THE SHOULDER GIRDLE AND CHARACTERISTIC OSTEOLOGY OF THE HEMIBRANCHIATE FISHES.

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My investigations of the group of Hemibranchiate fishes were undertaken primarily with a view of ascertaining the character of the interclavicles and making a comparative study of the shoulder girdle. So many important characters appeared, however, in other parts of the skeleton, and so many errors were found in current descriptions, that the scope of the paper has been somewhat broadened.

I have tried to describe in detail the posterior bones of the cranium in order to show the relationship of the post-temporal, which in many species is coossified with the cranium, and to identify the different skeletal elements, as the parietals are usually missing.

The family Gasterosteidæ in the following descriptions is represented by *Gasterosteus cataphractus* Pallas, from Japan. Specimens of *Eucalia*, *Apeltes* and *Pygosteus* were also examined. *Spinachia*, the only other genus, was not at hand.

The family Aulorhynchidæ is represented by *Aulorhynchus flavidus* Gill, from Puget Sound. *Aulichthys japonicus*, from Japan, was referred to. These are the only genera of the family.

The family Aulostomidæ is represented by *Aulostomus valentini* Lacépède, from the Hawaiian Islands. This is the only genus of the family.

The family Fistulariidæ is represented by *Fistularia petimba* Lacépède, from Japan. The only genus of its family.

The family Macrorhamphosidæ is represented by *Macrorhamphosus sagifue* Jordan and Starks (new species), from Japan. The only other genus of the family is *Centriscops*, which was not seen.

The family Centriscidæ is represented by *Æoliscus strigatus* (Günther), from Japan. *Centriscus*, the only other genus of the family (and closely related to *Æoliscus*), was also skeletonized and examined.

In each genus an abundance of material was at hand, and when characters could not be fully made out in one specimen others were used until a degree of certainty as to limits of bones and indistinct sutures was reached which would have been impossible with single specimens.

Among the mistakes that have been made in the osteology of the group from time to time (most of which have been many times repeated) are the following:

Dr. Cope,[1] besides speaking of the "presence of the interclavicles (which I find in all)," says "basis cranii simple; no tube."

The former statement is treated elsewhere in this paper. As to the latter, *Macrorhamphosus* has a double basis cranii with a well-developed tube or myodome. Both families of the Gasterosteoidea have the basis cranii rudimentary in bone but completed in cartilage. Both families of the Aulostomoidea have the basi-sphenoid bridging the anterior edges of the prootics above the rectus muscles of the eye, but with no tube in continuation. This character has not the value Dr. Cope placed upon it, as Dr. Gill has shown.

Dr. Gill, in his key to the families of these fishes,[2] includes Gasterosteidæ and Aulorhynchidæ under the character "pubic bones connected with scapular arch." In *Aulorhynchus* the pubic bones, though close behind, and slightly between the posterior part of the shoulder girdle, are not attached nor even in contact. In *Gasterosteus* a process from the shoulder girdle overlies the pubic bones slightly, but the integument and even the silvery pigment of the body is interposed between them. The pelvic girdle is easily movable, independent of the shoulder girdle. In *Eucalia* the pelvic does not nearly touch any part of the shoulder girdle.

Dr. Gill[3] says that the "palatine bones are directly articulated with the quadrate without the intervention of the pterygoids. In *Fistularia* it appears so, as the suture between the quadrate and the pterygoid which extends forward is difficult to make out. Prolonged maceration, however, always separates the quadrate from the pterygoid. In a small specimen bending the bones in this region often opens the suture.

In *Aulostoma* the suture is conspicuous in the same place that it is in *Fistularia*, but there is no anterior element (palatine) apparent. An examination of the cranium, however, will show that the palatines have become ankylosed to each other and to the cranium at each side of the ethmoid. The pterygoid lies at each side of them but slightly attached. They hook over the maxillaries slightly as is typical.

[1] Observations on the Systematic Relations of Fishes, Proc. Amer. Asso. Adv. Sci., 1871, p. 317.

[2] Proc. Acad. Nat. Sci. Phila., 1884, p. 156.

[3] Johnson's New Universal Cyclopedia, III, p. 801.

It is not apparent why Dr. Günther[1] should write, referring to the Fistularidæ, "ventral fins abdominal, separate from the pubic bones, which remain attached to the humeral arch." The "interclavicles" might easily be taken for pubic bones, but the ventral fins are attached directly to well-developed pubic bones.

Dr. Günther,[2] referring to *Æoliscus* (*strigatus*) as seen externally, makes the following statement: "The horizontal portion of the humerus,[3] which is visible externally, is of moderate length, rather broad at its middle, and obliquely truncated behind; the coracoid, which is situated immediately below, has its basal portion not styliform, but is broad like the humerus above." He has evidently taken the process of the clavicle for the hypercoracoid and the supraclavicle, including, possibly, the ankylosed plate above, for the clavicle.

