ICHTHYOTOMICAL CONTRIBUTIONS

I. THE STRUCTURE OF THE GENERA *AMPHISILE* AND *CENTRISCUS*

BY

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Boulenger, to whom we owe the latest reform of the systematic classification of the teleosts, founded in 1902 (3a, p. 151) a suborder *Catosteomi*, which with unchanged contents and with the same name was taken over into his general systematic synopsis of 1904 (3b, p. 172). The forms composing this suborder are placed by Boulenger in 11 families under 4 groups in the following manner:

I. *Selenichthyes.* 1. *Lamprididæ.*

II. *Hemibranchii.* 2. *Gastrosteidæ*, 3. *Aulorhynchidæ*, 4. *Protosyngnathidæ* (extinct), 5. *Aulostomatidæ*, 6. *Fistulariidæ*, 7. *Centriscidæ*, 8. *Amphisilidæ.*

III. *Lophobranchii.* 9. *Solenostomidæ*, 10. *Syngnathidæ.*

IV. *Hypostomides.* 11. *Pegasidæ.*

Regarding this whole suborder he says: "The whole question of the arrangement of the Physoclists with abdominal ventrals (Catosteomi and Percesoces) is, I feel, much in need of revision, and it may be found advisable to break up this group (Catosteomi) into a greater number of suborders, in which case the Selenichthyes would stand by themselves; the Hemibranchii and Lophobranchii would be united under the former name, as proposed by Woodward, or under that of Thoracostei (Swinnerton) or Phthinobranchii (Hay)". For my part I am quite at one with Boulenger on the necessity of a revision of this suborder; I believe, that not only should the suborder be broken up as several of its groups must be referred elsewhere, but also that its largest and central group, Hemibranchii, must be split up and some of its families likewise removed elsewhere. Group I, i. e. the genus *Lampris*, has already been removed by Gill (12c) from the relationship with the others; so far as I can judge, there is every reason to take it far away, but as I have as yet only glanced at its skeleton I shall not venture to express any definite opinion regarding its right place*. I have however studied the other forms more in detail, and I shall indicate here my view of their position. Group IV, i. e. *Pegasidæ*, should be removed to Boulenger's Subordo IX, Acanthopterygii, and within this to Boulenger's 7th division *Scleroparei*, the Mail-cheeked forms. The two nearly related families *Gastrosteidæ* and *Aulorhynchidæ* of Group II, the Hemibranchii, should be removed to the same place. The remainder form a natural

* Quite recently C. Tate Regan (25b p. 634 seq.) has placed the *Lamprididæ* with the *Veliferidæ*, *Trachypteridæ* and *Lophotidæ*, which four families he regards as forming one suborder *Allotriognathi* related to the *Beryciformes.*

group of related forms. For this we might possibly retain the name Hemibranchii, but this name is certainly somewhat misleading; it is due to COPE (6) and was intended to denote that the forms thus indicated are remarkable for a certain weakness and incompleteness in the branchial apparatus. This is true, however, of not a single one of the forms which Cope (and after him Boulenger) included under the Hemibranchii, and applies only to the *Solenostomidæ* and *Syngnathidæ*, which he did not include in this group. Whether now this natural series of forms "Hemibranchii" (÷ Gastrosteidæ and Aulorhynchidæ) + "Lophobranchii" (Solenostomidæ and Syngnathidæ) should be maintained as a suborder, and where it should be placed eventually in the system, I shall not discuss in the present communication, nor shall I enter here into the reasons why I remove the *Gastrosteidæ*, *Aulorhynchidæ* and *Pegasidæ* and place them with (or near to) the *Scleroparei*; I believe, in fact, that but little is gained by discussing the systematic position before the structure of the forms in question is better known than at the present moment. The truth is, indeed, that the descriptions of the structure of most of these fishes are defective, for some naturally more defective than for others; but even for such common forms as the sticklebacks and the pipe-fishes there are several features of considerable importance which have escaped attention or have been misunderstood*. In successive later communications I hope to give a description of the principal characteristics of the structure of all the forms in question, at least of their osteology; in the present paper I shall deal exclusively with the two genera *Amphisile* and *Centriscus*. I may however just mention here already, that this whole community of forms shows a number of characteristics in the skeletal structure of the head, which so far as I know are not found united in any other fishes whatsoever; namely: 1. the parietals and opisthotics are wanting; 2. the pterotic (squamosal) reaches ventrally to the base of the cranium, articulating there with the basioccipital or also with the parasphenoid, and thus excludes the exoccipitals and prootics from meeting; 3. the snout parts of the cranium (ethmoid and vomer) are extremely prolonged forming a "beak"; 4. the under margin of this beak is closely bound in the whole of its length with the whole of the upper margin of the part of the suspensorium lying in front of the hyomandibular; in this way an extremely characteristic tube is formed, which supports in front the true mouth parts; 5. the palatines are short and only connected with the vomer (in *Aulostomum* alone they are likewise in touch with the anterior end of the ethmoid); 6.

* In the Biologia Centr. Americana. Pisces, just published (February 1908) REGAN (pp. X—XI), after having excluded the *Hypostomides* and *Selenichthyes* from the *Catosteomi* Blgr., which suborder he finds "unnatural and indefinable", says that "the remainder, which corresponds to the *Hemibranchii* of Smith Woodward, is still a heterogenous assemblage which I find incapable of definition, and includes three well-marked but probably related groups which should, in my opinion, be given subordinal rank." These are 1) *Thoracostei* (= *Gastrosteidæ*, *Aulorhynchidæ*, *Fistulariidæ* and *Aulostomidæ*; 2) *Solenichthyes* (nom. nov.) (= *Amphisilidæ* and *Centriscidæ*); 3) *Lophobranchii* (= *Solenostomidæ* and *Syngnathidæ*). As stated above I do not at all agree in placing *Gastrosteidæ* and *Aulorynchidæ* together with *Fistulariidæ-Aulostomidæ*, but these matters I shall discuss in a later paper.

the metapterygoid (if it occurs) does not meet the hyomandibular; 7. the lateral line bones of the head are more or less reduced. In the future communications I shall discuss more closely these separate features in each of the genera of the group, but I may add here some brief notes regarding points 3—7.

Point 3. Of the two main constituents of the cranial "beak", the vomer and ethmoid, the vomer is always the longer part, reaching in general from the region under the orbit to the tip of the snout, while the ethmoid only begins in front of the orbit and ends at a longer or shorter distance from the tip of the snout. Regarding the beak from above, however, the part of these two bones which is observable on the cranial surface varies considerably; in *Amphisile* and *Centriscus* quite a small part only of the mesethmoid is seen, whilst a very long anterior part belongs to the vomer; in the Syngnathidæ (*Nerophis*) the vomer and mesethmoid each constitute approximately the half part of the dorsum of the beak in front of the frontals; in *Solenostomum* and *Fistularia* about three-fourths of this belongs to the ethmoid, a fourth part to the vomer, and in *Aulostomum* the ethmoid extends practically to the tip of the snout.

Point 4. In *Amphisile* and *Centriscus* we find all the components of the part of the mandibulary suspensorium in question which are typical of the bony fishes in general, namely: palatine, ecto-, ento- and metapterygoid, symplectic and quadrate; the palatine, ento- and metapterygoid form the upper edge connected with the cranial beak. In *Aulostomum* and *Fistularia* the ectopterygoid is wanting and the palatine, entopterygoid and metapterygoid form the connection with the cranial beak, also the symplectic in *Fistularia*. In *Solenostomum* and the *Syngnathidæ* the metapterygoid is wanting; in the former the palatine, entopterygoid and symplectic form the connection with the cranium, just as in *Hippocampus*, while in *Siphonostoma* and *Nerophis* the ectopterygoid also reaches to the cranium.

Point 6. The absence of the connection between the metapterygoid and hyomandibular, which is present in the majority of the bony fishes, is a result of the development of the snout into a tube; that not every elongation of the snout necessitates the removal of the metapterygoid from the hyomandibular is seen, for example, in *Spinachia* and *Aulichthys* where the usual connection is preserved.

Point 7. All the lateral line bones of the head are lacking in *Solenostomum* and *Fistularia*. The nasals are only found in *Amphisile* and *Centriscus*; the infraorbitals are wanting in all the genera with exception of the so-called preorbital or antorbital. This is much reduced in *Aulostomum*, fairly small in *Centriscus*, whilst it is much developed in *Amphisile* and the *Syngnathidæ*. In *Amphisile* a row of 2–4 thin bony plates connect directly with its anterior end and may be regarded as separate parts of it; undoubtedly homologous with these, we find in the *Syngnathidæ*, in front of and connected with the true preorbital, 1 bony plate (of considerable size in *Siphonostoma*, smaller in *Nerophis*) or 2 (*Hippocampus*, *Solenognathus*). In the *Syngnathidæ* a part of the lower edge of the preorbital is connected with the preoperculum (whereas it is the infraorbital No. 3, which is lacking in all these, which forms this connection in the *Gastrosteidæ*, *Aulorynchidæ* and *Pegasidæ*, thus exactly as in the *Scleroparei*). In none of the genera does the preorbital contain any canal for the lateral line; on the other hand the lateral line passes through the nasal in *Amphisile* and *Centriscus*.

Structure of the Genera Amphisile and Centriscus.

The grouping together of *Amphisile* and *Centriscus* is very old. LINNÉ as is known placed in the same genus *Centriscus* the species *C. scutatus* (= *A. scutata*) and *C. scolopax* (Syst. nat. Ed. XII, p. 415); later ichthyologists have however mostly endeavoured to emphasize the differences and to remove the two forms as far as possible from one another. They have rightly maintained two genera, each with its species; in recent times these have again been raised to the level of families, 2 in number, each with 2 genera. Too much concentration on the fairly obvious differences, which for a great part express themselves quite externally, seems however to have led observers to forget or to overlook the essential resemblances which really exist. These seem to me so considerable that I consider it right to maintain one family, *Centriscidæ*, with only two genera *Amphisile* and *Centriscus* *. Of the former, I know the species *A. scutata* L. (Gthr.), *strigata* Gthr. and *punctulata* Bianconi; of the latter, *C. scolopax* L., *gracilis* Lowe and *humerosus* Richards. I shall not discuss here the validity of the other supposed species of both genera, but I am most inclined to believe that they are not maintainable; nor does the division of each of the genera into 2 separate genera seem to me valid, but this question also will not be discussed.

In first dealing with *Amphisile* and thereafter *Centriscus* in the following pages, I have no intention naturally of giving the impression that I consider *Amphisile* the more primitive and simpler form — the opposite is indeed the case — but my investigations began with *Amphisile*, which seemed to me from GÜNTHER's description somewhat enigmatical and to have been on the whole curiously dealt with; it was only later that I took up *Centriscus* and saw clearly how much was insufficiently known in this form also, and how much in it threw light on the conditions in *Amphisile*.

Amphisile.

In appearance *Amphisile* is quite remarkable. The body is extremely compressed; the diameter at the broadest part of the trunk, as Günther remarks, is scarcely greater than the diameter of the orbit. The ventral edge is as sharp as a razor. The head is produced into a long tube, with a small terminal, toothless mouth, as in a pipe-fish. The trunk runs out posteriorly into a long spine, under which is seen two dorsal fins and a quite short caudal fin directed obliquely

* I disregard here the objections, which might be raised with a certain amount of right, against using this generic name for the species *scolopax*, *gracilis* and *humerosus*. In using the names the main thing for me, here as elsewhere, is that there can be no doubt what forms are being discussed.

downwards at an obtuse angle to the horizontal axis of the body; the anal fin lies immediately in front of the caudal. About half way along the ventral aspect we find the generally small ventral fins. The last are thus abdominal, lying far behind the pectorals, as is usual in the Physostomi. This form is however aphysostomous. The swim bladder is present; this can be seen easily by holding a specimen up against the light. It is noticed at the same time, that the sharpest part of the belly is devoid of contents and forms a thin, transparent region, a veritable knife-edge. It is said, from the observations by WILLEY (34 p. 719) and TOWNSEND (25a p. 318), that the fish swims in a vertical position, cutting the water with its belly — but I can hardly believe that this position is the normal one for the fish*.

Most of the fish is armoured; the part not covered by scutes is quite naked, without scales.

The head is movable, a little up and down; otherwise the whole body is quite stiff and only the tail and fins are flexible.

Exoskeleton.

