

THE OSTEOLOGY OF SOME BERYCOID FISHES.

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The material upon which this paper is based represents five families of Berycoid fishes, as follows:

Trachichthyidæ, represented by *Hoplostethus japonicus* Hilgendorf.

Berycidæ, represented by *Beryx splendens* Lowe.

Holocentridæ, represented by *Holocentrus ascensionis* (Osbeck) and *Myripristis occidentalis* Gill.

Polymixidæ, represented by *Polymixia japonica* Günther.

Monocentridæ, represented by *Monocentris japonicus* (Houttuyn).

These families are held together by some very constant characters, the most important of which, aside from the increased number of ventral rays, is the presence of well-developed orbitosphenoids.^a

When such diverse families as these possess so important a character, seconded as it is by several minor ones, it seems justifiable to base a group upon it.

^aIt is remarkable to find this archaic character among the spiny-rayed fishes, though it is well in keeping with the pneumatic duct to the esophagus, which some of the Berycoid fishes are said to have.

The presence of orbitosphenoids is common among the lower forms from the Bony Ganoids up to and including the Salmonoids. So far as the author can ascertain, they hitherto have not been found in forms more specialized than the last. They have been searched for in vain in the following: *Aulopus*, *Syngnathus*, *Esox*, *Fundulus*, *Aphredoderus*, and nearly all of the families of Hemibranchs, Synentognaths, and Peresoces.

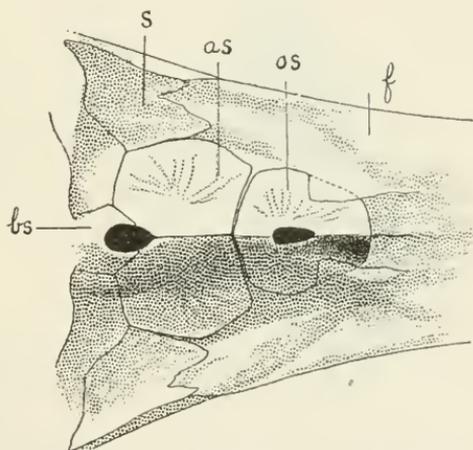


FIG. 1.—VIEW OF LOWER SIDE OF CRANIUM OF BERYX SPLENDENS, SHOWING THE ORBITOSPHEOID. THE PARASPHEOID HAS BEEN REMOVED. *as*, ALESPHENOID; *bs*, BASISPHENOID; *f*, FRONTAL; *os*, ORBITOSPHEOID; *s*, SPHENOTIC.

SYNOPSIS OF CHARACTERS OF THE BERYCOIDEA.

Orbitosphenoids present; meeting each other at their inner edges, and joined at an angle, either by simple suture or by ankylosis. Exoccipitals broadly joined to each other, and to the basioccipital, together forming a simple concave occipital condyle. The pit of the basioccipital above the middle of the bone, or near the middle of the entire condyle.^a Atlas more or less modified or convex to fit the occipital condyle; never deeply concave; the pit more or less obliterated, never deep and at the middle of the centrum. Interorbital septum always single. Myodome large in front, closed abruptly behind, or open to the exterior posteriorly only through a pore. Basisphenoid with a descending process. Head usually with conspicuous mucous cavities. A suborbital shelf present on the suborbital ring. Maxillary with a large

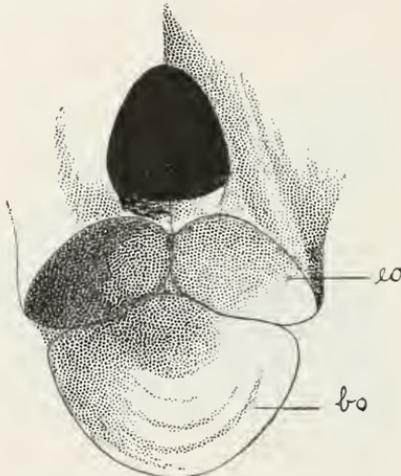


FIG. 2.—OCCIPITAL CONDYLE OF HOPILOSTETHUS JAPONICUS. *bo*, BASIOCCIPITAL; *co*, EXOCCIPITAL.

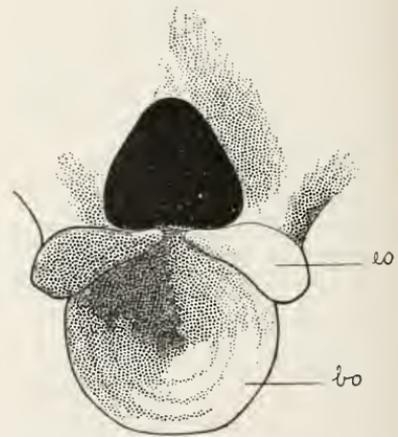


FIG. 3.—OCCIPITAL CONDYLE OF A TYPICAL PERCOID FISH. *bo*, BASIOCCIPITAL; *co*, EXOCCIPITAL.

supplemental bone. Nasals usually very large. Actinosts placed high; at least three of them on the hypercoracoid. Inner edge of pelvic bones, when thoracic, elevated and united; the opposite sides arching away from each other and meeting or nearly meeting below, inclosing a chamber between them; the bones usually deep, sharp, and compressed at the anterior end. Superior pharyngeals, 2 or 3. Ventral soft rays usually more than 5 (reduced in number in *Monocentris*). A pneumatic duct connecting the air bladder with the esophagus said to be present in some of the families. Vertebrae 24 to 30. Anal long or moderately long.

^aTypically in the spiny-rayed fishes, the basioccipital forms a concave condyle, with a deep pit directly at its middle. The exoccipitals are separate, or narrowly connected, and present flat oblique zygapophyses for the atlas, which has a deep pit directly at the middle of the centrum.

REJECTED FAMILIES.

Several forms have been examined which have been placed with the Berycoids at different times, but which are not related, or at least not closely enough to be retained in the group.

The family Mullidae has been associated with the Polymixidae because both families have barbels at the anterior end of the hyoids, though they differ in most other respects.

