

CONTRIBUTIONS TO THE STUDY OF BAGRID FISHES. 15.
A COMPARATIVE ACCOUNT OF THE CRANIAL
MUSCULATURE IN FOUR BAGRID GENERA
WITH A NOTE ON THEIR PHYLOGENY

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(With 3 Text-figures)

INTRODUCTION

The family Bagridae of the order Siluriformes contains 27 genera with about 200 species, distributed from Africa through the Middle east, India, Pakistan, Bangladesh, Sri Lanka, Burma, Malaya Archipelago, China and Japan. They are mostly freshwater fishes with a few species entering estuaries and brackish water. Such vast assemblage of species in so wide geographic range would naturally involve different structural patterns but these fishes are remarkably akin in their morphological facies. Jayaram (1966, 1966a and 1968) in a series of papers attempted to classify the genera of this family based on certain osteological features. He divided the family into five subfamilies: Ritinae, Chrysichthyinae, Bagrinae, Bagroidinae and Auchenoglanidinae.

The cranial muscles of siluroid fishes attracted the attention of several workers in the past, either from anatomical or functional morphology standpoint of view. The work of Mc Murrich (1884) and Juge (1899) relates to the myology of *Amiurus catus* and *Silurus glanis* respectively. Takahasi (1925) studied the cranial musculature of a number of siluroid fishes. Nawar (1955) described various muscular elements of *Clarias lazera*. Dubale and Vidyasagar (1960) and Munshi (1960) endeavoured to study the cranial musculature pattern of *Heteropneustes fossilis* and *Mystus* (= *Aorichthys*) *aor* respectively. Singh and Munshi (1969) investigated the functional morphology of *Rita rita* and *Wallago attu*. Mahajan (1971) while dealing with the adaptive radiation in *Sisor raddophorus*, studied the cranial muscles in relation to the morphology of the skull.

From the aforesaid review of literature, it is apparent that no effort has been made so far to study the cranial muscles of any particular family or subfamily in its entirety. An attempt has been made in this

paper to compare the cranial musculature of selected members of three subfamilies of Bagridae as proposed by Jayaram (1966), and derive their interrelationships. The genera studied are as under :—

1. Subfamily Ritinae—Genus *Rita* Bleeker
Rita rita (Ham.)
2. Subfamily Chrysichthyinae
Tribe Pelbeobagrini
Genus *Horabagrus* Jayaram
H. brachysoma Günther
3. Subfamily Bagrinae
Genus *Mystus* Scopoli
M. gulio (Hamilton)
Genus *Aorichthys* Wu
A. aor (Hamilton)

Relevant published data from literature on *Rita rita* by Singh and Munshi (1969) and on *A. aor* by Munshi (1960) have been taken for comparison purposes. In respect of *Horabagrus brachysoma* and *Mystus gulio*, fresh specimens were dissected out, stained and the data obtained first hand.

MATERIAL AND METHODS

The fishes for this study were collected from the back waters of Cochin and Vellar estuary (South India). Dissections were made on the specimens preserved in 10% formalin, after washing them thoroughly and under stereoscopic binocular for meticulous examination. The drawings were made by free hand.

The nomenclature adopted by various workers giving names to the different cranial muscles is not uniform and differs with different investigators. The terminology adopted here is of Winterbottom (1974) with some changes to facilitate better understanding.

OBSERVATIONS

For the purpose of this study only two complexes of the cranial muscles have been investigated: (1) Mandibular and (2) Hyoid. Further division and subdivision of these are primarily based on the disposition, origin, insertion and functions of each muscle. The pattern is given in the next page :—

I. Mandibular muscle complex	Abbreviation
1. Constrictor dorsalis group	
a. Levator arcus palatini	Lev. arc. pal.
b. Abductor hyomandibularis	Abd. hyom.
c. Dilator operculi	Dil. op.
(i) Dilator operculi superioris	Dil. op. sup.
(ii) Dilator operculi inferioris	Dil. op. inf.
2. Adductor mandibulae group	
a. Adductor mandibularis	Add. mand.
(i) Adductor mandibularis ₁	
(ii) Adductor mandibularis ₂	
(iii) Adductor mandibularis ₃	
(iv) Adductor mandibularis ₄	
(v) Adductor mandibularis ₅	
b. Intramandibularis	Int. mand.
3. Intermandibularis group	
a. Intermandibularis	In. mand.
b. Protractorhyoidei	Protr. hyoid.
II. Hyoid muscle complex	
1. Constrictor hyoideus dorsalis group	
a. Adductor arcus palatini	Add. arc. pal.
b. Extensor tentaculi	Ext. tent.
c. Levator operculi	Lev. op.
d. Adductor operculi	Add. op.
e. Adductor hyomandibulae	Add. hyom.
2. Constrictor hyoideus ventralis group	
a. Hyohyoides inferioris	H. hyoid. in.
b. Hyohyoidei abductores	H. hyoid. abd.
c. Hyohyoidei adductores	H. hyoid. add.

I. Mandibular muscle complex :

This is a well developed complex in both *Mystus gulio* and *Horabagrus brachysoma*. It is composed of three group of muscles.

1. Constrictor dorsalis group.

This group of muscles provides suspensary support to the suspensorium and comprises three main components,

a. *Levator arcus palatini*

This muscle is situated between the neurocranium and the hyomandibula and may be viewed after dissecting out the muscular elements of the Adductor mandibularis group (*Add. mand.*).

M. gulio : This muscle (Text-fig. 4 B) is moderately developed and originates mainly musculously from the ventrolateral surface of the frontal and the sphenotic though a few posterior fibres are also aponeurotically attached to the sphenotic. The muscular fibres run downwards in a convergent fashion to get inserted on the anterior surface of the hyomandibula through an aponeurosis. The free anterior margin of this muscle is bordered by a prominent narrow aponeurosis. It is comparatively longer than wide and partly overlaps the *Add. mand.*₄ and *Add. mand.*₅.

