CRANIAL MYOLOGY
INTRODUCTION


Winterbottom (1974a,b) made worthmentioning studies on cranial myology. He has prepared a descriptive synonymy of the striated muscles of the teleostei which may be considered as an invaluable
contribution to this field of study. He also pointed out the incompleteness of the knowledge of teleostean myology.

In India, the study of teleostean myology did not get due attention. However, mention may be made of Dubale (1952), Datta Munshi (1960), Saxena (1960), Dubale and Vidyasagar (1960), Dubale and Shah (1962), Bhattacharyya (1962), Datta Munshi and Singh (1967), Singh (1967), Singh and Datta Munshi (1968), Mahajan (1971), Datta (1972), Bandopadhyay (1980), Das (1982), Jayaram and Singh (1982), Jayaram, Dhanze and Singh (1983) who studied some aspects of cranial myology of the teleosts.

An enquiry into the literature concerning myological studies of the last one hundred and fifty years, reveals that, the attention was mainly focussed on three principal perspectives:

(1) anatomical
(2) functional morphological and
(3) taxonomical including phylogenetic considerations.

It is apparent that the works on teleostean myology upto 1935 are mostly done on anatomical perspective. Edgeworth (1935) summarized the knowledge of the cranial muscles of the vertebrates including the teleosts in his magnum opus, "The cranial muscles of vertebrates". It is indeed an invaluable treatise.

"The morbid morphology is greatly rejuvenated by functional morphological interpretation", (Datta, 1972), and the turning point in this direction was perhaps initiated by Dobben (1935), Klaauw (1950, 1963), Tchernavin (1948, 1953). Subsequently Günther and Deckert (op.cit.), Sarkar (op.cit.), Alexander (op.cit.), Field (op.cit.), Millard (op.cit.), Branch (op.cit.), Karrer (op.cit.), Dutta (op.cit.), Osse (op.cit.), Liem (op.cit.), Liem and Kaufman (1983) studied the functional morphology of the cranial muscles of a number of teleostean fishes. Such studies have contributed greatly to the realization of form and function relationship. Osse (op.cit.) added a new direction to the study of functional morphology of muscles, through the measurement of
action potentials i.e., electromyography, in combination with movement studies.

Recently the trend has been to utilize the myological variations in explaining taxonomic as well as phylogenetic relationships. Adams (1919), Schaeffer and Rosen (1961), Rosen (1962, 1964, 1973), Greenwood et al., (1966), Nelson (1967a,b, 1969a), Rosen and Patterson (1969), Rosen (1973), Winterbottom (op.cit.), Howes (1976, 1978, 1981, 1985), Godkin and Winterbottom (1985), Yabe (1985) pioneered this type of study, Winterbottom (1974b) rightly stressed, "this approach is used in order to facilitate recognition of evolutionary lines than may become obscured in a more compressed classification".

However, it has become evident from literature survey that the cranial myology of Ambassidae has not been studied yet. Thus while working out the taxonomy and osteology of this family an attempt has also been made to study all the cranial muscles of these fishes.

The main objective of this enterprise has been (i) to study the structural peculiarities in a comparative outlook and (ii) to assess similarities and dissimilarities at the generic and specific level for considering these in taxonomic as well as phylogenetic decision.
MATERIAL AND METHODS

The ambassid fishes were collected from ponds, Hooghly river (at different points) as well as coasts of Bengal, Orissa coast and Vembanad lake of Kerala. The following specimens were preserved in 10% formalin solution: 1. Parambassis thomassi (Day), 2. Ambassis commersoni Cuvier, A. gymnocephalus (Lacépède), A. nalua (Hamilton-Buchanan), 3. Chanda nama Hamilton-Buchanan, 4. Pseudambassis ranga (Hamilton-Buchanan). After thoroughly washing the specimens, the skin was carefully removed. Then dissections were made under the stereoscopic binocular microscope so as to expose different cranial muscles. The structure and the nature of origin, insertion and the course of muscle fibres were meticulously observed. Outer sketch of the cranium of P. thomassi, A. commersoni and C. nama were drawn with the help of camera lucida and then individual muscle components as seen under the stereoscopic binocular microscope were produced free hand. Since, the cranial muscle components of Pseudambassis ranga resembles too much to those of C. nama, separate illustrations of that of the former is not given.

Classification of cranial muscles of the studied fishes:

The cranial muscles, as the name itself implies, are very much associated, morphologically, functionally and embryologically with the cranium. They are also known as branchiomeric muscles from the embryological stand point (Edgeworth, 1935). The branchiomeric musculature are innervated by the branches of fifth, seventh, ninth and tenth cranial nerves. These muscles are mainly responsible for food capture and mastication as well as respiratory movements. Modifications occur in accordance with the functional needs associated with the visceral arches. On the basis of origin, insertion, disposition and function each complex can be further divided and subdivided into a number of distinct and discrete muscles. Nomenclature of the same muscle varied with
different investigators. Winterbottom's (1974a) descriptive synonymy although a way out in this arbitrariness but there are difficulties in following the same in toto. Hence nomenclature followed is mainly that of Vetter (1878), Takahasi (1925), Edgeworth (1935), Dutta (1968), Datta (1972) and Winterbottom (1974a).
Logic of the approach made in this scheme:

An outline classification along with the index to cranial muscles has been presented here in order to provide a ready reference (ready reckoner) of cranial muscles observed in ambassids. The approach is mainly morphological and functional.
Index to cranial muscles :

A. Mandibular muscle complex
   (a) Adductor mandibulae group
      i) Maxillar subgroup
         1. M. adductor maxillaris<sub>1</sub>
         2. M. adductor maxillaris<sub>2</sub>
         3. M. adductor maxillaris<sub>3</sub>
      ii) Mandibular subgroup
         1. M. adductor mandibularis<sub>1</sub>
         2. M. adductor mandibularis<sub>2</sub>
         3. M. intramandibularis

(b) Constrictor dorsalis group
    1. M. levator arcus palatini
    2. M. dilator operculi

(c) Intermandibularis group
    1. M. intermandibularis anterioris
    2. M. intermandibularis posterioris
       (or M. protractor hyoidei in part)

B. Hyoid muscle complex
   (a) Constrictor hyoideus dorsalis group
      1. M. adductor arcus palatini
      2. M. levator operculi
      3. M. adductor operculi

   (b) Constrictor hyoideus ventralis group
      1. M. interhyoideus (or M. protractor hyoidei in part)
      2. M. hyohyoidei abductores
      3. M. hyohyoidei adductores

C. Branchial muscle complex
   (a) Dorsal group
      1. M. levator arcus branchialis externus
      2. M. levator arcus branchialis internus
3. M. obliquus dorsalis superioris
4. M. obliquus dorsalis inferioris
5. M. adductor arcus branchialis
6. M. transversus dorsalis

(b) Ventral group
1. M. obliquus ventralis superioris
2. M. obliquus ventralis inferioris
3. M. transversus ventralis

(c) Masticatory group I
(Muscles connected with os pharyngeus superior)
1. M. retractor os pharyngeus superioris

(d) Masticatory group II
(Muscles connected with os pharyngeus inferior)
1. M. levator os pharyngeus inferioris
2. M. retractor os pharyngeus inferioris
3. M. depressor os pharyngeus inferioris
4. M. protractor os pharyngeus inferioris
5. M. transversus os pharyngeus inferioris

D. Anterior girdle muscle
1. M. protractor pectoralis

E. Hypobranchial spinal muscle
1. M. retractor hyoidei
OBSERVATION

In the present investigation all the muscles of mandibular, hyoid and branchial complexes have been studied.

A. Mandibular muscle complex:

This complex is divided into three principal groups: (a) adductor mandibulae group, (b) constrictor dorsalis group and (c) intermandibularis group.

(a) Adductor mandibulae group

This largest and most striking cheek muscle group, primarily responsible for closing the jaws, develops from the ventral subdivision of the masticatory muscle plate (Winterbottom, 1974a). The group adductor mandibulae contains a number of components which run from hyomandibular, preopercular, pterygoid and quadrate to the upper jaw or to the lower jaw or to the both. None of these components as observed presently either originate from or insert to the neurocranium, directly. The components of the adductor mandibulae group are placed on the outer lateral aspect of cheek and below the eye. These muscles can readily be viewed on removing the skin over the cheek. This apparently compact muscle (revealed by gross morphological examination), where the various components are not easily distinguishable, requires a meticulous examination for their proper identification, so as to designate them the suitable names. On the basis of insertion these muscles are divided into two subgroups as mentioned before, and are described below.

(i) Maxillar subgroup (A₁ of Vetter and Section A₁ of Winterbottom)

The muscle components inserting on the maxilla belong to maxillar subgroup. Winterbottom (1974a) defined it, "by its dorsal position and its insertion on the maxilla". According to him, "it
apparently developed from the dorsal encroachment of the fibres of A₂ along the primordial ligament between the lower jaw and the head of the maxilla.

The origin of the muscle components of this group is not fixed to any skeletal component but the point of insertion is more or less constant. The insertion usually takes place either on the maxilla or on the primordial ligament and also on the connective tissue plate connecting upper and lower jaws.

In all the four genera of Ambassidae, maxillar subgroup or Section A₁ is subdivided into a number of subsections which are termed m. adductor maxillaris₁, m. adductor maxillaris₂ and m. adductor maxillaris₃.

A peculiar feature is observed in the first two subsections of the maxillar subgroup is that M. adductor maxillaris₁ and m. adductor maxillaris₂ have separate origin and disposition but their insertion is common. The former originates from preopercular and the latter from preopercular as well as hyomandibular. The direction of muscle fibres are different in these two subsections and m. adductor maxillaris₂ is disposed little below the former one (m. adductor maxillaris₁), which justify the existence of these two different muscles. But both are converged to a common aponeurosis in the middle and their separate identity is lost.

1. M. adductor maxillaris₁ (ADD. MX₁)
   (A₁₁ of Winterbottom)

In Parambasssis thomasi (Fig.159) the fibres of m. adductor maxillaris₁ after orginating from preopercular musculously, run dorso-laterally for some distance, get transformed into a median aponeurosis mesially, then again move upwards musculously in a convergent manner. It is finally inserted to maxilla through a short and strong aponeurosis which lies below the primordial ligament.
In *Ambassis commersoni* (Fig. 160) m. adductor maxillaris\(_1\) also originates musculously from preopercular. Its origin is narrow and the posterior part of the muscle is thin. From the point of origin, it runs forward in a convergent manner and mesially it is transformed into an aponeurosis. Finally, it is inserted just by a short and thick aponeurosis on the anteromesial aspect of the inner surface of maxilla. In *A. nalua* some fibres of this muscle are attached to some infraorbital bones. In *A. gymnocephalus* it is poorly developed.

