

FURTHER STUDIES ON *GRAMMICOLEPIS BRACHIUSCULUS*, POEY.

By R. W. SHUFELDT, M.D., C.M.Z.S.

DURING the spring of 1872, Professor Poey of Havana, Cuba, came into possession of a very remarkable form of fish, which presumably was taken in Cuban waters.

Fortunate it was for science that it fell into such excellent hands, as that eminent ichthyologist promptly presented us (*Anal. de la Soc. Esp. de Hist. Nat.*, Tom. 11, 1873) with a very excellent account of this more than rare type, the duplicate of which, so far as I am aware, has yet to be found by naturalists.

This account of Professor Poey's, as will be seen, was published in the Spanish language, and it has given me much pleasure to make a translation of it, and present it here as an introduction to some subsequent examinations which I had the rare opportunity of undertaking upon the skeleton of the specimen in question. The osteology of this fish is very interesting, not only from the fact that it is the only specimen in the hands of science, but from its extraordinary peculiarities, and from the fact that it may some day be found upon our own coasts.

My translation of the original description just referred to reads as follows :—

“GRAMMICOLEPIS BRACHIUSCULUS.

TYPE OF A NEW FAMILY IN THE CLASS PICES.

By DON FELIPE POEY,

PROFESSOR IN THE UNIVERSITY OF HAVANA, AND CORRESPONDING MEMBER OF THE ACADEMY OF EXACT, PHYSICAL, AND NATURAL SCIENCES OF MADRID.

The length of this extraordinary fish is 470 millimetres. The head enters five times into the total length of the body, and two

and two-thirds times into its greatest depth. The body is much compressed, and quite deep. The very large eye is contained two and a third times in the length of the head, and lacks the *membrana adiposa*.

The branchial apertures are deeply cleft, but I fail to find more than four branchiostegal rays, without being able to assert that there may be a greater number of them. The snout is short. The prefrontal, the turbinal, and the anterior suborbital, are extremely hard, and covered with spiny rugosities. The preoperculum and interoperculum have rugose borders, while the remaining opercular bones are entirely so. The mouth is small, subvertically cleft; the premaxillary process is large, and is lodged in a fossa of the cranium. The maxillary is complicated. The teeth are simply a narrow row of minute prickles; they do not occur upon the vomer, nor the palatines.

D. 6-34; A. 2-33; V. 1, 6; P. 15; C. 1-13-1. The leading spine of the first dorsal series is rugose, as is the first ventral, the two post-anals, and the external ones of the tail, which latter show the condition equally well in either one.

The rays of the pectoral, second dorsal, and the anal fins are compressed, and do not ramify at their extremities. The pectorals are very short and rounded. On the other hand, the vertical fins, the dorsal, and anal are well developed.

The tail was injured, and apparently cut; the membrane which unites its rays had disappeared; the peduncle which supports it is large, and capable of communicating a powerful impulse to the act of progression. The thoracic pectorals unquestionably possess a rugose spine and six flexible ones that are branched.

Aside from the frontal bones and the suborbitals where the skin abruptly terminates, and the nasal portion of the snout, all the trunk and the head is covered with scales, including the inferior mandible.

These scales in no way resemble those found among the *acanthopterygean* fishes. Their length greatly exceeds their width; they have the appearance of parchment, — transparent, brittle when dry, — overlap each other, and are strengthened longitudinally by a raised lineal ridge.

Their contact with each other is so extremely intimate that it lends to the skin of either side a very smooth appearance — so

much so, that the rough borders of the scales would not be suspected without the aid of the fingers.

Thanks to the length of these scales, four, five, or six of them are sufficient to span the height of the trunk, one of such a series being crossed by the lateral line, where its presence is denoted by a raised ridge.

The leading scales on the body, above as well as below, are shorter, and where carried on to the head, are doubly as firm as those found at the base of the fin rays.

Without having done more than counted the scales in a longitudinal line, I calculate that the number is considerably above two hundred; those of the head, although shorter, have the same form as those of the trunk. There are no scales upon the fins.

The caudal peduncle develops neither a cartilaginous nor an osseous plate at its sides. Posterior to the arms the ventral keel is rough.

The cranium is more cartilaginous in structure than it is osseous, except the frontals, which are rugose in lines in the supraorbital region, and bristly in front, as are the turbinals and suborbitals; these latter are four in number, the last three being very slender. There are two supratemporals.

The inferior mandible is characterized by several rows of minute spines upon the dentary and articular elements. The vertebræ number $10+36$.

The anterior neural spine is not excavated, being lofty and smooth; the five that follow are short and inclined backwards. The remaining ones are slender, which applies also to their hæmapophyses. The last vertebra is without lateral spines.

The pleurapophyses are inconspicuous, feebly developed, and have much the same size and shape as the epipleurals. I discover but one pseudo-interneural spine in front of the one that supports the first dorsal fin ray.

The specimen I described, when received by me was without gills and without abdominal viscera. Preserved as it was three days upon ice, its general color appeared to be white; but we have reason to suspect that in the fresh condition this fish can easily assume a violet tint. The hard parts of the head were of an intense violet shade. The ascending border of the preoperculum, violet. The fins were white, changing to violet in cer-

tain lights; the caudal fin rays were of a reddish tint. Eye inclining to white.

FAMILY: The characters which are presented us in this fish are of such an extraordinary nature that they will not permit us to place their possessor in any of the recognized families of fishes. Its nearest affinities are with the *Berycidæ* and with the *Carangidæ*, two families widely separated from each other; I am inclined to believe that its better place is along-side of the last-named one. Its resemblance to the *Berycidæ* is seen in the large eye; the asperity of the cranium; the rugosities upon the fin rays; the ventrals composed of more than five soft rays, over and above the spiny one; its resemblance to the *Carangidæ* is seen in the two free spines which precede the anal fin, and especially to *Seriolas* for lacking the bony plate of the lateral line; but in the number of its vertebræ it approaches the *Scombridæ*, as the shape of its ventral fins are in pattern analogous to those of the *Acanthuridæ*, and its unramified fin rays agree with the *Balistidæ*.

The character of the scale, to which ichthyologists have attached so much importance, separates it from all other forms known to me.

My examination, then, authorizes me in establishing the family *Grammicolepidæ*, based upon the following characters: Lateral line unarmed with bony plates; ventral fins composed of more than five soft rays; two free postanal spines; caudal vertebræ numerous; scales very long and narrow, without fan-like expansions or denticulations.

GENUS: The genus *Grammicolepis* has for its etymology *γραμμικός*, line; *λέπις*, scale.