Though apparently similar the barbels are not exactly of the same character. In the Polymixidae each barbel is suspended from the lower edge of the hypophyal, where three modified branchiostegal rays curve around its thickened base (as described elsewhere in this paper). In the Mullidae the barbel is suspended from the extreme tip of a slender, nearly straight ray of bone attached to the end of the ceratohyal, which is exerted beyond the hypophyals.

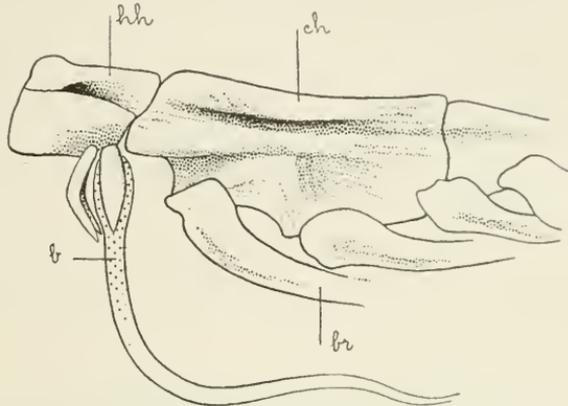


FIG. 4.—HYOID OF POLYMIxia JAPONICA. b, BARBEL; br, BRANCHIOSTEGAL RAY; ch, CERATOHYAL; hh, HYPOHYAL.

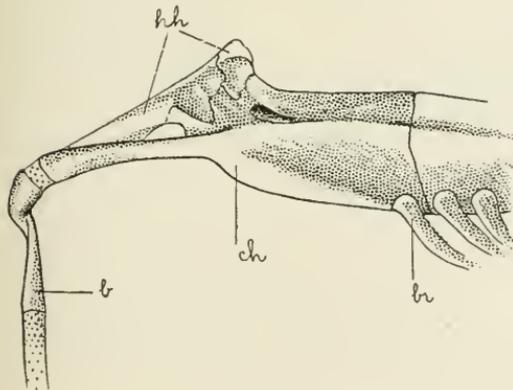


FIG. 5.—HYOID OF MULLOIDES AURIFLAMMA. b, BARBEL; br, BRANCHIOSTEGAL RAY; ch, CERATOHYAL; hh, HYPOHYALS.

the end of the ceratohyal, which is exerted beyond the hypophyals. This bone forms an integral part of the barbel, appearing as its ossified base.

The family Aphredoderidae has little in common with the Berycoid fishes, except the increased number of ventral rays. The orbitosphenoids are absent. There are two interorbital septa, which are widely separated. The exoccipitals are rather broadly connected, but the atlas is unmodified. The myodome, basisphenoid, suborbital shelf, and supplemental bone to the maxillary are all absent. The pelvic bones are forked,^a and only

are rather broadly connected, but the atlas is unmodified. The myodome, basisphenoid, suborbital shelf, and supplemental bone to the maxillary are all absent. The pelvic bones are forked,^a and only

^a It appears probable that parts of some skeleton other than that of *Aphredoderus* have become mixed with Doctor Boulenger's specimen. He states that the pelvic bones are not forked, as described by Cope and Woodward, and that there is a suborbital shelf. In my specimens the pelvic bones are distinctly and widely forked, and, though I have carefully examined three specimens, I have found no process on the inner edge of the suborbital ring.

loosely joined to each other by a ligament between the tips of the inner forks. The anal is very short. The vent is in front of the base of the ventrals.

The family Pempheridae can not be admitted to the group. It shows some relationship to the Bramidae, and possibly belongs near that family. The orbitosphenoids are absent. The exoccipitals are broadly united, but the basioccipital and atlas are unmodified, and the pit of each is deep and located at the center. The maxillary has no supplemental bone. The ventral soft rays number 5. The pelvic girdle is not compressed anteriorly but reaches to a sharp point, and is otherwise as in the Percoid fishes.

DESCRIPTIONS OF SKELETONS.

HOPLOSTETHUS JAPONICUS Hilgendorf.

CRANIUM.

The cranium has very high ridges, the walls of which are pierced by large holes, allowing communication between the cavities. The frontals above the middle of the orbital cavity, the bridge connecting the frontal ridges, and a region at the middle of the nasals are thin and honeycombed by small holes of irregular size, giving the bone a lace-like texture. A high ridge beginning at the anterior median line between the frontals diverges and runs back to the posterior end of each frontal above the parietal. A ridge curves back on each frontal from the anterior outer angle to the posterior end below the parietal, and is connected at about its middle to the upper frontal ridge by a wide horizontal bridge. Posteriorly between these ridges, and from the end of the connecting bridge, is a ridge running to the end of the parietal. A median ridge on the nasals runs forward from the median frontal ridge and diverges in front. From the anterior end of this ridge a ridge runs outward and backward on each nasal and forks near its middle, the anterior fork running to the side of the nasal, the posterior one to the posterior outer angle. The auditory bulla is large and has a very large cartilaginous area bounded by the parasphenoid, the exoccipital, the basioccipital, the opisthotic, and the prootic. The myodome is large, but its mouth is somewhat constricted.

The basioccipital spreads very wide over the lower surface of the auditory bullae. Its posterior end forms about half of the occipital condyle. The pit is near its upper edge. The supraoccipital does not project between the posterior ends of the frontals. Its crest does not extend above the rest of the cranium. The epiotic is but slightly covered by the parietal. It has no shelf projecting backward. The pterotic has a pair of rather sharp outward-projecting processes. The opisthotic is thickened, and the lower limb of the posttemporal is articulated closely to it without the agency of a ligament. The frontals end squarely in front, and do not extend beyond the pre-

frontals. The basisphenoid sends a process down to the parasphenoid. The process is extremely slender above, but grows wide below. The alisphenoids do not meet at the median line. The orbitosphenoids are moderate in size, and no suture is visible between them. There is a median hole in front of which they are drawn out into a very sharp, thin keel. The parasphenoid sends up large basitemporal wings, and spreads widely over the lower surface of the auditory bullæ. It extends posteriorly over the anterior fourth of the basioccipital, ending in a very small, slender, sharp process. The prefrontals are large bones pierced at their center by the olfactory foramen. They are separated only by cartilage except at their upper ends anteriorly, where the small ethmoid is interposed. The ethmoid is almost obsolete. It is a small thin bone, overlying cartilage, and it does not extend half the distance between its upper edge and the vomer. The

