Leighton Kesteven, H., 1928. Contributions to the Cranial Osteology of the Fishes. No. VI. *Records of the Australian Museum* 16(7): 316–346. [17 October 1928].

doi:10.3853/j.0067-1975.16.1928.793

ISSN 0067-1975

Published by the Australian Museum, Sydney

CONTRIBUTIONS TO THE CRANIAL OSTEOLOGY OF THE FISHES. No. VI.*

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SOME PERCOMORPH SKULLS.

PAGROSOMUS AURATUS *Gill.*

(Figs. 1-3.)

My material comprises several well grown skulls and one from a young fish, together with two specimens in the flesh.

THE SKULL.

In the skull of an "Old Man" Snapper, as the larger fish are called, with its tremendous occipital knob and massive solid frontal bones, the cranial cavity appears disproportionately small. This, however, is not the fact; the cranium and its processes are of normal size, but are overshadowed by the structures mentioned. The general outlines will be gathered from the drawings.

The large occipital knob is developed entirely from the crest of the supraoccipital bone. The lateral boundary of the occipital fossa is indicated, rather than defined, by the inferior buttress of the epiotic process, whilst the forward continuation of the same process indicates the lateral boundary of the same fossa superiorly. The temporal fossa is a broad trough which lies between the lateral boundaries of the occipital fossa and the outer margin of that flange of the pterotic bone which is continued forward from the pterotic process to articulate with the frontal bone. The dilatator fossa is large; it lies below the flange of the pterotic and above the postorbital lamina of the sphenotic, and its apex is lodged between the two laminæ of the hinder end of the frontal bone. The saccular cavities are approximated to the midline, and there are, therefore, no saccular bullæ. The trigemino-facialis chamber lies immediately below the anterior hyomandibular facet at the angle between the anterior and lateral faces of the prootic bone. The sloping hinder margin of the facet is thrown like a thin "flying buttress" across the chamber; that which may be regarded as the

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* For Nos. III-VI and index of abbreviations used on the drawings, see "Records," Vol. XV, No. 3, 1926, p. 201.

true outer wall of the chamber is a splint of bone in front of this. The ventral line of the skull is nearly parallel with the basicranial axis, for, though the myodome is much deeper in front than behind, the cava sacculi are placed between the cranial floor and the myodomial roof toward the hinder end of the myodome.

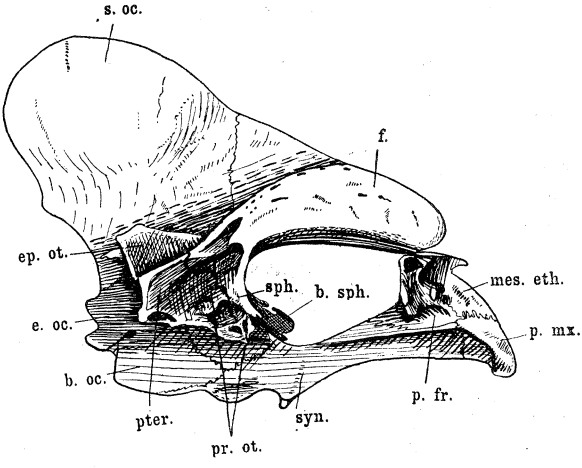

Fig. 1. *Pagrosomus auratus* Gill.

THE CRANIUM.

The *Basioccipital* bone is laterally compressed and rather deep dorso-ventrally. The myodomial recess is placed below the two saccular recesses, which are separated one from the other by a thin lamina of bone which constitutes their common median wall. This vertical lamina sutures with the two horizontal laminæ of the exoccipital bones in front of the azygos sinus. In front of these laminæ its superior margin divides the basicranial fenestra into right and left halves; anteriorly it sutures with the hinder end of the horizontal lamina of the prootic bone. The hinder end of the vertical lamina abuts against the upper half of the condyle. The azygos sinus is quite shallow; for the most part it lies between the horizontal laminæ of the exoccipital bones, but its depth just pits the dorsum of the basioccipital in front of the condyle. The lateral laminæ of the bone are not joined inferiorly, there being no basal lamina developed; the floor of the myodome is constituted by the synpterygoid. It should be noted that in this bone the lateral laminæ form the side walls of the myodomes as well as the side walls of the saccular cavities; this condition, of course, is only possible when these latter are placed close together at a higher level than the myodome. It appears probable that this feature of the basioccipital bone will prove of taxonomic value; it is therefore proposed to designate this type

of basioccipital bone the *hypomyodomial*, in distinction to the *paramyodomial* type, in which the myodome and cava sacculorum lie side by side at, or almost at, the same level.

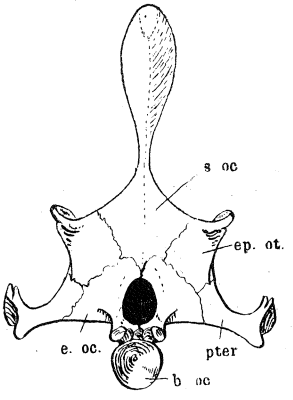

Fig. 2. *Pagrosomus auratus* Gill.

The buttress of the *Exoccipital* bone is but poorly developed and both the spino-occipital and the vago-accessory foramina issue below it. The inferior vertical lamina is small, the superior sutures with its fellow of the other side and with the inferior margin of the occipital crest. The horizontal lamina meets its fellow both behind and in front of the azygos sinus, and sutures with the median vertical lamina of the basioccipital bone. The small otic mass of the bone lodges portion of the posterior semicircular canal, but in a sulcus, not as usual in a complete canal.

The body of the *Supraoccipital* bone appears narrower than it really is, by reason of the large size of the crest. Anteriorly the crest is continued over the hinder end of the fused frontals for a little distance and then meets the median crest of those bones in a vertical suture. The vertical lamina is nearly as thick as it is broad, and carries the inferior and posterior portion of the crest.

The lateral surface of the *Prootic* bone and the myodomial lamina thereof lie almost in the same plane as the myodomial lamina of the basioccipital. The anterior surface of the bone, in the postorbital wall, is a relatively small area in the immediate vicinity of the trigemino-facialis chamber. The horizontal lamina is abruptly differentiated into cranial and saccular components. The former is a narrow triangular area, with the apex of the triangle as usual at the trigemino-facialis fossa; the latter is stepped down behind the former, and slopes from its origin upward towards the cranial floor. The trigemino-facialis and the lower

portion of the arcuate fossa are lodged in the body of the bone to the outer side of the horizontal lamina.

The *Opisthotic* and *Pterotic* bones are intimately fused, and, owing to the wide variations observable in other forms, it were not wise to attempt to decide the possible limits of the two components of the *Opisthopterotic* bone which results from the fusion. The bone presents a body, which shares in the formation of the outer wall of the otocrane, a pterotic process and an obliquely oriented flange which extends forward from the pterotic process, crossing the dorsal surface of the sphenotic, to reach the frontal. The body of the bone is roughly pyramidal, the apex of the pyramid being at the pterotic process. On the cranial aspect there are two conical pits; these communicate at their apex through the short horizontal bony canal. Together with that canal the pits lodge the horizontal semicircular canal. The pterotic process ends in a spur which stands out down and backwards, and bears the posterior hyomandibular facet on the under side at the root of this spur. The free edge of the flange presents the openings of three radiating canals of the latero-sensory system; these radiate from the base of the pterotic process, a short, fourth, canal opens behind the base of the process, and a fifth, opening just where the flange is sutured to the frontal, is so wide that in this situation the flange must be described as bilaminate. The bone presents sutures with the exoccipital, epiotic, sphenotic, prootic, and frontal bones.

The *Epiotic* resembles the body and process of the last bone; there is, however, but a single, and that a larger cavity on the cranial aspect. This cavity lodges part of the posterior semicircular canal and communicates with the posterior bony canal, which runs vertically upwards immediately beneath the external table of the posterior surface of the bone, to open into the cavity near its apex. The epiotic process is very like the pterotic and bears on its upper aspect the facet for the supraclavicula. The bone sutures with the exoccipital, supraoccipital, parietal, sphenotic, and pterotic bones.