Drs. Jordan and Evermann[4] give the number of "pectoral ossicles" (actinosts) in *Fistularia* as three. There are four, as usual, the upper one closely attached against the hypercoracoid.

The Hemibranchs certainly do not deserve coordinate rank with the *Acanthopteri*, but should be included as a suborder under them, coordinate with the *Percesoces*. Probably the Synentognath fishes should also be so included.

A representative of each of the four Synentognath families has been examined as follows: In Belonidæ, *Tylosurus fodiator* and *Tylosurus marinus;* in Hemiramphidæ, *Hyporhamphus unifasciatus;* in Scombresocidæ, *Cololabis saira;* in Exocœtidæ, *Cypselurus californicus* and *Cypselurus agoo*. They show relationship to the Hemibranchs in possessing the following characters: Exoccipitals not united over the basioccipital;[5] parapophyses developed on all abdominal vertebræ; postclavicle absent (absent only in some families of Hemibranchs); supraclavicle very small[6] (in all but *Cololabis*, in which it is absent); post-temporal, when present, usually simple[7] (absent in *Cololabis*, forked in *Tylosurus*); parietals absent[8] (absent in all the Hemibranchs except

[1] Cat. Fish. Brit. Mus., III, p. 529.

[2] Idem., III, p. 528.

[3] Dr. Günther in his Catalogue of the Fishes of the British Museum, p. 532, calls the clavicle of Parker the humerus, and in his Introduction to the Study of Fishes he calls it the clavicula. In the catalogue he calls the hypercoracoid of Gill the coracoid, and in the Study of Fishes the scapula.

[4] Fishes of North and Middle America, Bull. U. S. Nat. Mus., No. 47, p. 756.

[5] I put but little weight on this character, but give it for what it may be worth. It is not an uncommon condition, especially among the lower fishes, while the opposite seems to be the rule among the higher.

[6] Cope says: "Epiclavicle (=supraclavicle) not distinct." Systematic Relations of Fishes, Proc. Amer. Asso. Adv. Sci., 1871.

[7] Said by Cope to be "slender, furcate."

[8] Said by Cope to be "very much reduced." *Cypselurus* and *Hyporhamphus* appeared to have small parietals, but maceration of the specimens proved the contrary.

the Gasterosteoidea). The Synentognaths are at once separated from the Hemibranchs by the united inferior pharyngeals and the absence of fin spines, as well as by numerous minor characters.

The Hemibranchs show relationship with the Percesoces[1] in having the parapophyses developed on all the abdominal vertebræ; in having the supraclavicle, when present, small; in not having the exoccipitals united above the basioccipital; and in having the supraclavicle, when present, reduced in size. *Fistularia* and *Aulostomus* have processes running backward from the epiotics, which are strikingly similar to the epiotic processes possessed by all the Percesoces. Though they serve the same purpose (that of muscle attachments) in both, they are somewhat different in character, being in the Percesoces processes from and of the epiotics, while in the Aulostomoidea they are joined by ligaments to the epiotics. The Hemibranchs easily stand apart from the Percesoces in having no opisthotics and usually no parietals; in having the post-temporals simple, not typically forked; and in having the postclavicle composed of a single piece when present (composed of two pieces in the Percesoces).

Dr. Gill in his excellent paper,[2] though evidently having few internal characters at his command, has left little to be added in the arrangement of the Hemibranchiate families.

Gasterosteus and closely related genera are the most generalized of the Hemibranchs. They are the only ones in the group having the following typical characters: Anterior vertebræ unmodified; suspensorium and mouth normal; ribs typical; post-temporal approaching the normally forked condition, and parietals present (the last a superfamily character.)

Dr. Gill[3] has pointed out how the tube-mouthed forms have descended in an unbroken line from *Gasterosteus* through *Spinachia* and the family Aulorhynchidæ, these constituting the superfamily Gasterostoidea.

The Gasterostidæ and Aulorhynchidæ should perhaps be regarded as a single family, but following the lead of the above authority, they are here kept separate, though the latter family is regarded "simply as a convenient one at the most."

Between the other families occur wider gaps, that are more or less difficult to span.

The Fistularidæ and Aulostomidæ are well placed in the same superfamily. They show in a marked degree how two families of undoubtedly close relationship having many characters in common can still

[1] In each of these characters *Sphyræna* is excepted. It seems to be a very much more generalized form than the other members of the Percesoces.

[2] On the Mutual Relations of the Hemibranchiate Fishes, Proc. Acad. Nat. Sci. Phila., 1884, p. 154.