The armour of the body consists of a dorsal and a ventral cuirass. The dorsal cuirass on each side is composed essentially of 2 rows of slightly alternating plates, each row consisting of 5 parts; namely, an upper, dorsal row of scuta (Pl. I, (fig. 1, 1—5) and a lower, lateral row (Pl. I, fig. 1, I—V). The four anterior dorsal plates are elongated, narrow and meet the corresponding plates of the other side in the middle line of the dorsum in a simple, straight suture; the unpaired scutum covering the dorsal spine is wedged into the middle line of the dorsum behind no. 4 and the 5th, hindmost, dorsal plate is thus excluded from meeting its fellow of the opposite side. This plate is elongated, triangular, with its posterior point running out alongside the dorsal spine, whilst anteriorly it spreads down on the side more than the other plates in the same row. In the two species *A. strigata* and *punctulata* there is still another, small, unpaired plate anteriorly in the middle line of the dorsum, pushed in between the posterior ends of the first pair of plates and the neighbouring, anterior part of the 2nd pair. This unpaired plate, which belongs in reality to the endoskeleton, seems to have been hitherto quite overlooked, though its absence in *A. scutata* should be one more, easily observable character to distinguish this species from the two others.

Of the lower row of lateral plates the first (I) is the smallest and narrow; the remainder are of good size, especially III and IV. A distinct longitudinal line — sometimes somewhat depressed like a furrow — runs across these plates; in the first it goes right along the ventral border, in the three following nearer to the dorsal border; on the posterior plate it runs to the ventral border almost through the centre and parallel to the dorsal margin. On the naked portion of

* In one point the observations do not agree: while WILLEY represents the fish swimming with the head upwards, TOWNSEND (teste REGAN) says that those of his specimens which were "sufficiently alive when dredged to swim in a tub of water" swam head down.

the fish this line's continuation lies between the upper and lower lateral muscles.

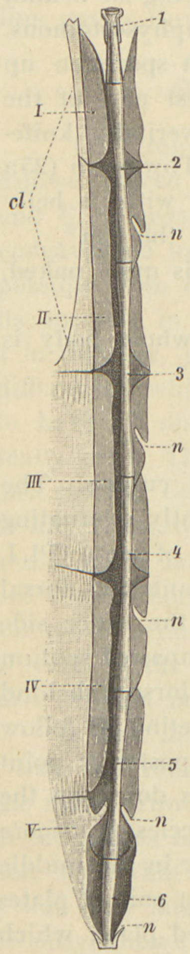

Fig. 1.
Amph. scutata. *1—6*: first to sixth abdominal vertebræ seen from below; the exoskeleton has been removed from the left side; the lateral plates *I—V* are seen on the right side; *n*: incision in the transverse processes for nerves; *cl*: upper margin of clavicle. The numbers *I-IV* point to the ridge.

This line on the lateral plates is due to a very prominent, thin ridge or lamella on their inner surface, which is joined to the likewise lamellar-like transverse processes on the corresponding part of the spinal column; an immovable connection is thus formed between the exo- and endoskeleton.

Examined more closely the condition is as follows (cf. fig. 1). A little behind the anterior end of the lateral plate I arises a single fold or ridge which soon divides into two lamellæ, an upper and a lower, separated by a very narrow cleft; in this is set the anterior end of the transverse process on the 2nd abdominal vertebra; the two lamellæ fuse again to one, which, traversed by the suture between plates I and II, is continued on plate II; between the two plates the lamella has a deep notch; on the plate II, close behind the notch, the lamella again becomes double and remains so nearly to III, where it is single, then we have a notch, it becomes double again on III and so on as far as IV. The thicker, middle part of the transverse processes on the 2nd, 3rd and 4th vertebræ is inserted in the notches, whilst the thinner, remaining part of the same process is enclosed between the double lamellæ as in a sheath. Each of the long transverse processes on the 2nd — 4th vertebræ is thus inserted into two lateral plates; the transverse process on the 5th vertebra on the other hand is only connected by its anterior part with one plate, IV. On plate V the lamella is single and low, and seems to be absent in *A. scutata*.

Further constituents of the dorsal armour are, on each side, the two plates *scl* and *cl*, Pl. I, fig. 1, as also the dorsal spine T.

The two former are in reality parts of the pectoral girdle; the upper, *scl*, is the supraclavicular. It is connected anteriorly by an articulation with the posttemporal (suprascapular, supraclavicula I), *pt*, which forms part of the skull; its other connections are immovable; it meets above with dorsal plate I in a simple straight suture, below with *cl* in a somewhat curved suture, posteriorly with the anterior end of the lateral plate II in a dentated, oblique suture. The lower plate *cl* is a good deal larger, elongated, somewhat crescent-shaped in *A. scutata*, shorter and relatively somewhat higher in the other two species; the posterior point reaches the upper edge of the base of the pectoral fin; the ventral border is in contact for a long distance with the upper margin of the 5th ventral scutum in *scutata* but not in the other species; the anterior part of the ventral border is in contact with the small scutum *S* in all three species, over a fairly long distance in the two species where the latter is large, but for quite a short way in *scutata*; the dorsal, curved margin seems to be a simple suture; in reality however the *cl* is here continued in under the edge both of the dorsal plate II and of the supraclavicle as a thin lamella which reaches nearly to the ridge which forms the connection with the vertebral column in this region.

The dorsal spine in *A. scutata* (Pl. I, fig. 1, *T*) is formed of a single, undivided piece, sculptured like the dorsal plates with fine longitudinal lines and intervening furrows; the anterior part inserted between the dorsal plates is somewhat flatter, the remainder is rounded, graduating evenly towards the posterior end, in cross-section vertically oval; there is a furrow along its ventral aspect occupied by the membrane of the first dorsal fin, the upper edge of which it supports. It is somewhat variable in length in this species, as also a little in its curvature. In the other two species the dorsal spine is more complex. In the first place, it has in these a spine articulated to its end, in reality a spinous ray (Pl. I, fig. 2, *R*); at the articulation are found some small bony pieces, one on each side (Pl. I, fig. 2, *l*) and one unpaired ventrally (Pl. I, fig. 2, *t*); on these see further p. 56 (18). In the second place, the spine is divided on both sides in the whole of its length by a lateral suture into an upper and a lower part. Indications of this longitudinal suture may sometimes be detected in *scutata*. It is very natural to suppose that the movable spine is a fin-ray and thus to conclude that the large dorsal spine supporting it must in some way or another represent an interspinous bone; this supposition has been expressed by Günther; that the spine represents however 2 interspinous bones and the same two interspinous bones in all the three species has not hitherto been recognised; the structure will be more closely discussed later (see p. 54 (16) et seq.).

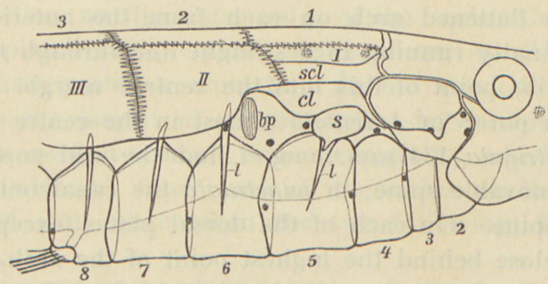

Fig. 2.
Amphisile punctulata. *bp* outline of base of pectoral fin. Lettering otherwise as in Pl. I fig. 1.

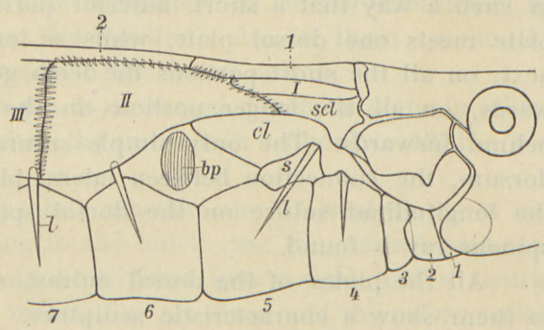

Fig. 3.
Amphisile strigata. Lettering as in fig. 2 and Pl. I, fig. 1.

The dorsal armour thus includes at the same time parts of the inner skeleton, namely parts of the shoulder girdle (*scl* and *cl*) and parts of the interspinous bones (the unpaired, small anterior dorsal plate in *A. strigata* and *punctulata*, and the dorsal spine in all three species). That these skeletal parts may appear from the outside as dermal parts in many other bony fishes, so that their surfaces seem to be exoskeletal for some distance, is not unknown; as examples I need only mention *Gastrosteus, Trigla.* All the other elements of the dorsal armour in *Amphisile* are purely exoskeletal. This view, which is also quite natural, is further supported by the fact that the lateral line courses through these bones.

The lateral line canal passes out from the pterotic (*sq* Tab. I, fig. 1) into the anterior, lower corner of dorsal plate 1, pierces this in an arch to the posterior, lower corner and then further through the succeeding dorsal plates, forming a flattened arch on each from the anterior to the posterior, lower corner, and finally running in a straight line through the 5th dorsal plate and from the posterior point of this into the ventral margin of the dorsal spine. Here it ends with a pore; in *A. scutata* almost in the centre of the ventral aspect; in a specimen of *strigata* 134 mm. long, I find the end pore 8 mm. from the articulation with the movable spine; in *punctulata* the canal only extends a short distance on the dorsal spine. On each of the dorsal plates (except the first) I find a single, ventral pore close behind the highest point of the arch. The position of the lateral line is thus remarkably near to the dorsal edge of the body and it has become connected in an extremely characteristic manner with structures (sc. interspinous bones, *T*) which do not usually take part in the lateral line system, perhaps because these structures are here in continuation of the main portion of the body.

The peculiar features of the sutures in the dorsal armour must also be mentioned. All the connections between the plates on the same side of the body are provided with long teeth fitting into one another; on the cross sutures these are generally vertical to the line of articulation, but in the longitudinal sutures they are obliquely placed. The lateral plates alternate somewhat with the dorsal plates in such a way that a short, anterior portion of the upper suture of each lateral plate meets one dorsal plate, whilst a longer, posterior portion is joined to the next; on all the short portions the teeth go one way obliquely from in front backwards, on all the longer portions in the opposite direction, i. e. obliquely from behind forwards. The only simple sutures are those in the middle line of the dorsum, the connection between lateral plate I and the supraclavicle and further the longitudinal suture on the dorsal spine in the two species where a movable spinous ray is found.

All the plates of the dorsal cuirass as well as the true skeletal parts united to them show a characteristic sculpture. On most we find rounded longitudinal striæ, which are again connected by numerous, short, irregular cross-lines, forming together rounded pits; wherever the margins form jagged sutures, groups of stronger striæ radiate out in the direction of the teeth from a spot in the upper half of the plate, but almost at an equal distance from the posterior and anterior margins. On some plates, e. g. the dermal part of the clavicle, the pitted sculpture is predominant, and the longer striæ scarcely occur; on the other hand, the longitudinal striæ are predominant on the dorsal spine. The lateral plates become very thin towards the ventral margin and the ribbed arrangement of the sculpture more open and irregular.

The bones of the cranium are also sculptured, like those of the dorsal cuirass.

The ventral cuirass consists of a row of 14 (sometimes 13 or 15) large, regular plates, the lowermost part of which forms the above-mentioned, thin, transparent edge. The anterior ventral scutum is in part covered by the preoperculum. In *A. scutata* the scuta 4—14 have a narrow, thickened, more solid stripe or rachis, *l* fig. 1 Pl. I, which arises at the upper margin of the transparent keel and forms above a prominent flat projection on the upper edge of the scale; the stripes on the 5th and 6th scuta are placed obliquely, diverging above, on the other plates they are vertical; on the three posterior scuta they do not reach the margin of the dorsal cuirass. No. 5 is the largest of all the plates; between its upper, anterior corner and the clavicula we find a small, separate plate (*s*), which at first glance seems to be a somewhat widened upper part of the rachis on the 5th ventral plate. No. 1 is of fairly good size, longer than the two following; 2, 3, 13 and 14 (15) are the smallest.

The ventral fins are inserted into the 8th plate. This holds good also for the other species; in these likewise the ventral plates 5—14 are provided with a rachis as in *scutata*; but no. 4 lacks this completely or has only a slight indication of it; the 5th plate is not, or not appreciably, larger than the 6th and has thus nothing more remarkable about it in comparison with the others than the oblique, posteriorly inclined rachis (cf. fig. 2, 3); the upper end of the latter in these species is also continued into a rachis for a small, separate plate (*s*), which forms the connection with the clavicle, but this plate is here considerably larger than in *scutata*. The anterior plate no. 1 is shorter than in the latter species, not or but little longer than 2 and 3, and is thus covered as a rule completely or almost completely by the preoperculum; nos. 2, 3, 12—14 are the smallest; also in these species the rachides of the posterior plates do not reach to the dorsal cuirass.

When the number of the ventral plates is increased to 15, a plate is added posteriorly in front of the anal plate; when the number is reduced to 13, the two penultimate plates are fused together.