In *Chanda nama* (Fig. 161) and *P. ranga* origin, insertion and pattern are similar to those of *P. thomassi* and *A. commersoni*. The aponeurosis through which m. adductor maxillaris\(_1\) is inserted on the anterior head of maxilla, is thin and long.

2. M. adductor maxillaris\(_2\) (ADD.MX\(_2\)) (A\(_1\)\(_β\) of Winterbottom)

In *P. thomassi* (Fig. 159) it is placed along the outer lateral aspect of the m. adductor maxillaris\(_1\) and is partly overlapped by the latter. It originates musculously from hyomandibular blade as well as from preopercular and then runs downward and forward. This muscle is converted to an aponeurosis in the middle and fuses with the aponeurosis of m. adductor maxillaris\(_1\) so intimately that its separate identity is not traceable. Presumably, therefore, this muscle inserts on the maxilla jointly with m. adductor maxillaris\(_1\).

In *A. commersoni* (Fig. 160), *A. nalua*, *A. gymnocephalus*, *C. nama* (Fig. 161) and *P. ranga* it is similar to that of *P. thomassi*.

3. M. adductor maxillaris\(_3\) (ADD.MX\(_3\)) (A\(_1\)\(_γ\) of Winterbottom)

In *P. thomassi* (Fig. 159) it is a moderately developed muscle which originates musculously from the lower aspect of the vertical arm of preopercular and passes below the m. adductor maxillaris\(_1\). Some of its fibres are fused aponeurotically with median aponeurosis of m. adductor maxillaris\(_1\). The rest portion
runs forward and upward and is finally inserted musculously to the median aspect of primordial ligament.

In *A. commersoni* (Fig. 160) and in other ambassids (Fig. 161) this muscular subsection is similar to that of the former.

(ii) Mandibular subgroup:

The individual muscles of this subgroup are inserted to the lower jaw. In all the four genera of the family Ambassidae, muscles of this subgroup are well developed, generally comprising two subsections: M. adductor mandibularis\(_1\) and mandibularis\(_2\).

1. M. adductor mandibularis\(_1\) (ADD.MD\(_1\)) (Section A2 of Winterbottom)

This is placed partly along the lower lateral aspect of the muscles of the maxillar subgroup and is roughly rectangular in outline. Below this muscle lies m. adductor mandibularis\(_2\). M. adductor mandibularis\(_1\) is represented by two fasciculi - the upper and the prominent one is designated as m. adductor mandibularis\(_1\) (ADD.MD\(_1\)) and the less developed lower one is m. adductor mandibularis\(_2\) (ADD.MD\(_2\)).

In *P. thomassi* (Fig. 159), m. adductor mandibularis\(_1\) is well developed and originates musculously from the lower anterolateral aspect of the preopercular. This thick and broad muscular subsection runs forward and is finally inserted aponeurotically to the articular sharing the aponeurosis with m. intramandibularis (Aw). M. adductor mandibularis\(_1\) is a small, somewhat triangular muscular flap contiguous with the lateral aspect of m. adductor mandibularis\(_1\). It originates musculously from the lower aspect (i.e., horizontal part) of the preopercular and its distal portion unites with the aponeurosis of m. adductor mandibularis\(_1\) before insertion.

The morphological disposition of m. adductor mandibularis\(_1\) of all the ambassids (Figs. 160, 161) is similar to that of *P. thomassi*. 
2. M. adductor mandibularis$_2$ (ADD.MD$_2$) (Section A3 of Winterbottom)

This is the innermost muscle of the mandibular subgroup. It is broad, flat and triangular in shape. It is difficult to separate this muscle from m. adductor mandibularis$_1$.

In *P. thomassi* (Fig.162) this muscle is very broad, thin and flat. It originates musculously from the inner vertical rim of preopercular and lower aspect of hyomandibular. It then runs obliquely forward over metapterygoid, symplectic and quadrate. Distally it becomes aponeurotic before insertion to the articular below the joint aponeurosis of m. adductor mandibularis$_1$.

The morphological disposition of this muscle in other ambassids (Figs.163 and 164) is similar to that of *P. thomassi*.

3. M. intramandibularis (IMD) (Section A$_w$ of Winterbottom) (Figs.159, 160 and 161)

According to Winterbottom (1974a) the section A$_w$ inserts in and fills the Meckelian fossa on the medial face of the dentary. The muscle is moderately developed and arises from the common aponeurosis of m. adductor mandibularis$_1$. The muscle fibres are directly attached to the inner surface of dentary and angular.

In all ambassids studied, this muscle conforms to the above description.

(b) Constrictor dorsalis group

Muscles of this group run between the cranium on one hand and hyomandibular, opercular as well as pterygopalatine arch on the other. The constrictor dorsalis group is represented in Ambassidae by the following two muscles: 1. M. levator arcus palatini and 2. M. dilator operculi.

1. M. levator arcus palatini (L.A.P)

It is a well developed muscle situated at the concavity of the forepart of hyomandibular, and in between the rear of the orbit
and the posterodorsal tip of the opercular. The muscle arises from below the sphenotic and is inserted to the depression of the hyomandibular. It serves to lift the hyomandibular and thus the pterygopalatine arch.

In *P. thomassi* (Figs. 159, 162), this muscle is well developed, elongated and gradually broadens as it goes downwards. It originates musculously from lower ventral edge of sphenotic, descends downwards over the blade of hyomandibular and is finally inserted to its lower edge. Few fibres reach the anterior margin of metapterygoid. This muscle at the lower edge covers the posterior portion of *m. adductor arcus palatini* and itself is covered by *m. adductor maxillaris₂*.

In *A. commersoni* (Figs. 160, 163) this muscle is elongated, well developed and originates musculously from the lower ventral edge of sphenotic and it extends below, beyond the hyomandibular. Some of the lowermost fibres get inserted to the shallow groove of metapterygoid musculously, some fibres have insertion on preopercular and the major portion on the hyomandibular itself. *M. adductor maxillaris₂* partly covers the lower portion of it. It covers only the posteriormost tip of *m. adductor arcus palatini*.

In *C. nama* (Figs. 161, 164) this muscle is elongated and thick. It originates musculously from sphenotic and pterotic and is inserted on the dorsal face of hyomandibular and metapterygoid. Ventrolateral portion of this muscle overlaps only a few fibres of *m. adductor arcus palatini*.

In the rest of the ambassids the muscle does not deserve any special mention.

2. *M. dilator operculi* (D.O)

This opercular muscle runs from the neurocranium to the opercular. It is formed by the posterior section of the constrictor dorsalis and is present in all the species of ambassids. The muscle inserts on the anterodorsal face of the opercular. It is well developed
and somewhat conical in shape. Sites of origin include sphenotic and pterotic. This muscle is usually placed posterior to m. levator arcus palatini, and is divisible into two distinct parts based on the nature of origin and insertion: (i) m. dilator operculi anterioris and (ii) m. dilator operculi posterioris.

(i) M. dilator operculi anterioris (D.O.A)

In P. thomassi (Figs. 159, 162) it is a well-developed muscle and is placed at the posterodorsal aspect of the m. levator arcus palatini, partly covering it. M. dilator operculi anterioris is more developed than the posterior one. It originates muscologically from the lateral aspect of the sphenotic and pterotic ridges. Origin is much broader than insertion. From its wide origin the muscle runs backwards and downwards. It then gradually converges, and the fibres run below the upper aspect of vertical limb of the preopercular, and finally terminates to an aponeurosis for insertion to the opercular. The aponeurosis is inserted on the anterodorsal aspect of the opercular. The anterior fibres of this muscle are much longer than the posterior ones.

In A. commersoni (Fig. 160), C. nama (Fig. 161) and P. range this muscle is similar to that of P. thomassi. Only it is less developed in case of these species.

(ii) M. dilator operculi posterioris (D.O.P)

In P. thomassi (Figs. 159, 162) it is comparatively less developed and is placed along the posterodorsal margin of the anterior one. Originating muscologically from the posterolateral part of the ridge of the pterotic, it runs obliquely downwards. Finally, it is inserted aponeurotically to the anterodorsal part of the opercular, posterior to the insertion of the anterior division. While inserting the muscle fibres run below the upper aspect of the vertical limb of the preopercular.

In all other ambassids (Figs. 160, 161, 163, 164) the muscle is similar to that of P. thomassi.
According to Edgeworth (1935), the muscle is derived from the intermandibularis muscle plate and is innervated by the r. mandibularis inferior of the Vth (trigeminal) cranial nerve. Embryologically the muscle separates into two portions. In adult fish, two separate muscles are usually recognized in this group: 1. m. intermandibularis anterioris and 2. m. intermandibularis posterioris, the latter often becomes incorporated in the formation of the protractor hyoidei. Of course, in some instances separate existence of intermandibularis posterioris is observed (Winterbottom, 1974a).

1. M. intermandibularis anterioris (IM.A)

This muscle is situated transversely between the dentaries of both sides just behind the symphysis.

In P. thomassi (Fig. 165) it is a well developed muscle, and is somewhat triangular in shape, anteriorly narrow and posteriorly wide. This short parallel-fibred muscle connects the dentaries of both sides and lies below the anterior end of m. protractor hyoidei. The attachment to the dentary is musculous.

There is not much difference in the shape and disposition of m. intermandibularis anterioris in all the species of the ambassids (Figs. 166 and 167).

2. M. intermandibularis posterioris or M. protractor hyoidei in part (PR. HY)

This muscle is well developed and is usually runs from the hyoid arch to dentary. M. intermandibularis posterioris is very often gets fused with the m. interhyoideus to form the m. protractor hyoidei (Holmqvist, 1910). In fact, in all the fishes of present study, m. protractor hyoidei is present in well developed condition and separate existence of m. intermandibularis posterioris could not be traced here.
In *P. thomassi* (Fig.165) this is a very well developed muscle, thick and elongated, originating from the ventrolateral part of ceratohyal as well as from the bases of first and second of the six branchiostegal rays. The origin is mostly musculous but intermingled with few aponeurotic slips. The right and left halves of the muscle run forward medially to meet the fellow of the other side and proceeds forward as a single unit. Insertion takes place on the dentary, covering entirely m. intermandibularis anterioris. Insertion is partly musculous and partly aponeurotic.