H. brachysoma : On the other hand this muscle (Text-fig. 4A) is well developed and extends its origin to the ventral surface of the lateral ethmoid in addition to frontal and sphenotic unlike *M. gulio*. Further, the muscle is broader than long and does not overlap any element of Adductor mandibularis complex.

b. *Abductor hyomandibularis* :

In general this muscle is situated posterior to the *Lev. arc. pal.* by which it is partly overlapped also. It is quite distinct in *Rita* than in other genera of the family Bagridae.

H. brachysoma : It originates from the ventrolateral surface of the sphenotic through a broad aponeurosis and then runs downwards in a divergent fashion to get inserted on the anterior surface of the hyomandibula. The posterior and the inner muscular fibres are comparatively shorter than the anterior and outer fibres (Text-fig. 4A).

M. gulio : This muscle seems to be fused with the fibres of *Lev. arc. pal.*

c. *Dilator operculi* :

This muscle lies below the *Lev. arc. pal.* It runs from the opercular to the neurocranium and is divisible into two distinct parts based on the nature of its origin and insertion : (i) Dilator operculi superioris and (ii) Dilator operculi inferioris.

(i) *Dilator operculi superioris* :

This muscle is developed moderately in both *Mystus* and *Horabagrus*. It originates from the ventral surface of the frontal, lateral ethmoid and lateral surface of the sphenotic and the orbitosphenoid. The muscle fibres run backwards and downwards in a convergent fashion

to get inserted aponeurotically on the dorsolateral cornu of the opercular. The aforesaid aponeurosis is elongated and very prominent along the ventral free margin of the anterior fibres of this muscle. The muscle overlaps the *Dil. op. inf.* and its anterior fibres are longer (Text-figs. 5A and B).

(ii) *Dilator operculi inferioris* :

In the present two genera of the family Bagridae, this muscle is poorly developed and is situated underneath the *Dil. op. sup.* The muscular fibres originate from the posterodorsal grooved surface of the hyomandibula and run downwards in a somewhat convergent fashion to get inserted on the opercular just below the insertion of *Dil. op. sup.* (Text-figs. 6A & B).

2. Adductor mandibulae group :

This group of muscles is well developed, having several muscular components which help in the closing of the mouth. These components run from the lower jaw to the branchiocranium and neurocranium. Each is very distinct and this group comprises only two components in *M. gulio* and *H. brachysoma*, whereas in *Rita rita* and *Aorichthys aor.*, this group of muscles is having one additional component called. Maxillaris (Admx.) or Retractor tentaculi.

a. Adductor mandibularis :

This is well developed in both fishes of the present study but the number of elements constituting this muscle is variable. In *M. gulio*, it comprises five muscular elements whereas in *H. brachysoma*, only three elements are observed.

(i) *Adductor mandibularis*₁ :

This element is very well developed in comparison to other elements of Adductor mandibularis group. It lies adjacent to the lower border of the *Add. mand.*₂. In the fishes studied, it originates from the preopercular, hyomandibula and the quadrate. The muscle fibres are arranged in two layers. The first superficial one is thick, long and runs downwards and forwards in a convergent fashion to get inserted by means of an aponeurosis to the posterodorsal aspect of the angular. This connecting aponeurosis is comparatively smaller in *M. gulio* (Text-fig. 1B).

The position and nature of origin of this muscle is somewhat different in both the genera. In *M. gulio*, it originates only from preopercular, hyomandibula and the quadrate but in *H. brachysoma* (Text-fig. 1 A),

it does not originate from the quadrate and also some of its muscle fibres originate aponeurotically.

The second, deeper layer of this muscle is thin, lying underneath the superficial layer and originates from the hyomandibula and the quadrate as well. The muscular fibres run anterodownwards which are finally inserted aponeurotically as well as musculously on the angular just underneath the insertion of the superficial layer. No difference is observed in either genera *Mystus* or *Horabagrus*. (Text-figs. 2 A & B).

(ii) *Adductor mandibularis*₂ :

In *M. gulio*, this muscle is narrow and developed moderately whereas in *H. brachysoma*, it is well developed and thick. In the former (Text-fig. 2B) it originates musculously from the preopercular and the hyomandibula but in latter (Text-fig. 2A) it originates partly musculously and partly aponeurotically from the preopercular, hyomandibula, sphenotic and the pterotic. From the place of origin the muscle fibres run forwards and downwards in a convergent fashion and are finally inserted on the ventral surface of the dentary through an elongated aponeurosis in *M. gulio*. In *H. brachysoma*, on the other hand these fibres are inserted on the ventral median surface of the angular and the aforesaid aponeurosis provides the attachment to the muscular fibres of *Intramandibularis* unlike that of *M. gulio* (see Text-fig. 2A).

(iii) *Adductor mandibularis*₃ :

This is a moderately developed element situated adjacent to *Add. mand.*₂ and originating musculously as well as aponeurotically from the preopercular, hyomandibula, sphenotic and the pterotic. Then it runs downwards and forwards in a convergent manner and is finally inserted on the angular through an elongated aponeurosis. This aponeurosis passes below (see Text-fig. 3) that of the *Add. mand.*₂ and provides the attachment to the fibres of *Intramandibularis*.

In *H. brachysoma*, this component is absent and it seems that the muscle fibres have become blended with the *Add. mand.*₂ as the latter one is comparatively thick and wide in this species unlike that of *M. gulio*.

(iv) *Adductor mandibularis*₄ :

In both the genera, this muscle is developed moderately and lies deeply. It takes its origin from the median surface of the hyomandibula and the dorsal surface of the quadrate and then runs downwards and forwards in a convergent fashion. Finally, the muscular fibres are

inserted aponeurotically on the ventral median surface of the angular. The dorsal fibers are longer than the ventral fibres.

