

THE OSTEOLOGY AND RELATIONSHIPS OF THE FAMILY ZEIDÆ.

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The position of the family Zeidæ having been so long in doubt, I have written this paper as an attempt to point out its relationships, and especially to describe its osteological characters and put the results of my investigations in such shape that they may be available when its allies nearer than these considered here shall be studied.

Notwithstanding the many characters in which *Zeus* differs from the Chaetodonts, the condition of the post-temporal, the crowded anterior vertebrae, and the inferior articulation of the ribs show its relation to them; and its relationship to that group is still more apparent when the Chaetodontoid fishes are studied as a whole.

Thus, the Teuthoidæ possess the simple post-clavicle of *Zeus* and approach it nearer in having the post-temporal more firmly articulated to the skull, while the Ephippidæ have no posterior opening of the myodome to the exterior.

Though showing an alliance to the Scombridæ, it is certainly much nearer to the Chaetodontidæ.

Zeus, however, presents some remarkable peculiarities and stands apart from the Chaetodontoids in the absence of a basisphenoid, in the peculiarly modified prefrontals, in the unmodified articulation of the skull with the vertebrae, in the arrangement of the suspensorium, and in the increased number of vertebrae.

It may be of interest to note, without attempting anything like an exhaustive survey, a few of the places in which the family Zeidæ, in its relations to the Chaetodontoid fishes, has been placed by different authors.

Swainson¹ has placed his large family Zeidæ, which includes many diverse and little related forms, after the Scombridæ (arranged in descending order), which are in a "tribe" apart from Chaetodontidæ.

¹ *Zeidæ* Swainson, Nat. Hist. Fishes, etc., 1839, II, p. 175.

Dr. Günther,¹ in his Catalogue of Fishes in the British Museum, places it among the Scombroid fishes, between Scombridae and Carangidae, while the family Chaetodontidae is separated from it by many large families, such as the Cottidae, Sciaenidae, and others.

In Dr. Günther's² Introduction to the Study of Fishes, Zeidae (Cyttidae) is happily placed in the same division with Acronuridae (=Teuthidae) (Eighth Division Acanthopterygii Cotto-scombriformes), though Carangidae is interposed between them, while Chaetodontidae is in a division with Percidae (First Division Acanthopterygii Perciformes) and separated from it by many large families.

Dr. Gill,³ in his Arrangement of Families of Fishes, has given it a place in the midst of his group Scombroidea which follows Chaetodontioidea.

In Dr. Gill's⁴ Families and Subfamilies of Fishes, Zeidae is placed in the same group as in his previous arrangement, but the group Chaetodontioidea is separated from it by the great group Percoidea and other related groups.

Dr. Gill,⁵ in his account of fishes in the Standard Natural History, has placed Zeidae after the Scombroid fishes and before the Chaetodontoids.

Jordan and Gilbert,⁶ in their synopsis of Fishes of North America, and Dr. Jordan,⁷ in his Catalogue of Fishes of North America, place Zeidae (Zenidae) between Bramidae and Berycidae (=Holocentridae), with several large families between it and Chaetodontidae.

Jordan and Evermann,⁸ in their Check-list of Fishes, have placed it just before the Chaetodontidae.

The skeletons from which my observations were made I prepared from an alcoholic specimen of *Zeus faber* (No. 48531) loaned me for that purpose, by the U. S. National Museum, and from specimens of several Chaetodontoid fishes from the collections of Leland Stanford Junior University, for which I am indebted to Dr. David Starr Jordan.

The plates illustrating this article are from drawings made by Chloe Lesley Starks.

DIAGNOSIS.

Prefrontals not pierced by an olfactory foramen; basis cranii well developed; basisphenoid absent; myodome not opening to the exterior

¹ *Cyttina* Günther, Cat. Fishes Brit. Mus., II, p. 393.

² *Cyttidae* Günther, Introduction to the Study of Fishes, 1880, p. 450.

³ *Zenidae* Gill, Arr. Fam. Fishes, 1872, p. 8 (Fam. No. 84).

⁴ *Zeidae* Gill, Families and Subfamilies of Fishes, Nat. Acad. Sci., Sixth Memoir, 1893, VI, p. 134.

⁵ *Zenidae* Gill, Standard Nat. Hist., Boston, 1885, p. 208.

⁶ *Zenidae* Jordan and Gilbert, Synopsis of Fishes, North America, Bull. XVI, U. S. Nat. Mus., 1882, p. 458.

⁷ *Zenidae* Jordan, Cat. Fishes North America., U. S. Fish Comm. Rept., 1884, p. 74.

⁸ *Zeidae* Jordan and Evermann, Check-list of Fishes, North and Middle America, Rept. U. S. Fish Comm., 1895, p. 418.

posteriorly; post-temporal forming an integral part of the skull; arrangement of elements of suspensorium not typical; post-clavicle of a single piece; two pairs of superior pharyngeals bearing teeth; basi-branchials united; vertebræ compressed anteriorly and number $13 + 17 + \text{hypural} = 31$; posterior surface of centrum convex; posterior and anterior zygopophyses present; inferior zygopophyses absent; parapophyses ankylosed at distal ends; articulation of ribs inferior on vertebræ or parapophyses; epipleurals absent.