The body of the *Sphenotic* is a low hollow cone. The cavity lodges the greater part of the temporal fossa in front and the arcuate fossa behind, the two being separated by a nearly vertical thin lamella of bone. Laterally, *i.e.*, externally, the bone bears a large flange, which constitutes the post-orbital wall lateral to the alisphenoid. This flange is well strengthened below, where, at its root, the bone contributes the upper half of the anterior and larger facet for the hyomandibular bone. Although not a large bone, the sphenotic sutures with the frontal, parietal, epiotic, opisthotic, pterotic, prootic, and alisphenoid bones.

The horizontal lamina of the *Basisphenoid* is a little wider antero-posteriorly than is usual in the Acanthopterygii, so that

quite a small pituitary fenestra is left between it and the horizontal laminæ of the prootic. The vertical lamina also is wider antero-posteriorly than is usual.

The *Parietal* bone is an approximately triangular lamina situated in front of the epiotic and sphenotic, between the supra-occipital to the inner side of the frontal laterally.

The two *Frontal* bones are fused together and swollen into an extraordinary tongue-shaped mass. Though this peculiar heavy deposition of bony tissue is heaviest forward, it is still sufficiently heavy posteriorly to disguise the fact that there is a narrow alisphenoidal lamina developed. Posteriorly the bone is split into anterior and posterior lamellæ, which lodge between the apex of the dilatator fossa. The anterior lamella sutures with the flange of the sphenotic, the posterior and more superficial lamella sutures with the anterior end of the pterotic process, and like that is split in two by a sensory canal.

No *Postfrontal* bones can be detected in either the young or adult skulls.

The inferior processes of the *Prefrontals* suture with the body of the synpterygoid on either side of the vomerine process thereof, and then meet above in a synchondrosis, which also involves the process. In some cases the two prefrontals are in actual contact in the suture, in others there is an appreciable quantity of cartilage between them and the synpterygoid, and this variation is not related to the age of the individual. The wings of the prefrontals are fairly wide and meet the mesethmoid both above and below the olfactory foramina, and make contact with the fused frontals by their dorsal edges, there being no definite superior processes. The bones bear each two facets for the maxillæ, and suture with the mesethmoid immediately in front of the anterior of these.

The relatively small *Alisphenoid* bone sutures with the frontal, prootic, and basisphenoid bones; there is no pterygoid process.

The irregularly shaped *Mesethmoid* bone is fitted in between the two prefrontals, with the anterior end of the synpterygoid and the premaxilla below it. Contact between it and the prefrontals is fairly close, but below there is a fairly extensive gap, which in the fresh state is filled by cartilage.

The *Nasals* are long narrow bones attached by fibrous union to the frontals above and to the inner margin of the anterior suborbital below.

The body of the *Synpterygoid* is triangular in section, and anteriorly the sides are continued upward as a low flange on each side, so that a trough is here formed on each side of the vomerine process. The alæ are small, and there are no alisphenoid processes.

Immediately below the alæ a triangular spur projects beyond the ventral line and just behind this the branchial tubercle is well developed. The posterior end of the bone is bifid, and between the two splints thus formed there is a considerable opening into the myodome.

There is, of course, no *Orbitosphenoid* bone present in this skull.

THE CRANIAL WALLS, RECESSES, AND FORAMINA.

The occipital segment of the cranial floor is formed by the horizontal laminæ of the exoccipital bones, which completely exclude the basioccipital from the foramen magnum. The azygos sinus is triangular; the apex of this triangle is anterior and the sinus grows shallower as the tip of the apex is reached. The vago-accessory foramen is situated at the side of the anterior edge of this segment of the floor. The basicranial fontanelle extends the full width of the floor in the mesotic region, leaving the saccular cavities widely open in the prepared skull. The prepituitary floor is tilted up from the preotic, than which it is a little narrower. The pituitary fenestra is smaller than usual. The lateral obturator membrane is attached in front to the edge of the lamina of bone which separates the temporal from the arcuate fossa. Above this it swings upward and back along the anterior and dorsal margins of the pterotic bone; it then swings mediad and downward along the dorsal and posterior margins of the same bone to the antero-dorsal corner of the vertical lamina of the exoccipital. By the anterior edge of this it is carried down to the floor level and crosses to the other side along the anterior edge of the horizontal lamina of the same bone. At the inferior end of the lamina with which we started the attachment of the membrane passes on to a ridge on the horizontal lamina of the prootic bone; by this it is carried slightly back and to the mid-line, where it meets and passes to a similar ridge on the other prootic. This description of the attachment of the membrane describes also the boundaries of the lateral and basicranial fenestræ, which are continuous one with another and across the mid-line, so that it is not possible to describe a basicranial obturator membrane apart from the other. The two large saccular cavities are separated by a thin partition of bone, and above this by a narrow band of fibrous membrane, which gains attachment to the basicranial obturator membrane along the mid-line.

The trigemino-facialis fossa has one small and three large foramina on its floor; apparently all transmit branches of the fifth and seventh nerves.

The internal carotid arteries perforate the horizontal lamina of the prootic at the boundary between the cranial and saccular

faces, appearing on the cranial aspect at the inner end of that ridge described as forming the posterior boundary of the trigemino-fascial fossa.

The *Myodome* is relatively a large cavity; it is triangular in outline in front and tapers from before back. The floor is formed entirely by the synpterygoid, and there is a deficiency in the floor posteriorly.

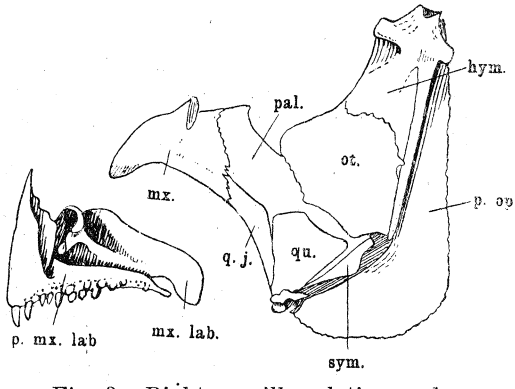

Fig. 3. Right maxillo-palatine arch and labial bones from within.

PALATE AND UPPER JAW.

The shape of these bones is adequately shown in the drawings; it remains only to state that the maxilla is monobisartete, and the hyomandibula binarticulate.

SPARUS.

One specimen of *Sparus australis* Günther has been examined; from this it may be stated that the only differences between this skull and the last are unimportant. There is quite an extensive hiatus, in the fresh specimen filled in by cartilage, between the pterotic, epiotic, and prootic on the dorsum of the skull. A similar, but smaller, hiatus is present in the young *Pagrosomus auratus*. There is no massive supraoccipital crest or fused frontals as in the last skull.

POMADASYS.

As I have but a single specimen of this skull, and as, moreover, this single skull will not disarticulate, a detailed description of it is not possible.

Generally the resemblance is to the skull of *Pagrosomus auratus*, but with marked differences. The frontals are fused

together as in that form, but they are channelled and pitted for the lodgment of organs of the lateral line system. The dorsum of the ridge which continues anteriorly and medially the pterotic process is markedly expanded and hollowed out to form a wide open trough for the reception of the hinder end of the series of organs lodged in the frontal bones. The pterotic lateral line trough is bridged by three or four spicules of bone which, equally spaced, have the appearance of a short ladder laid on its side along the trough. The auditory bulla is very large, apparently constituted as in *Pagrosomus*; it differs therefrom in being markedly inflated, so that the two together produce a cordiform prominence on the base of the skull. The basisphenoid is a much smaller bone in this form than in *Pagrosomus*, the three arms being little more than spicules of bone.

