Skeletal muscles are conventionally considered in the treatise of comparative anatomy under two broad headings:

1. Segmental (somatic or myotomic) musculature
2. Branchiomeric (visceral) musculature

1. Segmental musculature

The segmental muscles are the muscles of the trunk and tail i.e. axial muscle. The muscles of the paired and unpaired fins i.e. appendicular muscles are also derived from the myotomes and therefore segmental in nature. These muscles are innervated by spinal nerves and are meant for the production of motion and locomotion.

2. Branchiomeric musculature

Branchiomeric muscles on the other hand are the muscles of the jaws, hyoid and gill arches. These muscles are innervated by the trigeminal, facial, glossopharyngeal and vagus nerves and are usually meant for food capture, food mastication and respiratory movements.

From the morphological standpoint the branchiomeric muscles are commonly known as head or cranial muscles because of the fact that they are somehow or other connected with the neurocranium and branchiocranium or better syncranium as termed by Gregory (1951). The cranial muscles are included within three complexes such as (A) mandibular complex, (B) hyoid complex and (C) branchial complex (Edgeworth, 1935).

In order to provide a bird's eye view to all the cranial muscles of the fishes as revealed from the present investigation, a classified list of the same is given below. The same list may be used as an
index of the detail descriptions of the muscles as given below. In this connection it may be pointed out that segmental muscle has not been included in the plan of present investigation.

Further it is noteworthy to mention here that in order to avoid any repetition of facts the main description has been provided on the ocular side of *C. areol* only. However, the differences if any, marked on the blind side or in the rest of the fishes have been mentioned specially.

List of cranial muscles of the presently studied fishes

A. Mandibular muscle complex
   a) Constrictor dorsalis group
      1. M. levator arcus palatini
      2. M. protractor hyomandibularis
      3. M. dilator operculi
   b) Adductor mandibulae group
      4. M. levator maxillae superioris
      5. M. adductor mandibularis
      6. M. intramandibularis
   c) Intermandibularis group
      7. M. intermandibularis anterior
      8. M. intermandibularis posterior
         (or m. protractor hyoidei in part)

B. Hyoid muscle complex
   a) Constrictor hyoideus dorsalis group
      9. M. adductor arcus palatini
      10. M. adductor operculi
      11. M. levator operculi
b) Constrictor hyoideus ventralis group
12. M. protractor hyoidei
13. M. abductor branchiostegal is
14. M. constrictor branchiostegal is
15. M. adductor branchiostegal is

c. Branchial muscle complex
a) Dorsal group
16. M. levator externus
17. M. levator internus
18. M. obliquus dorsalis
19. M. adductor
20. M. transversus dorsalis

b) Ventral group
21. M. rectus ventralis
22. M. obliquus
23. M. transversus ventralis
24. M. cleithrobranchialis internus

c) Masticatory group I
(Muscles connected with os pharyngeus superior)
25. M. protractor os pharyngeus superioris
26. M. retractor os pharyngeus superioris
27. M. transversus os pharyngeus superioris

d) Masticatory group II
(Muscles connected with os pharyngeus inferior)
28. M. levator os pharyngeus inferioris
29. M. retractor os pharyngeus inferioris
30. M. depressor os pharyngeus inferioris
31. M. protractor os pharyngeus inferioris
32. M. transversus os pharyngeus inferioris
Anterior pectoral girdle muscle

33. M. protractor pectoralis

Hypobranchial spinal muscle

34. M. cleithrohyoideus

A) Mandibular muscle complex

The mandibular muscle complex gives rise to three groups of muscles which are known as constrictor dorsalis, adductor mandibulae and intermandibular groups.

a) Constrictor dorsalis group

These muscles usually extend from the neurocranium to hyomandibular, opercle and metapterygoid bones. Muscles of this group are as follows:

1. M. levator arcus palatini

This muscle usually extends from the sphenotic region of the neurocranium to the anterior aspect of hyomandibular and upper aspect of the metapterygoid.

In *C. arel* (Figs. 60, 68) on the ocular side, it is a well developed muscle having obtusely pointed dorsal margin. It is placed in the space between the posterior aspect of right orbit and the hyomandibular. Except the anterodorsal corner, the muscle remains completely concealed under m. adductor mandibularis. The m. levator arcus palatini originates both musculously and aponeurotically from the sphenotic, from its posterolateral ridge and frontal region. The sphenotic ridge provides a suitable area for strong attachment of this muscle. The proximal part of the muscle is thicker than the distal part and the fibres of the middle region are longer than the fibres of both the sides. The muscle fibres...
run downward and forward and are inserted on the anterolateral part of the hyomandibular and upper aspect of the metapterygoid. The insertion is partly musculous and partly aponeurotic. At the posterolateral aspect of this muscle lies the m. protractor hyomandibularis.

On the blind side (Figs. 61, 69) the muscle is relatively small and remains completely covered by m. adductor mandibularis.

In C. lingue (Figs. 62, 70) and C. bilineatus (Figs. 64, 72) m. levator arcus palatini remains completely concealed under m. adductor mandibularis on both the sides. In P. blochii (Figs. 66, 74) only the distal part of the muscle remains covered by m. adductor mandibularis on the ocular side. Some of the fibres of m. levator arcus palatini also pass over the posterolateral ridge of sphenotic and are attached to the dorsolateral part of sphenotic.

2. M. protractor hyomandibularis

It is a triangular muscle situated on the posterolateral aspect of m. levator arcus palatini. Anterolaterally the former gets partly fused with the latter. However, its origin and insertion as well as direction of the muscle fibres clearly indicate its separate identity.

In C. arel on the ocular side (Fig. 68), m. protractor hyomandibularis originates both musculously and aponeurotically from the distal end of sphenotic ridge. After origin the muscle fibres diverge out in a downward direction and are inserted musculously on the anterodorsal surface of the hyomandibular. At the posterolateral side of m. protractor hyomandibularis lies the m. dilator operculi.

On the blind side (Fig. 69) the muscle is relatively short. Further it may be mentioned that the nature and disposition of this muscle is identical in the rest of the fishes.
3. **M. dilator operculi**

This opercular muscle runs from the neurocranium to the opercle and is generally placed posterior to the m. protractor hyomandibularis. This muscle of both the blind and ocular sides is identical.

In *C. arel* (Figs. 60, 68) on the ocular side, it is a well-developed roughly cone-shaped muscle placed between m. protractor hyomandibularis and m. adductor operculi. It remains partly covered under the fibres of m. adductor mandibularis and m. protractor pectoralis. The origin of the muscle covers a wide range of area consisting of sphenotic ridge, sphenotic, and the pterotic regions. The muscle fibres originate musculously and move downward and backward in a converging manner and finally get inserted both musculously and aponeurotically on the anterodorsal process of opercle. It is similar in the rest of the fishes.

b) **Adductor mandibulae group**

This is a complex group of muscle having number of components which run from the anterior aspect of preopercle, hyomandibular, metapterygoid and quadrate as well as from the neurocranium to both the jaws.

