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# CONTRIBUTIONS TO THE CRANIAL OSTEOLOGY OF THE FISHES.

## Nos. III., IV. and V.

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## No. III. The Teleostome Skull; an Attempt to provide an Ichthyo-craniological Nomenclature.

The several skulls described in these communications were dealt with as they came to hand and not in any prearranged order. As the work progressed, the disability of the want of a recognised terminology for the various skull areas and cavities was increasingly felt. When a number of skulls had been described it was found that similar areas or cavities were not always similarly constituted in the different skulls. Two illustrations may be cited. There are at the back of all the skulls described three muscle fossae on each side. Of these, that which is next the mid-line appears to be constantly related to the most anterior epiaxial capiti-nuchal muscles; the middle fossa on each side appears equally constantly to be developed for the attachment of the anterior hypoaxial capiti-pectoral muscles, whilst the relation of the third fossa to the dilatator operculi muscle gained it the name of *dilatator fossa* from the pen of Sagemehl and Allis.[1] The three fossae are developed in very different degrees and constituted differently in different fish. Again, the various bony recesses for the parts of the auditory organ are not constantly accommodated in the same bones, yet the cavities themselves are constantly recognisable.

To obviate this disability a halt was called in the description of the skulls and the following general description of a fish skull was drawn up. It will be noted that this description is, for the most part, based on the form and constitution of the adult skull, without reference to the nature, covering, or origin of the constituent bones. Where suitable designations have been already used they have been availed of; in the absence of such, topographical terms have been applied in most instances, in preference to anatomical terms which imply relation to soft parts.

### General Description.

The cranium of the bony fishes presents three very readily recognisable regions; placed in line in front of one another, they are the *cerebral*, *orbital*, and *ethmo-nasal* or *preorbital* regions.

The nasal capsules are very incomplete, and the bones related to them are the premaxillae below, the mesethmoid behind, and the nasals above. Usually the premaxillary labial is also related to the capsule,

[1] See papers cited on pages 184 and 186.

and in some forms the anterior suborbital scute and the maxillary labial also share in providing bony protection for the organ. The prefrontal bone commonly shares in forming the hinder wall.

The orbital region is roofed by the frontal bones and is further protected in front and above by the prefrontal. A postfrontal is not commonly developed above behind, and the posterior wall is more or less completed by the anterior bones of the cerebral region. An orbitosphenoid, which may be fused with its fellow of the opposite side, may or may not be developed between the two optic capsules. In the absence of the orbitosphenoid the interorbital septum may be wholly membranous, or partly membranous and partly cartilaginous. Inferiorly the orbital region is strengthened by the synpterygoid, which extends forward under the premaxilla and backward under the basioccipital.

The cerebral region comprises the cavum cerebri and the otocrane. Neither of these capsules are complete, but, as it is the inner wall of the octocrane and a precisely corresponding portion of the outer wall of the cavum cerebri which are wanting, the deficiency is to be seen only from within the cranial cavity. This deficiency may be designated the lateral cranial fenestra. The bones which enter into its formation will be dealt with seriatim later, and we proceed to the description of the general features of this region. The shape of the conjoined cerebral and otic cavities is exceedingly variable; it may be almost cubical, nearly round, or flattened from side to side or dorso-ventrally. An occipital crest is very generally developed along the central dorsal line, projecting beyond the cranium posteriorly. On either side of this crest, in the upper part of the posterior aspect of the cranium, there is always defined an *occipital groove* or *fossa*. The outer boundary of this fossa is usually a ridge or flange developed on the epiotic bone; dorsally this boundary inclines toward the midline, and its real or imaginary continuation thereto constitutes the dorsal limit of the fossa. Inferiorly the fossa may not be defined, or its boundary may, as in *Platycephalus*, be determined by flanges from certain of the bones on the back of the cranium.

Allis[2, 3] has designated this occipital fossa "supra-temporal groove" in *Scomber* and "subquandrangular groove" in *Scorpaena*. Neither of these designations appears happy; the latter is emphatically not of general application, and by no stretch of the imagination could one justify the term supratemporal as applied to the occipital fossa of such forms as *Platycephalus*.

Lateral to the occipital fossa is the *temporal fossa*. The medial boundary of this is the lateral boundary of the other fossa; toward its dorsal limit this boundary inclines forward to meet the dorsal end of the pterotic process, which always forms the anterior or lateral boundary of the temporal fossa. Like the occipital, this fossa may be quite open and undefined below, or may be defined by the development of outstanding flanges of the bones of the back of the cranium.

The designation is here adopted from Allis (l.c.) after Sagemehl.

[2]Allis—Jour. Morph., xviii, 1903, pp. 45-328.
[3]Allis—Zoologica, 1910, Heft. 57, pp. 1-219.

The *dilatator fossa* is another constantly present muscle fossa on the side of the cerebral region of the skull. It will be found between the pterotic process and the posterior wall of the orbit. At times quite a little pit, it may in other forms, for example *Cheilodactylus*, assume a considerable size. Here again my designation is adopted from Allis after Sagemehl. Ridewood[4] termed this the lateral temporal fossa; if a purely topographical term is to be applied, *postorbital* would be preferable.

Turning our attention next to the base of the cerebral portion of the skull, the saccular cavities frequently bulge out so prominently that they call for special designation. They have been termed the "bullæ" by writers on ichthyo-craniology. The term is misleading and needs qualification; if they be designated *saccular bullæ* ambiguity will be avoided.

At the side of the skull the external aperture of the foramen trigemino-facialis is more or less completely covered by a broader or narrower arch of bone. The little cave which is thus formed on the side wall of the skull has been designated the *trigemino-facialis chamber* by Allis, and, though it is extremely doubtful whether all that he claims for the significance and homologies of the feature will stand the test of further examination, the constancy of the structure justifies the retention of his term.

The dorsal and ventral lines of the skull need no definition, but attention must be drawn to the fact that the latter is very frequently not parallel with the basicranial axis, owing to the presence of the myodome below the floor of the cerebral cavity. The ventral plane of the skull, with rare exceptions (for example in *Hippocampus*) corresponds with the axis of the body, and the angle between this line and the basicranial axis would appear to vary without any correlative features, and its variations to be devoid of taxonomic or comparative-morphological significance.

The two facets developed so commonly on the exoccipital bones for articulation with the first neural arch will be designated the *neural facets*.

Within the cranial cavity where are several more or less constantly recurring features which are deserving of recognition with proper names.

The cranial floor presents *occipital, mesotic, preotic*, and *prepituitary* segments. The occipital segment is constituted by the *horizontal* laminae of the exoccipital bones or by the dorsal surface of the basioccipital. The mesotic segment lies between the otic capsules; commonly it presents a more or less extensive *basicranial fenestra* in its posterior portion. This fenestra, when present, is due to the approximation of the cava sacculi to the mid line beneath the cranial cavity, and is made good by a horizontal extension of the membranes which close the lateral fenestrae, *membrana obturator basicranialis*. So much of the mesotic segment of the floor as is bony is constituted by portions of the horizontal laminæ of the prootic bones. The prootic segment of the floor lies in front of the otic capsules and behind the fenestra hypophysios or sella turcica; it is constituted by the anterior median portion of the

[4]Ridewood—Jour. Linn. Soc. (Zool.) xxix, 1905, p. 260.

horizontal laminæ of the prootic bones. The prepituitary segment is constituted by the basisphenoid, when that bone is present.

The *azygos sinus* is a little conical pit very constantly present on the dorsal aspect of the basioccipital bone just in front of the condyle; it is widest above and slopes down and backward to terminate in front of the centre of the depth of the condylar cavity, being separated therefrom by a thin partition of bone only. This pit may be roofed by the horizontal laminæ of the exoccipital bones, or the suture between these laminae may be interrupted so that the azygos sinus appears as a fossa on the floor of the occipital segment of the cranial floor. This sinus was designated "cavum sinus imparis" by Sagemehl[5] in his descriptions of the crania of the Characinidæ and Cyprinidæ, and his designation is adopted by Allis in his work on the Mail-Cheeked Fishes.[6] In the forms which Sagemehl studied, the sinus is roofed more or less completely so that it may appositely be termed a cave, not so however in many other forms. Rarely the sinus is divided more or less completely by a central transverse partition; these facts lead me to discard "cavum" and to adopt "azygos" in preference to "imparis."

The extent of the *lateral cranial fenestra* is variable in respect of its height; it may or may not reach the roof of the cranial cavity. Whether or no the fenestra reaches the roof, the cranial wall is by it divided into *postotic* and *preotic* areas. The designations opisthotic and prootic are deliberately avoided to prevent implicating the bones. In certain fishes, as for instance *Cheilodactylus*, the posterior attachment of the *lateral obturator membrane* of the cranial cavity is so far back that the postotic cranial wall is very narrow in its upper part and occupies the transverse plane of the head. It might appear that under such circumstances it were well to designate this wall "occipital" or "posterior," but there are many forms in which there is no posterior wall, the side wall sloping slowly to the upper margin of the foramen magnum. In such forms the postotic wall, in the sagittal plane, arches toward the midline in such manner that it were a purely arbitrary procedure to define wall from roof, for example, in *Platycephalus* and *Epinephelus*. In the great majority of cases the postotic cranial walls (and roof) are constituted entirely by the vertical laminae of the exoccipital bones, but exceptionally small areas of the epiotic and supraoccipital share in its formation.

The *preotic* cranial wall is bulged out laterally to form the *temporal* and *trigemino-facialis* fossæ. The latter are situated on either side of the prepituitary and prootic segments of the floor, with the temporal fossæ above and in front of them.

The *lateral cranial fenestra* exposes to view all the cavities in the outer wall of the otocrane. The *posterior ampullary fossa* is lodged to the outer side of the anterior margin of the postotic wall, that margin actually forming its medial lip, just above the level of the cranial floor. The *anterior ampullary fossa* is situated in front of the posterior at a slightly higher level. The *posterior semicircular bony canal* rises through the substance of the epiotic bone towards the roof at an angle of about

[5]Sagemehl—Morph. Jahrb., x, 1885, pp. 1-119; *ib.*, xvii, 1891, pp. 489-595.
[6]Allis—Zoologica, Heft. 57, 1910.

forty-five degrees with the sagittal plane. The *horizontal canal* connects the depths of the two ampullary fossæ. The two ampullary fossæ may or may not be separated by a quite appreciable interval, and this interval would appear to be constantly covered by cartilage. In front of the anterior ampullary fossa there is an *arcuate recess* whose higher limit is above, and whose lower limit is below, and it may be actually underneath the fossa. The axis of this recess is approximately at an angle of forty-five degrees with the sagittal plane and therefore at right angles to the posterior semicircular canal. The lower portion of the recess may be divided from the upper by a low shelf. This recess would appear to have been developed in relation to the anterior semicircular canal and its ampulla, but so far as my dissections have gone I have always found that canal lying to the inner side of the recess and not within it. The *cava sacculorum* lie below the ampulary fossæ, and may extend above or below the level of the cranial floor.

The anterior cranial wall is in part bony and for the rest membranous. I have in a previous contribution[7] adopted Gaupp's term *membrana spheno-obturatoria*[8] to apply to this membranous portion of the anterior wall of the cranial cavity of many of the fishes, birds, and reptiles in the adult condition, and practically all crania in early stages of development. In the absence of a basisphenoid there is no distinction between the lower end of the sphenoidal obturator membrane and the prepituitary segment of the cranial floor.

