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THE IMPORTANCE OF UROHYAL IN FISH SYSTEMATICS

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INTRODUCTION

Traditionally, the studies on fish systematics have been based on morphology, especially the skeleton which is the only complete organ system available for comparison with fossils. Among the skeletal elements, the urohyal bone which lies in the lower part of the head between the lower jaw bones, has proved to be of exceptional significance in fish systematics. This is because of the fact that the differences found in urohyal shapes between fish groups seem to be correlated with other morphlogical differences between them.

Chabanaud (1933a, 1933b), Kyle (1921), Tyler (1959) and Datta & Rao (1965) referred to the taxonomic importance of urohyal in classifying flatfish (Pleuronectiformes). Kusaka (1974), after studying the urohyal of about 700 spp, belonging to 460 genera, 184 families and 21 orders, came to a definite conclusion that the urohyal shape is so characterstic in different groups of teleostean fishes that it could be safely used for classifying families, genera and species.

This paper presents an attempt to assess the importance of urohyal in fish systematics by observing urohyal shape of different fish groups, representing members of different evolutionary levels.

MATERIAL AND ILLUSTRATION

The urohyal bones of the following species have been studied; those of the species marked with asterisk have been examined and relevant informations on the structure and shape of urohyal of other species have been obtained from the published work of Kusaka (1974) for the sake of comparison. The classification followed here is that of Greenwood, Rosen, Weitzman & Myers (1966).

Clupeiformes

Clupeidae	*Clupea pallasi* (Cuvier & Valenciennes)
	Ilisha elongatea (Bennett)
Engraulidae	*Engraulis japonica* (Houttuyn)

Osteoglossiformes

Notopteridae	*Notopterus* sp

Cypriniformes		
	Characidae	*Serrasalmus natteri* (Kner)
	Cyprinidae	*Cyprinus carpio* Lin.
		Labeo bicolor Smith
	Cobitidae	*Misgurnus* sp.
		Botia macracanthus (Bleeker)
Siluriformes		
	Clariidae	*Clarias lazera* Cav. & Val.
	Chacidae	*Chaca* sp.
Anguilliformes		
	Anguillidae	*Anguilla japonica* Temn & Schlegel
	Ophichthyidae	*Microdonophis erabo* Jerdan & Snyder
Atheriniformes		
	Poeciliidae	*Gambusia affinis* (Baird & Girard)
		Lebistes reticulatus (Peters)
Channiformes		
	Channidae	*Channa maculata* (Lacepede)
Scorpaeniformes		
	Scorpaenidae	*Sebastes joyneri* Gunther
Perciformes		
	Nandidae	*Monocirrhus polyacanthus* Heckel
	Cichlidae	*Tilapia nilotica* (Linn.)
	Mastacembelidae	**Mastacembelus armatus* Lacepedae
		**Macrognathus aculeatus* (Bloch)
		**Pillaia indica* Yazdani
Pleuronectiformes		
	Psettodidae	**Psettodes belcheri* Bennett
	Pleuronectidae	**Pleuronectes platessa* Linn.
	Scophthalmidae	**Scophthalmus maximus* (Linn.)
		Lepidorhombus whiffiagonis (Walbaum)
	Bothidae	*Laeops lanceolata* Frans
	Soleidae	**Solea solea* (Linn.)
	Cynoglossidae	**Cynoglossus* sp.

The main outlines of the figures have been drawn free hand. The evolutionary relationships of major groups of teleostean fishes are illustrated in Fig.1 in accordance with the concepts of Greenwood *et al.* (1966).

Structure and function of Urohyal

The position of urohyal in the head of fish is shown in fig. 2.

The urohyal is a single bone, the anterior tip of which is generally connected to the ventral hypohyal, the anterodorsal part connected to the first basibranchial and the posterior part connected to the pectoral girdle by a large muscle (Fig.3). The point of attachment of urohyal with the hypohyal is invariably thickened, sometimes forked to allow the connections of a paired ligament to the ventral hypohyals. In those fishes wherein the urohyal head is well-developed the anterior part is fixed to the hypohyals and first basibranchial without a ligament. The relative position of urohyal attachment with the hypohyal and basibranchial is an important feature in determining the differnt types of urohyal among fishes.

The urohyal length is defined as the length of the horizontal line joining the anterior and posterior most tips of the bone (Fig.3). The dorsal edge is the part behind the basibranchial attachment extending to the posterodorsal end and ventral edge is the ventral side from the hypohyal attachment to the postero-ventral end; the vertical plate extends vertically and lengthwise, the dorsal spread is a lateral expansion on the dorsal side and the ventral spread is a lateral expansion on the ventral side, the lateral spreads or pleat is a lateral expansion extending on a level about midway of the height. The posterior edge is the side between the posterodorsal and postero ventral ends. The frontal side is the interval between the hypohyal and basibranchial attachments.

The urohyal is the most functional bone in fishes. Its position is related to the functional difference of the mouth-opening mechanism. The urohyal is necessary for movement of the jaws and in those group of fish where the jaw bones are mechanically fused into a single hinge. This bone has degenerated or lost as in members of Tetraodontiformes and Lophiiformes.

The V-shaped urohyal bone in most flatfish (Pleuronectiformes) also performes an important function in breathing (See Yazdani & Alexander, 1967). In most flatfish the branchio-stegal membranes lie within the V-shaped urohyal and form a channel connecting the two opercular cavities. It is believed that water pumped through the gills of the blind side of a resting flatfish passes through this channel to escape through the opercular opening of the ocular side. Normally, resperatory water is not expelled from the opercular opening of the blind side of resting flatfish.

OBSERVATION

The outlines of fish, representing typical body form of each family and the urohyal of species dealt with in this paper are shown in Figs.4-8. The observations on the urohyal of mastacembeloid and pleuronectid fishes are detailed below.