In *A. commersoni* (Fig.166) this muscle is a well developed and originates musculously as well as aponeurotically from the ventrolateral part of ceratohyal and from the bases of first and second of the six branchiostegal rays. Insertion is similar to that of *P. thomassi*. The nature and disposition of this muscle is identical in all the ambassids excepting *C. nama* (Fig.167) where origin besides ceratohyal and epiphysial cover bases of all the first to fifth branchiostegal rays.

B. Hyoid muscle complex

Edgeworth (1935) concluded (based on embryological evidences) that the hyoid muscle primordium in adult stage gives rise to two groups of muscles - the constrictor hyoideus dorsalis and constrictor hyoideus ventralis group.

(a) Constrictor hyoideus dorsalis group

This muscle group in ambassids usually extends from the neurocranium to pterygopalatine arch, hyomandibular and opercular.

1. M. adductor arcus palatini (A.A.P)

The muscle develops from the anterior portion of the constrictor hyoideus dorsalis, and is innervated by the r. hyomandibularis of the VIIth cranial nerve (Edgeworth, 1935). This muscle usually runs from the parasphenoid to pterygopalatine arch, forming a
part of the floor of the orbit. It can be best seen on removing
the eyeball and the various muscles of the adductor mandibulae
group. Origin is from parasphenoid and prevomer. Insertion is
primarily on the hyomandibular and metapterygoid and also on the
endopterygoid and palatine.

In P. thomassii (Fig.162) it is well developed, lying on either
side of the parasphenoid. It is elongated, roughly rectangular
in outline. It originates musculously from the parasphenoid and
particularly in this species the origin extends anteriorly as
far forward as the ventrolateral margin of prevomer. It is inser­
ted finally on the hyomandibular, metapterygoid and palatine. The
insertion is musculous. The fibres run in the horizontal direc­
tion at a right-angle to the longitudinal axis of the head in a
divergent fashion.

In the other ambassids (Figs.163,164) studied here m. adductor
arcus palatini conforms more or less to the above description.
Minor variations are there which do not deserve any mention.

2. M. levator operculi (L.O)

This muscle develops from the posterior portion of the constrictor
hyoideus dorsalis, and is innervated by the r. hyomandibularis
of the VIth cranial nerve (Edgeworth, 1935). M. levator
operculi lies behind the m. dilator operculi and runs from the
posterolateral part of pterotic, and posttemporal to opercular.
In ambassids, it is placed posterior to m. dilator operculi as
usual and can be exposed on removing the skin of dorsolateral
aspect of the opercular and the adjacent parts of the neurocra­
nium.

In P. thomassii (Fig.162) it is broad and flat, almost rectangular
in shape. The muscle fibres originate musculously from the pos­
teriormost corner of pterotic, posttemporal, then runs obliquely
downward, and the fibres insert on the dorsal margin of the oper­
cular.
In other ambassids (Figs.163,164) studied this is same as that of \( \text{P. thomassii} \).

3. M. adductor operculi (A.O)

This muscle develops from the constrictor hyoideus dorsalis, and is innervated by the r. hyomandibularis branch of the VIIth cranial nerve (Edgeworth, 1935). It connects the dorsomedial face of the inner aspect of opercular to the lateral aspect of auditory region. It originates from the pterotic and prootic and inserts on the dorsomedial surface of the inner aspect of opercular. Its origin can be best exposed on removing m. dilator operculi and m. levator operculi as well as upper part of hyomandibular. Whereas its insertion can be viewed if the opercular be detached from the neurocranium along with relevant muscle.

In \( \text{P. thomassii} \) (Fig.162) it is a moderately developed muscle originating musculously from the innermost ventrolateral margin of pterotic, runs obliquely, backward, in a divergent fashion. It is finally inserted on the upper ventral margin of opercular, partly musculously and partly aponeurotically.

In \( \text{A. commersoni} \) (Fig.163), \( \text{A. gymnocephlus} \) and \( \text{A. palua} \), this muscle originates from the ventrolateral margin of prootic. In other respects it is similar to that of the former species.

In \( \text{C. nama} \) (Fig.164) it is similar to that of \( \text{A. commersoni} \). In \( \text{P. ranga} \), origin of this muscle is from exoccipital, insertion is similar to that of the former species.

(b) Constrictor hyoideus ventralis group

This group consists of three distinct muscle components, these are 1. M. interhyoideus, 2. M. hyohyoidae abductores, 3. M. hyohyoidae adductores.
1. M. interhyoideus (I.HY) or M. protractor hyoidei in part (PR.HY. in pari:)

This muscle when present separately usually runs from the ceratothyal to hypohyal or to dentary or may meet its fellow of other side at the midventral line. No separate existence of this muscle could be traced in any fish encountered in the present study. Possibly it is fused with the m. intermandibularis posterioris to form m. protractor hyoidei in the fishes of the present study and has already been considered.

2. M. hyohyoidei abductores (H.AB)

Millard (1966) had suggested two names hyohyoidei abductores and hyohyoidei adductores for the muscles of this region. The former spreads and the latter contracts the branchiostegal rays. According to Winterbottom (1974a), the muscles develop from the posterior part of the constrictor hyoideus ventralis, and are innervated by R. hyoideus VII. They exhibit considerable variation among the teleosts, and may serve one or many branchiostegal rays. This muscle in ambassids is present just behind the m. protractor hyoidei.

In P. thomassi (Fig.165) it is a moderately developed thin flap of muscle, arising from the ventral hypohyal musculously as well as aponeurotically. Fibres of this muscle serving the second branchiostegal ray arises from ceratohyal. The left and right muscles run downward, the left slip slightly overlapping the right one anteriorly. Insertion is musculous on the first and second branchiostegal rays.

In the rest of the ambassid species, the muscle is similar to that of P. thomassi.

3. M. hyohyoidei adductores (H.AD)

This m. hyohyoidei adductores muscle approximates the branchiostegal rays. The muscle develops from the posterior part of the constrictor hyoideus ventralis, being innervated by the
r. hyoideus VII. It continues dorsally to attach to the medial faces of opercular, preopercular and subopercular. The lateral fibres of the muscle usually pass from ray to ray. It is a very thin sheet of muscle.

In *P. thomassi* (Fig.165) it extends from the posterior part of the dorsalmost branchiostegal ray to the inner surfaces of opercular, preopercular and subopercular.

In *A. commersoni* (Fig.166), *A. gymnocephalus*, *A. nalua* and *C. nama* (Fig.167) this muscle follows the above pattern.

C. Branchial muscle complex

The branchial muscle primordium in adult stage gives rise to two groups of muscles: the dorsal and the ventral groups. Datta (1972) gave two hypothetical diagrams depicting the ideal condition of all branchial muscles including the masticatory ones, which give a thorough idea of all branchial muscles of teleosts (Figs.171,172). Nomenclature of Vetter (1878), Takahasi (1925), Eastman (1971), Winterbottom (1974a) is mainly followed while describing the dorsal and ventral groups of muscles.

(a) Dorsal group

These are muscles which connect the dorsal branchial elements with the neurocranium. According to Winterbottom (1974a) the muscles of the dorsal parts of the branchial arches consist of extrinsic and intrinsic types. The former connect the arches to the skull or vertebral column, all other muscles being intrinsic, i.e., having both sites of attachment on the arches themselves. Dorsal branchial group of muscles can be exposed on removing the opercular apparatus along with the hyomandibular and trimming the gill filaments. In order to expose all the branchial muscles including the dorsal it is better to detach the visceral skeleton from the neurocranium. Of course, proper care should be taken to keep all the relevant muscles intact with the visceral skeleton.
M. levator arcus branchialis externus (L.A.B.EXT) (levator externus of Winterbottom)

According to Edgeworth (1935) they develop from the dorsal ends of the muscle plate formed in each branchial segment, and are innervated by post trematic branches of the glossopharyngeal (IXth) and vagus (Xth). These slips of muscles connect the skull to the epibranchials. Origin is from prootic, insertion is on the dorsolateral faces of the epibranchials.

In P. thomassii (Fig. 173) it is represented by two slips in connection with first and fourth branchial arches. All these slips originate from prootic region of the skull. The first levator externus originates from the prootic musculously and partly aponeurotically, and then runs downward and backward. The muscle is the shortest of this group and is inserted musculously on the epibranchial of the first arch. The fourth m. levator arcus branchialis externus is very well developed and placed posterior to the first at the origin. The origin is like that of the previous one but insertion is on the epibranchial of the fourth arch. The second and third m. levator arcus branchialis externus are absent.

In A. commersoni (Fig. 174) it is represented by three slips in connection with first, third and fourth branchial arches. All these slips originate from prootic region of the skull. The first m. levator arcus branchialis externus originates from the prootic musculously and then runs downward and backward in close contact with the third. The muscle is the shortest of this group and is inserted musculously on the epibranchial of the first arch. The third one is contiguous with the origin of the first and runs downwards and is inserted musculously on the anterior aspect of the third epibranchial. The fourth m. levator arcus branchialis externus is very well developed and placed just posterior to third. The origin is similar to the previous two but insertion is on the epibranchial of the fourth arch.
In *C. nama* (Fig.175) and *P. ranga* two slips of well developed muscles are present in connection with first and the fourth epibranchials.

2. **M. levator arcus branchialis internus (L.A.B.INT)**
   (Levator internus of Winterbottom)

According to Edgeworth (1935), these muscles differentiate from the medial faces of the muscle plates formed in each branchial segment giving rise to the levator arcus branchialis externus and have a similar innervation. Winterbottom (1974a), stated that there are generally two or three of them, connecting the skull (prootic) to the infrapharyngobranchials.

In *F. thomassi* (Fig.173) this muscle is represented by only two slips. These are thick, well developed and originate musculously from prootic and insert on the dorsal surface of the first and third pharyngobranchial musculously, inner to the insertion of externus muscles.

In *A. commersoni* (Fig.174), *C. nama* (Fig.175) and *P. ranga*, this muscle is similar as above.

3. **M. obliquus dorsalis (OBL.D)**

This muscle can be divided into two subgroups: (i) *m. obliquus dorsalis superioris* and (ii) *m. obliquus dorsalis inferioris*.