On the cranial roof there is not uncommonly an area of cartilaginous "ceiling." This ceiling is situated around the forward end of the supra-occipital bone and the hinder ends of the frontals. Swinnerton[9] describing the development of *Gasterosteus* wrote:—"The supra-occipital is an unusually large bone. Anteriorly it seems to partially separate the frontals; in reality it extends under them almost to the level of the outstanding post-orbital process, and now *embraces the larger part of the epiphysial cartilage itself also.*" There can be little doubt that the cartilaginous ceiling so commonly present in the adult skull is the *epiphysial cartilage*, persistent in these forms. Accordingly it is so designated in the descriptions which follow.

The term "*eye-muscle canal*" will be discarded in favour of the later "*myodome.*" True, the former term has acquired an established meaning and general acceptance, but it does not admit of adjectival use, whilst the adjective "myodomial" lends itself to clarity and brevity of description of the parts of the various bones which enter into the composition of the myodome.

I have elsewhere[10] proposed the designation *sphenoidal cavity* for that anterior prolongation of the cranial cavity which, in certain fishes, accommodates the olfactory nerves.

It were, of course, beyond the scope of the present contribution to discuss the various modifications of the several bones which enter into the composition of the cranium, but certain of those bones present,

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[7]Kesteven—Jour. R. Soc. N.S. Wales, lix, 1925 (1926), pp. 108-123.
[8]Gaupp—Denkschr. Med. Ges. Jena, vi, 2, 1908, pp. 539-788.
[9]Swinnerton—Quart. Jour. Micro. Soc., xlv, 1902, p. 525.
[10]Kesteven—loc. cit.

more or less constantly, definite parts or processes the citation of which by pre-established designations will lead to brevity of description.

If we except the orbitosphenoid bone and the sphenoidal cavity, and one or two other very minor features, it may be said of the acanthopterygian skull that it presents all the features which are to be found in teleostean fishes, as well as some that are peculiar to the group. That being so, it is fitting that an attempt to establish a general nomenclature for the parts of the several bones of the fish skull should be based very largely on bones of the acanthopterygian skull.

The basioccipital bone presents *condyle* and *body*. The body may be excavated by a *saccular recess* on either side above, and a median *myodomial recess* below. The azygos sinus opens above in front of the condyle at the posterior end of the median ridge which is the roof of the myodomial recess. The outer walls of the saccular recesses may be known as the *lateral laminæ* of the bone. The *basal lamina* is that sheet of bone which forms the floor of the three recesses and appears on the ventral aspect of the cranium. This lamina is commonly deficient below the fore part of the myodomial recess, the deficiency being made good in the complete cranium by the hinder end of the synpterygoid.

The exoccipital bone bears the neural facet of its side supported on a more or less well developed *buttress*. The *superior vertical lamina* rises beside the foramen magnum, and commonly arches over it to meet its fellow of the other side. This lamina may occupy the sagittal or transverse plane or any position between them. The *inferior vertical lamina* sutures with the lateral lamina of the basioccipital, and forms the upper part of the outer wall of the saccular cavity of its side. The *horizontal lamina* may form, with its fellow, the occipital segment of the cranial floor, and, it may be, the hinder portion of roof the of the saccular cavity of its side. The *otic mass* of the bone lies in front of the buttress, between the diverging anterior ends of the superior and inferior vertical laminæ. For the most part this mass lies above the floor level, but may extend below it. The otic mass takes a greater or smaller part in the formation of the posterior ampullary fossa.

That part of the prootic which is presented on the ventro-lateral aspect of the cranium may be termed the *body* of the bone. From the inner side of this the *horizontal lamina* extends to the mid-line to meet its fellow of the opposite bone. The horizontal lamina forms the prootic segment of the cranial floor, the roof of the anterior part of the myodome, and the median sloping wall and floor of the saccular cavity in its fore part. Above the horizontal lamina the body of the bone is excavated on the inner side for the formation of the trigemino-facialis fossa, part of the arcuate recess, part of the anterior ampullary fossa, and the upper fore part of the cavum sacculi; the sloping medial floor of this cavum, on the horizontal lamina, dips below the level of the prootic cranial floor. The trigemino-facialis chamber is lodged on the outer side of the body near the anterior margin. Below and behind this chamber, the *myodomial wing* extends down and medially from the lower lateral margin of the body. This ala myodomialis is more or less covered below by the synpterygoid bone.

The basisphenoid presents a *horizontal lamina* forming the prepituitary segment of the cranial floor and the roof of the entrance to the myodome, and a *vertical process*, which sutures with the hinder end of the vomerine process of the synpterygoid.

The occipital crest of the supraoccipital bone needs no defining. The bone also develops horizontal and *vertical laminae* of varying extent; the horizontal lamina will be designated the *body*.

The epiotic process also needs no definition. The *body* of the bone shares with great constancy in the formation of the posterior ampullary fossa, and forms the greater part of the posterior semicircular bony canal, if, indeed, it does not form the whole of that canal.

The opisthotic bone may be a mere squame plastered over the meeting point of more or fewer of the other otic bones, or, pushing deeper into the otocranial wall, it may share in the bounding of the posterior semicircular canal, or again, the bone may be absent altogether, or it may be intimately fused with one or other of the remaining otic bones.

The pterotic is another well known process. The body of the bone very constantly shares in the formation of the two ampullary fossæ but especially the anterior one, and lodges the greater part of the horizontal semicircular canal.

The outer side of the body of the sphenotic bears the upper half of he anterior hyomandibular facet; the anterior surface of the body has frontal and alisphenoidal margins; the dorsal surface lies, in part, beneath the hinder end of the frontal bone. The internal aspect of the body is excavated to form the upper portion of the arcuate recess.

The body of the alisphenoid sutures with the frontal and sphenotic above and it gives of from its lower margin a *pterygoid process* which stands out and down to suture with the alisphenoid process of the synpterygoid and with the prootic just in front of the trigemino-facialis chamber.

The frontal bones develop a more or less extensive *sphenoidal process* which sutures towards its hinder extremity with the alisphenoid bone, and in front with the postero-superior processes of the prefrontal.

The synpterygoid develops paired ascending *alæ* and a median vertical *vomerine process*, and may develop paired *alisphenoid processes*.

Postfrontal bones are not of constant occurrence; when present they are little more than small squames of bone placed lateral to the frontals at the hinder edge of the roof of the orbit.

The body of the prefrontal bone may be defined as that portion which appears behind and, at times, below the nasal capsule. This bears anterior and posterior maxillary facets for the articulation of the maxilla. Posteriorly *superior* and *inferior processes* are given off to suture with the anterior end of the sphenoidal process of the frontal and the anterior end of the vomerine process of the synpterygoid bone respectively.

The mesethmoid presents no parts or processes that call for special designation.

The premaxilla presents a body, with ventral *alveolar margin*, and *palatine process*.

None of the bones of the palate and suspensorium except the maxilla

present processes which call for special designation. The anterior prolongation of the maxilla has been termed in the past the maxillary process. This will be designated the *labial process* in these contributions. This designation is necessitated by the nomenclature according to the new interpretation of the bones of the palate which is adopted here.

Swinnerton[11] proposed the terms panartete, disartete, and acrartete for the three types of attachment of the maxilla to the prefrontal. I have not met these terms elsewhere in literature but they are worthy of utilisation.

An extension of Swinnerton's nomenclature for the maxillary articulation is proposed in No. V. of these studies (p. 217).

In somewhat similar manner the hyomandibular may be slung to the cranium by one, two, or three short oval or circular joints, or it may be attached along the whole of its dorsal margin to one long articular furrow. It will be useful to be able to describe these modes of attachment by single words. Monarticulate, binarticulate, and trinarticulate are ready to our hand for the first three, and for the fourth condition *plenarticulate* is proposed.

Thus the suspensorium of *Epinephelus* will be described as trinarticulate, and the anterior attachment of the maxillary arch as disartete.

## No. IV. Some Scleropareian Skulls.

### Platycephalus.

(Figs. 1-4.)

*INDEX OF ABBREVIATIONS USED ON THE DRAWINGS.*

*Al.* alisphenoid.
*An.* angular.
*Ar.* articular.
*B. oc.* basioccipital.
*B. sph.* basisphenoid.
*D.* dentary.
*Ep. ot.* epiotic.
*E. oc.* exoccipital.
*F.* frontal.
*Hym.* hyomandibular.
*I. op.* interopercular.
*I. sep.* interorbital septum.
*La.* first suborbital.
*Mes. eth.* mesethmoid.
*Mx.* maxilla.
*Mx. lab.* maxillary labial.
*Na.* nasal.
*Op.* operculum.
*Op. ot.* opisthotic.
*O. tr.* os transversum.
*P. and Pa.* parietal.
*Pal.* palatine.
*P. e. c.* preethmoid cornu.
*P. fr.* prefrontal.
*P. mx.* premaxilla.
*P. mx. lab* premaxillary labial.
*Po. f.* postfrontal.
*P. op.* preoperculum.
*P. or.* postorbital bones.
*Pr. ot.* prootic.
*Pt.* post-temporal.
*Pter.* pterotic.
*Q. j.* quadrato-jugal.
*Qu.* quadrate.
*S. cl.* supraclavicular.
*S. o.* suborbital bones.
*S. oc.* supraoccipital.
*S. op.* suboperculum.
*Sph.* sphenotic.
*St.* supratemporal.
*Sy. and Sym.* symplectic.
*Syn. and Syn. pg.* synpterygoid.

*Platycephalus marmoratus* Stead, has provided the material on which the following description is based. This species is commonly

[11]Swinnerton—Quart. Jour. Micro. Soc., xlv, 1902, pp. 503-593.

brought in as a table fish, so that I have had ample material to disarticulate.

The cranium presents a fairly flat dorsal surface, broad behind, narrower between the eyes, broad again where the prefrontals are placed and once more narrowed in the ethno-nasal region.

The otocranes are situated on the same transverse plane as the *cavum cranii*, not, as in some forms, below it, so that there is rather more lateral expansion in the hinder part of the skull than is usual in the skull of members of the sub-order. This expansion is further increased by the development of laminæ of bone for the attachment of muscles from the opisthotic outward to the outstanding posterior process of the pterotic bone.

On the under-surface of the skull the well developed saccular bullæ are prominent, recalling those of certain of the Siluroid fishes. In front of the bullæ there is on each side an out-turned process of the synpterygoid, which, though it does not reach the *os transversum*, calls to mind the " parasphenoid peg " described by Ridewood[12] in *Osteoglossum*, *Arapaima*, *Heterotis*, and *Pantodon*. It might appear from my drawing (fig. 4) that this process articulates with the palatine bone, but this is not so, the process is on a higher plane than the palate. As is usual among the members of the Acanthopterygii there is no " sphenoidal cavity."[13] The myodome is shallow.

THE CRANIUM.

*Supraoccipital.* The body of the supraoccipital bone (*S. oc.*) is more extensive than the area exposed, being overlapped by both the parietal and frontal bones. The vertical occipital crest is a fairly long lamina of bone which overhangs the foramen and the hinder limit of the basioccipital bone. There is a shallow muscle recess immediately beneath the arcuate hinder border of the body of the bone on either side of the crest. The floor of this recess is a thin horizontal lamina of bone attached on the one hand to the under side of the hinder border of the body, and on the other hand to the occipital crest about the middle of its depth. The lamina narrows as it proceeds back, and is in sutural connection with a similar but much smaller lamina attached to the inner side of the epiotic bone. For purposes of future reference these laminæ are now termed the " muscle laminæ " of the supraoccipital and epiotic.

