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The Osteology of *Dallia pectoralis*.

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With 2 figs. in the text.

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Introductory remarks.

Dallia was described in the year 1880 from specimens collected at Saint Michaels, Alaska, by Dr. T. H. BEAN,¹⁾ who placed it near

1) In: Proc. U. S. nation. Mus., 1879, p. 358.

the genus *Umbra*, the sole representative of the family *Umbridae*, a member of the order Haplomi. He expressed his doubt as to the pertinence of so associating it by placing a question mark after *Umbridae*. From external characters Dr. BEAN was justified in considering it under this family. It resembles *Umbra* in having the dorsal and anal fins short, rounded, and posteriorly placed; the caudal fin broad and rounded; the small ventrals close in front of the anal; the caudal peduncle deep and compressed; small teeth in bands on jaws, vomer and palatines; cycloid scales on head and body; and in having similar habits of living in the mud and among the weeds of sluggish streams and ponds.

In the year 1885 Dr. THEODORE GILL¹⁾ in studying the skeleton discovered certain peculiarities of the shoulder girdle, and created for it the order Xenomi, which he thus defined: "Teleosts with the scapular arch free from the cranium laterally, and only abutting on it behind, coracoids represented by a simple cartilaginous plate without developed actinosts, and with the internaxillary and supramaxillary bones coalescent."

In 1893 Dr. C. H. GILBERT²⁾ found the character of the maxillaries and the posttemporal to be untenable (as quoted in this paper under the descriptions of those elements) thus leaving the order resting on the sole character of the shoulder girdle.

My object in undertaking this investigation of *Dallia* was to further study its remarkable shoulder girdle, and attempt to work out its entire osteology. Primarily, however, I was influenced in this direction by Dr. C. H. GILBERT who placed in my hands some particularly well preserved specimens, which he had collected in the swampy tundra near the mouth of the Nushagak River, Alaska, in the summer of 1903. Much of my success in working out the delicate shoulder girdle cartilages I attribute to this excellent material.

Osteology.

C r a n i u m.

Most of the bones of the cranium are rather widely separated by cartilage, especially those of the posterior and lower surfaces.

1) In: JORDAN's Catalog. of Fishes of N. A. U. S. Fish Comm. 1885, p. 839.

2) In: Rep. U. S. Fish Comm. 1893, p. 403.

There is a cartilaginous area between the pterotic and the sphenotic on the lower surface of the cranium; another at the junction of the