(i) **M. obliquus dorsalis superioris (OBL.D.S)**
   (Obliquus dorsalis of Winterbottom)

These muscles, whose number and sites of attachment are variable, interconnect the epibranchials and infrapharyngobranchials of the same or adjacent arches, (Winterbottom, 1974a). According to Edgeworth (1935) they are apparently derived from the lateral edge of the transversus dorsalis of the respective arch, and are innervated by branches of the vagus (Xth cranial) nerve.
In *P. thomassi* (Fig. 173) it is represented by second, third and fourth obliquus dorsalis superioris muscles. The second and third muscle slips are moderately developed and originate musculously from the second and third epibranchial respectively, then run forward and inward and are finally inserted on the dorsal aspect of the anterior part of the os pharyngeus superior, which represent the second, third and fourth pharyngobranchials. The fourth one is well developed and originates musculously from the fourth epibranchial and then runs forward and inward so as to insert on the dorsal aspect of the anterior part of the os pharyngenus superior.

In *A. commersoni* (Fig. 174), *C. nama* (Fig. 175) and *P. ranga* the muscles are same as above.

(ii) M. obliquus dorsalis inferioris (OBL.D.I)  
*Rectus dorsalis of Winterbottom*

It is usually represented by very ill developed muscle slips which are placed in between the epibranchials of adjacent arches. Factually, the epibranchials are fastened to each other by a connective tissue plate but some muscle fibres also are present.

In *P. thomassi* (Fig. 173), *A. commersoni* (Fig. 174), *C. nama* (Fig. 175), and *P. ranga* obliquus dorsalis inferioris is very ill developed.

4. M. adductor arcus branchialis (A.A.B)  
*Adductores of Winterbottom*

This muscle is placed at the inner angle of the epibranchial and ceratobranchial of the same arch. It is present in the form of small muscular patches in all ambassids.

5. M. transversus dorsalis (TR.D)  
*Transversus dorsalis of Winterbottom*

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 *P. thomassi* (Fig.173) there are two transversus dorsalis - the anterioris and posterioris. The transversus dorsalis anterioris is very well developed. It originates musculously from the midline, though there is fibre connection to the parasphenoid and basioccipital and is situated on the anterodorsal aspect of the first epibranchial and then runs inward to meet its fellow of the other side at the middorsal line of the branchial basket. The transversus dorsalis posterioris is less developed than the former. It originates musculously from the epibranchial of the fourth arch and then runs inward where it meets its fellow of the other side at the middorsal line of branchial basket. It partly covers the anterior aspect of m. retractor os pharyngeus superioris and the third m. obliquus dorsalis superioris.

In *A. commersoni* (Fig.174) and *C. nama* (Fig.175) and *P. ranga* this muscle is same as above. In *C. nama* and *P. ranga* the shape of the anterior muscle is rhomboid.

C.(b) Ventral group

These muscles are placed at the ventral aspect of the branchial arches, which can be well seen on detaching the branchial skeleton along with relevant muscles.

Following muscles are observed in this group.

1. M. obliquus ventralis superioris (OBL.V.S)  
   (Rectus ventralis of Winterbottom)

This muscle connects two adjacent branchial arches in the hypobranchial or ceratobranchial region. Of course, the first muscle runs from the first hypobranchial to the hypohyal. In *P. thomassi* (Fig.176) this muscle is represented by four slips. The first muscle slip originates aponeurotically from hypobranchial of the first arch and then runs forward for insertion to posterolateral aspect of the hypohyal. The second muscle extends from the hypobranchial of first arch to the hypobranchial of second arch. The fourth obliquus ventralis superioris extends
between the third and fourth ceratobranchials. The fifth slip is very well developed and elongated and extends from the lateral border of the fourth ceratobranchial to the anterodorsal process of the os pharyngeus inferior.

In _A. commersoni_ (Fig. 177) it is represented by similar muscle slips as in _P. thomassi_.

In _C. nama_ (Fig. 178) the first and the fifth muscle slip running between hypohyal and first hypobranchial, fourth arch and os pharyngeous inferior respectively.

In _P. ranga_, it is similar to that of _C. nama_.

2. _M. obliquus ventralis inferioris_ (OBL.V.I)
   (Obliquus ventralis of Winterbottom)

This muscle runs usually from the hypobranchial or ceratobranchial to the basibranchial.

In _P. thomassi_ (Fig. 176) this muscle is represented by three slips which are present in connection with first to third arches. All are moderately developed. The first one runs from the first hypobranchial to first basibranchial. The second muscle arises from the anterior part of the second hypobranchial and inserted to the second basibranchial. The third muscle slip extends from third hypobranchial to posterolateral margin of second basibranchial.

In _A. commersoni_ (Fig. 177) first two muscle slips are like those of _P. thomassi_, slips are shorter and thicker.

In _C. nama_ (Fig. 178) and _P. ranga_ three muscle slips, which are similar to those of _P. thomassi_, are present.

3. _M. transversus ventralis_ (TR.V)

This muscle runs from the ceratobranchial or hypobranchial to basibranchial. In some cases, the muscles of both sides meet
at the midventral line of the branchial basket. The number and position of this muscle is variable in different genera.

M. transversus ventralis is present in the form of very poorly developed muscle slips. The fourth one which is between the fourth branchial arches is little prominent in all ambassids (Figs.176, 177 and 178).

C.(c) Masticatory group I

This group is represented by one muscle which is designated as m. retractor os pharyngeus superioris and is connected with "os pharyngeus superior". It usually occurs from the ventral aspect of the centrum of the anterior vertebra to the dorsal aspect of the "os pharyngeus superior". In some cases, however, this muscle originates from the basioccipital region of the neurocranium. This muscle has been found to occur in all the ambassids studied (Figs.173, 174 and 175).


In P. thomassii (Fig.173), A. commersoni (Fig.174), C. nama (Fig. 175) and P. ranga, it is a paired muscle and is well developed. It originates musculously from the lateral side of the centrum of first vertebra. After originating it runs forward and downward and is inserted musculously as well as aponeurotically to the dorsal aspect of os pharyngeus superior or the third pharyngobranchial. This muscle is well developed and its anterior part is overlapped by the m. transversus dorsalis posterioris.

C.(d) Masticatory group II

This group includes the muscles connected with os pharyngeus inferior.

1. M. levator os pharyngeus inferioris (L.O.P.I) (Levator posterior of Winterbottom)

According to Edgeworth (1935), it supposedly represents the fifth
levator externus whose origin has migrated posteriorly. The muscle runs from the neurocranium to the anterodorsal process of the os pharyngeus inferior.

In *P. thomassii* (Fig. 179) this muscle is moderately developed. It originates musculously from the prootic and runs downwards and is finally inserted musculously to the dorsal aspect of the os pharyngeus inferior.

In *A. commersoni* (Fig. 180) it is same as above.

In *C. nama* (Fig. 181) and *P. ranga* this muscle is moderately developed which originates partly musculously and partly aponeurotically from the prootic and runs downwards. It is finally inserted musculously to the dorsal aspect of the os pharyngeus inferior.

2. M. retractor os pharyngeus inferioris (R.O.P.I)
   (Pharyngoclavicularis internus of Winterbottom)

It usually runs from the posterolateral aspect of os pharyngeus inferior to the anterior aspect of the cleithrum.

In *P. thomassii* (Fig. 179) this is a moderately developed muscular strap. It originates musculously from the anterior aspect of the cleithrum and then runs forward and downward. Finally it is inserted aponeurotically on the posterior aspect of the upper part of the "os pharyngeus inferior".

In *A. commersoni* (Fig. 180) it is same as above.

In *C. nama* (Fig. 181) and *P. ranga* two retractor muscles are present. M. retractor os pharyngeus inferioris_1_ is a moderately developed muscular strap and is placed at the upper lateral aspect of the m. retractor os pharyngeus inferioris_ which is very well developed, thick and broad. The individual entity of each muscle can be recognized by its separate and distinct aponeurotic insertion.
3. **M. depressor os pharyngeus inferioris (D.O.P.I)**
   (Pharyngoclavicularis externus of Winterbottom)

This muscle usually runs from the anterior aspect of the lower part of the cleithrum to the os pharyngeus inferior.

In *P. thomassi* (Fig. 179) it is moderately developed, and originates musculously and aponeurotically from the lower part of the cleithrum. It then runs upward and slightly forward and is inserted musculously on the ventral aspect of the os pharyngeus inferior. The origin of this muscle covers the origin of *m. retractor hyoidei*.

In *A. commersoni* (Fig. 180) it is same as above.

In *C. nama* (Fig. 181) and *P. ranga* this is a thin strap of muscle. Both the origin and insertion are partly musculous and partly aponeurotic.

4. **M. protractor os pharyngeus inferioris (P.O.P.I)**
   (Rectus communis of Winterbottom)

This muscle originates from the "os pharyngeus inferior" but insertion is variable which may be to the urohyal or to hypobranchial or to hypohyal or basihyal elements, as pointed out by Edgeworth (1935). It may have also simultaneous insertion on some ventral branchial elements as well as hyoide elements.

In *P. thomassi* (Fig. 179), *A. commersoni* (Fig. 180), *C. nama* (Fig. 181) and *P. ranga* this muscle is well developed. It arises partly aponeurotically and partly musculously from the antero-ventral aspect of the os pharyngeus inferior and then runs forward as an aponeurotic strap. Anteriorly it again becomes musculus and is partly inserted to the hypobranchial and partly to the urohyal.

5. **M. transversus os pharyngeus inferioris (TR.O.P.I)**
   (Transversus ventralis V)

This muscle is placed at the ventral aspect of os pharyngeus
inferior. It runs from the os pharyngeus inferior of one side to that of the other.

In *P. thomassii* (Fig.176), *A. commersoni* (Fig.177), *C. nama* (Fig.178) and *P. ranga* transversus os pharyngeus inferioris arises musculously from the ventral aspect of os pharyngeus inferior of one side and then runs inward towards the mid ventral line where it meets its fellow of other side. It is moderately developed in all the ambassids.

D. Anterior girdle muscle

These muscles in the case of ambassid fishes, are connecting the pterotic with the anterior part of the pectoral girdle i.e., the cleithrum and supracleithrum. Edgeworth (1935) proved its branchiomeric derivation though some workers have included it in the myomeric groups. Owen (1966) designated this muscle as"m. protractor scapulae." The terminology by Shann (1914) is followed here. Takahasi (1925) described this muscle as m. trapezius superficialis.