[3] Proc. Acad. Nat. Sci. Phila., 1862, p. 233.

diverge very widely and have many characters radically different, as may be seen by referring to the diagnosis here included.[1]

It is more difficult to see just where the family Macrorhamphosidæ comes in, whether it is higher than the Aulostomid fishes or has not departed so far from its parent stem. It is an offshot in another direction. It certainly is not so highly specialized as the Aulostomid families with their anterior vertebræ and parapophyses ankylosed; their weak or absent spinous dorsal and their peculiarly modified basioccipital condyle. It seems well placed above them, having a well-developed spinous dorsal and the anterior vertebræ, but slightly enlarged and normally articulated.

The family Centriscidæ shows evidence of having come from somewhere along the Macrorhamphosidæ stem, but so far back and along such different lines that the evidence is not satisfactory. It is much more highly specialized.

DIAGNOSIS OF THE HEMIBRANCHII.

Opisthotics absent; parietals usually absent; exoccipitals never meeting over surface of basioccipitals; myodome usually absent or rudimentary, sometimes present; post-temporal never typically forked, sometimes a ganoid plate with an inner process, sometimes united by suture to cranium; a portion of the hypocoracoid sometimes ganoid, and appearing externally as a separate element ("interclavicle"); supraclavicle usually absent, small when present; postclavicle sometimes absent, composed of a single element when present; superior pharyngeals and usually elements of branchial arches reduced in number; inferior pharyngeals present, not united; four anterior vertebræ more or less elongated, sometimes united; bony dorsal bucklers coinciding with vertebræ developed anteriorily (hidden by scales in *Macrorhamphosus*); transverse processes developed on all abdominal vertebræ, usually largest anteriorly (in the Aulostomoidea united, and forming lateral shelves); snout more or less produced and tube-like, with a small mouth at its end; ventrals abdominal, sometimes anteriorly placed; hypocoracoid foramen sometimes formed partly by clavicle, always bordered by clavicle as seen from outer side, though hypercoracoid may or may not entirely inclose its foramen as seen from within.

GASTEROSTEOIDEA.

Parietals present; pterotic normally placed above prootic exoccipital suture; condyle of basioccipital normal, concave; basis cranii or shelf covering myodome incomplete, not nearly reaching to anterior edge of prootics, but completed in cartilage; basisphenoid absent;

[1] It is this element of unstability in the coherence of characters that has made it so difficult to assign many forms to their proper groups. We do not know in what direction characters may be depended upon to show relationships.

ganoid plate ("interclavicle") of hypocoracoid more or less developed; postclavicle absent; actinosts small, without open spaces between; anterior vertebræ scarcely enlarged, not ankylosed; ventrals placed anteriorly; spinus dorsal represented by isolated spines; hypercoracoid foramen partly bordered by clavicle anteriorly; ribs developed.

a. Branchiostigals 3; ventrals with one soft ray each; snout conic, or but slightly tubiform; post-temporal and supraclavicle present; typical ribs present. *Gasterosteidæ*.

aa. Branchiostigals 4; ventrals with 4 soft rays each; snout tubiform; clavicle attached to cranium by one of the lateral line series of bones; ribs (or epipleurals) terminating in lateral plates ..... *Aulorhynchidæ*.

AULOSTOMOIDEA.

Parietals absent; pterotic interposed between and entirely separating prootic from exoccipital; condyle of basioccipital a round knob forming a ball-and-socket joint with atlas; basisphenoid bridging anterior edges of prootics above rectus muscles of eye making basis cranii appear double, but no myodome is in continuation; a long splint-like shield of bone is on each side of back attached in sockets of epiotics; hypocoracoid with a backward extending process ("interclavicle"); postclavicle present, simple; lower 3 actinosts subequal rod-like, with large open spaces between them; anterior 4 vertebræ elongate, ankylosed, and with coinciding bony dorsal bucklers above; ribs absent; ventrals placed at about middle of belly.

a. Skin smooth; body depressed; no dorsal spines developed; post-temporal suturally united to cranium; palatines normal, free from cranium; transverse processes normal ..... *Fistulariidæ*.

aa. Skin with well-developed ctenoid scales; body compressed; spinous dorsal developed; post-temporal not united to cranium; palatines united to each other and to cranium; each transverse process behind fourth vertebra is formed equally by a process from each adjoining vertebra (or each end of each vertebra carries a half of each transverse process ..... *Aulostomidæ*.

MACRORHAMPHOSOIDEA.

Parietals absent; pterotic normal in position; condyle of basioccipital concave; myodome present, well developed; basisphenoid small; no process or ganoid part (interclavicle) present on hypocoracoid; postclavicle present; actinosts without a space between them, the lowest elongated cutting into the hypocoracoid; post-temporal suturally united to cranium; supraclavicle coosified with clavicle; hypercoracoid entirely surrounding its foramen; anterior vertebræ somewhat enlarged, not united; transverse processes not united to form a lateral shelf; ribs absent; spinous dorsal well developed; ventrals placed at middle of abdomen.