On the under side of the body of the bone a stout vertical process projects down and backward from just in front of the attachment of the muscle lamina; the lateral edge of this process articulates with the epiotic and the inferior edge with the two exoccipitals. From the centre of the hinder face of this process the " occipital-crest " extends back to the foramen magnum, articulating with the two exoccipitals, taking, however, no part in the bounding of the foramen, for the two exoccipitals meet below it.

The suture between the vertical process and the two exoccipitals is situated just in front of the anterior limit of the medulla.

The *Parietal* (*Pa.*) is a squame of bone which overlies the body and

[12]Ridewood—Jour. Linn. Soc. (Zool.), xxix, 1905, pp. 252-282.
[13]Kesteven—Jour. R. Soc. N.S. Wales, lix, 1925, pp. 108-123.

the root of the posterior process of the epiotic bone, part of the side of the body of the supraoccipital, and a narrow area of the inner side of the pterotic; it is overlapped in front by the frontal, and, beneath this

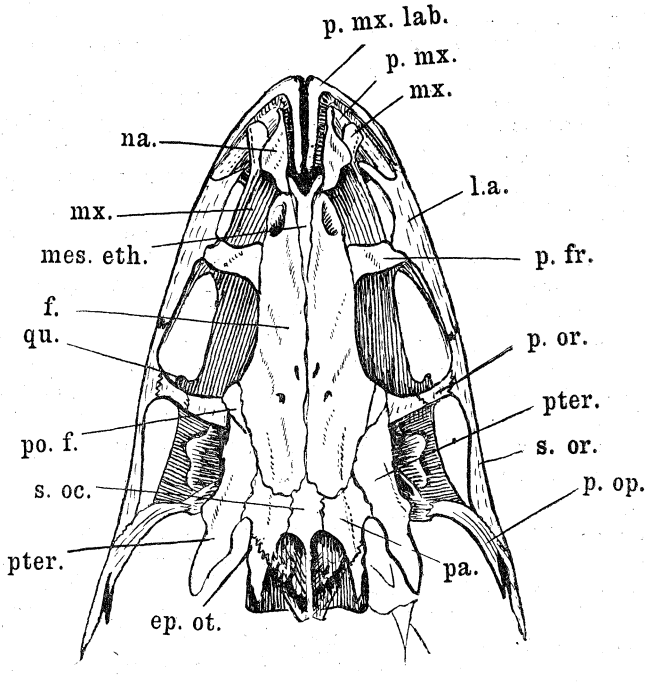



Fig. 1. *Platycephalus marmoratus* Stead.

bone, is in sutural contact with the prootic at the postero-median corner of that bone. The bone appears on the roof of the *cavum cranii* within, between the supraoccipital and the pterotic, in front of the epiotic and behind the frontal. The area so exposed on the inner side is small but quite definite.

The *Epiotic* bone (*Ep. ot.*) is wedged in between the parietal above, the supraoccipital to the inner side, the exoccipital and opisthotic below, and the pterotic laterally. The body of the bone is roughly pyramidal, hollow, and open in front. The cavity is divided by a sloping lamina of bone into an upper and lower compartment. The upper compartment lodges the upper part of the superior semicircular canal, the lower, is the upper half of the posterior ampullary fossa; both are, in the dried skull, freely open to the cranial cavity. The very short posterior bony semicircular canal lies behind the sloping lamina. The epiotic process projects well back over the outer edge of the exoccipital, and bears on its infero-median edge near the body the muscle lamina already referred to.

The *Pterotic* bone (*Pter.*) as viewed from above is very similar to the parietal and epiotic together. The body is a hollow mass of irregular

shape, which is sutured to the epiotic on the inner side, the opisthotic below and behind, the prootic below and in front, and on the dorsum of the skull with the sphenotic, frontal, and parietal bones. The cavity of the bone (anterior ampullary fossa), contains part of the anterior semicircular canal. The posterior semicircular canal passes through the back of the body from the depth of the ampullary fossa to reach the depth of the posterior ampullary fossa.

The elongated pterotic process bears a narrow muscle lamina, similar to those of the supraoccipital and epiotic bones, which, inclining in and downward, connects with a muscle lamina of the opisthotic.

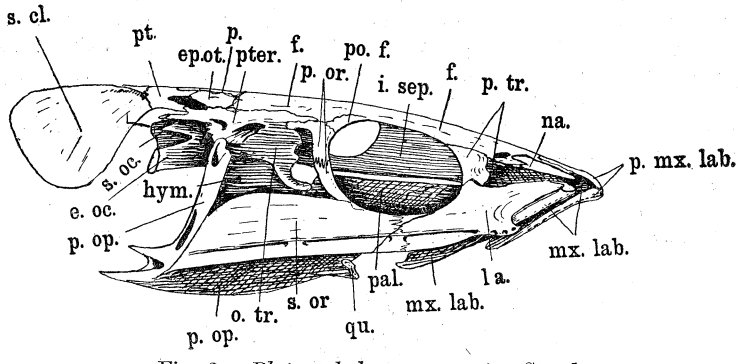



Fig. 2. *Platycephalus marmoratus* Stead.

The *Opisthotic* bone (*Op. ot.*) is of irregular shape, as exposed on the ventral aspect of the skull; it articulates with the exoccipital, prootic, and pterotic bones, posteriorly it is in sutural connection with the exoccipital and epiotic. At the apex of the temporal fossa, formed between this bone and the epiotic and pterotic, the opisthotic articulates with the inner side of the pterotic, and from this point the suture between the muscle laminæ af the two bones is continued back along the floor of the fossa. The suture between the opisthotic and epiotic, visible in the posterior view of the skull, is continued forward along the inner wall of this fossa.

The *Exoccipital* (*E. oc.*) is another bone of quite irregular shape. The solid neutral facet is the most outstanding portion of this bone as seen in a lateral or ventral view of the skull; the lower edge of the facet articulates with the basioccipital bone. Above the facet and its buttress the superior vertical lamina rises to meet its fellow of the opposite exoccipital and form the lateral boundary of the foramen magnum; this lamina is continued forward to form the whole of the postotic wall of the *cavum cranii* as far forward as the posterior limit of the otocrane and the anterior end of the medulla. At its anterior end the lamina in question turns outward and comes to look forward, here articulating with the inferior margin of the vertical process of the supraoccipital. Turning again to the base of the skull, the inferior vertical lamina of the bone will be seen extending between the pterotic and prootic bones, before reaching the prootic; this lamina is in sutural connection medially with the lateral lamina of the basioccipital. In front of the lamina

described as constituting the side wall of the brain box the otic mass of the bone enters into the formation of the otocrane. This portion of the bone is roughly pyramidal in shape and is hollow anteriorly; below and to the inner side of this the inner surface of the inferior vertical lamina just described on the base of the skull is found to contribute to the floor and side wall of the *cavum sacculi* posteriorly. The more massive portion of the bone forms portion of the posterior ampullary fossa; it articulates with the prootic, opisthotic, pterotic, and epiotic bones.

The temporal fossa has been described situated between processes of the epiotic, opisthotic, and pterotic bones. The occipital fossa is situated beneath the muscle laminæ of the supraoccipital and epiotic; its median wall is the occipital crest, the much less extensive floor is formed by laminæ from the exoccipital and opisthotic. The sloping anterior wall is contributed to by the posterior surface of the otic mass of the exoccipital, the epiotic, pterotic, and opisthotic bones; it is in fact the posterior wall of the otocrane.

The *Basioccipital* (*B. oc.*) sutures with the two exoccipitals and with the prootics. The condyle is of the usual vertebral centrum shape; the dorsal periphery of the condyle forms the floor of the foramen magnum.

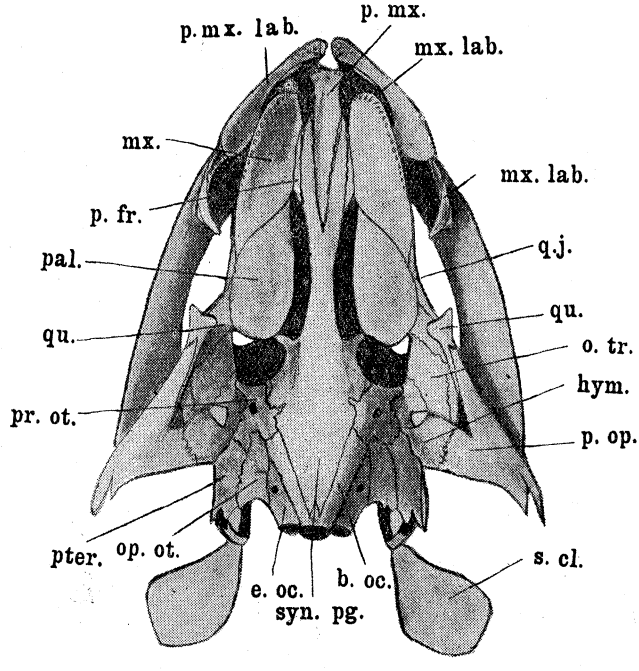



Fig 3. *Platycephalus marmoratus* Stead.

The bone is slightly constricted in front of the condyle and then expands laterally as it extends forward. The ventral surface is for the most part covered by the hinder end of the synpterygoid, the superior surface

is hollowed on either side of the mid-line by the two saccular recesses. The myodomial recess is very constricted and stops short at about the centre of the length of the bone. There are no horizontal laminæ in the exoccipitals, and the azygos sinus is a wide open, shallow, spoon-shaped fossa.

The *Sphenotic* (*Sph.*) is a triangular bone overlapped by the frontal and pterotic above, sutured to the alisphenoid in front, the prootic below, and meeting the pterotic again behind the last mentioned bone. The last three sutures are between the bones named and the edge of a descending process of the sphenotic. The outer aspect of the body bears the upper half of the anterior facet for the articulation of the hyomandibular bone. The upper part of the arcuate recess and portion of the anterior ampullary fossa are lodged in the substance of the body.

The prootic bones constitute the greater part of the saccular bullæ, which, as already noted, are particularly large in this species. The trigemino-facialis chamber is borne on the body of the bone near the anterior end, and the lower half of the anterior hyomandibular facet appears as though the outer wall of the chamber had been developed as its buttress. In front of the chamber the bone sutures with the alisphenoid below and the sphenotic above. Below and behind the chamber the body of the bone swells out to form the saccular bulla. Looking at the bone from in front, the horizontal lamina and the myodomial ala may be seen to spring together from the body just below the hyomandibular hemi-facet, their common line of attachment passing toward the midline and ventrally. From the line of attachment the two shelves extend medially, the former almost in the horizontal plane, the latter sloping down. The horizontal lamina sutures with its fellow, the myodomial ala beds into a recess on the upper surface of the synpterygoid. The postero-dorsal margin of the bone sutures with the inferior vertical lamina of the exoccipital, the epiotic, and pterotic bones. Viewed from within, the trigemino-facialis fossa is seen near the anterior margin of the body with the short margin of suture with the basisphenoid in front and to the inner side if it. The lower half of the arcuate recess lies above the nerve fossa, with the lower half of the anterior ampullary fossa just behind it. The portion of the horizontal lamina which forms the prootic cranial floor is triangular, the lateral side of the triangle being slightly arcuate, so that the fore part is broad and the hinder part tapers away to a point. From the arcuate border the horizontal lamina dips down to meet the body of the bone on the floor of the saccular cavity at the line of origin of the myodomial ala.