It is difficult to determine with certainty whether the 14 ventral plates are paired or unpaired formations — recalling in the latter case the ventral scales of the herring. The 8th plate can obviously be divided into a right and a ventral part, at least from the place where the ventral fins are fixed and the pelvic region protrudes on the ventral margin; we also find in most of the specimens of all 3 species, that the posterior, 14th, plate is paired, as its two sides tend to separate from one another (without preparation) and thus the sharp, ventral margin appears divided. But all the others appear in fact unpaired, the two sides of each plate being united to the thin ventral keel; it has at any rate been impossible for me to separate this into two lateral halves by maceration or by the use of potash. The marginal part of the transparent keel consists of a very hard, dense and firm, shining substance, obviously of the same nature as the rachides. This is readily seen on holding a specimen up against the light, and on drying this part stands out with a distinct boundary line against the remainder of the scale. If alizarin is used, only this part becomes red along with the rachides of the ventral plates as also all the plates of the dorsal cuirass and all the skeletal parts — with exception of a part (though not the margin) of the preoperculum, which assumes a yellowish tinge like the rest of the ventral plates. Likewise coloured red are some very fine lines which radiate out horizontally on each side from the lowest point of the rachides, specially distinct on the scuta in front of the ventral fins. These red-coloured parts are obviously ordinary bony substance, which is always coloured red by alizarin. The rachides and the faint lines connected with them seem to me to correspond to the almost similarly situated rachides on the ventral scales in *Centriscus*. And it seems reasonable to suppose that the dense marginal parts of the plates in *Amphisile* represent the unpaired ventral plates in *Centriscus*, which all have an often fairly high, compressed keel.

The first ventral plate in *Amphisile* may with a good deal of certainty be regarded as in reality unpaired; this applies very probably also to nos. 2 and 3; but it is possible that 4—7 have been formed by fusion, each of a pair of lateral plates and an unpaired keel plate; similarly the 8th with a short keel plate, in front of the ventral fins, and also the others with exception of the last. It is certainly against this view that just the last, quite indisputably paired plate also has a denser, ventral marginal part and further, that the unpaired keel plates in *Centriscus* alternate with the paired ventral plates. The possibility cannot be excluded therefore, I think, that (with exception of the first ventral plate) all the unpaired elements corresponding to the keel plates in *Centriscus* have fallen out in *Amphisile*, whilst the paired ventral plates corresponding to the paired in *Centriscus* have become greatly developed and fused together ventrally. Lastly, there is a third possibility, that it is just the unpaired keel plates of *Centriscus* which have developed so much in *Amphisile*, whilst the paired ventral plates have disappeared with exception of the small scutum *s* under the anterior edge of the clavicle, which has its definite, demonstrable homologue in *Centriscus*.

I may add further regarding the structure of the ventral plates, that they are smooth, without sculpture; the greater portion, excluding the parts coloured red by the alizarin, is fairly soft though tough and dense and does not seem therefore to be a true bony tissue; it does not dissolve however in potash, which completely isolates the ventral plates from the dense connective tissue of the skin; under the microscope it shows very similar, fine concentric lines of growth to those known in the scales of most bony fishes. The ventral plates are not articulated by sutures but overlap each other ventrally, whilst their margins touch higher up. In the 6 ventral plates which lie behind the pectoral fins the rachides reach up to the lower margin of the dorsal cuirass or sometimes in under this. The upper parts of the rachides are considerably longer in *A. strigata* and *punctulata* than in *scutata**[1].

Endoskeleton.

The vertebral column (cf. Pl. II, fig. 1) is formed of 20 vertebræ; of these I count 8 as abdominal vertebræ, 12 as caudal. Of the abdominal vertebræ the first 6 are much elongated, especially the 2nd to the fifth; the 2nd, 3rd and 4th are each almost as long as the rest of the vertebræ together, so that the elongated region is nearly four times as long as the whole of the remainder. In a small specimen of *A. strigata* the measurements are approximately as follows:

length of the whole column	ca. 47	mm.
— - body of 1st vertebra	3·5	—
— - — - 2nd —	7	—
— - — - 3rd —	8	—
— - — - 4th —	8	—
— - — - 5th —	6·5	—
— - — - 6th —	4	—
— - elongated part, thus	37·0	—
— - posterior 14 vertebræ together	ca. 10·0	—

In a (medium-sized) specimen of *A. scutata* the measurements were:

length of the whole column	ca. 52	mm.
— - body of 1st vertebra	3·5	—
— - — - 2nd —	8	—
— - — - 3rd —	9·5	—
— - — - 4th —	9	—
— - — - 5th —	7·5	—
— - — - 6th —	3·5	—
— - elongated part, thus	41	—
— - posterior 14 vertebræ	ca. 11	—

Vertebral arches. The arch of the first vertebra is quite low, simple; from its posterior margin projects a long, thin spinous process, which rests for a long distance on a part of the upper margin of the next vertebral arch; its posterior point reaches almost to the centre (in *scutata*) or a good bit behind the centre (*strigata*) of the following vertebra. True transverse processes are lacking on the first vertebra, but a short, thick lateral process on each side under the anterior margin of the arch forms an articulation with a corresponding pit in the exoccipital and can possibly be regarded as an articular process. On the following vertebræ, 2—17 inclusive, the arch is divided into an anterior (Pl. II, fig. 1, *a*) and a posterior (*b*) part, situated respectively over the anterior and posterior part of the centrum; the spinous process arises from the posterior part of the arch and

*1 This and the succeeding notes, marked with numbers, will be found later after the description of *Centriscus*.

rests on the upper margin of the anterior part of the succeeding vertebral arch. On the very long vertebræ 2—5 the arch is quite low, especially in *A. strigata*, where the spinous processes of this region lie almost horizontally, pressed against the arches; in this species the spinous processes are likewise longer than in *scutata* (in *strigata* the process on the 1st vertebra reaches posteriorly almost to the anterior margin of the 3rd vertebra, that on the 2nd vertebra to the 4th vertebra and so on). On the 6th vertebra only the anterior part is elongated; the two parts of the arch are therefore close to one another (especially in *strigata*). From the 7th vertebra the common vertebral form in fishes appears; on the 7th the anterior and posterior parts of the arch are separated by a narrow, but high groove; on the 8th the groove between the two parts of the arch is quite short, on the 9th it reaches right in to the centrum; posteriorly the anterior part of the arch gradually assumes the form of a large "articulating process"; on the 18th vertebra it can hardly be seen.

The transverse process, as mentioned, is lacking on the 1st vertebra; they are present however on the 2nd—6th and developed in the form of long lamellar projections for connection with the lateral plates of the dorsal cuirass (cf. text-fig. 1). The transverse process on the 2nd is prolonged forwards beyond the hind end of the 1st vertebra; posteriorly it is connected by a kind of suture with the anterior end of the next transverse process. Opposite the centre of the body of the vertebra there is a somewhat thicker, middle part (or axis), which corresponds in position to the interspace between 2 scuta; behind this axis there is a deep incision for the spinal nerve (fig. 1, *n*). The front part of the transverse process fits into the double lamella on the inner side of the 1st lateral plate, the hind part into the lamella on the next plate; the connections between the lateral plates and the transverse processes on the 3rd and 4th vertebræ are arranged in a similar manner, the processes having the same structure as on the 2nd; further, the part of the 5th vertebra's transverse process lying in front of the outlet for the nerves is also inserted into the lamella on the 4th lateral plate, but the posterior part of this transverse process as also the transverse process on the 6th vertebra is only joined by connective tissue to the 5th lateral plate, which has no lamella in *scutata* but a low one in *strigata*. As can be seen from fig. 1, the 6th vertebra is of a different pattern from the preceding 2—5; only the part lying in front of the hour-glass shaped constriction of the vertebra is prolonged and only the corresponding part of the transverse process in front of the nerve outlet is lamellar-like; the part behind this is more in the shape of a process. The bodies of these 6 long vertebræ are quite distinctly of the typical hour-glass shape, most modified in the 1st and 6th, where in the former case the anterior part of the hour-glass is quite short, in the latter the posterior part.

The vertebræ 7—13 (see Pl. II, fig. 1) bear lateral outgrowths in a similar position to the lamellar processes above described; but they only spring from the anterior half of the vertebra; they are triangular in shape, directed obliquely forward and somewhat downward and serve as base of attachment for powerful tendons in the musculature which moves the tail. The posterior vertebræ have very indistinct traces of these processes. Lower arches representing probably the true transverse processes are also present on the vertebræ from the 7th; on the 7th and 8th the lower arch is quite short, almost ring-shaped, surrounding the large blood vessels; on the 9th vertebra the arch begins to be greatly prolonged downwards, forming an inferior spine; for this reason I count this as the first caudal vertebra. Between the spinous process on the second last caudal vertebra and the urostyle on the last we find in *A. strigata* 2 independent skeletal parts, one between the very broad, lower spinous process on the second last vertebra and the broad hypural bone on the last; in *A. scutata* I find one piece at each of the corresponding places.

Ribs are quite wanting.

In the vertebral column the whole anterior part formed by the 6 elongated vertebræ is stiff, immovable; the connection with the cuirass would alone prevent movement; with this agrees, that the transverse processes are suturally connected with one another, whilst the corpora of the vertebræ are simply juxtaposed just as in movable vertebræ.

Interspinous bones. 1. Of the dorsal fins (Tab. II, fig. 1). To each of the first 4 vertebræ corresponds an interspinous bone, which is placed close to the anterior face of the spinous process of the vertebra. There are no interspinous bones for the 5th and 6th vertebræ, but interspinous bones again appear in front of the spinous processes of the vertebræ 7—10. Between the vertebræ 10 and 11 there are 2, also between 11 and 12, 12 and 13; between 13 and 14 there is 1, the hindmost*.

Some notes may be given on the 4 members of the first group. The first (Pl. II, fig. 1, *1*) forms a vertical plate in front of the spinous process and with its somewhat widened upper border reaches to the inner surface of the cuirass in *A. scutata*; in the other two species this upper border is wider still and shows itself externally in the middle line of the dorsum as the previously mentioned small unpaired dorsal plate; behind the point of the spinous process the interspinous

* This is the condition I find both in *A. scutata* and in the specimen examined of *A. strigata*, which was provided with 3 spines behind the dorsal spine; of these however only the first two were noticeable from the outside. Two noticeable spines are most probably the normal for the species *strigata*; but I believe I could detect a short 3rd on several specimens, hidden in the soft parts, closely pressed to the peculiar, rayless interspinous bone (* in Pl. II, fig. 1), the cartilage of which is fused to the one which bears the first ray of the 2nd dorsal fin; I imagine therefore that most specimens will be as described, thus agreeing with *scutata* which has normally 3 apparent spines. More spines can sometimes be found however in *strigata*; I have before me a specimen from Amboina with 4 apparent spines, of which the two following on the dorsal spine are thin and fine, the next two of the usual form, with lancet-like, compressed point. In *A. punctulata* there are two apparent spines, as is usual in *strigata*; if it should prove — which I have not been able to determine — that there is another hidden spine, the above account will hold good generally for the genus *Amphisile*.

bone runs out into a fine point which reaches to above the articulation between the 2nd and 3rd vertebræ.

The second interspinous bone is somewhat in the form of a *T* (Pl. II, fig. 1, 2); a thin stem lies in front of the spinous process of the 2nd vertebra, a shorter, anterior *T*-arm towards the preceding interspinous bone, which however it does not quite reach, and a longer posterior arm which reaches to above the proximal end of the next interspinous bone. In *A. strigata*, where the spinous processes are pressed against the neural arches, the stem and the anterior *T*-arm are almost in contact with one another.

The interspinous bones 3 and 4 are much stronger, especially 4; they are on the whole the strongest of all the interspinals and appear remarkably heavy in proportion to the thin spinous processes on which they rest; only the proximal part of each is seen distinctly and is for the most part rod-shaped, the remaining part of both is included in and concealed in the large dorsal spine. In all the interspinous bones mentioned as well as in those to be described below, there is a cartilaginous axis through the stem; it is specially thick in these two, 3 and 4. If a cartilage stain is used (methyl-green) we can follow the cartilaginous axis of these two in *A. scutata* almost to the end of the large dorsal spine (cf. Pl. II, fig. 1). It is thus certain that in *A. scutata* the spine represents two interspinous bones, 3 and 4. The same is the case in the other two species, but here the double nature is also visible externally in the already described longitudinal suture or groove which divides the spine into an upper and a lower part (cf. Pl. I, fig. 2).

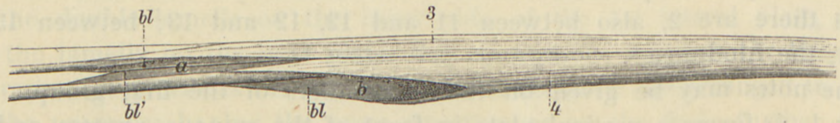

Fig. 4.
Amphisile strigata Part of the interspinous bones 3 and 4. *bl, bl'* the blade-like portions of the bones; *bl'* anterior, *bl* posterior. *a* situation of the *Musculus erector*, *b* of the *M. depressor* for the spinous ray.

