CHAPTER - III.

OBSERVATIONS.

PART - I. - MUSCLES OF THE HEAD APPENDAGES.

The various muscles operating the head appendages in the cases of different insectan types mentioned in the Chapter I, are described in the following pages, with special reference to their origin, insertion, functions and modifications.

The distribution and homology of these muscles in the insectan types is presented in Chart I that follows in the later pages.

(A) THE ANTENNAE MUSCLES:

1. The levators of the antenna - (Muscles 51 and 52 of Matsuda 1965).

Normally, these muscles are well developed and occur in pairs. In the ephemerid,odonate, Coleopteran types dealt with in this work, a single reduced antennary levator has been found.
In the dictyopteran and gymnocerate heteropteran types this muscle is represented by a single very well developed muscle bundle, whereas in the cryptocerate heteropteran type, it is absent.

Origin - On the dorsal or anterior tentorial arm.

In the gymnocerate heteropteran type, it arises on the cranial wall. In dipteran type, one of the component originates on the frons.

Insertion - On the dorsal basal margin of the scape or on the apodeme from this region.

2. The depressors of the antenna - (Muscles 53 and 54 of Matsuda 1965).

Like the levators of the antenna, these are also normally well-developed and paired muscles. In the ephemerid, odonate, coleopteran, cryptocerate heteropteran and dipteran types, single reduced antennary depressor occurs.

In the thysanuran type, the complement has four muscles inserted at various points on the ventral basal margin of the scape.
Origin - On the dorsal or anterior tentorial arm.
In the heteropteran types, these muscles originate on the cranial wall.

Insertion - On the ventral basal margin of the scape or on the apodeme from this region.

3. **The levator of the flagellum**

A slender muscle. It is present in all the insectan types dealt with in this work, excepting those of Odonata and cryptocerate Heteroptera.

Origin - On the dorsal basal margin of the scape.
Insertion - On the dorsal basal margin of the flagellum.

4. **The depressors of the flagellum**

A slender muscle, present in all the insectan types dealt with in this work, excepting those of Odonata and cryptocerate Heteroptera.

Origin - On the ventral basal margin of the scape.
Insertion - On the ventral basal margin of the flagellum.

(B) **THE LABRAL MUSCLES:**

(Muscle 61, the posterior fronto-labral muscles of Matsuda, 1965).
5. **The depressors of the labrum** -

It occurs in all the insectan types studied here, excepting those of Lepidoptera and Diptera.

In the heteropteran types, however, these muscles are modified into the protractors of the mandibular stylet.

**Origin** - On the lateral portion of the frons. In the heteropteran types, these muscles arise on the fronto-clypeal area or on the lorum or the mandibular plate.

**Insertion** - On the epipharyngeal process or on the labral tormae. When the tormae are absent these muscles insert on the corresponding position of the ventral labral wall. In the heteropteran types, these muscles insert on the outer basal margin of the mandibular stylet or on the mandibular lever.


A slender elongated muscle. Excepting the coleopteran, hymenopteran, lepidopteran and
heteropteran types, this muscle has been found in all the other insectan types examined presently.

In the dipteran representative, the labral levators of both the sides are fused to form a single median labral levator.

Origin - On the mesal part of the frons.
Insertion - Mesally on the dorsal proximal margin of the labrum.

7. The compressors of the labrum - (Muscle 63, the labro-epipharyngeal muscle of Matsuda 1965).

Short and stout muscles, present in all the insectan types that are studied here, excepting those of Heteroptera, Hymenoptera and Lepidoptera.

Origin - On the labral wall.
Insertion - On the sclerotized plate of the epipharyngeal wall.

(G) THE MANDIBULAR MUSCLES:

8. The main cranial adductor of the mandible - (Muscle 21, the first tergo-mandibular muscle of Matsuda, 1965).

A large, well-developed muscle present in all the insectan representatives under study, excepting those of the Heteroptera and Lepidoptera.
Origin - On the posterior and dorsal cranial wall.
Insertion - On the apodeme arising from the mesal mandibular base.

9. The second cranial adductor of the mandible -
(Muscle 22, the second tergo-mandibular muscle of Matsuda, 1965).

A small muscle found only in the thysanuran representative.

Origin - On the posterior cranial wall.
Insertion - On the mesal mandibular base.

10. The main cranial abductor of the mandible - (Muscle 23, the third tergo-mandibular muscle of Matsuda, 1965).

A well-developed muscle present in all the insectan types under study excepting those of Heteroptera and Lepidoptera.

Origin - On the postero-lateral cranial wall.
Insertion - On the apodeme from the lateral mandibular base, near the posterior point of articulation of the mandible.

11. The second cranial abductor of the mandible - (Muscle 24, the fourth tergo-mandibular muscle of Matsuda, 1965)
A small muscle found in the thysanuran type alone.

Origin - On the lateral postoccipital portion.
Insertion - On the base of the abductor apodeme of the mandible.

12. The main ventral muscle of the mandible - (Muscle 25, the tentorio-mandibular muscle of Matsuda, 1965).

In the thysanuran and ephemerid types this muscle is represented by two groups of well-developed muscles - the proximal group acting as abductors and the distal one functioning as the adductors. In the representatives of Odonata, Dictyoptera, Isoptera Orthoptera, Neuroptera and Diptera, this muscle is much reduced and acts only as the adductor of the mandible.

This muscle is modified into the retractor of the mandibular stylet in the heteropteran types. It is, however, absent in the representatives of Orthoptera and other holometabolous orders.

Origin - On the anterior tentorial arm.
Insertion - On the basal portion of the outer mandibular wall.
13. **The second ventral muscle of the mandible** - (Muscle 26, the hypopharyngeo-mandibular muscle of Matsuda, 1965).

   This muscle functions as the mandibular adductor in the representatives of Thysanura, Ephemeroptera, Odonata, Dictyoptera andIsoptera.

   It is absent in the orthopteran, heteropteran and in all the holometabolous types dealt with in this work.

   **Origin** - On the loral arm of the hypopharynx in the thysanuran type, in others it arises on the anterior tentorial arm.

   **Insertion** - On the basal portion of the outer mandibular wall.

(D) **THE MAXILLARY MUSCLES** :

14. **The dorsal retractor of the cardo** - (Muscle 1, the tergocardinal muscle of Matsuda, 1965).

   A well-developed muscle and its complement has more than one bundle of muscle fibers in the cases of thysanuran, ephemerid, odonatan, dictyopteran, isopteran, orthopteran, neuropteran, mecopteran and coleopteran representatives.
In the hymenopteran type, this muscle is represented by a single muscle bundle that protracts the entire maxillo-labial complex.

It is absent in the representatives of Heteroptera, Lepidoptera and Diptera.

Origin - On the epicranial area near the occipital foramen. In the coleopteran type it arises on the post-gena.

Insertion - On the internal ridge or process of the cardo. In the coleopteran type insertion is more lateral on the cardinal process.

15. The ventral adductor of the cardo - (Muscle 3, the tentoriocardinal muscle of Matsuda, 1965).

This muscle is represented by more than one bundle of muscle fibers in the representatives of primitive and generalized orders like Thysanura, Ephemeroptera, Odonata, Dictyoptera, Isoptera, Orthoptera, Neuroptera, Mecoptera and Coleoptera.

In the lepidopteran and dipteran types, the complement has a single muscle bundle. This muscle in the dipteran type inserts on the elongated apodeme from the junction of the cardo and stipes and brings
about the protraction of the maxillary stylet, while in the lepidopteran representative it acts as protractor of the galeal proboscis.

Origin - On the anterior tentorial arm. In the coleopteran type, all the component bundles arise on the posterior tentorial arm, whereas in the mecopteran type they originate on the clypeus.

Insertion - On the basal portion of the outer wall of the cardo. In the coleopteran type the insertion of this muscle is more mesal on the dorso-lateral cardinal process.

Because of this above mentioned shift in its origin and insertion, this muscle in the coleopteran type simulate the action of the dorsal retractor muscle of the cardo i.e. muscle 14 described above (Muscle 1, the tergo-cardinal muscle of Matsuda, 1965).

In the heteropteran and hymenopteran representatives, this muscle is lacking.

16. The ventral adductor of stipes - (Muscle 4, the tentorio-stipital muscle of Matsuda, 1965).

In the representatives of primitive and generalized orders like Thysanura, Ephemeroptera,
Odonata, Dictyoptera, Isoptera, Orthoptera, Neuroptera and Coleoptera, this muscle is well-developed and is represented by several muscle bundles.

In the hymenopteran and lepidopteran types, this muscle has three fasciculi. In the hymenopteran type, all these fasciculi originate on the clypeus and function as protractor and retractor of the maxillo-labial complex.

In the lepidopteran type, however, only one fasciculus has shifted its origin to the clypeus, whereas the other two arise on the anterior tentorial arm. All the fasciculi act as the extensors of the galeal proboscis. In the dipteran representative, this muscle occurs as a single muscle bundle functioning as the retractor of the whole maxilla.

Origin - On the anterior tentorial arm. In the mecopteran and hymenopteran types, this muscle (and all its complements) arises on the clypeus. In the lepidopteran type also one component bundle of this muscle originates on the clypeus.

Insertion - On the basal portion of the outer stipital wall.
This muscle is lacking in the heteropteran types.

17. **The cranial flexor of the lacinia** - (Muscle 5, the tergo-lacinial muscle of Matsuda, 1965).