The *Alisphenoid* (*Al.*) is a small triangular bone placed between the prootic below and behind, the frontal above in front, and the sphenotic above and behind. The pterygoid process sutures with the horizontal lamina of the basisphenoid, and alisphenoidal process of the synpterygoid.

The *Frontal* bones (*L.F.*) are long and narrow; they suturate with the supraoccipital, parietal, pterotic, sphenotic, postfrontal, prefrontal, mesethmoid, nasal, and alisphenoid bones; all these sutures except the last are visible on the dorsum of the skull.

The *Postfrontal* (*Po.f.*) is a small squame of bone inserted between

the frontal and sphenotic at the postero-superior corner of the orbit, and giving attachment to the upper postorbital bone.

The *Basisphenoid* (*B. sph.*) is a quite small triradiate bone, the horizontal lamina articulating with the prootic and alisphenoid bones and the vertical process with the vomerine process of the synpterygoid.

There is a small foramen at the meeting point of the inferior vertical lamina of the exoccipital, prootic, and epiotic bones. Apparently the internal carotid artery enters through this and crosses the outer wall of the cavum sacculi to reach the hypophysis.

The *Synpterygoid* (*Syn. pg.*) is a long thin bone bearing some resemblance to a double-ended spatula. It lies in the midline beneath the basioccipital, the prootics, and the mesethmoid. The palatine plate of the premaxilla lies below it in a groove along the centre of its forward part. The broadest portion of the bone lies below the fore end of the prootics. The bone narrows rapidly in front of this widest part and then quite suddenly expands laterally, where an auriculur alisphenoidal process is developed below the basisphenoid and the myodome. It is the outstanding anterior corner of this process which calls to mind the " parasphenoid peg " described by Ridewood in certain forms already referred to. A vertical " vomerine " lamina is present along the centre of its dorsal surface, forward of the basisphenoid.

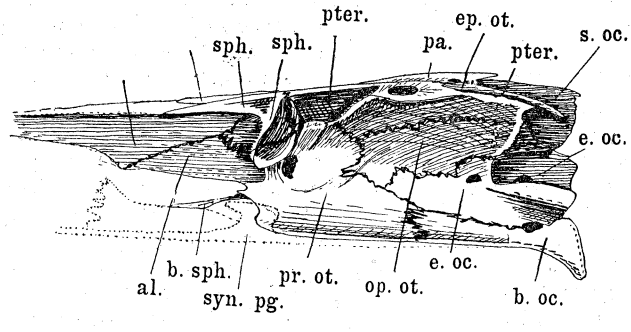



Fig. 4. *Platycephalus marmoratus* Stead, side view of the cerebral region of the cranium.

The *Prefrontal* bone (*P. fr.*) presents a roughly quadrilateral area on the dorsal surface of the skull; there is also a small triangular area in front of this at a deeper level on the inner side of the nasal fossa at its hinder end. The outer edge of the fore end of the frontal bone lies above a narrow area of the prefrontal and covers a narrow posterior dorsal process of the latter. When the prefrontal bone is disarticulated it is found that the dorsum of the bone has a triangular outline, but with the out-turned apex truncated; at this apex there is a saddle-shaped facet, for the articulation of the first subocular bone. The fore end of the median dorsal margin of the prefrontal sutures with the body of the mesethmoid. The ventral surface of the bone is very similar in outline to the dorsal, but smaller; the median edge is sutured to the synpterygoid. The ventral and dorsal surfaces are inclined at an angle to one another, the angle open posteriorly, so that a fairly considerable

recess is present between the upper and lower portions of the bone; at the depth of this recess the bone is perforated for the passage of the terminal branch of the superficial ophthalmic division of the trigeminal nerve and the olfactory peduncle, the former having its internal opening further back than the latter and more toward the side.

The *Mesethmoid* bone (*Mes. eth.*) is almost completely incased in other bones. The body of the bone lies in front of the frontal bones; portion of the dorsum is here exposed on the back of the skull, and a narrow posterior process extends back between the fore ends of the frontal bones, and this also is exposed on the back of the skull. From the front of the body two spurs stand forward and slightly upward; they embrace the tips of the ascending processes of the premaxillary labial bones and give attachment to the base of the nasals on their outer side. Below the spurs the bone is continued forward and down by two narrow squames which suture with the dorsal processes of the premaxilla.

The upper and lower moieties of the frontal bones thicken as they pass forward, so that there is quite an extensive interval between the point of union of the inner and outer surfaces on the median aspect of the bone; there is thus formed on this aspect of the bone a roughened area. When the prefrontals, synpterygoid, and mesethmoid are placed in correct position it is found that the rough areas on the prefrontals are continuous with a similar area on the back of the mesethmoid, and in this region the four bones surround a cavity, which, in the fresh state, is filled by the cartilaginous ethmoid to be described later.

The *Nasals* (*Na.*) are small triangular leaflets of bone attached to the outer side of the mesethmoid spurs, to the ascending processes of the premaxillary labials, and the labial process of the maxilla by fibrous tissue.

The *Premaxilla* (*P. mx.*) presents a short solid body and a long narrow palatine lamina as seen from below. The palatine lamina is strongly concave upwards and, at its union with the body, there rises on each side a short dorsal process; as already stated this latter sutures with the mesethmoid.

The mass of cartilage which is provisionally termed the *cartilaginous ethmoid* is T-shaped in cross section. Posteriorly, where it forms the interorbital septum, it is thin, and appears to be planted inferiorly on the upper edge of the vertical lamina of the synpterygoid; forward of the orbit it becomes much thicker, and is clearly seated on the upper surface of the anterior lamina of the same bone, and is incised along the centre to receive the dorsal lamina. The horizontal portion of the cartilage, like the vertical, is much thinner posteriorly than in front. The mass is very nearly divided into a smaller anterior and much larger posterior portion beneath the mesethmoid, where that bone bulges down nearly to the dorsal surface of the palatine plate of the premaxilla. In front of this point the cartilage is dorso-ventrally compressed, and fits in between the palatine plate and the dorsal processes of the palatine bone; a small gap between the bones here exposes the cartilage below the fore end of the mesethmoid bone.

CIRCUMORBITAL BONES.

(Figs. 1 & 2 s.or., p.or., la.).

There are two suborbital bones and two postorbitals; of these the anterior suborbital is an elongate triangular bone with the short anterior side deeply sinuated, so that the most anterior point lies behind and parallel to the shaft of the maxillary labial, whilst the lower point overlies both labial bones. At the junction of the anterior and middle thirds of the length of the dorsal edge the bone is thickened and developed into an articular condyle for the formation of a true joint with the lower edge of the prefrontal bone. The posterior suborbital is roughly quadrilateral, with a very acute angle between dorsal and anterior edges, and a consequential obtuse angle between anterior and ventral surfaces. The ventro-posterior angle is also acute, whilst the postero-dorsal angle is slightly obtuse and rounded off. The two postorbitals are small narrow bones, the dorsal attached to the postfrontal and the ventral to the posterior suborbital. These last two bones form the posterior boundary of the orbit and carry a branch of the latero-sensory canal system.

PALATE AND UPPER JAW.

The general shape of the palate and its constitution are shown in the drawings is sufficient detail to permit of very brief description.

The *Maxilla* is a fairly substantial bone, which may be described as having palatal, dorsal, and facial surfaces. The palatal surface is roughly triangular in outline, and hollowed longitudinally. Teeth are born only along the outer edge separating facial from palatal surfaces. The facial surface is broader in front than behind, and may be said to be the outer surface of the lateral wall of the trough on the palatal surface. When the mouth is fully open and the labial bones pulled well down there is formed a trough between the inner face of the suborbital bones and the facial surface of the maxilla. Both walls of this trough are lined by the skin, this and a thin layer of subdermal tissue alone covering the bony walls of the trough. At the alveolar margin of the maxilla the palatal epidermis, buccal mucosa, is reflected on to the inner side of the skin of the facial surface of the bone, and the two together are continued downward, presently to be separated again to enclose first the maxillary then the premaxillary labial bone. This double membrane including the labial bones is, of course, the true lip. The facial surface of the maxilla passes insensibly into the dorsal surface, though in a freshly prepared bone the true subdermal surface is clearly defined by its smoother finish. A ridge just to the median side of the upper limit of the facial surface marks the centre of a long narrow area along which a band of very tough fibrous tissue is attached. This band gathers to its greatest thickness immediately beneath the prefrontal bone at a point marked by the development of a small tubercle; this last is an imperfect facet for articulation with the prefrontal. Fibrous and fibrocartilaginous tissue is also attached to the whole of the dorsal surface of

the bone to the inner side of the ridge just described. All of the fibres of this dense tissue are attached above to the under side of the prefrontal bone. The labial process (maxillary process) rises from the anterior end of the dorsal surface of the bone and stands forward a little distance; at its root, on the inner side thereof, there is a small spur developed, which looks toward, and is attached to the premaxilla by very tough fibro-cartilage. The upper surface of the spur articulates with the pre-ethmoid cornu of the cartilaginous ethmoid.

The *Palatine* is a thin squame of bone of the shape indicated in the drawing.

The *Quadrato-jugal*[14] is a small splint of bone sutured to the outer edge of the palate, where it is in contact with the maxilla, palatine, and quadrate; its extreme anterior tip lies inside the extreme posterior tip of the maxilla.

The *Os Transversum* is of irregular shape, fitted in between the palatine and quadrato-jugal in front, quadrate and symplectic to the outer side and the hyomandibular to the inner side and behind.

The *Quadrate* presents a stout shaft, lying along, and firmly attached to the inner side of the antero-inferior arm of the preoperculum. This shaft bears the articular facet on its anterior free end; the facet is as usual elongated in the horizontal and transverse plane, the inner end being, again as is usual, deeper from above down than the outer end. To the inner side of the shaft the quadrate presents an expanded palatal amina; this is broadest anteriorly, and sutures with the quadrato-jugal palatine, and os transversum.

The *Symplectic* is of the typical narrow elongated shape; proximally it is sutured to the hyomandibular and preoperculum by hyaline cartilage, and the greater part of the median border is attached in the same way to the os transversum. Distally one third of the bone is imbedded in hyaline cartilage in a depression on the inner face of the quadrate immediately to the inner side of the shaft.

The binarticulate *Hyomandibular* is an irregularly shaped flat bone; it may be said to present a nearly straight median border, which makes the base of an irregularly indented semicircle. The middle third of the base line is occupied by a low boss, the posterior articular facet. Immediately in front of the base the curved outer border begins with the well developed anterior articular facet; beyond this the edge is slightly excavated, and there follows a double facetted area; the symplectic articulates with the anterior of these two, and the preoperculum and inter-hyal articulate with the other, the inter-hyal on the inner side, the hyomandibular on the outer. Behind this double facet the edge is again excavated, and the posterior segment of the border is occupied by the facet for the articulation of the operculum.

[14] It is now realised that this identification of the bone is incorrect; its position medial to the muscles of mastication is alone a sufficient proof that the bone cannot be the quadrato-jugal. On the other hand it is with equal certainty not the pterygoid. To attempt an enquiry into its correct identification here would be out of place, and in these papers the term quadrato-jugal will be used until opportunity offers to undertake that enquiry.

This description is taken from the hyomandibular of *P. fuscus* Cuvier and Valenciennes.

LATERO-SENSORY CANALS.

It has not been possible to work out this system in detail; there is one canal down each side of the dorsal surface of the skull, with temporal and supraoccipital cross bars. The temporal chain is continued down along the postorbital bones to join the suborbital chain, whilst the supraoccipital chain is continued down along the posterior margin of the preoperculum to the lower jaw.