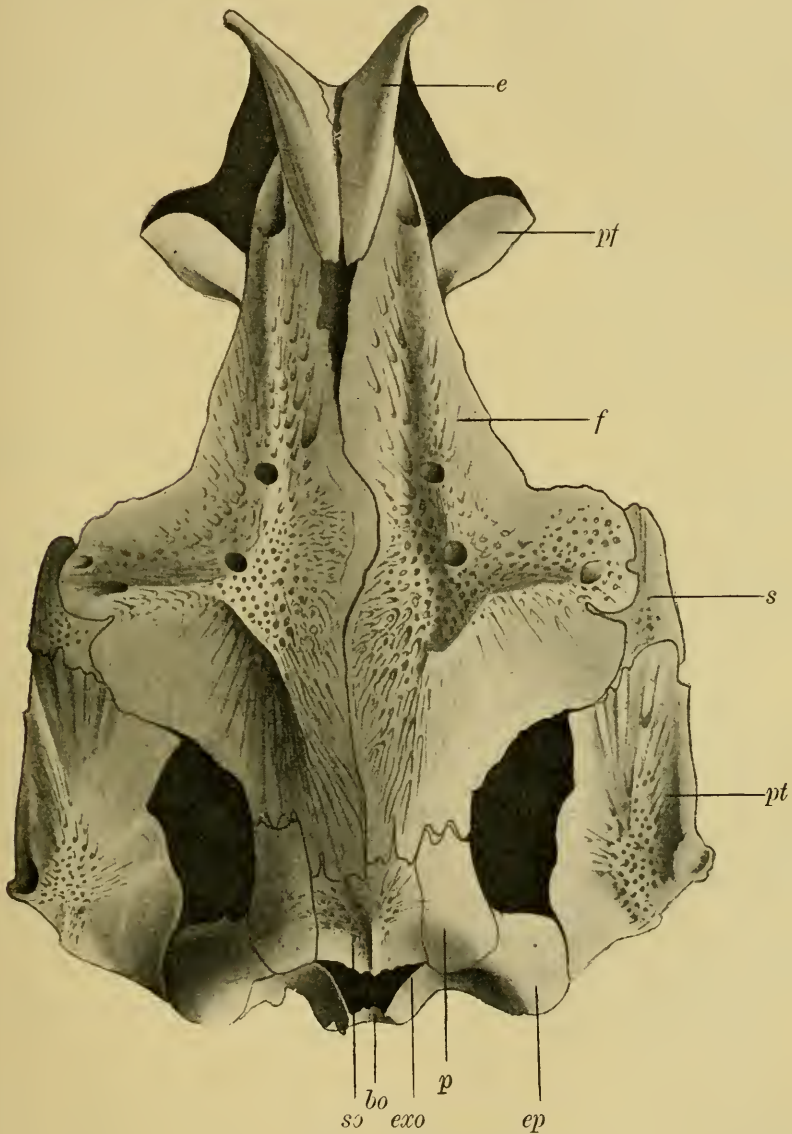


Fig. A. Cranium.

bo basioccipital. *e* ethmoid. *exo* exoccipital. *ep* epiotic. *f* frontal. *p* parietal.
pf prefrontal. *pt* pterotic. *s* sphenoid. *so* supraoccipital.
 The dark shaded portions represent cartilage.

pteric, the prootic, and the exoccipital, continued between the two latter bones entirely separating them, thence between the anterior end of the basisphenoid and the prootic. The prootics are entirely separated from each other by cartilage at the median line, where they are covered by the parasphenoid. A very large cartilaginous area is present on top of the cranium between the epiotic, the parietal, the frontal, and the pterotic. The supraoccipital is entirely separated from the exoccipitals. Some of these bones come in contact when the skull is dried and the cartilage shrunk.

The interorbital membrane is double and the two sides widely separated from each other. The base of the cranium is simple, or without a myodome.

The occipital condyle is simple, composed of the basioccipital only, and similar to the centrum of a vertebra. The pit in its face is much deeper than usual.

As viewed from below only a lateral wing on each side and the posterior end of the basioccipital appears from beneath the wide parasphenoid.

The exoccipitals do not meet either above or below the foramen magnum. They are pierced by the usual vagus foramen on their lower posterior surface. Posteriorly in place of the usual surface for articulation with the atlas is a small sharp spur.

The supraoccipital is very small and does not extend between the posterior ends of the frontals. There is only an indication of a crest on its oblique posterior surface.

The parietals lie parallel with each other and are well separated by the supraoccipital. Anteriorly they extend past the posterior ends of the frontals, while posteriorly they overlie the anterior upper surface of the epiotic.

The epiotics are shaped like a hollow cone with its opposite sides crushed nearly together. To the apex of each the ligament from the upper limb of the posttemporal is attached.

The pterotic does not send a lateral process backward, but has a moderate lateral angle opposite its middle.

The prootic is not pierced for the passage of the fifth and seventh nerves, but has a deep notch in its anterior edge. Just above the notch a long neural tunnel extends longitudinally backward for nearly the whole length of the bone, opening widely posteriorly. In the interior of the cranium a sharp

spur projects upward from the prootic, nearly reaching the cartilaginous area on top of head, between the pterotic and frontal, directly over it.

There is no alisphenoid unless a descending wing from the frontal can be interpreted as an anchylosed one. This seems improbable as in other forms the descending wing is nearly always present, the alisphenoid being articulated to it. On the other hand the prootic articulates to it as it does to the alisphenoid when present.

The sphenotic offers no peculiarities. The parasphenoid is very broad and thin, anteriorly growing broader and less ossified. It sends no lateral wings up to the prootics. Posteriorly it ends squarely a short distance anterior to the occipital condyle.

The vomer is very small, but little larger than the patch of teeth it bears. It overlies the parasphenoid, barely extending anterior to it and not nearly reaching to its lateral edges. It is easily detached, coming off with the investing membrane of the mouth.

The outline of the frontals together roughly form a diamond. From the projecting lateral angle of each a neural tunnel extends medially to about the middle of the bone, then turns sharply forward, opens at the anterior end of the bone, and is continued through the very small tubular nasals. On the frontals two pores open into it; one at its angle and one a short distance forward.