In *M. gulio* (Text-figs. 4B & 5B), this muscle is partly overlapped by the *Add. mand.*₂ and *Lev. arc. pal.* whereas in *H. brachysoma*, it is overlapped by the *Add. mand.*₁ and₂ and not by *Lev. arc. pal.* (Text-fig. 4A). In the former, the aponeurosis of this element distally passes over the aponeurosis of *Add. mand.*₃ and is inserted just below the latter while in *H. brachysoma*, this passes over that of *Add. mand.*₂ and is inserted ahead of the latter.

(v) *Adductor mandibularis*₅ :

This muscle is present only in *M. gulio* where it lies adjacent to the *Add. mand.*₄. The muscular fibres are elongated and originate from the dorsoanterior surface of the hyomandibula. The muscular fibres run downwards and forwards in convergent manner to get inserted on the angular through an elongated aponeurosis. This aponeurosis runs distally along side of the aponeurosis of *Add. mand.*₄ and is inserted on the angular. Distally, this aponeurosis is comparatively wider than that of other elements of this group (Text-fig. 5b).

b. *Intramandibularis* :

In both the genera, this muscle is developed moderately and is present on the inner side of the lower jaw. This is the only element of this group which does not connect the lower jaw directly with the neurocranium. In *M. gulio* (Text-fig. 3) and *H. brachysoma* (Text-fig. 2A), it originates from the dentary and angular. From the place of origin the muscle fibres run upwards and backwards in a convergent fashion to get inserted on the aponeurosis of the *Add. mand.*₃ and₂ respectively.

3. Intermandibularis group :

This group of muscle is situated on the ventral surface of the jaw and comprises of two components. These components help in opening of the mouth.

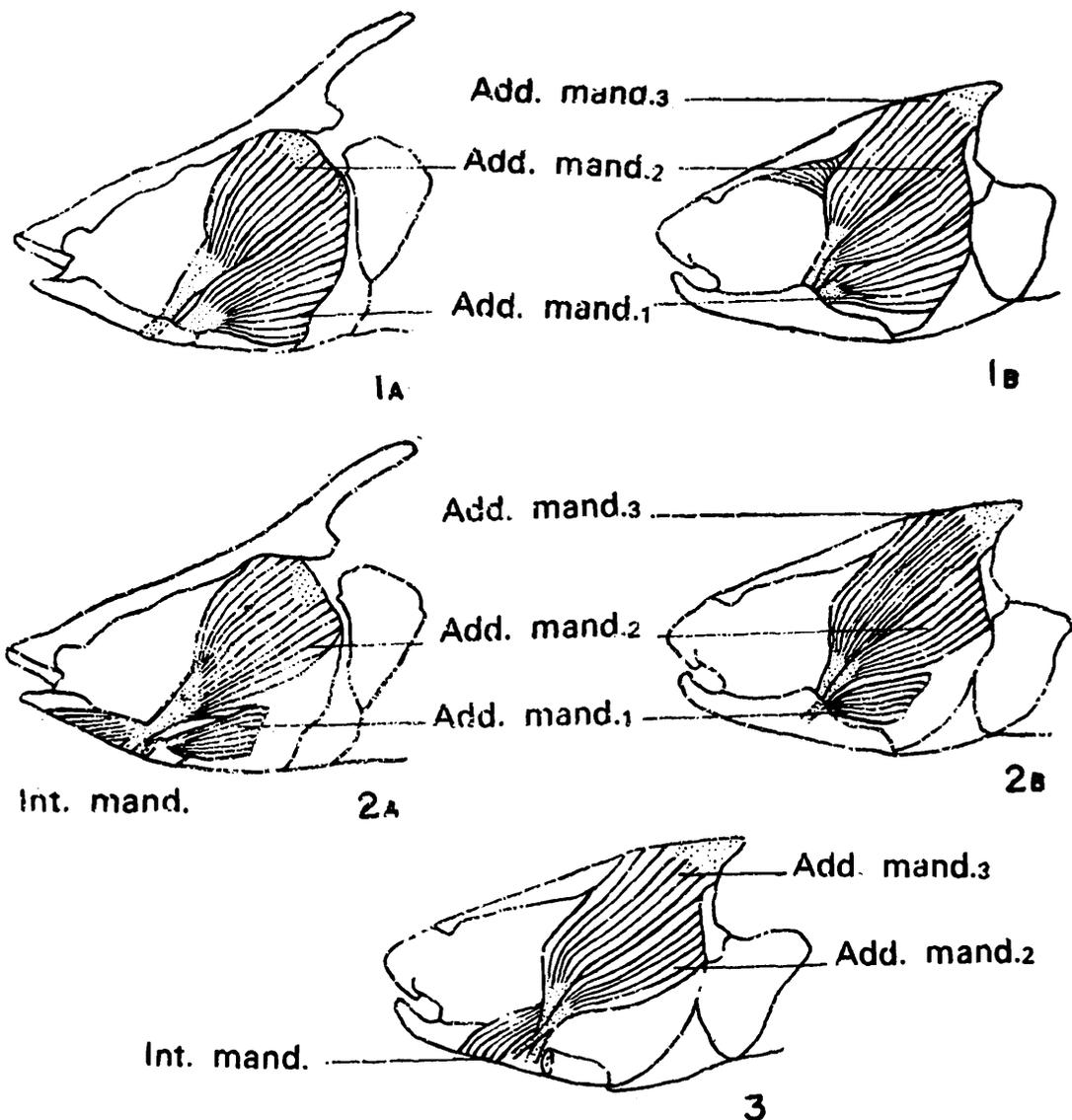
a. *Intermandibularis* :

In *H. brachysoma* (Text-fig. 8A) and *M. gulio* (Text-fig. 8B), this muscle is moderately developed and is arranged transversely inbetween the dentaries just below the symphysis. The muscular fibres are provided with an aponeurosis at deeper level. The whole muscle is sandwiched between the two halves of the *Protractorhyoidei*.

b. *Protactorhyoidei* :

This muscle is very well developed and connects the lower jaw with the hyoid cornu. It is in the form of two segments, one antero-

lateral and another postero inner portions. The anterolateral segment of this muscle is narrow and originates musculously as well as aponeurotically from the epihyal in case of *M. gulio* while only musculously



Text-fig. 1A. Left lateral view of the head region of *Horabagrus brachysoma*, showing the disposition of Adductor mandibularis components.