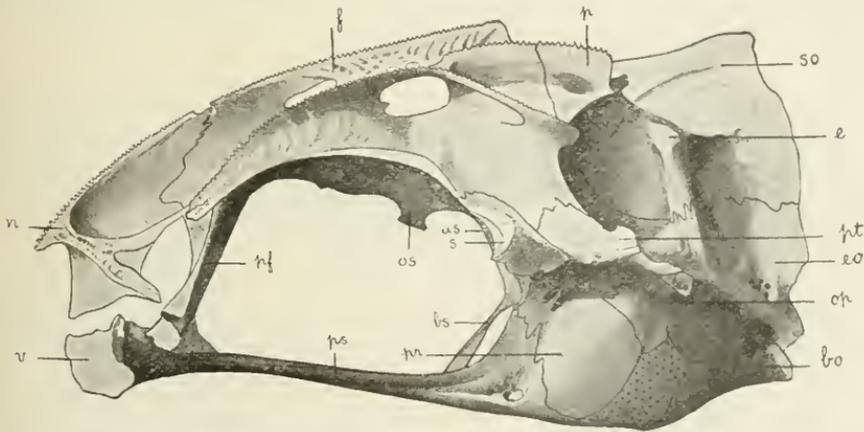


FIG. 6.—*Hoplostethus japonicus*. *as*, ALISPHEOID; *bo*, BASIOCCIPITAL; *bs*, BASISPHENOID; *c*, EPIOTIC; *eo*, EXOCCIPITAL; *et*, ETHMOID; *f*, FRONTAL; *n*, NASAL; *op*, ORBITOSPHTHIC; *os*, ORBITOSPHEOID; *p*, PARIETAL; *pf*, PREFRONTAL; *pr*, PROOTIC; *ps*, PARASPHEOID; *pt*, PTEROTIC; *s*, SPHEOID; *so*, SUPRAOCCIPITAL; *v*, VOMER.

nasals are very large bones, attached for nearly their whole length to each other, and by their entire posterior end to the wide frontals. They arch widely over the prefrontals, inclosing a chamber behind them.

FACE BONES.

The hyomandibular has an undivided head. From its inner upper edge a slender process descends toward a shorter one on the metapterygoid, but does not nearly reach it. The metapterygoid has no foramen. Its lower part is scarcely ossified. The symplectic is long and slender. Between its lower side and the angle of the preopercle there is a large open space. The preopercle is long, and the edges of its vertical limb are parallel. At its angle two bridges of lace-like bone span a large, deep channel; the lower one is much the larger and projects back as a stout spine. The subopercle is scarcely ossified. The angular is present. There is a large channel along the lower side

of the mandible, which is bridged once at the articular and twice at the tip of the dentary. There is no open space between the upper edge of the articular and the upper limb of the dentary. The premaxillary is long and slender, and has a moderate process. There is a very large supplemental bone on the upper edge of the maxillary, extending down over its outer surface nearly to its lower edge. The preorbital is not differentiated from the suborbitals. The suborbital ring is wide and cavernous. On the second suborbital is a slender triangular suborbital shelf, hooked backward. The other face bones are as in the Percoids.

HYOID.

The ceratohyal has a very large foramen through its middle. There are six branchiostegal rays on the ceratohyal and two on the epihyal. The hypohyals are wide and flat; the lower one is much the larger. The urohyal has a pair of small longitudinal basal wings. No glossohyal is present.

PHARYNGEALS.

The lower pharyngeals are slender and separate. There are two superior toothed pharyngeals on each side; that of the second arch is small and slender; that of the third and fourth is a large elongate patch, rounded behind and reaching to a point in front.

SHOULDER GIRDLE.

The hypocoracoid arches widely away from the clavicle, leaving a wide space between. Its lower limb is very slender. The hypercoracoid meets the hypocoracoid in a long straight suture. Its foramen is moderate and near its center. Three of the actinosts are on the hypercoracoid and one on the hypocoracoid. The first ray of the pectoral works directly on the hypercoracoid, as usual. The postclavicle is a single piece, formed as when in two pieces, the upper part widened into a thin plate, the lower a slender ray. A rather long superclavicle is present. The posttemporal is widely forked. Its upper fork is developed backward in a thin plate, which bears a large ridge ending in a stout spine behind.

PELVIC GIRDLE.

The opposite halves of the pelvic girdle are attached only for a short distance at their points and posteriorly at the ends of short projecting processes, leaving a space between them at their middle. Anteriorly the upper and lower edges of each arch inward inclosing a chamber between.

VERTEBRAL COLUMN AND APPENDAGES OF VERTICAL FINS.

Abdominal vertebræ 11 + caudal 14 + hypural = 26. The atlas is shallowly concave and the pit is near its upper edge. The sixth vertebra bears the first parapophyses. The opposing parapophyses are connected, and a haemal canal is formed. Posteriorly they are

lengthened, and are scarcely differentiated from the haemal spines. There are two auxiliary interneurals. The interneurals nearly agree in number with the neural spines. The first interhaemal is not enlarged or otherwise differentiated. Spines from the last two vertebrae assist the hypural in supporting the caudal fin.

BERYX SPLENDENS Lowe.

CRANIUM.

The cranium as viewed from above is widest at the pterotics; it thence narrows forward in long, regular curves to the nasals. It is much depressed in the parietal region. A long ridge runs from the anterior end of the frontal, meeting its fellow of the opposite side above the ethmoid; thence runs back across the frontals, sphenotic, and pterotic, at the posterior end of which it ends.