The characters, in addition to those I have already pointed out for the family, are: Body deep, compressed; eye large; mouth small; head, in part, rugose, which also applies to the interoperculum and the preoperculum; to all appearances a limited number of branchiostegal rays; teeth mere asperities, the palatine arch without them; two dorsals, the first short, the second very extensive, its height insensibly increasing; pectoral short and rounded; the dorsal, anal, and pectoral fin rays do not ramify at their extremities.

HISTORY: I saw this fish for the first time in Havana, on the 5th of April, 1872, and I have not observed it since; neither

fishermen nor students of the class have been able to give me its name, because neither one nor the other have seen it to know it. It is, then, one of the rarest forms in existence. The skeleton I have sent to the eminent Professor Gill, who has it in his possession, though I do not know but that he has preferred placing it in the collection of the Smithsonian Institution in Washington."

This account is completed by a plate and its accompanying description, showing the fish one-third the size of nature, and various illustrations of its scales and other parts.

Now about a year ago, Professor Gill did me the great honor to place in my hands, for a little more extended illustration, not only the skeleton of this rare type, but a life-size outline drawing of the fish made by Professor Poey himself. In addition to these treasures, this eminent zoölogist also placed at my disposal several crania of fishes, representing the genus *Caranx* and others, to be used in the present connection. Situated as I now am, at an outpost in New Mexico, notwithstanding the great value of these crania for comparison, I can only regret that the material at my hand is not still more extensive, as it might be, were I more favorably situated to undertake this kind of a paper. Especially would I like to examine specimens of *Brama Raii*,¹ which, if I have recalled the proper form, possesses vertical linear scales something like those in *Grammicolepis*, though, I believe, very much smaller.

In order to give an idea of the external appearance of the subject of this article, I brought to my aid the two drawings of

¹ Since writing the above, a very valuable work upon ichthyology has appeared, viz.: *The Fisheries and Fishery Industries of the United States*. By G. Brown Goode, Asst. Direc. U. S. Nat. Mus. and a staff of Associates. Washington, 1884. On page 335 of the text of this book, we read of the BRAMIDÆ that "The only member of this family of interest to us is the *Brama Raii*, called "Pomfret" in Bermuda, where a few individuals were observed by the writer in 1876. In 1880, an individual was obtained on the Grand Bank of Newfoundland, and more recently the species has been found to be somewhat abundant on the coast of Washington Territory and Vancouver's Island. This species was described from the coast of South America, under the name *Brama Chilensis*." In the second volume of this work, we find an excellent figure of *Brama Raii*, Plate 112, which shows the fish possesses vertical linear scales, although they are much shorter than they are in the subject of this article.

The Pomfret also has its tail more deeply forked, and the dorsal fin is seen to be continuous. The eye is very much smaller, though otherwise there are some general external resemblances between the two forms. (R. W. S., 7 Aug., '86.)

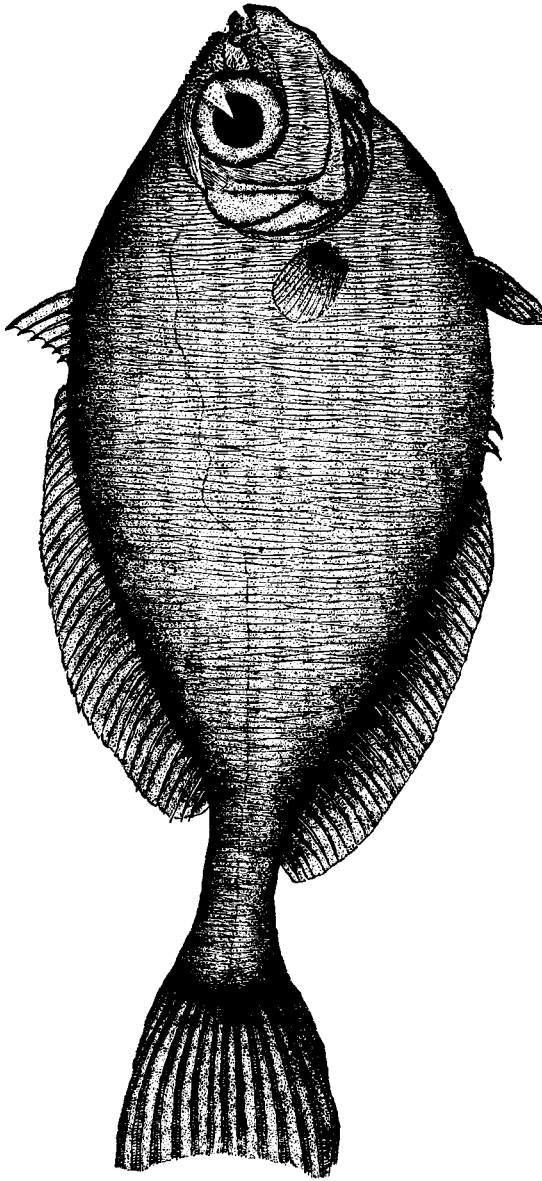


Figure 1. — Right lateral view of *Grammicolepis brachiusculus*. One-third size of nature. By the author, assisted by Poey's outline drawings, and existing material.

Professor Poey, neither of which profess to be anything more than the merest outline of *Grammicolepis*, and the scales, fins, and other parts that accompanied the skeleton. These, taken in connection with the lucid description of the fish, and all care-

fully compared, have resulted in my drawing presented in Fig. 1 of this memoir.

Owing to the fact that many parts of the skeleton, from long keeping and their delicate structure, have warped considerably out of shape, I propose to devote myself on the present occasion only to such as seem most important of them, and chief among these stands the cranium.

As I say, so far as I know, the specimen of the *cranium* of *Grummicolepis* before me is the only one in the hands of science, and a most extraordinary object it is. Three features strike us most forcibly when we first came to examine it: the enormous orbits, the truncate appearance of its anterior part, and the semi-transparency of its gelatinous-looking bones.

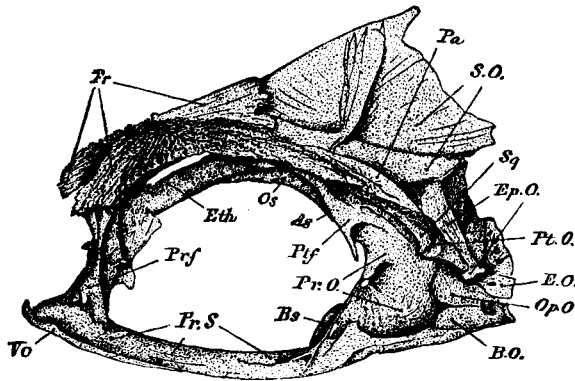


Figure 2.—Left lateral aspect of the cranium of *Grummicolepis brachiusc ulus*; life size, drawn by the author from the specimen. *Fr*, frontal; *Pa*, palatine; *S.O.*, supraoccipital; *Sq*, squamosal; *Ep.O.*, epiotic; *Pt.O.*, pterotic; *E.O.*, exoccipital; *Op.O.*, opisthotic; *B.O.*, basioccipital; *Bs*, basisphenoid; *Pr.O.*, proötic; *Ptf*, post-frontal; *As*, alisphenoid; *Os*, orbitosphenoid; *Eth*, ethmoid; *Prf*, prefrontal; *Pr.S.*, parasphenoid; *Vo*, vomer.