Characters of the family included above ..... *Macrorhamphosidæ*.

CENTRISCOIDEA.

Dermal armature connate with the internal skeleton, and developed as a dorsal cuirass in connection with the neuropophyses; six or more anterior vertebræ, extremely elongate, united; tail with its axis deflected from that of the abdomen by encroachment of dorsal cuirass over dorsal fin; branchial system feebly developed; parietals absent; pterotics normally placed; condyle of basioccipital concave; myodome absent; posttemporal united to cranium; supraclavicle present; foramen of hypercoracoid partly formed by clavicle; postclavicle present; lower actinost elongated, cutting into hypercoracoid; no open spaces between actinosts; ribs developed; ventrals at middle of belly; spinous dorsal developed below posterior spine of dorsal cuirass.

Family characters included above..... *Centriscidæ*.

THE SHOULDER GIRDLE IN DETAIL.

THE "INTERCLAVICLES."

The so-called interclavicles are here considered apart from the other parts of the shoulder girdle for purposes of closer comparison.

They may have been of different origin from the hypocoracoids, but if so they have lost all trace of ever having been a separate ossification. We can no more consider them as separate elements than we can divide other bones which are of both cartilaginous and dermal origin, and call each part by a different name. It is not true, as has been supposed, that all of the members of the order Hemibranchii have a differentiated part to the hypocoracoid.

In *Gasterosteus* the part termed interclavicle by Parker,[1] as seen externally, is the ganoid plate which bounds the lower edge of the silvery area in front of pectoral. (A process from the clavicle bounds it above.) It shows no sign of ever having been an ossification separate from the hypocoracoid. It is attached to the clavicle above, arching away from it and attached again at its lower end, thus inclosing an open space between. This is the typical arrangement of the hypocoracoid. The interclavicle may have been a plate of dermal bone that has become fused with the cartilage bone of the hypocoracoid beneath, but there seems to be no more necessity for giving it a separate name than there is for giving a separate name to the ganoid process from the clavicle.

In *Aulorhynchus* the lower outer edge of the hypocoracoid turns over slightly and forms the ganoid line which shows externally along the lower part of the side in front of the pectoral. This can certainly not be considered an interclavicle, and yet it differs but in degree from the interclavicle of *Gasterosteus*.

In *Fistularia* the interclavicle is the plate seen externally along the side of the breast and belly. It is larger than in any other member

[1] Structure and Development of the Shoulder Girdle, Ray Society, London, 1867.

of the group. It runs forward to the lower end of the clavicle and attaches by simple suture, as the lower end of the hypocoracoid usually does. Posteriorly it runs far backward. It appears as a process from the hypocoracoid, there being no suture between them; ridges and internal plates of bone are continuous between them. We can but wonder why, if of dermal origin, it has not fused to the clavicle as well as to the hypocoracoid, the former a bone supposed to be like it, of dermal origin.

In *Aulostomus* there is a process extending backward from the hypocoracoid, which for most of its length is broken up into fine bristle-like filaments. It does not appear at all externally.

In *Macrorhamphosus* there are no interclavicles, unless the series of bony plates along the median line of the breast and belly be considered as such. They can certainly not be considered homologous with the parts so termed in *Gasterosteus* and *Fistularia*.

In the new genus *Eoliscus* Jordan and Starks, typified by *Amphisile strigata*, there is no part homologous with the interclavicles of the other forms, unless the posterior part of the hypocoracoid, which is partly divided from the anterior part by the encroachment of the lower actinost, be considered as such.

The Shoulder Girdle of Gasterosteus cataphractus.

GASTEROSTEIDÆ.

The elements of the cranium are typical in number and arrangement except the opisthotics are absent. The parietals are widely separated by the supraoccipital. On the superior surface the epiotic articulates to the supraoccipital, the parietal, and the pterotic. On the posterior subvertical surface it articulates to the pterotic, the exoccipital, and the supraoccipital. The pterotics form the outer lower angle of the cranium. The articular facets of the exoccipitals are on a level with the middle of the basioccipital. The concave "centrum" of the basioccipital is exceedingly deep.

The post-temporal is a wide, nearly flat, ganoid bone, joined firmly and broadly (but not by dentate or inflexible suture) to the epiotic and pterotic. From its lower inner edge it sends a lower fork along the under part of the pterotic to where that bone joins the exoccipital, or to the place where the opisthotic typically is.

The supraclavicle is represented by a very small scale-like bone which is interposed between the clavicle and post-temporal, but not suspending the clavicle lower than it would be were it attached directly to the post-temporal.

The upper end of the clavicle turns backward around the hypercoracoid foramen. It shows exteriorly as a triangular ganoid plate behind the post-temporal, bounding the upper part of the round, naked space in front of the pectoral. The lower part of the clavicle runs obliquely downward and forward.