Mastacembelidae : In *Mastacembelus*, the vertical plate of the urohyal is elongated, roughly triangular, its posterior edge wavy, deeply forked, the basibranchial attachment protrudes dorsally, hypohyal attachment having two lateral lobes, well-developed. The urohyal length is nearly 30 % of head length.

In *Macrognathus*, the urohyal is similar to that of *Mastacembelus*, except that the posterior edge is not deeply forked, and the basibranchial attachment is better developed. The urohyal length is nearly 30 % of head length.

Pillaiidae : In *Pillaia*, the vertical plate of the urohyal is rather narrow, elongated, the posterior edge very wavy; dorsal spread fairly developed anteriorly the basibranchial attachment situated dorsally well behind the hypohyal attachment which is well marked and deeply divided into two lateral lobes. The urohyal length is nearly 30 % of head length.

Psettodidae : In *Psettodes*, the vertical plate of the urohyal is rather elongated, its ventral edge slightly concave, the dorsal edge somewhat convex, the frontal side projected dorsally; the posterior edge tapering.

Pleuronectidae : In *Pleuronectes*, the vertical plate of the urohyal is curved in such a way that it looks hook-shaped or V-shaped; the posterior edge of the vertical plate is bent down and turned forward to give this shape; the actual ventral edge of the urohyal forms the cavity of the 'V' The real dorsal edge of the bone now forms the posterior side of the urohyal.

Scophthalmidae : In *Scophthalmus*, the urohyal is similar to that of the *Pleuronectes*, except that the antero dorsal part of the vertical plate is longer than the postero ventral part and the cavity thus formed is typically 'V' shaped.

In *Lepidorhombus*, the vertical plate is roughly triangular in shape, the antero-dorsal and postero ventral parts forming a shallow cavity.

Bothidae : In *Laeops*, the urohyal is similar to that of *Scophthalmus*.

Soleidae : In *Solea*, the urohyal is a narrow, angular bone, its anterodorsal and postero-ventral parts forming a very broad 'V' or 'U'

Cynoglossidae : In *Cynoglossus*, the urohyal is a small, roughly triangular bone, its ventral edge is straight or slightly curved not forming any 'V' shaped cavity; the dorsal edge much developed and convex; posterior edge is tapering, frontal side narrow and tapering.

DISCUSSION

The fore going observations on the urohyal of different species clearly reveal the fact that each taxonomic group possesses a characterstic type of urohyal shape. The differences between urohyals seem to correspond to the known differences between groups of teleostean fishes.