Closer investigation of the interspinous bones 3 and 4 shows, that their structure differs greatly from the usual type more in appearance than in reality. The latter is generally described as dagger-shaped, the laterally compressed blade having on each side a raised longitudinal keel or ridge, separating the anterior muscles (M. anterior s. erector) from the posterior muscles (M. posterior s. depressor) of the ray and at the same time enlarging the surface of attachment of the muscles; through the centre of the spine runs generally a rod-like cartilaginous axis. A glance at Text-fig. 4 of *A. strigata* will show (the same can be seen though less distinctly in fig. 1, Pl. II of *A. scutata*), that the blade part *bl* is present lying fairly close behind the point of the spinous process to which these interspinous bones are attached; on 3 however, only the posterior part of the blade *bl* is present; the hind margin of this is joined to the front margin of the blade *bl'* of 4 (a similar condition is also found in many other bony fishes between more or fewer, sometimes all the interspinous bones); on the other hand, the hind margin of the posterior part of the 4th interspinous bone is not in contact with any following interspinal. In the remaining, distal part the usual interspinal form is now greatly altered; the longitudinal keels (i. e. the continuation of the rod-like proximal part) extend out in both into the skin and there broaden out so as to be mutually in contact and form the previously mentioned longitudinal suture (in *scutata* this disappears through fusion); on 4, further, the broadened part bends round and fuses with the hind (ventral) margin of the blade *bl.* In this way the bed both for the anterior and posterior muscles of the spinous ray which is articulated to the dorsal spine is covered over. The dorsal spine thus comes to enclose two canals, an upper (anterior) and a lower (posterior) on each side; these canals are very narrow but contain in the greater part of their length only the long thin

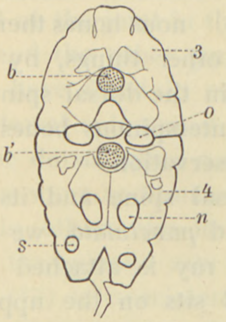

Fig. 5.

Amphisile scutata. Cross-section through the dorsal spine. *3*: third interspinous bone, *b* its cartilaginous axis; *4*: fourth interspinous bone, *b'* its cartilaginous axis; *o*: canal for tendon of M. erector, *n* for M. depressor; *s*: canal for lateral line.

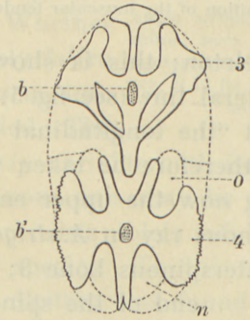

Fig. 6.

Centriscus scolopax. Cross-section of the upper ends of interspinous bones *3* and *4*. Letters as in fig. 5. Dotted lines indicate circumference of the parts which would bring about agreement with the condition in *Amphisile*. *3* and *4*, Cross-section of longitudinal keels on the 3rd and 4th interspinous bones.

tendons of the respective muscles; the muscles themselves chiefly occupy the space indicated by a and b (which is covered over outwardly by the dermal armour) and extend only a short distance into the beginning of the canals. On transparent specimens of *A. strigata* the muscles can be seen quite distinctly without preparation under the exoskeleton. The cross-section (fig. 5) will possibly show the main characteristics better than any further description. It shows how the upper canal (*o*) is formed by both of these interspinous bones, whilst the lower (*n*) is only formed by the 4th. Fig. 6 shows for comparison a cross-section through the upper part of the two corresponding interspinous bones in *Centriscus scolopax,* and gives an indication of the bony parts which could produce the condition characteristic for

Amphisile. Fig. 5 is of *A. scutata* in which the movable spinous ray is lacking and the muscles belonging to it being superfluous are atrophied; but, in the main features, even down to details, the cross-section agrees with that of *strigata*, except that in the latter the line of division between the two fused interspinous bones is much more distinct; in several cross-sections it is only seen right in the middle between the two upper canals, sometimes also on the one or the other side; it is thus made somewhat more distinct in the figure than it usually appears in this species. This figure also shows that the bony mass of the dorsal spine has quite a complicated structure which I have not succeeded in fully clearing up; it is clear, however, that the peripheral portion of the bony mass does not belong to the interspinous bones themselves but arises from the exoskeleton; this is shown, amongst other things, by the fact that the canal for the lateral line (see fig. 5) is enclosed in the dorsal spine. The statement made above that "the longitudinal keel of the interspinous bones broadens out in the skin" must therefore be taken with some reservation.

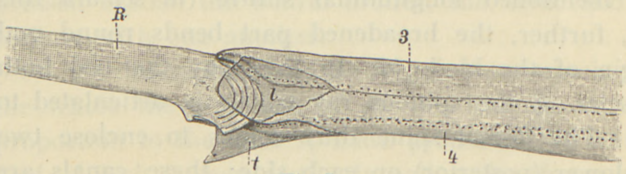

Fig. 7.

Amphisile strigata. End of the dorsal spine with spinous ray *R*, lateral bony piece *l* and spinous piece *t*. The dotted lines indicate the position of the muscular tendons.

Considering now the upper end of the dorsal spine and its connection with the movable spinous ray in *A. strigata* (fig. 7) and *punctulata*, we find that there is no ray to the interspinous bone 3; the spinous ray is attached to 4. The lower end of the spine is cleft and sits on the upper, wedge-shaped end of this interspinal (fig. 8); on each of the lateral surfaces of the wedge we find a series of 5—6 concentric, half-circular, very sharply marked ridges (figs. 8, 9); into these fit very exactly corresponding ridges on the inner surface of the cleft of the spinous ray. This arrangement excludes all other kinds of movement than one in a vertical plane, but on the other hand makes the joint unusually firm and steady; the joint is further supported by the small plate *l* (fig. 7) which covers both sides of the end of the interspinous bone and a part of the base of the ray. On the side of this plate which covers the ray we find some slightly raised, circular ridges and others corresponding to these are seen on the outer surface of the base of the ray. The angle through which the ray can move is not very large; in an upward direction the ray can only turn until it is almost in line with the dorsal spine, downwards so far that it lies almost parallel to the small spine *t* (fig. 7). It is probable that the fish can at will fix the spinous ray immovably at any point between these limits; the joint is indeed of the same type as the corresponding articulation in *Centriscus*, where W. Sørensen (32) has distinguished it as a "stop-joint".

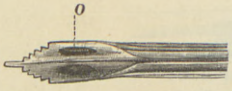

Fig. 8.

Amph. strigata. Hind end of dorsal spine, seen from below; spinous ray and spinous piece *t* (fig. 7) removed; o: opening for exit of tendon to M. depressor of spinous ray *R*.

The tendon of the elevating muscle (M. anterior s. erector) passes out between the ends of the interspinous bones 3 and 4 and is attached to the base of the ray above the cleft; the tendon for the flexor, M. posterior s. depressor, passes out through a separate opening on the under side of the interspinal 4 (see fig. 8), but is covered below by the broadened base of the plate *t*; the tendon is attached to a small process at the base of the ray. Fig. 8 shows this part of the interspinous bone 4 seen from below. The end of this is hollowed out, spoon-shaped on the under surface; at the bottom of the spoon opens the canals for the depressor muscles; to its margin is apposed the margin of the spinous piece *t*; the tendon passes out to the ray between this and the interspinous bone.

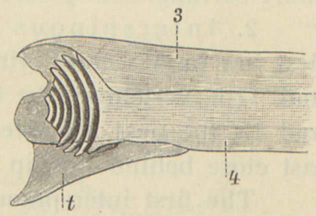

Fig. 9.
Amph. strigata. Hind end of dorsal spine, seen from the side. *3, 4* interspinous bones *3* and *4*; spinous ray, *R* in fig. 7, removed as also the lateral piece *l*.

In *A. scutata* the various parts composing the spine have become unrecognisable through fusion; not only, further, is an articulated spinous ray wanting, but also the special pieces, lateral plate *l* and the spinous piece *t* which are present at the joint in the other two. Whether the spinous ray and the other parts have simply fallen out in *scutata*, or have fused in rudimentary form into the point of the dorsal spine must be left unsettled. The extreme end of the dorsal spine seems to me very variable both in outer form and inner structure; in some specimens the cartilaginous axis may be detected almost right to the tip, in others the last 1—2 mm. consists solely of bony substance, reminding one of the spinous ray in the other species. To this must be added, that Hilgendorf (17) in specimens from New Britain has found a small spine under the tip, ca. 1 mm. from this, obviously the same small spinous piece *t* which is characteristic of the other two species. I may mention that Hilgendorf considers these specimens as a special species, which he calls *A. finschii.*

In the second group of interspinous bones (cf. Pl. II, fig. 1, 5, 6, 7), the three which are placed in front of the spinous processes 7, 8 and 9 are long and thin and extend as stays through the membrane of the first dorsal fin; in *scutata* all three, in *strigata* the two seen externally, have a distal compressed part more or less lancet-shaped (but the form is not very constant). These stays have hitherto been generally regarded as spinous rays, both by the few authors who have seen that they extend right in between the spinous processes, and by the majority who have kept to the outward appearance. With a cartilage stain or simply under the microscope the cartilaginous axis can be seen running out more or less to the tip; as far as the cartilage reaches, at any rate, there can be no talk of anything but interspinous bones, but the condition in *Centriscus* (see later) seems to indicate that the hard, shining and solid lancet-point beyond the cartilage may be regarded as a short spinous ray fused with the interspinous bone.

The interspinous bone in front of the spinous process 10 has no ray (fig. 1, Pl. II); proximally it has the same appearance as the foregoing, but distally it ends in a fairly large cartilage; this is fused to the cartilaginous ends of the succeeding interspinals. All the interspinous bones so far mentioned are unisegmented; the succeeding which support the rays of the 2nd dorsal fin are bisegmented, but their distal joint is cartilaginous. These interspinous bones, whose arrangement between the spinous processes was described above, have the usual form but end distally in cartilage; so far as I could see, the cartilaginous ends are fused into one compressed plate in the whole group; but to this plate are articulated separate, terminal, short cartilaginous pieces which are enclosed in the base of the rays.

2. Interspinous bones of the anal fin. These are 10 in number. The first lies in *A. scutata* with its proximal end between the hæmal spines of the 10th and 11th vertebræ; the following 3 lie between the tips of the hæmal spines 11 and 12, the next 3 between 12 and 13, the following 2 between 13 and 14 and the last close behind the tip of 14.

The first interspinous bone is larger and broader than the others; it is connected with the first two rays (but is certainly single, as it has but one cartilaginous axis); the hindmost is short, broad distally and in connection with the two posterior rays; otherwise each interspinous bone corresponds to one ray, but alternate somewhat in position with these. All the interspinous bones are distally cartilaginous. The cartilaginous parts are closely united, but quite clearly not fused; they support a small, terminal cartilaginous piece for each ray and are thus bisegmented[2].

The rays in the 2nd dorsal fin are all simple, non-articulated, as also in the anal in *scutata* and *strigata*; in *punctulata* on the other hand I find that some few of the rays in the anal fin are provided with a single or a few joints.

The rays of the caudal fin are the same in all 3 species: only the uppermost and the lowest small, supporting rays as also the uppermost and the lowest of the long rays are unjointed, all the others are distinctly jointed. The number of rays in the unpaired fins I find in my material to be: *A. scutata*: D. 3/10—12; C. 1 + 4 + 5 + 1*; A. 12—13. *A. strigata*: D. 3/10—11; C. 1 + 4 + 5 + 1; A. 11—12. *A. punctulata*: 3/10—11; C. 1 + 4 + 5 + 1; A. 12.

The cranial skeleton. The skull in agreement with the whole form of the fish is narrow and compressed. The most striking characteristics are the great prolongation of the snout and the development of a part of the preopercular to form a high, thin, transparent plate which covers the anterior part of the ventral margin of the trunk under and in front of the gill-cover.