The development of outstanding laminæ and spinous processes from the periotic and cranial bones gives rise in many fishes to two more or less definite fossæ. These are particularly well developed in *Platycephalus* and were described in detail in connection with that skull[1]. In *Pomadasys, Pagrosomus, Sparus,* and *Girella* the occipital fossa can hardly be said to be present, though its situation and extent are clearly indicated by the prominent ridges of the supraoccipital and the epiotic. The temporal fossa is well developed in all these forms, lacking only the roof, which, however, is present in only a small proportion of those skulls in which the fossa is developed. The floor of the temporal fossa is the meeting place of some or all of the following bones: epiotic, exoccipital, opisthotic, pterotic, prootic, sphenotic, and parietal, and it forms the outer wall of the otocrane. No true suture is formed between epiotic, pterotic, prootic, and parietal, and the cartilage of the synchondrosis it at times so extensive as to result in a marked hiatus in the outer otocranial wall. Amongst the skulls which I have examined this "lateral cranial foramen" reaches its maximum in *Pomadasys hasta.* The term "lateral cranial foramen" is taken from Ridewood,[2] who describes very similar conditions in some of the Mormyridæ. In these forms the deficiency between the epiotic and pterotic (squamosal of Ridewood) is such that the exoccipital bounds the foramen posteriorly; in my forms the epiotic and pterotic always meet to exclude the exoccipital from the boundary of the foramen. Ridewood states that the foramen opens into the cavum cranii; there is little doubt that it opens, as in my forms, into the otocranial cavity.

As a whole the skull of *Pomadasys* is more dorso-ventrally compressed than is that of *Pagrosomus.*

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[1] Kesteven.—Rec. Austr. Mus., xv, 3, 1926, p. 218.
[2] Ridewood.—Linn. Soc. Lond., Journ. Zool., xxix, 1904, pp. 188-215.

GIRELLA.

Girella tricuspidata Quoy and Gaimard is one of the commonest food fishes of the Myall Lakes in my immediate neighbourhood so that I have had an unlimited supply of material for the study of this skull. Having described *Pagrosomus* in detail the description of *Girella* is not called for, such is the resemblance between the two forms. The skull of *Girella* is devoid of the massive supra-occipital crest, and the massive fused frontals, and it is more dorso-ventrally compressed, approaching more nearly the shape of *Pomadasys*. In *Sparus*, *Pagrosomus*, and *Pomadasys* the frontal bones override the mesethmoid. In *Girella* the mesethmoid is lodged between the fore ends of the frontals and continues forward of them in the same plane a little distance before dipping ventrally to suture with the premaxilla.

EPINEPHELUS.

(Figs. 4-7.)

Under the name of *Promicrops itaiara* I described the upper jaw and palate of *Epinephelus lanceolatus* Bloch. and illustrated the lateral aspect of the cranium.[3] The correction in the name is adopted from McCulloch.[4]

It is not proposed to repeat the description of the palate and upper jaw; the outline drawing provided is sufficient for all present purposes. The detailed descriptions of the cranium and component bones which follows is founded on the same material that was used in 1922; it comprises a very fine complete skull prepared from a fish weighing 62 pounds, which I had the pleasure of catching on a hand line myself, and the completely disarticulated skull of a slightly smaller specimen captured at the same time by another member of our party off the Great Barrier Reef near Gladstone in Queensland.

The general shape of the cranium is well shown in the drawings.

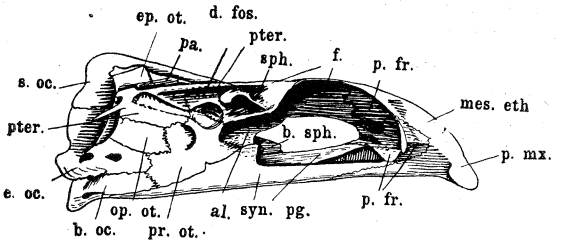

Fig. 4. *Epinephelus lanceolatus* Bloch.

[3] Kesteven.—Journ. Anat., lvi, 1922, p. 308, figs. 1-4.
[4] McCulloch.—The Australian Zoologist, ii, 2, 1921, p. 55 [*or* Check List of the Fishes . . . of New South Wales, 1922, p. 45].

CRANIUM.

The *Supraoccipital* appears on the dorsum of the skull as a relatively long narrow bone, coming abruptly to a point in front, where it sutures with the frontals, tapering slowly to a point behind, where it projects well beyond the hinder limit of the other bones on the dorsum of the skull, to form the supraoccipital crest.

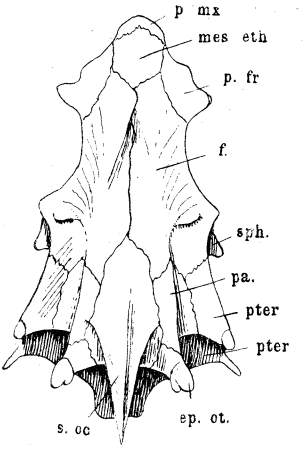

Fig. 5. *Epinephelus lanceolatus* Bloch.

The crest is fairly deep and its free edge drops nearly vertically to meet both exoccoipitals above the foramen magnum; these latter bones meet one another in an extensive suture, and along their dorsal edges provide a sulcus for the ventral edge of the occipital crest. On either side of the crest near its dorsal edge there is a narrow horizontal flange, which, widening as it passes forward, gains attachment to the dorsum of the body of the bone towards its hinder border; it is the presence of these two flanges that enables one to describe the bone as tapering slowly behind. A sharp ridge runs down the centre of the dorsum of the bone; low anteriorly it becomes more elevated behind and becomes the crest beyond the body of the bone.

The under surface of the body of the bone occupies the centre of the cranial ceiling posteriorly. A little in front of the centre of its length a small pocket with an arcuate margin is found to constitute the hinder boundary of a shallow depressed area in the middle of the width of the bone; this area is continued forward on to the frontals, and corresponds with the area described as covered with cartilage on the ceiling of the cranial cavity of *Pterygotrigla*.[5] In that case, however, the cartilage covered area

[5] Kesteven.—*Loc. cit.*, p. 220.

was confined to the frontals, in this the cartilage extends back to fill the pocket described above on the under surface of the supra-occipital. The supraoccipital bone sutures with the exoccipital, the epiotic, parietal, and frontal bones.

The *Epiotic* bone is wedged in between the supraoccipital, parietal, pterotic, and exoccipital bones. The body of the bone bears some resemblance to a low four-sided pyramid, hollowed on the inner side. The articular facet for the upper arm of the supratemporal is borne on a short stout ridge, which crosses the dorsum of the bone from before backward and slightly outward, and on the upper edge of a strong flange of bone which stands out from the postero-lateral angle of the bone; the postero-dorsal angle of the bone is also developed into a strong ridge for the further support of the inner side of the facet. The cavity is apparently entirely otocranial, and the bony posterior semicircular canal is to be found in the posterior angle thereof separated from the general cavity of the bone by a thin bony partition; superiorly this canal opens into the general cavity, inferiorly it is continued in a somewhat similar canal in the exoccipital bone. In a dorsal view of the skull little of this bone except the epiotic process and its two solid struts is to be seen; in a posterior view of the skull the body of the bone is visible between the vertical flange of the process and the supraoccipital bone, whilst in a lateral view, with the pterotic bone removed, a nearly correct idea of the size of the body can be obtained.