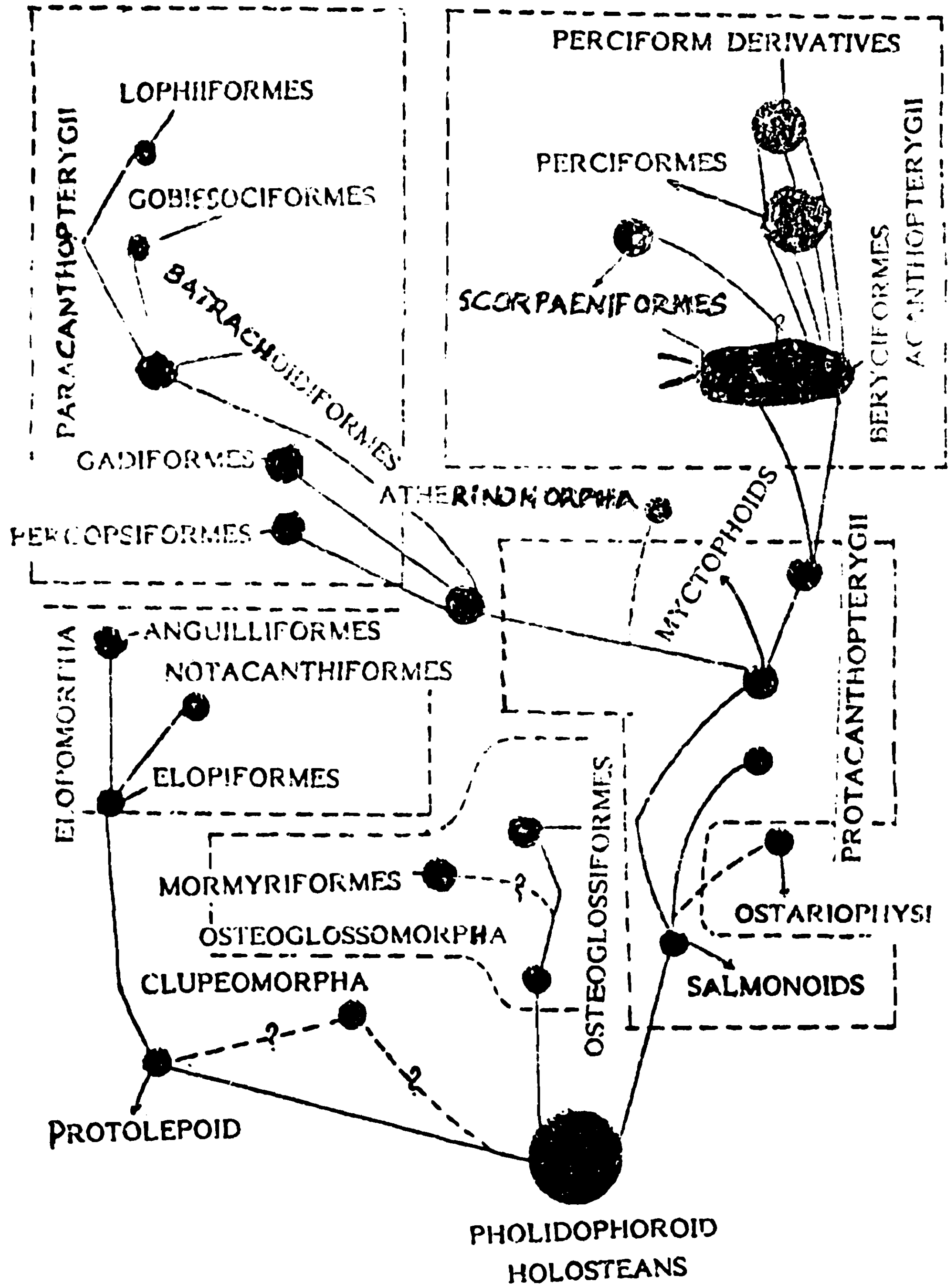

Fig. 1. Diagram showing the evolutionary relationships of major groups of teleostean fishes (based on the conception of Greenwood *et. el.* (1966).

Abbrevations used in figures

ba - basibranchial attachment; bb - basibranchial; 1st bb - First basibranchal; 2nd bb - Second basibranchal; 3rd bb - Third basibranchal; bh - basihyal; bm - branchiostegal members; br - branchiostgal ray; ch - ceratohyal; chl - channel; cr - cranium; d - dentary; dhh - dorsal hypohyal; ds - dorsal spread; e - eye; eh - epihyal; ha - hypobranchial attachment; ih - interhyal; kp - keep part; I - ligament; Is - lateral spread; m - muscle; me - migratory eye; mst - mesopterygoid; mx - maxilla; ne - normal eye; pal - palatune; pe - posterior edge; pf - pectoral fin; pmx - premaxilla; ps - parasphenoid; s - section; t - tendon; uh - urohyal; ve - ventral edge; vhh - ventral hypohyal; vs - ventral spread.

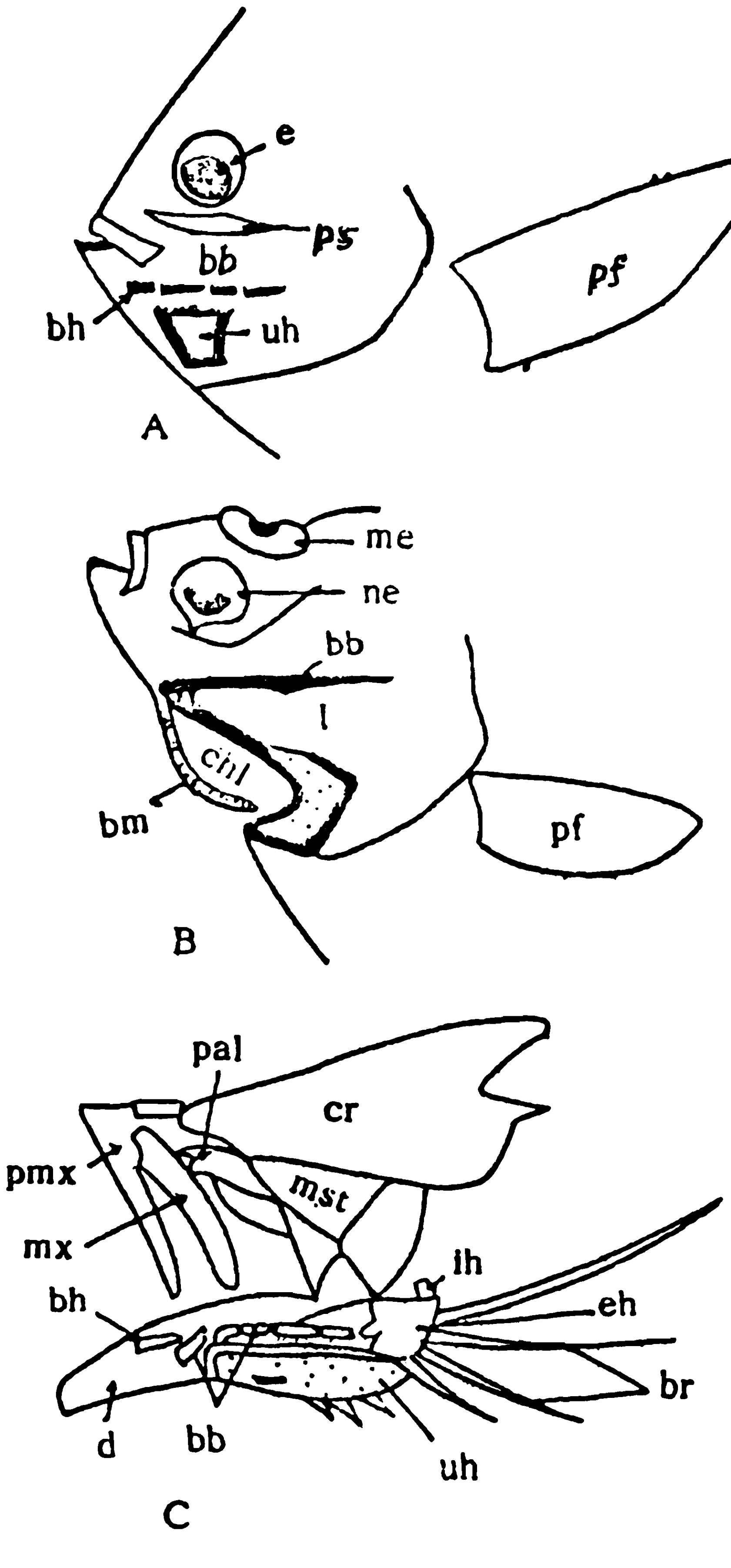

Fig. 2. Position of urohyal in the lower part of the head of (A) a percoid fish (B) a flatfish (Pleuronectiformes) (C) a teleost, when the mouth is opened.