Viewed from above the only bones of the skull to be seen are the supraoccipital, the frontals, nasals, mesethmoid and the vomer. The mesethmoid is almost completely covered by the anterior ends of the frontals so that only a very small part of it is visible; the supraoccipital projects far forwards between the two frontals and has posteriorly an occipital process. Viewed from the side (fig. 10) we

* 1 indicates the short supporting ray, 4 the rays attached to the upper, 5 those on the lower hypural bone.

observe behind the orbit, in addition to the supraoccipital (*so*) and the frontals (*fr*), a small postfrontal (*pf*), a large pterotic (squamosal, *sq*) and a small posttemporal (supraclavicular I, *pt*). The last is attached by a wedge-shaped suture to the pterotic, the only bone with which it enters into contact on the side, whereas on the posterior aspect of the skull it extends upwards to the epiotic (fig. 11). The epiotic (*ep*) is not visible from the side; it is covered here by the frontal, which by means of a prolongation reaches right back to the posterior surface of the

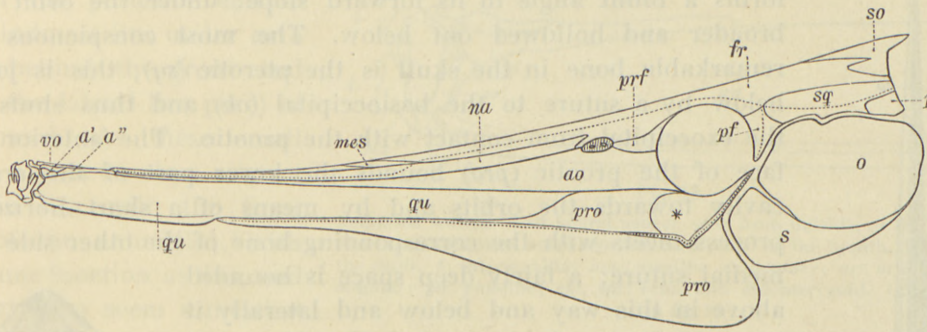

Fig. 10.

Amphisile scutata. Skull from the left side. *so*: supraoccipital; *pt*: posttemporal (supraclavicular I); *sq*: pterotic (squamosal); *fr*: frontal; *pf*: postfrontal; *prf*: prefontal. *mes*: mesethmoid; *na*: nasal; *ao*: antorbital; *a'*, *a"*: detached parts of the same; *qu*: quadrate; *pro*: preoperculum; o: operculum; *s*: suboperculum. The dotted line indicates the canal for the lateral line.

skull, projecting in between the pterotic and the supraoccipital; a slightly shorter prolongation is sent by the frontals into the supraoccipital. The triangular piece of the supraoccipital thus included between these prolongations of the frontals might very easily be taken for a separate bone (thus by Starks (30) who describes it as belonging to the epioticum). Parietals are wanting; also opisthotics. On the part of the skull lying in front of the orbits we have, in addition to the frontals, a small part of the prefrontals (*prf*) between the nasal openings and the orbits; the remainder of the prefontal is covered by the large ant- or preorbital (*ao*) which is triangular in shape and anteriorly sharply pointed. This has a sharp border below for a very long distance, a small curved incision above for the nasal openings and is connected otherwise by a long suture to the nasal (*na*), which is sutured at its long anterior end to the vomer, but does not reach quite to the extreme end of the latter bone. The anterior half of the nasal is pierced by a canal for the lateral line in continuation of the canal which passes through the frontals; of the remaining bones the postfrontal and the pterotic also contain a lateral line canal.

On the posterior aspect of the skull (fig. 11), the two epiotics (*ep*) meet together for quite a short distance round the foramen magnum and thus exclude the supraoccipital (*so*) from the latter; we see further the exoccipitals (*eo*), attached laterally by a suture to the posttemporals (*pt*), of which much more is seen than from the lateral aspect; on the lower, inner border of each exoccipital, close to the basioccipital articulating surface, we find a narrow, deep groove (*gr*) for articulation with the articulating process of the first vertebra. On the posterior surface of the skull in *A. strigata* are very deep hollows, much deeper than in *scutata*; the exoccipitals especially, with the adjoining parts of the posttemporals, have deep hollows surrounded by sharp margins.

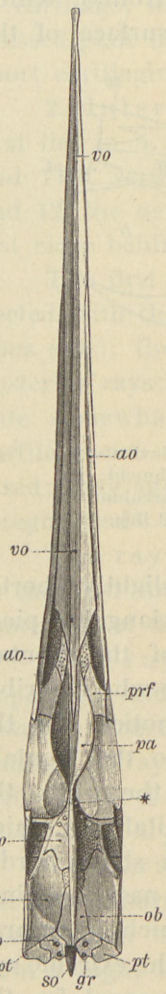

Fig. 12.
Amphisile scutata. Skull seen from below. *pa*: parasphenoid; *ob*: basioccipital; *pro*: prootic. Other letters as in figs. 10 and 11.

The under surface of the skull (fig. 12) most posteriorly is flattened, but soon becomes angular; at * the parasphenoid (*pa*) forms a blunt angle in its forward slope; under the orbit it is broader and hollowed out below. The most conspicuous and remarkable bone in the skull is the pterotic (*sq*); this is joined below by a suture to the basioccipital (*ob*) and thus shuts out the exoccipital from contact with the prootic. The anterior surface of the prootic (*pro*) bounds the lower part of the cranial cavity towards the orbits and by means of a short horizontal process meets with the corresponding bone of the other side in a medial suture; a fairly deep space is bounded above in this way and below and laterally it is enclosed by the parasphenoid. The recti inferiores muscles of the eye are attached in this, i. e. *Amphisile* has a distinct indication of a "myodome"; it is however not continued far back like a true "eye-muscle canal", as is the case in *Centriscus* (cf. later under this species); apart from this the conditions are the same in both species. A small alisphenoid and probably a small orbitosphenoid are present as in *Centriscus*. Under the broadened, concave part of the orbital portion of the parasphenoid lies the posterior, finely pointed end of the vomer (*vo*); slightly in front of the prefrontals (*prf*) — where the cartilaginous portion of these passes over into the mesethmoid — the vomer increases greatly in breadth, and from there, accompanied in the beginning by the cartilaginous mesethmoid, later alone, forms the beak-like anterior part of the skull. The under surface of the vomer is channelled; the lateral edges are (somewhat) thickened; along these edges are attached the mandibular suspensorium, whilst the concave lateral surfaces above the margins are covered by the nasals. Under the broad posterior part of the antorbital bone (*ao*) lies the anterior portion of the preopercular muscle (*M. adductor mandibulæ*) and the long, thin tendon of this muscle is covered by the remaining lower, very thin and transparent edge which extends slightly out over the edge of the vomer; the anterior end of the tendon, almost right to its attachment to the upper and under jaw, is

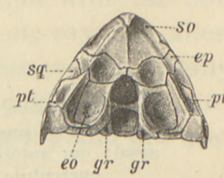

Fig. 11.
Amphisile strigata. Posterior surface of the skull. Letters as in fig. 10. *gr*: articulating grooves on exoccipitals for articulation with 1st vertebra.

covered by some small, thin bony plates (fig. 10 and 13 *a' a''*), which form a continuation of the antorbital. These occur in somewhat varying number: in *A. scutata* I have as a rule found 2 on each side, most frequently (*a' a''* as the figs. show) the first is quite short, the posterior longer, rarely the reverse; in *A. strigata* I find as a rule 4 on each side; in a specimen of *A. punctulata* 2 on the left, 3 on the right side, in another 3 on the right, 4 on the left side. In all the posterior end of the hindmost lies under or a little behind the front end (with the lateral line pore) of the nasal. As these small bones appear in close contact and in line with the front end of the antorbital, with the same function as this, and as they also seem somewhat inconstant in number, in two of the species often different on the two sides, we may well consider them as disconnected parts of this bone. They seem to me to have special interest as they give us the key to understand the relatively much larger bones, which occur in the true *Lophobranchii* in quite a similar position.

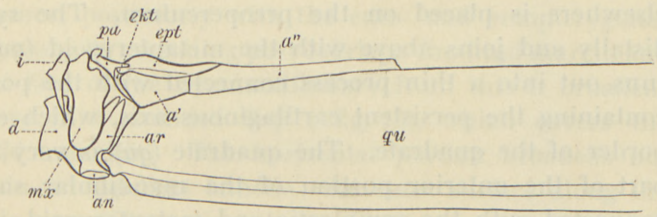

Fig. 13.

Amphisile scutata. Left lateral aspect, seen from outside, of the anterior end of mandibulary suspensorium and parts of the mouth, freed from the skull. *i*: intermaxilla; *mx*: maxilla; *d*: dentary; *ar*: articular; *an*: angular; *pa*: palatine; *ekt*, *ept*: ecto- and entopterygoid. Other letters as in fig. 10.

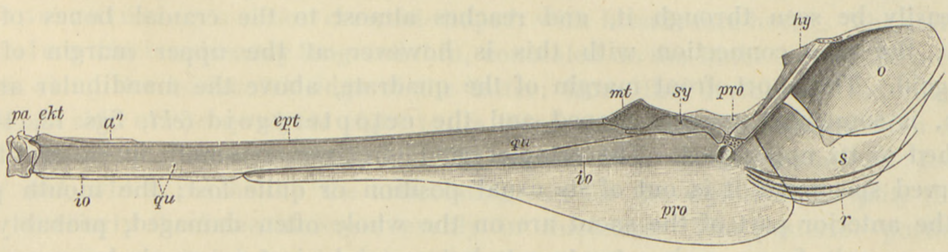

Fig. 14.

Amphisile scutata. Mandibulary suspensorium and opercular bones with the 4 branchiostegals, right side, seen from within. *hy*: hyomandibular; *sy*: symplectic; *qu*: quadrate; *ekt*, *ept*, *mt*: ecto-, ento- and metapterygoid; *pa*: palatine; *a''*, *see* figs. 10, 13; *io*: interoperculum; *pro*: preoperculum; *o*: operculum; *s*: suboperculum; *r*: branchiostegals.

The true mouth-parts (fig. 13) are small. The intermaxilla (*i*) has a distinct, though weak, ascending branch; the maxilla (*mx*) is relatively of fair size and as elsewhere in the bony fishes supported above by a process from the palatine (*pa*). The lower jaw is composed of the usual 3 parts on each side: the articular (*a*) and dental (*d*) which together form a high ascending process for the attachment of the tendon of the *M. adductor mandibulæ*, and a small angular (*an*), which is connected with the interoperculum as is usual by a ligament. At the front end of the dental there is a blunt or sometimes a quite pointed hook directed downwards.

Of the suspensorial parts of the jaws (fig. 14) the hyomandibular (*hy*) is of good length, slender, with a wing-like broadening along the upper part of the inner margin; it is directed obliquely from before backwards and is obviously very firmly connected with the skull; at its lower, cartilaginous end it is connected by connective tissue with the cartilaginous, proximal end of the symplectic (*sy*) and forms with this the upper border of the articulating socket for the stylohyal, which elsewhere is placed on the preoperculum. The symplectic (*sy*) becomes broader distally and joins above with the metapterygoid (*mt*), whilst below and in front it runs out into a thin process connected with the posterior end of the quadrate and containing the persistent cartilaginous axis, which continues directly into the lower border of the quadrate. The quadrate (*qu*) is very long and constitutes the largest part of the anterior portion of the mandibular suspensorium. Its posterior end, connected with the symplectic and metapterygoid, is somewhat pointed; otherwise its upper and lower margins are almost parallel; its lower margin, which is thickened to form a ridge, is for a long distance connected with a ridge on the inner surface of the preoperculum; at the termination of the latter the lower margin of the quadrate becomes a sharp and thin edge, whilst a ridge on the inner surface continues the thickened part right to the articulation with the mandible. The sharp edge lying below this ridge is fairly long in *A. scutata*, much shorter in the other two species. The outer surface of the quadrate is cylindrical, arched and sculptured; the inner surface is concave and the whole bone has thus the form of a half-tube; the upper, thin margin folds over the entopterygoid (*ept*), which can easily be seen through it, and reaches almost to the cranial bones of the snout; the true connection with this is however at the upper margin of the pterygoid. The short, front margin of the quadrate, above the mandibular articulation, is somewhat crescent-shaped and the ectopterygoid (*ekt*, figs. 13, 14) is attached to its upper part. The ectopterygoid is extremely small; in most of the preserved specimens it is out of its usual position or quite lost; the mouth parts and the anterior part of the snout are on the whole often damaged, probably not always or only from careless treatment, but certainly just as much because some of these thin and delicate parts are easily broken or displaced by the contraction of the mandibular muscles and the shrinking of their long tendons in alcohol (or on dying?). The entopterygoid (*ept*) is a long and narrow, quite thin bone with almost parallel margins; it lies along the whole upper margin of the quadrate, being covered on the outer side by this bone except quite in front, where the entopterygoid is much thickened and on the outer side has an overhanging margin which is connected with the upper margin of the first of the small infraorbital bones (*a' a''*, fig. 13). The whole of its upper margin is connected — under the edge of the preorbital — with the margin of the snout, i. e. with the vomer; with the thin, partly cartilaginous (or with but a very thin bony sheath) posterior end it touches the metapterygoid.

The metapterygoid (*mt*) is fairly large, connected in addition to the entopterygoid with the quadrate and symplectic; its inner surface is very concave; its upper margin is arched and somewhat bent inwards; it is very firmly attached to the ethmoid and vomer.

The palatines (*pa*) in *A. scutata* are extremely short, in the other two species somewhat longer, especially in *A. punctulata*; a small knob-like process projects forwards from the anterior end over the maxilla; on the inner side it is articulated with the anterior end of the vomer, posteriorly with the ento- and ectopterygoids.