4. **M. levator maxillae superioris**

In *C. arel* (Fig. 69) it is observed only on the blind side. It is a thin band of roughly rectangular muscle with narrow anterior extremity and remains in between the m. adductor mandibulariaI and m. adductor mandibulariaII, III. It originates both musculously and aponeurotically from the distal part of hyomandibular and anterior margin of the preopercle. Then the muscle runs forward and slightly upward. Distally the muscle gives rise to a long cord-like aponeurosis which runs along the inner aspect of the maxilla and finally gets inserted to the maxillary spine.
In *C. lingua* (Fig. 71) the muscle originates by a thin membranous aponeurosis. In *C. bilineatus* (Fig. 73) and *P. blochii* (Figs. 67, 75) the origin is musculous and in the latter the distal end of the muscle extends beyond the anterior border of m. adductor mandibularis and hence externally visible.

5. M. adductor mandibularis

1) M. adductor mandibularis

In *C. arel* on the ocular side (Figs. 60, 68), it is a well developed muscle occupying the space between the hyomandibular, preopercle region and the posterior limit of the orbits. The anterior margin of the muscle gets inwardly curved along the posterior margin of the lower eye (left eye). M. adductor mandibularis covers m. levator arcus palatini except its anterodorsal margin and m. adductor mandibularis excepting the lower portion of m. adductor mandibularis. The muscle originates musculously from along the lateral aspects of frontal, sphenotic, hyomandibular and the preopercle. The fibres of the upper region run in a forward and downward direction. The fibres of the lower part run in a forward and slightly upward direction. There runs a strong aponeurosis along the anterior border of the muscle whose anterior end is inserted on the maxilla at a point below the lower orbit. The posterior end of the aponeurosis gets curved along the angle of the mouth and finally gets inserted on the inner side of angular close to Meckel's cartilage.

On the blind side (Figs. 61, 69) m. adductor mandibularis is relatively large, thick and roughly rectangular in outline. Besides m. levator arcus palatini and m. adductor mandibularis, m. levator maxillae superioris also lies beneath it. Posteriorly the muscle partly extends over m. dilator operculi and gets attached to m. protractor pectoralis by a membrane which passes over m. dilator operculi.
The origin of this muscle is like that of the ocular side but the insertion is quite different. Anteroventrally the muscle gives out an aponeurosis which becomes tendinous, enters into the lower jaw and finally gets inserted near the Meckel's cartilage. As a result unlike the ocular side the m. adductor mandibularis I of the blind side gets inserted totally on the lower jaw. This muscle on the blind side is similar in all fishes studied here.

It may be mentioned here that, the above muscle of the blind side is almost of similar nature in all the fishes studied presently. However, the differences which have been found on the ocular side, are given below.

In C. lingua (Figs. 62, 70) on the ocular side this muscle covers the m. levator arcus palatini completely. In C. bilineatus (Fig. 64) on the ocular side the muscle under question is roughly rectangular and covers m. dilator operculi and m. levator arcus palatini completely. In P. blochii (Fig. 66) the muscle of the ocular side is relatively small and anterodorsally it becomes narrow. Only the distal part of m. levator arcus palatini remains beneath it.

ii) M. adductor mandibularis II

In C. arel (Figs. 60, 68) on the ocular side, it originates musculously from the hyomandibular, preopercle and quadrate. Dorsally this muscle slightly overlaps the posteroventral margin of m. adductor mandibularis III. While the upper muscle fibres run downward and forward the lower fibres run forward and upward and finally all the fibres are connected to an aponeurosis present along its anterolateral margin. Finally the aponeurosis is connected to the aponeurosis of m. adductor mandibularis I before entering the lower jaw. On the anterodorsal side of it is present the m. adductor mandibularis III.
On the blind side (Figs. 61, 69) it is relatively large otherwise it is similar.

The nature of this muscle is similar in *C. lingua* (Figs. 70, 71), *C. bilineatus* (Figs. 72, 73) and *P. blochii* (Figs. 74, 75).

iii) M. adductor mandibularis III

In *C. areol* on the ocular side (Fig. 68), it is a small muscle present along the anterodorsal margin of m. adductor mandibularis II. It originates musculously from the metapterygoid and its fibres move downward and forward. Anteriorly the fibres are inserted to the aponeurosis of m. adductor mandibularis II. Anterodorsally this muscle remains contiguous with the distal end of m. levator arcus palatini.

On the blind side (Fig. 69) the muscle is better developed and its dorsal margin overlaps the distal part of m. levator arcus palatini.

The nature of this muscle is similar in *C. lingua* (Figs. 70, 71), *C. bilineatus* (Figs. 72, 73) and *P. blochii* (Figs. 74, 75).

6. M. intramandibularis

In *C. areol* on the ocular side (Fig. 76), it is present on the inner aspect of the mandible in the Meckelian fossa. It originates aponeurotically from the inner side of quadrate, runs forward and slightly upward and is finally inserted musculously on the dentary.

However, on the blind side (Fig. 76) a small additional aponeurosis is found which connects the common aponeurosis of m. adductor mandibularis I,II,III with its own aponeurosis.

The nature and disposition of this muscle is similar in *C. lingua*, *C. bilineatus* and *P. blochii*. 
c) Intermandibularis group

Two muscle are present in this group: (I) M. intermandibularis anterior (II) M. intermandibularis posterior

7. M. intermandibularis anterior

In C. arel (Figs. 76, 77) it is a moderately developed muscle placed a little behind the symphysis of the dentaries of both the sides and is almost transverse to the longitudinal axis of the body. It connects musculously the dentaries of both the sides, and the muscle fibres run slightly obliquely downward from blind side to ocular side. This muscle is present anterior to m. intramandibularis of either side.

The muscle is of similar nature in C. lingua, C. bilineatus and P. blochii.

8. M. intermandibularis posterior

In all the fishes of the present study, this muscle is relatively well developed than the former and runs from the hyoid arch to dentary. It should be noted that m. intermandibularis posterior gets fused with the m. interhyoideus to form the m. protractor hyoidei as indicated by Holmqvist (1910). So the above muscle has been dealt under the hyoid muscle complex.

B. Hyoid muscle complex

Basing on embryological evidences Edgeworth (1935) subdivided this muscle complex into two groups: (a) constrictor hyoideus dorsalis group and (b) constrictor hyoideus ventralis group.
a) Constrictor hyoideus dorsalis group

The muscles of this group extend from the neurocranium to pterygo­palatine arch, hyomandibular and opercle. Four distinct muscle·belong to this group as revealed from the present study and they are accounted below.

9. M. adductor arcus palatini

In C. arel on the ocular side (Fig. 68), it is a moderately developed sheet of muscle which is present in between the parasphenoid and the pterygopalatine arch. It forms the part of the floor of the left orbit and can be best seen by removing the lower eye ball and m. levator arcus palatini. The muscle originates musculously from the ventrolateral aspect of the parasphenoid and becomes gradually narrow anteriorly. After origin the fibres run downward and slightly forward and finally get inserted on the pterygopalatine arch. However, some of its fibres extend to below the metapterygoid. While the posterior fibres are inserted musculously, the anterior ones are inserted by a thin membranous aponeurosis.

On the blind side (Fig. 69) the muscle is relatively ill developed.

The nature and disposition of this muscle is similar in C. lingua (Figs. 70, 71), C. bilineatus (Figs. 72, 73) and P. blochii (Figs. 74, 75).

10. M. adductor operculi

In C. arel on the ocular side (Fig. 68), it is a well developed roughly cone shaped muscle placed below m. protractor pectoralis and posterior to m. dilator operculi. It originates aponeurotically from the basisphenoid projection and becomes broad distally. The distal part of the muscle is covered by a silvery membrane. The muscle fibres run in a downward and backward direction and are inserted to the anterior half of the dorsal border of opercle below the insertion of m. levator operculi. The insertion is muscular.
The nature and disposition of this muscle is similar on the blind side and as well as in the rest of the fishes presently studied.