1B. Left lateral view of the head region of *Mystus gulio*, showing disposition of Adductor mandibularis components.

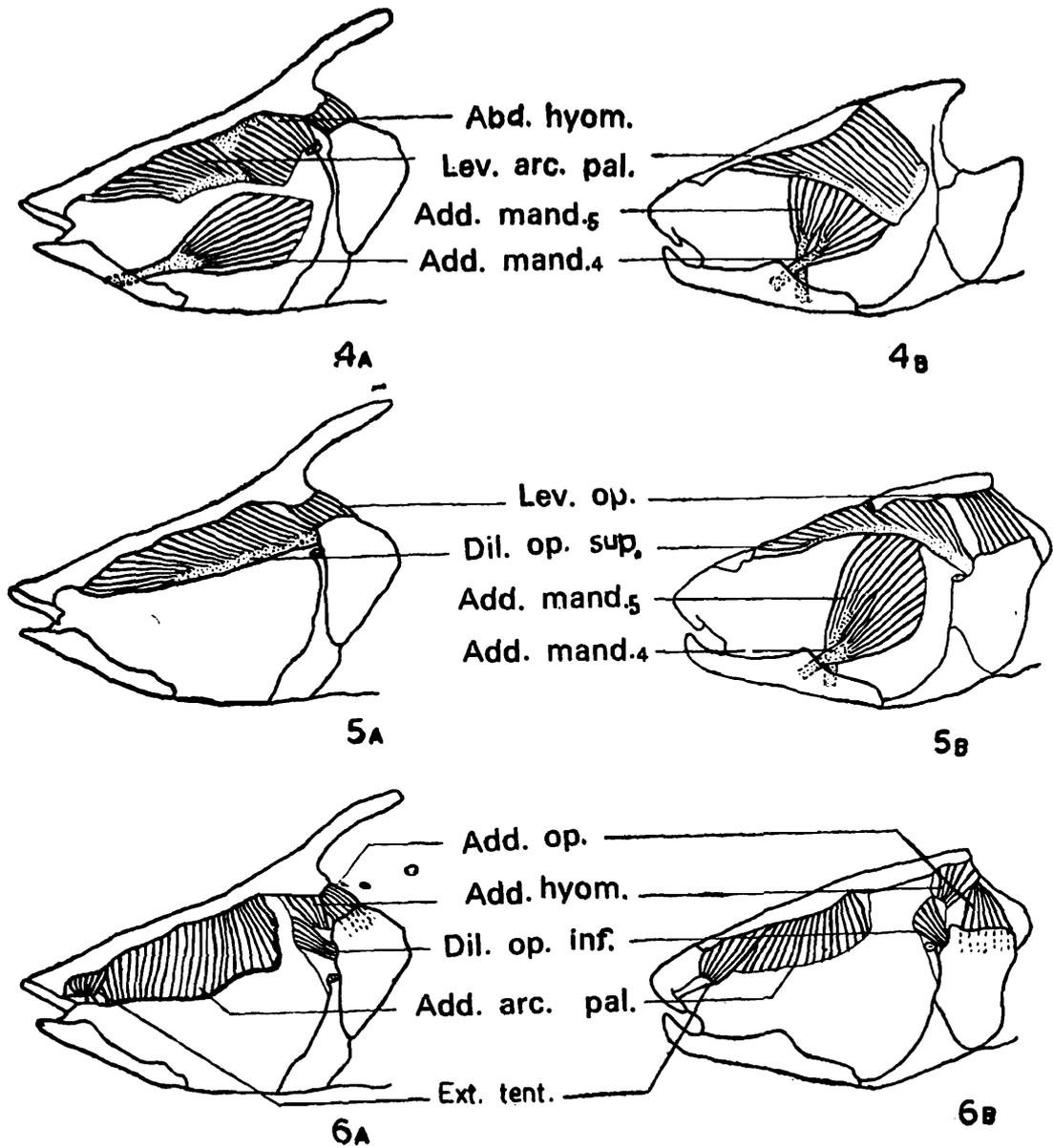
Text-fig. 2A. Left lateral view of the head region of *Horabagrus brachysoma*, showing the disposition of Adductor mandibularis components.

2B. Left lateral view of the head region of *Mystus gulio*, showing the disposition of the Adductor mandibularis components.

Text-fig. 3. Left lateral view of the head region of *Mystus gulio*, showing the disposition of the Adductor mandibularis components.

in case of *H. brachysoma*. Finally the fibres of this segment are inserted on the mesial surface of the dentary through an aponeurosis in *M. gulio* whereas in *H. brachysoma*, the insertion is partly musculous and partly aponeurotic. The posteroinner portion of this muscle is thick,

wide and covering almost the entire anteroventral surface of the head. Its fibres originate partly aponeurotically and partly musculously from the ceratohyal and epihyal in *M. gulio* but only from ceratohyal



Text-fig. 4A. Left lateral view of the head region of *Horabagrus brachysoma*, showing the disposition of the components of Adductor mandibularis and Constrictor dorsalis groups.