MYODOME.

In both *Platycephalus marmoratus* and *P. fuscus* the myodome is very much dorsoventrally compressed, and it extends back only to the middle of the length of the basioccipital bone in *P. marmoratus*, and to the posterior end of the prootic in *P. fuscus*. The pterygoid process of the alisphenoid is produced further forward in contact with the alisphenoid process of the synpterygoid, so that the anterior end of the myodome is carried further forward than is usual.

*Platycephalus fuscus* Cuv. & Val. has also been examined, but the resemblance is such that this species may be very briefly dealt with. The palatine bone articulates with the os transversum. The description given above of the hyomandibular is founded on that of *P. fuscus*; that of *P. marmoratus* differs in having a thin squame of bone springing from the edge between the anterior articular facet and the double facet, and extending across to articulate with the os transversum, and in having the double facet standing out to a greater extent. In the cranium there is little that calls for comment, beyond the fact that the saccular cavities are adpressed to the sides of the skull so that saccular bullæ are not present.

NEOSEBASTES THETIDIS.

(Fig. 5.)

Of this species I have a single complete skull; in the drawing the attempt has been made to show the form of the component bones of the maxillo-palatine arch through the subocular scutes.

This skull presents features of resemblance to both the preceding and succeeding forms; the general shape is that of *Pterygotrigla*, whilst in the conspicuous sensory canals and the form of the cheek armature the resemblance is to *Platycephalus*.

The supraoccipital appears on the surface of the dorsum of the skull between the parietals; for the rest, excepting the prefrontal, the arrangement of the bones of the cranium and otocrania is so essentially the same as that of *Pterygotrigla* as to call for no separate description. There is no postfrontal, and the position of the prefrontals resembles that in *Pterygotrigla* rather than of the other genus, although they do not meet in the mid line on the dorsum of the skull; they are closely juxtaposed below in front of the orbit. The relation of the narrow nasals to the mesethmoid and prefrontal bones differs from both the other orms; they are planted in small recesses on the dorsum of the prefrontals

immediately in front of the fore end of the frontal bones, and project forward over the mesethmoid. The circumorbital bones are heavier but otherwise similar to those of *Platycephalus*.

The body of the *Prefrontal* is antero-posteriorly flattened and stands nearly vertically in the transverse plane, inclining, however, slightly backward above. Dorsally the body ends as a pointed squame underlying the antero-lateral corner of the frontal, but also showing on the dorsum of the skull, where it forms the anterior boundary of the orbit. No postero-dorsal process is developed. Though generally presenting the flattened appearance described, inferiorly the bone is triangular

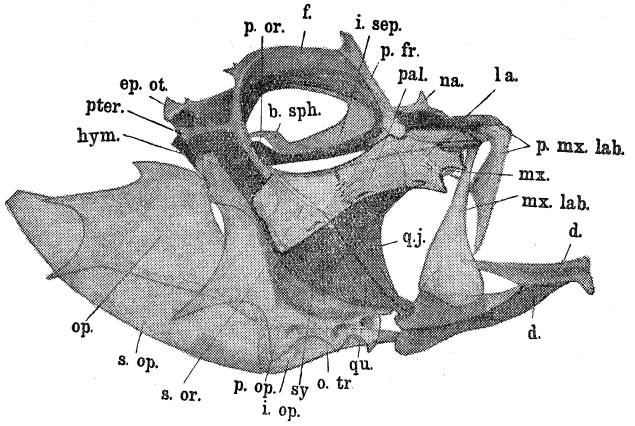



Fig. 5. *Neosebastes thetidis* Waite.

when viewed either from below or from the median aspect. The outstanding infero-lateral angle bears a well developed facet; to the inner side of this the inferior free margin of the flattened portion of the bone is continued inward under the solid triangular portion, and terminates in a second, much smaller facet. The outer articular facet is for the first subocular bone, the inner for the posterior, parethmoid articulation of the maxilla. In front of the subocular facet the body of the bone is hollowed out, and there then stands forward a buttress which terminates as the facet for the pre-ethmoid maxillary articulation. The common foramen for the transmission of the olfactory nerve and the terminal branch of the ramus opthalmicus superficialis lies to the inner side of the root of this buttress, perforating the solid portion of the body. The ventral surface of the body is in contact with the upper surface of the synpterygoid. There is no infero-posterior process, and therefore no suture with the vomerine process of the synpterygoid.

The *Hyomandibular* bone is binarticular. The *Maxilla* is disartete, whilst the form of the bone is similar to that of *Platycephalus*, but the manner of its articulation is not the same. In this form both articulations are with the prefrontal, whilst in that the anterior is with the pre-ethmoid cornu of the ethnoid cartilage.

## PTERYGOTRIGLA.

(Figs. 6-9.)

The following description is based on the skull of *P. polyommata* Rich., of which I have had for study four crania, two specimens in the flesh and a nearly complete skull dredged off Montague Island and forwarded to me by the Director, Australian Museum.

### CRANIUM.

The general shape of the cranium is well shown in the drawings and hardly calls for description.

The *Supraoccipital* bone appears only on the posterior aspect of the

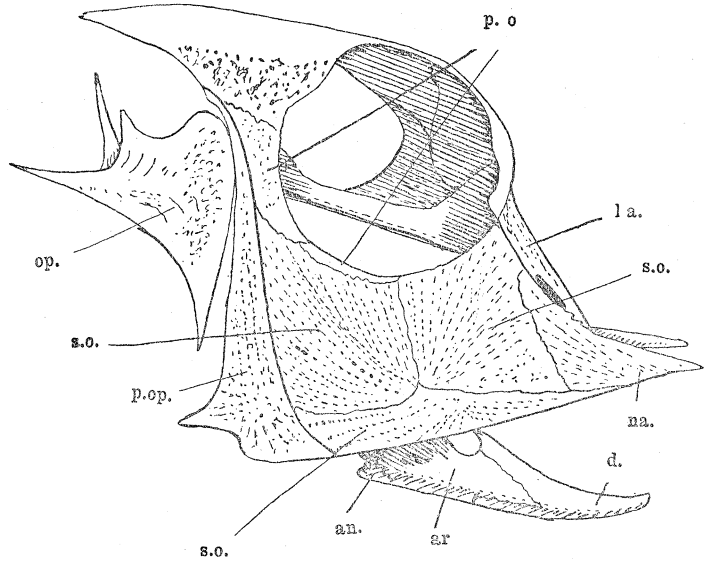



Fig. 6. *Pterygotrigla polyommata* Richardson.

skull; the body, similar in shape to that of *Platycephalus*, is completely hidden dorsally by the parietals and frontals, which meet in the midline above it. The vertical process is broad and arranged nearly in the transverse plane. The upper lateral portion of the vertical process enters into the formation of the postero-superior wall of the cavity for the posterior semicircular canal. The bone sutures with the parietals and frontals above, and the with epiotic and exoccipital of each side behind.

The *Epiotic* is a hollow pyramidal bone divided by a horizontal shelf into upper and lower compartments similar to those of *Platycephalus*. The bone sutures with the supraoccipital, parietal, opisthotic, and exoccipital bones.

The *Pterotic* appears to be represented by a small nodule of bone, wedged on the surface of the skull between the base of the supratemporal behind, the opisthotic in front, and the parietal to the inner side (*Pter.*).

The *Opisthotic* bone (*Op. ot.*) is placed higher in this form than in *Platycephalus* and occupies much the position of the opisthotic and pterotic together in that form, that is, relative to the intracranial structures. The sutural relations of the opisthotic are with the exoccipital, epiotic, pterotic, parietal, frontal, sphenotic, and prootic.

The *Exoccipital* bone (*E. oc.*) presents fairly expansive surfaces on both the posterior and lateral walls of the cranium, bounds the foramen magnum laterally, meets its fellow of the opposite side above, is excavated inside to form part of the posterior ampullary fossa and is in sutural connection with the supraoccipital, epiotic, supratemporal, opisthotic, prootic, and basioccipital bones.

The *Basioccipital* (*B. oc.*) is relatively a much smaller bone than in *Platycephalus*, the " saccula " recesses are very small but quite recognisable, and the body of the bone is excavated to form the hinder end of the myodome. The basioccipital sutures with synpterygoid, prootic, and exoccipital bones.

The *Sphenotic* (*Sph.*) may have the postfrontal fused with it, for that bone is otherwise not present. The sphenotic sutures with the opisthotic, frontal, alisphenoid, and prootic bones.

The *Alisphenoid* is quite a small squame of bone, which sutures with the sphenotic, frontal, and prootic bones. The suture with the frontal is immediately behind the alisphenoid lamina thereof, and the bone is here very much thickened to form a strong antero-superior wall to the cranial cavity. The frontal bones are excluded from actual participation in the formation of the ceiling of the cavity by the epiphysial cartilage, which underlies them between the alisphenoid, superior periotic bones, and the supraoccipital. There is no pterygoid process.

The *Prootic* (*Pr. ot.*) bone is, as usual, bilaminate inferiorly, the upper horizontal lamina forming the floor of the cranial cavity, the lower myodomial process the outer part of the floor of the myodome. Above the junction of these two laminæ the body of the bone provides an extensive area of the side and front wall of the cranial cavity. The bone sutures with the exoccipital, synpterygoid, basisphenoid, alisphenoid, sphenotic, and opisthotic bones. The outer wall of the trigemino-facialis chamber is a mere spicule of bone.

The *Basisphenoid* bone is of the typical triradiate form; the horizontal lamina sutures with the prootics, and the somewhat longer vertical process with the vertical lamina of the synpterygoid.

The *Parietal* bones (*Pa.*) are thick, flat, cancellous bones, whose shape is well shown in the drawing.

The shape and situation of the *Frontal* bones is sufficiently indicated in the drawings. (*F.*). There is a small alisphenoidal lamina developed on the under side in front of the alisphenoid bone and also to the medial side thereof, the latter portion forming the extreme antero-median and upper part of the front wall of the cranial cavity.

The *Synpterygoid* (*Syn. pt.*) is essentially similar to that of *Platycephalus*. There is however no auricular alisphenoidal process; this is

probably correlated with the much larger eye-muscle canal in the present form.

The *Prefrontal* (*P. fr.*) bones are remarkably massive and meet in the midline and occupy the space which in *Platycephalus* is occupied by the cartilaginous ethmoid. Like the prefrontals of that form these are perforated for the passage of the olfactory peduncle and a terminal branch of the superior ophthalmic division of the fifth nerve.

The *Mesethmoid* (*Mes. eth.*) is presented on the dorsum of the skull between the prefrontal and nasal bones; a posterior spur extends back between the two prefrontals but is hidden beneath them. The body of the bone is massive and extends down almost to the synpterygoid, leaving only a very shallow space between to be filled by cartilage.

The shape of the *Nasal* squames is indicated in the drawing.

The *Premaxilla* (*P. mx.*) is essentially similar to that of *Platycephalus*, a little broader in front and having rather more of the dorsum exposed in front of the mesethmoid, but with the same processes and containing the anterior smaller part of the cartilaginous ethmoid between the dorsal processes and the palatine lamina.