The peculiar rugose condition of a *frontal bone*, referred to by Professor Poey, is well shown in Figs. 2 and 3, *Fr*. It will be seen that these rugosities of the frontal radiate from a common centre on its superior aspect, this centre being found at about the middle of the bone, or what would be the middle of its oblong figure were its anterior internal notch completed, and we do not regard its postero-lateral prolongation. This latter part of the bone forms the superior periphery of the orbit, and is produced backwards as far as the squamosal (*Sq*). To the inner side of

this process, the posterior border of the frontal shows at least one conspicuous notch, while its free margin overlaps the supraoccipital, and is in turn overlapped by the parietal (*Pa*) more externally (Fig. 2). Mesially, its surface turns upwards, more particularly behind, where with the fellow of the opposite side it grasps in the middle line the anterior portion of the supraoccipital crest. Below this point the two frontals have their straight, free, mesial edges roughly in contact with each other, and slope gradually downwards to the margin of that concavity which is found in front (Figs. 2 and 3).

This extraordinary fossa on the anterior aspect of the cranium of *Grammicolepis* is entirely open above; its rugose and subcircular margin being formed by the frontals; while below it becomes conical with its apex in the middle line, and in the ethmoid. Above, where it is most capacious, it has its posterior wall formed by descending plates developed on the part of the frontals, the left one considerably overlapping the right. Below this, in the middle line, there is an opening of some size, which leads into a commodious chamber lying between the frontals above and the mesethmoid below.

A frontal is truncate in front, where it overhangs the corresponding prefrontal, and internally articulates with the curiously shaped ethmoid. Behind this, and on its under side, it forms the major share of the roof of the orbit. Then occurs a longitudinal keel, which separates this from that other part of its under surface which forms the roof of the mid-chamber described in the last paragraph. Viewed together from above (Fig. 3), it will be observed that the rugosities of the frontals are limited behind by a subparabolic curve with its arc anteriorly directed.

In this dried cranium a *parietal* (*Pa*) is represented by a thin, flake-like, semi-transparent piece of bone, of a form shown in Fig. 3. To the outer side of its mid-longitudinal line it develops for its entire length quite a prominent, though thin, crest, which is rugose all along its superior margin.

The anterior three-fifths of the under surface of this element simply rests upon the frontal and supraoccipital, while the remaining portion behind is more firmly attached, and really holds the bone in its position. Its outer free margin articulates principally with the inner border of the posterior prolongation of the corresponding frontal, though still more posteriorly it meets

to some extent the squamosal (*Sq*). With the epiotic (*Ep.O.*) it is connected simply by a feeble and thin band of bone. The parietals, then, seem to play the part here of binders, rather than their presence is at all essential to covering over any sizable vacuity in the cranial vault, that might exist were either of them removed.

The *supraoccipital* is a very extensive ossification, and is characterized by a fairly prominent crest.

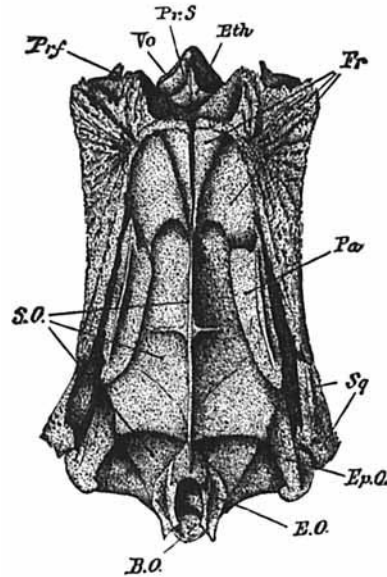


Figure 3. — Cranium of *Grammicolepis brachiusculus*, seen from above; life size, by the author. Lettering as before.

This crest is triangular in outline, with its apex above, and its base attached in the middle line, to the horizontal portion of the bone. From the middle point of this base, a narrow, fan-shaped development springs upon either side, which is incorporated with the crest, to strengthen it, being carried nearly as high as its apex (Fig. 2).

The broad and spreading horizontal portion of the bone forms the roof of the brain-case, while posteriorly, just before the termination of the crest, it is bent abruptly down to meet the exoccipitals. The flexure, being sharply defined by a transverse line, the outer end of which, either way, terminates in the apex

of a pyramid, the lateral and upper sides of each being also formed by the supraoccipital. The lateral aspect of this pyramid is overlapped by the epiotic (*Ep.O.*), while outwardly its free margin articulates with the squamosal (Fig. 3).

Regarding one of these *epiotics*, we find that its fan-like portion is finished off behind by a semicircular piece, which is thickened below, where it becomes firmly attached to the neighboring bones. The blade portion is longitudinally fluted, but no rugosities are found upon it. This does not apply to the element at its outer side, the *squamosal* (*Sq*), which element develops very conspicuous rugosities upon its upper aspect in direct continuation with the longitudinal ones on the long, backward-extending process of the corresponding frontal (Fig. 3).

At the distal extremity of the squamosal I detect a small, flake-like piece of bone, thoroughly attached, though individualized by sutural traces, which I take to be the representatives of the *pterotie* (*Pt.O.*). Beneath and beyond, the squamosal seems to make the usual ichthyic articulations with the postfrontal (*Ptf*) and the prootic (*Pr.O.*). At its under side we find a small hyomandibular facet (Fig. 4, *hf*).

A *postfrontal* of considerable size (*Ptf*) develops at its outer side, a sharp, descending, spicula-form process of bone, which is transversely pierced at its base by a small foramen. The inferior articular sutural trace of the postfrontal, as I make it out, is subcircular in outline, and closely meets corresponding marginal concavities offered by the proötic and alisphenoid.

Each *alisphenoid* is necessarily a very extensive ossification, forming, as they conjointly do, the major part of the bony wall of the posterior aspect of the immense orbit (*As*).

In front they articulate with far smaller *orbitosphenoids*, which in their turn meet in the median line anteriorly (*Os*). Now above the basisphenoid (*Bs*), the alisphenoids and orbitosphenoids are separated from each other, mesially, by a vertical vacuity, broadest below, gradually tapering to a blunt apex above, which constitutes a great fenestra for the anterior wall of the cranial casket (Fig. 4).