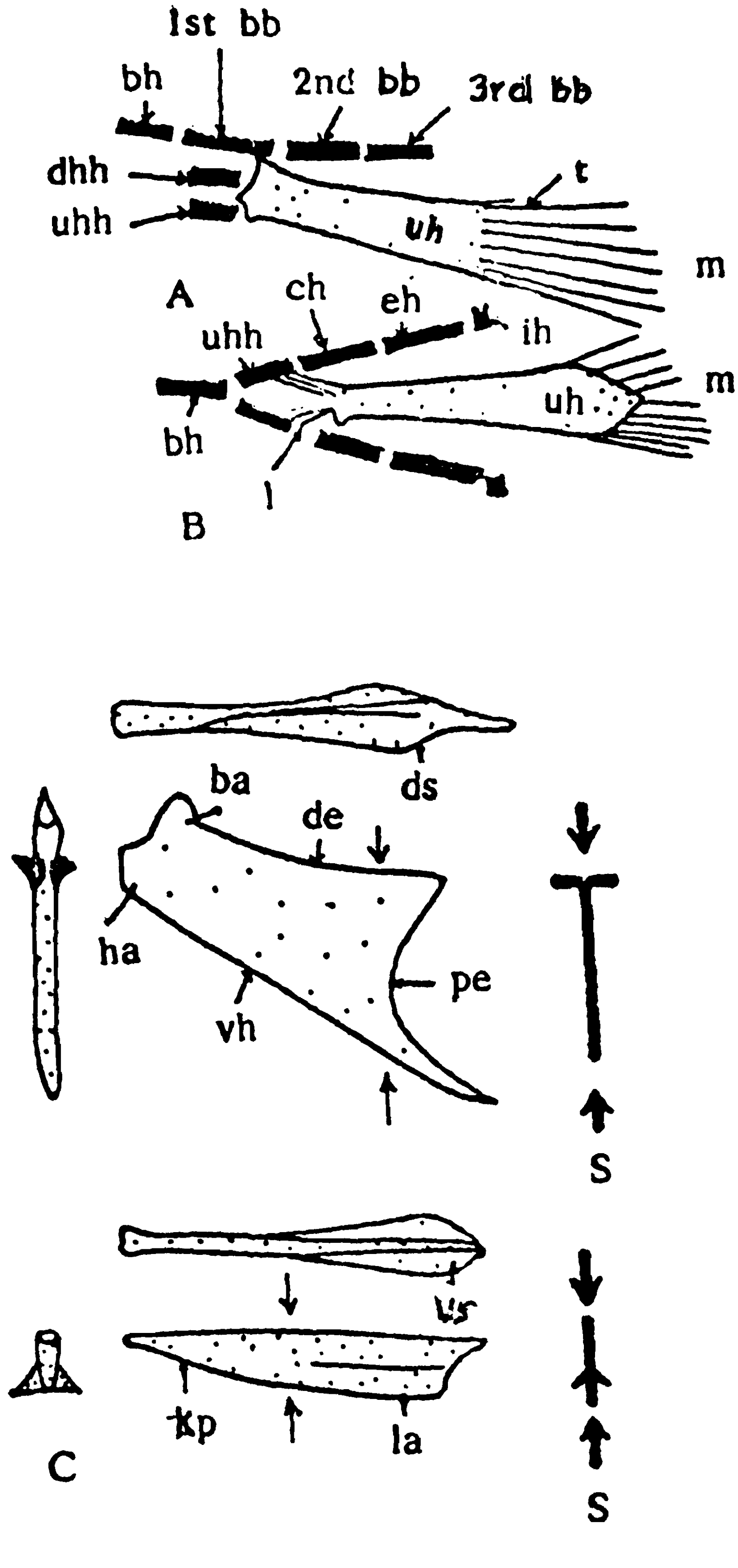

Fig. 3. Relative position of urohyal in (A) Lateral view (B) Ventral view (C) Shape of urohyals in dorsal, lateral, anterior views, showing terminology of parts.