1. M. protractor pectoralis (P.P)

This muscle runs from the posterolateral aspect of the pterotic to the upper anterior aspect of posttemporal, cleithrum and supracleithrum as well.

In *P. thomassii* (Fig.179) this muscle is very well developed. This is almost rectangular shaped and is represented by one slip. It originates musculously from the pterotic and inserts musculously mainly to the posttemporal and partly to the supracleithrum.

M. protractor pectoralis is most well developed in *A. commersoni*, in *P. thomassii* and *P. ranga*, it is moderately developed and in *C. nama*, it is poorly developed.

A well developed body muscle is present just below the m. protractor pectoralis. First it seemed to be m. levator pectoralis, but a thorough observation showed that, this muscle does not have any
connection with the pectoral girdle, but it passes just beneath the supracleithrum, and continues with the epaxialis body musculature.

E. Hypobranchial spinal muscle

1. M. retractor hyoidei (R.H)
   (Sternohyoideus of Winterbottom)

According to Winterbottom (1974a), this muscle develops from the ventral ends of the hypobranchial muscle plates of the first few spinal myomeres, which grow down behind the branchial arches and then course anteriorly to acquire attachment to the hyoid arch. The fibres are innervated by branches of the occipito-spinal nerves.

In *P. thomasi* (Fig. 179), *A. commersoni* (Fig. 180), *C. nama* (Fig. 181) and *P. ranqa* the muscle originates musculously from the lower aspect of cleithrum, then runs forward and gradually becomes narrow. Finally it is inserted musculously on the urohyal. The left and right halves are fused.
While studying the systematics and cranial osteology of the Indian ambassids, it was thought that in order to define the functional unit, head, completely, the study of cranial myology should also not escape attention. A survey of relevant literature incidentally, indicates that this aspect has so far remained neglected. Therefore, the muscles of the cranium were studied in order to examine the structural peculiarities in a comparative outlook as well as to evaluate similarities and dissimilarities at the generic and specific levels for consideration in taxonomic analysis. A search has also been made in the respective study, to assess the extent of advancement, since ambassids belong to the highly evolved group of percoid fishes.

The comparative cranial myological studies of the genera under present consideration, clearly indicate that each genus exhibits a more or less uniform pattern in respect of the nature of origin, insertion and morphological disposition of muscles. The differences though exist, are not very great which probably indicates their conformity owing to their origin from a common ancestry.

The terminologies used by Takahasi (1925) and Winterbottom (1974a) are mostly followed here, as these provide descriptive information for the muscles while retaining many of the earlier terminologies and without making changes for purely pedantic or etymological reasons.

The invaluable work of Edgeworth (1935) provides a lot of information regarding the development and differentiation of branchiomeric muscles of different vertebrates including fish. According to him the branchiomeric musculature gives rise to mandibular muscle primordium, hyoid muscle primordium, and branchial muscle primordium. Each of these primordia gives rise to few complexes and each of which in turn, breaks up into few distinct muscles.
It is well-known that the mandibular muscle complex gives rise to three well defined groups of muscles: adductor mandibulae group, constrictor dorsalis group and intermandibularis group. The varied nature and disposition of the various components of the adductor mandibulae group present a vast array of variations, which have led to enormous nomenclatorial problems. Rosen (1962) pointed out that, various problems of the muscle nomenclature in teleosts are unresolved.

Vetter (1878), Allis (1903), Eaton (1935a) later Winterbottom (1974a) and many others, distinguished three levels of cheek or adductor mandibulae muscles in teleosts as \( A_1 \), \( A_2 \) and \( A_3 \). Takahasi (1925) based terminology primarily on muscle insertion instead of origin. All cheek muscles of which the principal force is applied chiefly to the maxilla are referred to as \( A_1 \) and those on mandibulae are known as a composite of \( A_2A_3 \) which may be distinguished as separate \( A_2 \) and \( A_3 \). In the present investigation the adductor mandibulae complex is divided on the basis of insertion (following Takahasi, 1925) and further subdivisions of these muscles are also based more or less on insertions because the insertion points are stable. In case where muscle lies parallel to each other, the naming order is from upper to lower. In this connection it may be stated that Vetter (1878) and Dietz (1914) called the ventrolateral sections of \( A_1 \) as \( A_{1a} \) and the other one \( A_{1b} \). Accordingly if the subsections are more, \( A_1 \) has also been utilized. In the present context, \( A_1 \) muscle of Vetter (1878) and others, is designated as m. adductor maxillaris and this represents the maxillar subgroup (as stated previously in the observation chapter). The \( A_2 \) of Vetter is designated as m. adductor mandibularis\(_1\) and \( A_3 \) of Vetter is termed m. adductor mandibularis\(_2\) and these represent the mandibular subgroup. Thus, instead of an abbreviated designations (such as \( A_1 \), \( A_2 \) and \( A_3 \)) a definite name to each muscle component has been given.
In the present observation m. adductor maxillaris is subdivided into three subsections on the basis of disposition of the muscle fibres. All the fishes representing the four genera of the Indian ambassids, viz. Parambassis, Ambassls, Chanda and Pseudambassis possess three subsections e.g., m. adductor maxillaris₁, m. adductor maxillaris₂ and m. adductor maxillaris₃ of the maxillary subgroup.

According to Lubosch (1938) the variable nature of the adductor in teleosts is an indication of a multiple evolutionary origin of the group.

Datta (1972) observed that the presence of many muscles in the cranial region of the teleosts, was in accordance with the functional needs associated with the visceral arches and their derivatives such as jaws and hyomandibular and Winterbottom (1974b) opined that the subdivisions of section A₁ presumably allow more controlled nibbling movements of the upper jaw. It is observed that the jaw movements in the ambassids are also versatile allowing more manipulations in capturing prey.

The variations found in the components of the adductor mandibulae group with regard to origin, course and insertion, might be profitably utilized as taxonomic criteria providing some important clues to the various problems of teleostean classification. Virtually Rosen (1962, 1964), Greenwood et al., (1966), Rosen and Patterson (1969) and Rosen (1973), Winterbottom (1974a) considered the myological features in teleostean classification. Godkin and Winterbottom (1985) studied myology along with the other anatomical characters of the Congrogadidae for elucidating the phylogenetic relationships and Yabe (1985) studied the monophyly of the super family Cottoidea (Pisces : Scorpaeniformes) and the interrelationships of the cottoid fishes through comparative osteomyological studies.

Minor myological variations also exist intergenerically, which along with the osteological features help much in evaluating taxonomic and phylogenetic relationships. In all the four genera,
m. adductor maxillaris$_1$ and m. adductor maxillaris$_2$ are mesially transformed into an aponeurosis. Both the aponeurosis are fused and some of the fibres of m. adductor maxillaris$_3$ also join the fused aponeurosis. Although this type of orientation is uncommon but only in leiognathids (Singh, 1979), such a condition (to some extent) is observed. Among all the four ambassid genera, these subsections are more or less similar in morphological disposition. Only in case of _A. nalua_, some fibres of this muscle are attached to infraorbital bones which may be considered as a secondary phenomenon.

Transformation of the first two muscular subsections into a median aponeurosis, which later moves again musculously and adjoins maxilla aponeurotically, is a distinct family character of the ambassids. Centropomidae (under which family ambassidae was previously considered by Berg, 1940; Greenwood _et al._, 1966; Nelson, 1976; etc.) differs from Ambassidae in not having aponeurosis medially of the m. adductor maxillaris$_1$ and m. adductor maxillaris$_2$. On the other hand, Ambassidae shows a closer relation to Leiognathidae in having similar morphological disposition of the m. adductor maxillaris$_1$ though m. adductor maxillaris$_2$ differs in morphology and disposition.

According to Gosline (1963), the great similarity of the members of each group is a measure of their common heritage. The existing similar specializations in each line are really parallel modifications of the basic raw materials. Incidentally the present observation on the muscle components of maxillar subgroup provides evidences in favour of the contention of Gosline (1963).

In ambassids, m. adductor maxillaris$_1$ and m. adductor maxillaris$_2$, the two subsections jointly, insert to the maxilla through a common aponeurosis, which lies just below the maxilla-mandibular ligament. Similarly Dobben (1935) in some Percomorphs (e.g. _Perca_ ) observed that a separate tendon for A$_1$ (m. adductor maxillaris$_1$ of the present study) may differentiate from the rest of the maxilla-mandibular ligament (primordial ligament of others).
He showed how a better control of the twisting movement of the maxilla is achieved in certain species by the separation of the maxilla-mandibular ligament from the tendon of A₁.

According to Dutta (1968) adductor maxillaris₁ is attached to the medial surface of the maxilla by means of a strong, long aponeurosis, which is tendinous at the rostral part and almost round in cross-section. In another family, the Centropomidae, the genus *Lates* shows a specialization as observed by Rosen and Patterson (1969), a dorsomedial part of the adductor mandibulare inserts on the maxillary tendon and has become functionally dissociated from the underlying muscle, which now has developed a major insertion on the maxilla-mandibular ligament. In *Perca*, a fully developed external or maxillary division (A₁) of the adductor mandibulare has been developed. Liem (1970), on the other hand, designated this aponeurosis as tendon of pars A₁ of adductor mandibulare muscle. In the present study, it is designated as an aponeurosis, since it is a flat sheet of connective tissue.

All the components of the mandibular subgroup are inserted by aponeurosis, a condition supporting Klaauw's (1963) statements that smaller area for insertion of muscle is compensated by aponeurotic attachment. *M. adductor mandibularis₁* and *m. adductor mandibularis₂* are similar in origin, insertion and disposition in all the four ambassid genera studied. This again supports the contention of Gosline (1963) as stated earlier.

Recently an interesting histochemical study has been made by Maeda, Miyashi and Toh (1984) on this jaw-closing muscle, adductor mandibulare of the Japanese salmon, *O. masou*. Three main types of fibres is distinguished on the basis of differences in succinate dehydrogenase activity. It is concluded that the adductor mandibulare muscle is composed of at least more than 3 types of fibres. Of course, such studies are beyond the purview of the present programme.
In ambassids the constrictor dorsalis group includes m. levator arcus palatini and m. dilator operculi. There are some confusions regarding the morphology and nomenclature of m. levator arcus palatini. The confusion stems from the various names of the same muscle in one and different languages though essentially they have identical meaning.