As already stated, the hinder portion of the *ethmoid* (*Eth*) forms the mid-roof of the orbital space. This division of the bone is of an oblong outline, being encroached upon by the common, circular, anterior margin of the orbitosphenoids behind,

the two elements being completely united. Below, it is convex from side to side, correspondingly concave above, where it forms the floor of the interfronto-ethmoidal chamber, already alluded to above. I have previously described how now the ethmoid is deflexed, and becomes concaved in front to form the lower limits of that excavation on the anterior aspect of the cranium.

This, as we have already seen, terminates in a conical point, and even beyond this the bone is carried forwards as a median

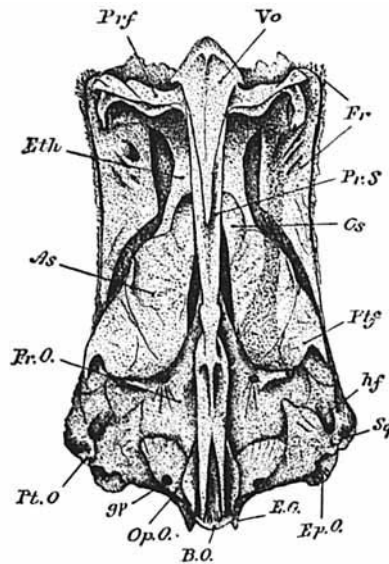


Figure 4. — Under side of the cranium of *Grammicolepis brachiusculus*; life size; reference letters the same as in former figures, with *hf*, hyomandibular facet, and *gp*, foramen for the exit of the glossopharyngeal nerve in the opisthotic (*Op.O.*).

triangular process, the apex of which rests upon the parasphenoid (Fig. 3, *Eth. Pr.S.*).

Upon either side of the ethmoid, the flat anterior aspect of this cranium is completed by a broad prefrontal (*Prf*). The form assumed by one of these elements can best be appreciated by referring to Fig. 5, which represents the cranium of *Grammicolepis* seen from behind, while the anterior face is in the horizontal plane. In this position the posterior aspects of the prefrontals come into view.

Each one essentially consists of a thicker and vertical outer

column of bone, antero-posteriorly compressed, and an expanded inner portion, which latter is reenforced by radiating projections that converge to meet at a point at the lower part of the inner margin of the columnar portion. It is hardly necessary to state that these prefrontals form the externo-lateral parts of the anterior orbital wall, the ethmoid completing it mesially.

Coming now to the *vomer* (*Vo*), we find it to be a thin scale-like bone, of a form best shown in Fig. 4. It rests in the longitudinal excavation of the anterior and lower side of the parasphenoid, while its firmest attachment to that bone seems to be by the periphery of its anterior margin.

The parasphenoid (*Pr.S.*) is gently arched as it spans the orbital space below, having its convex arc downwards. The lower side of this part of the bone, as I have already intimated, is longitudinally scooped out, while the upper side presents lateral surfaces, which are inclined so as to meet in a median line. Posteriorly, the parasphenoid makes the usual teleostean connections with the basioccipital, basisphenoid, and prootic, being deeply cleft as it passes to cover the under side of the first-named element (Fig. 4).

Occupying its usual position, the *basisphenoid* (*Bs*) not only develops the median process (Fig. 2) seen in so many true teleosts, but furnishes a firm horizontal roof for the three-sided pyramidal eye-muscle canal, the lateral walls of which are completed by the prootic and parasphenoid.

As in the majority of osseous fishes, the *prootic* is a well-defined and important element at the lateral aspect of the brain-case (*Pr.O.*). Its anterior margin is pierced by the foramen for the trigeminal nerve, from which point faint lines in the tissue of the bone are seen to radiate.

The basioccipital (*Bs*) has its thickened and longitudinal portion underlying the brain-case, as in most fishes, being completed behind the facet for the leading vertebra of the spinal column. This facet is comparatively rather small, with its conical depression very deep.

At either of its sides the basioccipital develops an upturned and semicircular plate of bone, similar in structure to the other flat bones of the lateral cranial walls, which articulates with the lower margin of the opisthotic and the posterior margin of the prootic (Fig. 2).

The *opisthotic* (*Op.O.*) is large and occupies its usual position, as generally found, in the cranium of the teleosts. Its posterior margin is pierced by a conspicuous foramen for the exit of the glossopharyngeal nerve from the brain-case. The intersutural traces defining its borders are easily made out in the specimen, and this element contributes not a little to the lateral wall of the cranial cavity, — a large vacuity existing after its disarticulation.

Each *exoccipital* (*E.O.*) develops at the outer sides of the vertically oval foramen magnum, a fan-shaped, bony thickening (Fig. 5), which nearly meets at the middle point above.

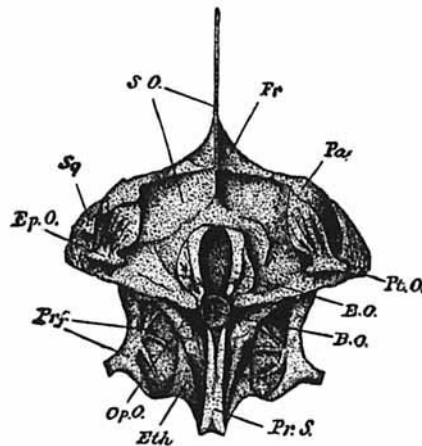


Figure 5. — Posterior aspect of the cranium of *Grammicolepis brachiusculus*; life size. Letters have the same significance as in former figures. The cranium is represented as resting upon its anterior face on the horizontal plane, the line of sight being perpendicular to the latter, and passing through the imaginary centre of the foramen magnum.

Further, these bones spread out so as to complete the hinder cranial wall, where the supraoccipital and osseous elements at the lateral angles have failed to do so.

Now a number of the bones required to complete the skull of this fish have been lost, and, as I said before, the others in my possession are too much out of shape, from their fragile nature, for me to decide, with any degree of certainty, as to their several proper positions. This is much to be regretted, as I expect a complete skull of *Grammicolepis* would prove a very interesting and instructive object.

To return to the cranium for the purpose of taking a general glance at it: we are to note especially the almost entire absence of those parial and lateral crests, developed on the part of the parietals and squamosals, so manifest in some fishes, as for instance the genus *Caranx*; we are to note, also, the very peculiar texture of the bone that composes this cranium, being more like the material that is found in ordinary fish scales rather than bone; particularly are we to observe the relation between the anterior portion of the supraoccipital crest, and the upturned portions of the frontals.

There are but few striking features within the cranial case of this strange form of fish. For the most part, surfaces, convexities, and concavities on the outside give rise to similar surfaces on the inside, the last two being, of course, reversed. The fossæ for the *otoliths* are ample and well defined, but the elements themselves have been lost.