The preoperculum (*pro*) along its ascending part overlaps the hind margin and a great part of the outer lateral face of the hyomandibular; from this it broadens out on the cheek under the eye in a rounded flap (* fig. 10), which covers the origin of the cheek muscle (add. mandib.). The horizontal portion broadens out below and posteriorly into a thin, transparent lamella; the outer surface along the canal for the lateral line bears a row of low, irregular projections or spines, which together form a kind of ridge separating the thin expansion from the somewhat firmer portion of the bone; at the corresponding place on the inner surface there is a true, but fairly low ridge which terminates at the deep, articulating cup for the stylo-hyal under the end of the hyomandibular. The anterior, evenly pointed portion of the preoperculum is attached for a long distance to the lower margin of the quadrate; in *A. scutata* it is considerably shorter than in the other two species.

The 3 bones of the gill-cover are present; the operculum (*o*) is oval with a projection on its lower margin; its external surface is marked by fine lines. The suboperculum (*s*) is almost crescent-shaped, with broad "fore-horn". The interoperculum (*io*) is extremely long and thin, concealed on the inner side of the preoperculum along the horizontal ridge of the latter; from this it follows the ridge on the inner side of the quadrate right to its front end, where by means of a short, thick ligament it becomes attached to the angular bone on the mandible. Its posterior end, which reaches to the articulating cup for the stylohyal, is quite thread-like; anteriorly the bone increases evenly in thickness. The posterior portion is sometimes interrupted by a short stretch of connective tissue.[3]

The hyoid arch (figs. 15, 16) is represented by the normal number of bones; it is short and extends backwards only to about the front margin of the hypobranchial of the first gill-arch. Its special character consists partly in the much shortened stylohyal (*st*), partly and chiefly, in the greatly developed lowermost hypohyal I (*hy I*), partly finally in a certain amount of displacement towards one another of the parts composing it. Viewing the arch from the outer side (fig. 15) the small, rounded stylohyal (*st*) is seen as if inserted in and surrounded by the epi- and ceratohyal. It has a head-shaped, rounded articulating surface for the above-mentioned articulating cup on the suspensorium; on the outer side it has a deep groove (* fig. 15) which is completed by the other two bones, the epi- and ceratohyal; this is filled by a short, thick ligament, which holds the hyoid arch to the preoperculum (and symplectic). Very little of the epihyal (*eh*) is seen from this side, as its upper part is covered by the stylohyal; on the other hand, a great deal of the ceratohyal (*ch*) is to be seen; along with the hypohyal I (*hy I*) it forms the most of the hyoid arch to be seen from the outer side. When observed from the inner side, however, the epihyal is of good size (fig. 16) and connected anteriorly with a small hypohyal II (*hy II*) and with hypohyal I; posteriorly it covers the stylohyal, which is almost completely hidden; of the ceratohyal only a small part is seen (*ch*). The (in other fishes) upper hypohyal II (*hy II*) is very small; as in other bony fishes it is firmly attached by a ligament to the basis of the glossohyal. The lower hypohyal (*hy I*) is, as already mentioned, the largest bone in the whole arch, composing about half of its length; its front end is somewhat bent downwards (larger and stronger in *A. strigata* than in *A. scutata*); it is connected for a long distance with the corresponding bone of the opposite side, and a cartilaginous mass is found on the inner side of the anterior end. Cartilage is also present between the epi- and ceratohyal in the lower, thinner part of the posterior portion of the arch, further in the interior of the bones. In a depression on the outer side of the arch formed by the epi- and ceratohyal (fig. 15 **) and overhung by a projecting ridge are attached the 4 branchiostegals (see fig. 14). The hindmost (uppermost) of these is the strongest and largest, the first quite thin and short. A groove under the base of the curved front end of the hypohyal I is for the attachment of the strong ligament for the urohyal. This bone (Pl. II, fig. 1 *u*) is of a considerable size and is continued backwards in 2 very long, thin bones, each of which runs far back on the outer aspect of the clavicle of its own side and serves as tendon for the attachment of a feather-like muscle; the posterior portion of this muscle is attached to the postclavicle (*pcl*), whilst the fibres arising ventrally from the tendon are fixed along the outer side of the coracoid (*co*).

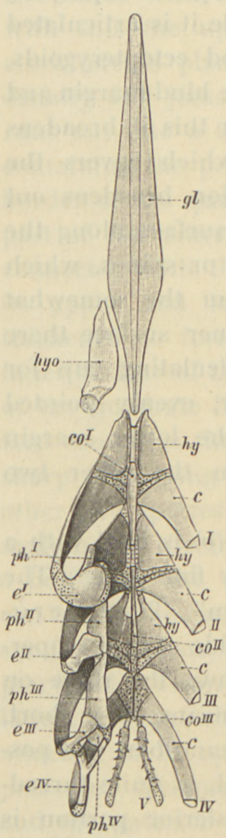

Fig. 17.
Amphisile scutata. Gill-arches seen from above; on the right side the hyoid and upper parts of the arches have been removed. *gl*: glossohyal; *hyo*: left hyoid; co^{I}—co^{III}: copulæ (basibranchials); *hy*: hypobranchials; *c*: ceratobranchials; e^{I}—e^{IV}: epibranchials; ph^{I}—ph^{IV}: pharyngobranchials.

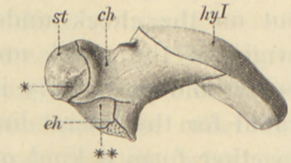

Fig. 15.
Amphisile strigata. Right hyoid arch, from the outer side. *st*: stylohyal; *ch*: ceratohyal; *eh*: epihyal; hy^{I}: lower hypohyal.

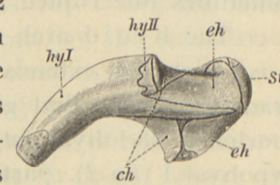

Fig. 16.
A. strigata. Right hyoid arch, inner side. Letters as in fig. 15. hy^{II}: upper hypohyal.

The glossohyal (entoglossal, lingual; fig. 17, *gl*) is very long, flat and thin; in *A. scutata* it is of the same length as the whole of the remaining portion of the gill-arches, in *A. strigata* even somewhat longer. Seen from above it is leaf-like, elongated, oval, with narrow stalk-like base (this has on its under aspect a forked process directed forwards); the anterior end is cartilaginous and a cartilaginous axis is continued throughout the whole of its length. Behind this begins a continuous cartilaginous rod, which extends in between the front ends of the gill-arches IV; it contains 2 ossified copulæ (or basibranchials); the first (*co I*) arises on the ventral side in front as a spur and extends almost from the middle of the hypobranchials of arch *I* to near the middle of the hypobranchials of arch *II*; the second (*co II*) reaches to the posterior edge of hypobranchials *III*. There is no copula between the cartilaginous, basal ends of arch *IV*, which meet together in the middle line; but immediately behind these there is a small, unpaired piece of cartilage (*co III*), to which the cartilaginous, basal end of arch *V*, the lower pharyngeal, is attached.

The whole branchial apparatus is elongated, even the part lying above the pharynx; in consequence, all parts are more easily observed than is the case in many other fishes; any incompleteness or imperfection in the various parts in comparison with other fishes which might justify Cope's name "Hemibranchii" does not exist; in all essential regards it agrees with the condition in for example an Acanthopterygian such as *Sebastes*. The first three gill-arches each consist of 4 parts; the hypobranchial (*hy*) is short, broad; seen from above it is more or less distinctly 3-sided, largest in arch *I*, shortest in arch *III*; as is generally the case in other fishes the hypobranchial *III* has a forwards projecting process or keel on the under side; it is absent from arches *IV* and *V*. The ceratobranchial (*c*) is the longest bone, with cartilaginous upper and lower ends; ceratobranchial *IV* has a longer, lower cartilaginous end than the others, meeting directly with the corresponding part from the opposite side, thus taking the place of the absent hypobranchial *IV*. As is generally the case in bony fishes the ceratobranchial composes the whole of arch *V*; here it has proximally a small cartilaginous end, distally (upper) a fairly large, somewhat broadened cartilaginous end; the surface towards the pharynx is beset with teeth. The epibranchial (*e*) *I* is short, broad, with the upper thickened margin cartilaginous and extending over the outer margin of the pharyngobranchial *II*. The epibranchial *II* is somewhat curved over the throat; at the bend it sends out an upward process (an indication of a similar process is found on epibranchial *I*). The distal part lying over the throat ends in a rounded cartilaginous border connected with the pharyngeals *II* and *III*. Epibranchial *III* has a similar form, but its upward process is much longer and articulates with the corresponding process on epibr. *IV*; its distal main part ends in a cartilaginous border, connected with the adjacent pharyngeal *III* and also touches the pharyngeal *IV*; owing to the length of the

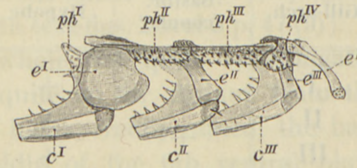

Fig. 18.

Amphisile scutata. Upper pharyngeal bones (ph^{I}—ph^{IV}) and epibranchials (e^{I}—e^{IV}), with the upper ends of the ceratobranchials (c^{I}—c^{III}); right side, seen from within and somewhat below. A portion of the mucous membrane with gill-rakers is also shown.

process mentioned above this epibranchial seems to be bifurcated. This is even more the case with epibranchial *IV*, which is much more slender than the foregoing epibranchials; its long process is directed obliquely forwards to connect with the process on epibr. *III*, whilst the distal (inner and longer) head-part is connected by a cartilaginous end with the corresponding pharyngeal and likewise touches the upper cartilaginous part of the pharyngeal in front. Of the 4 pharyngeals (ph^{I}—^{IV}, figs. 17 and 18) the one belonging to arch I is short, wedge-shaped and without teeth; in *A. strigata* I find that it is not bone but cartilage; the next 3 form together the epipharyngeals (upper "throat-bones"), and are beset on the surface towards the throat with a number of pointed teeth; the pharyngeals *II* and *III* are elongated, narrow, the group of teeth oval; pharyngeal *IV* is short, rounded, its tooth plate of similar form.

Of the gill-rakers it is mainly the outer (front) row which is well-developed; the inner (posterior) is quite wanting on arch *I*, is only indicated by some scattered parts on arch *II*, more numerous and more distinct on *III* and is most developed on *IV* (it is hardly necessary to say that it is absent on *V*). The outer or front row is specially long on arches *I*—*III*, much shorter on *IV*; they are flat, pointedly triangular, rod-shaped when seen in profile; their inner skeletal axes are not ossified on the anterior arches or but little ossified at the base; on *IV* the axes are ossified to a greater extent; the ossifications are not fused to the skeleton of the arch; on *V* a small row of 4—5 short gill-rakers is present distally in front of the teeth. The inner row of gill-rakers is, as above mentioned, weakly developed everywhere, and the rakers short and fine (easily overlooked between the numerous papillæ on the throat), but usually with a small bony axis, especially on *IV*, where however owing to the shortness of the gill-cleft they do not occur on the epibranchials[4].

The most important features of the branchial apparatus can be represented in tabular form as follows:

Gill-arch	Basibr. (copula)	Hypobr.	Ceratobr.	Epibr.	Pharyng.	anterior gill-rakers	posterior gill-rakers
I	+	+	+	+	+	+	
II	+	+	+	+	+	+	(+)
III		+	+	+	+	+	+
IV	(+)		+	+	+	+	+
V			+			+	

The shoulder girdle (Pl. II, fig. 1 and text-fig. 19) has been very carefully and correctly described by Starks (30, pp. 633—34) in *A. strigata*. On one point only, but that a fairly important point, Starks has misunderstood the conditions; he states namely (p. 634): "The hypercoracoid (scapula here, *sc* in fig. 1, Pl. II and fig. 19) does not nearly contain its foramen, but is assisted above by the inner plate of the clavicle"; and with this his figure 6 also agrees. The true condition I have shown in the figure of *A. scutata.* We see here that the large, oval foramen is quite surrounded by the scapular alone, as elsewhere in the bony fishes. Starks' error has possibly arisen from investigation of a dried specimen, in which the anterior, extremely brittle and almost unossified boundary of the opening has fallen out. As in many other fishes the coraco-scapular cartilage has been preserved to such an extent that there is but a small ossified portion, in parts exceedingly thin, outside it. The whole of the inner part of the scapula is cartilaginous and the cartilage on the front, upper corner is quite uncovered by bone; from the boundary between the scapula and coracoid the cartilage extends into the latter as a broad triangle, continuing from the lower angle as a thin axis across the horizontal part and increasing evenly in thickness towards the clavicle, where finally the anterior end is quite cartilaginous. The horizontal part of the coracoid unites so firmly with its fellow of the other side, that they give the impression of having grown together; obviously a result of the extremely compressed condition on the ventral side of the fish. The ridge *l* on the clavicle, to the hindmost part of which the scapula is attached, continues under the scapula right to the posterior end of the portion of the clavicle visible externally (*cl*, fig. 1, Tab. I).

