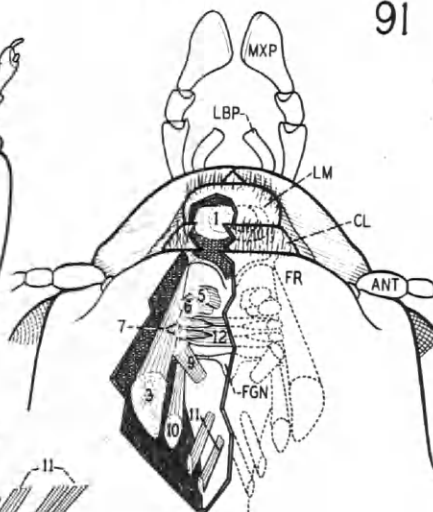
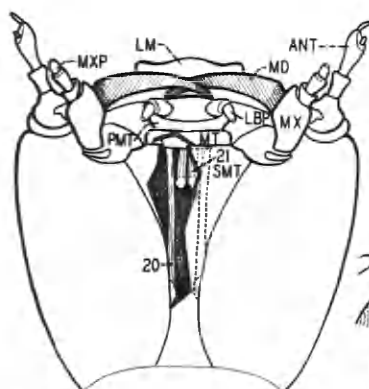
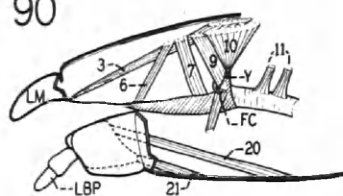
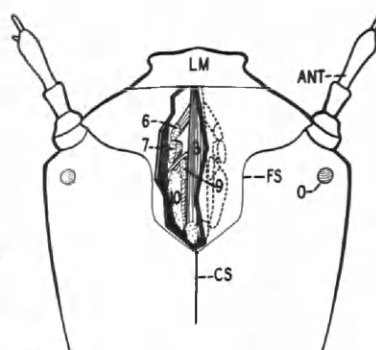
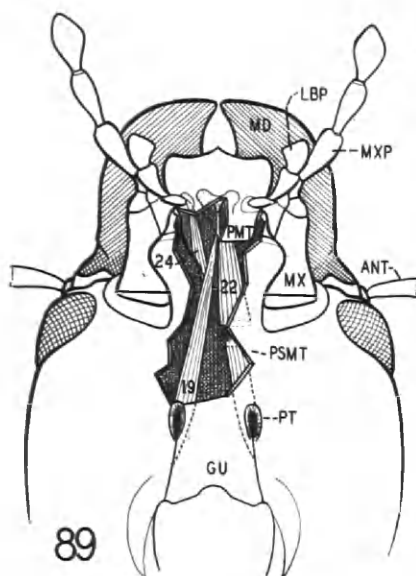