The m. levator arcus palatini was first recorded by Cuvier (1840) as "Releveur de l' arc tympanique". Subsequently, Owen (1866) named it as "m. levator tympani". However, the name levator arcus palatini is largely used since Vetter (1878). Allis (1897) opined that m. levator arcus palatini and m. dilator operculi were originally one muscle in Amia but it is denied by Eaton (1935a). According to latter, in Amia and in teleosts excepting the Anacanthini the two muscles were separate. Present study corroborates Eaton's (op.cit.) view at least, with regard to teleosts. Alexander (1964) described it as "m. levator hyoidei". Liem (1967b) commented that m. levator hyomandibulae is a synonym for m. levator arcus palatini. Surprisingly, the same author in 1970 illustrates m. levator arcus palatini without giving any description. However, it is evident that by the usage of different names for one and the same muscle a disorder is resulted.

It seems that the name levator arcus palatini is meaningful and therefore, utilized in the present investigation. The study of Juge (1898), Takahasi (1925), Pankratz (1928) and Nawar (1955) revealed that the origin of this muscle in different fishes although differs depending upon the position of eye, but the insertion in most cases takes place invariably on the hyomandibular. Of course, in some cases the insertion may extend upto metapterygoid.

A lot of anomalies and ambiguities have been brought about by Eaton (1935a) who recorded various conditions of m. levator arcus palatini. With reference to m. levator arcus palatini in Eupomotis, he recognized two m. levator arcus palatini and designated them as "l.a.p.₁ and l.a.p.₂". On careful analysis it is very difficult
to substantiate Eaton's view. From the present as well other studies of similar nature, it is evident that m. levator arcus palatini is a single muscle. It is explicitly clear that Eaton's (op.cit.) "l.a.p.1" is the true m. levator arcus palatini as is evident from the nature of origin and insertion described by Eaton (op.cit.) himself. While his "l.a.p.2" which lies "under the eye ball, its fibres extending transversely from parasphenoid to the edge of the hyomandibular and metapterygoid" is unmistakably a part of m. adductor arcus palatini. In fact, as Eaton (1935a) himself pointed out that Vetter (1878) already called the muscle similar to "l.a.p.2" as adductor palatini. Curiously enough, the reason for calling these two discrete muscles as parts of one and the same muscle remains obscure. Virtually, m. levator arcus palatini is a well defined muscle as revealed from present and all other previous studies. Further, it is regrettable to point out that Eaton (1935a) did not refer the work of Takahasi (1925) which could perhaps, prevented him from creating this anomaly.

Again it is interesting to note that Adams (1919) labelled a muscle identical with "l.a.p.2" of Eaton as m. levator arcus palatini and the muscle identical with "l.a.p.1" of Eaton as m. retractor hyomandibularis. Obviously the contention of Adams (op.cit.) is also erroneous, owing to the facts stated above. The identity and nature of m. retractor hyomandibularis has been demonstrated by Edgeworth (1935) who described it as a detached part of m. adductor operculi the position of which being very close to the same. The present investigator is in full agreement with Edgeworth's contention. The fusion of m. levator arcus palatini and m. dilator operculi into a single muscle in Anacanthini as studied by Eaton (1935a) is perhaps a secondary phenomenon and the same is possible owing to their very close situation. Otherwise, from the present investigation, it is evident that these are two distinctly separate muscles. Further from the standpoint of embryology as emphasized by Edgeworth (1935) m. levator arcus palatini develops from mandibular muscle primordium whereas, m. adductor arcus palatini develops from hyoid muscle primordium and therefore,
Eaton's labelling of these two muscles as "l.a.p.₁" and "l.a.p.₂" does not stand.

The name m. protractor hyomandibularis has been used by Vetter (1878) in *Acipenser*, Danforth (1913) in *Polyodon* and many other workers used the same name in different fishes (Edgeworth, 1935). Gregory (1933), while referring the work of Edwards (1926), mentioned that expansion of orobranchial cavity is accomplished largely by the cooperation of m. protractor hyomandibularis and of m. levator arcus palatini with the ventral muscles of the mandible. Evidently, both Edwards and Gregory were aware of the existence of m. levator arcus palatini and m. protractor hyomandibularis as separate muscle. Saxena (1960) stated that m. protractor hyomandibularis is synonymous with m. levator arcus palatini. Further, he erroneously attributed Gregory (1933) for the name, m. protractor hyomandibularis despite its usage by many previous workers as stated above. Gosline (1966) has subdivided the percoids into two major subdivisions. In one group, the levator hyomandibulae (levator arcus palatini) is small, resulting in limited abduction and in the second group the muscle is large, resulting in greater expansion of the buccopharynx. This generalization, based on casual observations of muscle size in fixed material is difficult to accept. Gans and Bock (1965) have demonstrated convincingly that muscle size has no relationship with degree of movement and strength. The separate existence of m. protractor hyomandibularis in addition to m. levator arcus palatini has been observed in few cases by Dutta (1968). Osse (1969) stated that this muscle structure is clearly an adaptation to the available space; it combines a large physiological cross-section with a limited area of origin and with relatively the most favourable working angle of the fibres. Abduction of the suspensory apparatus is brought about by the levator arcus palatini muscles (Liem, 1970).

In the opinion of the present investigator when a distinct muscle whose fibres are inserted only on the hyomandibular, the name
protractor hyomandibularis will be appropriate. In ambassids, only m. levator arcus palatini is found to be present. The morphological disposition of this muscle is more or less similar in the fishes of all the four genera of ambassids.

M. dilator operculi, a well developed muscle, is present in all the teleosts so far known (Datta, 1972). In this case, this muscle is found to be of two parts, (i) anterioris and (ii) posterioris, the former is more developed than the latter. The pattern of this muscle is similar in all the fishes studied here.

According to Edgeworth (1935) the intermandibularis muscle complex is differentiated into distinct anterior and posterior muscles. The m. intermandibularis anterioris is present in all ambassids of the present study. According to Winterbottom (1974a), the muscle is widely present in the teleosts. Its absence is often attributable to the fusion of the halves of the lower jaw in the midline, thus depriving the muscle of any possible function. M. intermandibularis posterioris or protractor hyoidei in part is a muscle of great controversy. It is found to be formed by the fusion of the m. intermandibularis posterior and the m. interhyoideus. A protractor hyoidei is apparently present in all fishes except the notopterids and mormyrids (Greenwood, 1971). Osse (1969) demonstrated, that the anterior portion of the muscle (his geniohyoideus anterior) contracts during expiration, but that the posterior portion (his geniohyoideus posterior), which attaches to the lower jaw above the intermandibularis, contracts mainly during inspiration (although it contracts during expiration also). According to Winterbottom (1974a), the choice of the name 'protractor hyoidei' over that used by Osse and many others (geniohyoideus anterior and posterior) may cause some concern among anatomists (especially those interested in function), since at least part of the activity of the muscle is not concerned with the protraction of the hyoid. The name 'geniohyoideus' has been shown to be phylogenetically incorrect (the teleostean geniohyoideus is in no way homologous
to that of the tetrapods, from which the name was taken) and that Osse's (op.cit.) experiments show that, during quiet respiration, both geniohyoideus sections contract simultaneously to raise (or protract) the hyoid arch. Thus during the more quiescent periods of the fish's activity cycle, the name protractor hyoidei is functionally valid. M. protractor hyoidei receives innervation both from nervus trigeminus and nervus facialis which definitely indicates that this muscle receives contribution both from mandibular and hyoidean muscle plate (Edgeworth, 1935; Jarvik, 1963).

According to Edgeworth (1935) hyoid muscle plate in embryonic stages is a dorsoventral sheet extending from auditory capsule to hyoid region and is innervated by n. facialis. With subsequent development the muscle plate separates into dorsal and ventral portions which finally give rise to a number of well defined muscle components. Edgeworth (1935) further stated that m. adductor arcus palatini develops from anterior portion of constrictor hyoideus dorsalis. Greene and Greene (1913) divided the muscle into anterior and posterior parts, on the basis of insertion of fibres on hyomandibular, pterygoid and palatine. Takahasi (1925) divided this muscle in three portions: hyomandibular, pterygoid and palatine. Pankratz (1928) and Datta (1972) called the posterior division as m. adductor hyomandibularis. According to Rosen (1964), the extent of m. adductor arcus palatini is inversely proportional to the size of metapterygoid ossification. M. adductor arcus palatini covers the floor of orbit in Paracanthopterygii, whereas in Acanthopterygii, m. adductor arcus palatini usually confined to posterior wall of orbit (Greenwood et al., 1966). Liem (1967a,b) recognized separate m. adductor hyomandibulae but the same author in 1970 mentioned nothing about this muscle. Winterbottom (1974a) commented that, in the generalized lower teleosts, the adductor arcus palatini connects the prootic to the dorsomedial face of the hyomandibular. It is therefore, morphologically an adductor hyomandibularis. However, the name becomes inappropriate where the muscle has expanded anteriorly along the floor of the orbit, and there the name adductor arcus palatini
has been applied to both conditions. About this muscle he said that it expands anteriorly in more advanced forms ... forming the floor of the orbit between the skull and the palatal arch.

In case of ambassids, this muscle expands anteriorly and is a continuous sheet hence it conforms Winterbottom's (1974a) observation, and in contradiction with observation made by Greenwood et al., (1966).

Edgeworth (1935) denied the existence of m. retractor hyomandibularis in the teleosts. Datta Munshi (1960) recognized it in his study. Datta (1972) stated that this muscle is not a well defined muscle. In ambassids m. retractor hyomandibularis is absent. M. levator operculi and m. adductor operculi both are well represented in all ambassids. Origin and insertion of m. adductor operculi is similar in all ambassids, except in P. ranga, where the origin of this muscle is from exoccipital instead of pterotic.

Cuvier (1840) recorded the ventral hyoid muscles as "abducteur des rayons" and "releveur des rayons". Datta (1972) while discussing about these muscles gave synonyms of all the relevant muscles used by several workers. Special mention may be made of Millard (1966) who proposed the term m. hyohyoideus adductores and m. hyohyoideus adductores for the ventral hyoid muscles. Despite assignments of large number of names to the ventral hyoid muscles by a number of workers, it seems reasonable to follow Millard's terminology for these muscles from functional morphological standpoint. Winterbottom (1974a) though retained the names hyohyoidei adductores and hyohyoidei adductores, recorded another muscle termed hyohyoides inferioris spanning the ventral region of the hyoid arch and not (directly) the branchiostegal rays. He further stated that this muscle is by no means universally present in teleosts. Incidentally it is also absent in ambassids. According to Winterbottom (1974a) the fibres of hyohyoidei adductores inserting on the anteriormost branchiostegal
ray may arise from the hyoid arch and the m. hyohyoidei adductores lies as a variously developed sheet of fibres between the branchiostegal rays.