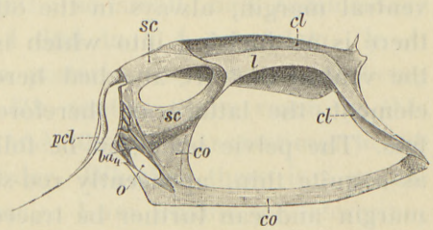

Fig. 19.
Amphisile scutata. Left pectoral arch, seen from within; supraclavicular removed. *cl*: clavicle; *l*: ridge on clavicle; *sc*: scapula; *co*: coracoid; *pcl*: postclavicle; *ba4*: lowermost basal; *o*: foramen.

Fig. 19 shows likewise that the postclavicle (*pcl*) has essentially the same form as in *A. strigata*, but is much shorter. In *A. strigata* it extends backward beyond the pelvis as far as the posterior margin of the 8th ventral plate.

In *A. scutata* there is an oval opening *o*, bounded partly by the coracoid, partly by the very considerable, lowermost (4th) basal (*ba4*). The part of the clavicle visible externally is longer in *scutata* than in the other two species, where it also has a somewhat different form (cf. Pl. I, fig. 1 with text-figs. 2 and 3 p. 47 (9)). In the other two species the shoulder girdle is on the whole not quite so elongated as in *scutata* and the pectoral fins are therefore not quite so far distant from the gill-opening as in the latter; as LÜTKEN (24a, p. 216) has correctly stated, the base of the pectoral lies in *scutata* (almost) above the middle of the 6th ventral plate, whilst in the other two species it is (almost) over the boundary between the 5th and 6th[5].

The number of rays in the pectoral fin I find to be 11 in *A. strigata*, 12 in *A. punctulata*, 10 in *A. scutata* (though 11 in one of 11 specimens); in addition, there is in all 3 species a small, quite rudimentary ray at the upper border of the base of the pectoral. In a single specimen of *scutata*, further, there was on the left side 1 more rudimentary ray above and on the right side 1 rudimentary but longer ray at the lower edge, in addition to the 10 rays developed. All the rays are unbranched, but finely threaded at the ends (the same applies to the rays of the ventrals and the other fins). The uppermost rays are the longest and strongest in all the species; the breadth of the rays decreases evenly towards the lower margin; the lowermost ray and the uppermost 2—4 are quite unarticulated, the remainder distinctly articulated though in extremely varying degree.

The pelvic bones (fig. 20) can be seen in all the species through the sharp ventral margin, always in the 8th ventral plate. On the lower edge of the latter there is an incision into which is fitted the lower margin of the pelvic bone, and the ventral fins are attached here; if this plate is fused below with an unpaired element, the latter can therefore not extend any further back than to the ventral fins. The pelvic bone can be followed from this place, directed obliquely forward, as a quite thin, apparently rod-shaped process up through the transparent ventral margin and can further be traced more or less distinctly higher up, crossing the rachis of the 8th plate; its upper end is not as a rule seen through the skin, as it is hidden in the muscular mass. In *A. strigata* it seems to be placed in a somewhat more vertical position than in the other two species and may lie almost parallel to the above-mentioned rachis.

Fig. 20. *Amphisile strigata.* Left pubic bone, seen from outside.

Closer examination shows that each half of the pelvics greatly resembles a fin-ray; it is a quite thin and narrow bone, broader at the base and here with a cartilaginous lower edge, to which the ventral fin-rays are attached; the cartilage continues from here as a thin axis through the whole bone, the upper end of which again is cartilaginous. The portion of the bone which surrounds the cartilaginous axis is somewhat thicker and thus more prominent than the remaining, thinner surface; it separates — like the muscular ridge on an interspinous bone — the anterior and posterior muscles (or muscular tendons) for the rays of the ventral fins. In *A. strigata* (and probably also *punctulata*) the whole pelvic bone is somewhat broader than in *scutata*, where it is extremely narrow. Long muscular tendons lie, as above mentioned, along the anterior and posterior lateral surface, separated by the faint axial thickening, and also on the inner side of the half facing forward — thus between the two halves of the pelvics (corresponding to the ventral musculature on the pelvics of a typical fish). The muscular fibres which move the rays of the ventral fins by means of these tendons form a muscular mass, which as mentioned above hides the upper ends of the pelvic bones, and the main portion at any rate takes its origin from the inner wall of the abdomen. This pelvic region thus seems quite different from that of all other bony fishes in regard to position, form and arrangement of the muscles. The position and something of the form will however be found again in *Centriscus*. The large amount of compression suffered by the abdomen in *Amphisile* has obviously influenced the form and position of the pelvic region and thus made it expedient that the musculature should for the most part move out to the inner surface of the abdominal armour[6].

The ventral fins are coalesced along their inner margin as in the Gobies. The number of rays is 5, 1 spinous and 4 soft, but unarticulated and unbranched rays; these naturally are distinctly composed of paired parts in contrast to the spinous ray. The spinous ray is very fine, much shorter than the other rays, sometimes of different length on the two sides (in a ♂ of *A. strigata* I find it half as long on the left as on the right side); it may be so small, half rudimentary that it is difficult to find; this is the condition I find in 2 *A. punctulata*. In *A. strigata* the males have long ventral fins the two posterior rays especially being long; the ventral fins, which are placed on the 8th ventral plate, reach in this case to or beyond the boundary between the 9th and 10th plate, sometimes to the middle of the latter or even to its posterior border. Whether there is a sexual difference in the ventral fins in the other two species I am unable to determine; I do not think so however and in any case it will scarcely be obvious. In 10 specimens of *A. scutata* before me the variation in length of the ventrals is quite unimportant and in 11 *A. punctulata*, which I have examined with regard to this point, I likewise find but little variation; I find that the fin never reaches beyond the 9th ventral plate. That specimens of *A. strigata* with long ventrals are really ♂, as stated by earlier authors, I have had the opportunity to confirm by the examination of one specimen[7].

Remaining anatomical features.

With regard to the anatomy of the soft parts I shall restrict myself to some few remarks, as my investigation was chiefly concerned with the osteology; the remaining organs have only received occasional attention.

The character of the musculature is in high degree determined by the stiff armour. The lateral muscles have for a great part disappeared; only the dorsal portion is fully preserved. The part of this which lies on each side along the elongated, anterior vertebræ, above the attachment of these to the ridges on the lateral plates, are attached in front to the skull, very firmly especially to the supraoccipital, by means of a thick tendinous mass, which further back divides into two long tendinous strips along the upper border of the muscles; the whole of this muscular part probably represents a number of muscular segments corresponding to the 5—6 vertebræ and we find also, that it is penetrated longitudinally by ca. 10 long, shining tendinous strips, which seem parallel but in reality converge posteriorly at very pointed angles, whose apices lie near the limit of the movable part of the spine and somewhat further back. The muscular mass is specially tendinous along the ventral edge of this region and constantly more tendinous the more we approach the movable part of the vertebral column; the tendons are fixed to the transverse processes of the posterior, movable abdominal vertebræ and those of the anterior caudal vertebræ. The dorso-lateral muscles, which belong to the unarmoured portion of the vertebral column, are segmented, as is the rule in fishes, and provided with strong tendons attached to the transverse processes of these vertebræ. The ventro-lateral muscles are only completely developed in the same region; further forward there is but a weaker part which extends forward under the armour towards the posterior end of the swim-bladder; the uppermost portions of this also have strong tendons, attached to the transverse processes of the 2 hindmost abdominal vertebræ. Otherwise the whole abdominal wall within the armour is reduced to a thin membrane.

The musculature for the anal, 2nd dorsal and caudal fins is well-developed; in the last the muscles to the lowermost ray on the upper hypural bone and to the uppermost ray on the lower hypural are specially strong. On the other hand the muscles for the 1st dorsal fin are atrophied, as true rays are wanting with exception of the spinous ray in *punctulata* and *strigata*; the two pairs of muscles for this ray have already been described.

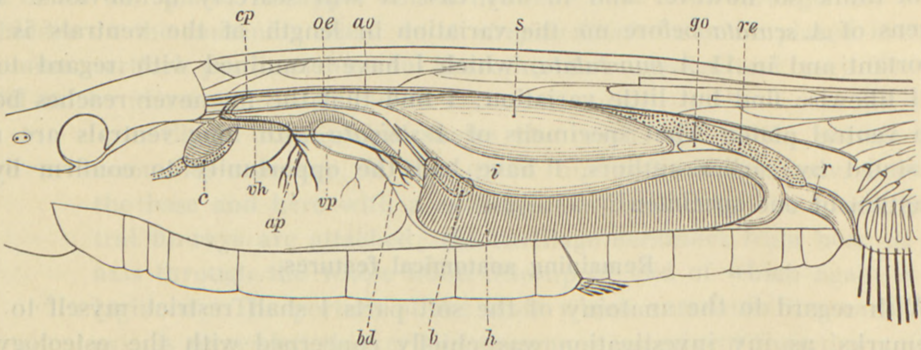

Fig. 21.
Amphisile scutata. Viscera seen from the left side. *ao*: aorta; *c*: heart; *ap*: artery of left pectoral fin; *cp*: left posterior cardinal vein; *vh*: hepatic vein; *vp*: vein of left pectoral fin; *oe*: oesophagus (and stomach); *i*: intestine; *r*: rectum; *h*: liver; *b*: gall-bladder; *bd*: bile-duct; *s*: swim-bladder; *re*: kidney; *go*: ovary.

I may add, that the arrangement of the musculature can in the main be studied without preparation, being seen through the skin.

The muscles seen through the skin over the base of the 1st dorsal fin do not belong to this, but to the 2nd dorsal; most of the fibres are collected in a flat tendon to the uppermost interspinous bone (* fig. 1, Pl. II) of the latter.

The muscles for the pectoral fins are specially strong, corresponding to the considerable size of the pectoral girdle. The musculature of the pelvic region was described above, as also the muscle of the long tendon to the urohyal; the posterior, strong part of this is attached with its dorsal fibres to the postclavicle.

The pharynx is well provided with papillæ of fairly considerable size.

There are 4 complete gills on each side (i. e. a double row of laminæ on each of the arches I—IV) and a large pseudobranchia; the last is placed along the posterior border of the hyomandibular and is composed of numerous, well-developed laminæ in a single row. There is a distinct cleft between the hindmost, gill-bearing arch (IV) and the lower pharyngeal bone (V), surrounded on both margins by gill-rakers (cf. above, p. 66 (28)).

Behind the gullet the alimentary canal (fig. 21, 22) is at its beginning, between the spinal column and the pectoral arch, a horizontal, narrow, muscular tube (*oe*); under the front end of the swim-bladder it bends downwards somewhat and at the same time widens evenly; here the strong musculature suddenly ends; on the inner side the numerous, strong longitudinal folds, which characterize this part, likewise cease; the continuation of the canal increases regularly in circumference — like a spindle — becomes quite thin-walled, provided on the inner surface with much less numerous, lower longitudinal folds often connected to form a network. The canal continues still with the same shape under the swim-bladder, narrowing somewhat, as far almost as the posterior end of the abdominal cavity; here it bends over to the right side, passes forwards, bends again — a little in front of the middle of the swim-bladder — in a sling, in which the spleen (*l*) rests, runs further posteriorly under the genital organs (*go*) and the kidney (*re*) and passes over with a distinctly marked boundary into a short rectum (*r*) and then bends down to the anus. The walls of the rectum are somewhat thicker; even the hindmost part of the small intestine has thicker walls than the remainder and is less in diameter. The bile duct (*bd*) opens on the under side immediately behind the boundary mentioned between the anterior, thick-walled narrow part and the wide thin-walled continuation. The intestine thus begins here in reality and the narrow, thick-walled anterior tube represents the œsophagus and stomach. A true stomach can thus be said to be absent. There is no indication of pyloric appendages. In the anterior, spindle-shaped part of the intestine and for a long distance further, to a little in front of the rectum, I found plentiful food in *A. scutata*, consisting of quite recognizable copepods, crab-larvæ and similar small Crustacea.

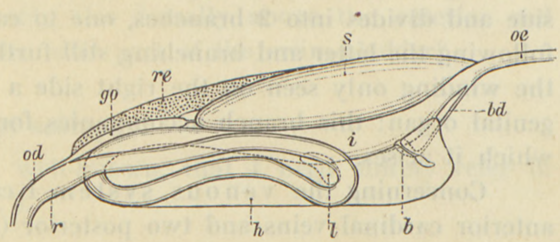

Fig. 22.
Viscera from right side. Letters as in fig. 21. *l*: spleen; *od*: oviduct.