PLATE 16

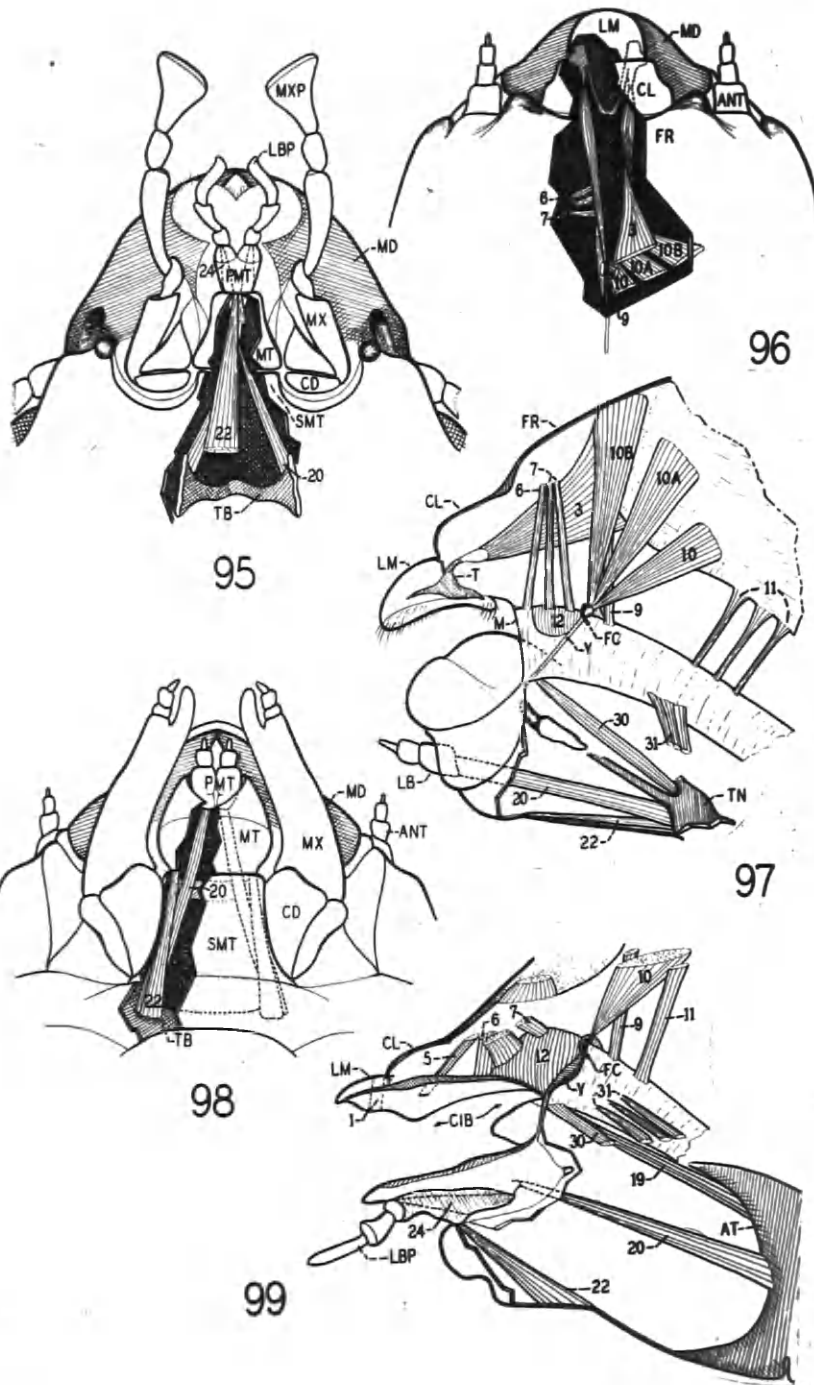


PLATE 17