In the present case, the ventral hyoid muscle is divided into m. interhyoideus, m. hyohyoideus abductores and m. hyohyoideus adductores. The m. interhyoideus in the fishes under study is, however, fused with m. intermandibularis posterior to form the m. protractor hyoidei. The other two muscles conform to the description of Millard (1966) and Winterbottom (1974a).

Branchial muscles seem to be very complicated in nature. Study of these large number of muscles are made further complicated by a large variety of names used by several workers. About its development Edgeworth (1935) said that branchial muscle primordium on further development and differentiation, gives rise to dorsal and ventral branchial groups of muscles. Dorsal branchial muscles are those fastening branchial arches to the neurocranium, and ventral branchial muscles are present near the meeting places of branchial arches with the basibranchial elements.

In naming the branchial muscles terminologies used by Vetter (1878), Takahasi (1925), Eastman (1971), Datta (1972) and Winterbottom (1974a) are mainly followed.

The number of m. levator arcus branchialis externus varies from two to four in most teleosts. In the present investigation, it is found that in Parambassis, Chanda and Pseudambassis two slips are present in connection with the first and fourth branchial arches while in Ambassis there are three slips in connection with the first, third and fourth branchial arches.

The m. levator arcus branchialis internus is represented by two slips in the ambassids and such a condition has been observed in other teleost groups also.
The nature and number of m. obliquus dorsalis (i) superioris and (ii) inferioris are almost similar in all the four ambassid genera and m. adductor arcus branchialis is poorly developed. Levator posterior of Winterbottom (1974a) is absent as such in ambassids. In ambassids m. obliquus dorsalis superioris (m. obliquus dorsalis of Winterbottom, 1974a) and m. obliquus dorsalis inferioris ("Recti dorsales" of Winterbottom, 1974a) are present and are well developed. According to Winterbottom these names have not been previously used. Obliquus posterior of Winterbottom (1974a) is the muscle which connects the posterodorsal tip of ceratobranchial 5 to the posteromedial face of epibranchial 4, and is innervated by the vagus nerve. It is absent in ambassids. Winterbottom (1974a) clarified the confusion with regard to this muscle.

M. transversus dorsalis, develops by subdivision of the sphinctor oesophagi, which itself is derived from the upgrowth around the oesophagus of the ventral ends of the muscle plates of the fifth branchial arch. The fibres connect the dorsal elements of the branchial arch across the midline, and are innervated by branches of the vagus (Xth), (Winterbottom, 1974a).

M. transversus dorsalis offers a variable disposition in different groups of fishes (Greene and Greene, 1913; Takahasi, 1925; Holstvoogd, 1965; Nelson, 1967a,b; Singh, 1967a; Liem, 1970).

This muscle in ambassids is represented by two distinct components: anterior and posterior. The anterior one is more well developed than the posterior.

The ventral group of muscle components are placed at the ventral aspect of the branchial arches. Winterbottom (1974a) has identified and described three components of ventral branchial muscles e.g. obliqui ventrales, transversi ventrales and recti ventrales. In the present study, the above three muscles are addressed as m. obliquus ventralis superioris, m. obliquus ventralis inferioris and m. transversus ventralis respectively following Takahasi (1925). M. obliquus ventralis superioris is moderately developed
in ambassids. In *P. thomassi* and *A. commersoni* four slips are present, in *C. nama* and *P. ranqa*, the fourth slip between the third and fourth arch is the only well developed slip.

M. obliquus ventralis inferioris is represented by three slips in *P. thomassi, A. commersoni, C. nama* and *P. ranqa*.

M. transversus ventralis is a poorly developed muscle in ambassids. The fourth muscle slip between the fourth branchial arches is the most well developed one.

Sphincter oesophagi develops from the ventral end of the fifth branchial muscle plate, and is innervated by fibres of the post trematic ramus of the Vagus (Xth) nerve (Edgeworth, 1935). The fibres of this muscle develop around the oesophagus and ultimately meet in the dorsal and ventral midlines. In ambassids, it is well developed.

The muscles connected with fifth ceratobranchial ("os pharyngeus inferior" of Goodrich, 1930) and fused pharyngobranchials of some posterior branchial arches ("os pharyngeus superior" of Goodrich, 1930) are called masticatory muscles though Datta (1972) explained that these masticatory muscles are in no way homologous with the masticatory muscles of higher vertebrates. Though some sort of mastication is performed in ambassids when both the "os pharyngeus superior" and "os pharyngeus inferior" (with large number of villiform teeth) are brought close together by the masticatory muscles. Of course, true mastication is almost absent in ambassids as their teeth do not have any platform to make effective mastication as it is in grasscarp, where pharyngeal teeth are very well developed so as to tear and cut the macrophytic vegetation into pieces (Hickling, 1966).

Masticatory group I is represented by one muscle only which is designated as "m. retractor os pharyngeus superioris" by Datta (1972) because this name is "the most appropriate and meaningful in functional morphology" and is connected with "os pharyngeus
superior". "Os pharyngeus superior" is present in percoids (including ambassids) but absent in cyprinoids. Obviously, therefore, in cyprinoids, there is no muscle corresponding to m. retractor os pharyngeus superior.

M. retractor os pharyngeus superioris is synonymous with m. retractor arcuum branchialium of Holmqvist (1910), Dietz (1912, 1914, 1921), Holstvoogd (1965), Rosen (1973) and retractor dorsalis of Nelson (1967a, 1967b), Winterbottom (1974a).

Eastman (1971) described a muscle of the same name as above in Cyprinus carpio, which probably is not homologous with the muscle of the percoids because both origin and insertion are different. Hence there is a basic difference between the pharyngeal bone musculature of the cyprinoid and perciform fishes. In order to remove the present confusion as well as to impart a clear understanding Datta (1972) proposed that the masticatory muscles of "os pharyngeus superior" and "os pharyngeus inferior" should be considered separately with proper and meaningful terminology.

M. retractor os pharyngeous superioris is well represented in ambassids, and connects the first vertebra and the third pharyngobranchial. It is no way comparable to the muscle of same name of cyprinoids which runs from pharyngeal process of the basi-occipital and the pharyngeal bone (Eastman, 1971).

Holstvoogd (1965) observed retractores arcuum branchialium (=m. retractor os pharyngeus superioris) in Ambassis gymnocephalus (Lacépède) along with other physoclistous fishes and he (op. cit.) concluded that the development of the m. retractores arcuum branchialium allowed for the exclusion of the maxillae from the border of the mouth. The presence of the retractores arcuum branchialium is a progressive character, though, its absence, is not a degenerative one.

According to Nelson (1967a) this muscle has been developed independently a number of times during the evolution of the teleostei.
Rosen (1973) divided euteleosteans into two groups on the basis of the presence or absence of this muscle. He (op. cit.) further commented that, during neoteleostean evolution there has been a shift in the insertion of the muscle from the fourth, or third and fourth, largely to the third pharyngobranchial.

Winterbottom (1974a) assumed that, "the muscle(s) between the basioccipital and ceratobranchial 5 of cyprinids are embryologically derived from the same source as the retractor dorsalis of neoteleosts, but there is no convincing evidence as to whether they are morphologically (and phylogenetically) homologous or not". One of the most convincing reasons given by him (op. cit.) of non-homology is that the sites of both origin (basioccipital rather than vertebral column, though there are few instances of origin from the occipital region in neoteleosts) and insertion (ceratobranchial 5 as opposed to one or more infrapharyngobranchials) differ.

After reviewing all the previously worthmentioning works done on the muscles belonging to masticatory group I it may be presumed that the m. retractor os pharyngeus superior in ambassids is not homologous to that observed in cyprinoid and presence of it is an advanced feature.

Masticatory group II represents the muscles connected with os pharyngeus inferior. The terminology by Girgis (1952) for the muscles of this group is somewhat modified so as to make the names more meaningful from functional standpoint.

M. levator os pharyngeus inferioris is a moderately developed muscle in ambassids and runs between prootic and the os pharyngeus inferior. It is synonymous with m. trapezius profundus of Takahasi (1925) and m. levator arcus branchialis V of Edgeworth (1935) and Eastman (1971). Edgeworth (1935), refuted its homology with any part of m. trapezius of other vertebrates with embryological as well as neurological evidences.
M. retractor os pharyngeus inferioris as designated by Datta (1972), is synonymous with m. pharyngoclavicularis internus of Vetter (1878), Dietz (1912), Takahasi (1925), Liem (1970) and Winterbottom (1974a).

According to Edgeworth (1935), the pharyngoclavicularis of teleosts represents a single division of the fifth branchial arch muscle and becomes divided into an externus and an internus portion in most groups of fishes including ambassids.

In ambassids, m. retractor os pharyngeus inferioris originates from the anterior aspect of cleithrum and has insertion on the posterolateral margin of the "os pharyngeus inferior".

The name m. retractor os pharyngeus inferioris is also used by Eastman (1971) for a muscle in C. carpio, originating from the lateral aspect of the pharyngeal process of the basioccipital and inserting on the pharyngeal bone. This is synonymous with m. retractor ossis pharyngi inferioris of Holstvoogd (1965) and m. retractor pharyngeus of Winterbottom (1974a). This muscle is present only in cyprinoids having their origin (as mentioned above) from basioccipital and insertion to the os pharyngeus inferior but in ambassids the corresponding muscle is absent.

Therefore, it is evident from the above that the m. retractor os pharyngeus inferioris of ambassids is not comparable with that of cyprinoids from morphological standpoint.

M. depressor os pharyngeus inferioris is a moderately developed muscle in the presently studied fishes. It is synonymous with m. pharyngoclavicularis externus of Vetter (1878), Takahasi (1925) and Winterbottom (1974a). This muscle represents a single division of the fifth branchial arch muscle plate (Edgeworth, 1935).

According to Nelson (1967a) the subdivision of pharyngoclavicularis muscle (described here as m. retractor os pharyngeus inferioris
and m. depressor os pharyngeus inferioris) represents the plesiomorph (primitive) condition for the teleosts, and that the two muscles so formed, together with the sphincter oesophagi and its derivatives, arose from the modifications of the original 'preteleostean' obliquus ventralis V.