Well developed muscle, found in the representatives of all orders excepting those of Lepidoptera and Hymenoptera.

In the cases of heteropteran and mecopteran types, this muscle has several component bundles.

These muscles, in the heteropteran and dipteran representatives, function as the retractors of the maxillary stylet.

**Origin** - On the posterior cranial wall or on the postoccipital area. In the coleopteran type, it partly originates on the posterior tentorial arm.

**Insertion** - On the lacinial base or on the apodeme arising from this place.

18. **The stipital flexor of the lacinia** - (Muscle 6, the stipitolacinial muscle of Matsuda, 1965).

This is a short, slender muscle present in the representatives of all insectan orders dealt with in this work, excepting those of Mecoptera, Lepidoptera and Diptera.
In the ephemerid and odonatan types this muscle acts as the flexor of the 'mala', which is a fusion product of the galea and lacinia. (Strenger 1953, Ando 1962, vide Matsuda, 1965). This muscle, therefore, may be the fusion product of the stipital flexors of the galea and lacinia (Muscles 6 and 7 of Matsuda).

In the heteropteran types, this muscle is represented by more than one muscle bundle which function as the protractors of the maxillary stylet.

This muscle is absent in the mecopteran, lepidopteran and dipteran types.

Origin - On the outer basal margin of the stipes.
Insertion - On the base of lacinia.

19. The stipital flexor of the galea - (Muscle 7 the stipitogaleal muscle of Matsuda, 1965).

This is a short slender muscle. Excepting those of the Heteroptera, Mecoptera, and Diptera, this muscle is present in all the insectan types dealt with in this work.
In the ephemerid and odonatan types, this muscle acts as the flexor of the 'dentate male', which is a fusion product of the galea and lacinia (Stronger 1953, Ando 1962 vide Matsuda, 1965). Consequently this muscle may be the fusion product of stipital flexors of lacinia and galea (Muscles 6 and 7 of Matsuda) or it may be only the stipital flexor of the lacinia or galea.

In the case of the lepidopteran type, this muscle functions as the retractor of the galeal proboscis, while in the hymenopteran representative, it folds the galea by virtue of special modifications at the base of the appendage.

**Origin** - On the outer basal margin of the stipes.
**Insertion** - On the base of the galea.

20. The stipital levator of the maxillary palp- (Muscle 9, the stipito-palpal levator of Matsuda, 1965).

A small, slender muscle. This has been found in the representatives of all hemimetabolous orders excepting only those of Heteroptera. In the Holometabola, it occurs in the neuropteran, coleopteran and mecopteran representatives, whereas it is lacking in the cases of the hymenopteran, lepidopteran and dipteran types.
Origin - On the inner wall of the stipes.
Insertion - On the ventral proximal margin of the palp.

21. **The stipital depressor of the maxillary palp** - (Muscle 10, the stipito-palpal depressor of Matsuda, 1965).

A short and slender muscle found in all the representatives excepting those of Heteroptera and Lepidoptera.

Origin - On the inner wall of the stipes.
Insertion - On the dorsal proximal margin of the palp.


A minute muscle, found only in the thysanuran type.

Origin - On the outer distal portion of the stipes.
Insertion - On the proximal margin of the palp in between the stipital levator and depressor muscles of the palp.


These are special oblique muscles, serially present all along the coileable length of the characteristic galeal proboscis in the lepidopteran types. Since the distribution of these muscles is
restricted only to the Lepidoptera, the homology of these muscles is elusive.

Origin - On the ventro-mesal portion of each sclerotic ring in the galeal cylinder.

Insertion - On the dorsal proximal part of the respective succeeding sclerotic rings in the galeal cylinder.

24. **The intrinsic distal (lateral) elevators of the galea** - (Eastham and Eassa 1955; Matsuda, 1965).

These are also special oblique muscles, serially present all along the coilable length of the proboscis in the lepidopteran type. Since these muscles are not found in other insectan types, the homology of these muscles can not be determined.

Origin - On the ventro-mesal portion of each sclerotic ring in the galeal cylinder.

Insertion - On the dorsolateral part of the respective succeeding sclerotic rings in the galeal cylinder.


These are also special oblique muscles forming an additional layer only in the 'Knee-bend' region of the
lepidopteran proboscis. They are disposed in the opposite direction of the intrinsic proximal and distal galeal elevator muscles and therefore are antagonistic to them in function.

Origin - On the ventromesal portion of each sclerotic ring in the Knee-bend region of the galeal cylinder.

Insertion - On the dorsolateral and dorsal proximal part of the respective preceding sclerotic rings in the 'Knee-bend' region of the galeal cylinder.

26. **The intrinsic levator muscles of the maxillary palp-**

The muscles are found to occur in the first three palpal segments of the thysanuran type, in the first two palpal segments of the orthopteran, neuropteran mecopteran and coleopteran types, and only in the basal segment of the ephemeron, dictyopteran and isopteran representatives.

These muscles are, however, absent in the odonatan, heteropteran, hymenopteran, lepidopteran and dipteran types, since the palp is either extremely reduced or absent in the insects.
Origin - On the basal margin of the respective palpal segment.

Insertion - On the outer basal margin of the succeeding palpal segment.

In the orthopteran and mecopteran types, these muscles connect the basal margins of the first and third palpal segments.

27. **The intrinsic depressor muscles of the maxillary palp -**

These muscles are present in the first four segments of the palp in the thysanuran, dictyopteran, isopteran, orthopteran, neuropteran and coleopteran representatives, in the third and fourth palpal segments of the mecopteran type and only in the basal palpal segment of the ephemerid type.

Origin - On the inner basal margin of portion of the respective palpal segment.

Insertion - On the outer basal margin of the succeeding segment.

These muscles in the second and third palpal segments of the dictyopteran type unite and connect the base of the second segment with that of the fourth. Likewise these muscles in the first two palpal segments
of the orthopteran type unite and connect the base of
the first segment with that of the second segment.

(B) **LABIAL MUSCLES**:

28. **The cranial depressor of the glossa** - (Muscle 31, the
postoccipitoglossal muscle of Matsuda, 1965).

This muscle has been found only in the
thysanuran type.

**Origin** - On the postoccipital phragma.

**Insertion** - Inner posterior region of the glossa.

29. **The cranial levator of the glossa** - (Muscle 32, the

This muscle also occurs in the thysanuran type only.

**Origin** - On the postoccipital phragma.

**Insertion** - Dorso-lateral area of the glossal base.

30. **The cranial depressor of the paraglossa** - (Muscle 33,
the postoccipito-paraglossal muscle of Matsuda, 1965).

This muscle occurs only in the thysanuran,
nymphal ephemerid and neuropteran types.

**Origin** - On the postocciput.

**Insertion** - On the base of the paraglossa.
31. The cranial (dorsal) retractor of the prementum -  
(Muscle 34, the postoccipito-premental muscle of 
Matsuda, 1965).

Origin - On the postocciput.
Insertion - On the dorsal proximal margin of the 
prementum.

32. The tentorial (ventral) retractor of the prementum -  
(Muscle 35, the tentorio-premental muscle of 
Matsuda, 1965).

Origin - On the posterior tentorial arm.
Insertion - On the lateral premental area.

In the thysanuran type, muscles 31 and 32 -  
the cranial and tentorial retractors of the prementum 
(Muscles 34 and 35 of Matsuda) - are quite distinct, 
while in the ephemerid type, only the muscle 31, i.e. 
cranial retractor of prementum (Muscle 34 of Matsuda) 
is present.

In the dictyopteran, orthopteran, neuropteran 
and coleopteran representatives, both these muscles 
originate on the posterior tentorial arm; whereas in 
the isopteran and dipteran types, only one of these 
muscles is present originating on the tentorium, in 
which case, it is impossible to determine whether this
muscle represents muscle 31 or 32. Thus it may be 
either 31 or 32 (i.e. muscles 34 or 35 of Matsuda, 
1965).

In the hymenopteran type, both the cranial and 
tentorial retractor of the prementum i.e. muscles 31, 
32 (i.e. Muscles 34 and 35 of Matsuda, 1965) are 
present. One of the muscles originates on the 
anterior tentorial arm, while the other originates 
on the cranium. These shifts in the points of origin 
of these muscles in the hymenopteran type have been 
secondarily acquired in association with the formation 
of the labio-hypopharyngeal lobe in the Hymenoptera, 

In the heteropteran types, one of these 
muscles i.e. either 31 or 32 (Muscle 34 or 35 of 
Matsuda, 1965), is inserted on the apodeme from the 
proximal area of the first palpal segment and functions 
as the retractor of the rostrum. Both these muscles 
are lacking in the odonatan, mecopteran and 
lepidopteran types.

33. The extrinsic flexor of the paraglossa - (Muscle 36, 
the tentorioparaglossal muscle of Matsuda, 1965).

This muscle is present only in the thysanuran 
type and is found to be lacking in all the other
insectan representatives dealt with in this work.

Origin - On the posterior tentorial arm.
Insertion - On the base of the paraglossa.

34. **The median retractors of the prementum** - (Muscle 38, the submento-premental muscle of Matsuda, 1965).

This is a single median retractor of the prementum present only in the thysanuran, dictyopteran, isopteran mecopteran and coleopteran types.

Origin - On the postmentum.
Insertion - On the median portion of the posterior premental margin.