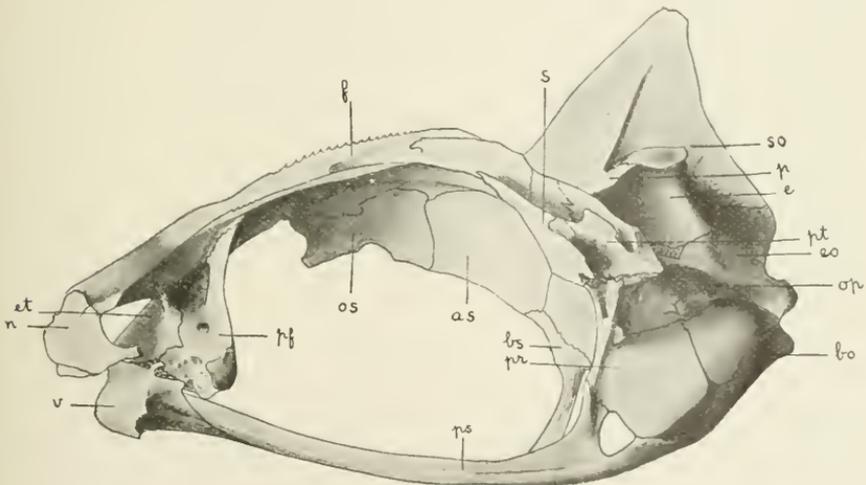


FIG. 7.—BERYX SPLENDENS.

For lettering see fig. 6.

As the cranium is viewed directly from the side the supraoccipital crest is seen to be high and triangular, rising far above the rest of the cranium. Its apex is directly above the epiotic. It appears to end anteriorly above the alisphenoids, as shown in the drawing. It, however, is continued anteriorly by the frontals to above the anterior fourth of the orbital cavity, being hidden in this view by the high frontal ridges. The occipital condyle projects far posterior to the pterotic region. The posterior ventral outline of the cranium is rounded steeply downward and forward to below the beginning of the orbital cavity, and continues in a more gentle curve over the parasphenoid. The auditory bulla is large and projecting. Its investing bones are thin and polished. At the junction between the pterotic, epiotic, exoccipital, and sphenotic there is an area of cartilage. On the auditory bulla there is a similar area between the prootic, basi-

occipital, exoccipital, and parasphenoid. The myodome is very large at its mouth, but abruptly grows narrow a short distance back. It does not open to the exterior posteriorly. The cranial cavity is entirely closed anteriorly except in two places, one small hole through the orbitosphenoid and one between the basisphenoid and alisphenoid.

The basisphenoid widens over the base of the auditory bulla. It forms but little over a third of the occipital condyle. The supraoccipital is but little covered by the parietals. It ends squarely at the frontals, without dividing them at their ends. A strengthening ridge runs upward on its crest from the base to the point. The parietals are elongate and project anteriorly beyond the supraoccipital. Posteriorly they cover the top of the epiotic to the articulation of the post-temporal. The epiotics have no backward projecting process. The surface over which the post-temporal lies is large and nearly horizontal. The opisthotic covers the suture between the exoccipital and the pterotic below. It has a slight nodule developed, to which the lower limb of the post-temporal is closely joined. The parasphenoid is long and narrow. It sends basitemporal wings upward at the mouth of the myodome, which join descending processes from the prootics, inclosing behind a large lateral opening into the myodome. The parasphenoid grows broad over the floor of the myodome, and then abruptly narrow, running backward in a depression in the basioccipital. It ends in a point some distance from the end of that bone. The basisphenoid sends a long, slender process down to the parasphenoid. Anteriorly the basisphenoid extends partly around a hole into the cranial cavity. The large alisphenoids meet broadly at the median line. Posteriorly they are notched by the hole between them and the basisphenoid. The orbitosphenoids are large. They meet at an angle and ankylose. There is a small hole at the median line opening into the cranial cavity. The frontals project widely over the ethmoid to opposite the front of the vomer. Anterior to the ethmoid they are divided, leaving a large notch. The prefrontals are in contact behind, but are separated in front by the ethmoid. The olfactory foramen pierces them transversely across the cranium. There is an area of cartilage between the ethmoid and the vomer. The nasals are large and are attached to the ends of the projecting frontals. They nearly touch each other in front and develop laterally around the end of the snout, inclosing a chamber behind.

FACE BONES.

The opercle has a prominent ridge and two slight ones radiating from a common center. Between each ridge its posterior edge is concave. Its upper end extends above the head of the hyomandibular. The subopercle is very thin and flexible, and only slightly calcified. The preopercle is deeply channeled and has two rough spines at the

angle of its prominent ridge. Its lower edge is sharply denticulate. The interorbital is rather broad, but is almost completely covered by the preopercle. Its lower edge is sharply denticulate. The hyomandibular has an undivided head. Its form is elongate and rather simple. There is no opening between it and the metapterygoid, or symplectic. The metapterygoid is a simple flat bone without any foramen or outer wing. There is a space between the upper edge of the articular and the upper limb of the dentary. The angular is present. A very large auxillary bone extends along more than half of the posterior upper edge of the maxillary, and reaches down over the face of it to the lower edge. The suborbital ring is long and narrow, and with a deep channel. The suborbital shelf is elongate and narrow.

SHOULDER GIRDLE.

The hypocoracoid arches away from the clavicle, leaving a wide open space between. The hypercoracoid foramen is small and just above the middle of the bone. The four actinosts are in contact for their whole length, leaving no open space between. They grow larger downward. They are all on the hypercoracoid except about half of the lower one. The upper ray of the pectoral works directly on a condyle on the hypercoracoid. The postclavicle is in two pieces, the upper piece wide and thin, the lower long and slender. The supraclavicle is present. The post-temporal is widely forked and normally attached to the cranium.

PELVIC GIRDLE.

Each side of the pelvic girdle extends upward anteriorly at its inner edge, so that it is deeper than wide, and compressed to a thin vertical edge. Its upper angle is produced into a slender process which extends between the two sides of the shoulder girdle a distance above the points of the clavicles. At its posterior end between the fins is a triangular sharp process.

HYOID ARCH.

Branchiostegals seven; five of which are borne by the ceratohyal and two by the epihyal. The ceratohyal has a large foramen through its center. The hypohyals are wide and flat, the inferior the larger. The glossohyal is very small. The urohyal is a large, triangular, thin bone, without ridges or wings.