DESCRIPTION IN DETAIL.¹

THE SKULL.

(Plate XXXIII, figs. 1-3.)

Exoccipitals (*eo*) entirely surrounding foramen magnum, broadly meeting above and below; articular facets not meeting.

Supraoccipital (*so*) exposing only a small surface above; crest very small; posteriorly two knife-like ridges, continuous with similar ones on exoccipitals, extend downward to articular facets; between them supraoccipital reaches down over upper suture of exoccipitals to border of foramen magnum.

Basioccipital (*bo*) alone forming condyle for centrum of atlas.

Frontals (*fr*) large and exceedingly thick; much pitted and irregularly honeycombed, breaking up large sensory canals posteriorly.

Ethmoid (*e*) blade-like, thin, and high; its length slightly less than that of frontals, or about one-third length of entire skull; much cartilage between its anterior end and vomer.

Prefrontals (*pf*) rather long; no olfactory foramen; large space between them and ethmoid for olfactory nerve, connection with vomer through intervention of cartilage.

Vomer (*v*) wide and flat; at right angles with ethmoid; small patches of teeth at outer anterior corners only.

Parasphenoid (*pas*) sending lateral processes upward to articulate with prootic; posterior end forked, nearly reaching to condyle of basioccipital.

Parietals (*p*) broadly meeting in front of supraoccipital.

Alisphenoids (*als*) long, bordering upper two-thirds of brain cavity; upper ends nearly meeting.

Basis cranii well developed and thick; myodome large, not opening to exterior posteriorly.

SHOULDER GIRDLE.

(Plate XXXVI, figs. 11, 12.)

Post-temporal (*pot*) bent at an obtuse angle rather than forked; from deep notch for articulation of supraclavicle its respective ends run upward and inward, and downward and inward at about the same

¹Elements not mentioned are typical or sufficiently explained by the drawings.

slant; upper portion twice as long as lower; articulated with skull by subdentate sutures; entire portion below angle joined to pterotic and opisthotic; upper end joined broadly to epiotic; two narrow dermal bones articulated firmly along its anterior edge, but not bridging over space between it and skull proper.

Supraclavicle (*sc*) comparatively short, spreading out fan-like and divided into three short spines.

Clavicle (*cl*) very slender and long, bent at an angle at about its middle; pectoral fin well below angle; about half of hypercoracoid lying under it and joined by squamous suture.

First actinost (*a*) very large and long, joined to hypocoracoid; upper three gradually growing smaller and joined to hypercoracoid; upper ray of pectoral working directly upon hypercoracoid.

Postclavicle (*pcl*) of a single piece; heavy, long, and bayonet-shaped.

SUSPENSORIUM, OPERCLES, MAXILLARIES, AND MANDIBLE.

(Plates XXXVI, fig. 9; XXXVII, fig. 13.)

The suspensorium is turned back upon itself. The mesopterygoid has crowded itself in between the quadrate and metapterygoid, still holding its attachment with the pterygoid by drawing the upper end of that bone after it and bending it around the upper end of quadrate, carrying the palatine back till it is posterior to the mandibular articulation of the quadrate, attaching itself to the side of the symplectic, and crowding the metapterygoid far from its usual proximity to the quadrate.

This crowding back of the suspensorium has worked in an opposite way upon the opercular apparatus. The mandible in following the palatine back has swung on the quadrate as a fulcrum, and thrown its long lower or posterior end (angular) forward, which has drawn the opercular bones after it, elongating them and giving them a general trend downward and forward.

Perhaps this state of affairs is all brought about by a gradual decrease in the size of the skull proper, pulling the palatine toward the hyomandibular, and the rest following as described.

Hyomandibular (*hm*) rather elongate; its head simple without differentiated knob; separated by a long space from symplectic.

Symplectic (*sy*) an exceedingly long, slender splint, its anterior end running in a groove behind posterior third of quadrate.

Pterygoid (*pt*) extending upward and backward; upper end turning backward around quadrate.

Mesopterygoid (*mspt*) articulated with symplectic posteriorly, and holding on its posterior upper edge the metapterygoid.

Metapterygoid (*mpt*) very small; its upper end touching hyomandibular.

Preopercle (*pop*) a long, slender bone bent on a slight even curve.

Opercle (*op*) triangular in shape, bearing subopercle (*sop*) below, which turns up around its anterior edge a short distance.

Interopercle (*iop*) long and feather-shaped, supported by ligaments only; attached to opercle and subopercle posteriorly, to angular anteriorly.

Mandible strong and heavy; nearly vertical; lower edge¹ only of articular united with dentary (*d*), leaving a space above which is bounded by an upper limb of articular extending forward to meet upper limb of dentary.

A portion of articular (*ar*) projecting backward from its articulation with quadrate.

Angular (*an*) large; pointed behind and extending posteriorly past articular; reaching to dentary anteriorly.