4B. Left lateral view of the head region of *Mystus gulio*, showing the disposition of Levator arcus palatini.

Text-fig. 5A. Left lateral view of the head region of *Horabagrus brachysoma*, showing the disposition of Dilator operculi superioris and Levator operculi.

5B. Left lateral view of the head region of *Mystus gulio*, showing the disposition of the components of Adductor mandibularis, Constrictor dorsalis and Constrictor hyoideus dorsalis groups.

Text-fig. 6A. Left lateral view of the head region of *Horabagrus brachysoma*, showing the disposition of the components of Constrictor hyoideus dorsalis and Constrictor dorsalis groups.

6B. Left lateral view of the head region of *Mystus gulio*, showing the disposition of the components of Constrictor hyoideus dorsalis and Constrictor dorsalis groups.

in *H. brachysoma*. The muscle fibres run forwards and inwards in a divergent fashion to get inserted on the dentary. Before insertion the muscle is bifurcated into two parts (superior and inferior) which fuses with the fellow of other side along a mid ventral line. The superior part provides the support to the mandibular barbels and passes over the *Intermandibularis*, while the inferior part passes below the *Intermandibularis*. In *M. gulio*, the insertion is partly aponeurotic and partly muscular. (Text-figs. 7A & B).

II. Hyoid Muscle Complex :

The muscles of this complex are divisible into two main divisions

1. Constrictor hyoideus dorsalis group :

This group of muscles is situated in the interspace between the suspensorium and the neurocranium and comprises of five components.

a. *Adductor arcus palatini* :

This muscle is well developed and occupies the entire space between the neurocranium and the pterygo-hyomandibular arch. The muscle fibres take their muscular origin from the parasphenoid except few posterior fibres which originate aponeurotically. The muscle fibres run downwards at a right angle to the longitudinal axis of the skull and in a somewhat divergent fashion to get inserted on the anterolateral surface of the hyomandibula, dorsolateral surface of the metapterygoid and ectopterygoid. The insertion of the fibres are partly muscular and partly aponeurotic. Anteriorly the muscle is partly overlapped by the *Extensor tentaculi* in both the genera (Text-fig. 6A & B).

b. *Extensor tentaculi* :

This muscle is situated anterior to the *Add. arc. pal.* and overlaps the latter partially. The development of this muscle varies among the two genera. In *M. gulio* (Text-fig. 6B) it is well developed and is having longer muscle fibres but in *H. brachysoma* (Text-fig. 6A) the muscle fibres are shorter and the muscle is moderately developed. The muscular fibres originate from the ventral surface of the lateral ethmoid and anterolateral surface of the parasphenoid and then run downwards in a convergent manner to get their insertion on the distal end of the autopalatine. The nature of insertion differs in both the genera. In *M. gulio*, the posterior fibres are inserted through an aponeurosis and the anterior fibres are inserted muscularly ; in *H. brachysoma*, on the other hand all the fibres of this muscle are inserted muscularly. Contraction of this muscle moves the autopalatine thereby causing the head of the autopalatine to move, which in turn abducts the maxillary barbels,

c. *Levator operculi* :

This muscle is moderately developed lying underneath the skin and just behind the *Dil. op.* In both the genera, it originates musculously from the pterotic except few fibres which originate from the posterodorsal surface of the hyomandibula. The muscle fibres run downwards in a divergent fashion to get inserted on the dorsal surface of the opercular. It overlaps the *Add. hyom.* (Text-figs. 5A & B).

d. *Adductor operculi* :

It is present beneath the *Lev. op.* and is well developed in *M. gulio* while it is moderately developed in *H. brachysoma*. In both the genera (Text-figs. 6A & B), the muscle originates from the prootic and then runs downwards in a divergent fashion after which the fibres are inserted on the dorsoinner surface of the opercular.

e. *Adductor hyomandibulae* :

This muscle is moderately developed, situated beneath the *Lev. op.* In *M. gulio* (Text-fig. 6B) as well as in *H. brachysoma* (Text-fig. 6A), the muscle originates from the ventral surface of the pterotic and then runs downwards in an anterior direction. It is inserted on the posterodorsal surface of the hyomandibula. The insertion is partly aponeurotic and partly muscular. It partly overlaps the *Add. op.* and is itself overlapped by the *Lev. op.*

2. Constrictor ventralis group :

This group comprises three main muscular elements which are lying on the ventral side of the head and connects the hyoid bones of one side with the other side. It may be viewed after removing of *Protractorhyoidei*.