PHARYNGEALS.

The inferior pharyngeals are large, separate, their inner edges in contact. There are three toothed superior pharyngeals on each side. That of the second arch is long and narrow, that of the third and fourth together forming an ovate patch, having the line of separation at the posterior third.

VERTEBRAL COLUMN AND APPENDICES OF THE UNPAIRED FINS.

Abdominal vertebræ 10+caudal 14+hypural=24. The atlas is irregularly convex to fit the modified occipital condyle. The sixth vertebra has the first pair of parapophyses developed. The posterior pairs are unconnected by a bridge at their bases. The first two vertebræ bear only single rays in line with the intermusculars, which are developed only on the first few ribs. The neural spines are directed rather irregularly. The interneurals are in greater number than the neural spines below them. Posteriorly the interneurals become directed backward so that they meet the neural spines at an angle, though the latter at this point are somewhat turned forward. The appearance of the interneurals indicate that while holding their connection with the neural spines the dorsal rays have become crowded together. There are four auxiliary interneurals in front of the ray-bearing ones. The first interhæmal is enlarged and expanded in front into a wide, flat plate of bone. The interhæmals exceed the hæmals in number, three or four to one.

HOLOCENTRUS ASCENSIONIS (Osbeck).

CRANIUM.

The top of the cranium is transversely uniformly convex. The occipital crest is developed backward, and not at all above the rest of the cranium. The auditory bulla is moderately large, elongate, tube-like, opening to the exterior at its posterior end in a rather large, round hole, which is stopped by a lateral anterior process from the air bladder. The hole is bounded on its inner and lower edges by the basioccipital, on its outer edge by the prootic, and above by the exoccipital. The myodome is large, but is not continued back in a tube. The anterior opening to the cranium is restricted to a very small slit in the middle of the anchylosed orbitosphenoids, and a slightly larger hole, inclosed at its sides and posterior end by the basisphenoid, at its anterior end by the united alisphenoids.

The supraoccipital shows very little of its upper surface, being covered by the frontals, but projecting slightly between their posterior ends. Its crest is confined entirely to its posterior vertical surface. The basioccipital and exoccipitals form the occipital condyle as usual, though the notch between them is deeper than in the other families. The pit in the basioccipital is near its upper edge. Just anterior to the condyle, and between the openings to the auditory bullæ, the basioccipital is compressed. The frontals are exceedingly large, projecting posteriorly almost to the posterior angle of the cranium, where the cranium drops off at a right angle, and becomes vertical. They cover almost the entire parietals, which in turn cover the upper surface of the epiotics, the supraoccipital, as described, and much of the

upper surface of the pterotics. Anteriorly they do not project beyond the ethmoid. Between their anterior ends there is a large pit for the reception of the premaxillary processes. On their upper surface, behind the eyes, they are armed with stout, smooth, radiating ridges, each ending in a spine posteriorly. The epiotic has a large articular facet, for the accomodation of the post-temporal, projecting laterally to a point. The opisthotic is entirely inferior, presenting a nodule to the lower limb of the post-temporal. The basisphenoid sends a very long, strong process down to the parasphenoid. The alisphenoids meet at the median line. The orbito-sphenoids meet at a right angle and are fused into a solid plate, which has a small slit through its middle. The parasphenoid sends out a long lateral wing on each side, below the orbital cavity. Behind the basitemporal wings, which it sends up to the prootics, is a small opening into the myodome. Posteriorly it ends in a point without reaching to the occipital condyle.

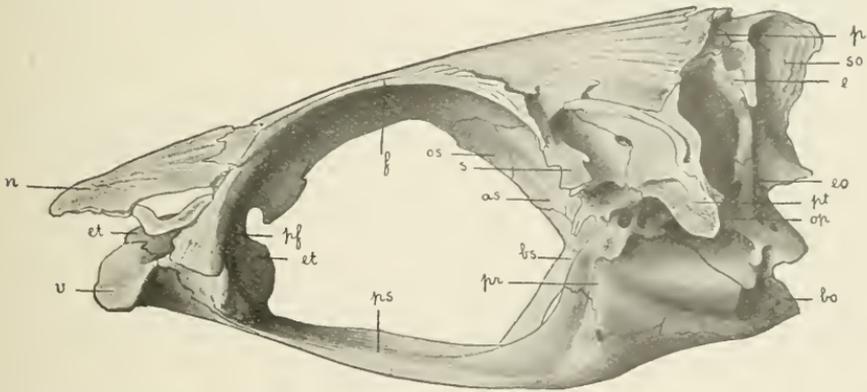


FIG. 8.—HOLOCENTRUS ASCENSIONIS.
For lettering see fig. 6.

The prefrontals are nowhere in contact, the ethmoid projecting both before and behind them. The olfactory foramen is between the ethmoid and the prefrontal, each bone forming about half of it. The nasals are about twice as long as wide, projecting far over the ethmoid, leaving an olfactory chamber beneath. At each side there is a small, curved, auxiliary nasal, which arches away from the base of the nasal on the prefrontal and joins it again at about the middle of its outer edge, inclosing a round space (probably the nostril). The same bone is present in *Myripristis*.

FACE BONES.

The opercular bones all have smooth ridges, each ending in a small, sharp spine. The preopercle is scarcely channeled. The hyomandibular has a divided head. There is a small opening between the metapterygoid and the hyomandibular. The former has a very slight outer wing developed. The symplectic is large and bent to conform

to the angle of the preopercle. The angular is present. There is a large space between the upper edge of the articular and the upper limb of the dentary. The maxillary has two supplemental bones; the anterior very small and round, the posterior very large, extending along more than the posterior half of the upper edge of the maxillary and over its outer surface to a longitudinal ridge near its lower edge. The premaxillary has very large backward extending processes. The suborbital chain is narrow and is not channeled on its outer side. The suborbital shelf is very large, extending nearly around the entire chain.

HYOID.