11. M. levator operculi

In C. arel on the ocular side (Fig. 60), it is a thin sheet of superficial muscle placed above the m. protractor pectoralis and posterior to m. dilator operculi. The origin of the muscle is from pterotic region of the skull by a membranous aponeurosis. The muscle fibres run downward and backward and inserted on the posterior two third of the dorsal border of opercle. While the anterior fibres are inserted musculously the posterior fibres are inserted by an aponeurotic membrane.

The muscle is identical on the blind side and as well as in the rest of the fishes studied.

b) Constrictor hyoideus ventralis group

The muscle of this group run from dentaries to hyoid elements including branchiostegals rays and extend to the inner aspect of opercular apparatus. This group comprises several distinct muscle components as described below.

12. M. protractor hyoidei

This muscle is well developed in all the fishes studied presently. It is really worthmentioning that this muscle is further divisible into two discrete components. In accordance with their morphological disposition these can conveniently be called as m. protractor hyoidei superioris and m. protractor hyoidei inferioris.
i) M. protractor hyoidei superioris

In C. arel on the ocular side (Fig. 77), it is a moderately developed elongated superficial muscle and is readily exposed by removing the skin. It originates musculously from the inner aspect of the anterior part of dentary and runs posteriorly. The muscle becomes gradually narrow posteriorly and gets closely apposed to its counterpart of the blind side, retaining a line of demarcation between them on the midventral line. Finally the muscle is inserted musculously on the anterior most branchiostegal ray.

The muscle of the blind side (Fig. 77) is relatively narrow.

The nature of the muscle is similar in C. lingua, C. bilineatus and P. blochii.

ii) M. protractor hyoidei inferioris

This muscle is also well developed and its anatomical make up is quite interesting. Meticulous examination reveals that this can further be subdivided into m. protractor hyoidei inferioris internus and m. protractor hyoidei inferioris externus basing on their topographical disposition.

a) M. protractor hyoidei inferioris internus

In C. arel on the ocular side (Fig. 78), this is a well developed muscle present below the m. protractor hyoidei superioris and on the inner aspect of m. protractor hyoidei inferioris externus. It originates musculously from the inner aspect of the anterior part of dentary and runs backward. After a short distance it gets fused with its counterpart of the blind side on the midventral line. Then again it separates and gets inserted both musculously and aponeurotically on the anterior most branchiostegal ray below the insertion of m. protractor hyoidei superioris.
It is similar on the blind side (Fig. 78) as well as in \textit{C. lingua}, \textit{C. bilineatus} and \textit{P. blochii}.

b) \textit{M. protractor hyoidei inferioris externus}

In \textit{C. areol} on the ocular side (Fig. 78), it is a moderately developed muscle present on the outer aspect of \textit{m. protractor hyoidei inferioris internus}. It originates from the inner aspect of dentary in contact with the internus muscle and runs backward along the outer lateral aspect of the latter. It also gets partly fused with the \textit{m. protractor hyoidei inferioris internus} and again distally separates out from it in a divergent manner. Finally it is inserted on the branchiostegal rays as well as on the ceratohyal of the respective side. While some of the fibres of the muscle are inserted both musculously and aponeurotically over the anterior most ray (sixth ray) the other fibres insert over the fourth and fifth rays. A thin narrow thread like aponeurosis also connects the distal part of the muscle with the ceratohyal near the base of fourth branchiostegal ray.

The nature of the muscle is identical on the blind side.

In \textit{C. lingua} on both the sides, the insertion of \textit{m. protractor hyoidei inferioris externus} on the branchiostegal ray is musculously. While some of its fibres are inserted on the sixth ray, some pass over the fifth ray and are inserted on the fourth ray. The narrow aponeurosis connecting the distal part of the muscle with the ceratohyal is attached to the latter near the base of fifth ray.

In \textit{C. bilineatus} (Fig. 79) on both ocular and blind sides, some of the fibres of the muscle pass over the sixth ray, covering the latter completely and are finally inserted on the fourth ray by a thin aponeurotic membrane. The aponeurosis connecting the distal part of the muscle with the ceratohyal is attached to the latter near the base of fifth ray.
In _P. blochii_ out of the fibres which pass over the sixth ray, some are attached to the fifth and fourth rays by thin membrane. The aponeurosis connecting the distal part of the muscle with the ceratohyal is attached to the latter near the base of sixth ray. The condition is identical on both the sides of head.

13. M. abductor branchiostegalis (M. hyohyoideus inferior)

In _C. arel_ (Fig. 57) it is a moderately developed elongated cylindrical muscle originating musculously from the inner aspect of lower hypohyal. The muscle runs backward and slightly downward and is inserted musculously on the inner lateral side of the sixth branchiostegal ray. The muscle remains completely concealed by the m. protractor hyoidei group of muscles. This muscle is identical on both the sides of head.

The nature and disposition of this muscle is similar in _C. lingua, C. bilineatus_ and _P. blochii_.

14. M. constrictor branchiostegalis (M. hyohyoideus superior)

In _C. arel_ (Fig. 77) it is a symmetrical muscle and is represented by a thin sheet of muscle present between the successive branchiostegal rays. The sheet of muscle present between fifth and sixth rays is the thickest. The fibres of the muscle are attached musculously to the branchiostegal rays. The muscle fibres present between fourth-fifth and fifth-sixth rays are relatively long and run in a forward and upward direction. While the fibres present between the rest of the rays are shorter and run in a backward and downward direction.

The nature of this muscle is similar in the rest of the fishes studied presently.
15. M. adductor branchiostegalis

In *C. arel* (Figs. 77, 80) it is a thin plate of muscle which extends from the posterior part of the first branchiostegal ray to the inner surface of opercle, subopercle and interopercle. However, this sheet of muscle continues ventrally along the inner aspect of the branchiostegal rays to meet its counterpart in the midventral line.

The nature and the disposition of the muscle is similar in *C. lingua, C. bilineatus* and *P. blochii* and no asymmetry is found in the disposition of this muscle.

Branchial muscle complex

It is divisible into two groups of muscles: the dorsal and the ventral group. However, the masticatory muscles which although form a part of the branchial muscle complex has been dealt with separately for the convenience of description as well as for their direct role in mastication. It is worth mentioning here that the branchial muscle complex does not exhibit any asymmetry and as such no distinction could be made between the muscles of the ocular and blind side.

a) Dorsal group of branchial muscles

These are muscles which connect the dorsal elements of the branchial basket with the neurocranium and also connect the branchial elements of both the sides dorsally.

16. M. levator externus

It runs from the hyomandibular to the epibranchial elements of branchial arches and is usually represented by five slips in connection with the first four arches. All the muscle slips originate from the hyomandibular region and their origin is in touch with each other.
In C. arel (Fig. 81) the first levator externus is a thin, elongated band of muscle which originates aponeurotically from the inner aspect of the posterior side of hyomandibular. The muscle runs backward and downward and is finally inserted musculously on the distal part of the epibranchial of the first arch.

The second levator externus is a well developed muscle and is placed posterior to the first. The muscle originates both musculously and aponeurotically from the inner aspect of the ventral side of hyomandibular in connection with the origin of first levator externus. It runs downward and backward and is finally inserted musculously on the crest like projection of the epibranchial of second arch.