On the rostrum projecting a little over the premaxillaries, are a pair of bones suturally joined to each other posteriorly, and diverging anteriorly. They are homologous with the bones of the pickerel numbered 2 by HUXLEY in his *Anatomy of Vertebrate Animals*, which with his bone number 1 (homologous with the nasals of the Acanthopteri) are said by that author to be bones replacing nasals. ALLIS¹⁾ identifies them with the dermal ethmoid of *Salmo* and *Amia* which, however, are not homologous with the more deep seated ethmoid of the Acanthopteri. They overlie the large ethmoidal cartilage, which projecting laterally bears a small ossification, the prefrontal. The olfactory nerve pierces the ethmoidal cartilage at some distance from the prefrontal.

1) ALLIS, E. P. jr., On the morphology of certain of the bones of the cheek and snout of *Amia calva*, in: *Journ. Morphol.*, V. 14, No. 3, 1898, p. 434.

No basisphenoid, orbitosphenoids, opisthotics, or supraorbitals are present.

Lateral bones of head.

The head of the hyomandibular is undivided. It articulates to the extreme outer edge of the pterotic in front of the outer angle, anteriorly overlying the cartilaginous area between the pterotic, the prootic, and the sphenotic, without, as is usual, articulating with the two latter bones. A long strong process runs back from the hyomandibular to support the opercle, leaving a large open passage between it and the upper end of the preopercle. Anteriorly the hyomandibular sends a short stout process to the symplectic, and a long more slender one to the metapterygoid.

There is an area of cartilage between the symplectic and the hyomandibular process. The former bone is very large and extends some distance along the inner edge of the quadrate.

The metapterygoid is unusually thick for that bone, and is triangular in shape. Cartilage separates it rather widely from the broad thick quadrate.

Above the quadrate and the anterior end of the metapterygoid is the thin mesopterygoid extending a little anterior to the quadrate.

There is no pterygoid, but the end of the palatine is attached directly and rather narrowly to the quadrate and the mesopterygoid, the latter bone extending slightly over it. The palatine is normal in shape, bearing teeth along nearly its entire lower edge, and has a process at its anterior end which hooks slightly over the maxillary.

The elements of the mandible are normal in arrangement. There is no space between the upper edge of the articular and the dentary. The angular is present and well developed.

The opercular bones are all present. A very wide preopercle almost entirely covers the long slender interopercle, the anterior end of which is attached by a long ligament to the angular. The preopercle does not bear an open neural channel as usual, but a closed tunnel, open only at each end, curves nearly vertically downward from the tip of its upper end to its lower edge.

"The premaxilla while lying closely appressed to the maxilla, is readily separated from it, the two being in no sense 'coalescent'"

(GILBERT l. c.). It is a long slender curved bone, not widened at its lower end, extending some distance below the maxillary. Its upper end is attached a short distance below that of the premaxillary, or opposite to the place where the palatine process is attached. There is no backward extending process from the latter bone.

There are no suborbitals present. In front of the eye is a small curved tubular preorbital.

Hyoid and branchial arches.

The hyoid apparatus offers little that is different from the usual condition. The inter-, epi-, cerato-, hypo-, glosso-, and urohyals are all present. The epi- and ceratohyals each carry four branchiostegal rays. The latter bone is unpierced by a neural foramen. The hypohyals are paired; the lower element is much the larger. There are no keels or ridges on the small thin urohyal.

There are but two toothed superior pharyngeals on each side. The posterior one is the larger, ovate in outline, and attached to the epibranchial of the last arch. The anterior one is only about half covered by the tooth patch, which is triangular in shape. It is articulated with the third arch. The first and second epibranchials each carry a short broad pharyngeal without teeth, that of the first the smaller. The lower pharyngeals meet at the median line but are not ankylosed, or suturally attached. The hypobranchial of the fourth arch is absent as usual. There are four basibranchials present; one to each arch. The two posterior ones are armed with teeth similar to those on the lower pharyngeals.

Shoulder and pelvic girdles.