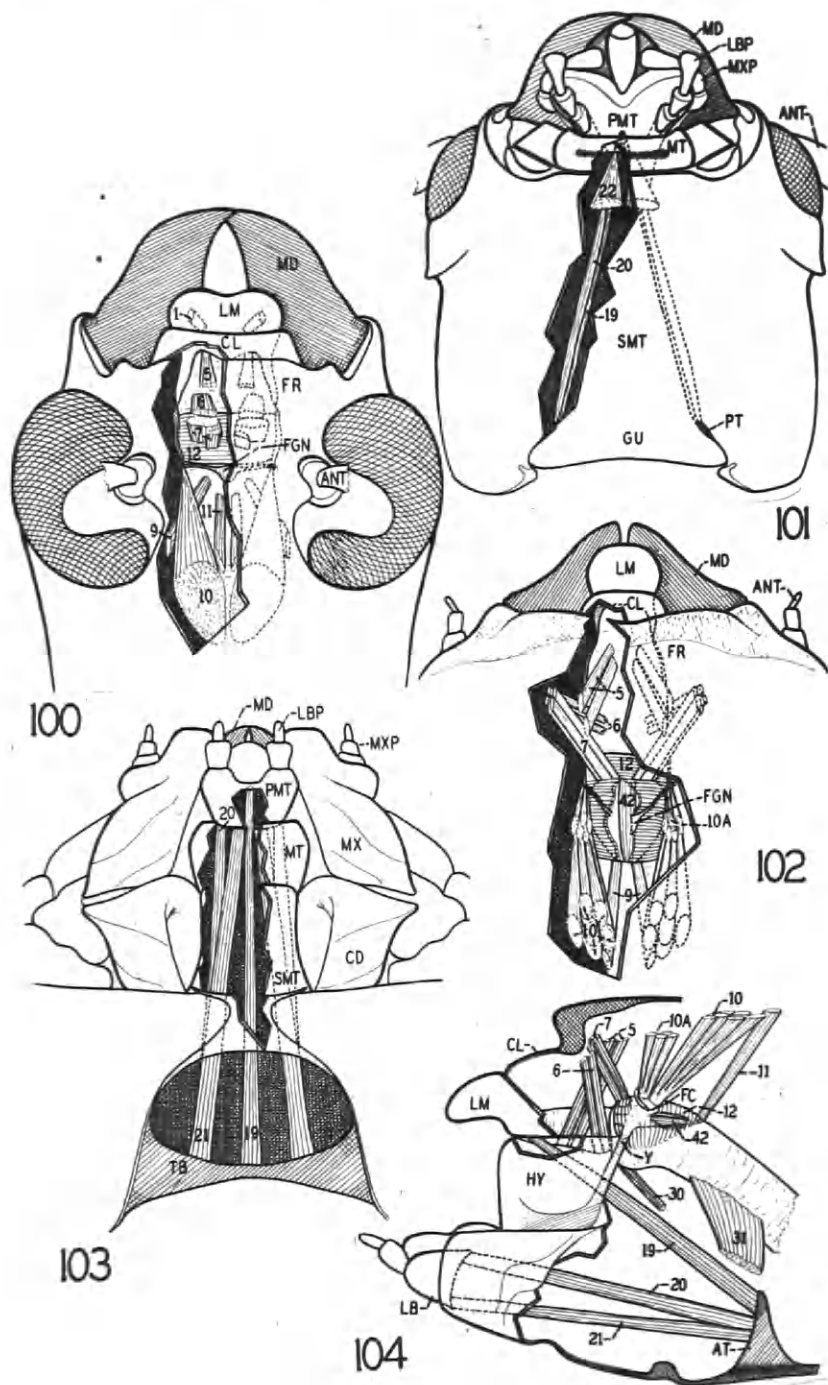


PLATE 18

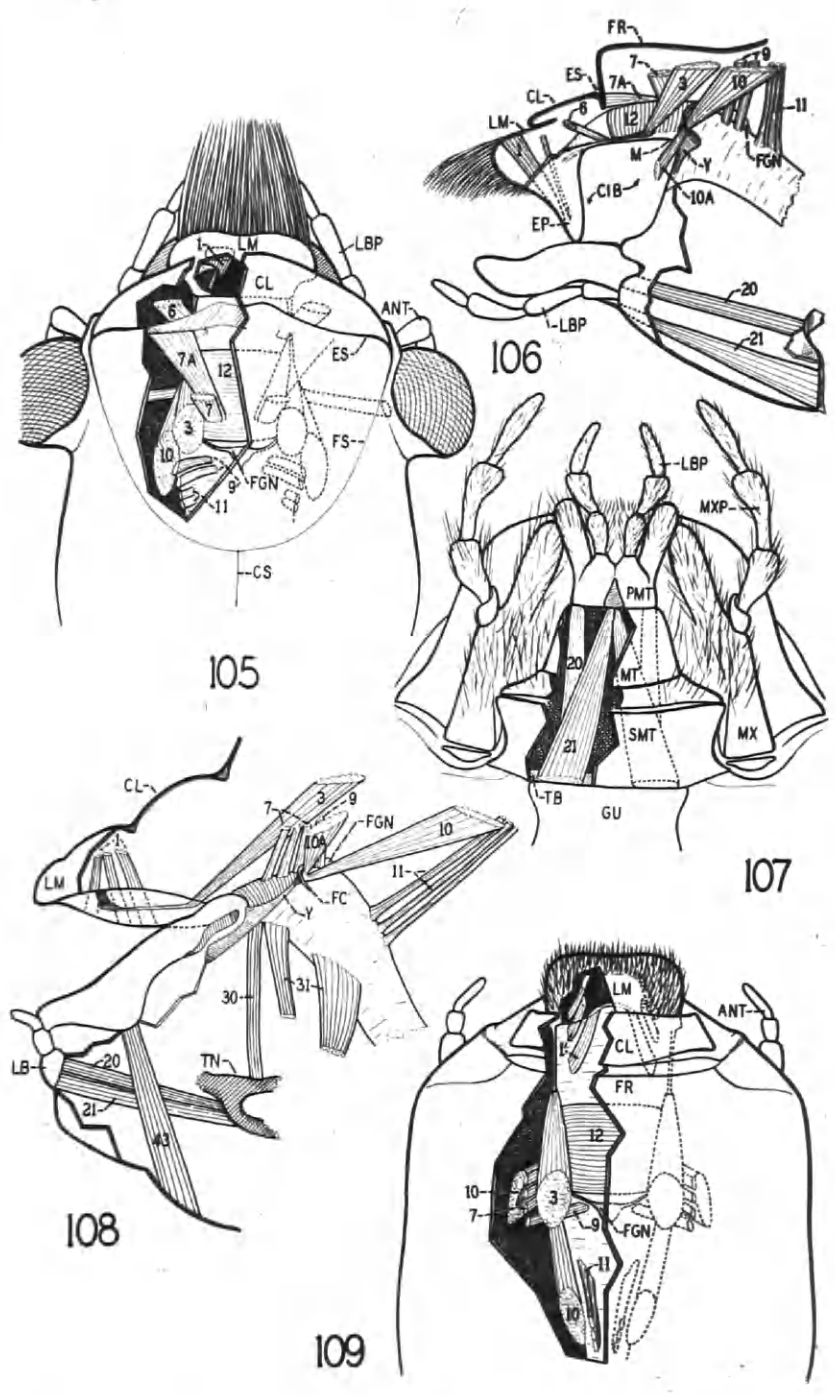