The hypocoracoid is attached broadly to the clavicle above, arches away from it, and returns to its lower end, inclosing a triangular space. Its lower ganoid part, the "interclavicle," is rough on the outer surface, but not otherwise differentiated from the rest of the bone.

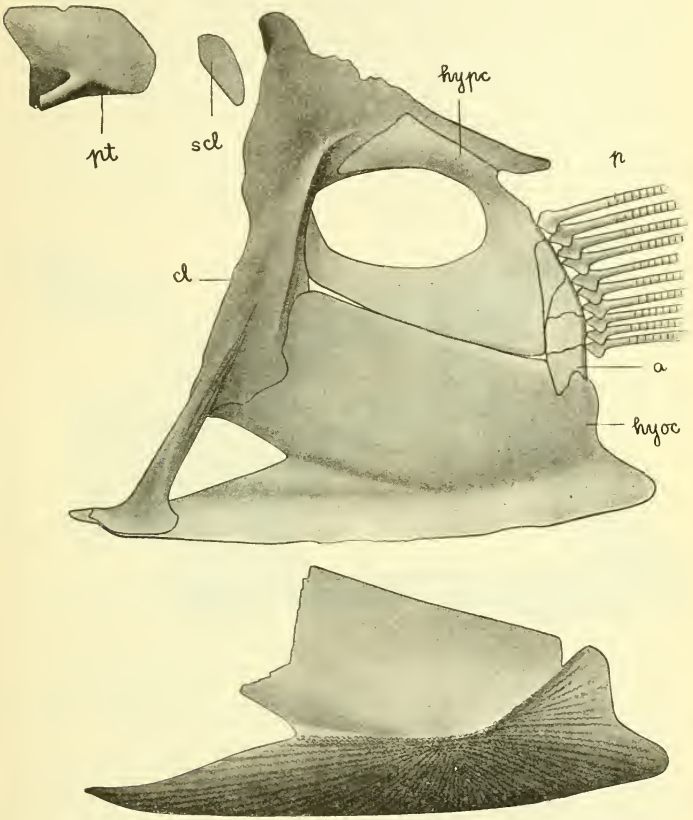

FIG. 1.—RIGHT SHOULDER GIRDLE OF GASTEROSTEUS CATAPHRACTUS FROM INNER SIDE AND HYPOCORACOID OF LEFT SHOULDER GIRDLE FROM OUTER SIDE. *a*, ACTINOSTS; *cl*, CLAVICLE; *hyoc*, HYPOCORACOID; *hypc*, HYPERCORACOID; *p*, PECTORAL FIN; *pt*, POSTTEMPORAL, AND *scl*, SUPERCLAVICLE.

The hypercoracoid is assisted for a short space anteriorly by the clavicle in inclosing the large hypercoracoid foramen.

The actinosts are very small, about as wide as long, and have no openings between them. The lowermost one is attached to the hypocoracoid, the remaining three to the hypercoracoid.

THE SHOULDER GIRDLE OF AULORHYNCHUS FLAVIDUS.

AULORHYNCHIDÆ.

The posterior elements of the cranium resemble *Gasterosteus* in being more typical in arrangement than in other examples of the order. The pterotics form the outer lower angle of the cranium, and the articulations of the epiotics are the same.

There is but a single plate joining the clavicle to the cranium. It is one of the series of lateral line plates, bearing a tube continuous with the lateral line sensory system, and it is in no way differentiated from the rest of them. It is attached to the cranium over the pterotic

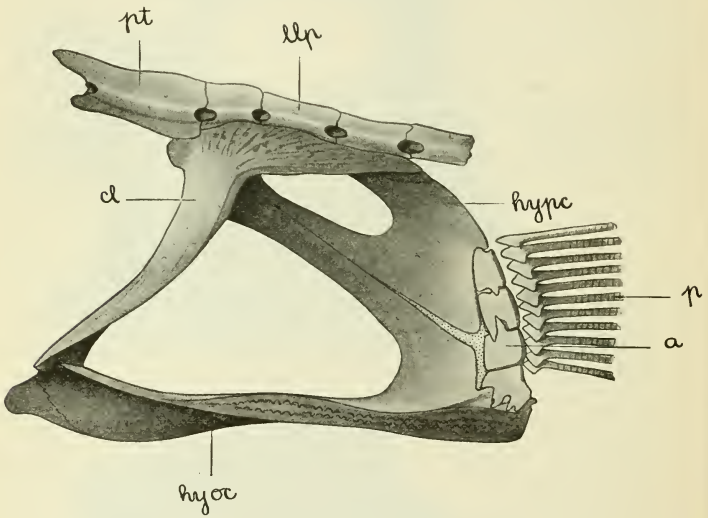

FIG. 2.—LEFT SHOULDER GIRDLE OF AULORHYNCHUS FLAVIDUS FROM OUTER SIDE. *a*, ACTINOSTS; *cl*, CLAVICLE; *hyoc*, HYPOCORACOID; *hypc*, HYPERCORACOID; *llp*, LATERAL LINE PLATES; *p*, POSTCLAVICLE, AND *pt*, POSTTEMPORAL.

and the epiotic. Over its anterior end is a small bone bearing a branched tube of the sensory system, which directs one branch along the pterotic and another over the occipital region. It is typical in shape and function of the supratemporal.