I have already expressed my regrets at not having at hand more extensive material wherewith I might compare this extraordinary fish; they only increased as my investigations proceeded, while the remaining consolation left me, is, that I feel I have added at least my mite to the labors of Professor Poey; so should another specimen of *Grammicolepis* fall into the hands of naturalists, we can, at least, meet it with drawings of its cranium and other skeletal parts, as well as with similar drawings of some of the forms to which it is supposed to be related.

Through the courtesy of the Smithsonian Institution, and the kindness of Dr. Gill for selection, I find before me the cranium of a specimen of *Caranx hippos*, with the spinal column of the same fish (No. 13,561 S. I. Coll.). There is also the cranium (No. 11,385) of another and still larger *Caranx*, the species being unknown. This last specimen presents some points of peculiar interest not so well shown in the first. I have also the cranium of a specimen of *Teuthis cæruleus*, which will be introduced to show certain points; and finally, the cranium of *Pomacanthus paru* (No. 12,770 S. I. Coll.) brought forward to illustrate still other points.

Professor Poey's investigations evidently led him to believe that *Grammicolepis* was more nearly related to the *Carangidæ* than any other family of fishes known to him. And in this opinion, so far as I can see or am able to judge, I must concur.

The cranium of the *Caranx* No. 11,385, which bears a very close resemblance to *C. hippos*, shown in Fig. 6, although, be it known, it possesses marked differences, is composed of a bone tissue much more like that seen in the cranium of *Grammicolepis* than any of the other specimens before me. As much as it is unlike it, it evidently approaches the semi-transparent and brittle condition found in our subject. The next thing that our attention is directed to, is the strikingly large orbit of this *Caranx*, and the evident, though distant, similarity of the elements that go to form its walls. The chief difference we meet with here is the absence in the *Caranx* of the backward-extending plate of the ethmoid seen in *Grammicolepis*, while there is much to support a probable relationship of the forms, in the parasphenoid, the basisphenoid, and less so in the prefrontals, of the two.

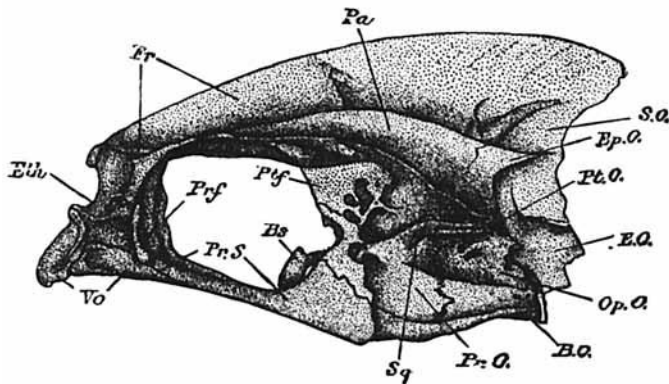


Figure 6. — Left lateral view of cranium of *Caranx hippos*. Spec. No. 13,561, Collection of the Smithsonian Institution; life size, by the author. Letters signify the same as in the other figures.

Again, in the *Caranx*, the ethmoidal mass, and parts, which of a consequence associate with it, are produced forwards, and we fail to find anything upon this aspect that in any way reminds us of the curiously truncate appearance of the front part of the cranium in *Grammicolepis*.

Another marked difference is seen in the vomerine element; this bone, as we have observed, is in our subject merely a kite-shaped scale, in no way incorporated with the parasphenoid, being merely attached around its anterior rim. Now our speci-

men of *Caranx*, No. 11,385, foreshadows in its vomer what eventually comes to pass, between this condition in *Grammicolepis* and what we find in *C. hippos*. In this latter fish, as will be observed by referring to the figures Fig. 6, *et seq.*, the vomer is quite a solid bone, and is moulded upon the anterior end of the parasphenoid, forming a more or less massive termination of this end of the cranium.

In our unspecified specimen of *Caranx*, this general appearance is likewise maintained; but upon a lateral view, we are enabled to look in between the vomer and parasphenoid, and the less solid formation of either can at once be appreciated as well as their less intimate relation to each other. It is a shame that this species is not known, nor was ever diagnosed when this specimen of cranium was taken, as this condition is very interesting in the present connection, as are several others, as we shall presently see.

As representatives of the *Carangidæ*, neither of these specimens develop a spine-like process descending from the post-frontal, which is a very marked feature of that bone in *Grammicolepis*. It is, however, present in other teleosteans, as seen in one crania of *Pomacanthus* and *Teuthis*, Figs. 10 and 11.

Before leaving this region of the cranium, I would like to invite attention to the anterior aspect of it, in this very specimen of *Pomacanthus* (Fig. 10). It approaches to some degree the truncate appearance, so often alluded to in *Grammicolepis*; a closer resemblance, however, is vitiated by the extraordinary forward and upward projection of the vomer in *Pomacanthus*. Posterior to this bone, in the individual in question, an extraordinary concavity is seen, the sides of which are formed by the prefrontals and parasphenoid, being perforated on either side by a group of foramina. Its bottom is completed entirely by the latter bone.

Teuthis cæruleus offers us in its ethmoid and vomer just the very reverse of this condition, as may seen by a reference to Fig. 11.

It may be as well to note in passing that in *Pomacanthus paru* the parasphenoid is very deep in the vertical direction, being longitudinally excavated above and continuous with the capacious eye-muscle canal, while anteriorly and below it is sharply carinated. Posterior to this carination the bone develops a

rounded and descending prominence, which is bifid, the two lamina being directed backwards and outwards. The behavior of the anterior end of the parasphenoid of *Pomacanthus* has already been described above.

This bone is also wonderfully developed in our cranium of *Teuthis* (Fig. 11). Here the carination in front is exceedingly deep, while behind it, a distinct descending process is also seen.

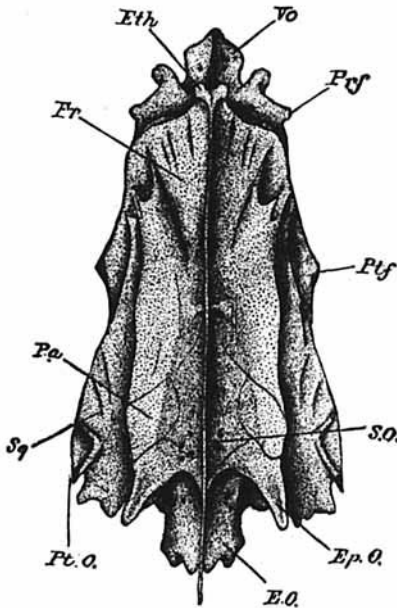


Figure 7.—Superior view of the cranium of *Caranx hippos*, same specimen as in Fig. 6; life size.