The *Exoccipital* bone is of quite irregular shape. The exoccipital condyle is of the usual form and is surmounted anteriorly by the vertical lamina. This lamina forms the side wall of the cranial cavity in its posterior portion and meets its fellow of the other side above the foramen magnum and along the posterior segment of the cranial ceiling. The laminæ do not meet one another in linear suture dorsally as in the other forms described, but fairly extensive areas on the median surfaces of the two bones are in contact; these areas are composed of open cancellous bone, and are united by cartilage. In front of the condyle and in front of and below the lamina, an irregular otic mass of the exoccipital bone contributes to the formation of neurocrane and otocrane. Immediately to the inner side of the condyle a stout narrow horizontal lamina projects medially to meet its fellow of the other side and forms the postotic floor of the cranial cavity; proceeding forward the floor widens slightly as the side wall recedes from the centre line till the spino-occipital foramen is reached. From this point the inferior margin of the vertical lamina rises dorsally and arches towards the centre. Between the lower margin of the vertical lamina and the lateral edge of the floor there is a triangular area which looks upward and inward. The apex of the triangle is at the spino-occipital foramen, at the antero-ventral

angle is the vago-glossopharyngeal foramen. The triangular area itself is composed of a thin lamina of bone which separates the cranial from the otic cavity, and forms the outer wall of the bony compartment for the posterior semicircular canal, which latter communicates when in position with the segment of that compartment lodged in the epiotic bone. Lateral to this compartment the remainder of the otic mass of the bone, of irregular shape, contributes to the formation of the outer wall of the otocrane and the compartment for the horizontal semicircular canal. To the inner side of the triangular area the horizontal lamina forms the floor of the cranium and also the roof of the cavum sacculi. There is a pit, the azygos sinus, in the floor of the cranial cavity between the two spino-occipital foramina; in this situation the inter-exoccipital suture is interrupted by a cordate gap. This gap is the opening of the sinus, which extends down through the exoccipital bones into the basioccipital; the long axis is directed down and back and ends in a blind point immediately in front of the depth of the basioccipital condyle. Very definitely there is no communication with the hollow of the condyle. I have not the material in the flesh to investigate the contents of this peculiar little pit, but suggest that it may be that it is in some way related to the fore end of the notochord. Below the level of the cranial floor the inferior lamina forms the upper outer wall of the hinder half of the cavum sacculi. The buttress of the neural facet is short and stout.

The paramyodomial *Basioccipital* bone presents the typical condylar facet posteriorly, and has in front thereof a triangular body, which is excavated dorsally on either side of the mid-line for the lodgment of the lower portions of the two cava sacculi, and ventrally along the mid-line to form the hinder end of the myodome. The two saccular cavities are widely open dorsally, whilst the myodomial cavity is closed on all sides and ends in a blind point about the centre of the length of the bone. A thin lamina of bone surmounts the length of the upper surface of the myodomial ridge and articulates with the two exoccipital bones, separating the two saccular cavities. Posteriorly this lamina develops horizontal flanges which form the floor of the azygos sinus.

The *Parietal* is a nearly triangular bone lying between the supraoccipital to the inner side, the pterotic and sphenotic to the outer side, the epiotic behind it, and the frontal in front. For the most part it is flat, but there is a narrow down-turned flange suturing with the epiotic. A forward continuation of the superior ridge of the epiotic process runs along the length of the dorsum of the parietal bone as a low ridge and is continued along the frontal in front of it.

The *Pterotic* bone may be described as composed of a body, pterotic process, and anterior process. The body is of a flattened

pyramidal shape; its cavity is apparently for the lodgment of the horizontal semicircular canal and its ampulla. The anterior process is a flange of bone, which is thrown across the sphenotic to suture with the frontal as in *Pagrosomus;* posteriorly this anterior process becomes the pterotic process, and is continued medially and downward behind the body of the bone as a broad flange terminating at the postero-median and ventral corner of the body. Immediately behind and below the pterotic articular facet there is a spur, developed from the upper end of the flange, which stands out and back under the dorso-lateral arm of the supratemporal bone.

The *Opisthotic* bone is a squame which overlies the suture between the pterotic and exoccipital on the side of the skull and portions of the sutures of the pterotic and exoccipital with the prootic. Immediately beneath the pterotic process the opisthotic bears an articular facet for the attachment of the ventral arm of the supratemporal bone.

The *Prootic* bone is quite irregular and its shape must be gathered from the drawings. On the external surface a fairly broad lamina forms an outer wall to the trigemino-facial chamber, leaving anterior and posterior openings. The inner side of the bone is even more irregular than the exterior and more difficult of description. The horizontal lamina which forms the anterior moiety of the cranial floor and myodome roof is readily recognisable and may be used as the starting point of our description. Below, this myodomial wing forms the outer wall and floor of the anterior part of the myodome; this does not reach its fellow of the opposite side, but sutures with a ridge on the dorsal surface of the synpterygoid. To the outer side of the cranial floor there are several recesses in the body of the bone; of these the largest is the anterior portion of the cavum sacculi, which extends below and behind the horizontal lamina, there being a gap here between the exoccipital and prootic components of the cranial floor, except in the mid-line where the two infero-median walls of the cava sacculi meet at floor level. Lateral to the preotic cranial floor there is a recess with honeycombed walls, the trigemino-facial fossa; its wall is perforated by three foramina for the exit of the trigeminal and facial nerve trunks, and it probably lodges the ganglia of those nerves. Above the level of this last recess and also behind it there are four otocranial recesses. The prootic bone sutures with the synpterygoid, basisphenoid, alisphenoid, sphenethmoid, pterotic, opisthotic, exoccipital, and basioccipital bones. Immediately to the inner side of the trigemino-facial fossa is a foramen, probably the oculomotor foramen.

The *Sphenotic* appears to have the post-frontal fused with it; it lodges part of the anterior semicircular canal, sutures with the alisphenoid, frontal, pterotic and prootic. Where the bone sutures

with the prootic it forms the upper half of the anterior facet for the articulation of the hyomandibular.

The *Alisphenoid* sutures with sphenotic, prootic, synterygoid, and frontal bones; a flat bone placed diagonally in the wall of the cranium antero-superiorly, it bears a small flange, the pterygoid process, close to its inferior edge, which projects down and out to suture with the prootic and synpterygoid; this suture is interrupted by a foramen, which either gives access to a vein entering, or egress to a nerve leaving, the trigemino-facial chamber in the prootic bone.

The *Basisphenoid* is of the usual form and calls for no further comment.

The *Synpterygoid* bone is broad behind, where it underlies the prootic bones and forms the median portion of the floor of the myodome; in front of the prootic bones there is an alisphenoid process on either side which strongly resembles that of *Platycephalus,* and, like that, serves as the anterior part of the floor of the myodome. In front of the alisphenoid processes the bone narrows rapidly and bears a vomerine dorsal lamina; the vertical limb of the basisphenoid sutures with the hinder end of this lamina, and anteriorly median, backwardly projecting spurs of the prefrontals suture with it. The palatine plate of the premaxilla is applied to the under surface of the anterior one-third of the bone.

The form and situation of the *Frontal* is adequately shown in the drawings.

The *Prefrontal* bone is antero-posteriorly flattened, concave behind and convex in front; from the median border there is given off a backwardly projecting boss, which divides into superior and inferior processes. The upper sutures with the frontal, the lower with the anterior end of the vomerine lamina of the synpterygoid. A deep sinus separates the superior process from a smaller process just above it; the olfactory peduncle passes forward to the nasal chamber through the sinuation enclosed in the cartilage which fills the spaces between the bones in this situation. Immediately to the outer side of the sinus the bone is perforated for the passage of a terminal branch of the superficial ophthalmic nerve. To the outer side of this foramen, in front, there is the superior condyle for the articulation of the maxilla; the inferior condyle is situated below, behind, and to the inner side of the superior. The infero-lateral corner of the bone bears a facet for the attachment of the first subocular bone. The prefrontal bone sutures with the frontal, mesethmoid, premaxilla, and synpterygoid, and articulates by amphiarthroses with the maxilla and first subocular bone. The two bones meet one another in a short median suture above the fore end of the synpterygoid; above this interprefrontal suture there is a considerable space between these two bones on either

side, the frontals above, the mesethmoid in front, and the premaxilla below, filled with hyaline cartilage in the fresh state; the cavity in question extends forward into the premaxilla, as also does the filling of cartilage.

The *Mesethmoid* bone presents a strong ridge down the centre of the sloping anterior face and a level triangular area between the anterior ends of the frontal bones.

The *Premaxilla* presents an anterior sloping surface which continues the mesethmoid plane and central ridge; the latter, however, ceases before the inferior margin of the bone is reached, and below it the surface of the bone is evenly rounded. Inferiorly the bone bears teeth on an arcuate area in front; behind that area the surface of the bone lifts. The palatine process is strongly convex and tapers to a terminal point.

CIRCUMORBITAL BONES.

The form of these is shown in the little sketch of the lateral aspect of the orbit (Fig. 6); the second suborbital carries a large internal lamina supporting the globe of the eye, as in *Girella* and other Sparids.