Premaxillaries (*pm*) with a long, backward-extending process reaching to above eye, or well past the anterior half of skull; lower ends forked; large process developed on the posterior edge extending behind maxillary; anterior or toothed part of premaxillaries slightly meeting above, but immediately behind a large open space is left between them.

HYOID APPARATUS.

(Plate XXXIV, fig. 5.)

Interhyal (*ih*s) very long and rather stout, firmly articulated in a shallow socket in epihyal.

Epihyal (*ephy*) triangular in shape.

Ceratohyal (*chy*) with a concave portion cut out below, which breaks its subcircular outline; a narrow foramen slightly above center.

Hypohyals (*hhy*) exceedingly large and conspicuous; entirely lateral in position; urohyal and glossohyal so placed between opposing pairs of hypohyals that they connect only through those bones.

Urohyal (*uhy*) higher than long, attached a little above the middle of its anterior edge.

Branchiostegals (*br*) eight in number, all attached to outer surface of ceratohyal.

BRANCHIAL ARCHES.

(Plate XXXIV, fig. 4.)

Basibranchials (*bbr*) coossified, forming a long splint of bone reaching from between front of hypobranchials of third arch to glossohyal.

Hypobranchials (*hbr*) of third arch short, meeting in a median line behind basibranchial; each sends a long process forward, which curves under basibranchial to in front of hypobranchials of second arch where it meets its opposite fellow.

Ossified hypobranchials and basibranchials of fourth arch absent as usual.

First pair of superior pharyngobranchials (*phbr*) extraordinarily long and slender; upper ends hollow and quill-like; toothless.

Second pair of superior pharyngobranchials as long as first, but stouter; tooth patches at lower ends small.

Third and last pair of superior pharyngobranchials large; tooth patches several times larger than those of second pair; rather elongate above.

¹ Described as if mandible were in its normal position—that is, subhorizontal.

Third epibranchials (*ebr*) broadly join large superior pharyngobranchials.

Fourth epibranchials closely join third along upper half, but very slightly, if at all, joined to large superior pharyngobranchials.

PELVIC GIRDLE.

(Plate XXXV, fig. 7.)

Pelvic girdle (*pg*) composed of two wide, thin, nearly vertical plates, braced through their middle by a long ridge; each sending a long process backward just under skin of belly.

ORBITALS AND NASALS.

(Plate XXXVI, fig. 10.)

Orbitals forming a long narrow chain of bones some distance below eye; preorbital (*por*) attaching to near lower end of palatine; at its center is a short hooked spine; suborbitals (*sor*) five in number.

Nasals (*na*) present; rather small; posterior in position owing to produced ethmoid and vomer.

VERTEBRAL COLUMN.

(Plate XXXVIII, figs. 14-16.)

Vertebral formula: 13+17+hypural = 31.

Body of vertebrae round and symmetrical, but very deeply pitted; anteriorly much compressed and higher than long; no inferior zygopophyses; posterior zygopophyses only on anterior vertebrae; anterior zygopophyses well developed for whole length of vertebral column.

Atlas higher than long; centrum deeply concave on anterior surface, deeply convex on posterior; neural processes not connected above; flaring outward anteriorly and joined rather firmly to ridges on each side of foramen magnum; lateral to condyle for articulation with exoccipitals a notch is developed for reception of a corresponding process on exoccipitals.

No parapophyses on first seven vertebrae; well developed on succeeding abdominal vertebrae; those of opposite sides of each vertebra ankylosed at their distal ends, as well as those of different vertebrae being joined together by sutures forming a sharp ridge, to the very edge of which ribs are joined, thus bringing bases of opposing ribs close together.

Hæmal processes of the fourteenth, fifteenth, and sixteenth vertebrae form a tube which surrounds the upper end of large interhæmal spine.

Neural spines pointing irregularly on account of interneurals not coinciding with them, the latter being less in number.

Anterior zygopophyses developed upward, forming a sheath for spinal cord.

Last vertebra assisted in forming hypural by the spines of the two succeeding vertebræ.

Ribs slender; anterior ones fitting into deep sockets low on the vertebræ; no epipleurals in evidence.

DORSAL AND ANAL ELEMENTS.

(Plate XXXV, figs. 6-8.)

First two dorsal spines with backward-downward developed processes at their bases for attachment of muscles.

First two interhæmal spines ankylosed, forming a large spine which runs upward, bordering abdominal cavity behind and at its upper end fitting into a tube formed by the hæmal spines of three vertebræ.

Interneurals of spinous dorsal wide and rather irregular in shape.

Interspinous rays of fin spines of dorsal and anal without greatly developed lateral laminae.

Interspinous rays of soft fin rays uniformly thin and flat, with a wide, thin lateral lamina of bone developed at right angles to them at their middles. At the base between each two spines an arch is left, each one forming half an arch on each side of it.

EXPLANATION OF PLATES.

SIGNIFICANCE OF REFERENCE LETTERS USED ON PLATES.

PLATE XXXIII.