The cerato and epihyals have a deep channel along their outer surface near their upper edge. Neither of them is pierced. Six branchiostegal rays are on the former and two on the latter. The lower hypohyal is much larger than the upper one. The glossohyal is large and flat. The urohyal is large and triangular, and there is the beginning of a longitudinal lateral wing along its lower edge.

SHOULDER GIRDL.

The hypocoracoid arches away from the clavicle, leaving a wide space between. There is a very large foramen through the center of the hypercoracoid. Three and a half of the actinosts are on the hypercoracoid, and a half of the lower one is on the hypocoracoid. The postclavicle is in two pieces. The superclavicle is present. The posttemporal is widely forked. Its upper fork is widened into a large "surface plate," which is denticulate behind.

PELVIC GIRDL.

The pelvic girdle is triangular as viewed from the side, being deep and compressed anteriorly and depressed posteriorly. The inner edges arch up and meet at the median line, inclosing below them a large chamber. At the posterior end there is a wing developed posteriorly and laterally over the base of the fins. From the under side of the posterior end a pair of long slender processes project anteriorly.

PHARYNGEALS.

The lower pharyngeals are somewhat triangular. Half of their inner edges are in contact but are not connected. There are three superior pharyngeals on each side. That of the second arch is very slender, carrying scarcely more than a single row of fine teeth. That of the third arch is the largest, somewhat triangular, and better separated from the third pharyngeal than in the other families. The third pharyngeal is ovate in shape and of about half the size of the second.

VERTEBRAL COLUMN AND APPENDAGES OF VERTICAL FINS.

Abdominal vertebrae 11 + caudal 15 + hypural = 27. The atlas is irregularly convex to conform to the occipital condyle. The upper half is separated from the lower by a transverse ridge, under the middle of which is a slight depression. The sixth vertebra bears the first pair of parapophyses. The posterior parapophyses are connected with their fellows of the opposite side by a bridge of bone, forming a haemal canal beneath. The first two vertebrae bear only intermuscular rays. Each anterior rib is longitudinally widened above into a thin plate. The posterior ones are widened transversely, the last pair being extremely wide and forming wing-like processes at each side of the first interhaemal spine. The intermusculars extend posterior to the abdominal cavity. The interspinous rays of the spinous dorsal coincide in number with the vertebral spines. Those of the soft dorsal and anal exceed them about two to one. The first interhaemal is exceedingly long and stout. It is formed by the fusing of three spines. There are two auxiliary interneurals anterior to the spine-bearing ones. The spines of the last two vertebrae assist the hypural in supporting the caudal fin. The two vertebrae immediately in front of these have the spines above and below flattened into plates.

MYRIPRISTIS OCCIDENTALIS Gill.

CRANIUM.

The cranium differs from that of *Holocentrus* in having the mucous channels better developed and the bones not so thick and solid. The posterior part of the cranium does not turn vertically downward at a right angle with the top. The frontals are not so large and do not project over the parietals so much. The epiotic is not covered by the parietal. The depression for the reception of the premaxillary process is small and scarcely extends between the frontals. The condition of the anterior opening to the brain case is as in *Holocentrus*. The alisphenoids are joined at the median line, and the orbitosphenoids are fused into a single V-shaped plate. The ethmoid does not project backward between the prefrontals, which are in contact behind. The olfactory foramen is through the prefrontal, rather than between it and the ethmoid. The auditory bulla does not extend back tube like and open in a round hole, but the entire side of the bulla is open. The open space is surrounded by the same bones that it is in *Holocentrus*. The air bladder sends lateral processes forward in the same way, covering the opening. The rest of the skeleton is essentially as in *Holocentrus*.

POLYMIXIA JAPONICA Günther.

CRANIUM.

The top of the head is slightly depressed in the region above the alisphenoids. The frontals have each a thin bony tunnel, which opens anteriorly at the nasals, and laterally a short distance behind the prefrontal. A thin high ridge runs from the posterior end of the pterotic, along the frontal, becoming low anteriorly, and disappearing a little in front of the orbital cavity or opposite the anterior end of the supraoccipital crest. The supraoccipital crest rises well above the rest of the cranium. The myodome is large and is continued backward as a tube, which narrowly opens to the exterior posteriorly under the end of the parasphenoid. The anterior opening to the brain case is unobstructed except by the orbitosphenoids, which narrowly bridge the alisphenoids. The auditory bulla is moderate, not much projecting, and formed by thin polished bones. There is an area of cartilage at the junction between the epiotic, the parietal, and the pterotic.

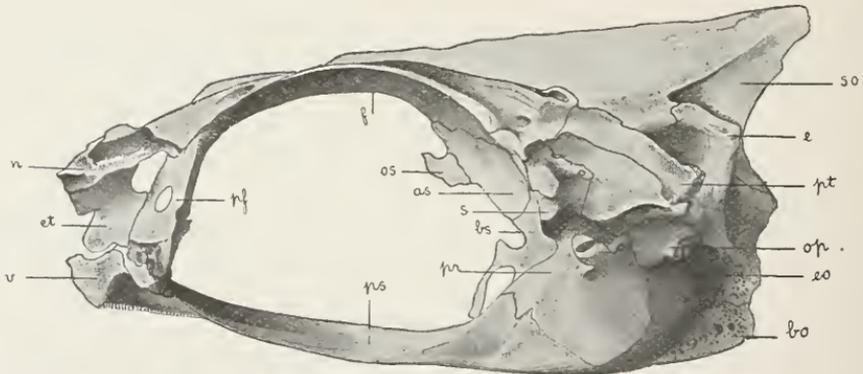


FIG. 9.—POLYMIXIA JAPONICA.

For lettering see fig. 6.