The upper part of the clavicle turns backward in a triangular process as in *Gasterosteus*. The lateral line system of bones is attached along its upper edge and is continued backward along the side of the body. The lower part of the clavicle is slender and is inclined obliquely downward and forward.

The hypercoracoid foramen is bounded for a very short space along its anterior side by the clavicle.

The hypocoracoid is a very slender, widely forked bone. Its upper fork is attached above the middle of the clavicle, inclosing a large triangular space between. Its outer lower edge turns over slightly and forms the slender ganoid line along the lower part of the side in front of the pectoral.

The actinosts are very small, semiquadrate, and without openings. One and a half of them are attached to the hypocoracoid, two and a half to the hypercoracoid.

The Shoulder Girdle of Aulostomus valentini.

AULOSTOMIDÆ.

The epiotocs are large, low, conical bones at each side of the supraoccipital. Each articulates to the frontal anteriorly, to the exoccipital

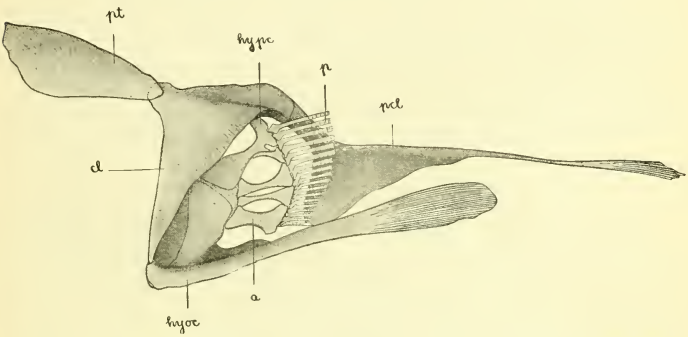

FIG. 3.—LEFT SHOULDER GIRDLE OF AULOSTOMUS VALENTINI FROM OUTER SIDE. *a*, ACTINOSTS; *cl* CLAVICLE; *hypo*, HYPOCORACOID; *hypc*, HYPERCORACOID; *p*, PECTORAL FIN; *pcl*, POSTCLAVICLE, AND *pt*, POSTTEMPORAL.

posteriorly, and to the pterotic at its outer edge. The pterotic forms the posterior lateral angle of the cranium. It is anterior to the exoccipitals, which form, with the basioccipital, a posterior projection. The exoccipitals project downward on each side far below the condyle of the basioccipital. They meet broadly above the foramen magnum.

The post-temporal is not united with the cranium. It is a large ganoid plate seen externally behind the head, above and anterior to the triangular ganoid portion of the clavicle. It lies rather loosely against the cranium, over, but scarcely in contact with, the pterotic and epiotic. From its inner surface it sends a fork which rests rather loosely behind the part of the exoccipital that projects below the basioccipital.

The supraclavicle is absent.

The clavicle is a rather heavy triangular bone, as viewed from the outside. The anterior edge which borders the branchial cavity is

straight. From its anterior inner part a plate of bone folds back to support the hypo and hypercoracoid.

The latter is a thin plate, not strongly ossified. Through it and entirely within its edges is a very large fenestre, which from the outer side seems to be partly inclosed by the clavicle, as the hypercoracoid is attached flat against the inner surface of that bone.

The hypocoracoid is attached along its entire anterior edge to the clavicle without leaving the usual opening between. The lower edge is thickened and extends backward as a long process, which, growing thin posteriorly, is divided for most of its length into many bristle-like filaments.

The three lower actinosts are long and rod-like, with large spaces between them. The second and third are somewhat closer together than the others. The fourth is smaller, and is articulated closely against the upper outer end of the hypercoracoid. Two of them are above the hypercoracoid and two above the hypocoracoid.

The postclavicle is a broad triangular-shaped bone, with a process running obliquely from the upper corner for articulation with the clavicle, and the posterior corner prolonged into a long ray of bone.

The Shoulder Girdle of Fistularia petimba.

FISTULARIIDÆ.

The post-temporal is united to the cranium by dentate suture, forming an outer produced angle on each side wholly posterior to the pterotic. It is articulated laterally to the epiotic and the exoccipital, posteriorly slightly to the frontal and broadly to the pterotic.