	Page
Figs. 1-3. Lateral, superior, and posterior views of skull.....	171
als. Alisphenoid.	
bo. Basioccipital.	
epo. Epiotic.	
e. Ethmoid.	
eo. Exoccipital.	
fr. Frontal.	
na. Nasal.	
pas. Parasphenoid.	
p. Parietal.	
pot. Post-temporal.	
pro. Prootic.	
pto. Pterotic.	
pf. Prefrontal.	
spo. Sphenotic.	
so. Supraoccipital.	
v. Vomer.	

PLATE XXXIV.

Fig. 4. Branchial arches	473
bbr. Basibranchials.	
cbr. Ceratobranchials.	
ebr. Epibranchials.	
hbr. Hypobranchials.	
iph. Inferior pharyngeal.	
phbr. Superior pharyngobranchials.	

Fig. 5. Hyoid apparatus	473
<i>brr.</i> Branchiostegal rays.	
<i>chy.</i> Ceratohyal.	
<i>ephy.</i> Epihyal.	
<i>ghy.</i> Glossohyal.	
<i>hhy.</i> Hypohyal.	
<i>ihy.</i> Interhyal.	
<i>uhy.</i> Urohyal.	

PLATE XXXV.

Fig. 6. Anterior elements of dorsal fin	475
<i>ds.</i> Dorsal spines.	
<i>ins.</i> Internatural spines.	
7. Pelvic girdle	474
<i>pg.</i> Pelvic bone.	
<i>vf.</i> Ventral fin.	
8. Anterior elements of anal fin	475
<i>as.</i> Anal spines.	
<i>hs.</i> Hæmal spines.	
<i>ihs.</i> Interhæmal spines.	

PLATE XXXVI.

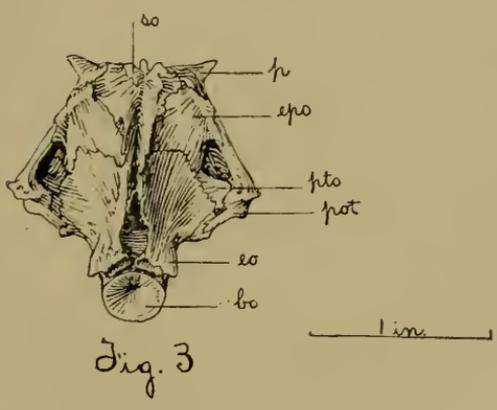
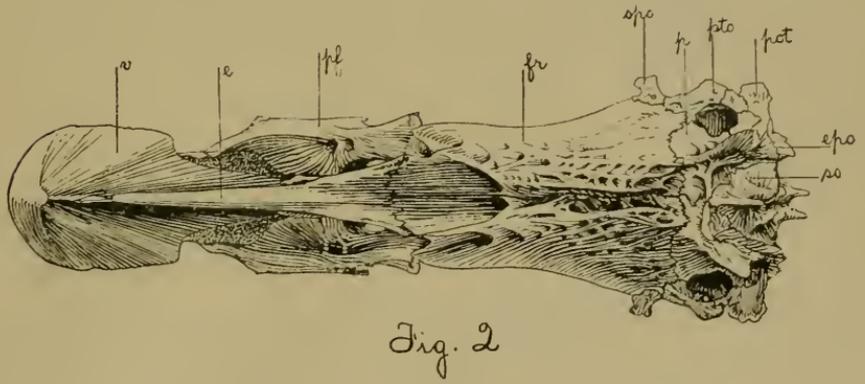
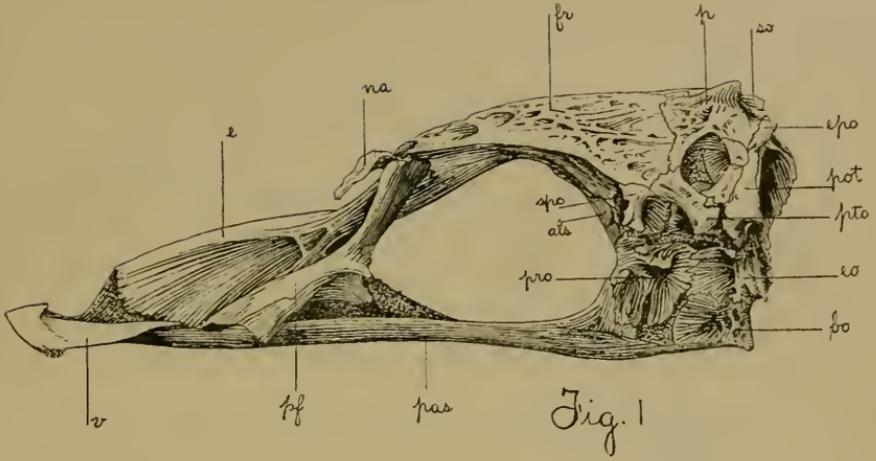
Fig. 9. Maxillaries	473
<i>m.</i> Maxillary.	
<i>pm.</i> Premaxillary.	
10. Suborbital ring	474
<i>por.</i> Preorbital.	
<i>sor.</i> Suborbitals.	
11. Supraclavicle	472
<i>scl.</i> Supraclavicle.	
12. Shoulder girdle	471
<i>a.</i> Actinosts.	
<i>cl.</i> Clavicle.	
<i>hyc.</i> Hypercoracoid.	
<i>hypc.</i> Hypocoracoid.	
<i>pcl.</i> Postclavicle.	
<i>pf.</i> Pectoral fin.	