The posterior end of the basioccipital slopes toward the exoccipitals, as is typical for the group. Its usual depression is at its upper edge, and is inclined downward. The epiotics are but slightly covered by the parietals. The surface to which the posttemporal articulates does not project backward as a shelf. The supraoccipital comes between the frontals as a long wedge, separating them for two-thirds of their length. The opisthotics are well developed. They overlie the suture between the pterotic and the exoccipital below. To their posterior surface is developed a nodule, to which the lower limb of the posttemporal is closely attached. The parasphenoid is rather wide. Posteriorly it broadens out over the floor of the myodome and is articulated broadly to the pterotic, without leaving an open space, as in *Beryx*. It reaches back and ends bluntly at the occipital condyle. The basi-sphenoid has a slender descending process, which fails to reach the

parasphenoid. Behind it is a small opening. The alisphenoids do not nearly meet at the median line, but are bridged by the small orbitosphenoids. The orbitosphenoids meet at an angle and are fused into a small Λ -shaped plate which is placed between the alisphenoids near their anterior end, leaving a small space anteriorly between them and the frontals. The frontals do not project over the ethmoid anteriorly. The prefrontals are united behind, but are separated by the ethmoid anteriorly. The olfactory foramen, which is near their inner edge, is rather large. The nasals are not very large, nor do they inclose a chamber between them, as in *Beryx*. They are attached to each other and to the ethmoid by rough suture.

SHOULDER GIRDLE.

The hypocoracoid arches away from the clavicle leaving a large open space between. The hypercoracoid foramen is very large and near the middle of the bone. The four actinosts are all on the hypercoracoid except about half of the lower one. They are elongate, cylindrical, not in contact except at the ends, and grow longer downward. The upper ray of the pectoral works directly on a condyle on the hypercoracoid. The postclavicle is in two pieces, arranged as usual, with the upper piece thin and wide and the lower long and slender. The supraclavicle is present. The posttemporal is widely forked.

PELVIC GIRDLE.

The pelvic girdle is abdominal but anterior. Its anterior point in a specimen $8\frac{1}{2}$ inches long is nearly three-fourths of an inch from the union of the tips of the clavicles below. It is not high and vertical as in *Beryx*, but wide and depressed. The two halves are joined posteriorly, and only for a short distance at their points, leaving a wide open space between them at their middle. The posterior union is peculiar. A long spur is developed on each side toward the opposite side at a right angle to the ventral fins. They overlap each other for their whole length, that of the right side being uppermost. A long sharp process is developed posteriorly from each side between the ventral fins.

LATERAL BONES OF HEAD.

The head of the hyomandibular is divided where it articulates with the cranium. The anterior edge of the hyomandibular sends a process down to articulate with the metapterygoid, leaving an open space behind. The metapterygoid has a slight outer wing developed which partly extends over the opening between it and the hyomandibular. The symplectic extends in a channel about half way down the inner surface of the quadrate. The preopercle has a large ridge with the usual channel behind it. Its lower edge is sharply toothed. The interopercle is wide but is nearly covered by the opercle. The

opercle has a strengthening ridge developed on its inner surface extending back from its articulation with the hyomandibular. The lower jaw has a very small angular. There is no space between the upper edge of the articular and the upper limb of the dentary. The maxillary has a large thin supplemental bone on its upper edge near the posterior end. The premaxillary is long and slender and reaches nearly to the end of the maxillary. The suborbital ring has a very long narrow shelf which tapers nearly to each end of it but does not extend on the preorbital. On its outer side there is a deep channel.

HYOID ARCH.

The interhyal is rather long and is attached by a ligament at its lower end to the upper part of the interopercle as well as to the symplectic at its upper end. There is a channel running the length of the ceratohyal and extending on the epihyal. The urohyal is simple and flat without lateral wings or ridges. The hypohyals are paired on each side as usual. There are four unmodified branchiostegal rays; one and a half on the epihyal, and two and a half on the ceratohyal. On the lower hypohyal are too small, curved rays of bone, one fitting closely against and on the inner side of the other, so that it is nearly covered when viewed from the side. The hyoid barbel springs from a point just posterior to the base of these, and around its slightly swollen base they curve and are attached. To the outer side of the barbel is attached a third bone, very thin and flat, which also springs from the hypohyal. These are doubtless modified branchiostegal rays, so the entire number on each side is seven.

PHARYNGEALS.

The lower pharyngeals are straight on their inner edges, and in contact but are not united. There are two toothed superior pharyngeals. That of the second arch is long and narrow, that of the third and fourth is large, ovate, and cut rather square behind.

VERTEBRAL COLUMN AND THE APPENDAGES OF THE UNPAIRED FINS.

Abdominal vertebrae 12+ caudal 15+ hypural = 28. The first vertebra is not concave in front, but is modified to fit the unevenly concave occipital condyle. It has a small pit near its center. The third vertebra has the first parapophysis developed. The parapophyses grow more downward posteriorly, and the last two are connected near their bases with their fellows of the opposite side. The first two vertebrae, as usual in the spiny rayed fishes have only small single rays more in line with the intermusculars than with the ribs. The row of intermusculars follows along the parapophyses, a little above the base of the ribs to the last abdominal vertebra, where it arches upward and runs along the sides of the neuropophyses nearly to

opposite the posterior end of the soft dorsal. A lower row of intermusculars runs low along the posterior ribs and is continued on the hæmal spines nearly to opposite the posterior end of the anal. Spines from the last two vertebrae assist the hypural in supporting the caudal fin. The interspinous rays of the fins exceed in number the spines. The first interhæmal is enlarged (doubtless formed of the united first two or three interhæmals), and is tubular for the reception of the posterior end of the air bladder, as in the genus *Eucinostomus*.

MONOCENTRIS JAPONICUS (Houttuyn).

CRANIUM.

The top of the cranium is full of deep cavities between high ridges which form a complex pattern. The ridges are all very rough on

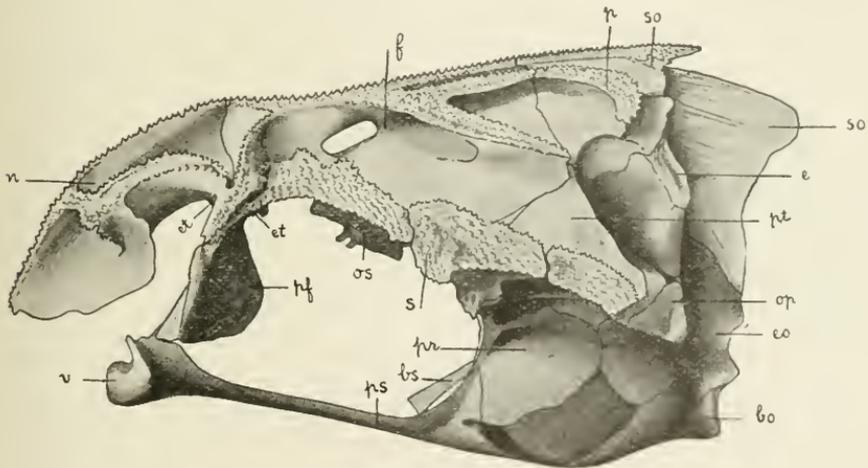


FIG. 10.—MONOCENTRIS JAPONICUS.