The upper limb of the posttemporal lies free two or three millimeters behind and parallel to the posterior upper edge of the epiotic, being attached to it, however, by a narrow band of connective tissue. Its tip meets that of its opposite fellow at the dorsal median line. The lower limb of the posttemporal has been rather fully reported upon by Dr. GILBERT. The posttemporal "seems at first sight to lack entirely the inner fork to join the pterotic process of the cranium. Closer examination shows, however, that a strong ligament replaces the lacking arm, and answers to it in all its relations. We find, furthermore, that while in some specimens it retains its

ligamentous condition the entire distance between the opisthotic and the simple posttemporal, in others the proximal portion of the ligament is more or less ossified, the bony rod thus formed being an integral part of the posttemporal and representing the proximal portion of the missing fork. As stated the ossification invades the ligament to a varying extent in different specimens. In at least two

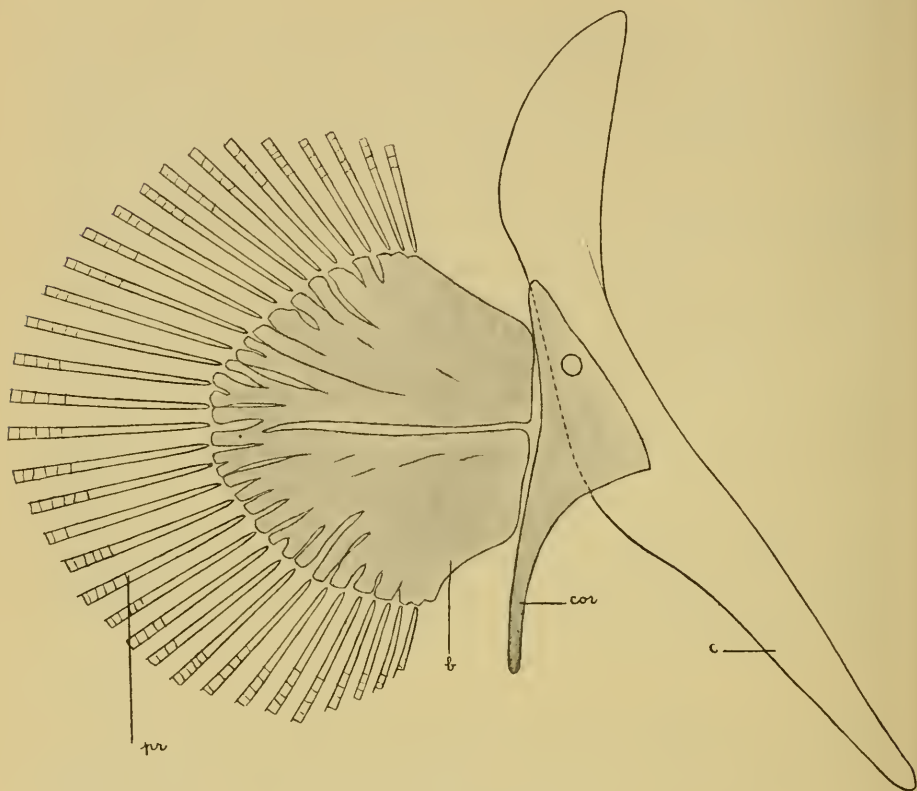


Fig. B. Shoulder girdle.

b basal plate representing actinosts. *c* clavicle. *cor* coracoid plate. *pr* pectoral rays.
The shaded portions represent cartilage.

which have come under our observation, the fork of the posttemporal thus formed has extended almost the entire distance across to the opisthotic, the shape and relation of the bone being then entirely normal and usual."

The ligament joins the cranium near the middle of the posterior surface of the exoccipital, the opisthotic being absent as stated elsewhere in this paper. In none of several specimens examined is the ligament ossified entirely to the cranium. Thus the posttemporal is entirely free. In the majority of fishes there is a short ligament from the lower fork connecting it with the cranium.

The shoulder girdle is laterally braced by the stout nearly straight first rib, which is interposed and securely attached between the lower end of the supraclavicle and the head of the clavicle.

The supraclavicle is long, slender, and expanded towards its lower end: It is rather narrowly attached to the posttemporal.

The clavicle is a long slender curved bone, not much expanded anywhere, and has a simple rounded thin head. It is somewhat folded over or hollowed on its posterior surface for the reception of the other elements of the shoulder girdle. No postclavicle is present.