PLATE XXXVII.

Fig. 13. Suspensorium, lower jaw, and opercles	472
<i>an.</i> Angular.	
<i>ar.</i> Articular.	
<i>d.</i> Dentary.	
<i>hm.</i> Hyomandibular.	
<i>iop.</i> Interoperculum.	
<i>mspt.</i> Mesopterygoid.	
<i>mp.</i> Metapterygoid.	
<i>op.</i> Operculum.	
<i>pa.</i> Palatine.	
<i>pop.</i> Preoperculum.	
<i>pt.</i> Pterygoid.	
<i>q.</i> Quadrate.	
<i>sop.</i> Suboperculum.	
<i>sy.</i> Symplectic.	

PLATE XXXVIII.

Fig. 14. Vertebrae	474
<i>hs.</i> Hæmal spines.	
<i>ihs.</i> Interhæmal spine.	
15. Hypural	475
16. Posterior and anterior views of atlas	474



LATERAL, SUPERIOR, AND POSTERIOR VIEWS OF SKULL.

FOR EXPLANATION OF PLATE SEE PAGE 475.

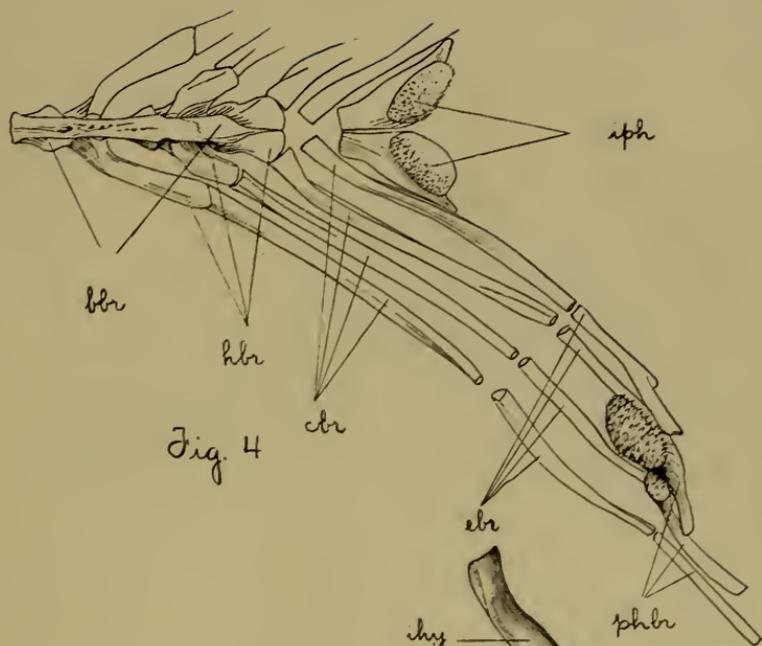


Fig. 4

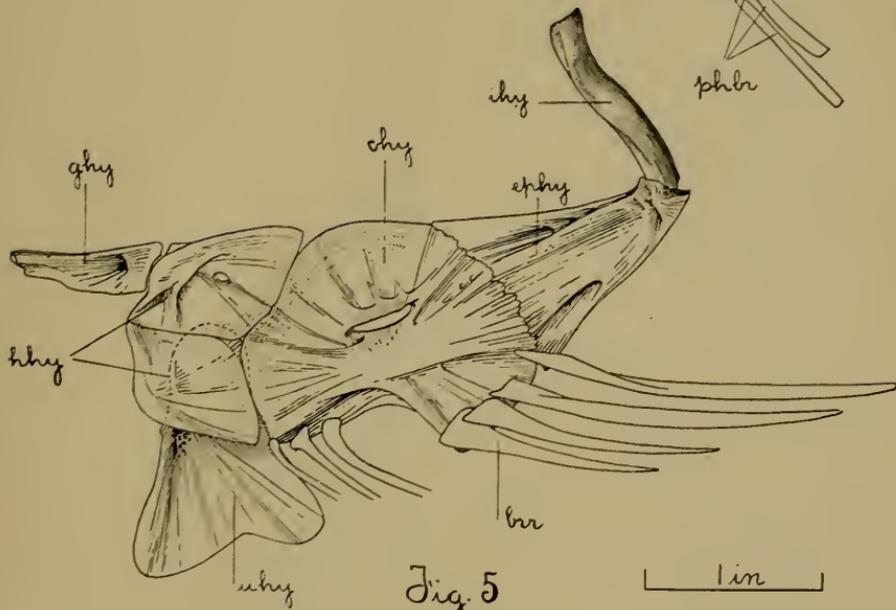
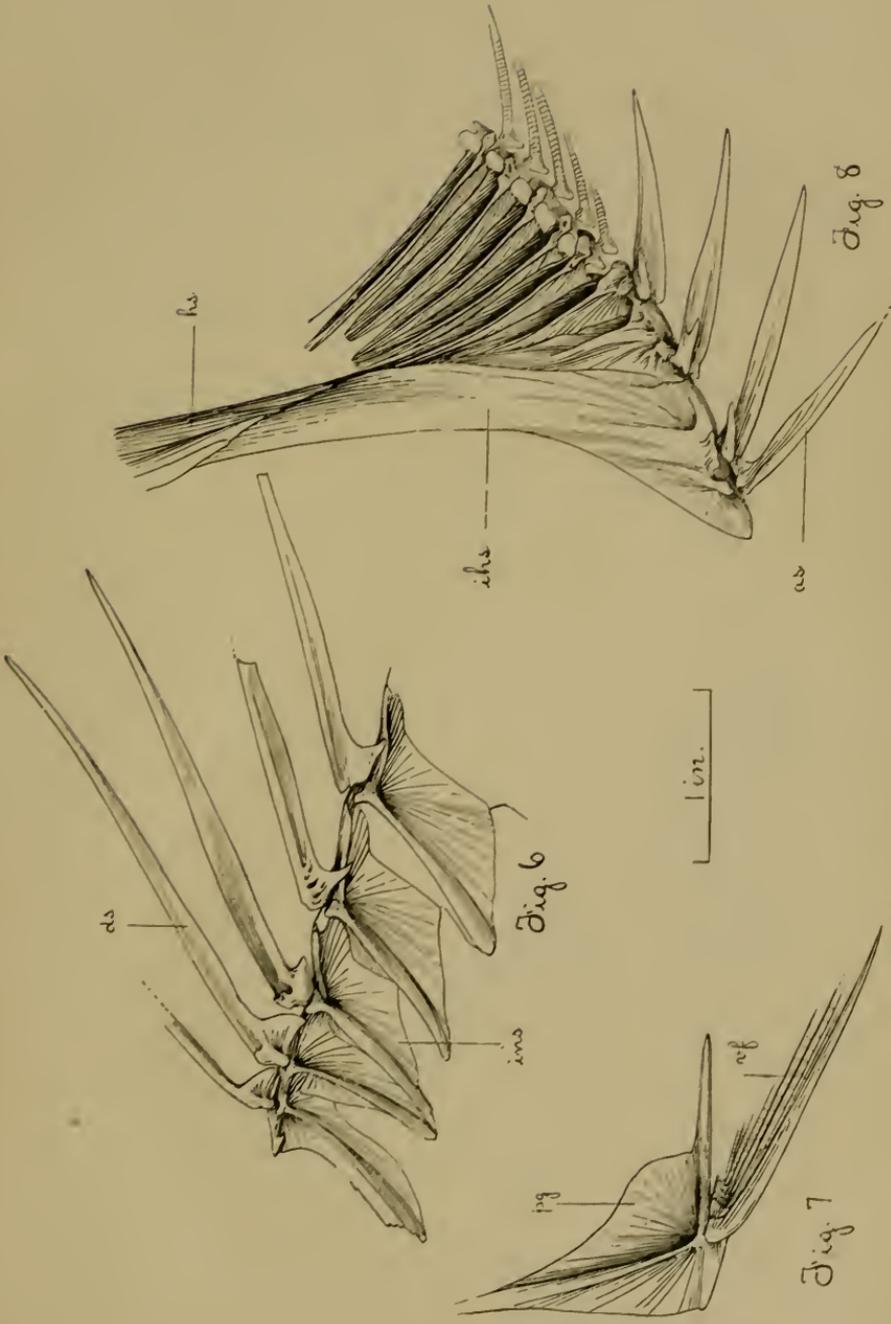


Fig. 5

BRANCHIAL ARCHES AND HYOID APPARATUS.

FOR EXPLANATION OF PLATE SEE PAGES 475, 476.



ANTERIOR ELEMENTS OF DORSAL AND ANAL FINS, AND PELVIC GIRDLE.

FOR EXPLANATION OF PLATE SEE PAGE 476.