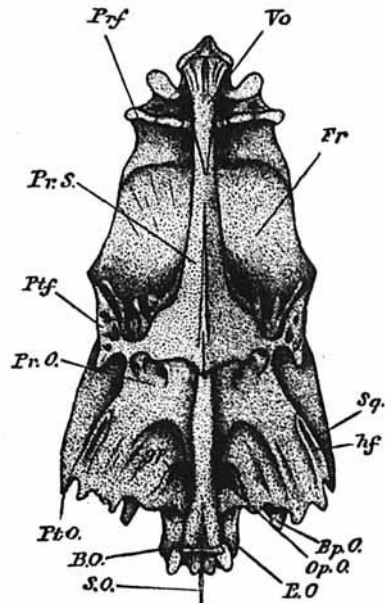


Figure 8.—The same seen from below. Letters as in the former figures.

Further, this elegantly developed element makes another curious departure from all the specimens thus far examined. It is this: where it forks over the basioccipital behind, a large foramen is found between the diverging limbs; this opening is in reality the apex of the eye-muscle canal in this fish, and consequently leads through that fossa to its continuation, which again is the longitudinal excavation on the upper side of the parasphenoid or the floor common to the orbits.

But to return to our cranium of the *Caranx* No. 11,385: we find that the anterior and horizontal portions of the frontal bone

are quite transparent at their centres, while raised flutings radiate from their hinder points, forwards and outwards. The transparent areas are found to be even perforated in my specimen of *Caranx hippos*, so thin do they become. Now it will be remembered that in *Grammicolepis*, from the horizontal portion of either frontal, was developed an upturned, scroll-like projection, the free edges of the two bones meeting in the median line. There was thus formed sort of a conical prominence, the lower part and base of which was anterior, being terminated by the transverse rugosity in front, while the apex, or highest part, seized the free front margin of the supraoccipital crest. In *Caranx hippos* these vertical portions of the frontal bones are in close approximation, so that they appear to be the continuation forwards of the supraoccipital crest; the sutural traces, however, have entirely disappeared; while in the cranium of our other *Caranx*, the method of formation is very evident from the fact that the vertical frontal plates are not thus coössified, but plainly show their individual origin as well as their relation and connection with the anterior free margin of the supraoccipital crest, which is wedged in between them. (Compare Figs. 2 and 6, as well as 7 and 3.)

Pomacanthus paru has very extensive rugosities upon its frontal bones, but these latter elements are exceedingly dense and thick, as is the anterior border of the supraoccipital crest in this fish, which measures at its widest part nearly five millimetres across.

Such forms as *Pomacanthus paru* do not develop conspicuous parietal and squamosal crests; they are still less manifest in *Teuthis*. On the other hand, in the *Carangidæ* these crests constitute the most striking feature of the cranium. As already stated above, they are but feebly produced in *Grammicolepis*, though they are plainly indicated.

All the lateral parts of the cranium, made up of the hinder portion of the parasphenoid, the prootic, opisthotic, exoccipital, basioccipital, and below the squamosal line, are very much alike in *Caranx* and our unique subject, more particularly in our undiagnosed specimen of a *Caranx*. But in the latter the basioccipital enters far more extensively into the formation of the eye-muscle canal than it does in *Grammicolepis*, as in the *Caranx* we find a condition existing, as regards the opening between

the hinder forks of the parasphenoid, very much the same as described for *Teuthis cæruleus*.

Upon comparing the posterior views of the crania of *Caranx hippos* and *Grammicolepis* (Figs. 5 and 9), we find, indeed, but few points of resemblance between them. The occipital crest in the former comes almost down, as it does in *Pomacanthus*, to the supero-median point of the foramen magnum. It is far above it in the latter fish. There the absence of the spreading lateral crests, seen in the *Caranx*, constitute a marked difference. Professor Pocy's fish also has bony pillars developed by the exoccipitals, one being on either side of the foramen magnum. These are absent in the *Carangidæ*.

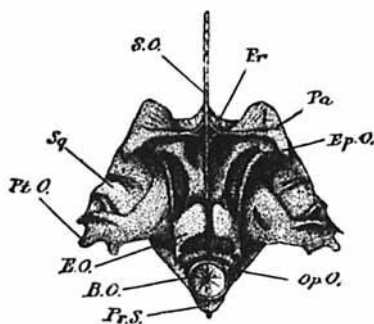


Figure 9. — Posterior view of the cranium of *Caranx hippos*, Spec. 13,561, Smithsonian Institution Collection. Life size, by the author from the specimen. Letters as before.

In *C. hippos* the facets on the exoccipitals for the first vertebra of the column meet in the middle line; these parts, however, in *G. brachiussculus* have been injured, probably during the first dissection, so that I am unable to say positively upon this point in regard to them. In *P. paru* the first vertebra of the column coossifies with the basioccipital, but this condition does not obtain in *Teuthis*. In this latter form the supraoccipital crest also fails to reach the upper periphery of the foramen magnum at its middle point.

We find that both *P. paru* and *Teuthis* have the squamosal curled downwards and forwards in the most extraordinary manner, best marked in the latter type. This is well shown in lateral view in Fig. 11, though I am not sure but that the piece there indicated by *sq* may not be a separate ossification, in

which case it would be a pterotic. I would have to dissect a young fish to decide this point. These processes are very conspicuous upon posterior view, and of course *Grammicolepis* can show nothing like them.

Pomacanthus paru has another condition present, not seen in any of the other forms alluded to above. Just posterior to the proötic, and above the basioccipital and parasphenoid in the cranium of this fish, on either side, we find a subelliptical foramen, with its major axis placed longitudinally, of no inconsiderable size, through which we can easily observe the movable otolith (Fig. 10, *otl*).

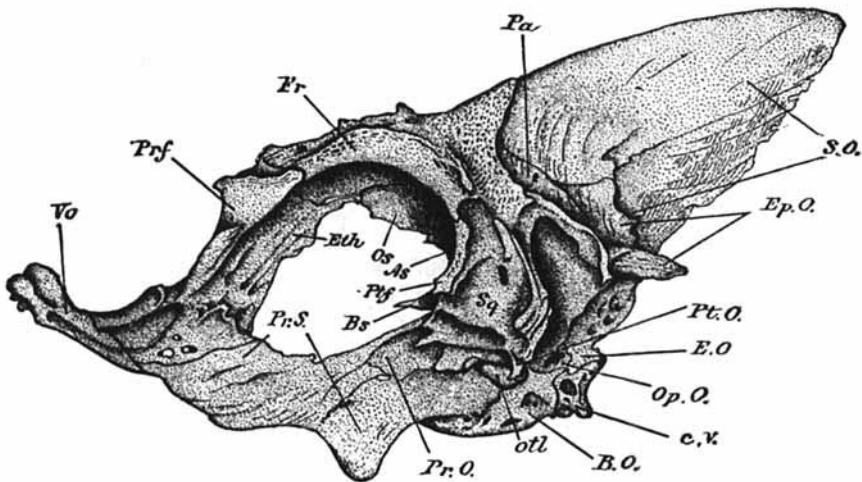


Figure 10. — Left lateral view of the cranium of *Pomacanthus paru*; life size, by the author, from specimen 12,770 of the Smithsonian Institute. Lettering as before, with *otl*, otolith, and *c.v.*, first vertebra of the spinal column, which is here coössified with the basioccipital.