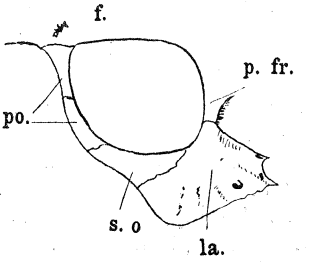

Fig. 6. *Epinephelus lanceolatus* Bloch.

THE CRANIAL BOUNDARIES AND THE OTOCRANE.

(Fig. 7.)

In the region of the exoccipital bones the cranial walls are complete except for the azygos sinus already described. In front of this bone the cranial walls and floor are formed by the membranous inner walls of the otocrane and the roof of the cava sacculorum where they are in contact beneath the brain case (lateral and basicranial obturator membranes).

The outer wall of the otocrane as viewed from within presents seven recesses; of these the most posterior is in the exoccipital bone. Its opening is directly above the vago-glossopharyngeal foramen (ix, x) and is a deep conical pit which extends back almost to the spino-occipital foramen (xi, xii). Immediately within the pit are two apertures of the incomplete bony semicircular canals; that for the posterior semicircular canal (P.c.) is in the roof, and the canal itself can be followed as it curves upward on the surface of the epiotic bone, to open close to the roof. The posterior aperture of the horizontal canal lies just below the lower opening of the other (H.c.). The canal itself is situated entirely

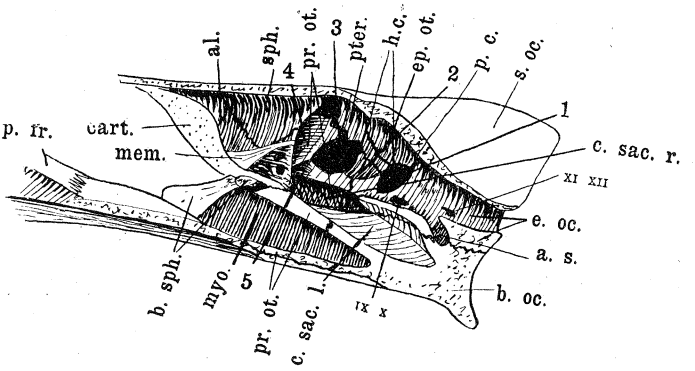

Fig. 7. *Epinephelus lanceolatus* Bloch.

in the pterotic bone; its anterior opening will be found in the upper part of the recess No. 3. The second recess is very similar to the first but smaller, and, like it, extends back in the substance of the exoccipital bone beneath No. 1. It opens on to a shallow fossa (2) crossed by the suture between the exoccipital and prootic bones.

The third recess (3) as depicted in the drawing, lies in the upper part of the prootic, but almost as large a portion of the recess extends up into the pterotic, and is hidden from view. The fourth recess (4) is the arcuate fossa; it lies in the prootic below and the sphenotic above and anteriorly; this is the largest recess of all and as far as my material allows me to judge, it contains nothing but fatty connective tissue. The fifth is a small

recess in the prootic bone below and behind the fourth, really a separated portion of the arcuate fossa; it also, apparently, lodges only fatty tissue. The sixth recess is the cavum sacculi (C. Sac. l., C. Sac. r.). The seventh recess is almost the mirror image of the second, lying in front of the fossa, on to which the second opens, in the prootic bone. Posteriorly the floor, lower half of the lateral, and the whole of the median walls of the saccular recesses are formed by the basioccipital bone, the roof and upper half of the lateral walls by the exoccipital bones. Forward of these bones the recesses are lodged in the periotic bones.

The lateral obturator membrane is attached in front to the vertical anterior margin of the arcuate fossa, from the foot of which its ventral edge passes back to the lower extremity of the posterior margin of the first recess; between these two points of attachment the membrane spreads out horizontally to form the floor of the cranial cavity and roof of the saccular recesses, meeting its fellow of the opposite side in the mid-line, where they combine and give off a vertical partition downward between those two recesses. The attachment of the membrane dorsally appears to be along the outer edge of the epiotic and across the pterotic to the upper end of the anterior margin of the fourth recess.

The trigemino-facial fossa lies in front of the arcuate fossa. The foramina for the fifth and seventh nerves are towards the upper outer corner, and the oculomotor foramen lies to the inner side of these at a lower level.

In the fresh state a strong band of fibrous tissue extends across the cranial cavity from the upper and outer corner of one trigemino-facial fossa to the other, and the optic foramen lies below the middle of this band, between it and the middle of the basisphenoid bone. Immediately behind the body of the basisphenoid there is a small gap in the floor between that bone and the fore ends of the prootic bones; this is the pituitary fontanelle. Above the band of fibrous tissue, the space between the alisphenoids, basisphenoid, and frontal bones is filled by a thick mass of hyaline cartilage, permeated, however, on its lower face by a layer of tough fibres. This lower layer of fibro-cartilage may be described as derived from the fibro-cartilaginous inter-orbital septum, which splits into right and left halves where it meets the hyaline cartilage, each half becoming strongly reinforced by additional fibres.

There is a foramen in exactly the position of that which Allis[6] terms the internal carotid foramen in *Scomber* between the

[6] Allis.—Journ. Morphol., xviii, 1903, p. 91.

synpterygoid and the prootic, and there is also a foramen in the situation of that which he terms the abducent foramen, and I believe that I have located the trochlearis foramen above the transverse band of fibrous tissue between the alisphenoid and the hyaline cartilage, just as he describes and figures it.

Epinephelus merra *Bloch.*

The possession of one small complete skull of this species enables me to state that it resembles in all essential respects the previous species.

Other Serranids which I have been able to examine include *Acanthistius serratus* Cuv. and Val., and *Callanthias allporti* Gthr., and their resemblance to *Epinephelus* is such that that they do not call for separate description.

Oligorus.

(Figs. 8-10.)

My material for the study of the skull of this genus consists of a complete skull and a cranium of *Oligorus macquariensis* Cuv. and Val. Since I have been able to partially disarticulate the cranium, the illustration of the skull is undertaken with confidence; both the specimens are from young fish, but there is no reason to doubt that they present all the features of the adult skull.

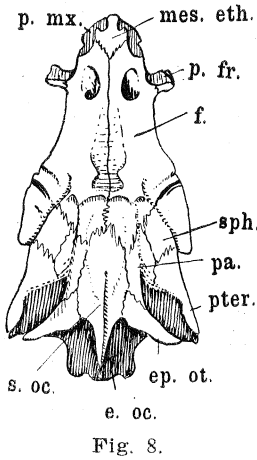

Fig. 8.

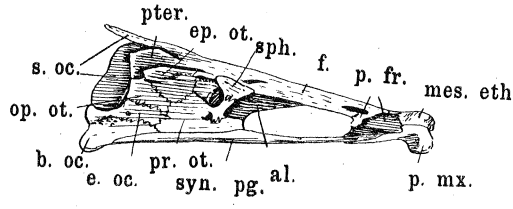

Fig. 9.

Oligorus macquariense Cuv. and Val.

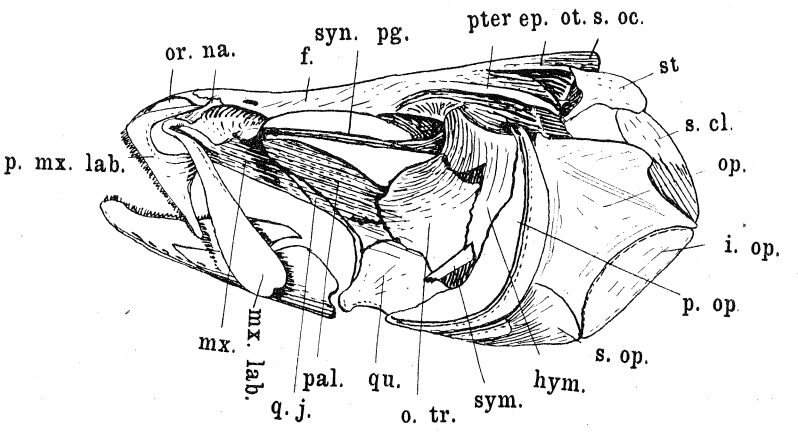

Fig. 10. *Oligorus macquariense* Cuv. and Val.