35. **The retractor of the mentum** - (Muscle 41, the submento-mental muscle of Matsuda, 1965).

This muscle has been found only in the neuropteran type.

Origin - On the proximal margin of the submentum.
Insertion - On the proximal margin of the mentum.

36. **The intrinsic flexor of the glossa** - (Muscle 42, the prementoglossal muscle of Matsuda, 1965).

This muscle occurs in the representatives of all hemimetabolan orders excepting those of Heteroptera and Odonata. In the Holometabola, it is present only
in the hymenopteran type, wherein it is extremely well-developed and paired.

In the odonatan types, it flexes the labial terminal lobe. Since the terminal (lateral) labial lobe is, in Odonata a fusion product of glossa and paraglossa, (Snodgrass 1954, Matsuda, 1965) this muscle moving the lateral lobe of the labium is either only the flexor of the glossa i.e. muscle 36 (Muscle 42 of Matsuda) or only the flexor of the paraglossa i.e. muscle 37 (Muscle 43 of Matsuda) or it may also be the fusion of the flexors of the glossa and paraglossa i.e. muscle 36 and 37 (Muscle 42 and 43 of Matsuda, 1965).

Origin - On the posterolateral angle of the prementum.

Insertion - On the base of the glossa.

37. The intrinsic flexor of the paraglossa - (Muscle 43, the prementoparaglossal muscle of Matsuda, 1965).

This muscle is present in the representatives of all the hemimetabolan orders, excepting those of Heteroptera. In the Holometabola, its distribution is found to be restricted only to the hymenopteran type,
wherin it is well-developed and functions as the retractor of the ligula.

In the odonatan types, this muscle acts as the flexor of the labial lateral lobe. Since the lateral labial lobe is a fusion product of the glossa and paraglossa (Snodgrass, 1954, Matsuda, 1965), this muscle moving the lateral labial lobe is either only the flexor of the glossa i.e. muscle 36 (Muscle 42 of Matsuda) or only the flexor of the paraglossa i.e. muscle 37 (Muscle 43 of Matsuda, 1965). It may also however, be the fusion product of the flexors of the glossa and paraglossa i.e. muscle 36 and 37 (Muscle 42 & 43 of Matsuda).

Origin - On the posterolateral angle of the prementum near the point of origin of the flexor of the glossa.

Insertion - On the base of the paraglossa.

38. The extrinsic levator of the labial palp - (Muscle 45, the prementopalpal muscle of Matsuda, 1965).

This muscle is present in the representatives of all the orders, excepting those of the Odonata and Hymenoptera.
Origin - On the lateral basal portion of the prementum.

Insertion - On the dorsal basal margin of the first palpal segment.

In the case of the ephemerid type, this muscle extends between the distal lateral part of the prementum and the inner basal margin of the second palpal segment.

This muscle in the mecopteran type originates on the mesal basal part of the prementum.

In the heteropteran types, either the extrinsic palpal levator, i.e. muscle 38 (Muscle 45 of Matsuda 1965) or the extrinsic palpal depressor i.e. muscle 39 (Muscle 44 of Matsuda, 1965) or the fusion product of both these muscles is modified into the adductor of the rostrum. In this case, these muscles arise on the premental apodeme and are inserted on the base of the first rostral segment.

In the dipteran type, this muscle is modified into the extensor of the labellum (Premento-hypoglossal muscle of Matsuda, 1965) which also rotates the labella.
39. **The extrinsic depressor of the labial palp** - (Muscle 44, the premento-palpal muscle of Matsuda, 1965).

This muscle occurs in the representatives of all hemimetabolan orders. In the Holometabola, this muscle is present in the representatives of Neuroptera, Hymenoptera, Mecoptera and Diptera, whereas it is absent in the lepidopteran and coleopteran representatives.

The palpal muscle of the labium in the hymenopteran type may be either palpal levator i.e. muscle 38 (Muscle 45 of Matsuda, 1965) or it may be also palpal depressor i.e. muscle 39 (Muscle 44 of Matsuda, 1965). However, this muscle in the hymenopteran representative functions as the flexor or the depressor of the palp.

In the mecopteran and dipteran types, this muscle is represented by two fasciculi— one inserts normally at the base of the first palpal segment, whereas the other has shifted its attachment to the base of the second one.

In the dipteran representative, both the fasciculi of this muscle are further modified into the flexors of the labellum (the premento-furcal and epifurcal muscles of Matsuda, 1965).
Origin - On the mesal basal portion of the prementum.

Insertion - On the ventral basal margin of the first palpal segment.

In the case of the ephemerid type, this muscle connects the distal lateral part of the prementum and the outer basal margin of the second palpal segment.

40. The intrinsic levators of the labial palp.

This muscle is present in the first two palpal segments of the thysanuran, dictyopteran, isopteran and neuropteran types.

In the orthopteran, coleopteran, hymenopteran and lepidopteran types, this muscle occurs only in the first palpal segment.

Origin - On the proximal basal margin of the palpal segment.

Insertion - On the same portion of the succeeding palpal segment.

In the case of the dictyopteran type, this muscle connects the distal portion of the prementum and the proximal basal margin of the third palpal segment.
These intrinsic labial levator muscles in the heteropteran representatives are modified into the distal retractors and adductors of the rostrum.

They are absent in the ephemerid, odonatan, mecopteran and dipteran types.

41. The intrinsic depressor of the labial palp-

This muscle occurs in the first two segments of the labial palp in the cases of the thysanuran, dictyopteran, isopteran and neuropteran types.

In the lepidopteran type, this muscle occurs only in the first palpal segment, whereas in the orthopteran, coleopteran and hymenopteran types, this muscle occurs in the second palpal segment alone.

The intrinsic depressors of the labial palp in the heteropteran type are modified into the distal retractors and adductors of the rostrum.

They are absent in the ephemerid, odonatan, mecopteran and dipteran types.

Origin - On the lateral basal portion of the palpal segment.

Insertion - On the same portion of the succeeding palpal segment.
In the dictyopteran type, this muscle extends between the distal lateral part of the prementum and the lateral basal part of the third palpal segment.

42. The hypopharyngeo-premental retractor muscles - (Muscles 46 and 47 the premento-salivarial muscles of Matsuda, 1965).

These are the ventral dilators of the salivary apparatus in the dictyopteran, isopteran, orthopteran and neuropteran types.

In the ephemerid and odonatan types, this muscle serves as the retractor of the prementum, since the muscle inserts on the hypopharyngeal sclerite.

This muscle is absent in the thysanuran, heteropteran, coleopteran, mecopteran, hymenopteran, lepidopteran and dipteran representatives.

Origin - On the lateral basal part of the prementum.

Insertion - On the ventral part of the salivarium or on the hypopharyngeal sclerite.

43. The hypopharyngeo-premental protractor muscle - (Muscle 79, the loral arm - lingual sclerite muscle of Matsuda, 1965).
This is a hypopharyngeal muscle. However, in the heteropteran types, this muscle has shifted its attachments to the wall of the first definitive rostral segment and the apodeme from the prementum and thus functions as the protractor of the rostrum.

**Origin** - On the wall of the first definitive rostral segment.

**Insertion** - On the adductor apodeme of the prementum.

44. **The muscles of the labial elbow** -

These are the special labial muscles found only in the odonatan types. They are believed to have been acquired coenogenetically by the odonate nymphs during their evolution. These muscles are retained in the adult stages also. Consequently, their homology is impossible to determine. (Munscheid 1933, Snodgrass 1954, Asahina, 1954).

**Origin** - On the postmental ridge.

**Insertion** - On the basal area of the prementum.

45. **The compressors of the labial haustellum** -

These are the special vertical (transverse) labial muscles in haustellar region of the dipteran
representative. These muscles control the depth of the labial gutter.

Since these muscles are absent in all the other insectan types, their homology can not be determined.

Origin - On the distal dorsal wall of the haustellum.

Insertion - On the distal ventral wall of the haustellum.
PART - II. THE THORACIC MUSCLES

The various thoracic muscles of the insectan types, mentioned in the chapter I, are described in the following pages, with special reference to their attachments, modifications and functions.

The homologies and distribution of these muscles, in the insectan types, are presented in the chart II that follows in the later pages.

(A) THE TERGAL MUSCLES:

1. The median dorsal longitudinal muscles - (Muscles t 11 and t 14 and muscles 4 and 5 in Lepisma- Matsuda, 1970).

These muscles are present in all the insectan types excepting those of the Odonata. They are very weakly developed in the thysanuran, dictyopteran and isopteran representatives. In the other pterygote types, these muscles are the indirect wing depressors and in the strong fliers like the coleopteran, hymenopteran, lepidopteran and dipteran types, these muscles are represented by several bundles of muscle fibers.
Origin - On the posterior face of the phragmata.
Insertion - On the anterior face of the succeeding phragmata in the thorax.

In the metathorax of the heteropteran types, these muscles insert anteriorly on the movable metanotal plate, and thus on contraction, they unfold the wings.

2. The oblique dorsal longitudinal muscles - (Muscles t 12 and t 13 and muscle 6 in Lepisma - Matsuda, 1970).

These muscles are present in all the insectan types dealt with in this work, excepting those of the Odonata. They are very weakly developed in the thysanuran, dictyopteran and isopteran types. In the ephemerid type, they occur only in the prothorax.

In the other pterygotes types, these muscles are the indirect flight muscles antagonistic to median dorsal longitudinals in function. In the heteropteran types, these muscles are responsible for unlocking the wings.