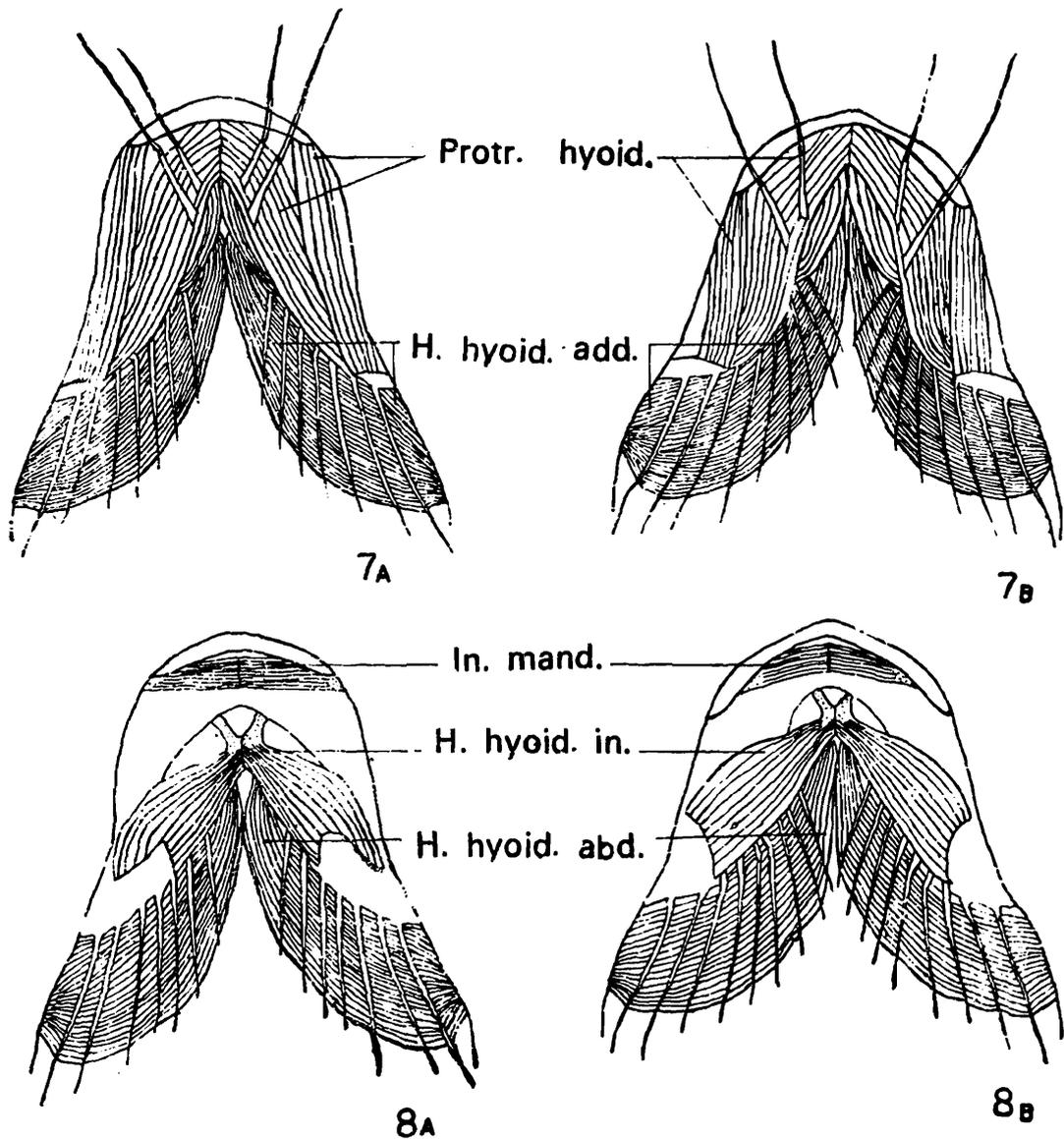
a. *Hyohyoides inferioris* :

This muscle is well developed, lying beneath the *Protr. hyoid.* and arising from the ceratohyal in *M. gulio* (Text-fig. 8B) and *H. brachysoma* (Text-fig. 8A) as well. It is seen that some smaller fibres also arise from the hypohyal in *M. gulio*. The muscle fibres of each side run forwards in a convergent fashion, fused with its fellow of the other side anteriorly along a mid ventral line. Finally, the fibres are attached on the anterodorsal surface of the hypohyal through a V-shaped aponeurosis. It partly overlaps the *Hyohyoidei abductores*.

b. *Hyohyoidei abductores* :

It is a well developed muscle, situated beneath and behind the *Hyohyoides inferioris*. In both the genera (Text-figs. 8 A & B), the muscle

fibres originate aponeurotically from the hypohyal. In *M. gulio*, the aforesaid aponeurosis is attached with its fellow of the other side before its attachment on the hypohyal. It also provides the attachment to



Text-fig. 7A. Ventral view of the head region of *Horabagrus brachysoma*, showing the disposition of Protractorhyoidei and Hyohyoidei adductores.

7B. Ventral view of the head region of *Mystus gulio*, showing the disposition of Protractorhyoidei and Hyohyoidei adductores.

Text-fig. 8A. Ventral view of the head of *Horabagrus brachysoma*, showing the disposition of Intermandibularis, Hyohyoidei inferioris and Hyohyoidei abductores.

8B. Ventral view of the head of *Mystus gulio*, showing the disposition of Intermandibularis, Hyohyoidei inferioris and Hyohyoidei abductores.

some inner fibres of *Hyohyoidei inferioris* unlike that of *H. brachysoma*. This aponeurosis lies just below that of *Hyohyoidei inferioris*. In *H. brachysoma* on the other hand the muscular fibres are closely applied to the ventral surface of the aponeurosis of *Hyohyoidei inferioris*. After their aponeurotic origin, the muscle fibres run downwards in a divergent fashion and get attached on the first branchiostegal ray in both the genera.

c. *Hyohyoidei adductores* :

This is a moderately developed muscle, present in between the branchiostegal rays in various bands and finally inserted on the inner surface of the opercular. There is variation in the number of muscle bands in each one of the genus. In *M. gulio* (Text-fig. 78), it is present in nine bands while only seven bands in *H. brachysoma* (Text-fig. 7A). It is very thick between the 2nd, 3rd, 4th and 5th branchiostegal rays.

DISCUSSION

The fishes of the family Bagridae has been considered as a base for the derivation of other siluroid families such as Amblycipitidae, Amphiliidae, Akysidae etc. Regan (1911) and Gosline (1944) postulated that the phylogeny of many Asiatic siluroids are interlinked with that of the Bagridae. Tilak (1961 ; 1963 a, b, & c ; 1964 ; 1965 a & b ; 1966 and 1967) in a series of papers demonstrated that such a hypothesis is more or less true at least in regard to the Indian siluroid families. Jayaram (1966 a) after a world revision of the fishes of family Bagridae, divided the family into five subfamilies : Ritinae, Chrysichthyinae, Bagrinae, Bagroidinae, Auchinoglanidinae. *Rita* was included under the subfamily Ritinae while *Mystus*, *Aorichthys* were included under Bagrinae and *Horabagrus* under Chrysichthyinae. Ritinae was considered more primitive than the other subfamilies.