The third levator externus is also a well developed muscle with a flattened belly and is placed posterior to the second levator externus. It originates both musculously and aponeurotically from the inner aspect of the hyomandibular just above the origin of second levator externus. After origin it runs backward and downward in close contact with the second levator externus but towards the distal end it is well separated from the latter. It is inserted both musculously and aponeurotically on the crest like projection present on the dorsal side of the epibranchial of the third arch.

The fourth levator externus is a cylindrical muscle placed posterior to third levator externus. The belly of the muscle is wide. It originates both musculously and aponeurotically from the inner aspect of hyomandibular in close contact with the origin of third levator externus. After origin it moves downward and backward and is finally inserted both musculously and aponeurotically on the dorsal side of epibranchial of fourth arch.

The fifth levator externus is the innermost muscle placed posterior to the fourth levator externus. It originates both musculously and aponeurotically from the inner aspect of hyomandibular above the origin of fourth levator externus and in close
contact with the latter. It is inserted both musculously and aponeurotically on the dorsal side of the fourth epibranchial near the insertion of the fourth levator externus. However, both the muscles fuse with each other near their point of insertion. These five slips of levator externus muscles cover all other dorsal group of branchial muscles.

The nature and disposition of the levator externus muscles in all the fishes of present study are similar excepting the minor variations mentioned below.

In *C. lingua* the first, second and third levator externus muscles originate both musculously and aponeurotically of which the first and second have a common aponeurosis. The origin of fourth and fifth levator externus is musculous. In *G. bilineatus* the first and second levator externus originate both musculously and aponeurotically and the third, fourth and fifth levator externus originate musculously. While the insertion of first, second and third muscles is musculous, the insertion of fourth and fifth muscle is both musculous and aponeurotic. In *P. blochii* unlike the previous fishes there are only four slips of levator externus muscles in connection with the first four arches. All of them originate by a common aponeurosis. The insertion of these muscles is musculous. These muscles cover only the distal part of m. levator internus.

17. M. levator internus

There are two such muscles which are present in connection with the second and fourth branchial arches.

1) M. levator internus II

M. levator internus II (Fig. 61) is a thick, well developed roughly pear shaped muscle which remains completely concealed under the levator externus group of muscles. It originates both musculously and aponeurotically from the inner aspect of the posterior condyle
of hyomandibular. After origin the muscle runs downward and slightly backward and finally gets inserted musculously on the proximal part of second epibranchial. However, some of its fibres are also inserted on the cartilaginous structure, in which are embedded the proximal end of first as well as second epibranchial and the proximal part of third pharyngobranchial. Over the distal part of the muscle passes m. protractor os pharyngeus superioris.

It is similar in C. lingua and C. bilineatus. In P. blochii only the distal part of the muscle remains covered by the levator externus group of muscles.

ii) M. levator internus

It is (Fig. 81) also a moderately developed elongated muscle which originates musculously from the basioccipital region of the skull and runs backward and downward. Finally it is inserted both musculously and aponeurotically on the proximal part of the fourth epibranchial. This muscle remains partly covered by the fifth levator externus muscle.

The muscle is of identical nature in C. lingua, C. bilineatus and P. blochii.

18. M. obliquus dorsalis

It is represented by a single muscle band m. obliquus dorsalis on the third arch only. In C. arel (Fig. 81) it is a well developed thick muscle which is present below the levator externus group of muscles. It originates musculously from the dorsal surface of third epibranchial, runs forward and inward and finally gets inserted musculously on the dorsal surface of os pharyngeus superior. However few of its fibres are also attached to the fourth epibranchial.
In C. lingua, C. bilineatus and P. blochii the nature of origin and insertion is both musculous and aponeurotic.

19. M. adductor

This muscle is generally present between the inner angle of epibranchial and ceratobranchial of the same arch. In the fishes (Fig. 81) under the present investigation the muscle m. adductor is represented by a thin strip of muscle present between the inner angle of epibranchial and ceratobranchial of the fourth arch.

This muscle is of similar nature in C. lingua, C. bilineatus and P. blochii.

20. M. transversus dorsalis.

This muscle is placed dorsal to the branchial basket and ventral to the neurocranium. It extends from the branchial arch of one side to the corresponding arch of other side. In the fishes under the present study there are three such muscles: (i) M. transversus dorsalis. (ii) M. transversus os pharyngeus superioris. (iii) M. transversus os pharyngeus inferioris dorsalis. However, the last two muscles have been described under the masticatory muscles.

i) M. transversus dorsalis

In C. arell (Fig. 81) it is a moderately developed muscle which originates both musculously and aponeurotically from the dorsal side of second epibranchial. This muscle lies between the first and second levator externus muscles. The muscle has a long aponeurosis which passes in between the m. protractor os pharyngeus superioris and m. levator internus, and meets its fellow of other side at the middorsal line of the branchial basket.
It is identical in C. lingua, C. bilineatus and P. blochii.

b) Ventral group of branchial muscles

These are muscles placed at the ventral aspect of the branchial basket.

21. M. rectus ventralis

It interconnects the hypobranchial, ceratobranchial or both elements of one arch to the preceding one (Datta, 1972 and Winterbottom, 1974). In the fishes under the present investigation there are two such muscles: (i) M. rectus ventralis $_IV$ and (ii) M. rectus ventralis $_V$.

i) M. rectus ventralis $_IV$

In C. areol (Fig. 82) it is a well developed spindle shaped muscle interconnecting the fourth ceratobranchial with the hypobranchial of the third arch. It runs from the ventral aspect of the anterior prolongation of the hypobranchial to the crest like process present on the ventral side of the ceratobranchial. The nature of attachment of both the ends of the muscle is musculous.

In C. lingua and C. bilineatus some aponeurotic fibres are present towards the proximal part of the muscle. In P. blochii this muscle is similar to that of C. areol.

ii) M. rectus ventralis $_V$

In C. areol (Fig. 82) it is a weak band of muscle connecting musculously the fourth and fifth ceratobranchials.

The nature and disposition of the above muscle is similar in C. lingua, C. bilineatus and P. blochii.
22. M. obliquus ventralis

This muscle runs usually from the ceratobranchial to basibranchial. It may also run from the ceratobranchial to hypobranchial of the same arch. In the present group of fishes this muscle is represented by two distinct muscles which are as follows:

i) M. obliquus ventralis externus

This muscle is represented by two slips on each side which connect the first and second ceratobranchials with the second and third basibranchials respectively.

In C. arel (Fig. 82) it is a moderately developed elongated muscle which originates aponeurotically from the ventral side of the distal end of ceratobranchial. After origin the fibres run upward and inward and finally get inserted musculously on the mid ventral side of the corresponding basibranchial. Ventrally this muscle covers m. obliquus ventralis internus.

In C. lingua and C. bilineatus the muscles originate by a long narrow aponeurosis otherwise they are similar with those of C. arel. In P. blochii the nature is similar to that of C. arel.

ii) M. obliquus ventralis internus

In C. arel (Fig. 82) this muscle is represented by three slips which are present between the ceratobranchials and hypobranchials of the first, second and third branchial arches. While the first two of these muscles remain covered by the corresponding m. obliquus ventralis externus muscle, the third slip remains partly covered by the m. rectus ventralis.