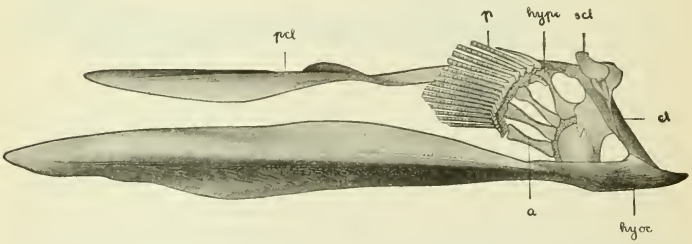

Fig. 4.—Right shoulder girdle of Fistularia petimba from outside. *a*, actinosts; *cl*, clavicle; *hyoc*, hypocoracoid, *hypc*, hypercoracoid, *p*, pectoral fin; *pcl*, postclavicle, and *scl*, superclavicle.

Though the post-temporals appear to play an important part in forming the cranium when viewed from above, they form no part of the cranial wall, being only thin sheets of bone attached at their lateral and anterior edges. Were they removed the remaining elements would bear about the same relationship to each other as they do in the cranium of *Aulostomus*.

The supraclavicle is a short, scale-like bone, setting low on the clavicle, simply serving as a septum between the clavicle and post-temporal, and not suspending the former lower than it might be were it articulated directly to the post-temporal.

The clavicle is a complex bone, bending backward at its upper end to support the long simple postclavicle, which appears exteriorly as the upper lateral plate behind the head. It (the clavicle) borders nearly half of the fenestre, which typically is through the center of the hypercoracoid. It sends a wide process from its middle directly below this fenestre backward and downward to the hypocoracoid. Its lower end is straight, running obliquely forward to where it joins the lower end of the hypocoracoid ("interclavicle"), leaving an open space behind and between the forks of the hypocoracoid.

The hypercoracoid is little more than a rod of bone forming somewhat more than half of the fenestre, between it and the clavicle. It strongly resembles in shape and position the long, slender actinosts. The first pectoral ray works directly on it, as usual, and from this fact and its appearance one not knowing the cartilaginous origin of the bone might conceive the possibility of the hypercoracoid having originated from an actinost. This fancy is perhaps disturbed by the fact that the upper actinost is attached to its upper outer edge.

The other three actinosts are attached to the hypocoracoid or end in cartilage over it.

THE SHOULDER GIRDLE OF MACRORHAMPHOSUS SAGIFUE, (NEW SPECIES.)

MACRORHAMPHOSIDÆ.

The cranium is wedge-shaped as viewed from above. Posteriorly it is abruptly vertically truncated. The epiotics reach to the posterior edge of the cranium, and, bending sharply over, show about half of their surface above and half posteriorly.

The post-temporal is small and conical and ankylosed to the cranium, forming the outer lower angle. On the lower surface of the cranium it articulates with the exoccipital at its inner edge, and with the pterotic anteriorly; on the posterior surface, with the exoccipital and the epiotic; on the superior surface with the pterotic anteriorly, and with the epiotic at its outer edge.

The supraclavicle is so closely attached against the outer upper part of the clavicle that it is difficult to make out. It scarcely rises above the head of the clavicle.

The line of bony plates along the upper part of the sides is continuous over the clavicle, with a ridge on the post-temporal and the pterotic. These are doubtless homologous with the lateral line plates of *Aulorhynchus*.

A broad, thin plate projects backward from the middle of the inner edge of the clavicle and supports the hypercoracoid and the upper

part of the hypocoracoid. It laps over the hypercoracoid and borders the anterior half of the hypercoracoid foramen, as seen from the outer side of the shoulder girdle; but as seen from the inner side, the hypercoracoid entirely incloses its foramen, protecting it anteriorly, however, by a very narrow margin.

The postclavicle is a long, simple ray of bone carried by a projecting plate from the upper end of the clavicle.

The hypoclavicle is a very wide, thin plate, with an anterior rod of bone reaching to the lower end of the clavicle and inclosing a large fenestre. From just in front of the lower actinost a straight ridge