### CIRCUMORBITAL BONES.

There are four suborbital bones and two postorbitals; of these latter, one is actually suborbital in position, but there is little doubt that it is truly a postorbital. The anterior suborbital is firmly attached to the labial process of the maxilla and to the nasal bone. The attachment to the nasal is double, the anterior point to the anterior process of the bone and the posterior to the body of the bone; between the two points of attachment there is a gap between the bones, and in the flesh the two apertures of the nasal capsule are found in this gap. Two of the suborbital bones are attached to the preoperculum, as also is the upper postorbital. Except for a small area surrounding the eye, the whole of the face is encased in the circumorbital bones. These as well as the dorsal covering bones are all subdermal and finely shagreened in radiating patterns. The area between the two anterior suborbitals alone is unprovided with a subdermal bone.

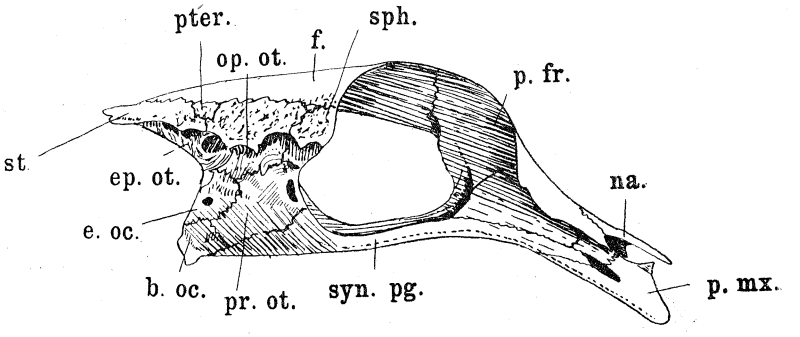
### PALATE AND UPPER JAW.

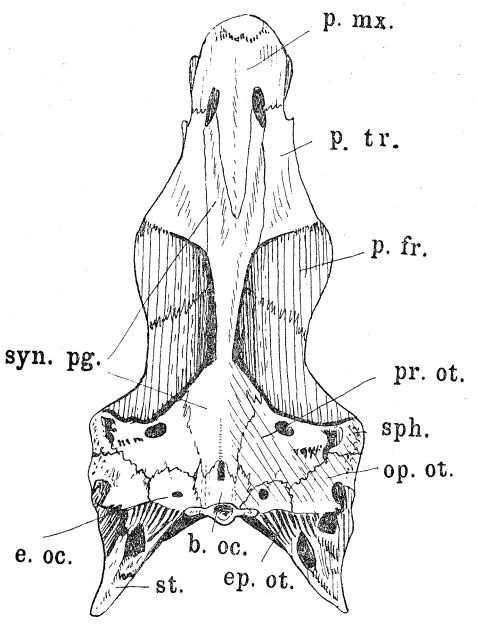
These bones are arranged almost in the vertical plane, and there is little that calls for special mention either in their shape or their relations. The maxilla is articulated to the pre-ethmoid cornu at the margin of the premaxilla, and attached to the front outer corner of the prefrontal and to the two anterior suborbital bones. The hyomandibular bone is binarticulate.

### CRANIAL WALLS AND NERVE FORAMINA.

The lateral walls of the cranial cavity, and medial walls of the otocrania, are almost entirely membranous, so that there is practically no part of the preotic or postotic wall in the sagittal plane. The two lateral obturator membranes are almost in contact at the posterior end

of the roof; from this point each passes down and outward across the vertical lamina of the supraoccipital and the vertical lamina of the exoccipital just to the inner side of the posterior ampullary fossa. Below this each passes forward to the outer side of the foramen for the ninth



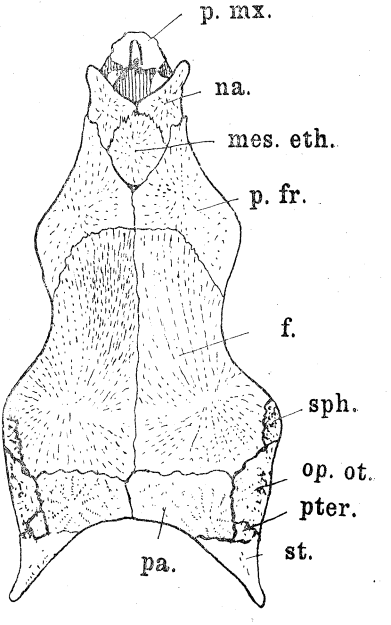




Fig. 8. Fig. 9.

Figs. 7, 8, and 9. Three views of the cranium of *Pterygotrigla poyommata* Richardson.

and tenth nerves and on to the basioccipital. It crosses this bone along the edge of the inner margin of the saccular recess, then passes forward, along the floor of the cavity, first on the basioccipital and then on the horizontal lamina of the prootic. The anterior end of the cavum sacculi is indicated on the inner surface of the prootic by a small pit; im-

mediately in front of this the two foramina for the exit of the trigemino-facial roots are placed, at a slightly higher level. The membranous side wall swings to the outer side of these and then upward across the front wall, approximately along the line of suture between the alisphenoid and sphenotic, to reach the roof, which it crosses back to the starting point. The trigemino-facialis fossa is not defined, and the temporal fossa is very much reduced.

The floor of the cranial cavity as defined by the attachments of the membranous side walls is composed of the basioccipital behind and the two prootics in front with no basicranial obturator membrane between.

There follows next the pituitary fossa, with its floor of tough membrane, and then the bar formed by the horizontal lamina of the basisphenoid, marking the lower limit of the front wall. Above the basisphenoid the front wall is composed of tough fibro-cartilage. The centre of this fibro-cartilaginous wall is attached to the septum interorbitale and lifts toward the dorsum cranii with a curve, the sides rising more rapidly, so that there is here formed a trough-like v-shaped forward prolongation of the cranial cavity immediately under the roof and above the hinder end of the septum. At the anterior termination of this cavity the olfactory nerves pierce its walls and pass forward on either side of the septum just under the frontal bones. The bony front walls of the cavity rise with a forward slope in the one plane to the roof. A wide shallow fossa on the occipital segment of the floor may represent the azygos sinus.

The optic nerves leave the cavity through the membrana sphenoobturatoria just above the basisphenoid.

Nerve iii penetrates the prootic bone just to the outer side of the basisphenoid, with the fourth nerve perforating the same bone immediately to its outer side.

The sixth nerve penetrates the prootic on the floor of the cavity just behind the pituitary fossa, and passes along under the roof of the myodome on its way forward.

The roots of the fifth and seventh nerves, intricately commingled, leave the cavity through two foramina in the prootic, lateral to and below those for the third and fourth nerves. The trigemino-facialis ganglion is apparently lodged in a shallow fossa on the front of the prootic bone; the outer wall of this fossa is perforated for the passage of the inferior trunks of the complex.

### MYODOME.

This chamber is widely open in front, nearly as deep as it is wide, the floor extending forward so far as to be nearly as far in front of the anterior limit of the roof as the full depth of the cavity beneath the roof. The roof is composed of basisphenoid, prootic, and basioccipital bones; the floor, of prootic and synpterygoid. At its depth the chamber opens on to the base of the basioccipital bone.

## SYNANCEJA.

This study of the skull of *Synanceja horrida* Linné is based on a single specimen which reached me in the flesh from the Trustees of the

Australian Museum. It was therefore not possible to check all the identifications of the nerve foramina ; they are, in consequence, to some extent determined by their position.

This skull is in many respects very dissimilar to any other scleropareian skull that has heretofore been described. I have therefore sacrificed the specimen to the description and have divided it down the mid sagittal plane and have disarticulated one half, so that, though based on a single skull, full reliance is placed in the accuracy of the description of the relation of the bones to one another.

In the flesh this head is indeed a bizarre specimen. The large suborbital hollows give it an appearance of extreme emaciation, the eyes are so small that in the formalin specimen they need looking for, whilst the large frontal eminences and supratemporal ridges impart the fearsome character that was doubtless responsible for its specific name.

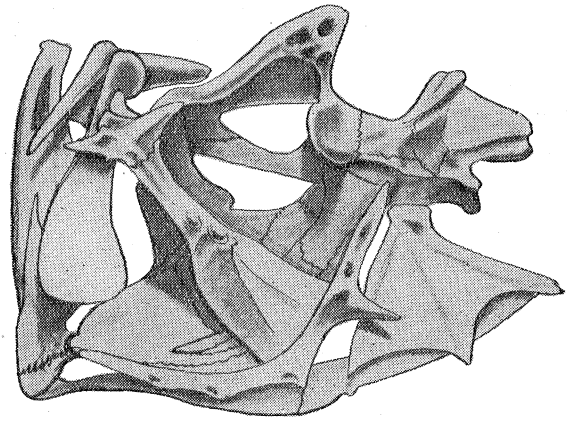


Fig. 10. *Synanceja horrida* Linné.

The cerebral region of the skull has a quadrilateral outline, with back and front sides sloping forward. From above the outline is roughly square, with an abruptly truncated wedge attached at the back. The dorsum of the skull is carried out in this region by relatively broad flanges developed from the sphenotic and pterotic bones ; between these there is a stepped-up, flat, central area. The hinder end of this flat area is flanked on either side by a large, dorsally projecting, flattened process developed from the parietal and epiotic bones. The epiotic component of this process is the epiotic process ; its base of attachment is in the usual position, but its abnormal dorsal extension disguises that fact. Behind these processes the dorsum of the skull falls away both laterally and posteriorly. The forward boundary of the cerebral region coincides with base of origin of the remarkable frontal eminences and an upturning of the postorbital process of the sphenotic. The occipital and temporal fossæ are but poorly separated from each other by a low ridge, which passes down and back from the middle of the broad attachment of the pterotic process. The dilatator fossa is a mere groove on the under surface of the postorbital process of the sphenotic bone, above the an-

terior hyomandibular facet. The temporal fossa does not extend upward between the epiotic and pterotic processes as is usual; low flanges from each of the two bones unite the processes and form the upper limit of the fossa. The hyomandibular is binarticulate. The posterior fossa is lodged on the side of the pterotic process as usual, and the larger anterior fossa is for the most part accommodated under the posterior edge of the postorbital process of the sphenotic, the prootic forming only the lower edge. The outer wall of the trigemino-facialis chamber is quite extensive, and is continued up to form a buttress to the antero-ventral corner of the sphenotic bone. The saccular bullæ, though not large, are quite obvious; they give rise to a low keel which starts below the trigemino-facial chamber and passes diagonally backward across the base of the skull to the mid line. The saccular cavities are separated only by a membranous partition beneath the cerebral floor, and, as the myodome is short, extending hardly behind the pituitary region; the basicranial axis is nearly parallel with the ventral line of the skull.

The orbital region of the skull is strikingly ornamented by the eminences of the frontal bones. The form of these extraordinary bosses can better be realised from the drawings than from description. Immediately under the bosses there is a broad, shallow, open furrow; in this the diminutive eyes are lodged. In front of the groove and boss each frontal is tilted in towards the midline, the two together forming a broad deep gutter down the forward part of the orbital region. The usual prefrontal mass is replaced by quite a small peg, standing out from a prefrontal bone which is much less massive than in other sclero-pareian skulls.

The preorbital region is broader and flatter than usual.

CRANIUM.

The *Basioccipital* presents the usual two saccular recesses above separated by a low central ridge. Below the fore part of the saccular recesses and the central ridge there is a low cavity which extends across the full width of the bone. The floor of this cavity is the upper surface of the basal lamina. Apparently the homologue of the posterior portion of the myodome of other forms, it does not communicate with the myodome in this, but is completely shut off from it by the suturation of the prootic with the basal lamina. The basal lamina is fairly broad, and forms, by its outer edge, the posterior end of the keel of the saccular bulla; the vertical lamina is low. In front of the condyle the dorsum of the bone forms part of the cerebral floor, but the major portion of this surface is occupied by a broad, shallow, spoon-shaped fossa, which is apparently the azygos sinus.