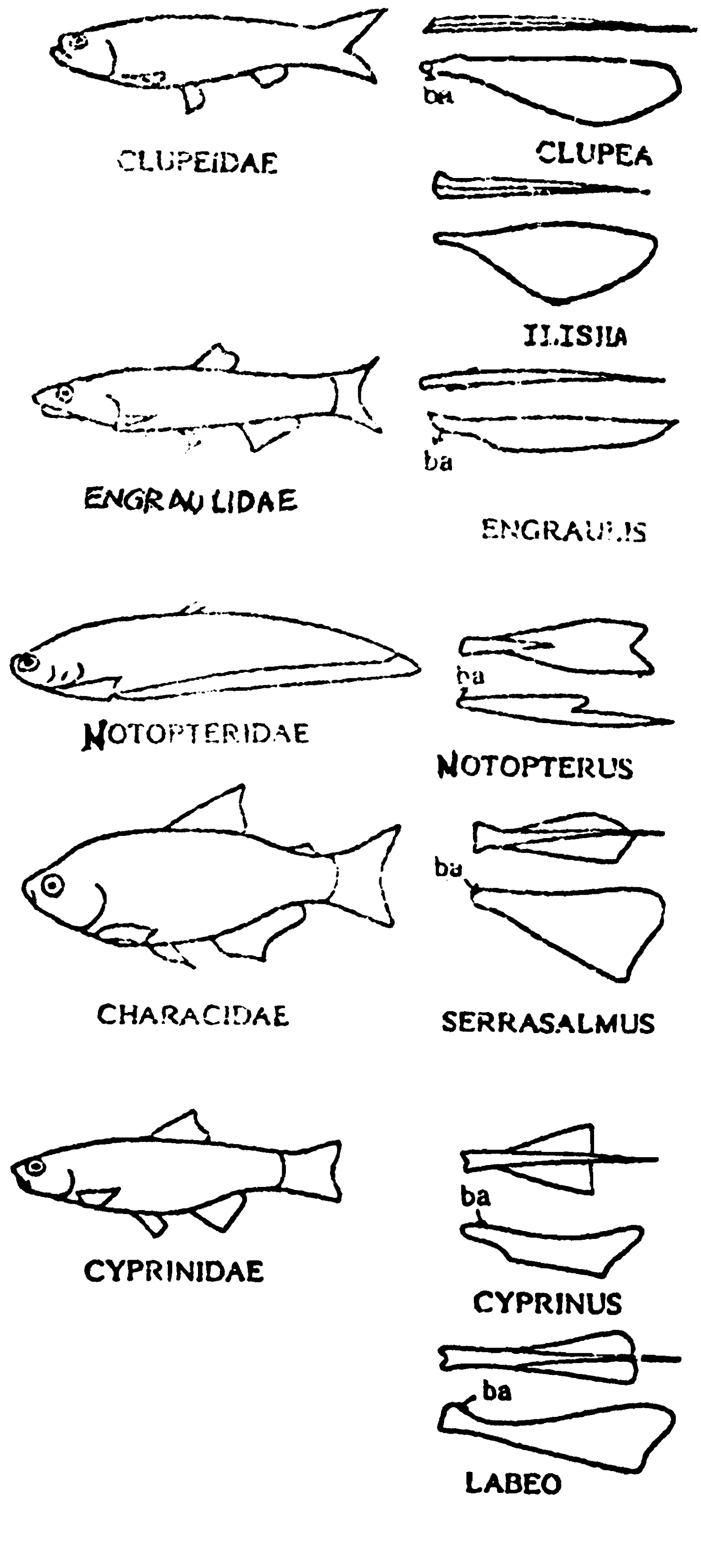

Fig. 4. Dorsal and lateral view of urohyal in some members of Clupeiformes, Osteoglossiformes and Cypriniformes.

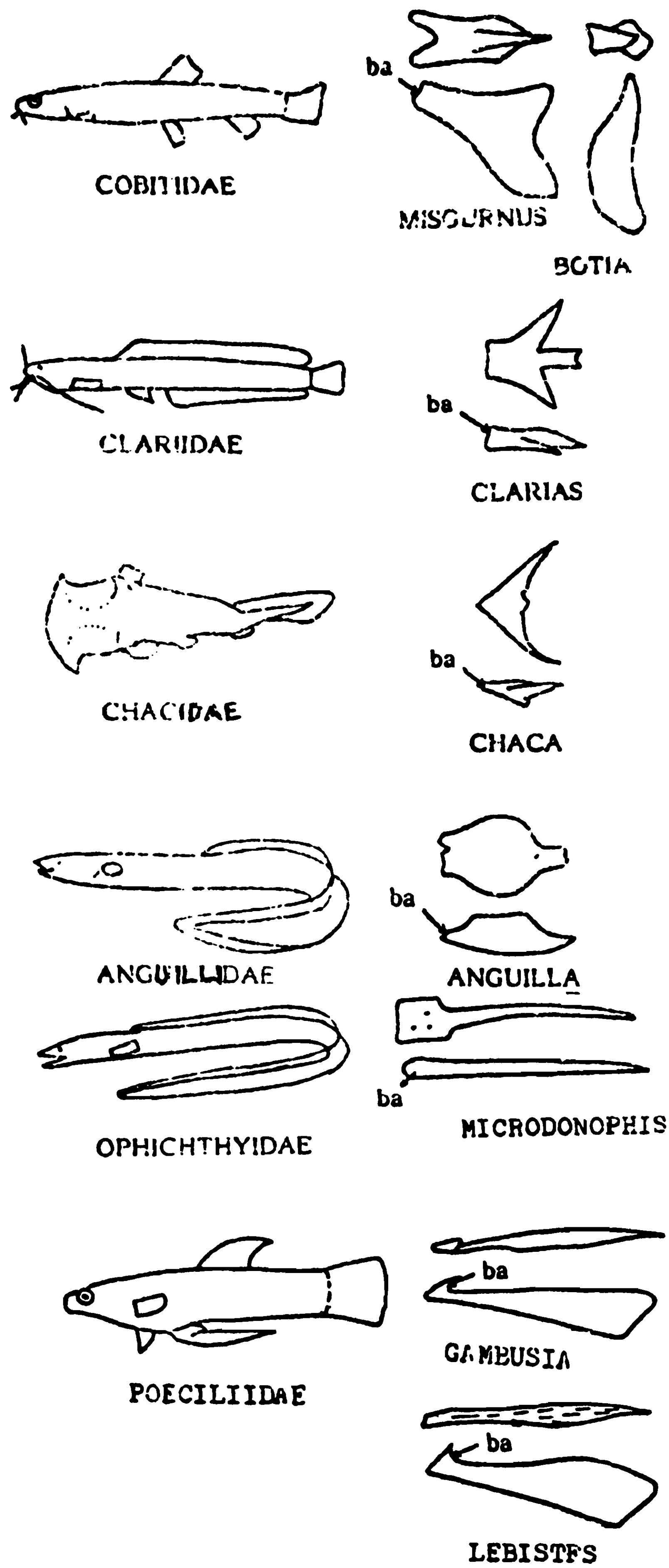

Fig. 5. Dorsal and lateral view of urohyal in some members of Cypriniformes, Siluriformes, Anguilliformes, and Athereniformes.