M. protractor os pharyngeus inferioris is derived from the anterior growth of rectus ventralis V, considered by Edgeworth (1935). It is synonymous with m. pharyngoarcualis hyoideus of Takahasi (1925) and m. rectus communis of Nelson (1967a), Liem (1970), Greenwood (1971), and Winterbottom (1974a). Nelson (1967a) said that rectus communis is developed from the backgrowth and splitting off the ventral fibres of rectus ventralis IV. Eastman (1971) observed its origin from the third basibranchial and the third hypobranchials, and its function is to pull the pharyngeal bone anteriorly and also slightly ventrally. Edgeworth (1935) stated that this muscle extends forward from the fifth bar for a variable distance. Its anterior end may be attached to hypobranchial$_3$ or to hypobranchial$_1$ or to the hypohyal or the basihyal or the urohyal.

Some muscles of branchiomeric origin have eventually shifted their origins from the branchial arches to the cleithrum. M. protractor pectoralis is one such muscle.

Winterbottom (1974a) clarified the confusions regarding m. protractor pectoralis and therefore further discussion is avoided. According to Rosen (1973), formation of this protractor pectoralis muscle is an advanced character.

In ambassids it is a well developed muscle originating musculously from pterotic and inserting mainly on the posttemporal arm and partly to the supracleithrum.

The muscle situated ventrolaterally to the m. protractor pectoralis was called by Shann (1914, 1920) and Datta (1972) m. protractor pectoralis posterior, in relation to m. protractor pectoralis anterior (here called m. protractor pectoralis). Winterbottom
(1974a) designated the muscle as m. levator pectoralis following Shann (1914, 1920).

In ambassids, m. levator pectoralis is absent. At the same position is situated another muscle. After a thorough examination of its nature of insertion, it is seen that the muscle fibres are not inserted to supracleithrum or cleithrum, but running along the body muscle. Hence, it becomes evident, that it is a part of body or epaxial muscle.

Some muscles of branchiomeric origin have eventually shifted their origins from the branchial arches to the cleithrum. Such two muscles are m. cephaloclavicularis and m. cucullaris (Edgeworth, 1935). M. protractor pectoralis anterior is synonymous with m. cephaloclavicularis of Edgeworth (1935) and m. protractor pectoralis of Winterbottom (1974a) and the latter author clarified the confusion regarding this muscle. According to Rosen (1973) formation of this protractor pectoralis muscle is an advanced character. According to Winterbottom (1974a) the protractor pectoralis appears to be confined to the neoteleosts.

The branchial muscle complex as a whole is observed to be variable in nature the basic pattern being constant. Each cranial muscle is directly or indirectly involved in feeding (deglutition) and respiration. Performance of these two major functions, has made the nature of cranial muscles variable specially those connected with feeding. Though the mandibular, hyoid and branchial muscle complexes of the four genera of ambassids are studied, the phylogenetic relationships between the genera and the evolutionary status of the Ambassidae in the order Percoidei are still a matter of speculation.

Some of the myological features (on the basis of observations made by Greenwood et al., 1966; Rosen, 1973; and Winterbottom, 1974a) as observed in the ambassids are:
Advanced characters

(1) Superficial division of the m. adductor mandibulae well developed.
(2) M. retractor os pharyngeous superioris (RAB of Holstvoogd, 1965 and Rosen, 1973 and others) has insertion on third pharyngobranchial.
(3) Presence of the protractor pectoralis muscle.
(4) M. adductor arcus palatini covering floor of orbit.

By observing all these features, it can be said that the ambassids perhaps have reached a highly advanced evolutionary stage among the percoids.

In concluding the discussion it may be stated that despite paying detailed attention to various problems relating to descriptive and comparative morphology of cranial muscles, the present investigator is fully aware of the necessity to consider the problem with such more facts and evidences, which will lead to better understanding of phylogenetic relationship. Further, the present investigator can not help but be impressed by the structural variability as well as by functional complexities of the cranial muscles of the teleosts. More exhaustive researches in this line can only provide further insight to fill up the still left lacunae in the subject.
EXPLANATION OF FIGURES (159-161) AND ABBREVIATIONS USED

Lateral view of head region showing disposition of some cranial muscles

Fig. 159: *P. thomasi*
Fig. 160: *A. commersoni*
Fig. 161: *C. nama*

ABBREVIATIONS:

ADD.MX₁ - m. adductor maxillaris₁
ADD.MX₂ - m. adductor maxillaris₂
ADD.MX₃ - m. adductor maxillaris₃
ADD.MD₁' - m. adductor mandibularis₁ (upper fasciculi)
ADD.MD₁" - m. adductor mandibularis₁ (lower fasciculi)
AP - aponeurosis
D.O.A - m. dilator operculi anterioris
D.O.P - m. dilator operculi posterioris
IMD - m. intramandibularis
L.A.P. - m. levator arcus palatini
MX.MND.LIG - maxilla-mandibular ligament
EXPLANATION OF FIGURES (162,163,164) AND ABBREVIATIONS USED

Lateral view of head region showing disposition of some cranial muscles

Fig.162 : P. thomassi
Fig.163 : A. commersoni
Fig.164 : C. nama

ABBREVIATIONS :
A.A.P  -  m. adductor arcus palatini
ADD.MD,2  -  m. adductor mandibularis,2
A.O  -  m. adductor operculi
AP  -  aponeurosis
D.O.A  -  m. dilator operculi anterioris
D.O.P  -  m. dilator operculi posterioris
L.A.P  -  m. levator arcus palatini
L.O  -  m. levator operculi
EXPLANATION OF FIGURES (165,166,167) AND ABBREVIATIONS USED

Ventral view of head region showing ventral cranial muscles

Fig. 165 : Ventral muscles of *P. thomassii*
Fig. 166 : Ventral muscles of *A. commersoni*
Fig. 167 : Ventral muscles of *C. nama*

ABBREVIATIONS :

- **H.AB** - *m. hyohyoidei abductores*
- **H.AD** - *m. hyohyoidei adductores*
- **IM.A** - *m. intermandibularis anterioris*
- **PR.HY** - *m. protractor hyoidei*
EXPLANATION OF FIGURES (168, 169, 170) AND ABBREVIATIONS USED

Ventral view of hyoid apparatus showing hyoid muscles

Fig. 168 : Hyoid muscles of P. thomassi
Fig. 169 : Hyoid muscles of A. commersoni
Fig. 170 : Hyoid muscles of C. nama

ABBREVIATIONS :

BH — basihyal
CH — ceratohyal
EH — epihyal
IH — interhyal
H.AB — m. hyohyoidei abductores
H.AD — m. hyohyoidei adductores
HH — hypohyal
Hypothetical plan of the dorsal and ventral branchial muscles

Fig. 171: Dorsal view of the branchial basket showing dorsal branchial muscles including the muscle of the os pharyngeus superior

Fig. 172: Ventral view of the branchial basket along with hyoid elements showing ventral branchial muscles including the muscles of the pharyngeus inferior

ABBREVIATIONS:

A.A.B - m. adductor arcus branchialis
D.O.P.I - m. depressor os pharyngeus inferioris
L.A.B.EXT\textsubscript{1–4} - m. levator arcus branchialis externus\textsubscript{1–4}
L.A.B.INT - m. levator arcus branchialis internus
OBL.D.S - m. obliquus dorsalis superioris
OBL.D.I - m. obliquus dorsalis inferioris
OBL.V.S\textsubscript{1–5} - m. obliquus ventralis superioris\textsubscript{1–5}
OBL.V.I\textsubscript{1–4} - m. obliquus ventralis inferioris\textsubscript{1–4}
P.O.P.I - m. protractor os pharyngeus inferioris
R.O.P.I - m. retractor os pharyngeus inferioris
R.O.P.S - m. retractor os pharyngeus superioris
TR.D.A - m. transversus dorsalis anterioris
TR.D.P - m. transversus dorsalis posterioris
TR.O.P.I - m. transversus os pharyngeus inferioris
TR.V\textsubscript{4} - m. transversus ventralis
UH.HH.LIG - urohyal-hypohyal ligament
EXPLANATION OF FIGURES (173-178) AND ABBREVIATIONS USED

Dorsal and ventral view of branchial baskets showing dorsal and ventral branchial muscles and the muscles of the os pharyngeus superior.

Fig. 173 : Dorsal branchial muscles of *P. thomassii*
Fig. 174 : Dorsal branchial muscles of *A. commersoni*
Fig. 175 : Dorsal branchial muscles of *C. nama*
Fig. 176 : Ventral branchial muscles of *P. thomassii*
Fig. 177 : Ventral branchial muscles of *A. commersoni*
Fig. 178 : Ventral branchial muscles of *C. nama*

ABBREVIATIONS :

A.A.B — m. adductor arcus branchialis
L.A.B.EXT — m. levator arcus branchialis externus
L.A.B.INT — m. levator arcus branchialis internus
OBL.D.I — m. obliquus dorsalis inferioris
OBL.D.S — m. obliquus dorsalis superioris
OBL.V.I1-5 — m. obliquus ventralis inferioris
OBL.V.S1-5 — m. obliquus ventralis superioris
R.O.P.S — m. retractor os pharyngeus superioris
TR.D.A — m. transversus dorsalis anterioris
TR.D.P — m. transversus dorsalis posterioris
TR.O.P.I — m. transversus os pharyngeus inferioris
TR.V — m. transversus ventralis
EXPLANATION OF FIGURES (179-181) AND ABBREVIATIONS USED

Lateral view of os pharyngeus inferior and cleithrum to show the muscles of the os pharyngeus inferior

Fig. 179 : *P. thomasi*
Fig. 180 : *A. commersoni*
Fig. 181 : *C. nama*

ABBREVIATIONS : 

D.O.P.I - m. depressor os pharyngeus inferioris
EPAX - epaxialis
L.O.P.I - m. levator os pharyngeus inferioris
P.O.P.I - m. protractor os pharyngeus inferioris
P.P - m. protractor pectoralis
R.H - m. retractor hyoidei
R.O.P.I - m. retractor os pharyngeus inferioris
R.O.P.I₁ - m. retractor os pharyngeus inferioris₁
R.O.P.I₂ - m. retractor os pharyngeus inferioris₂