The resemblance of this skull and of its related arches to *Epinephelus lanceolatus* is in all respects so close that it does not call for separate description.

Cheilodactylus.

(Figs. 11-16.)

My material for the study of this genus is a single complete skull of *C. spectabilis* Hutton. Though I have not risked its destruction by endeavouring to disarticulate it, I have removed the visceral bones as the description progressed, and have divided the cranium with a fine saw in the sagittal plane so as to examine the interior of the cranial cavity.

The skull proper in its contours bears a general resemblance to that of *Sparus,* but it is deeper from above down. Lateral and posterior outlines are shown in the drawings. From above

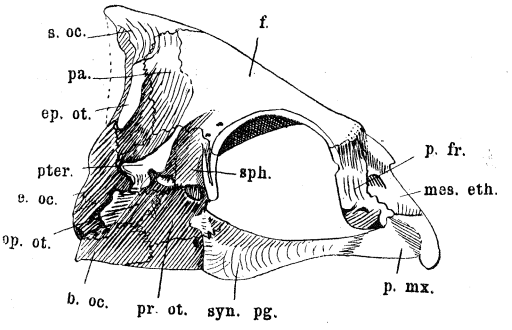

Fig. 11. *Cheilodactylus spectabilis* Hutton.

the cranial outline is quadrilateral with epiotic, pterotic, and sphenotic ridges standing well out. The quadrilateral outline of the cranium is continued forward in the inter-orbital region. In front of the prefrontal bones there is a sudden constriction: the outline tapers to the premaxilla, which is squarely truncated in front.

THE CRANIUM.

The *Supraoccipital* is a roughly pyramidal bone, the laterally flattened apex of which is the occipital crest. The dorsal line of the crest is continuous with that of the skull, so that the crest stands out posteriorly only; it is short and stout. Below the crest a thin lamina is continued down to the ventral limit of the bone. There is reason to believe that a straight line drawn from the extremity of the crest to the lower limit of the bone would coincide with the true posterior limit of this lamina. In my specimen it is imperfect, the dotted line (Fig. 11) indicating its assumed true extent. The body of the bone is more massive than is general, the portion which forms the posterior moiety of the roof being particularly thick, whilst the portions which form the contiguous side walls of the cavity are only a little less substantial. The lamina which forms the upper part of the posterior wall of the cranial cavity is a good deal thinner than the rest of the bone. The supraoccipital articulates with the frontal, parietal, pterotic, and epiotic bones.

The *Epiotic* is an irregular concavo-convex bone the concave face being, of course, internal. The external surface presents both posteriorly and laterally. The posterior laminæ meet in the median sagittal plane, separating the supraoccipital from the exoccipital bones. As seen from without this contact is nearly hidden by a median downward projecting spur of the supraoccipital which overlies most of the contact (in the drawing, Fig. 12, this spur has been omitted so as to show the full length of the contact). Viewed from within, the contact is found to be a synchondrosis, the strip of cartilage being wider below than above. The cartilage, however, does not extend through the full thickness of the suture; it is rather as though the little fissure had been "tuck-pointed" from within. This tuck-pointing has been continued right round the periphery of the epiotic, gives off short branches which extend between the prootic and opisthotic and between the opisthotic and exoccipital, and it acquires both breadth and depth of surface at the point of contact of the exoccipitals and epiotic bones in the mid-line. The epiotic bone forms the middle third of the posterior wall of the cranial cavity and an equal extent of the side wall at the same level. At the junction of the posterior and lateral external surfaces, the bone is produced into a prominent ridge, the epiotic process. This ridge commences on the parietal and is crossed near its upper limit by the suture between the

two bones. The cavity of the bone may be likened to the cast of a very flat cone, almost symmetrical. At the apex of the cavity there is situated the upper end of the bony canal for the posterior semicircular membranous canal; the lower end of this canal will be found perforating the cartilaginous tuck-pointing at the lower periphery of the bone.

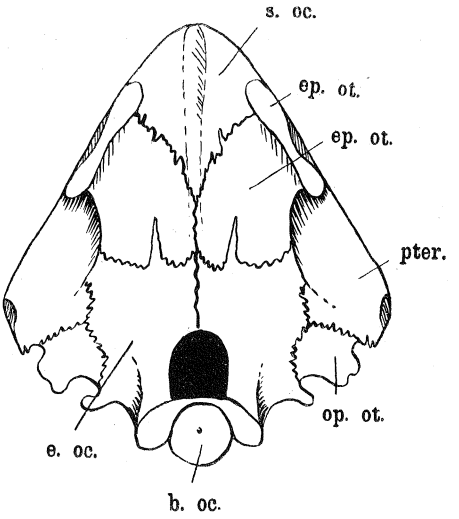

Fig. 12. *Cheilodactylus spectabilis* Hutton.

The *Exoccipital* bone presents the usual neural facet and superior vertical lamina and a quite small inferior vertical lamina. The extent of the superior vertical lamina is greater than usual, whilst the bone might appear to have invaded the side of the skull below the buttress only to place the nerve foramina in their correct situation. The superior vertical laminæ together surround the foramen magnum, meeting one another in the mid-line both above and below it. Contiguous to the foramen each lamina provides back and side walls to the cranial cavity and merges with the reduced otic mass which forms the median wall to the posterior cavum ampullæ. The lamina also provides the hinder wall of this cavum. As is usual the two exoccipital bones provide the hinder portion of the floor of the cranial cavity. Immediately in front of the anterior margin of this horizontal lamina the apparent floor of the cavity dips downward to the horizontal laminæ of the prootic bones. The spino-occipital foramen pierces the bone in the angle between the horizontal and superior vertical laminæ immediately within the foramen magnum, to appear on the outside on the side of the buttress of the neural facet. The vagus foramen pierces the bone in the same angle a little farther forward, and

appears on the outside just in front of the buttress. The small glosso-pharyngeal foramen is present immediately in front of the last. The azygos sinus is entirely devoid of roofing.

The hypomyodomial *Basioccipital* is, as usual in this type, laterally compressed, and the two cava sacculi are placed for the most part above the level of the hinder end of the myodome.

The *Opisthotic* is an irregular bone, which presents on the side of the skull below the pterotic process as a stout lamina of bone continuing that process downward; it also contributes to the side wall of the skull a small area in front of the vertical lamina of the exoccipital.

The *Sphenotic* bone presents on the outside of the skull as an outstanding postorbital process; closer examination discovers medial to this a quite appreciable postorbital surface which sutures with the postorbital lamina of the frontal, the alisphenoid, and prootic bones. It is flush with these bones, and with them makes a postorbital wall which is more extensive than is usual. Besides the postorbital surface there is also a temporal surface which contributes largely to the formation of the floor of the external temporal fossa. The postorbital process calls for further description. It is a laterally compressed lamina attached by its anterior margin to the outer edge of the postorbital surface. Broader below than above, it is slightly concave on its outer aspect at the lower end, this concavity being converted into a narrow trench as the upper end is reached. From the top end of this trench the otic canal passes down, inward and slightly forward to open near the centre of the postorbital surface, above and to the outer side of the anterior opening of the trigemino-facial foramen. The bone also contributes the upper half to the formation of the anterior facet for the hyomandibular, the suture between the prootic and this bone passing across the centre of the depth of that facet. Within the cranium the sphenotic appears as a roughly pyramidal hollow, above and in front of the opisthotic, which is crossed from above down and forward by a thin lamina of bone which divides its cavity approximately into two halves; of these the upper and anterior half is the internal temporal and the lower half is the arcuate fossa.