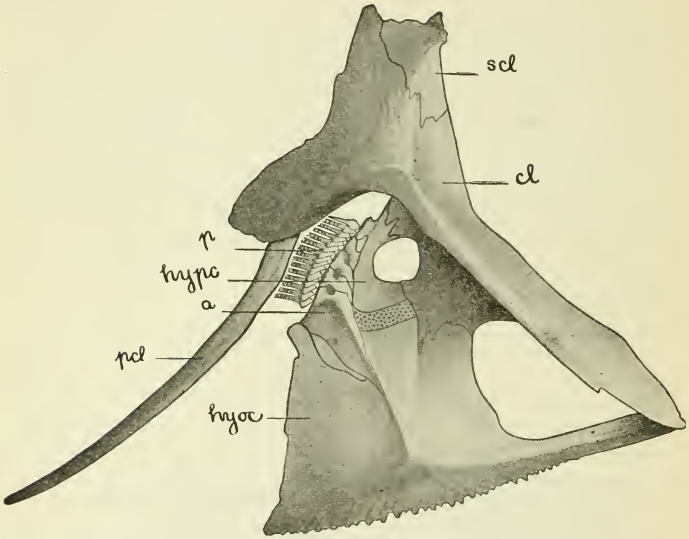

FIG. 5.—RIGHT SHOULDER GIRDLE OF MACRORHAMPHOSUS SAGIFUS FROM OUTER GIRDLE. FOR LETTERING SEE FIG. 1.

runs obliquely forward to near the lower edge of the hypocoracoid, where it turns at a sharp angle, and, following the edge of that bone, runs horizontally forward to its end at the clavicle.

The lower actinost is very much enlarged. It cuts a large space from, and continues down over the outer surface of, the hypocoracoid nearly to its middle. It ends in a sharp point. The others are somewhat pointed below, and grow smaller upward. There is a raised condyle on the hypercoracoid resembling the heads of the actinosts for the first rays of the pectoral to work on. All but the lowest actinost are attached to the hypercoracoid.

THE SHOULDER GIRDLE OF ÆOLISCUS STRIGATUS.

CENTRISCIDÆ.

The shape of the cranium resembles that of *Macrorhamphosus*, being wedge-shaped as viewed from above and vertically truncated posteriorly.

On its superior surface are five narrow wedge-shaped bones. The longest is the supraoccipital. About half of its length separates the posterior part of the frontals. On each side of it are the epiotics, of the same width but shorter. Anteriorly they cut a V-shaped piece out of the end of each frontal. The posttemporals are the most lateral and the shortest of these bones. They cut a V-shaped piece from the ends of the pterotics. On the superior-lateral surface of the cranium they are remote from the epiotics, but on the posterior surface they send a process up to them.

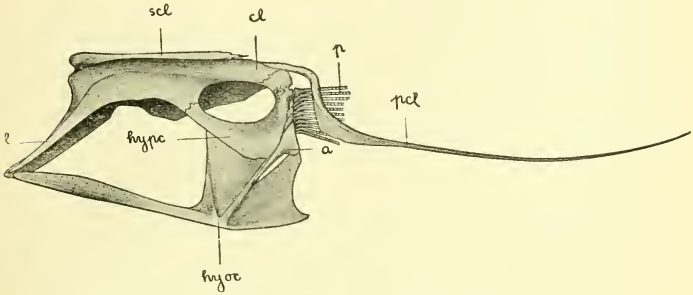

FIG. 6.—RIGHT SHOULDER GIRDLE OF ÆOLISCUS STRIGATUS FROM INNER SIDE. FOR LETTERING SEE FIG. 4.

The parietals and opisthotics are absent. The articular facets of the exoccipitals are at the extreme lower part of the cranium below the middle of the basioccipital condyle. The exoccipitals show no tendency to approach and join over the basioccipital.

The myodome appears to be wholly absent.

The supraclavicle shows externally as a long, narrow, ganoid bone, extending horizontally. It is enlarged anteriorly and is concave at its end for the reception of the end of the posttemporal. It laps over the edge of the clavicle somewhat and is firmly attached by a simple suture.

Directly above is a somewhat similar ganoid plate attached along the edge of the supraclavicle by a smooth inconspicuous suture. It extends farther back than the supraclavicle and appears to be one of the series of lateral plates. Both it and the supraclavicle attach by dentate suture to the wide lateral plate behind it. Above these are the median plates of the back.

The clavicle shows externally as a wide triangular plate reaching nearly to the pectoral, its anterior end descends bordering the gill opening as usual. From the inside the clavicle appears about three times longer than deep. From the inner upper edge a thin plate of bone turns down to the hypercoracoid.

The hypercoracoid does not nearly contain its foramen, but is assisted above by the inner plate of the clavicle.

A simple postclavicle is attached to the posterior end of the clavicle directly above the hypercoracoid. It is a very slender ray of bone bending sharply down to a level with the lower pectoral ray and thence reaching horizontally far back and ending as a fine filament.

The hypocoracoid is a nearly square thin plate, with a slender process running from its lower anterior corner at a right angle with its anterior edge to the lower end of the clavicle. From its upper posterior corner obliquely toward the lower anterior corner the lower actinost cuts in and subdivides it.

The upper ray of the pectoral works directly upon the hypercoracoid. Three of the actinosts are borne by the hypercoracoid and one by the hypocoracoid.

All of the inner elements of the shoulder girdle are extremely thin delicate plates, but slightly ossified, and generally strengthened by osseous ridges.