Origin - On the ventral end of the phragma.
Insertion - On the postero-lateral area of the tergum.

This muscle has been found only in the orthopteran type. It regulates the curvature of the tergum. Since this muscle is absent in all the other insectan types, its homology is impossible to determine.

It passes transversely across the median lobe of the definitive scutellum and is attached to it at either side.

4. **The lateral transegmental dorsal longitudinal muscles**
   (Muscles 1, 2, 3 in Lepisma - Matsuda, 1970).

These muscles are found only in the thysanuran type, wherein they bind and brace the thoracic dorsum internally.

**Origin** - On the lateral tergal area.
**Insertion** - On the posterolateral area of the succeeding tergum.

5. **The median transegmental dorsal longitudinal muscles**
   (Muscles t 18 and t 19 of Matsuda, 1970).

These occur only in the odonatan types, wherein they regulate the curvature of the thoracic dorsum during flight.

**Origin** - On the tergal apophyses.
**Insertion** - On the succeeding tergal apophyses or on the anterolateral areas of the tergum of succeeding segments.

These muscles are present only in the thysanuran type. They help in binding the abdomen and the thorax.

Origin - On the second phragma.
Insertion - On the anterior margin of the second abdominal segment.

(B) THE TERGO-PLEURAL MUSCLES :


These muscles are present in the representatives of the primitive and generalized orders like Thysanura, Ephemeroptera, Orthoptera, Neuroptera and Mecoptera. They are also present in the odonatan types. In the other insectan types under study, these are absent.

Origin - On the posterolateral part of the pronotum.
Insertion - On the dorsal portion of the interpleurite.


These muscles occur in the ephemeropteran, dictyopteran, isopteran, Lepidopteran and dipteran types.
In the thysanuran type, these muscles are present only in the prothorax.

Origin - On the pre-alar sclerite of the phragma or on the corresponding area.

Insertion - On the dorsal margin of the episternum or on the upper part of the basalar sclerite.

In the mesothorax of the coleopteran type, this muscle connects the anterolateral corner of the mesonotum and the pre-alar apophysis and extends the elytron.

In the dipteran type, this muscle inserts on the episternum and functions as the extensor of the wing.

In the other insectan types examined, this muscle is absent.


This muscle has been found only in the neuropteren, hymenopteren, coleopteran and dipteran types. It is absent in all the other insectan representatives.

Origin - On the lateral margin of the scutum.

Insertion - Between the anterior and posterior notal wing processes.
This muscle in the coleopteran type extends the elytron.

10. **The first tergo-pleural muscles or the tergo-ketapleural muscles** - (Muscle t-p; Muscles 81-86 in Lepisma - Matsuda, 1970).

   These muscles are present in all the thoracic segments of the thysanuran type. In the cases of the ephemerid, neuropteran and mecopteran types, these muscles are present only in the prothorax, whereas in other insectan types, these are absent.

   **Origin** - On the antero-lateral or mesolateral part of the tergum.

   **Insertion** - On the ketapleuran.


   In the case of the thysanuran representative, these muscles occur in all the thoracic segments. In the ephemerid, neuropteran and mecopteran types, however, these muscles are present only in the prothorax. In all the other insectan types, these muscles are absent.
Origin - On the posterolateral or posteromesal part of the tergum.

Insertion - On the anapleuran.


These muscles are found only in the representatives of all holometabolous orders dealt with in this work. They are lacking in the representatives of the Thysanura and those of the hemimetabolous orders.

Origin - On the laterophragma. In the coleopteran type, it arises on the pre-alar sclerite.

Insertion - On the ridge of the pleural wing process.

In the coleopteran type, it bends the pleural wing process during flight.

In the mesothorax of the hymenopteran representative, this muscle arises on the epistemum and inserts on the ventral side of the humeral complex of the fore-wing and thus helps in pronation depression of the wing during flight.

This muscle in the dipteran type, stabilizes the pleural wing process during flight.

These muscles are found in all the insectan types under study excepting those of the Odonata.

In the cases of the dictyopteran and isopteran representatives, these muscles are poorly developed and occur only in the metathorax.

In the coleopteran type also, these muscles occur only in the metathorax but they are well-developed.

In all the other pterygote types, these muscles are extremely well-developed and function as the indirect wing-levators. These muscles in the orthopteran type are peculiarly represented by two large muscle bundles.

**Origin** - On the anterior part of the tergum.

**Insertion** - On the ventral part of the pre-episternum or on the lateral part of the basisternum.

In the thysanuran type, this muscle inserts on the ventral part of the anopleuron.

In the heteropteran types, these muscles unfold the wings from wing locking devices.
This muscle in the metathorax of the hymenopteran type, connects metafurcal arm and the metanotal lateral plate.


These muscles are found only in the dictyopteran isopteran and dipteran types. They are absent in all the other insectan representatives dealt with in this work. Normally, these muscles help in pronation extension of the wing during flight.

Origin - On the anterolateral scutal area. In the dipteran type, this muscle arises on the anteromesal part of the scutum.

Insertion - On the lower part of the basalar or on the apodeme from this region.

In the dipteran type, since it originates on the deeper part of the scutum this muscle retracts the wing over the back and thus functions antagonistic to muscle the first tergo-episternal muscle (t-p3 of Matsuda).

This muscle has been found in the ephemerid, heteropteran, coleopteran and dipteran types. It is lacking in all the other insectan types.

Origin - On the anterolateral part of the notal wing process.

Insertion - On the basalare or on the anterior margin of the episternum.

In the ephemerid type, this muscle connects the episternum and the lateral scutal margin above the basalare.

This muscle in the heteropteran type, functions as the wing elevator. It controls the pronation-extension and - depression of the wing in the coleopteran, dipteran types.


These muscles are present in the ephemerid, odonatan, dictyopteran, isopteran, mectopteran and dipteran types.

In the ephemerid type, these muscles help in holding the wing vertically along the axillary inflection, whereas in the other types, it helps in effecting the wing flexion.
Origin - On the anterior notal wing process.
Insertion - On the pleural arm (wing process) or on the first axillary sclerite.

In the mesothorax of the zygopteran odonate type and in the metathorax of zygopteran and anisopteran odonate types, this muscle is proximally attached to the tergal apophysis and is inserted on the axillary plate. In the mesothorax of the anisopteran type, this muscle arises on the plate lateral to scutum and inserts on the axillary plate.

This muscle, in the odonatan types, is the M. tensor lateralis of Tannert (1958).

It supports the wing base during the flight.

17. The first muscle of the third axillary sclerite- (Muscle t-α 13 of Matsuda, 1970).

This muscle is present in all the holometabolan insects examined in this work and it functions as the wing-flexor.

It is absent in all the hemimetabolan types and in that of the Thysanura.

Origin - On the dorsal part of the anepisternum. In the dipteran type, it arises on scutum.
Insertion - On the third axillary sclerite.

18. **The second muscle of the third axillary sclerite**
   (Muscle t-p14 of Matsuda, 1970).

   Excepting those of the thysanuran, ephemerid, odonatan and heteropteran types, this muscle is present in all the insectan representatives dealt with in this work. It is the usual wing flexor muscle.

Origin - On the pleural ridge near the pleural wing process.

Insertion - On the third axillary sclerite.

19. **The muscle of the fourth axillary sclerite**

   This muscle occurs in the ephemerid, dictyopteran, isopteran, neuropteran, coleopteran, mectopteran, lepidopteran and dipteran representatives. Normally, it partakes in effecting the wing-flexion.

   In the ephemerid type, however, this muscle helps in holding the wings vertically along the axillary inflection.

Origin - On the dorsal portion of the pleural ridge.
Insertion - On the fourth axillary sclerite.
This muscle in the dipteran type is represented by three muscle bundles; two are inserted on the posterior notal wing process and third one is inserted on the fourth axillary sclerite. The muscles inserted on the posterior wing process cause the deflection of the posterior margin of the wing during its upstroke.


This muscle is present only in the neuropteran, coleopteran, mectopteran and lepidopteran representatives. It functions as the depressor-extensor of the wing.

It is absent in the other insectan types examined in this work.

Origin - On the postero-dorsal part of the epimeron.

Insertion - On the subalar sclerite.

In the coleopteran type, it controls the position of the second axillary sclerite during wing flexion.


This muscle occurs only in the hymenopteran and mectopteran types, wherein it is a depressor-extensor of
the wing during flight.

It is absent in all the other insects dealt with in this work.

Origin - On the pleural ridge.
Insertion - On the subalare.


This special muscle occurs only in the odonatan types. It is the M. gubernator analis 2 of Tannert (1958) and the third subalar muscle of Neville (1960). It supinates the wing during flight.

In all the other insectan types, this muscle is absent and hence its homology can not be determined.

Origin - On the interpleural ridge.
Insertion - On the ventral pleural margin of the axillary plate.


This also is a special muscle occurring in the odonatan types only. It is the M. gubernator costae of Tannert (1958) and the second basalar muscle of Neville (1960). It controls the downstroke pronation-supination balance of the wing during flight.
Since this muscle is lacking in all the other insectan types, its homology cannot be determined.


A muscle characteristic to the odonatan types alone. It is the M. depressor anterior of Tannert (1958) and the first $\alpha$ basalar muscle of Neville (1960). This muscle helps in controlling the downstroke pronation-supination balance of the wing during flight.