The *Prootics* present the salient features of these bones throughout the Teleostomi. They form the roof, side wall, and part of the floor of the myodome, the floors and part of the side walls of the cava sacculi, lodge the trigemino-facial ganglionic complex in the similarly named fossa, and form the cranial floor immediately behind the pituitary fossa. Externally the bone presents a myodomial wing and a postorbital surface. On the latter surface the foramina from the trigemino-facial fossa are recognisable on sight. Below these a spur of the bone extends downward to suture with an upthrown flange of the synpterygoid. To the inner side of

the trigemino-facial foramen is the abducent, and above that is the trochlearis foramen, perforating the alisphenoid bone. An antero-posteriorly flattened arch is thrown across over the V-VII foramen and is continued down, to suture with a similar, but thinner flange of the synpterygoid, thus forming the outer wall of the trigemino-facial chamber. The arch in question gives to the V-VII foramen the appearance of having anterior and posterior openings.

The *Pterotic* is an irregular compressed and dorso-ventrally elongated bone which presents on the lateral aspect of the skull to a much greater extent than it does internally. In this latter situation it appears as the deep conical cavity which lodges the ampulla of the horizontal membranous canal, and as the roof, anterior wall, and upper part of the posterior wall of the posterior ampullary cavity. The horizontal membranous canal is lodged in a bony canal which connects the depths of these two cavities. Above the middle ampullary cavity, between the epiotic and sphenotic bones, the pterotic is covered internally by cartilage.

Externally the pterotic bone presents a ridge which forms the posterior boundary of the temporal fossa. This ridge begins at the lower corner of an elevated triangular area at the postero-lateral angle of the frontal, where the suture between the frontal and pterotic marks the upper limit of the latter bone. At its lower end the ridge becomes swollen, and bears, almost at its antero-inferior corner, a tubercle for the posterior hyomandibular joint, and behind and a little above that the little cup-like facet for the articular head of the operculum. On either side of the ridge the epiotic contributes to the floors of the lateral and middle temporal fossæ.

The *Parietal* bone extends through the whole thickness of the skull. On the outer surface it appears as an irregular area behind the frontal, suturing with that bone and with the pterotic, epiotic, and supraoccipital. Internally it appears as a small area between the epiotic, supraoccipital, frontal, sphenotic, and the cartilage-covered portion of the pterotic.

The body of the *Basisphenoid* is peculiar in being in the vertical plane. It appears as a small stout forward wall to the pituitary fossa, articulating on either side with the alisphenoid and the inner edge of that spur of the prootic which extends down to suture with the synpterygoid. It is separated from the horizontal laminæ of the prootic bones by the pituitary fontanelle. The descending lamina of the bone is broadest above, with a peculiar little hook at the upper end just below its attachment to the body.

The *Alisphenoid* is a more extensive bone than usual; it contributes largely to the well developed postorbital previously noted. It sutures with frontal, parietal, sphenotic, prootic, and basi-sphenoid bones.

The *Frontal, Prefrontal,* the *Mesethmoid* and *Premaxilla,* are all so essentially similar to the same bones in *Epinephelus* that they do not call for separate description.

The *Sympterygoid* is so similar to that of forms already described that it may be dismissed with brief comment on the fact that ventrally it is markedly compressed from side to side and, as it were, squeezed into a keel. Mention should again be made of the vertical flange which crosses the bone below the arch over the V-VII foramen.

The *Nasals* are elongated spatulate bones firmly attached by fibrous tissue and fibro-cartilage to the mesethmoid and prefrontal bones at the proximal end, and standing out above the premaxilla, above, medial, and parallel to the upper edge of the first suborbital bone.

RECESSES.

The *Dilatator fossa* is very much larger and better defined, that is, more obviously defined, than usual. The lower boundary is the upper edge of the hyomandibular bone, when that is in position. When the hyomandibular is removed, the lower boundary is only a little less obvious. It is defined by the anterior facet and posterior tubercle for the two hyomandibular articulations and a ridge which joins these two articular structures. The anterior boundary is the postorbital ridge of the sphenotic bone, and the posterior boundary is the pterotic process. These two processes meet above; the latter, inclining forward, is continued to the former by the lower anterior edge of the raised triangular area on the frontal to meet the upper end of the postorbital process.

The *Temporal fossa* is bounded in front by the pterotic process and the outstanding flange of the opisthotic; posteriorly it is bounded by the epiotic process. A thickening of the parietal swings forward from the upper end of the epiotic process to meet the upper end of the posterior edge of the raised triangular area of the frontal, and this in turn is continued down to meet the upper end of the pterotic process.

The limits of the *Occipital fossa* are rather indicated than defined by the epiotic process and the vertical lamina of the occipital crest.

THE CRANIAL BOUNDARIES AND THE OTOCRANE.

The floor of the cranial cavity is raised at an angle of about forty-five degrees from the plane of the base line of the sympterygoid; this gives to the cavity an appearance of greater depth than usual. The floor within the foramen magnum is formed by the two exoccipital bones; the portion so formed is short and is per-

forated by the azygos sinus. Almost immediately forward of the sinus the exoccipital bones terminate, and there is a sharp dip to the horizontal laminæ of the prootic bones. From this point the floor rises evenly till the pituitary fontanelle is reached; in front of the fontanelle the basisphenoidal component of the floor rises vertically for a short distance. In front of this bone the median cranial flooring is provided by the spheno-obturator membrane.

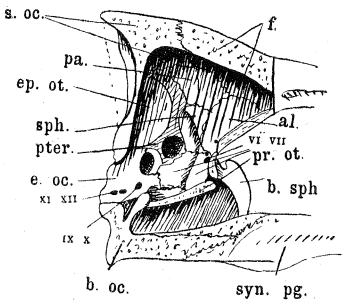

Fig. 13. *Cheilodactylus spectabilis* Hutton.

Behind the pituitary fontanelle the cranial floor appears to be wider than farther back; it is carried out on the anterior portion of the horizontal lamina of the prootic to the trigemino-facial fossa. The hinder wall of this fossa is a lamina of bone which continues downward that which has been described above as dividing the cavity of the sphenotic bone into two halves. From the median end of this bone a very slight ridge crosses the cranial floor to the median end of the opposite lamina. This ridge is of importance; to it there is attached, in the flesh, the anterior margin of a horizontal membrane whose posterior margin is attached to the anterior free edges of the exoccipital bone. The membrane forms the floor of the cranial cavity in this region and the roofs of the contiguous cava sacculi. The two saccular cavities are separated one from the other by a narrow vertical membrane which is attached above to that just described and below to the line of suture between the two prootic bones. The flooring membrane is not attached at the sides, but, curving upward, it extends both back and forward to form the inner wall of the otocrane. Its posterior margin is attached below to the exoccipital bone in front of the X foramen and behind the posterior ampullary cavity; passing higher it finds attachment around the periphery of the epiotic bone. It apparently did not reach quite to the roof of the cranial cavity, but passing down from the height of the epiotic it crossed the ribbon of cartilage between that bone and the parietal to reach the lamina which divides the cavity of the sphenotic; down this its

anterior margin is attached to the ridge on the horizontal lamina of the prootic with which we started.

The location of the posterior and horizontal membranous canals and their ampullæ has already been described. It would appear that the anterior membranous canal was lodged in the posterior cavity of the sphenotic and the groove below it formed by the descending lamina, the ampulla probably lying at the bottom of that groove.

The large size of the alisphenoid makes for a very complete anterior wall to the cranial cavity, and a much reduced sphenotic obturator membrane, the whole recalling strongly the anterior wall of a bird's skull.

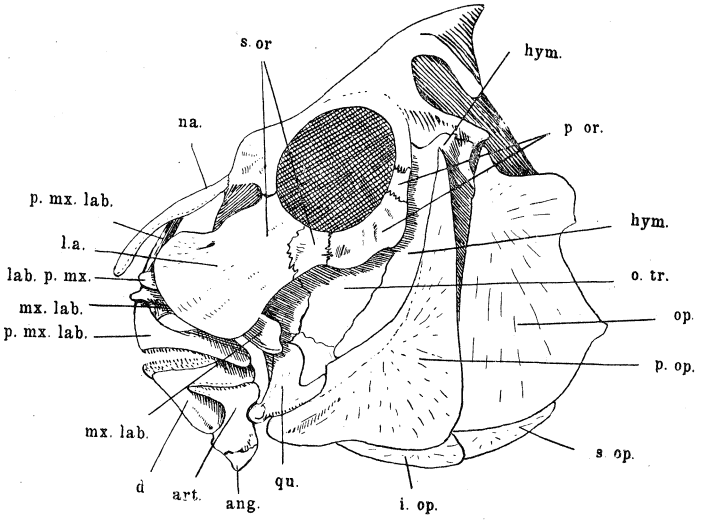

Fig. 14. *Cheilodactylus spectabilis* Hutton.