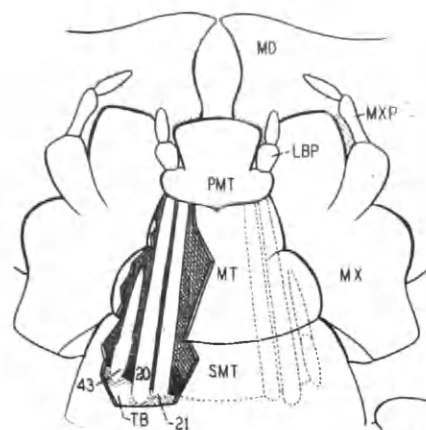
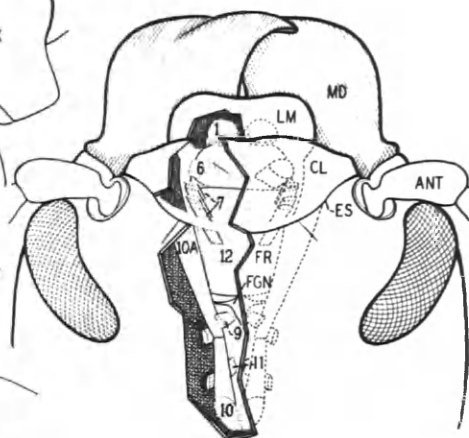