M. obliquus ventralis internus I, II are weak band of muscles which originate aponeurotically from the ventral side of the distal end of
ceratobranchials of first and second arches. However, the third slip of muscle is relatively wide and originates musculously from the ventral side of the distal end of ceratobranchial the third arch. After origin the muscle moves upward and inward and gets inserted musculously inside the ventral groove of the corresponding hypobranchial.

The above muscle is identical in C. lingua, C. bilineatus and P. blochii.

23. M. transversus ventralis

This muscle is present on the ventral side of the branchial basket and connects the branchial arches of both the sides. In the presently studied group of fishes this muscle is represented by m. transversus ventralis only. In C. arel (Fig. 82) it is a weak band of muscle which connects ventrally the ceratobranchials of both the sides of fourth arch. The muscle is placed anterior to m. transversus os pharyngeus inferioris ventralis anterioris.

This muscle is of similar nature in the rest of the fishes studied presently.

24. M. cleithrobranchialis internus

In C. arel (Fig. 83) it is a well developed flat muscle whose proximal part remains covered by the m. cleithrohyoideus. This muscle originates by a long thin strap like aponeurosis from the anterovelar part of cleithrum and transformed into a wide muscle band. It runs in a upward and forward direction over m. retractor os pharyngeus inferioris and is inserted musculously on the lateral side of the ceratobranchial and the distal part of epibranchial of the fourth arch.

The structure and disposition of this muscle is similar the rest of the fishes investigated presently.
Masticatory muscles

These are the muscles which are connected with the os pharyngeus superior and os pharyngeus inferior. These apt to function as the muscles of mastication and can be described under two groups.

Group-I. Includes muscles connected with os pharyngeus superior.

Group II. Includes muscles connected with os pharyngeus inferior.

C. Masticatory group I

25. M. protractor os pharyngeus superioris

It is worth mentioning here that an identical muscle has not yet been described by any worker. Therefore, it is a record of altogether new muscle in teleosts.

In C. arel (Fig. 81) it is a well developed cylindrical muscle which originates musculously from the prootic region of the skull. However, some of its fibres also originate from the inner aspect of hyomandibular. After origin it moves backward and downward below the hyomandibular and finally gets inserted musculously on the dorsal side of os pharyngeus superior. While this muscle passes above the distal part of m. levator internus II, its distal end remains covered by the m. obliquus dorsalis III.

The nature and disposition of this muscle is identical in the rest of the fishes studied.

26. M. retractor os pharyngeus superioris

In C. arel (Fig. 81) it is a well developed muscle having tripartite origin. The anterior fibres originate musculously from the lateral
aspect of the centrum of the first and second vertebrae and then run downward and forward. The median fibres also arise musculously from the lateral aspect of the centrum of the third vertebra and then run downward and forward and finally meet the anterior fibres at the belly. The posterior fibres arise musculously from the anterolateral side of haemal spine of the fourth vertebra. After origin they also move downward and forward and finally fuse with the anterior and median fibres. Ultimately, the fused anterior parts of these three portions are inserted musculously to the os pharyngeus superior on the inner lateral aspect.

This muscle is identical in *C. lingua*, *C. bilineatus* and *P. blochii*.

27. M. transversus os pharyngeus superioris

In *C. arel* (Fig. 81) it is a small transverse band of muscle present on the dorsal side of the branchial basket and connects the os pharyngeus superior of both the sides.

The muscle is identical in the rest of the fishes presently investigated.

d) Masticatory group II

28. M. levator os pharyngeus inferioris

In *C. arel* (Fig. 84) it is a small and weak band of muscle which originates musculously from the inner lateral side of the epibranchial of the fourth arch. It runs downward and is inserted musculously on the posterior side of the os pharyngeus inferior.

The nature of this muscle is similar in *C. lingua*, *C. bilineatus* and *P. blochii*.
29. **M. retractor os pharyngeus inferioris**

In *C. arel* (Fig. 84) it is a moderately developed flat band of muscle which originates musculously from the anterior aspect of the proximal part of cleithrum and then runs forward. The fibres of the lower part of the muscle are longer than the fibres of the upper part and the distal part of the muscle remains covered by a silvery membrane. Finally the muscle gets inserted musculously on the posterolateral aspect of os pharyngeus inferior.

In *C. lingua* and *C. bilineatus* the insertion is both musculous and aponeurotic. However, in *P. blochii* the insertion of this muscle is musculous like that of *C. arel*.

30. **M. depressor os pharyngeus inferioris**

In *C. arel* (Figs. 83, 84) it is a moderately developed elongated muscle which becomes narrow distally. It originates musculously from the anterior aspect of the distal part of the cleithrum. After origin it runs upward and forward and is finally inserted by a narrow aponeurosis on the crest like process present on the posteroverntral part of os pharyngeus inferior.

In *C. lingua* the distal part of the muscle is covered by a thin silvery membrane. In *C. bilineatus* and *P. blochii* it is identical with that of *C. arel*.

31. **M. protractor os pharyngeus inferioris**

In *C. arel* (Figs. 83, 84) it is a well developed roughly triangular muscle which originates musculously from the anterodorsal part of the urohyal. After origin the fibres move upward. The anterior fibres are shorter than the posterior ones. There runs a strong thread like aponeurosis along the anterior margin of the muscle which finally gets inserted on the posteroverntral projection of
os pharyngeus inferior where the aponeurosis of m. depressor os pharyngeus inferioris also gets inserted.

It is identical in C. lingua. However, in C. bilineatus (Fig. 85), and P. blochii the insertion of m. protractor os pharyngeus inferioris is posterior to the insertion of m. depressor os pharyngeus inferioris.

32. M. transversus os pharyngeus inferioris

In C. oral it is represented by three slips of muscles which connect the os pharyngeus inferior of both the sides. A detail description of each slip of muscle is given below. It is noteworthy to mention here that these muscles are identical in the rest of the fishes studied presently.

i) M. transversus os pharyngeus inferioris dorsalis

It is a thin band of transverse muscle present on the dorsal side of the branchial basket and connects musculously the os pharyngeus inferior of both the sides (Figs. 81, 84).

ii) M. transversus os pharyngeus inferioris ventralis anterioris

This is a transverse band of muscle which is present on the ventral side of the branchial basket (Fig. 82). It connects musculously the os pharyngeus inferior of both the sides and is placed posterior to the insertion of m. depressor os pharyngeus inferioris and m. protractor os pharyngeus inferioris.

iii) M. transversus os pharyngeus inferioris ventralis posterioris

It is also a thin band of transverse muscle present on the ventral side of the branchial basket and is placed posterior to
m. transversus os pharyngeus inferioris ventralis anterioris (Fig. 82). This muscle connects musculously the os pharyngeus inferior of both the sides.

Anterior pectoral girdle muscle

This muscle is branchiomeric in nature despite its inclusion in the myomeric group by some workers. Edgeworth (1935) conclusively proved its branchiomeric derivation. The terminology of Shann (1914) is followed here.

33. M. protractor pectoralis

In C. arel (Fig. 60) on the ocular side it is a well developed block of muscle which remains partly covered by the m. levator operculi. It extends from pectoral girdle (supra cleithrum and cleithrum) to the pterotic region of the skull. Anteriorly some of its fibres extend over m. dilator operculi and gets connected with the m. adductor mandibularis by a membrane. However, some of its fibres are also inserted to the dorsal margin of opercle. Origin and insertion of this muscle is both musculous and aponeurotic.