Since this muscle is absent in all the other insectan types, its homology cannot be determined.

A muscle peculiarly found in the odonatan types only. It is the M. depressor medianus of Tannert (1958) and the first subalar muscle of Neville (1960). This muscle directly depresses the wing during flight.

Since this muscle is absent in all the other insectan types, its homology can not be determined.

Origin - On the ventral portion of the epimeron.
Insertion - On the posterior cap-tendon which articulates with the process of R + M veins.


A muscle, exclusively found in the odonatan types. This muscle is the M. depressor posterior of Tannert (1958) and the second subalar muscle of Neville (1960). This muscle depresses the wing and causes supination control of the pronation of the wing during downstroke.

The homology of this muscle can not be determined, since it is lacking in all the other insectan types.
Origin - On the ventral portion of the epimeron.
Insertion - On the ventral posterior margin of the axillary plate.


This muscle also is characteristically found in the odonatan types. It is the \( M. \) gubernator analis of Tannert (1958). It acts as the wing depressor.

Origin - On the posterior surface of the pleural wing process.
Insertion - On the proximal part of the Z-vein in the axillary plate.

Since this muscle is not found in the other insectan types, its homology can not be determined.

(C) **THE TERGOSTERNAL MUSCLES**:

28. **The intersegmental tergo-sternal muscles** - (Muscles t-s1 and t-s2; and muscles 46 and 42 in Lepisma - Matsuda, 1970).

This muscle is persistently present in all the insectan types investigated presently. It functions as the wing levator and thus supplements the action of
the fourth tergo-pleural muscle • muscle 13, (Muscles t-p5 and 6 of Matsuda, 1970).

Origin - On the furca.
Insertion - On the phragma of the succeeding thoracic segment.

In the metathorax of the odonatan types, this muscle connects the posterior end of the furcal invagination and antecosta of the first abdominal segment and therefore acts as the levator of the abdomen.


These muscles are present only in the thysanuran type.

Origin - On the endosternal process.
Insertion - On the anterolateral area of the tergum of the succeeding segment.

30. The furco-subalar muscle - (Muscles t-s4 and t-s5 of Matsuda, 1970).

These muscles are found to occur only in the ephemerid and hymenopteran types, wherein they
act as the depressor-extensors of the wing.

In the other insectan types investigated here, these muscles are lacking.

**Origin** - On the subalar sclerite or on the apodeme from this area.

**Insertion** - On the furca or furcosternum.


These muscles are present only in the thysanuran type and are represented by many bundles of muscle fibers.

**Origin** - On the endonotal phragma and on the lateral tergal area.

**Insertion** - On the different points of the endosternal tigella.


These muscles are present in the thysanuran, ephemerid, and neuropt eran types, wherein they are represented by many bundles of muscle fibers. They are absent in the other insects investigated in this work.
They also act as the wing levators, thereby supplementing the action of the fourth tergo-pleural muscle (t-p5 and-6 of Matsuda, 1970).

**Origin** - On the antero-lateral tergal area or on the scutum or on the phragma.

**Insertion** - Partly on the sternum, furca and on spina.

**33. The third tergo-sternal muscles** - (Muscles t-s10 and t-s11 of Matsuda, 1970).

These are exclusively present in the odonatan types, where in they are represented by two large muscle bundles in each thoracic segment. They are the **Regio anterior musculi elevatoris** and **Regio Posterior musculi elevatoris** of Tannert (1958) and the anterior- and posterior wing elevators of Neville (1960).

The contraction of these muscles, indirectly, causes elevation of the wing.

Since these muscles are absent in all the other insectan types studied hereby, the homology of these muscles can not be determined.

**Origin** - The anterior muscle bundle arises on the prefurca, whereas the posterior muscles originate on the furca.
Insertion - The anterior muscle bundle inserts partly on the tergal apophysis and partly on the antero-mesal scutal area. The posterior muscle bundles are attached dorsally on the postero-mesal scutal area and on the notal wing process.

34. The furcal muscle of the third axillary sclerite - (Muscle t-s3; and muscle 45 in Lepisma - Matsuda, 1970).

This muscle has been found only in the ephemeropteran representative, wherein, it causes a slight flexion of the wing and is also responsible in holding the wings vertically along the axillary inflection.

Since this muscle is absent in all the other insectan types examined here, the homology of this muscle remains unclear.

Origin - On the furca.
Insertion - At the junction of the first and second axillary sclerites.

(D) THE TERGO-TROCHANTINAL AND TERGO COXAL MUSCLES;

35. The tergo-trochantinal muscles - (Muscles t-ti (cx) 1, t-ti (cx) 2, t-ti (cx) 3; and Muscles 71, 72 and 73 in Lepisma - Matsuda, 1970).
These muscles are present in all the insectan types dealt with in this work, excepting that of the Hymenoptera. They are primarily the leg muscles, promoting the coxa.

In the ephemerid and odonatan types these muscles are modified into the tergocoxals, since the trochantin is absent in Ephemeroptera and Odonata (Snodgrass, 1954, Matsuda, 1970).

In the orthopteran, dictyopteran and isopteran types, these muscles are bifunctional, since they also help in wing elevation during flight. (Wilson 1962, Chapdwick, 1953).

In the heteropteran types, these muscles help in the wing depression, since in the Heteroptera, the dorsal longitudinal muscles are weakly developed and are inserted on the movable plate at the anterolateral scutal area (Larsen 1949a).

In the coleopteran type, these muscles are modified completely into the wing elevators, since the coxalbase is incorporated into the body wall (Chapdwick, 1953).

Origin - On the anterior portion of the tergum.
Insertion - On the trochantin or on the apodeme from it.

These muscles are present only in the thysanuran, ephemerid and odonatan types. In the other insectan types examined in this work, these muscles are absent.

In the ephemerid and odonatan types, this muscle functions as a direct flight muscle. In the former, it is responsible for holding the wings vertically along the axillary inflection, whereas in the odonatan types, this muscle acts as wing supinator.

In the thysanuran type, however, these are the leg muscles.

Origin - On the coxal process.
Insertion - On the first or second axillary sclerite in the ephemerid type. In the odonatan types, it inserts on the axillary plate.

In the thysanuran type, these muscles attach on the antero-lateral part of the tergum.

37. The tergal remotors of the coxa - (Muscles t-cx5, t-cx6, t-cx7, Muscles 61 and 63 or 64 and 65 in Lepisma - Matsuda, 1970).
These muscles are found in all the insectan types under present investigation excepting that of the Hymenoptera. They are represented by three muscle bundles, which primarily function as the leg muscles.

In the orthopteran, dictyopteran, isopteran and heteropteran types, these muscles are bifunctional, since they also act as the wing elevators during the flight. (Larsen 1949, Chadwick 1953, Wilson, 1962).

In the coleopteran types, these muscles are modified completely into the wing elevators, as the coxal base is incorporated into the bodywall (Chadwick, 1953, Larsson, 1966).

Origin - On the postero-lateral part of the tergum. One of the component muscle bundle arises on the anterolateral part of the tergum.

Insertion - On the posterior coxal margin.

In the mecopteran, lepidopteran and dipteran types, these muscles are represented by only two muscle bundles.
The subalar-coxal muscle - (Muscle t-cx8 of Matsuda, Matsuda, 1970).

The presence of this muscle is noted in all the insectan types excepting those of the Thysanura and Odonata. Normally, this muscle is bifunctional, since it remotes the coxa and during flight, it depresses and supinates the wing.

This muscle in the isopteran type is alone responsible for depressing of the wing during flight.

In the coleopteran type, this muscle is completely modified into a flight muscle as the coxal base in the Coleoptera is incorporated into the body wall (Chadwick 1953, Larsen, 1966). It acts as a supinator depressing the posterior margin of the wing during upstroke. This is done by virtue of the connection of the subalar (to which this muscle is attached) with the second and third axillary sclerites.

Origin - On the subalar.
Insertion - On the posterior coxal rim.

In the metathorax of the dipteran type, this muscle connects the ventral pleural arm and the basalar and hence it acts as the depressor of the halter.

This muscle is present in the orthopteran, neuropteran, coleopteran and dipteran types. In all the other insectan types under investigation, this muscle is lacking.

Origin - On the anepisternum.
Insertion - On the basisternum.

40. The second pleural muscle - (Muscle p2; Muscle 26 in Lepisma- Matsuda, 1970).

The presence of this muscle has been noted in all the holometabolan insects excepting the coleopteran type.

It is absent in all the hemimetabolan representatives investigated here.

This muscle in the dipteran type is greatly enlarged. By pulling the basalar ventrad and inward, it accounts for the ventral deflection and forward thrust of the anterior margin of the wing during downstroke.

Origin - On the intersegmental pleurite.
Insertion - On the basalar.

This muscle is present in the orthopteran, heteropteran and all the holometabolan types examined.

It usually functions as the pronator-depressor of the wing.

In the heteropteran type, however, this muscle levates the wings; and in the hymenopteran type, it controls the amplitude of the wingbeat.

**Origin** - On the anterior part of the anepisternum or on the basalare.

**Insertion** - On the ventral part of the pre-episternum.

This muscle is absent in all the other insectan types dealt with in this work.

42. **The fourth pleural muscle** - (Muscle p5 of Matsuda, 1970).

This muscle has been found only in the ephemerid type. It functionally compensates the absence of the third pleural muscle (p3 of Matsuda) in this type.