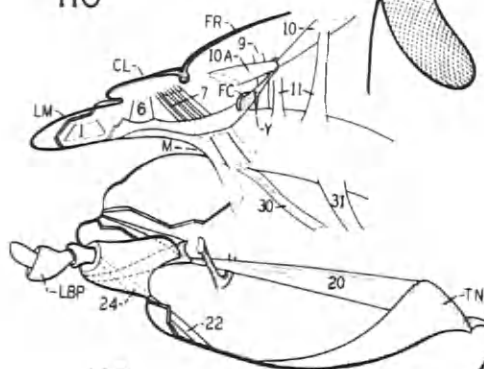
PLATE 19



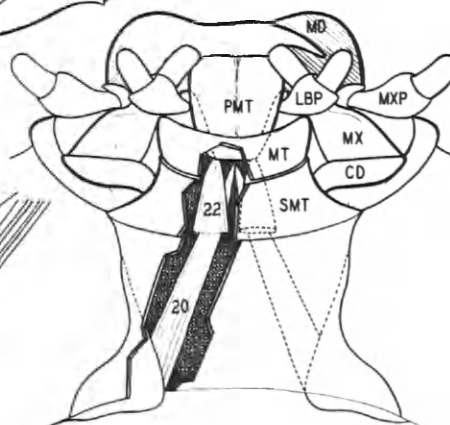
110



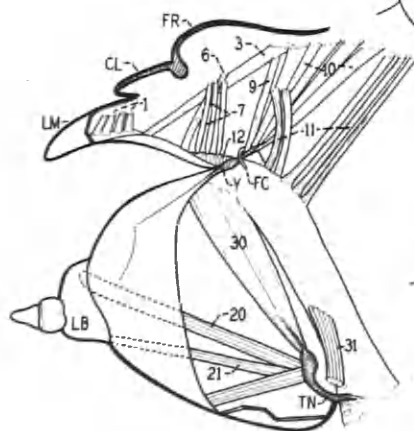
111



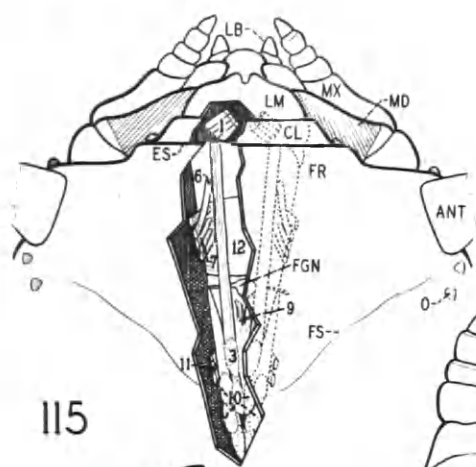
112



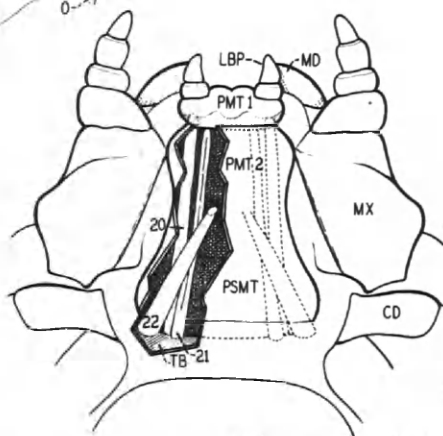
113



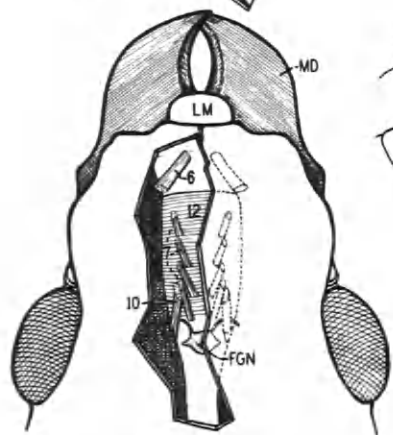
114



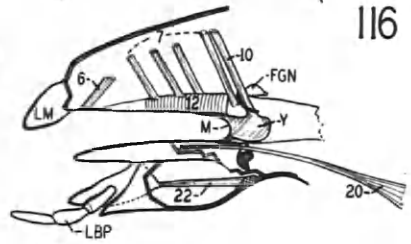
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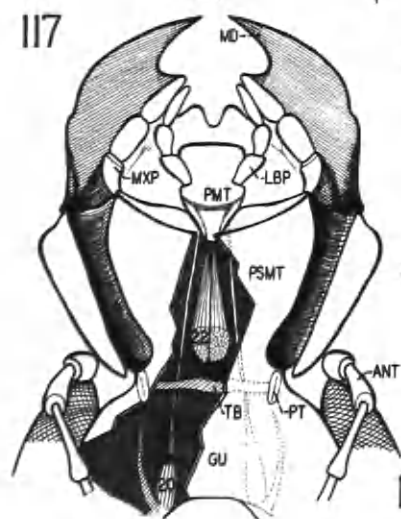
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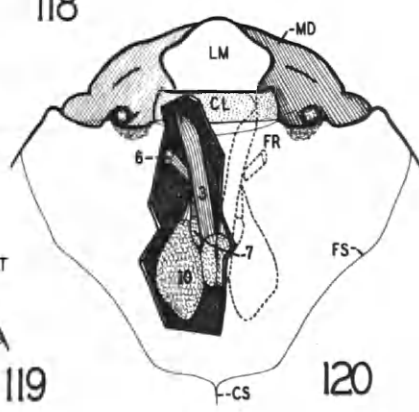
117