Before concluding our comparison of these crania, we must note another point in the cranium of *Pomacanthus*, and this is, the ossified orbitosphenoids and the ethmoid meet in the middle and interorbital line, immediately beneath the frontals.

We have already fully described above, the relation of these several elements in the subject of this paper, and how any such condition is entirely absent in *Caranx*. This latter form, however, may have the ethmoid extended backwards in cartilage, which material may be missing in these dried preparations.

Now my material on this occasion will not admit of such a thing as an analysis of characters for comparison. In my opinion, without a thorough examination of the entire organization of not only the forms at my command at the present writing, but several others, such a tabulated synopsis, made up at the best from such fragmentary material, would be of but little service to us. The structure of *Seriola* taken in the present connection would come handsomely into play. *Naucrates ductor* would be another good form to examine.

From a comparison of the crania alone, I should say that the relation between *Grammicolepis* and such a fish as *Pomacanthus paru* was very distant, while its affinity with *Teuthis cæruleus* is still more remote. I should have liked, however, to have examined some of the *Salistidæ*, and perhaps glanced at one or two more of the *Chatodonts*.

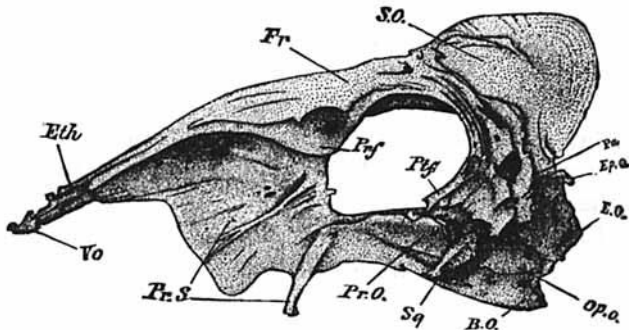


Figure 11. — Left lateral view of the cranium of a specimen of *Teuthis cæruleus*; life size. Kindly loaned the author by Professor Gill. Letters have the same significance as in the foregoing figures.

Its relationship with the *Carangidæ*, as Professor Poey predicted, is far more evident, though this, too, is extremely indirect, and many forms still unknown to us are required to demonstrate the connection.

These forms must especially show an increased density in the cranial bones; a decrease in the size of the eye and orbits; a gradual disappearance of the rugose condition of some of the flat bones of the cranium, particularly the frontals; a gradual protrusion of the snout; and finally the development of the parial cranial crests.

Of the shoulder girdle. — Although a number of the bones are

lost, I am enabled at least to present a very good idea of the shoulder girdle in this fish. This is shown in Fig. 12, illustrating this paper, and if the reader happen to have at hand a copy of my osteology of *Amia calva*, published in the Annual Report of the Commissioner of Fish and Fisheries for 1883, it will be well to compare it with the figure I there gave of the shoulder girdle of *Micropterus salmoides* (Pl. 14, Fig. 35). It represents these parts as they appear in a typical teleostean fish. A glance is sufficient to satisfy us that the general form of the proscapula (*Ps*) of *Grammicolepis* is very much like that element in the Bass, differing principally in being slenderer and more sloping, and in its relations with some of the other bones. I am very sorry that I have not at hand the shoulder girdle of a *Caranx*, as it would be interesting to compare it in the present connection.

As is most usual in teleosteans, the hypercoracoid and hypocoracoid (Fig. 12, *Hyp.c.* and *Hyo.c.*) are fused together, and in the present instance, to the proscapula also. The hypercoracoid (*Hyp.c.*) is pierced by the usual foramen seen in this element among typical teleosts. The anterior projection of the hypocoracoid (*Hyo.c.*) is long and slender, almost reaching to the extremity of the proscapula (*Ps*).

It will be noted in Fig. 12 that each of these elements develop a backward, extending process, and the letters *Hyp.c.* stand between them. This recess harbors the *actinosts* of the pectoral fin, when these parts are *in situ*. These pectoral fins have been carefully wrapped up by Professor Poey in a separate little package, and I find three of these actinosts attached to each fin. It does not appear as though any of them had been lost, and I am led to expect that that is the correct number in life. They are composed of rather elementary bone, as is so much of the rest of the skeleton in this curious fish. Now the bone marked *T* in Fig. 12 I take to be the *teleotemporal*, and designated by the same letter in my drawing of the shoulder girdle of the Black Bass. On this latter form, however, as it is also in *Amia*, the teleotemporal is very loosely attached to the rest of the girdle by ligament, while here in *Grammicolepis*, it is represented (*T*) by an exceedingly long and slender bone, which has its superior extremity moulded upon the side of the proscapula *s*, and firmly attached thereto. I fail to find in any of

the little packages put up by Professor Poey anything that might answer for a *lower teleotemporal*, *T*, of my Bass figure. We would, however, hardly expect to find such an addition, where the superior element proves to be so very much elongated.

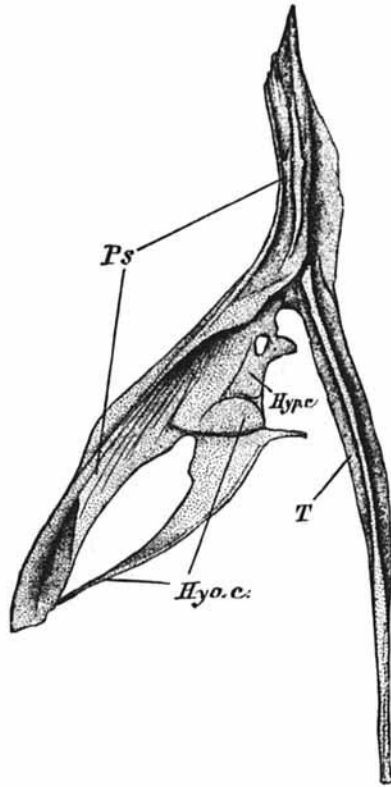


Figure 12.—Outer view of the principal elements of the left side of the shoulder girdle of *Grammicolepis brachiusculus*; life size, from the specimen. *Ps*, proscapula; *Hyp.c.* hypercoracoid; *Hyo.c.* hypocoracoid; *T*, teleotemporal. The *actinosts* are attached to the vertical border of the recess in which the letters *Hyp.c.* are contained.