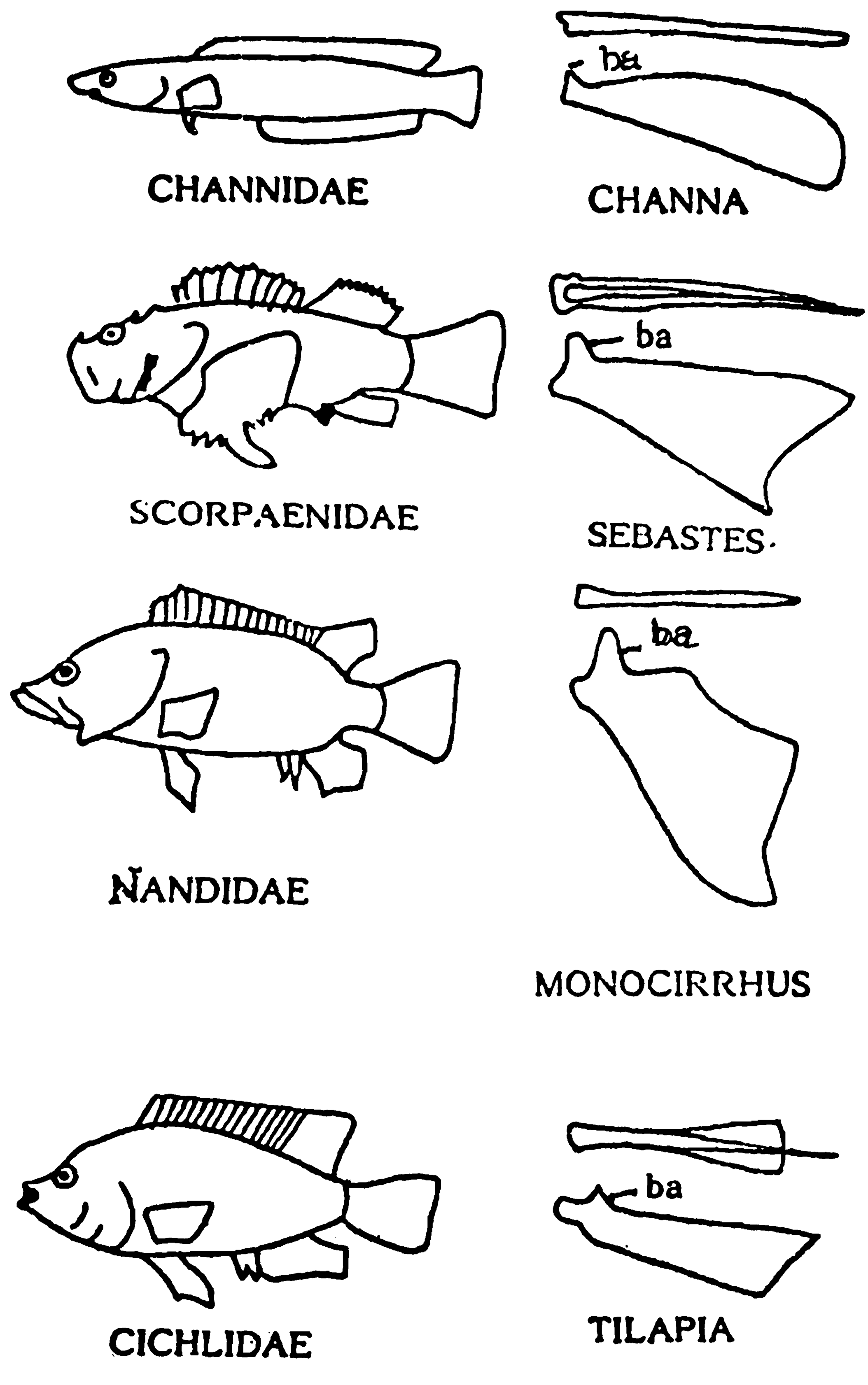

Fig. 6. Dorsal and lateral view of urohyal in some members of Channiformes, Scorpaeniformes, Perciformes.