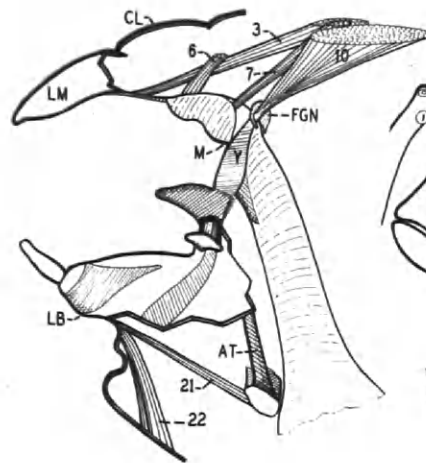
118



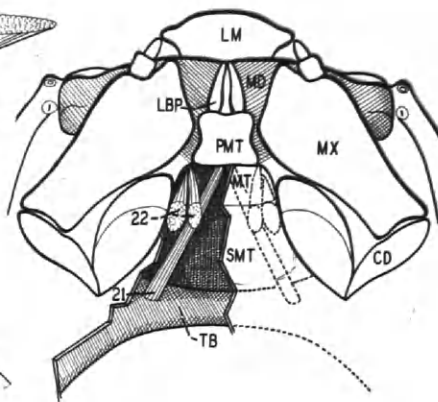
119



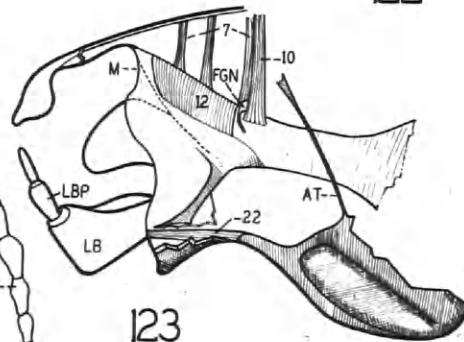
120



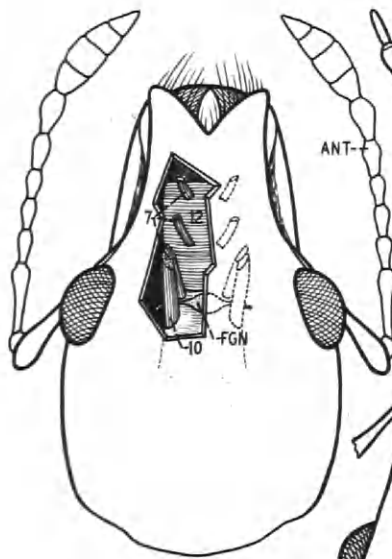
121



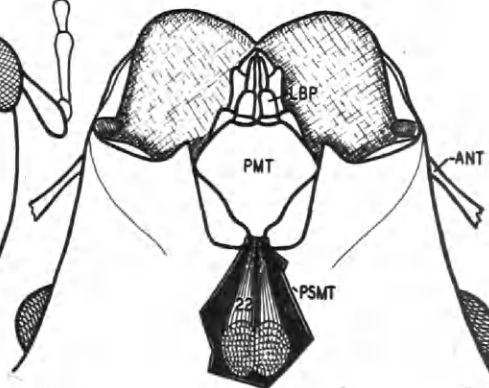
122



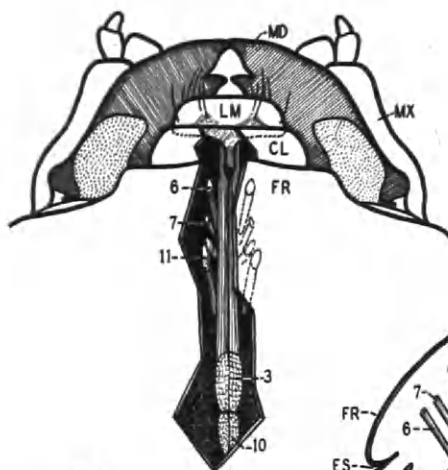
123



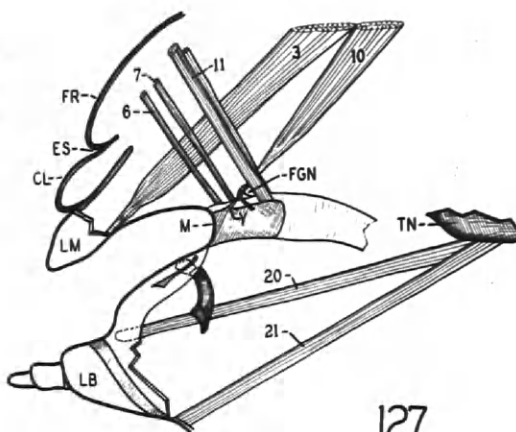