The nature and disposition of this muscle is similar on the blind side. It may further be mentioned that the above muscle is of identical nature in the rest of the fishes studied presently.

Hypobranchial spinal muscle

34. M. cleithrohyoideus

It is a hypobranchial spinal muscle (Edgeworth, 1935). Although topographically it is a cranial muscle but from developmental standpoint it is a myomeric muscle. In C. arel (Fig. 85) on the ocular side it originates musculously from the anterior aspect of cleithrum and is inserted musculously on the urohyal.

It is of similar nature on the blind side as well as in the rest of the fishes investigated presently.
Lateral view of head region showing the nature and disposition of cranial muscles. M. dilator operculi, m.levator operculi and m. protractor pectoralis have only been shown in fig. 60.

Figs. 60 and 61 - Ocular and blind sides respectively of C. arel (Bl. 320 mm).
Figs. 62 and 63 - Ocular and blind sides respectively of C. lingua (Bl. 320 mm).
Figs. 64 and 65 - Ocular and blind sides respectively of C. bilineatus (Bl. 320 mm).
Figs. 66 and 67 - Ocular and blind sides respectively of P. blochii (Bl. 260 mm).

/Abbreviations/

a.mn - m. adductor mandibularis
a.mn II - m. adductor mandibularis II
d.o - m. dilator operculi
l.a.p - m. levator arculus palatini
l.o - m. levator operculi
pr. pe - m. protractor pectoralis
m - musculus
m.a - musculus and aponeurotic
a - aponeurosis
EXPLANATION OF FIGURES (68-76) AND ABBREVIATIONS USED

Lateral view of head region showing the nature and disposition of cranial muscles after the removal of m. adductor mandibularis, m. levator operculi, m. protractor pectoralis and the lower eye.

Figs. 68 and 69 - Ocular and blind sides respectively of C. arel (Bl. 320 mm).

Figs. 70 and 71 - Ocular and blind sides respectively of C. lingu (Bl. 320 mm).

Figs. 72 and 73 - Ocular and blind sides respectively of C. bilineatus (Bl. 320 mm).

Figs. 74 and 75 - Ocular and blind sides respectively of P. blochii (Bl. 260 mm)

Fig. 76 - Inner view of lower jaw of C. are (Bl. 320 mm) showing the muscles and ligament.

/Abbreviations/

a.a.p - m. adductor arcus palatini
a.mn - m. adductor mandibularis
a.mnIII - m. adductor mandibularis
a.o - m. adductor operculi
d.o - m. dilator operculi
im.l - intermandibular ligament
itm - m. intramandibularis
item - m. intermandibularis anterior
l.a.p - m. levator arcus palatini
l.mx.s - m. levator maxillae superioris
lt.pt - lateral projection of ectopterygoid
p - autopalatine
pr.hy - m. protractor hyomandibularis
m - musculous
m.a - musculous and aponeurotic
a - aponeurosis
EXPLANATION OF FIGURES (77-85) AND ABBREVIATIONS USED

Hyoid and branchial muscles of C. arel (Bl. 320 mm) and C. bilineatus (Bl. 320 mm) [Symbols as given for figs. (60-67)]

Fig. 77 - Ventral view of cranium showing the nature and disposition of different hyoid muscles of C. arel.
Fig. 78 - Ventral view of cranium of C. arel showing the hyoid muscles after removal of m. protractor hyoidei superioris.
Fig. 79 - Nature of insertion of m. protractor hyoidei inferioris externus of C. bilineatus.
Fig. 80 - Inner view of the branchiostegal rays of C. arel showing m. adductor branchiostegalis.
Figs. 81 and 82 - Nature and disposition of dorsal and ventral groups of branchial muscles respectively of C. arel.
Figs. 83 and 84 - Lateral view of urohyal, os pharyngeus inferior, fourth gill arch and cleithrum showing the disposition of some branchial muscles of C. arel.
Fig. 85 - Lateral view of some branchial muscles of C. bilineatus.

/Abbreviations/

ad - m. adductor
ad.b - m. adductor branchio-stegalis
c.b - m. constrictor branchio-stegalis
cl - cleithrum
cl.i - m. cleithrobranchials internus
cle - m. cleithrohyoides
d.o.i - m. depressor os pharyngeus inferioris
f - fourth arch
item - m. intermandibularis anterior
l.e - m. levator externus
l.i - m. levator internus
l.o.i - m. levator os pharyngeus inferioris
o - os pharyngeus inferior
o.d - m. obliquus dorsalis
o.v.e - m. obliquus ventralis externus
o.v.i - m. obliquus ventralis internus
p.h.i.e - m. protractor hyoidei inferioris externus
p.h.s - m. protractor hyoidei superioris
p.h.i.i - m. protractor hyoidei inferioris internus
p.o.i - m. protractor os pharyngeus inferioris
p.o.s - m. protractor os pharyngeus superioris
r.o.s - m. retractor os pharyngeus superioris
r.o.i - m. retractor os pharyngeus inferioris
r.c - m. rectus ventralis
t.d - m. transversus dorsalis
t.o.i.d - m. transversus os pharyngeus inferioris dorsalis
t.o.s - m. transversus os pharyngeus superioris
t.o.i.v.a - m. transversus os pharyngeus inferioris ventralis
u - urohyal
The study of teleostean cranial myology is rather difficult in spite of many valuable studies already made by a number of competent anatomists like Vetter (1878), Allis (1903), Greene and Greene (1913), Takahashi (1925), Edgeworth (1935), Sarkar (1960), Alexander (1964), Dutta (1968), Liem (1967b, 1970), Datta (1972) and Winterbottom (1974), due to the extreme complexity as well as variability of muscular morphology in various groups of teleostean fishes. In the flatfishes the asymmetry of the head has also brought about remarkable departure in the form and function of usual cranial musculature. This has made the study far more complicated. Kyle (1923) studied few jaw muscles of some flatfishes and tried to correlate them with the closing and opening of mouth. Cunningham (1890) studied some of the cranial muscles of Solea and made an attempt to explain their functional morphology. Yazadani (1969) also studied only few jaw muscles of different groups of flatfishes and tried to correlate them with the adaptation of those fishes. But none of the earlier workers has studied the cranial myology in detail especially the branchial muscles in particular of the fishes belonging to the family Cynoglossidae. So an intimate study of the cranial myology of the flatfishes so long remained almost neglected. The present investigator has made a sincere effort to study all the cranial muscles in detail and to correlate them with the cranial asymmetry and with the feeding biology of the fish.

According to Edgeworth (1935) the branchiomeric musculature gives rise to mandibular muscle primodium, hyoid muscle primodium, and branchial muscle primodium. Each of those primodia gives rise to few complexes and each of which in turn, breaks up into few distinct muscles. Datta (1972) opined that the presence of many muscles in the cranial region of the teleosts, is in accordance with the functional needs associated with the visceral arches and their derivatives like jaws and hyomandibular.
The mandibular muscle complex gives rise to those well defined categories of muscles, which are designated as constrictor dorsalis group, adductor mandibulae group and intermandibularis group (Edgeworth, 1935).

The present study of the components of the constrictor dorsalis group in the adult flatfishes reveals that m. levator arcus palatini, m. protractor hyomandibularis and m. dilator operculi run from various parts of the neurocranium and spreads backwards to the hyomandibular and opercle instead of palatoquadrate only. This finding corroborates the earlier findings of Edgeworth (1935) and Datta (1972).