The *Exoccipital* is a very typical bone. The horizontal lamina curves round the side of the azygos sinus to meet its fellow of the other side in front of the dorsum of the basioccipital, there forming the anterior part of the occipital segment of the cranial floor and the hinder part of the roof of the saccular cavities. The buttress is but poorly developed, and the neural facet is intimately fused to that of the first neural spine, whilst the spine itself is as intimately fused to the hinder border of the superior vertical lamina. The vertical lamina is oriented in the longi-

tudinal plane of the body and arches over the foramen magnum to suture with the much reduced crest of the supraoccipital bone. The spino-accessory foramen is placed far back, its hinder margin being provided by the first neural spine. The otic mass of the bone accommodates the

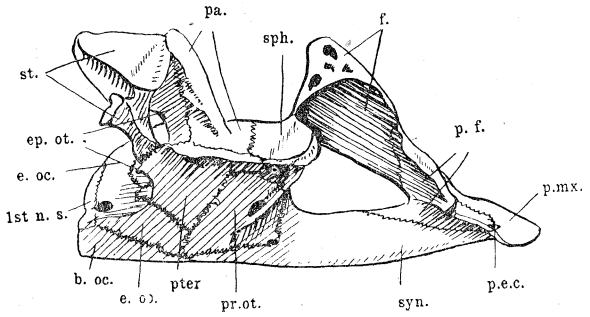



Fig. 11.

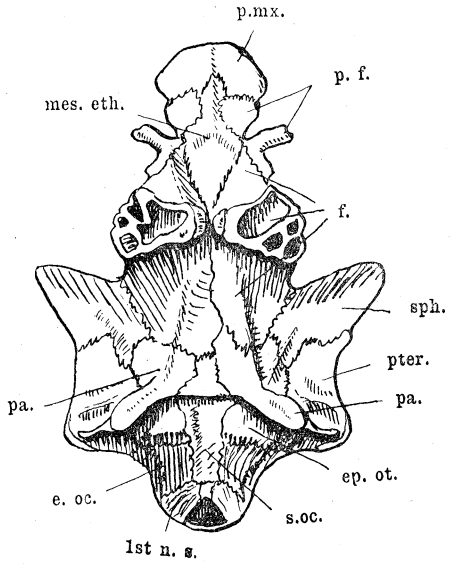



Fig. 12.

Figs. 11 and 12.—Cranium of *Synanceja horrida* Linné.

greater part of the posterior ampullary cavity and part of the posterior bony semicircular canal. The inferior vertical lamina is, relatively, a little more extensive than is usual.

The body of the *Prootic* bone forms the anterior portion of the saccular bulla and an area of the side wall of the skull in front thereof. The trigemino-facial chamber is situated on the upper part of the body and its outer wall is continued upwards to form a buttress to the lower

corner of the postorbital process of the sphenotic bone. The horizontal lamina is inclined at an angle of forty-five degrees to the central plane of the skull; the portion which forms the prootic segment of the cranial floor is quadrilateral in outline, the antero-medial and postero-lateral angles are very obtuse, and the other two angles correspondingly acute. The portion of the lamina which forms the anterior part of the floor of the saccular cavity is clearly defined by a slight ridge, and dips ventrally from that ridge. The body lodges the lower end of the arcuate fossa, a ridge of cartilage which is seated near the posterior margin of the body forming the anterior boundary of the anterior ampullary fossa.

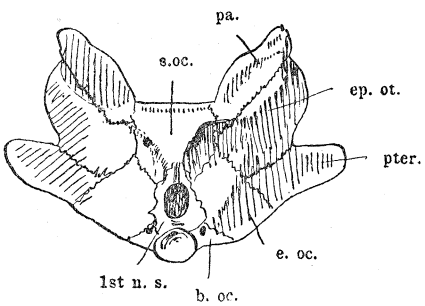



Fig. 14.

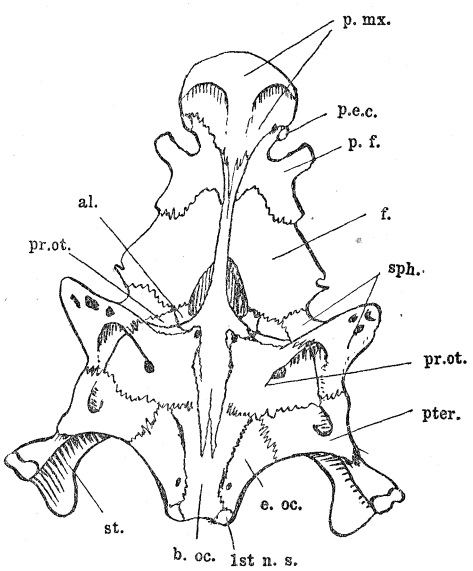



Fig. 13.

Figs. 13 and 14.—Cranium of *Synancęja horrida* Linné

No *Basisphenoid* bone was found, nor is there any trace of fractured surface in the accustomed place where a basisphenoid bone sutures. It is concluded that no basisphenoid bone is present in the complete skull.

The *Supraoccipital* bone is smaller than is usual. There is but a small horizontal lamina and a much reduced crest, the latter lying flush with the dorsal surface of the skull, separating the superior vertical laminæ of the exoccipital bones.

The *Pterotic* lodges the anterior ampullary fossa and the short horizontal bony semicircular canal.

The body of the *Pterotic* is excavated to form a deep conical recess in the postero-dorsal corner of the otocrane, and the upper part of the posterior semicircular canal lies behind the back wall of this pit. The posterior hyomandibular facet is situated under the pterotic process.

No separate *Opisthotic* bone is present.

The *Sphenotic* provides a small area of the lateral wall of the cranial wall in the extreme antero-dorsal corner. The major portion of the anterior facet for the hyomandibular is borne on this bone just behind.

The *Alisphenoid* bone is represented by little more than the pterygoid process of other forms.

The *Frontal* bones have already been sufficiently described in the description of the orbital region of the skull.

*Postfrontal* bones are absent.

The *Mesethmoid* bone is diamond-shaped as viewed from above, the long axis of the diamond being in the length of the skull. The longer posterior half is concave whilst the anterior half is convex. The bone is overlapped by the fore ends of the frontal bones, and the posterior margin under those bones is nearly as broad as any part of the bone. The mesethmoid ridge is confined to the fore end of the bone.

The *Prefrontal* bone is almost devoid of the lateral preorbital lamina usually developed on this bone. An outstanding spur is developed for the articulation of the first suborbital bone. In front of this a marked sinus in the lateral margin is succeeded by a small facet with which the maxilla articulates. Immediately in front of this the pre-ethmoid cornu of the cartilaginous ethmoid is presented through a gap between this bone and the premaxilla.

The dorsal surface of the *Premaxilla* is flush with the surfaces of the prefrontal and mesethmoid ridge behind it. The alveolar margin is quite smooth and devoid of teeth, and is followed by an extensive palatal process, which is tapered off gradually to a point below the anterior end of the synpterygoid.

The *Synpterygoid* presents the usual features posteriorly. In the orbital region it is deep from above down, compressed from side to side, and grooved above. The groove widens slightly anteriorly and deepens markedly; the side walls of the groove suture with the postero-medial corner of the body of the prefrontal. There is no vomerine process.

### PALATE AND UPPER JAW.

The hyomandibular is binarticulate, the maxilla acrartete. There is little that calls for comment on the form of the arch or its component bones, the details being clearly shown in the drawings.

### MYODOME.

The myodome is relatively high and relatively shallow from before back. That portion of this cavity which normally lies above the basal lamina of the basioccipital bone is, in this form, completely shut off from

the anterior widely open portion by bony partitions, and is a very low cave, walls and floor being close together.

WALLS OF THE CAVUM CRANII AND OF THE OTOCRANE.

The occipital segment of the cranial floor is formed by the basi-occipital behind and the exoccipital bones in front in almost equal proportions. The azygos sinus is widely open and occupies the full width and the greater part of the depth of the dorsum of the basioccipital bone. The whole of the mesotic segment of the floor is made good by the basicranial obturator membrane. The prootic segment is short and constituted as usual by the horizontal lamina of the prootic. There is no prepituitary bony floor, the basisphenoid being apparently not developed. The lateral cranial fenestra is very large, reaching right to the roof. The postotic wall occupies the longitudinal plane of the skull as it arches over to meet its fellow on the other side. The preotic wall is nearly flat, there being but mere indications of the temporal and trigemino-facialis fossæ.

There is a greater amount of persistent cartilage in the outer wall of the otocrane than is usual, so that on the inner side practically every suture is a synchondrosis and, further than that, the cartilage invades the bones between the inner and outer tables. The usual cavities in the outer wall of the otocrane are the anterior and posterior ampullary fossæ, the arcuate fossa and the saccular recesses. In the present form the two ampullary recesses are partly confluent, and there is no trace of partition between the arcuate and anterior ampullary fossae in the bony preparation. In the flesh the missing partitions are made good by cartilage. The saccular recesses are almost devoid of bony roof, and are separated in the mid line beneath the basicranial obturator membrane by a membranous partition. The anterior boundary of the arcuate fossa is clearly indicated by a ridge, which commences above on the parietal and is continued down across the pterotic and prootic. This ridge provides the anterior line of attachment of the lateral obturator membrane. The membrana spheno-obturatoria is fairly broad.

The points of emergence of nerves iii, iv, and vi have not been determined; the other nerve foramina are situated in the usual situations. The internal carotid artery interrupts the prootic synpterygoid suture in the angle behind the alisphenoid process of the latter bone.

CIRCUMORBITAL BONES.

There are only two bones of this series developed, none of the post-orbital chain are present, and there remain but the two suborbitals. The anterior suborbital is articulated to the lateral process of the prefrontal already described, and firmly attached to the outer side of the labial process of the maxilla. The bone stands out and down from its attachments at an angle of forty-five degrees with the sagittal plane; the bone is therefore foreshortened in the drawing. This bone terminates in two spines, which stand forwárd and out over the labials

when the mouth is closed. The form of the second subocular is sufficiently well shown in the drawing.

REVIEW.

From the four descriptions above and from the work of Allis[15] it is possible to review ten scleropareian skulls. It is a surprising fact that five distinct types of skull may be recognised among these.

Type i. *Scorpaenid.* This includes the skulls of *Scorpaena*, *Sebastes*, *Neosebastes*, *Cottus* and *Ophiodon* (?).

Type ii. *Platycephalan*; includes *Platycephalus* only.

Type iii. *Synanceian*; *Synanceja* only.

Type iv. *Triglid*, *Trigla*, *Pterygotrigla*, and *Peristedion*.

Type v. *Dactylopteran*, *Dactylopterus*.

The scorpaenid skull is characterised by its generally rounded form, compact cerebral region, spiny roofing, periorbital bones and obvious latero-sensory canal system. The myodome is large and extends back under the mesotic segment of the cranial floor. The cheek armature is incomplete.

The platycephalan skull is characterised by its extreme dorso-ventral flattening, relatively large cerebral region, non-spinous covering bones, obvious latero-sensory canals, small myodome, extending only half way under the mesotic segment or terminating at the hinder end of the prootic segment of the cranial floor. The cheek armature is still incomplete, but more complete than in the last type.

The synanceian skull presents several characteristics which make its inclusion in the present company (Scleroparei) seem a *mésalliance*; much more do these characteristics appear in evidence against the inclusion of the genus in the Scorpaenidæ.