While comparing the four genera myologically it is seen that these genera show uniformly a pattern in respect of the nature of origin, insertion and disposition of the following muscles viz. *Extensor tentaculi*, *Adductor operculi*, *Adductor arcus palatini*, *Intermandibularis* and *Dilator operculi inferioris*.

The features which are unique in respect of *Rita* are as below :

1. *Retractor tentaculi* :

This muscle is present in the form of muscular fibres in *Rita*, in the form of a ligament in *Aorichthys*, and is completely absent in *Mystus* and *Horabagrus*. It is known that *Retractor tentaculi* helps mainly in the movement of the maxillary barbels. It appears that in the case of *Mystus* and *Horabagrus* this function is taken over by the *Adductor mandibularis* muscle. Considering the fact that *Mystus gulio* and *Horabagrus brachysoma* are found in stagnant back waters where the visibility is less than as compared to the habitats of *Rita* and *Aorichthys* which are found in clear fast flowing streams this modification seems justified. The effective function of the maxillary barbel is more advanced in *Rita* and *Aorichthys* than in *Mystus* and *Horabagrus*.

2. *Adductor mandibularis* :

The origin of *Adductor mandibularis*₁ extends upto supraoccipital in *Rita* whereas in the other three genera it originates only from the branchiocranium. The number of muscular elements of *Adductor mandibularis* component is also significant. There are five elements in *Mystus*, four in *Rita* and *Aorichthys* and three in *Horabagrus*. In respect of the constituent elements of *Adductor mandibularis* component as stated above, it may be that the habitat of these fishes and also the large size of their head may have a bearing on the disposition of these muscles.

3. *Intramandibularis* :

In the case of *Mystus* and *Horabagrus*, this muscle is inserted on the aponeurosis of *Adductor mandibularis*₃ and₂ respectively. On the other hand in *Rita* this muscle is inserted only on the quadrate. In *Aorichthys* besides the quadrate, the insertion is on the aponeurosis of *Adductor mandibularis*₂ also. Additional difference in respect of *Aorichthys* is that this muscle is present in two parts unlike the other three genera where it is present as a single part.

The peculiar insertion of the *Intramandibularis* muscle only on the quadrate in *Rita* is a primitive feature indicating lack of support for the movement of the dentary bone. It may be due to the feeding habits as well as the dentition pattern in *Rita*. It may be noted that the dentition in the lower jaw of *Rita rita* is an elliptical patch with large molariform teeth towards the inner side and small villiform teeth towards the outer side of the jaw (See Jayaram, 1966, p. 441 and fig. 4).

4. *Levator operculi* :

Here also as in the case of *Intramandibularis* discussed above, this muscle originates from the pterotic by means of a tendon instead of a muscular origin as in the case of the other three genera. This also indicates the primitive feature of *Rita* showing the less efficient mechanism in the movement of the opercular bone.

5. *Hyohyooides inferioris* :

Rita is unique in having this muscle arranged in the form of 8 transverse muscular bands unlike other genera where it is present in the form of a single muscle. These bands are not inserted on the hypohyal but are fused with its antimere along the midventral line unlike the other genera.

The modification in *Hyohyooides inferioris* in the form of muscular bands, appears to be a progressive character considering the fact

that *Rita* generally prefers bottom areas and that its requirement of oxygen are comparatively less than those of other genera. This modification of *Hyohyooides inferioris* is a significant feature.

6. *Hyohyoidei abductores* :

This muscle generally assists in the movement of the branchiostegal membrane. It shows a somewhat progressive feature in the case of *Rita* unlike the other genera. The tendon of this muscle is criss-crossed whereas in other genera they are arranged in a simple manner. Reasons adduced above relating to the habitat of the fish would seem to apply here also.

It may thus be seen from the above discussion that *Rita* has the following features which are indicative of its primitive nature.

1. Presence of *Retractor tentaculi*.
2. The origin of the element of *Adductor mandibularis* component extending upto supraoccipital bone.
3. The insertion of the *Intramandibularis* muscle only on the quadrate.
4. Origin of *Levator operculi* from the pterotic by means of a tendon instead of a musculous origin.

The characters which may be stated as progressive are

1. Modification in *Hyohyooides inferioris* in the form of muscular bands.
2. The tendons of *Hyohyoidei abductores* in the form of a criss-cross.

Comparing the overall features of *Rita* with other genera it is seen that *Horabagrus* resembles a greater extent to *Rita* than *Mystus* and *Aorichthys*. As for instance out of 15 myological features (Tab. 1) listed for the four genera it is seen that only in respect of three main characters the two genera differ. The *Retractor tentaculi* and *Adductor mandibularis*₃ are absent in *Horabagrus* vs. present in *Rita* and the *Hyohyoidei adductores* have 7 bands vs. 8 bands in *Rita*.

Mystus and *Aorichthys* are naturally expected to resemble each other since taxonomically both of them are almost akin. However *Aorichthys* appears to be more specialised in possessing the *Abductor hyomandibularis*, in having a larger *Levator arcus palatini* and in the absence of *Adductor mandibularis*₃. The number of bands of *Hyohyoidei adductores* is maximum (eleven) in *Aorichthys* which also supports the view that *Aorichthys* is more specialised than the other three genera.