M. levator arcus palatini was first recognised by Cuvier as Releveur de l'arc tympanique. This muscle is inserted on the hyomandibular and metapterygoid and there by corroborates with the earlier findings of Takahashi (1925), Pankartz (1928), Nawar (1955), Datta (1972) and Winterbottom (1974). The muscle is asymmetrical and that of the blind side is smaller because the pterygopalatine arch of that side is relatively close to the neurocranium (vide Chapter I - osteology part).

The name m. protractor hyomandibularis was used by Vetter (1878), Danforth (1913) and Edgeworth (1935) along with many other zoologists. This muscle is also asymmetrical. It is smaller on the blind side due to the presence of a relatively long sphenotic ridge which projects more over the hyomandibular.

M. dilator operculi is of a typical teleostean type and does not have any peculiarity for discussion.

The nature and disposition of the various components of the adductor mandibulae group present variations, which have led to enormous confusion. Datta (1972) and Winterbottom (1974) attempted to clarify the confusions. The present worker has followed the terminology of
the components of adductor mandibulae group used by Datta (1972) instead of following the abbreviated designations like $A_1$, $A_2$ and $A_3$ (Vetter, 1878). Winterbottom (1974) himself stated that the subsections i.e., subdivision of adductor mandibulae have been the source of some confusions in both the recent and the past literature. The investigator has divided the adductor mandibulae group on the basis of insertion (Takahasi, 1925). In case where the muscles lie parallel to each other, the naming order is from upper to lower.

The m. levator maxillae superioris was thought to be absent as such in the teleosts (Baton, 1935). But Rosen (1962, 1964) demonstrated the presence of such muscle in some teleost. Datta (1972) has reported such muscle in *Etroplus suratensis*. Yazdani (1969) demonstrated the presence of m. levator maxillae superioris on the ocular side of *Cynoglossus* sp. But he was not sure about its separate entity. On the contrary to the earlier findings of Yazdani (1969) the present investigator has revealed the presence of m. levator maxillae superioris only on the blind side.

M. adductor mandibularis$_1$ is of peculiar nature and exhibits extreme asymmetry. On the ocular side, while the dorsal end of its aponeurosis is inserted on the maxilla, the ventral end is inserted on the mandible. This indicates that, probably m. adductor mandibularis$_1$ is formed by the fusion of a dorsal and a ventral muscle components. The dorsal and ventral muscle components may be homologised with the $A_1$ of Vetter (1878). However, on the blind side the entire muscle is inserted on the mandible only by an aponeurosis. Below the m. adductor mandibularis$_1$ are present the m. adductor mandibularis$_{II}$ and m. adductor mandibularis$_{III}$. It is quite interesting to record that the m. adductor mandibularis$_{II,III}$ are relatively large on the blind side.

The above mentioned modifications i.e., the insertion of m. adductor mandibularis$_1$ of blind side totally on the mandible and the presence of relatively large m. adductor mandibularis$_{II,III}$ on the blind side, probably provide more adduction power to the lower jaw which is required for catching and cutting the prey efficiently.
M. intramandibularis is an ill developed muscle and designated as A. by Yetter (1878). The present finding that the muscle originates from the quadrate is supported by the earlier findings of Allia (1903). This muscle is hardly symmetrical on both the sides. While the proximal part of the muscle of the blind side has an aponeurotic connection with the common aponeurosis of the adductor mandibularis muscles, such connection is not found on the ocular side. The presence of the connecting aponeurosis on the blind side probably coordinates the function of m. intramandibularis with the adductor mandibularis muscles more effectively.

The findings of the present investigator regarding the intermandibular complex tallies with Edgeworth (1935) that the above muscle complex consists of the two muscles, anterior and posterior.

Holmqvist (1910) called m. intermandibularis posterior as m. protractor hyoidei which receives innervation both from fifth and seventh cranial nerves and definitely indicates that this muscle receives contribution from mandibular as well as hyoidean muscle plate (Edgeworth, 1935; Jarvik, 1963). This view was also supported by Datta (1972). The findings of the present investigator is concurrent with those findings. But m. protractor hyoidei in the present group of fishes is very complex one. While both m. protractor hyoidei inferioris externus and m. protractor hyoidei inferioris internus are symmetrical on both the sides, m. protractor hyoidei superioris is asymmetrical. The latter is smaller on the blind side as the dentary of the same side is more flattened and approaches almost the midventral line. It is noteworthy to mention here that m. protractor hyoidei inferioris externus and m. protractor hyoidei inferioris internus of either side fuse with each other at about their mid-length forming a complex. Probably this fusion line represents the myoseptum of siluriforms as reported by Winterbottom (1974).

A meticulous examination of the dorsal hyoid muscles of the fishes under present study confirms the earlier findings of Datta (1972)
that m. adductor arcus palatini, m. adductor operculi and m. levator operculi are general features in the teleostean cranial myology.

M. adductor arcus palatini is highly asymmetrical on both sides. The above muscle of the blind side is ill developed due to the fact that the pterygopalatine arch of the side is situated at a higher level and the parasphenoid is bent towards the blind side as a result there remains a small gap in between them to be occupied by the m. adductor arcus palatini.

The nomenclature of the ventral hyoid muscles is confusing till recently due to use of different names for the same muscle by the different earlier workers like Cuvier (1840), Vetter (1878), Greene and Greene (1913), Edgeworth (1935), Sarkar (1960), Jarvik (1963) and Millard (1966). Very recently Datta (1972) divided the ventral hyoid muscles into m. interhyoideus and m. hyohyoideus subdivisions. He subdivided the m. hyohyoideus into three portions on the basis of their functional morphology. They were designated as m. abductor branchiostegalis, m. constrictor branchiostegalis and m. adductor branchiostegalis. The structure and disposition of these muscles of the fishes under the present study has already been described.

The structure of m. adductor branchiostegalis exhibits peculiarities. The muscle extends ventrally beneath the first branchiostegal ray and meets the counterpart on the midventral line. Such modification has also been reported by Winterbottom (1974). But no clear mid-ventral raphe has been observed as reported by Winterbottom (op. cit.).

The m. interhyoideus in the fishes under present study is, however, fused with m. intermandibularis posterior to form the m. protractor hyoidei which has already been discussed.

The many and varied form of branchial muscles, with different terminologies designated by different workers, made the study of the muscles
very complicated. It is an established fact that out of the five pairs of gill arches in the teleosts, the anterior four pairs bear gill filaments, whereas the fifth pair is devoid of any gill filament and bears teeth on it. The muscles which are connected with the dorsal and ventral side of the anterior four pairs of gill arches are known as dorsal and ventral group of branchial muscles respectively. The group of muscles which are connected with the os pharyngeus superior and os pharyngeus inferior are known as masticatory muscles. It is very interesting to note that in the group of fishes under the present study the branchial muscles are symmetrical on both the sides unlike the mandibular and hyoid muscle complex. This is in accordance with the symmetrical condition of the branchial basket.