**Origin** - On the pleural wing process.

**Insertion** - On the basalare.

This muscle occurs only in the thysanuran type. It probably helps in producing traction movements of the thorax that trails on the ground, since the limbs are weak in this type. It also controls the curvature of this part of the thorax.

Origin - On the posterior anapleural apophysis.
Insertion - On the endosternum of the succeeding segment.

44. The first pleuro-sternal muscle - (Muscle p-s1; 27(?) in Lepisma-Matsuda, 1970).

This muscle is present in all the insectan types dealt with in this work, excepting those of the Ephemeroptera and Odonata. It braces the ventral portion of the pleuron and by its tonic contraction, it maintains the curvature of this part of the thorax.

Origin - On the pleuron.
Insertion - On the endosternum.

   This muscle occurs in the dictyopteran, isopteran, orthopteran and neuropteran types. It is absent in all the other insectan types examined. This muscle also helps in maintaining the curvature of the ventral part of the pleuron by its tonic contraction.

   **Origin** - On the spina.

   **Insertion** - On the anterior margin of the episternum.

46. **The first intersegmental pleurosternal muscle** - (Muscle p-s3; muscle 42 in Lepisma-Matsuda, 1970).

   This muscle is present in the thysanuran, orthopteran, neuropteran, coleopteran, mecopteran and lepidoteran representatives.

   It maintains and regulates the curvature of the ventral part of the pleuron, it also keeps up the lateral tension in the thoracic capsule. Furthermore, it partakes in the production of the traction movement in the thorax, in the case of the thysanuran type.

   In the other insectan types examined, this muscle is absent.
Origin - On the furca.
Insertion - On the anterior margin of the epistemum of the succeeding segment.


These muscles are found only in the dictyopteran, isopteran, heteropteran, neuropteran and dipteran representatives, wherein they function as the abductors of the coxa.

They are lacking in all the other insectan types examined.

Origin - On the furca.
Insertion - On the post-coxal membrane.


This muscle occurs in the thysanuran, dictyopteran, isopteran and orthopteran types, wherein it helps in regulating the ventral pleural curvature. It is absent in all the other insectan types investigated here.

Origin - On the spina.
Insertion - On the intersegmental pleurite.

This muscle is present in the thysanuran and ephemerid types and it is lacking in all the other insectan representatives examined here.

In the thysanuran type, it helps in producing the traction in the thorax.

This muscle in the ephemerid type is well-developed and has two component muscle bundles. On contraction, these muscles cause the extension of the wing. Because the basalare, on which these muscles originate, is connected with the tegula and the humeral plate.

**Origin** - On the basalare and in the thysanuran type, on the corresponding part.

**Insertion** - One of the component muscles inserts on the furca of the preceding segment, whereas the other component muscle inserts on the posterolateral portion of the preceding sternum.

This is crucial muscle present only in the dictyopteran representative. It is absent in all the other insectan types examined presently.

Origin † On the profurca.
Insertion - On the mesepisternum of the opposite side.

This muscle serves to maintain the pleural curvature by its tonic contraction.

51. The third intersegmental pleurosternal muscle -

This muscle is present only in the dictyopteran and isopteran representatives. It is absent in all the other insectan types studied presently.

Origin - On the second spina.
Insertion - On the anterolateral part of the second abdominal segment.

This muscle, seemingly, helps in keeping the abdomen lifted above the ground level by its tonic contraction.
52. The first sternal promotor of the coxa - (Muscle S-cx1; Muscle 31 in Lepisma - Matsuda, 1970).

This muscle is found in the representatives of the Thysanura, Dictyoptera, Isoptera, and Orthoptera and Neuroptera. It is absent in the other insectan types dealt within this work.

Origin - On the spina.

Insertion - Near the pleuro-coxal articulation or on the trochantin.

53. The second sternal promotor of the coxa - (Muscle S-cx5; Muscle 34 in Lepisma - Matsuda, 1970).

This muscle occurs in all the insectan representatives, excepting those of the Odonata, Heteroptera and Coleoptera.

Origin - On the furca or the basisternum.

Insertion - On the anterior coxal margin.


The presence of these muscles has been noted in all the insectan types dealt with in this work, excepting those of the Odonata and Hymenoptera.
Origin - On the furca or on the basisternum.

Insertion - On the anterior coxal margin or on the internal coxal ridge.

55. The first sternal remotors of the coxa - (Muscle S-cx2; Muscle 33 in Lepisma - Matsuda, 1970).

Only the odonatan and heteropteran types exhibit the absence of this muscle. In all the other insectan representatives examined this muscle occurs.

Origin - On the furca.

Insertion - On or below the pleural ridge. In the orthopteran type, this muscle arises from the posterior coxal margin. In the dipteran type, this muscle is inserted on the pleural ridge process.

56. The second sternal remotors of coxa - (Muscles S-cx3, S-cx4; Muscles; 36, 37 in Lepisma - Matsuda, 1970).

This muscle persistently occurs in all the insectan types dealt with in this work.

Origin - On the posterior furcal margin or on the spina. In the orthopteran type, it arises on the secondary sternal ridge, posterolateral to the furcal base.
Insertion - On the posterior coxal margin.

57. The third sternal remotor of the coxa - (Muscle S-cx3; Muscle 31 in Lepisma - Matsuda, 1970).

The distribution of this muscle is restricted only to the thysanuran and ephemerid types.

Origin - On the basisternal invagination.
Insertion - On the basal margin of the coxa of the opposite side.

(H) THE PLEURO-COXAL AND THE PLEURO-TROCHANTINAL MUSCLES

58. The Pleuro-trochantinal muscles - (Muscles P-ti(cx)1, P-ti(cx)2, P-ti(cx)3 of Matsuda, 1970).

These muscles are present in all the insectan types examined hereby, excepting those of the Thysanura, Ephemeroptera, Odonata and Hymenoptera.

Normally, they function as the leg muscles. However, in the dictyopteran, isopteran and orthopteran types, they are bifunctional (Chadwick 1953, Wilson 1962), since they also act as the pronator-depressor of the wing during flight.

In the coleopteran type, these muscles are completely modified into the pronator-depressors of the
wing, as the leg-base in the Coleoptera is incorporated into the body wall. (Larsen 1966, Chadwick 1953).

Origin - On the lower anterior margin of the episternum. In the dictyopteran type, this muscle arises on the dorsal area of the anepisternum.

Insertion - On the anterior part of the trochantin.


These muscles are persistently present in all the insectan types investigated in this work. These are normally abductors of the leg.

In the coleopteran type, however, they are modified into the pronator-depressors of the wing, since the leg base in the Coleoptera is incorporated into the body wall. (Chadwick 1953, Larsen 1966).

Origin - Dorsal area of the anepisternum or on the pleural arm.

Insertion - On the anterior coxal rim. In the heteropteran types, these muscles insert, on the pleural process.
60. **The first pleural remotor of the coxa** (Muscle p-cx6; Muscle 102 in Lepisma - Matsuda, 1970).

This muscle occurs only in the thysanuran type. It is found to be lacking in all the other insectan types investigated.

Origin - On the dorsal portion of the pleuron or on the pleural arm.

Insertion - On the posterior margin of the coxa.


These muscles are present only in the dictyopteran, isopteran and neuropteran representatives. In all the other insectan types examined hereby, this muscle is lacking.

Origin - On the interpleural sclerite.

Insertion - On the pleural articulation of the coxa of opposite side.


Origin - On the epimeral area.

Insertion - On the posterior coxal margin.
I. THE TROCHANTERAL MUSCLES:

63. The tergal depressor of the trochanter - (Muscle t-tr1; Muscle 52 in Lepisma, Matsuda, 1970).

This muscle is present in all the insectan types investigated hereby, excepting those of the Odonata and Hymenoptera. Primarily, this is a leg muscle.

In the dictyopteran, isopteran and orthopteran types, this muscle is bifunctional, since it also acts as a levator of the wing during flight (Chajfidwick 1953, Wilson 1962).

In the dictyopteran, isopteran and orthopteran types, this muscle again is bifunctional, since it depresses the wing during flight and acts as a functional replacement for the weak dorsal longitudinals, which insert on the movable plate at the anterolateral scutal area. (Larsen, 1949a).

In the case of the coleopteran types, this muscle is completely modified into a levator of the wing (elytron), since in the Coleoptera the base is incorporated into the body wall. (Chajfidwick 1953, Larsen 1966).

This muscle in the dipteran types acts as a 'starter' in flight (Smart, 1958).
Origin - On the scutum.
Insertion - On the trochanter or on the apodeme from this part.

64. The trochanteral muscle of the axillary sclerite - (Muscle t-tr2; Muscle 62? in Lepisma - Matsuda, 1970).

A unique muscle present only in the ephemerid type. It is a direct wing muscle and is responsible for holding the wings vertically along the axillary inflection by virtue of its dorsal attachment on the first axillary sclerite.

Origin - On the trochanter.
Insertion - On the first axillary sclerite.

65. The first pleural levator of the trochanter - (Muscles P-tr1 and P-tr4; muscles 53 or 54 in Lepisma - Matsuda 1970).

This muscle is present in the representatives of the Thysanura, Ephemeroptera, Orthoptera, Heteroptera, Neuroptera, Hymenoptera and Coleoptera. In all the other insect types dealt with in this work, this muscle is lacking.

Origin - On the episternum or on the pleural arm.
Insertion - On the trochanter or on the apodeme from it.