124



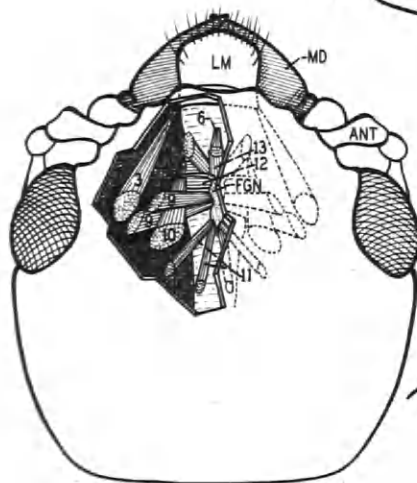
125



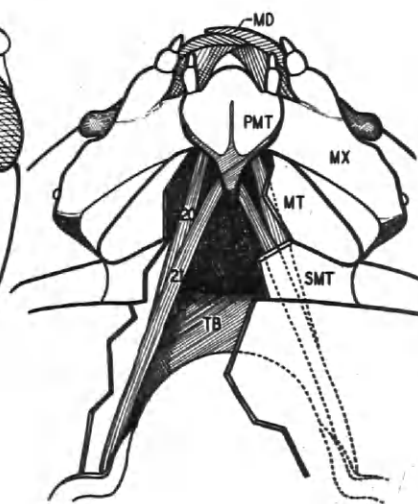
126



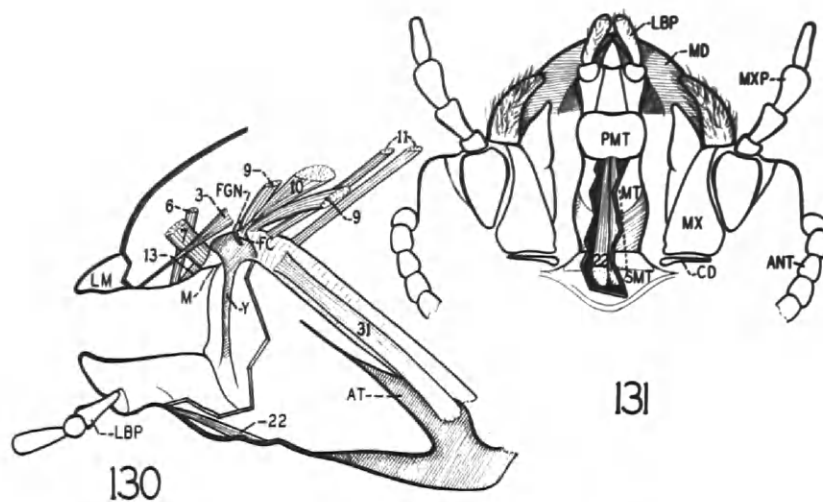
127



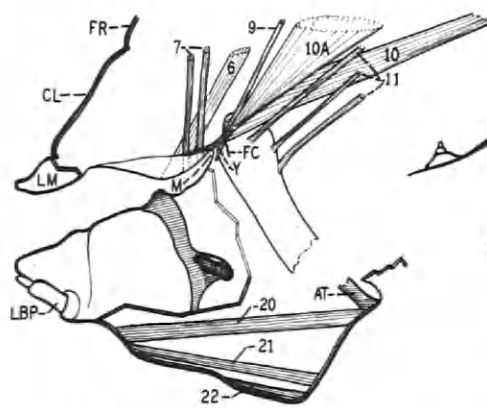
129



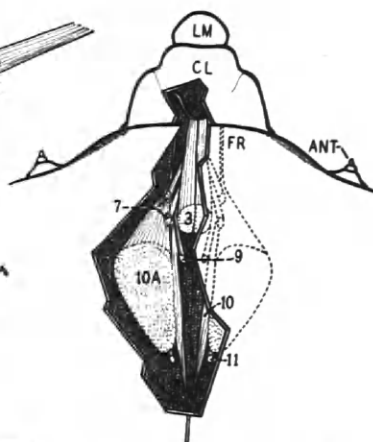
128



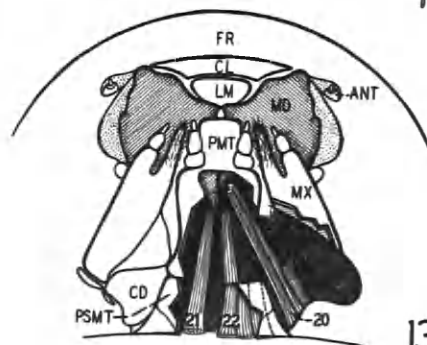
131



132



133



134