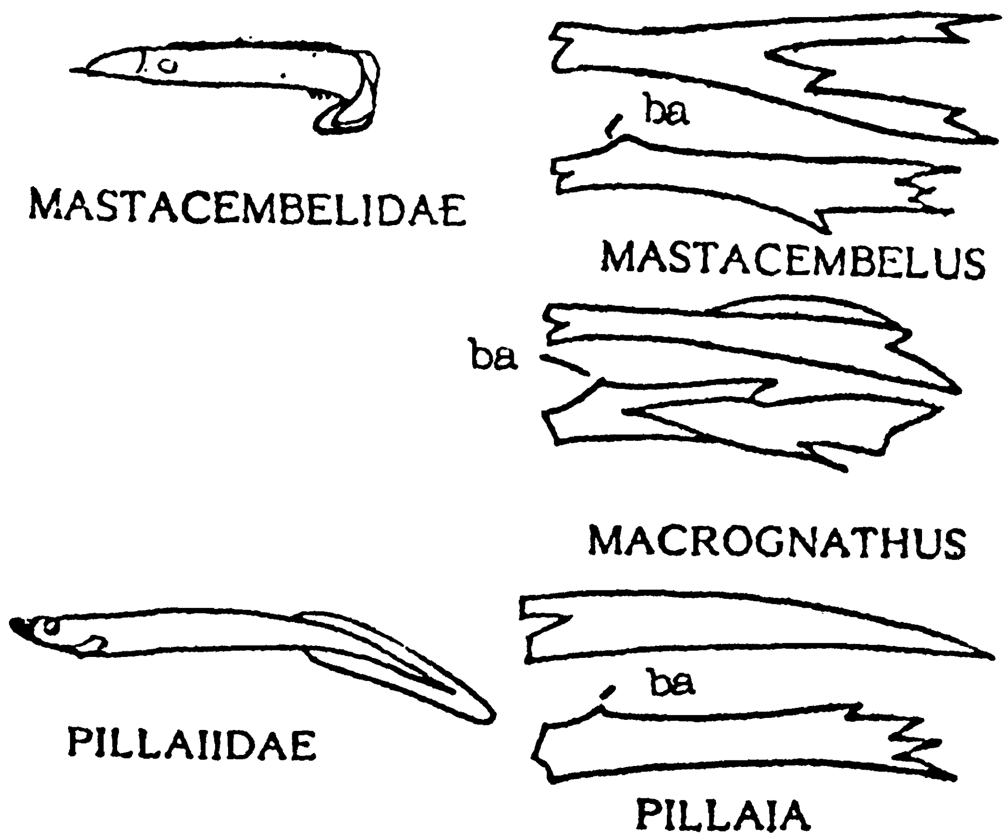

Fig. 7. Dorsal and lateral view of urohyal in some members of suborder Mastacembeloides (Perciformes).

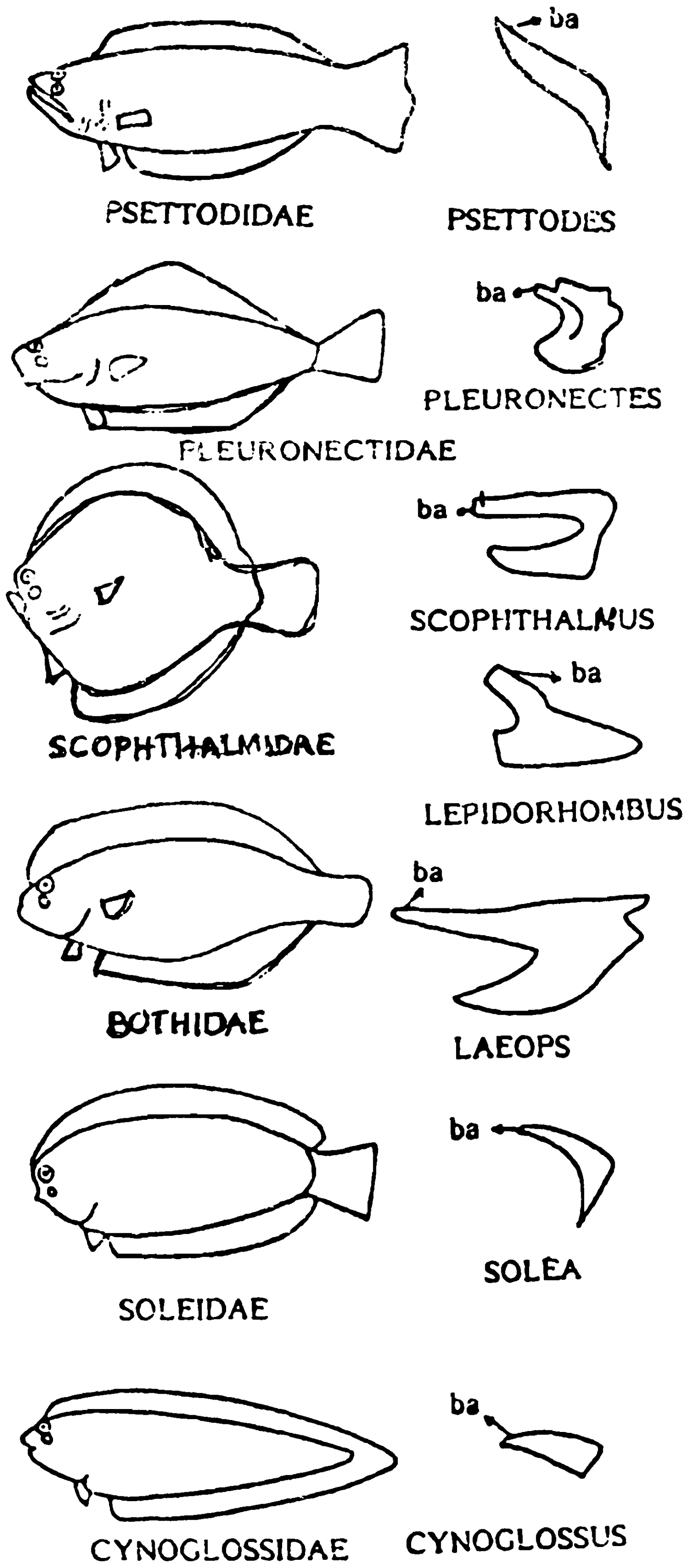

Fig. 8. Dorsal and lateral view of urohyal in some members of Pleuronectiformes.

We shall now discuss in detail the importance of urohyal in fish systematics.

In Clupeiformes which contains primitive teleosts the urohyal is rather large and bears lateral pleats. In *Clupea*, it is spatula shaped, whereas in *Engraulis* it looks like a table-knife. The large urohyal with lateral pleats may be correlated with their active mode of life which would entail active movements of jaws and associated structures.

In Osteoglossiformes, which contain freshwater fishes of ancestry at or near holostean level of organisation, the urohyal is narrow, its vertical plate is less developed than the ventral spread and bears no resemblance with that of Clupeiformes. This may be expected because clupeiform fish are not believed to be involved in the ancestry of Osteoglossiformes. The extraordinary development of ventral spread seems to be related to their specialisation for insectivorous or piscivorous feeding habits.

In Cypriniformes which do not show holostean affinity, the urohyals exhibit diverse forms and shape and in them the ventral spread is always developed. In charcins and cyprinids which are closely related groups there is striking resemblance in their urohyals. As they lead active mode of life, they possess fairly large urohyal. In cobitids which are believed to have evolved from cyprinoid ancestor, the urohyal is small, but the ventral spread is well-developed. This may also be correlated with their mode of life. The remarkable development of ventral spread in the urohyal of all Cypriniformes seems to be related to their feeding habits as Kusaka (1974) pointed out that ventral spread is well developed in omnivorous fish such as cyprinids and this feature perhaps helps in lateral swing of the throat.