The other elements consist of: 1) A triangular basal cartilage, one side of which is attached to the clavicle, and with the outer lower angle prolonged into a thickened styliiform rod. A round foramen is present near its upper end. 2) Attached to the outer edge of this basal element is a thin delicate plate of cartilage, nearly round in outline, and more or less completely divided into an upper and lower half. In about half of the numerous specimens examined the incision between the halves does not completely divide them (as shown in the accompanying figure B). In the others they are entirely divided. Toward the distal edge the plate begins to divide rather irregularly into narrow strips which nearly but not quite coincide in number with the pectoral rays. The incisions between the strips are of varying lengths, and near the middle of the plate are a few short slits which do not communicate with the marginal incisions.

The pelvic elements are very small rather simple rods, which converge inward from the base of the fins to meet on the median line.

Vertebrae, ribs, and vertical fins.

The vertebrae number: abdominal 21, caudal 18, which with the hypural element is a total of 40.

All of the abdominal vertebrae have developed parapophyses

and bear ribs. The parapophyses are attached to the centra by suture except the posterior three or four, which are anchylosed as usual. Posteriorly they grow longer and are turned downward. No boney bridge connects the opposite ones at the base.

The ribs are articulated rather broadly to the parapophyses. No epipleurals are present.

On the ventral surface of each abdominal vertebra is a large rather deep pit. Anteriorly these are on the median line, but a short distance posteriorly they are gradually deflected towards the left side until at the beginning of the anterior third of the abdominal cavity they are wholly to the left of the median line where a slight depression on the opposite side appears leaving a small median keel between. Posteriorly the pits gradually turn again to the median line until they are symmetrically in the middle again on the posterior abdominal vertebrae.

Three specimens of *Dallia* were examined for this character and no variation was found. I know of no other form in which this peculiar unsymmetrical arrangement of these pits occur.

The hypural is a simple conical boss attached apparently by suture only to the three or four flattened rays which form the plate to support the caudal fin. Extending obliquely backward and upward is the usual ridge or urostyle, representing the upturned end of the pre-existing notochord.

The flattened haemal and neural spines of five vertebrae anterior to the hypural assist in supporting the caudal fin and are attached to the vertebral centra by suture.¹⁾

With the exception of three or four rays extending back from the hypural these rays are not in contact with each other to form a broad hypural plate. Anterior to these caudal fin vertebrae all of the haemal and neural spines are anchylosed to the centra.

Large cartilaginous basal elements are present between the dorsal and anal rays and their respective interspinous bones. They fit into cup-shaped pits in the heads of the latter.

Anterior to the dorsal many of the neural spines carry a supplementary internural spine.

1) Often the spines of only the last four vertebrae are attached to the centra by suture, or sometimes one spine only, or one side of one or both spines of the fifth are so attached.

Splanchnology.

The air-bladder is very small; in a specimen 145 mm in length it is but 24 mm long and 3 or 4 mm wide at its widest part. It extends back just beyond the tip of the pectoral, its posterior fifth being above the stomach. It is widest at its posterior part tapering gradually forward, and attaching directly at its anterior end to the dorsal wall of the oesophagus. It appears as a diverticulum from the oesophagus, and opens into it through a comparatively large pore. Usually the pneumatic duct connecting the air-bladder with the oesophagus is a slender short tube springing from the lower surface of the latter a little distance from its anterior end.

The oesophagus bends slightly downward and enters the stomach at an oblique angle. It is very much constricted and crowded into the stomach so that the walls of the latter slightly enfold it.

The stomach is short and broadly cone-shaped, more than half as broad as long and has its widest part placed anteriorly. Towards its anterior end its walls become much thickened and are lined with longitudinal folds.

The intestine is somewhat constricted as it leaves the stomach, passing abruptly forward as the duodenum, slightly tapering to the anterior part of the abdominal cavity, turning abruptly backward and without convolutions, running to the anal opening. The rectum is not at all enlarged, but its origin is indicated by an internal fold, or ring-like valve.

The liver is moderate in size, having no median lobe and with short lateral lobes; the right lobe is more slender and thinner than the left, but is no longer.

The spleen is a nearly round body, situated below the pylorus.

The gall-bladder is large and thin walled, and is placed anteriorly above the right lobe of the liver and below the anterior bend of the intestine.

As compared with the salmon, the reproductive organs, the kidneys, and the other organs of the abdominal cavity not described offer nothing peculiar.