CIRCUM-ORBITAL BONES.

These are four in number. The anterior is very much larger than any of the others and extends well forward, overlapping the labial bones and forming a side wall to the nasal cavity. The second suborbital is similar to the two postorbital scutes. The form and arrangement of these bones recall that of *Epinephelus,* though in that form the first suborbital is not so large.

UPPER JAW AND PALATE.

The hyomandibular articulation is peculiar in that the posterior articulation is double. The usual two tubercles are present for articulation with the two facets on the skull, but, in addition,

there is developed immediately behind the posterior tubercle a well defined cup for articulation with an equally well developed tubercle on the lower end of the pterotic process (trinarticulate hyomandibular). All these articulations are lined by hyaline cartilage.

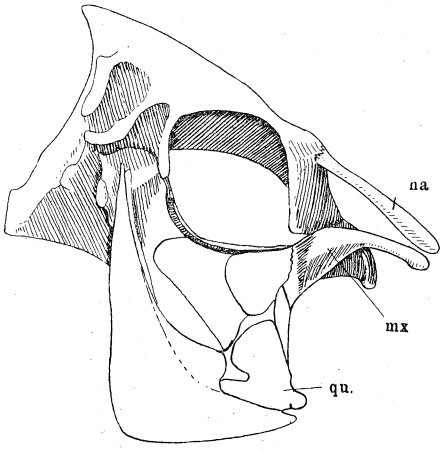

Fig. 15. *Cheilodactylus spectabilis* Hutton.

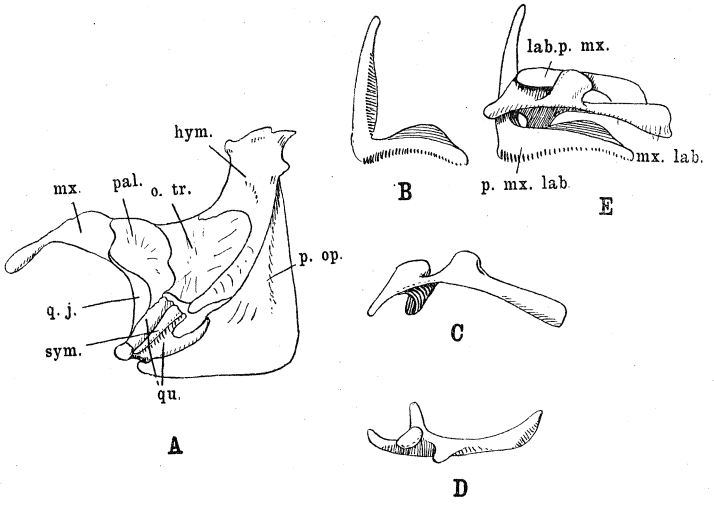

Fig. 16. *Cheilodactylus spectabilis* Hutton.

The remaining bones of the upper jaw and palate are in all essentials similar to those of *Epinephelus*, and as their form and relations to one another are fully shown in the drawings, they may be dismissed without further comment, beyond remarking that as in that genus the maxilla is monobisartete.

In the preceding pages three Percomorph skulls have been described in some detail, and one other is illustrated without description. In addition to these there are in my collection skulls from over thirty other Percomorph genera. Examination of these shows that they do not differ from those described in any essential details that cannot be adequately explained in a brief review, comparing them with those described.

It will facilitate this comparative review if types of reference be established at the outset.

(1) The *Sparid* type is exemplified in *Pagrosomus*, but that form is peculiar in the possession of the tremendous occipital and fused frontal mass. This type is laterally compressed and dorso-ventrally lengthened. With the bones of the upper jaw, palate, suspensorium, and lower jaw in place, it has the same general appearance as that of *Cheilodactylus*. Viewed from below, the bones of the visceral skeleton are all seen practically edge on. The occipital segment of the cranial cavity is constricted, though not so much as in the Serranid type. The basioccipital bone is hypomyodomial. The maxilla is monobisartete and the hyomandibular is binarticulate. The myodome is large and open below posteriorly.

(2) The *Girella* type is very similar to the last, but the skull itself is more rounded as viewed either from in front or behind. The basioccipital bone is paramyodomial.

(3) The *Cheilodactylid* type differs from the Sparid in that the occipital segment of the cranial cavity is not constricted, and correlated with this the posterior wall of the skull occupies more nearly the transverse plane, whilst that of the previous types slopes forward rather more than it spreads laterally.

(4) In the *Serranid* type we have the Girella type of skull proper elongated antero-posteriorly, and the visceral skeleton so spread out that, viewed from below, all the component bones are to be seen almost in full face. The basioccipital is paramyodomial; whereas in the preceding types the synpterygoid is keeled below, in this it is flat.

(5) The *Sphyræna* type of skull resembles the Serranid in contours, but there is a very marked elongation of the ethmo-nasal region of the skull, as it were a step half way to the Esox type of cranium, and as in *Esox* the maxilla is dibisartete.

Glyphisodon.—Sparid type, branchial tubercle well developed.

Achærodus.—Girella type.

Lutjanus.—Serranid type.

Etelis.—Serranid type, but the orbits are particularly large and the maxilla is dibisartete.

Scomber.—Girella type.

Sparus.—Naturally a Sparid type, but my particular species has a small boss at the base of the occipital bone which is not constantly present in *Sparus* itself and not typical of the "type" as here understood.

Sphyrena.—Sphyrenid type; the dilatator fossa is open to the orbit and the postorbital bone reduced to a splint, placed along the outer side of the fossa, and continuing downward and back the orbital margin. The labial process of the maxilla is short.

Alectis.—Sparid type; the occipital crest is continued forward to the mesethmoid bone by a frontal crest. The hyomandibular is binarticulate but almost plenarticulate. I have but one, rather poor, young skull for study of this form, and there is a hiatus in the roof of the cranium above the pterotic crest, between the parietal, pterotic, and frontal bones, and further, it appears that this form is monartete, but I am doubtful of this observation. The resemblance of this skull to the other two Carangidæ is such that I think the observed differences are due to the age and poor state of preservation of the specimen.

Caranx and *Ulua* are essentially similar to the last, differing only in the absence of the hiatus in the roof, and in the fact that the maxilla is monobisartete. Such is the resemblance of these three Carangids one to the other that I am tempted to establish a Carangid type, which would occupy a position between the Girella and Sparid types.

Percalates.—Girella type.

Cœsioperca.—Serrandid type.

Helotes.—Girella type. Apparently monartete to trabecula cornu, but I have but a single young skull and do not trust the observation.

Scolopsis.—Girella type.

Priacanthus.—Girella type.

Therapon.—One very young skull, apparently serranid in type.

Pentapus.—Here again I have but one quite small skull; it is apparently of Girella type.

Nemipterus.—Sparid type.

Upeneus and *Upenichthys* resemble one another and may be said to present a Mullid type. This is intermediate between the Serranid and Sphyrenid types, and, as in the latter, the maxilla is dibisartete. The ethmo-nasal region is longer than in the Serranid, but shorter than in the Sphyrenid.

Crinodus, Platax, Dactylophorus are Cheilodactylid in type.

I have also material for the study of *Scatophagus, Psettus, Teuthis* and *Drepane,* but these differ from those already dealt with to an extent that calls for more detailed description. I may, however, state that if those already dealt with may be deemed typical Percomorph skulls, *Drepane* and *Scatophagus* may not, whilst the skulls of *Teuthis* and *Psettus* present a closer approximation to the typical form.

I hope to describe these four forms at a later date.