This muscle is present in the thysanuran, ephemerid, orthopteran, heteropteran, neuropteran, coleopteran, mecopteran and lepidopteran types. It is absent in the other insectan types under study.

Origin - On the dorsal part of the episternum.
Insertion - On the trochanter.


This muscle occurs in the ephemerid, odonatan, dictyopteran, isopteran and coleopteran representatives. In the other insectan types investigated here, this muscle is found to be lacking.

Origin - On the epimeron. In the coleopteran type it arises on the crypto-pleural ridge which is the displaced epimeron.

Insertion - On the trochanter.

This muscle is present in all the insectan types investigated hereby, excepting that of the Ephemeroptera.

Origin - On the furca.
Insertion - On the anterior wall of the trochanter.

(J) THE STERNAL MUSCLES :

69. The ventral longitudinal muscles - (Muscles S11, S12, S13, S14, S22; and Muscles 12, 15, 18, 19 - Matsuda, 1970).

These muscles are persistantly present in all the insectan types investigated presently. They brace and help in binding the thoracic ventrum. In the thysanuran type, they help in producing the traction in the thorax.

Origin - On the spina or furca of the thoracic segment.
Insertion - On the same parts of the succeeding thoracic segment.

In the odonatan representatives, these muscles occur only in the metathorax, wherein they connect the metafurcal invagination and the poststernum.

These occur only in the thysanuran, dictyopteran, isopteran and orthopteran types. In all the other insectan types examined, this muscle is lacking. They also help in binding the thoracic ventrum. In the thysanuran type they partake in the production of the traction in the thorax.

**Origin** - On the furca of the thoracic segment.
**Insertion** - On the spina of the succeeding thoracic segment.


These muscles are present only in the odonatan types. They are lacking in all the other insectan types examined hereby. These muscles, perhaps, help in binding the abdomen with the thorax and lifting it when needed.

In the odonatan types, these muscles exhibit a unique disposition -
Origin - On the profurca.

Insertion - On the anterior margin of the first abdominal segment.

In the dictyopteran type, these muscles occur only in the metathorax.

Origin - On the metafurca.

Insertion - On the anterior margin of the second abdominal segment.
PART - III. THE MUSCLES IN THE PREGENITAL ABDOMINAL SEGMENTS. (SEGMENTS 1-7.)

The various muscles in the pregenital abdominal segments of the insectan types mentioned in the chapter-I are described below, with special reference to their attachments and functions.

The homology and distribution of these muscles in the insect types is given in the chart III, that follows in the later pages -

(A) THE DORSAL ABDOMINAL MUSCLES :


These are the median dorsal longitudinal muscles represented by muscle strips of segmental length, occupying the inner tergal area. They are present in all the pregenital abdominal segments in the cases of the thysanuran, ephemerid, dictyopteran, isopteran, orthopteran, neuropteran, mecopteran, coleopteran hymenopteran and lepidopteran types. On the contrary, these muscles are lacking in all the abdominal segments in the representatives of the Odonata and cryptocerate Heteroptera.
In the gymnocerate heteropteran type, however, these muscles are restricted only to the abdominal segments No. 1, 2, 3 and 6, whereas in the lepidopteran and dipteron types they occur, only in the first segment of the abdomen.

Normally, these muscles bind and brace the abdominal dorsum. In the thysanuran and ephemerid types, these muscles fuse with the M. dorsales interni laterales (Muscle 2; 'dil' of Snodgrass, 1935) to form the large muscle bundle that braces and binds the abdominal terga. In the thysanuran type, (and perhaps in the nymphal ephemerids) these muscles produce undulating and traction movements in the less sclerotized abdomen trailing and thus help in locomotion.

In all the pterygote types, they also serve to keep the abdomen lifted above the ground level by their tonic contraction.

Besides, these muscles retract the abdomen anteriorly and thereby help in effecting the expiratory movements.

In the cases of the hymenopteran type, these muscles are reduced and are represented by a single strip of muscle fibers that brings about the telescoping of the abdomen, since it is disposed obliquely with an
outward slant anteriorly towards its point of origin.

Origin - On the posterior face of the phragma, mesally.

Insertion - On the anterior mesal face of the succeeding phragma in the abdomen.


These are the lateral dorsal longitudinal muscles of segmental length, occurring in the inner tergal area. They are present in all the pregenital abdominal segments in the thysanuran, ephemerid, dictyopteran, isopteran, orthopteran, neuropteron coleopteran and mecopteran types.

In the gymnocerate heteropteran and lepidopteron types, they are present only in the first abdominal segments.

They are lacking in all the abdominal segments of the odonatan, cryptocerate-heteropteron, hymenopteron and dipteran types.

Normally, these muscles brace and bind the lateral tergal area. In the thysanuran and ephemerid types, these muscles fuse with the *M. dorsales interni mediales* (Muscle 1, 'dim' of Snodgrass 1935) to form a
single large dorso-lateral muscle bundle, that braces and binds abdominal terga. In the thysanuran type and perhaps in the nymphal ephemerid type also, these muscles produce undulating and traction movements in the less sclerotized and trailing abdomen and thus help in locomotion.

In all the pterygote types, these muscles also keep the abdomen lifted above the ground level by their tonic contraction.

Besides these muscles retract the abdomen anteriorly and thereby help in effecting the expiratory movements.

Origin - On the posterolateral face of the phragma.
Insertion - On the anterior lateral face of the succeeding phragma in the abdomen.


These are the short dorsal longitudinal muscles lying in the posterior mesal part of the abdominal terga and occupying the exterior and peripheral position. Usually, they are obliquely disposed with an anteriorly outward slant. They occur in all the pregenital abdominal segments of the thysanuran, ephemerid, odonatan,
dictyopteran, orthopteran, cryptocerate-heteropteran, hymenopteran coleopteran and mecopteran types.

In the cases of the lepidopteran and dipteran types, these muscles occur in the abdominal segments No. 2-7.

They are lacking in all the abdominal segments in the isopteran, gymnocerate heteropteran and neuropteran representatives.

Normally, these muscles brace and bind the junction portions of the abdominal terga. They also impart torsion and twisting movements to the terga against each other by virtue of their oblique disposition.

Origin - On the posterior mesal part of the tergum.
Insertion - More mesally on the anterior face of the tergum. In the cryptocerate heteropteran type, these muscles insert on the elongated apodeme from this area.

In the cases of the orthopteran and hymenopteran types, these muscles are represented by a single reduced muscle strip, the origin of which is transposed to the posterior tergal margin. As a result, this muscle is reversed in position and functionally it becomes antagonistic to the other dorsal longitudinal
muscles. It acts as the protractor of the abdomen since its contraction lengthens the abdomen by decreasing the overlap of the segments.

These muscles in the isopteran queen are well-developed; and they exhibit strong obliquity to such an extent that they almost get transversely disposed. Consequently they function as the transverse compressors of the abdomen and thereby partake in the production of the posteriorly directed peristalsis in the abdomen of the queen. This enables the queen to discharge her eggs fast.

In the dipteran type, these oblique muscles have an outward slant posteriorly towards their point of insertion.


These are the short dorsal longitudinal muscles occupying the exterior and peripheral portion in the posterolateral part of the abdominal terga. Usually, they also show oblique disposition with an anteriorly outward slant.

These muscles are present in all the pregenital abdominal segments in the representatives of the Thysanura, Ephemeroptera, Dictyoptera, Isoptera,
Orthoptera, Cryptocerata, Heteroptera, Hymenoptera, Mecoptera and Diptera.

In the lepidopteran type, however, these muscles occur in the abdominal segments No. 2-7.

They are absent in all the abdominal segments in the odonatan cryptocerate-heteropteran, neuropteran and coleopteran types.

These muscles normally brace and bind the abdominal terga, particularly at the lateral portions. They also impart torsion and twisting movements to the terga against each other, by virtue of their oblique disposition with an outward slant anteriorly.

In the Isopteran queen, these muscles exhibit a very strong obliquity - to an extent that the muscles get almost transversely disposed. Consequently, the muscles function as transverse abdominal compressors and help in producing the posteriorly directed peristalsis. This enables the queen to expell out the eggs at a quicker pace. In the case of the hymenopteran type, these muscles serve also in causing the telescoping of the abdomen, since in this type the oblique disposition of these muscles has an outward slant posteriorly towards their point of insertion. In the dipteran type
also these oblique muscles have an outward slant posteriorly towards their points of insertion.

**Origin** - On the postero-lateral portions of the abdominal terga.

**Insertion** - On the anterolateral part of the phragma of the succeeding segment. In the crypto-cerate-heteropteran type, these muscles insert on the elongated apodeme from the corresponding phragmal area.

**(B) THE VENTRAL ABDOMINAL MUSCLES:**

5. **M. ventrales interni mediales** - (Muscle 'vim' of Snodgrass, 1935).

These are the median ventral longitudinal muscles in the form of muscle bands of segmental length located in the inner sternal area. They are present in all the pregenital abdominal segments in the cases of the thysanuran, ephemerid, zygopteran odonate, dictyopteran, isopteran, orthopteran, neuropteran, hymenopteran and mectopteran representatives.

In the cases of the gymnocerate-heteropteran and lepidopteran types, these muscles have been found only in the first abdominal segment; whereas in the
coleopteran type their presence is restricted to the abdominal segments No. 1, 6 and 7.