Summary.

Homology of the shoulder girdle.

Dr. GILL in his interpretation of the basal cartilages to the pectoral ("coracoids represented by a simple cartilaginous plate without developed actinosts") evidently overlooked the basal cartilage which is without doubt the homolog of the combined hypercoracoid and hypocoracoid. Its lower half exactly resembles in shape and position the normal condition of the hypocoracoid, except that its lower process is free instead of being attached to the lower end of the clavicle. A foramen in the upper half of the basal cartilage, giving passage to the ramus ventralis establishes the identity of the hypercoracoid.

That there is no suture in the cartilage dividing these two elements counts for nothing. Sutures are not found in the primordial cartilage, but the bones ossifying from centers either on or in it meet to form the sutures. *Amia calva* in which the coracoid elements are cartilaginous has no suture dividing the hypercoracoid from the hypocoracoid.

In this interpretation of the basal cartilage, the outer plate can only be the homolog of the actinosts, but what the median or marginal sutures may signify I find myself unable to suggest. I know of no similar adult or embryonic condition.

Relationship.

The following osteological characters show *Dallia* to be related to the order Haplomi.

1. The paired condition of the dermal ethmoid.

This character, so far as I can ascertain, is found elsewhere only in *Umbra* and *Lucius*. In other fishes it is a single median bone whether it be a dermal scale overlying the unossified cartilage, as in *Salmo*, or a cartilage bone as in the Acanthopteri.

2. Four separate superior pharyngeals on each side; those of the anterior two arches toothless, the others with teeth.

This condition also I find only in *Umbra* and *Lucius*. Four separate pharyngeals are often present in other forms, but where any of them bear teeth that of the second arch is never toothless.

When only two tooth bearing pharyngeals are present one of them represents the anchylosed pharyngeals of two arches.

3. The upper limb of the posttemporal attached to the epiotic by a ligament.

This character is common to *Umbra* and *Lucius*, but is also found among several soft rayed fishes of other orders. So far as they have been studied the members of the Iniomi, Heteromi, and Lyopomi are known to have it.¹⁾

4. The palatine pterygoid arch reduced to a single element.

This is a character of neither *Umbra* nor *Lucius*, but of members of the *Poecillidae*, another family of the order Haplomi.

5. The splanchnic anatomy is very similar to that of *Umbra*.

They differ in no essential particular.

Diagnosis of characters of *Dallia pectoralis*.

Cranium with much of the primordial cartilage remaining; alisphenoids, orbitosphenoids, basisphenoid, opisthotics, supraorbitals and suborbitals absent; a paired dermal ethmoid overlying the unossified ethmoidal cartilage; occipital condyle confined to the basioccipital; interorbital membrane double and widely separated; supraoccipital without a developed crest; prootic not pierced for passage of fifth and seventh nerves; pterygoid absent, the palatine attached directly to the quadrate and mesopterygoid; maxillary and premaxillary closely attached to each other but not anchylosed; the hyper- and hypocoracoids represented by a solid plate of cartilage, the actinosts by a thin divided fringed plate; shoulder girdle not joined to cranium, but laterally braced by first rib; no mesocoracoid; superior pharyngeals all present and separate, the posterior two only bearing teeth; lower pharyngeals separate; teeth on vomer, palatines and premaxillary; all of the abdominal vertebrae bearing ribs; no epipleurals present; parapophyses present on all abdominal vertebrae, only the posterior three or four anchylosed to vertebral centra; spines of last five

1) "The character of having the scapular arch free from the cranium and attached to the anterior vertebrae, shared by these fishes [the Heteromi] with the eels and several other groups may be, in the different cases, of independent origin, and is probably not indicative of any special affinity." GILL, in: Amer. Naturalist, Nov. 1889.

vertebrae assisting to support caudal fin, and not anchylosed to centra; air-bladder small and connected to the oesophagus by pneumatic duct; ventrals few rayed, abdominal placed near anal; dorsal and anal without spines, placed far back and opposite to each other caudal and pectoral rounded in outline, and without outer angles.

Definition of order.

The order Xenomi may be thus defined: Soft rayed fishes without a mesocoracoid nor modified anterior vertebrae; coracoids coalesced and cartilaginous; actinosts represented by a longitudinally divided and distally fringed cartilaginous plate.

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