For lettering see fig. 6.

their upper edges. On the frontals extending their whole median length the ridges form a diamond. From the posterior point of the diamond the supraoccipital ridge extends back. From the anterior point a ridge runs forward on the nasals, diverging anteriorly. A ridge on each nasal runs backward and outward from the point of divergence of the median nasal ridge to the outer posterior angle of the nasal. From the outer angle of the diamond on each side a pair of ridges diverge backward; the upper one runs over the frontal and parietal, the lower one over the frontal and supratemporal. From the middle of each anterior side of the diamond a ridge runs forward and outward to the anterior outer angle of the frontal. A ridge runs along the supraorbital rim across the sphenotic to the pterotic. The supraorbital rises but slightly above the rest of the cranium. The exoccipitals and the basioccipital mutually assist in forming a

single concave occipital condyle, as described elsewhere. The auditory bulla is rather prominent and there is a very large area of cartilage between the exoccipitals, parasphenoid, basioccipital, and prootic. The myodome is moderate in size and is not continued back in a tube.

The supraoccipital slightly separates the posterior ends of the frontals. Its crest is developed posteriorly, scarcely extending above the rest of the cranium. The epiotic is somewhat covered by the parietal. The surface that receives the posttemporal slopes steeply downward. The opisthotic bends up at a right angle around the posterior surface of the exoccipitals and pterotic. The frontals are wide and truncate anteriorly; they do not extend forward of the ethmoid. The parasphenoid sends up the usual basitemporal wing, but without an opening behind it into the myodome. It ends in a sharp point on the basioccipital some distance from the occipital condyle. The basisphenoid sends down a slender process, which just reaches to the parasphenoid. The alisphenoids do not meet at the median line, leaving a wide opening between them into the cranial cavity. The orbitosphenoids are large, meeting at their inner edges at about a right angle and uniting in a simple suture. The ethmoid is a very small, thin, horizontal plate of bone, lying under the front of the frontals, between the extreme upper end of the prefrontals. Below it is a wide open space between the prefrontals extending down to the vomer. The prefrontals are nowhere in contact. They are not pierced by the olfactory nerve, but deeply notched on their inner edge. The vomer is supported anteriorly only at the extreme upper corners, which touch the prefrontals. The nasals are very large bones, broadly united to the frontals and to each other. They arch widely over the anterior part of the cranium and inclose a chamber behind them.

FACE BONES.

The hyomandibular has an undivided head. There is a small opening between its lower anterior edge and the metapterygoid, which runs downward behind the latter, though no wing is developed in front of it. There is a deep channel around the side of the preopercle connecting with a similar one along the lower part of the mandible. The angular is present. There is a small space between the upper edge of the articular and the upper limb of the dentary. The mesopterygoid has a patch of teeth on its inner surface. The maxillary has a large supplemental bone along the posterior half of its upper edge, and extending down over its surface to its lower edge. The premaxillary processes are rather long and stout. The suborbital ring is very wide and deeply channeled, completely covering the cheek. There is a prominent process on the inner surface of the preorbital, and a long triangular process (the suborbital shelf), hooked downward, on the second suborbital. Other face bones are essentially as in the Percoids.

HYOID.

The interhyal is very long. The ceratohyal is pierced at its middle by a small long foramen. The lower pair of hypohyals is larger than the upper. Seven of the branchiostegal rays are borne by the ceratohyal and one by the epihyal. The urohyal is wide and thin and without longitudinal wings or ridges.

PHARYNGEALS.

The lower pharyngeals are not united but are in contact at the median line. The first branchial arch bears the usual styliiform, toothless pharyngeal, but in addition the upper gill-raker is broadened and toothed, and appears as a very small pharyngeal. The pharyngeal of the second arch is very small. That of the third and fourth arches is united into an exceedingly large oval patch, much wider behind than in front. Along the basibranchials and basal ends of the epibranchials are toothed patches, similar in appearance to the surface of the lower pharyngeals.

SHOULDER GIRDLE.

The hypocoracoid arches away from the clavicle, leaving a large opening between. The hypercoracoid foramen is large, and through the middle of the bone. The four actinosts are in contact with each other for their whole length, and all are on the hypercoracoid except the lower one. The first pectoral ray works directly on the hypercoracoid. The postclavicle is a single elongate piece. The supraclavicle is present. The posttemporal is widely forked.

PELVIC GIRDLE.

The pelvic girdle is thoracic, wide, and of complex shape, deep and compressed anteriorly. The ventral spine is locked out by a powerful twisting motion, bringing in close contact roughened surfaces, which engage only on closing the fin.

VERTEBRAL COLUMN AND APPENDAGES OF VERTICAL FINS.

Abdominal vertebræ 11 + caudal 14 + hypural = 26. The anterior vertebræ bear no ribs or intermusculars. The first pair of parapophyses is on the seventh vertebra. The parapophyses grow long posteriorly and are joined in pairs, appearing almost identical with the hæmal spines. The slender ribs are joined to their extreme tips. The pit in the atlas is small, though larger than in the other families. The first interhæmal is scarcely enlarged. The interneural spines of the spinous dorsal equal in number the neural spines under them. Those of the soft dorsal slightly exceed them in number. The interhæmals exceed the hæmal spines two to one. The dorsal spines have oblique bases and open obliquely outward alternately to the right and left. The spines of two vertebræ anterior to the hypural assist in supporting the caudal fin.