These muscles are absent in all the abdominal segments of the anisopteran Odonate, cryptocorate-heteropteran and dipteran representatives.

Normally, these muscles bind and brace the abdominal ventrum. In the thysanuran and ephemerid types these muscles fuse with the M. ventrales intemal laterales (Muscle 7; muscle 'vil' of Snodgrass, 1935) to form the large muscle bundle that braces and binds the abdominal sterna. In the thysanuran type (and perhaps in the nymphal ephemerids) these muscles produce undulating and traction movements in the less sclerotized and trailing abdomen and thus help in locomotion.

In all the pterygote types, these muscles also serve to keep the abdomen lifted above the ground level by their tonic contraction.

Besides, these muscles retract the abdomen anteriorly and thereby help in effecting the expiratory movements.

In the case of the hymenopteran type, these muscles are reduced and are represented by a single strip of muscle fibers which brings about the
telescoping of the abdomen, since it is disposed obliquely with an outward slant anteriorly towards its point of origin.

Origin - On the posterior face of the furca mesally.
Insertion - On the anterior mesal face of the succeeding furca in the abdomen.


These are the lateral ventral longitudinal muscles of segmental length, occurring in the inner sternal area. They are present in all the pregenital abdominal segments in the thysanuran, ephemeropteran, zygopteran-odonate, dictyopteran, isopteran, orthopteran, neuropteran, hymenopteran and mecopteran representatives.

In the cases of the gymnocrate-heteropteran and lepidopteran types, these muscles occur only in the first abdominal segment; whereas in the coleopteran type, these muscles are restricted to abdominal segments No.1,6 and 7.

They are lacking in all the abdominal segments of the anisopteran-odonate, cryptocerate-heteropteran and dipteron representatives.
Normally, these muscles brace and bind the lateral sternal area. In the thysanuran and ephemerid types, these muscles fuse with the M. ventrales interni mediales (Muscle 6; Muscle 'vim' of Snodgrass, 1935) and form a single huge muscle bundle that braces and binds the abdominal sterna. In the thysanuran type, (and perhaps in the nymphal ephemerid also), these muscles produce undulating and traction movements in the less sclerotized and trailing abdomen and thus help in locomotion.

In all the pterygote types, these muscles also serve to keep the abdomen lifted above the ground level by their tonic contractions.

Besides, these muscles retract the abdomen anteriorly and thereby help in producing the expiratory movements. In the hymenopteran type, these muscles help in effecting the telescoping of the abdomen.

Origin — On the posterolateral face of the furca.
Insertion — On the anterior lateral face of the succeeding furca in the abdomen.


These are the short ventral longitudinal muscles lying in the posterior mesal part of the abdominal sterna occupying the exterior and peripheral position. Usually, they are obliquely disposed with an anteriorly
outward slant. They occur in all the pregenital abdominal segments of the thysanuran, ephemerid, odonatan, dictyopteran, orthopteran, cryptocerate-heteropteran, mecopteran and dipteran types.

In the lepidopteran type, these muscles are present in the abdominal segments No. 2-7; whereas in the case of the coleopteran type they occur in the abdominal segments No. 1, 2, 6 and 7.

In the case of the gymnocerate heteropteran representative, their presence is restricted only to the abdominal segment No. 6.

These muscles are, however, absent in all the abdominal segments of the isopteran and hymenopteran types.

Normally, these muscles serve to bind and brace the junction portions of the abdominal sterna. They also impart torsion and twisting movements to the sterna against each other by virtue of their oblique disposition.

Origin - On the posteromesal part of the sternum.
Insertion - More mesally on the anterior face of the furca of the succeeding segment. In the cryptocerate-heteropteran type, these
muscles insert on the median apodeme from the furca of the succeeding segment.

In the odonatan types, these muscles are represented by two small muscle bands. The first one arises on the anterolateral part of the sternum and inserts on the apophysis in the anteromesal sternal area, thereby disposing itself almost vertically. The second one has its usual origin on the posteromesal part of the sternum, but its insertion is transposed to the lateral sternal area, orienting the muscle in the transverse plane in the posterior sternal area. Thus, both these muscles become intrasegmental and serve to compress the abdominal sterna in different planes.

These muscles, in the isopteran queen exhibit a very strong obliquity - to an extent that the muscles almost get transversely disposed. Thus the muscles act as the transverse compressors of the abdomen and help in effecting the posteriorly directed peristalsis. This enables the queen to expell out the eggs at a quicker rate.


These are the short dorsal longitudinal muscles occupying the exterior and peripheral position in the
posterolateral part of the abdominal sterna. Usually these muscles are obliquely disposed with an anteriorly outward slant.

These muscles occur in all the pregenital abdominal segments in the thysanuran, ephemerid, anisopteran-odonate, dictyopteran, orthopteran, crypto- cerate-heteropteran, mectopteran and dipteran representatives.

In the lepidopteran type, these muscles are present in the abdominal segments No. 2-7; whereas in the coleopteran type, they are present in the abdominal segments No. 1, 2, 6 and 7.

In the case of the gymnocerate-heteropteran type, however, these muscles are restricted only to the abdominal segment No. 6.

They are lacking in all the abdominal segments of the anisopteran and hymenopteran representatives.

Normally, these muscles brace and bind the abdominal sterna, particularly at the lateral portions. They also impart torsion and twisting movements to the sterna against each other by virtue of their oblique disposition with an anteriorly outward slant.
In the isopteran queen, these muscles have a maximum oblique disposition. As a result, these muscles get almost transversely disposed and on contraction they compress the abdomen in the transverse plane. Thus, they help in producing the posteriorly directed peristalsis in the abdomen of the queen, which enables her to dispose off the eggs in a quick manner and continuously.

In the case of the hymenopteran type, these muscles serve also in causing the telescoping of the abdomen, since in this type the obliquity of these muscles has outward slant posteriorly towards their points of insertion.

Origin - On the posterolateral portions of the abdominal sterna.

Insertion - On the anterolateral part of the succeeding segment. In the cryptocerate-heteropteran type, these muscles insert on the median apodeme from the succeeding furca.

(C) THE LATERAL ABDOMINAL MUSCLES:


These are the vertical tergo-sternal muscle strips located in the inner lateral portions of the
abdominal segments. They are present in all the pregenital abdominal segments of all the insectan types under investigation excepting those of the Odonata.

In the representatives of the primitive and generalized orders like Thysanura, Ephemeroptera, Dictyoptera, Isoptera, Orthoptera, Neuroptera and Mecoptera, these muscles are inter-segmental. For they have their -

Origin - On the posterolateral part of the tergum.
Insertion - On the lateral furcal area of the succeeding segment.

Thus, these muscles in such cases brace and bind the lateral abdominal area and maintain the elasticity of the abdominal capsule by their tonic contraction. They also function as the vertical compressors of the abdomen and thereby produce the expiratory movements.

In the representatives of the higher orders like Heteroptera, Hymenoptera; Coleoptera, Lepidoptera and Diptera, these muscles are intrasegmental, since they have their -

Origin - On the posterolateral part of the tergum.
Insertion - On the same portion of the corresponding sternum.
In such cases, these muscles function purely and more efficiently as the abdominal vertical compressors and hence produce quicker and more effective expiratory movements.

These muscles in the cryptocerate-heteropteran type are represented by several small muscle strips that are distributed all along the length of each pregenital abdominal segment.


These are the vertical (or obliquely disposed) tergo-sternal muscle bands occupying the lateral peripheral portions of the abdominal segments. They occur as the intrasegmental muscle strips in all the pregenital abdominal segments of all the insectan types dealt with in this work, excepting those of the Odonata.

These muscles function as the vertical compressors of the abdomen and thus effect the expiratory movements.

Origin - On the extreme lateral portions of the tergum.

Insertion - On the same portions of the corresponding sternum.
In the orthopteran type, these muscle bands cross each other before they insert on the sternum.

These muscles in the cryptocerate-heteropteran type are represented by several small muscle strips that are distributed all along the length of each pregenital abdominal segment.

(D) **THE TRANSVERSE ABDOMINAL MUSCLES** :

11. *M. transversi dorsales* -

These are the fan-shaped muscles of the dorsal diaphragm or the alary muscles, located internally to the dorsal longitudinal muscles.

They occur in all the pregenital abdominal segments of all the insectan types dealt with in this work, and they serve in effecting the diastole of the cardiac chambers. They also play an important role in circulation by separating the pericardial and pervisceral sinuses by their contractions.

**Origin** - The fibers of these muscles arise in groups on the anterior edges of the lateral parts of the abdominal terga.

**Insertion** - These muscles spread mesally and have broad insertions along the ventral wall of the
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heart, or they may be continuous across
the ventral wall with muscle fibers from
the opposite side.


These are the muscles of the ventral diaphragm
located internally to the ventral longitudinal muscles.
Usually, they consist of compact bundles of muscle fibers
crossing the anterior part of the abdominal sterna and
connecting the lateral sternal parts of both the sides.

They occur in all the pregential abdominal
segments of the thysanuran, ephemerid, dictyopteran,
isopteran, orthopteran, neuropteren, coleopteran,
hymenopteran, mectopteran, lepidopteran and dipteren
representatives.

In the hymenopteran type, however these muscles
form a continuous sheet of weblike structure along with
the connective tissue membranellae.

Usually these muscles play an important role in
circulation by separating the perivisceral and ventral
sinuses and also by their contractions.