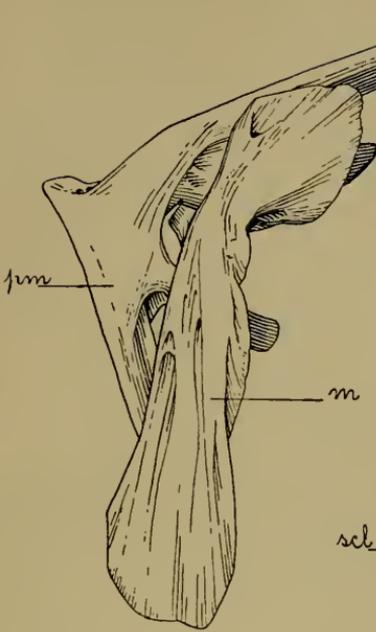


Fig. 9

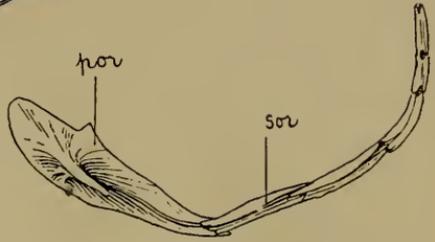


Fig. 10

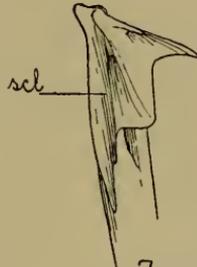


Fig. 11

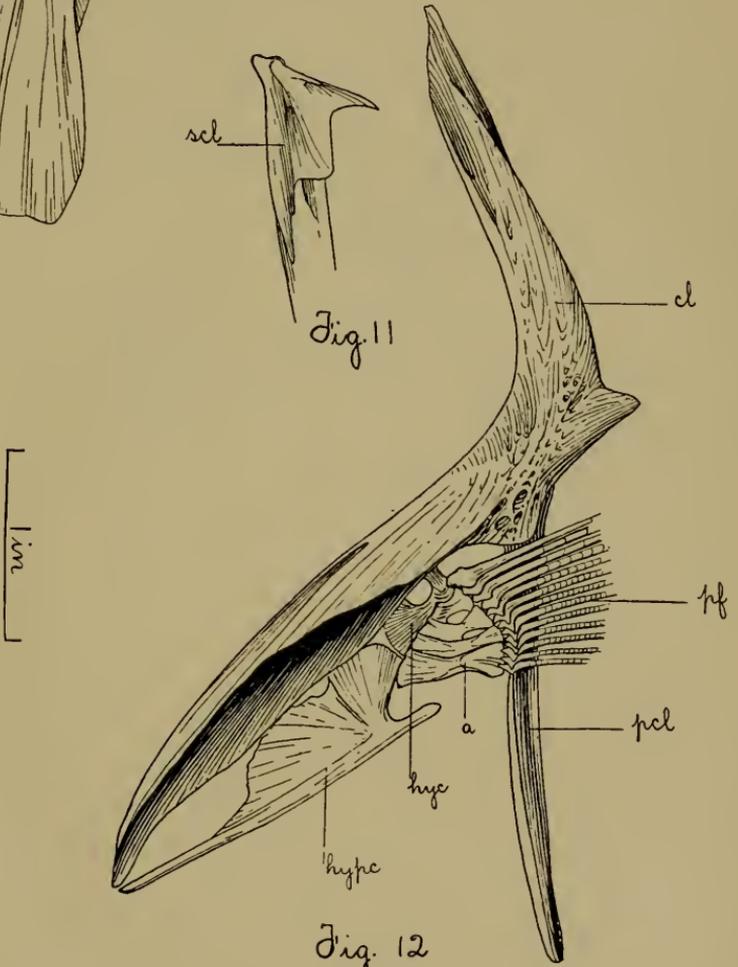


Fig. 12

MAXILLARIES, SUBORBITAL RING, SUPERCLAVICLE, AND SHOULDER GIRDLE.

FOR EXPLANATION OF PLATE SEE PAGE 476.