Whatever we may see in the cranium of *Grammicolepis* to remind us of like parts in any of the *Carangidae*, such resemblances are certainly not borne out when we come to compare the vertebral column of our subject with the column of a specimen of *Caranx hippos*. Figs. 13 and 14 are presented to show the extraordinary departures that take place in this part of the skeleton.

Of all the bizarre structures that pertain to the organization of fishes which it has been my pleasure to examine, I cannot recall at this moment one that presents quite so supremely a fantastic arrangement as the eleven or twelve leading vertebræ in the column of *Grammicolepis*. These are represented in Fig. 13, but I have omitted to include the first vertebra, or that one which is found between the basioccipital and the one shown in the figure with the enormous neural spine. In it the neural spine is not developed, and its connections with the skull are very intimate.

Taken in connection with Professor Poey's account of these parts, this figure obviates the necessity of my presenting a verbal description of any great length, as all the details can be plainly studied without any such additional assistance.

I am inclined to think that the bony pillars, which I described in a previous paragraph, found on either side of the foramen magnum, and completely fused with the exoccipitals, are the halves of the neural spines of this first vertebra of the spinal column. To support this view, we find by placing this vertebra in position, that their pedicles spring from the centrum as in other vertebræ, and that, moreover, the sculpturing on the external surfaces of these pillars is precisely like that upon the sides of the neural spine of the second segment of the column.

This last process is very strong, and quite firmly attached to its centrum: it curves gracefully first backwards, then upwards, in a gentle curve, as shown in Fig. 13.

The succeeding four neurapophyses are inclined well backwards, each one, as we advance in that direction, becoming shorter, more slender, and with a gradual disposition to assume the vertical attitude. This is nearly accomplished by the neural spine of the next segment following, or the seventh vertebra. Fig. 13 shows, also, the eighth, ninth, tenth, and eleventh vertebræ, and, as will be seen, the neurapophyses of these segments actually lean *forwards*. The one on the twelfth, not here shown, is nearly vertical again, while after that, they gradually incline backwards. The broken spines on the last two vertebræ of the figure I have restored by dotted lines.

Now a glance at Fig. 14 is enough to convey to us that the arrangement of these neurapophyses are entirely different in *Caranx hippos*. In this latter drawing the first vertebra is

shown, and it has a vertical neural spine movably articulated with its centrum. The succeeding spines, firmly fused with their centra, gradually become slenderer, longer, and more inclined backwards, to again become nearly vertical in the mid-series of the column, to incline once more as we approach the caudal end.

In *Grammicolepis* the ventral parial apophyses at first support the freely articulated ribs with their attached epipleural appen-

Fig. 13.

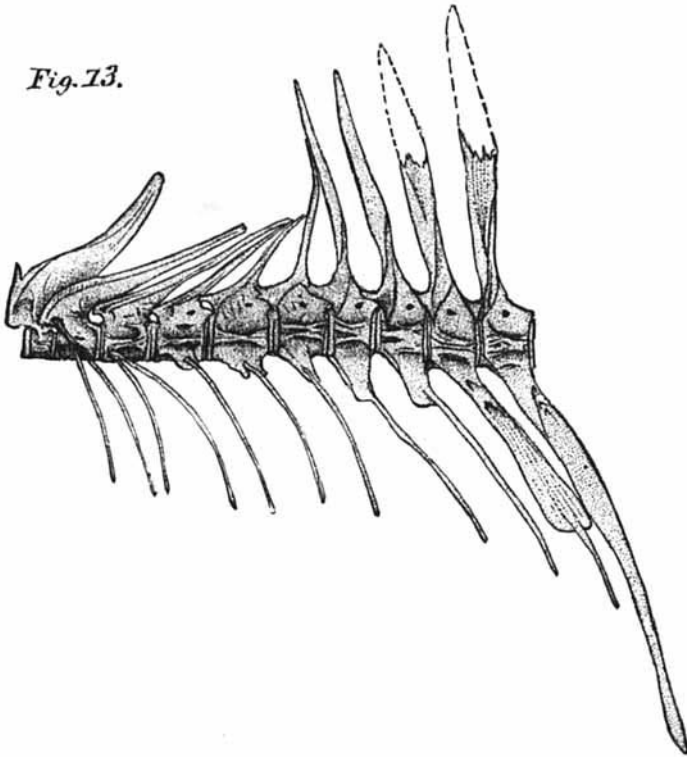


Figure 13. — Left lateral view of the anterior end of the vertebral column of *Grammicolepis brachiussculus*, the first vertebra removed; life size from the specimen.

dages, but in the seventh vertebra the capitulum of the rib completely fuses with the apophysis, and as the latter lengthens, the two become indistinguishably blended. The first and second vertebræ do not support ribs, and in the third pair only, they articulate high up on the sides of the centrum, at the base of the neural arch.

The appendages have been lost in my specimen of *Caranx hippos*, so I am unable to say anything about them.

When we come to compare the existing differences in the latter halves of the spinal columns of these two fish, we find that they are quite as great as those shown in Figs. 13 and 14. Indeed, I can see there nothing to indicate that the forms in question have any relationship whatever and were they in the

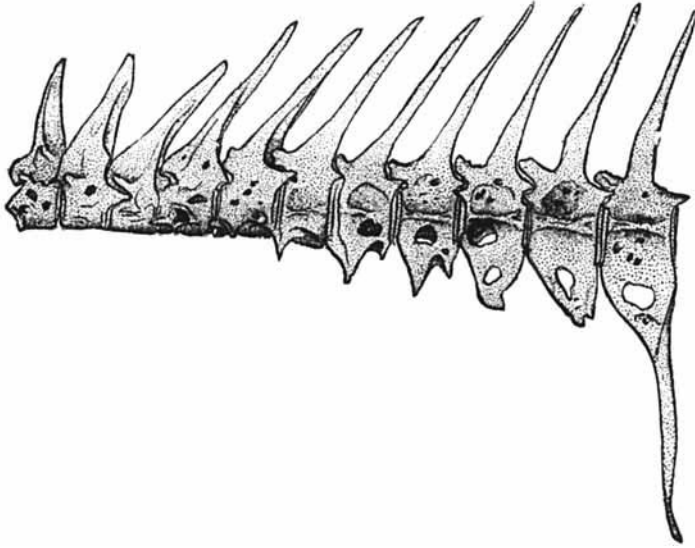


Figure 14. — Left lateral view of the first eleven vertebrae of the spinal column of *Caranx hippos*; specimen 13,561, of the Smithsonian Institution collection; life size, from the specimen.

class *Aves*, I should feel justified in placing one at one end of the system and one at the other.

The absence of the *hypural spine* in *Grammicolepis* has already been commented upon by Professor Poey in his memoir at the head of this article; this apophysis is quite manifest in the genus *Caranx*, as in most true teleosteans.