The contribution of earlier workers like Cuvier (1840), Owen (1866), Vetter (1878), Dietz (1912, 1914, 1921), Greene and Greene (1913) and Takahasi (1925) towards the study of branchial muscles is quite remarkable. But none of them could give a typical structural plan for the teleostean branchial muscles. Datta (1972) provided a typical hypothetical structural plan for branchial muscles from which morphological variations can be conveniently deduced. Winterbottom (1974) also did a very valuable work by synonymyzing different names assigned to the branchial muscles. The present author has followed the hypothetical plan of Datta (1972) with the addition of some more terminologies for the muscles which are specially found in the fishes under the present study.

Holstvoogd (1965), Karrer (1967), Nelson (1967a,b), Singh (1967) and Winterbottom (1974) in their studies recorded four pairs of levator externi. Lien (1970) found three pairs of such muscles in N. mandus. But a meticulous observation by Datta (1972) revealed the presence of five pairs of such muscles in N. mandus in place of three pairs. The investigation on the present group of fishes indicates the presence of five pairs of muscles in C. arel, C. lingua and C. bilineatus but four pairs in P. blochii. Takahasi (1925, 1929) pointed out that these muscles normally originates from the prootic
and pterotic but may include sphenotic, intercalar, parasphenoid and even the exoccipital. But the present findings indicate the origin of these muscles from the hyomandibular, a rare phenomenon indeed as far as the information goes.

The number of m. levator internus is generally two (Datta, 1972; Winterbottom, 1974). In the fishes under present study there are also two such muscles. According to Winterbottom (1974) the origin of these muscles is normally from the prootic region, but may also include the intercalar, pterotic, parasphenoid and in ostraciids, the epiotic and exoccipital. But the present study indicates that m. levator internus II and m. levator internus IV originate from the hyomandibular and the basioccipital regions respectively.

Datta (1972) described the presence of m. obliquus dorsalis superioris and m. obliquus dorsalis inferioris in some teleosts. However, Winterbottom (1974) synonymized both the muscles to one component and named it obliquus dorsalis. The same author also stated that usually, teleosts possess two of these muscles (between the epi- and infrapharyngobranchials of the third and fourth arches), but many acanthopterygians retain only the anterior muscle. The present study indicates the presence of only one obliquus dorsalis (m. obliquus dorsalis III).

The presence of only m. adductor IV, confirms the finding of Winterbottom (1974) that m. adductor IV is most common and adductors I-III are most uncommon in the fishes.

Variation in the disposition of m. transversus dorsalis has been discussed in length by the earlier workers like Greene and Greene (1913), Takahashi (1925) and Datta (1972). Winterbottom (1974) stated that these muscles involve the dorsomedial faces of the epibranchials, infrapharyngobranchials and occasionally fifth ceratobranchial. The present findings record the presence of three bands of transversus dorsalis muscle, one between the epibranchials.
of second arch, another between the os pharyngeus superiors and the third one between the fifth cerabranhial or os pharyngeus inferiors. However, the muscles between os pharyngeus superiors and os pharyngeus inferiors have been considered under the masticatory group.

Dietz (1914) reported that m. rectus ventralis is invariably present in acanthopterygian. Four recti (I-IV) have been reported from some cyprinoids (Takahasi, 1925). Bishai (1967) and Datta (1972) pointed out the presence of m. rectus V in some teleosts. The present findings shows the presence of m. rectus ventralis. However, they are very peculiar in the sense that while m. rectus ventralis is well developed m. rectus ventralis is a very weakly developed muscle.

According to Takahasi (1925), Karrer (1967), Nelson (1967a,b) and Singh (1967) m. obliquus ventralis is extremely variable and are ill developed. Winterbottom (1974) showed that the muscle is occasionally double, as in certain tetraodontiforms. The present investigation indicates that the above muscle is divisible into externus and internus subdivisions and the former is relatively well developed.

The number of m. transversus ventralis varies from one to few as recorded by different workers like Takahasi (1925) and Datta (1972). According to Winterbottom (1974) there are two of these muscles between the ventromedial faces of the fourth and fifth pair of ceratobranchials respectively. The present investigator, however, has found the presence of one such muscle between the fourth ceratobranchials and a pair of muscles between the fifth ceratobranchials. However, the muscles between the fifth pair of ceratobranchials have been considered under the masticatory groups of muscles and have been named as m. transversus os pharyngeus inferioris ventralis.
In spite of the sincere attempt made by Eastman (1971) to describe the masticatory muscles according to their functional morphology, there has been lot of confusion regarding nomenclature of these muscles until Datta (1972) made another attempt to redescribe them. In the present investigation m. retractor os pharyngeus superioris is a muscle connected to os pharyngeus superior and is similar with the m. retractor arcum branchialium of Holstvoogd (1965) and m. retractor dorsalis of Winterbottom (1974). Presence of m. protractor os pharyngeus superioris is completely a new record in the teleosts as it does not have a parallel in other teleosts. It seems that m. protractor os pharyngeus superioris is antagonistic in action to m. retractor os pharyngeus superioris.

M. levator os pharyngeus inferioris of the present study is synonymous with m. levator arcus branchialis \(_v\) of Edgeworth (1935) and m. trapezius profundus of Takahasi (1925). Edgeworth (1935) however with embryological as well as neurological evidences refuted its homology with any part of m. trapezius of other vertebrates. It seems to be a reasonable conclusion that it is a branchial levator muscle connected with the fifth arch. It is noteworthy to mention here that in the present group of fishes m. levator os pharyngeus inferioris originates from fourth epibranchial instead of neurocranium as reported by Datta (1972) in \(N.\) \(nandus\).

M. retractor os pharyngeus inferioris of the present group of fishes is synonymous with m. pharyngoclavicularis internus of Vetter (1876), Dietz (1914), Takahasi (1925), Liem (1970) and Winterbottom (1974). M. depressor os pharyngeus inferioris of the present investigation is synonymous with m. pharyngoclavicularis externus of Vetter (1878), Dietz (1914), Takahasi (1925), Liem (1970) and Winterbottom (1974).

M. protractor os pharyngeus inferioris of the present investigator is synonymous with the m. subarcualis rectus communis of Edgeworth (1935), Eastman (1971) and m. pharyngoarcualis hyoideus of Takahasi (1925) as well as m. pharyngohyoideus of Liem (1970).
M. protractor pectoralis is branchiomeric in nature despite its inclusion in the myomeric group by some workers. Edgeworth (1935) conclusively proved its branchiomeric derivation. The terminology of Shann (1914) is followed here. It is noteworthy to mention here that Yazdani (1969) also reported the presence of such a muscle in the Cynoglossus sp. and termed it as m. cephaloscapularis which is nothing but a synonym of m. protractor pectoralis.

M. cleithrohyoideus is a hypobranchial spinal muscle (Edgeworth, 1935). Although topographically it is a cranial muscle, but from developmental standpoint it is a myomeric muscle. In the present investigation the terminology of Shann (1914) has been followed.

To summarize the above discussion it can be said briefly that the pattern of cranial myology of the fishes under the present investigation is like that of a typical teleostean type but with certain modifications. Those modifications have taken place mainly in accordance with the asymmetry of the cranial osteology. It has been observed in the previous Chapter (vide Chapter I - osteology part) that the jaws of the blind side have stronger osteological framework and provided with dentition for carrying out mastication. The present investigation also indicates that the jaw muscles of the blind side are relatively well developed than the ocular side. This type of modification provides the jaws of the blind side with more muscular power to carry out the feeding effectively. And thus it can be concluded that the muscular make up of the blind side is better suited for carrying out feeding effectively.