Like Cypriniformes, the Siluriformes also contain fishes of extraordinary diverse forms and habits, belonging to teleostean level of ancestry. In them, the urohyal is relatively small, its ventral plate very reduced but the ventral spread fully developed. This may be correlated with the fact that these fishes are mainly carnivorous and their jaws have to move actively for capturing food.

The Anguilliformes (Super order Elopomorpha) contain true eels - a highly specialised group. In most eels, the urohyal is a small narrow, elongated bone possessing a swollen, somewhat flattened anterior end which bears attachments for basibranchial and hypohyals. In *Anguilla*, however, there is a remarkable modification in the urohyal shape. Kusaka (1974) pointded out that the urohyal in young *Anguilla* is shaft-like with anterior tip a little forked. But as soon as the young ones move to freshwater from the sea, the anterodorsal part of the urohoyal develops into a disc on the forked tip dorsally and the posterior part gets reduced. It is rather difficult to explain the reasons for these modifications but it would seem probable that it is related to some kind of specialisation.

In Atheriniformes, which contains small surface feeding fishes of truly teleostean ancestry, the urohyal is fairly large and bears striking resemblance with those of Acanthopterygii (Orders Scorpaeniformes and Perciformes). This is because

Atheriniform fishes are known to be of ancestry more or less at the same organisation levels as the fishes of superorder Paracanthopterygii and Acanthopterygii and their nearest relatives are presumed to be among the ancestors of Acanthopterygii (Fig.1). The difference betwwen urohyal of *Lebistes* and *Gambusia* is well marked to distinguish these genera from each other.

In Channiformes, which contain freshwater fishes belonging to extra perciform group, the urohyal is fairly large, the vertical plate which is not very deep, bears a constriction near the anterior end. Unlike Atheriniformes, the urohyal of Channiformes lacks the dorsal protusion near the anterior end. These difference also support the view that Channiformes is not directly related to either Atheriniformes or Perciformes.

In Scrpaeniformes, which contain truly teleostean fishes of doubtful ancestry among the Acanthopterygii, the urohyal is fairly large and bears close resemblance with those of Atheriniformes and some members of Perciformes, especially in respect of its frontal side where the basibranchial attachments protrudes dorsally and the hypohyal attachment is knob-like anteriorly. This would at least suggest that ancestors of fishes of all the three orders were perhaps related to each other.

In Perciformes, which contains fishes of extremely variable form and habits the urohyal is similar to that of Scorpaeniformes in most of its features. This clearly suggests that both the groups are related and perhaps had common ancestors, although Greenwood *et al.* (1966) believed that Scorpaeniformes are not directly related to Perciformes. The differences in urohyal between genera are also sufficiently marked, to be used in the taxonomy of this order. In Sciaenidae, where the taxonomy has until recently remained in controversial stage, the classification had to be based on the structure of swim bladder, rather than any osteological character. It would be desirable to try to classify sciaenid fishes on the basis of their urohyal shape.

In Mastacembelidae, the spiny eels, which presumably evolved from some perciform stock, the urohyal shape is quite characterstic of the group and offers a osteological basis for classifying these fishes. Like perciform fishes, the basibranchial attachment of urohyal lies on a dorsal protruberance a little posterior to the anterior bilobed head which provides attachment to hypohyals.

In *Pillaia* (Pillaiidae) which is related to Mastacembelidae, the urohyal bears resemblance with those of *Mastacembelus* and *Macrognathus* in respect of basibranchial and hypohyal attachments. However, the difference in urohyal between *Pillaia* and members of Mastacembelidae is also so sharp that it can be used to distinguish these two groups.

In Pleuronectiformes which contains flatfish - a group of asymmetrical fishes related to Perciformes, the urohyal of the most primitive flatfish, *Psettodes* (Psettodidae) is very much similar to that of *Perca* (Percidae) (Yazdani, 1977). In most other flatfishes, such as Pleuronectidae, Scophthalmidae, Bothidae and Soleidae, however, the urohyals are more or less curved like a 'V', yet differences between them are sufficient to distinguish them at generic or familial level. In *Cynoglossus* (Cynoglossidae), the urohyal is not curved. However, it is much different from that of other groups and may be used for distingushing genera and species.

The functional significance of V-shaped urohyal in most flatfish has already been explained in the earlier section of this paper.

CONCLUSION

The following conclusions may be drawn a result of the present study. The urohyal bone has a definite form and shape in each taxonomic group. It bears closer resemblance in closely related forms. This study further supports the conception of Greenwood *et al.* (1966) about the evolutionary relationship of the principal groups of teleostean fishes.

The study of the urohyal in fishes have also revealed that this bone is large in active fishes, elongated in slender headed fishes and quite deep in deep bodied fishes. The development of ventral spread of the urohyal largely depends on the behaviour of fishes. The spatula-shaped urohyal without development of ventral spread is found in active swimmers such as members of Clupeidae. The well developed ventral spread is found in omnivorous fishes such as members of Cyprinidae.

SUMMARY

The urohyal - a single bone anteriorly connected to the ventral hypohyal and basibranchial and posteriorly to the shoulder girdle by a large muscle, has of late attained special importance in fish systematics. The urohyal of some fish, representing members of different evolutionary levels, have been studied and illustrated to show its modifications in shape and size among different groups of bony fishes. The taxonomic value of such modifications has been assessed and their possible use in fish taxonomy of the group.

It is suggested that an attempt should also be made to classify some fish groups such as cobitids and sciaenids on the basis of urohyal shape and size.

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