TABLE—I

	<i>M. gulio</i>	<i>H. brachysoma</i>	<i>R. rita</i>	<i>A. aor</i>
1. <i>M. abductor hyomandibularis</i>	Absent	Present	Present	Present
2. <i>M. levator arcus palatini</i>	It is longer than broad, originates from frontal and sphenotic.	Broader than long, originates from frontal, sphenotic and lateral ethmoid.	Similar to that of <i>H. brachysoma</i>	Broader than long, originates from sphenotic and frontal only.
3. <i>M. dilator operculi superioris</i>	Originates from frontal, sphenotic, lateral ethmoid and the orbitosphenoid.	From frontal, sphenotic, lateral ethmoid and orbitosphenoid.	From sphenotic, pterotic and hyomandibula.	From sphenotic, pterotic and frontal.
4. <i>M. retractor tentaculi</i>	Absent	Absent	Present in the form of muscular fibres.	Present in the form of ligament.
5. <i>M. adductor mandibularis</i> ₁	Originates from preopercular, hyomandibula and quadrate.	Similar to that of <i>M. gulio</i> .	From the preopercular hyomandibula, supraoccipital and the frontal.	From preopercular and the quadrate.
6. <i>M. adductor mandibularis</i> ₂	Originates from branchiocranium and is inserted on the dentary. Present in one part.	Originates from branchiocranium and neurocranium. Inserted on the angular. Present in one parts.	Originates from branchiocranium and neurocranium excluding preopercular. Inserted on the dentary. Present in two parts.	Similar to that of <i>H. brachysoma</i>
7. <i>M. adductor mandibularis</i> ₃	Originates from branchiocranium and neurocranium and present in one part.	Absent	Originates from branchiocranium only and present in two parts.	Similar to that of <i>R. rita</i> .
8. <i>M. adductor mandibularis</i> ₄	Originates from branchiocranium and present in one part and is partly overlapped by the <i>M. lev. arc. pal.</i>	Originates from branchiocranium, present in one part and is not overlapped by the <i>M. lev. arc. pal.</i>	From neurocranium, present in two parts and is partly overlapped by the <i>M. lev. arc. pal.</i>	From neurocranium and branchiocranium, present in one part and is partly overlapped by the <i>M. lev. arc. pal.</i>

	<i>M. gulio</i>	<i>H. brachysoma</i>	<i>R. rita</i>	<i>A. aor</i>
9. <i>M. adductor mandibularis</i> ₂	Present	Absent	Absent	Absent
10. <i>M. intramandibularis</i>	Insertion on the aponeurosis of <i>M. add. mand.</i> ₂ . Present in one part.	Insertion on the aponeurosis of <i>M. add. mand.</i> ₂ . Present in one part.	Insertion on the quadrate, present in one part.	Insertion on the quadrate as well as on the aponeurosis of <i>M. add. mand.</i> ₂ . Present into two parts.
11. <i>M. levator operculi</i>	Originates musculously from the pterotic.	Similar to that of <i>M. gulio</i> .	Originates from the pterotic through a tendon.	Similar to that of <i>M. gulio</i> .
12. <i>M. protractorhyoidei</i>	Originates from epihyal and ceratohyal.	Similar to that of <i>M. gulio</i>	From ceratohyal only.	Similar to that of <i>R. rita</i> .
13. <i>M. hyohyoidei inferioris</i>	Not present in the form of different bands. Inserted aponeurotically on the hypohyal.	Similar to that of <i>M. gulio</i> ,	Present in the form of eight muscular bands. Not inserted on the hypohyal but is fused with its fellow of otherside in the middle.	Similar to that <i>M. gulio</i> .
14. <i>M. hyohyoidei abductores</i>	The tendon of this muscle is not arranged in a criss-cross fashion with that of its fellow of other side.	Similar to that of <i>M. gulio</i> .	The tendon of this muscle of one side is criss-crossed to that of otherside.	Similar to that of <i>M. gulio</i> .
15. <i>M. hyohyoidei adductores</i>	Present in 9 bands.	Present in 7 bands.	Present in 8 bands.	Present in 11 bands.

As stated earlier Jayaram (1966) in his classification placed *Rita* under the subfamily Ritinae, *Mystus* and *Aorichthys* under Bagrinae and *Horabagrus* under Chrysichthyinae. Of these *Rita* was considered more primitive as already stated.

From the evidence of myology and considering the ecology of these fishes the above conclusions seem to be aptly justified. Osteologically it is known that *Aorichthys* and *Mystus* are derivatives from *Porcus* like ancestors. *Rita* appears to have evolved independently and may have given rise to *Chrysichthys* like fishes found in Africa which in turn may have given rise to *Horabagrus* like forms. The unique myological features of *Rita* justifies the above conclusion.

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SUMMARY

The mandibular and hyoid musculature in the osteocranium of four bagrid genera *Rita* Bleeker, *Horabagrus* Jayaram, *Mystus* Scopoli and *Aorichthys* Wu belonging to subfamilies Ritinae, Chrysichthyinae and Bagrinae of the family Bagridae was investigated. Published data on these muscular complexes on *Rita rita* by Singh and Munshi (1969) and *Aorichthys aor* by Munshi (1960) were utilised for comparing with the patterns obtained in *Horabagrus brachysoma* and *Mystus gulio* of which dissections were made and data retrieved first hand. The muscles in these latter two fishes are described in detail.

A comparison of the four genera myologically indicates that *Rita* is primitive in possession of *Retractor tentaculi* and in having the origin of *Adductor mandibularis* component extending up to the supraoccipital bone. Further in *Rita* the *Intramandibularis* muscle is inserted only on the quadrate. The origin of *Levator operculi* from the pterotic is by means of a tendon instead of a muscle. In respect of *Hyohyoideus inferioris* and *Hyohyoidei abductores* *Rita* exhibits some specialised features. Comparing the overall features of *Rita* with other three genera it becomes apparent that *Rita* is primitive than others. *Aorichthys* and *Mystus* are interrelated, *Rita* appears to have evolved independently and may have given rise to *Chrysichthys* like fishes which in turn may have given rise to *Horabagrus* like forms. The classification of Jayaram (1966) is justified.

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