The most outstanding, and at the same time perhaps the most fundamentally important, feature of this skull is the peculiar form of the orbital region. This is regarded as of prime importance because it is intimately related to, and probably consequent on the small size of the eyes.

It would appear that on its craniological characters *Synanceja* should be made the type genus of the family SYNANCEIIDÆ.[16] The members of this family will present more or fewer of the following characters in addition to the peculiar form of the frontal bones and the associated small eyes.

Skull more or less dorso-ventrally compressed, palato-quadrate arches wide apart ventrally and the gape at right angles to the long axis of the skull with the mouth shut. Suborbital bar complete but the postorbitals missing. Hyomandibular binarticulate, maxilla acrartete. Cerebral region of the cranium compact, parietal, epiotic, and pterotic processes large and more or less coalescent, with the supratemporal standing out above them. Occipital, temporal, and dilatator fossæ ill defined. Myodome small, not extending behind the prootic segment

[15]Allis—Zoologica, Heft. 57, 1910, pp. 1-212.

[16]Since writing this I have found that Tate Regan (Ann. Mag. Nat. Hist., (8), xi, 1913, pp. 173-175) has already done as suggested.

of the cranial floor. Opisthotic, basisphenoid, and postfrontal bones wanting. Synpterygoid without a vomerine process.

The triglid skull presents the same contours as the scorpaenid; covering bones are characteristically shagreened, not spiny, and the latero-sensory canals are well concealed. The myodome is large and extends back into the basioccipital bone; it may open behind on to the inferior surface of that bone. The cheek armature is complete.

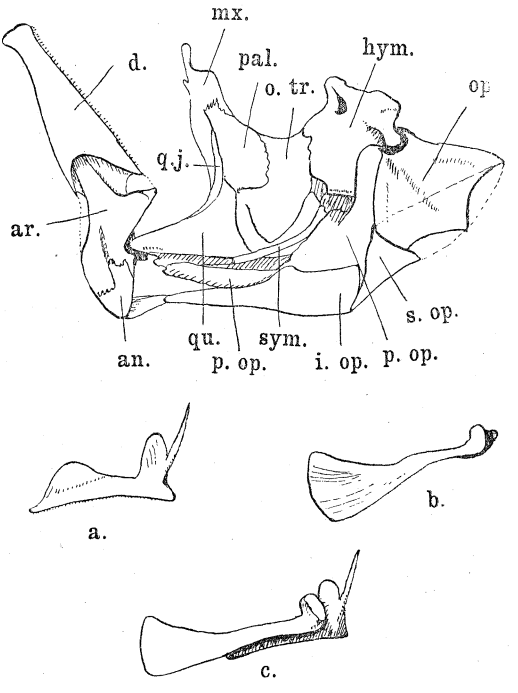



Fig. 15. Palato-quadrate arch and lower jaw of *Synanceja horrida*. *a* the premaxillary labial; *b* the maxillary labial; *c* the two labials in position.

The dactylopteran skull presents a general resemblance to the triglid; the covering bones are not spiny and are pitted instead of shagreened, and the latero-sensory canals are concealed. The cheek armature is not quite complete, but it is more firmly attached than in the triglid type. The upper scapular elements are very firmly attached to the posterior elements of the skull, and, being expanded in the same plane as the dorsal covering bones, with them constitute a remarkable cuirass which extends back well beyond the occiput. Along the base of the cranium the orbital and preorbital regions are markedly expanded.

## No. V. A Discussion on the Maxillo-ethmoid articulation in the Skulls of Bony Fishes.

The variations in the mode of articulation of the maxilla in the four genera describedin No. IV. of these studies, and in the related forms described by Allis (*loc. cit.*) may be made the basis of a general discussion on the maxillo-ethmoid articulation in the teleostome skull.

Be it noted at the outset that in all the forms which will be here passed in review (with the exception of *Neosebastes*) the pre-ethmoid cornu (Swinnerton[17]) is presented on the surface of the skull, between the premaxilla below and in front, and the mesethmoid above and behind.

In *Platycephalus* a small spur is developed on the inner side of the proximal end of the labial process of the maxilla. This spur, surrounded by fibro-cartilage, articulates with the pre-ethmoid cornu. Well back on the dorsum of the bone a small tubercle marks the gathering point of the mass of fibres which attach the maxilla to the under side of the body of the prefrontal. No articular face is discoverable on either bone in this location.

In *Pterygotrigla* there is no spur, but in the same position a small facet is present. This facet articulates with the pre-ethmoid cornu. There is no massive attachment to the under side of the prefrontal, but the postero-median and dorsal corner of the bone is attached, along with the first suborbital, to the inferior margin of the body of the prefrontal.

In *Neosebastes* a facet at the root of the labial process faces upward and backward to articulate with the anterior facet on the prefrontal; behind this a smaller facet on the postero-median corner of the body articulates with the posterior maxillary facet on the inner corner of the flattened portion of the body of the prefrontal. It must be remarked that *Neosebastes* is peculiar among the Scleroparei here reviewed in that the ethmoid cartilage does not present on the exterior of the skull, and that the anterior maxillary facet on the prefrontal occupies almost precisely the situation of the pre-ethmoid articulation in the other forms. Further the prefrontal is a parethmoid ossification.

In *Synanceja* the well developed tubercle on the body of the maxilla to the inner side of the root of the labial process articulates with the anterior corner of the prefrontal just behind the tiny peeping pre-ethmoid cornu. The strong underlying ligament is attached to the periphery of the "port-hole" through which the cartilage peeps. The median edge of the bone is attached along its length to the body of the prefrontal by a band of fibrous tissue, but this attachment is not in any way homologous with the stout attachment of *Platycephalus*, but is similar to that of *Pterygotrigla*. It is, in fact, the fore end of the fascia which floors the orbit and gives attachment to many of the fibres of the levator arcus palatini muscle.

[17]Swinnerton—Quart. Jour. Micro. Sci., xlv., 1902, p. 514.

In *Scorpaena* Allis describes and figures a maxilla (he terms it the palatine, in conformity with the old interpretation of the piscine palate) which is in every way similar to that of *Neosebastes*, but the anterior articulation is with the pre-ethmoid cornu, which he terms the " anterior palatine process of the ethmoid cartilage."

In *Cottus*, according to Allis, the anterior and posterior ethmo-maxillary articulations are both wanting. There is, however, a small dorso-medially directed process at the base of the labial process which is " strongly bound by tissue to the lateral edge of the ethmoid cartilage, but does not have articular contact with that cartilage." Though there may be no articular cavity, there can be no question that this is strictly the homologue of the anterior ethmo-maxillary articulation of other forms. In *Scorpaenichthys* (Allis, p. 109) the process is large and articulates with the pre-ethmoid cornu ; no mention is made of a posterior articulation.

In *Trigla* Allis describes an anterior articulation of the prevailing type with the pre-ethmoid cornu, and a probable articulation with the antero-ventral corner of the body of the prefrontal.

In *Peristedion* Allis describes again the prevailing type of anterior articulation, but it is quite clear from his description that the posterior articulation is absent.

In *Dactylopterus*, according to Allis, there is on the internal surface of the base of the labial process of the maxilla " a V-shaped groove . . . (which) articulates with the anterior edge of the lateral process of the vomer, and possibly also with adjacent portions of the corresponding edge of the pedicle (body) of the ectethmoid " (prefrontal). The dorsal edge of the body of the maxilla is attached along with the " dorsal edge of the ' entopterygoid ' (palatine) immediately posterior to it " to the ventral surface of the prefrontal by strong tissue, which is apparently the anterior part of the subdermal palatal facia, as in *Pterygotrigla* and *Synanceja*.

It may be remarked that in all those forms in which the maxilla is provided with a palatine lamina behind the normal situation of the posterior ethmo-maxillary articulation, the medial edge of the lamina is attached to the body of the prefrontal or synpterygoid near the mid ventral line by a strong sheet of fascia, which continues the palatal arch to the mid line. In the absence of the posterior maxillo-ethmoid articulation this fascia becomes strengthened in front and is continued right up to the vomero-maxillary and anterior ethmo-maxillary ligaments. When the posterior articulation is present and is approximated to the mid line, as in the majority of the Acanthopterygii, the fascia becomes weaker where it spreads out below the peri-articular ligaments. In those forms in which the anterior and posterior maxillo-ethmoid articulations are separated by an appreciable distance, or when the posterior joint is situated on the dorsum of the body or palatine plate of the maxilla, the fascia is continued forward as though there were no joint, but in such cases there is no marked strengthening of the fascia in its forward end.

The fascia in question is of very general occurrence throughout the whole of the bony fishes, being absent only in forms such as the Mormyridæ[18] and Symbranchii, in which the bones of the palate are directly attached to the synpterygoid, more or less completely abolishing the subocular vacuity, and even in these forms there is usually present a small portion of the fascia at the hinder end of the palate.

It may be usefully designated the *palatine fascia.*

We may recognise both primary and secondary attachments of the maxilla to the fore end of the cranium. The primary attachments are the ethmo-maxillary articulations, or fibro-cartilaginous unions. The secondary attachments are the maxilla-vomerine ligament and the anterior end of the palatine fascia, and at times a prefronto-maxillary ligament behind the posterior primary joint.

Ridewood says of *Mormyrops* that the maxilla is " small and fused on to the side of the vomer." Though I have not had the opportunity of examining *Mormyrops*, in view of all the facts before us, it may be said with confidence that it is with the anterior cornu of the ethmoid that the maxilla is fused. There is no posterior maxillo-ethmoid articulation. The condition is a primary acrartete union, but for this solid fusion, which also occurs in some other forms, the term *synartete* is now proposed.

Returning now to the variations observed in the ten scleropareian genera reviewed, *Platycephalus*, *Neosebastes*, *Scorpæna*, and *Peristedion* present the disartete, whilst the remaining six genera present the acrartete condition. A comparison of *Neosebastes* and *Scorpæna* will show that the articulations are absolutely homologous, although in the former the anterior articulation is with the anterior corner of the frontal bone, whilst in the latter it is with the anterior cornu of the ethmoid. In *Platycephalus* the elongation of the snout has separated the two articulations, producing a condition exactly paralleled in *Esox*. Here a comparison with *Neosebastes* must convince one that the two articulations are still homologous. This is in accord with Swinnerton's conclusions.

Whilst the two articulations or unions of the disartete condition are always completely homologous, there are nevertheless two distinct varieties in the adult skull. In the one variety the articulations are both with the same bone, in the other they are not. Believing, with Swinnerton, that concise designations are desirable in this connection, I propose to designate the former variety *monobisartete* and the latter *dibisartete.*

The great majority of the Acanthopterygii are monobisartete.

Swinnerton[19] assigned a good deal of taxonomic value to the character of the ethmo-maxillary articulation, and made the statement that " notwithstanding all the changes of form which the head undergoes

[18]Ridewood—Jour. Linn. Soc. (Zool.), xxix, 1904, pp. 188-215.

[19]Swinnerton—*loc. cit.*, p. 556.

among the Acanthopterygii . . . the double articulation is retained." *Scorpaena*, *Neosebastes*, and *Synanceja* are at present placed together in the Scorpaenidæ. The first is dibisartete, the second monobisartete, and the third is acrartete. *Trigla*, *Pterygotrigla*, and *Peristedion* are placed together in the Triglidæ. The first is dibisartete and the other two are acrartete.

As my studies in ichthyology have been confined to the anatomy of the head, I leave this question without further comment.

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