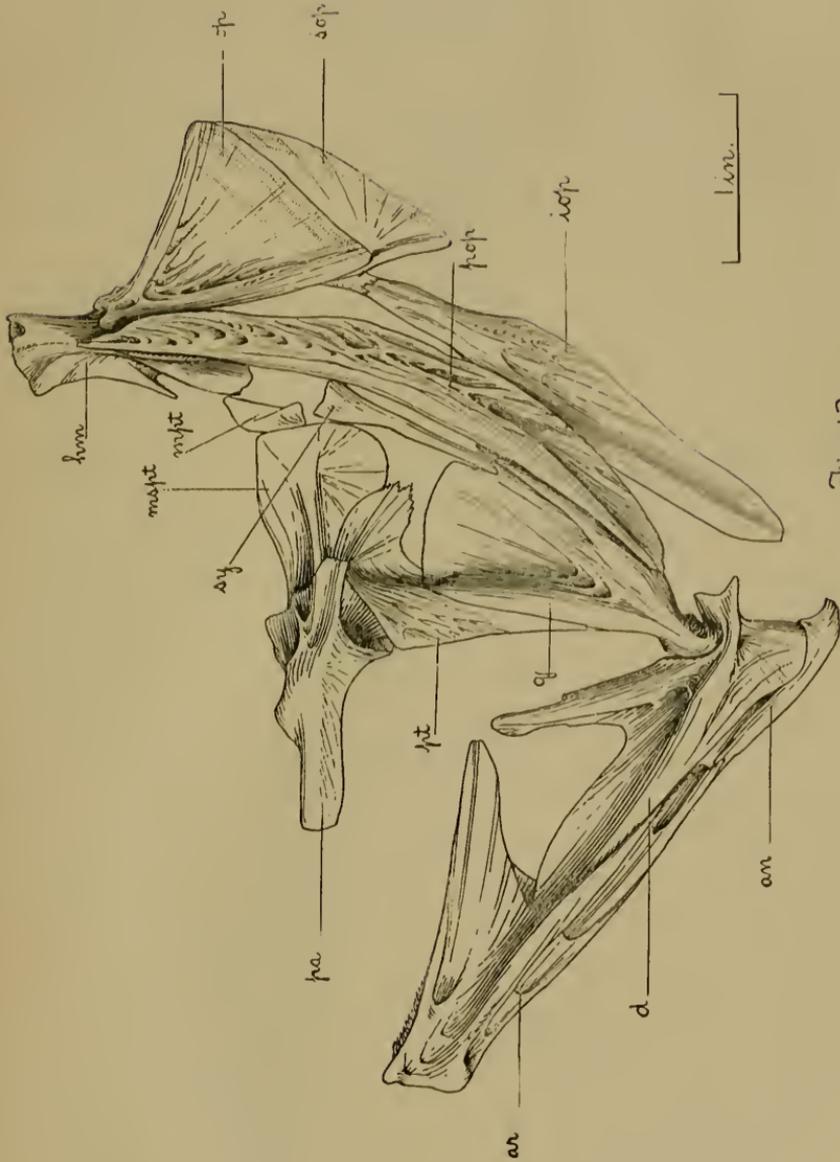


Fig. 13

SUSPENSORIUM, LOWER JAW, AND OPERCLES.

FOR EXPLANATION OF PLATE SEE PAGE 476.

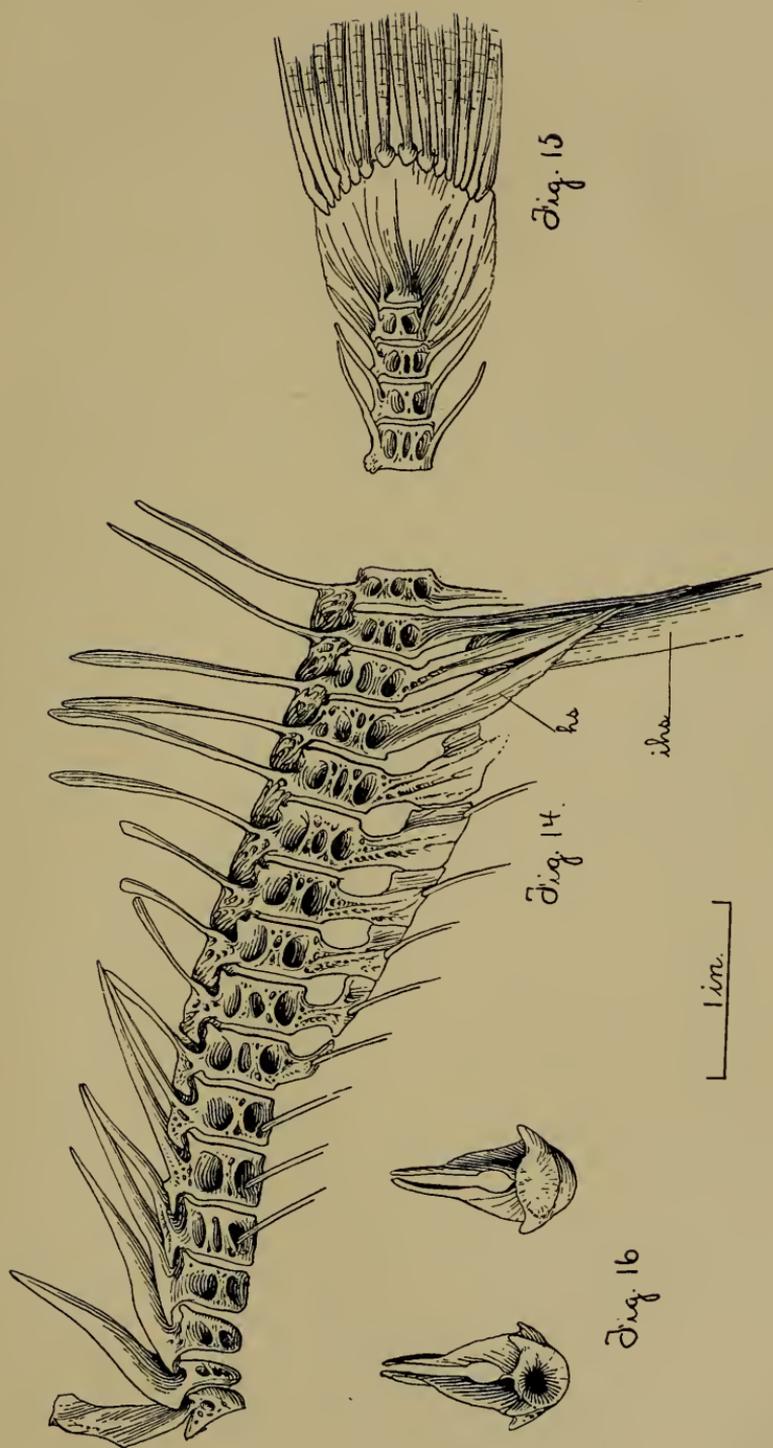


Fig. 15

Fig. 14.

Fig. 16

VERTEBRÆ, HYPURAL, AND ATLAS.
FOR EXPLANATION OF PLATE SEE PAGE 476.