The liver (*h*) has 2 main lobes, a long one on the left, a shorter to the right. The anterior part of the alimentary tract (behind the œsophagus-stomach) is surrounded by both lobes of the liver; the left lobe occupies completely the first winding of the intestine; seen from the left side the latter is covered over from the posterior to the anterior bend by the left lobe of the liver with which it is closely connected. The gall-bladder (*b*) lies on the dorsal side of the right lobe, sunk into this in a break in its substance and the right lobe is thus divided by the break into an anterior and a posterior portion. Along the middle of the inner surface of the left lobe runs a large hepatic duct, accompanying the vena hepatica for a long distance and thereafter the arteria hepatica; it receives the duct from the gall-bladder, then that from the right lobe of the liver and — still accompanied by the A. hepatica — enters into the alimentary canal on the ventral side at the spot indicated above.

The heart (*c*) lies remarkably far from the ventral margin, high up between the clavicles, with the longitudinal axis placed obliquely so that the bulbus of the branchial artery points downwards and forwards. The aorta (*ao*) lies to the right of the middle line of the vertebral centra, accompanied by a large right cardinal vein and a thin left cardinal (*cp*). Close behind the head the aorta gives off to each side — a little asymmetrically — a large artery to the muscles of the pectoral fins (*ap*), and almost at the same place though more ventrally and to the right the large *Arteria cœliaca*. This runs along the right side of the œsophagus-stomach, with branches to this, then further under the swim-bladder; under the middle of this it gives off a fairly large branch to the "red body" (*rete mirabile*) on the under side and divides into 2 branches, one to each of the two windings of the intestine following the latter and branching still further; from the branch which accompanies the winding only seen on the right side a long branch is sent off to the tip of the genital organ; this branch accompanies for a long distance the branch artery from which it arises.

Concerning the venous system I can only say that there are as usual two anterior cardinal veins and two posterior (*cp*), of which the right is much larger than the left. The caudal vein enters at the posterior end of the kidney. There is only one very large vena hepatica (*vh*), remarkably long, as the liver lies behind the elongated pectoral arch whilst the heart is in front. Into this flows the large vein (*vp*) from the muscles of the pectoral fins, the latter receiving a small vein from the pubic arch and the ventral fins.

The swim-bladder (*s*) is of very considerable size, spindle-shaped; it is seen, as is well-known, through the dorsal cuirass. Its walls are very thin; at about the middle of the ventral wall we find on its inner side a large, well-developed *rete mirabile*, in shape like a horse-shoe with the concavity turned posteriorly (it is slightly asymmetrical, the left side being somewhat longer than the right).

If an *Amphisile* is held up against the light, we can notice (in most specimens) a thin, whitish streak passing from the under margin of the dorsal musculature across over the swim-bladder and disappearing at the lower margin of the latter under the opaque ventral plates; this is the nerve to the ventral fins. It comes out through the incision in the transverse process of the 3rd vertebra, runs a small distance backwards and then follows the course seen from the outside through the dorsal cuirass to pass almost vertically down to the pubic arch.

Genital organs. The ovary (*go*) is unpaired; it has transverse lamellæ (*A. scutata*) and lies behind the end of the swim-bladder along the under side of the kidneys. At about the posterior end of these it is reduced to a long, stringlike oviduct (*od*), which follows the dorsal surface of the rectum to the genital opening behind the anus. The testis is also unpaired (*A. strigata*), like the ovary in external appearance and with the vas deferens following the same course as the oviduct.

The kidneys (*re*) are fused posteriorly into one body which reaches backward to the rectum; at about the anterior end of the genital organ this body divides into two weak and thin parts which accompany the cardinal veins. Whether they follow these right forward I have not been able to determine with certainty; but there is a "head-kidney" round these veins anteriorly before they open into the ductus Cuvieri. This head-kidney is traversed anteriorly by the large nerves to the pectoral fins. It is most probable that only the posterior, voluminous part is functional; as is usually the case in fishes the caudal vein enters into this posterior kidney. I have not been able to find a urinary bladder.

A plentiful, yellowish fatty tissue is developed along the whole of the ventral margin, above the transparent ventral keel; also dorsally above the anterior end of the genital organ, between this and the hind part of the swim-bladder[8].

Centriscus scolopax.

The appearance of this fish is so well-known, that I need simply refer in regard to it to the figure on Plate I, fig. 3.

Exoskeleton.

In contrast to *Amphisile*, *Centriscus* is covered by scales. These are present not only on the whole of the body but also on the head, even on the long, tube-like snout, on a great part of the eye, especially its posterior part; further, on the anterior dorsal fin and on the fin-rays of the other fins. A number of spinous or sculptured ridges project up through the scaly covering; on the head especially there is a strong ridge from the upper corner of the gill-opening along the frontal margin over the orbit and further above the nostrils out to the base of the snout (Pl. I, fig. 3); a second is continued from the anterior, lower border of the orbit forward under the nostrils and joins with the previous in front of these; a third oblique ridge on the ascending branch of the preoperculum behind the orbit and a fourth, weaker on the operculum (see Pl. I, fig. 3) etc. On the body of the fish, in line with the ridge on the head first mentioned, there is a very apparent ridge-like strip over the trunk above the pectoral fin and running almost horizontally or sometimes a little obliquely; from this lateral ridge arise others, short below, longer above, the last passing up in front of the base of the large dorsal spine. There is also a short, curved ridge (*cl*) round the root of the pectoral fin, and a short ridge (*scl*) runs down towards the front end of this ridge from the junction of the lateral body-ridge with the head-ridge. Lastly, the ventral margin in front of the ventral fins forms a sharp edge and there is a similar but shorter edge going towards the anus behind the groove in which the ventral fins can be hidden.

Closer examination of the ridges on the body shows, that those marked with *scl* and *cl* belong to parts of the inner skeleton, namely, to the supraclavicle and clavicle respectively, and that the remainder belong to some peculiarly modified, large scales; these taken together correspond to the armour in *Amphisile.* Just as in the latter the cuirass belonged in reality only to the trunk, we find that the condition is the same in *Centriscus*; but it is easier to recognise in the latter, where the disproportion between the fore-trunk and the rest of the fish is less obvious than in *Amphisile.* In describing the exoskeleton of *Centriscus* we must distinguish between (1) the armour on the trunk or thorax and (2) the true scales.

(1) The thoracic armour makes its presence felt as soon as we take the fish in the hands; in fact, it makes the anterior part of the fish quite stiff and immovable. It is therefore so much the more remarkable, that this has hitherto been but little observed and never, so far as I know, compared closely with the condition in *Amphisile.* This may be due partly to the fact, that the large scales, of which it is composed, are more or less hidden by scales of the ordinary type, which cover them to a greater or less extent, in some specimens more than in others. The thoracic armour here also consists of a dorsal and a ventral part.

When the covering scales are removed, the dorsal armour is seen, as in *Amphisile*, to be composed on each side of two rows of plates, an upper, dorsal, and a lower, lateral (Pl. I, fig. 3). The upper consists of 3 members, connected with one another by dentate sutures and likewise with the anterior 3 of the lower row; their upper margin does not reach to the middle line of the back and thus, in contrast to *Amphisile*, they do not meet the corresponding plates from the opposite side. The posterior and largest is closely attached at its upper point with a part of the upper end of the interspinous bone for the small, first spinous ray of the dorsal fin (R', Pl. I, fig. 3).

The lower row consists of 5 plates (Pl. I, fig. 3 and text-fig. 23, *I—V*), firmly connected with one another by dentate sutures where they meet; two oblong interspaces covered by ordinary scales are found between the first three plates and the upper row; a similarly scaled, narrow interspace, opening upwards and backwards, separates the two posterior, much smaller plates from the last plate of the upper row. The outer surface of all the plates of the dorsal armour is provided with strong, finely toothed ridges; on the two anterior, somewhat rhomboidal plates in the lower row these form a kind of oblique cross; on the third plate the posterior arm of the cross bends upwards and continues as a medial ridge on the two remaining, smaller plates of the lower row. On the plates of the upper row the ridges form a kind of oblique T, the upper arm of the cross being absent.

The first plate in the lower row covers at its anterior corner the upper part of the supraclavicle and the hindmost corner of the skull and is closely attached by means of dense connective tissue to the underlying bone, (supraclavicle I or) posttemporal (*pt*); the lower margin of the same plate overlaps the upper part of the clavicle.

The inner surface (fig. 23) of the dorsal cuirass is smooth and somewhat concave in the upper plates and the two posterior of the lower row; but on the first 3 large plates of the lower row there is a very prominent ridge (*l*); this is firmly attached by means of dense connective tissue to the transverse processes on the 2nd, 3rd and 4th vertebræ. Examined more closely, the conditions are as follows: the transverse process of the 2nd vertebra lies at its outer end in a notch, which is formed by a shallow depression on the upper edge of the clavicle and by the anterior margin of the ridge on plate I; the transverse process of the 3rd vertebra fits into an incision (*a*) almost in the centre of the part of the ridge belonging to plate II and the tip of the transverse process of the 4th vertebra is similarly situated on the ridge on plate III. On close inspection of the ridge we find that the long teeth of the sutures on the one plate fit into those on the others in such a way that they almost reach to the notches.

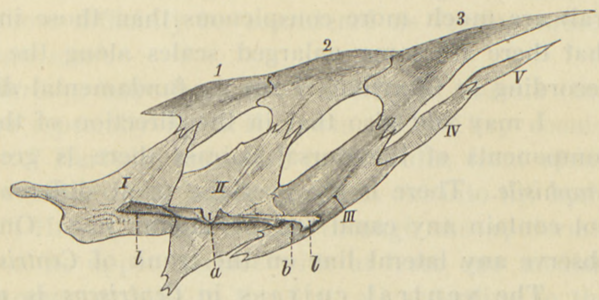

Fig. 23.
Centriscus scolopax. Right dorsal cuirass from inside. *1*—*3*: plates of upper row; *I*—*V*: of lower row; *l*: ridge on plates I—III; *a*: notch for the transverse process of 3rd vertebra; *b*: for that of 4th.

There is thus no small resemblance to *Amphisile*; there can scarcely be any doubt that the plates marked *I*—*V* in Plate I, figs. 1 and 3 are completely homologous. In both genera no. I is firmly attached to the posttemporal and is connected with both the supraclavicle and the clavicle as well as with the transverse process on the 2nd vertebra; nos. II and III are connected by means of a prominent ridge with the transverse processes on the 3rd and 4th vertebræ, the ends of which fit into incisions on the ridge; the plates IV and V are somewhat different, as they have no ridge in *Centriscus* and no connection with vertebræ, whilst IV in *Amphisile*, sometimes also V, possesses a ridge and is connected with the vertebral column. Nor can there be any doubt that the plates of the upper row in the two genera are also "general homologues" and represent each other; but there may be some doubt, naturally, as to whether the plates in *Centriscus* marked 1, 2, 3 in Pl. I, fig. 3 and text-fig. 23, are strictly homologous with the plates of *Amphisile* in fig. 1, Pl. I indicated by the same numbers; their connection with the plates I, II and III seems to be in favour of homology, but on the other hand, the posterior plate 3 in *Centriscus* resembles plate 5 in *Amphisile* both in form and in the fact that it is connected with the 3rd interspinous bone. If the numbers given, 1, 2, 3 are correct in *Centriscus*, compared with *Amphisile*, then the posterior plates, 4 and 5 in *Amphisile*, are not developed in *Centriscus scolopax* and *C. gracilis* (which is in complete agreement with *scolopax*). For *Centriscus humerosus* GÜNTHER (14a, p. 523) gives 4 plates in the upper and 4 in the lower row, but so far as I can judge from the figure given by Richardson (26, Pl. 34, fig. 5), the number of plates in this species are just as in the other two species; but there is the interesting difference in arrangement, that no. IV of the lower row has become larger and moved down in line with I—III (and at the same time almost certainly become provided with an inner ridge and connected with the 5th vertebra); no. V is likewise larger and has become attached by suture to 3 in the upper row, so that an extra, completely bounded interspace is present in addition to the two in the other two species. In this peculiar species all the large plates of the skin (also the ventral) are much more conspicuous than those in *C. scolopax* and *gracilis*, but except that there are some enlarged scales along the dorsal edge of the trunk (3 rows according to Günther), I see no fundamental differences.

I may add also that in the direction of the teeth on the sutures between the components of the dorsal cuirass there is great agreement with the condition in *Amphisile*. There is however the great difference in the upper row, that it does not contain any canal for the lateral line. On the whole I have been unable to observe any lateral line on the trunk of *Centriscus*, but only on the head.

The ventral cuirass in *Centriscus* is represented by (*a*) a paired row of bony plates, one on each side of the lower edge of the belly and (*b*) an unpaired, median row from the isthmus to the anus, broken only by the groove for the ventral fins; it is this row which forms the above-mentioned, sharp ventral keel.

(a). Of the paired plates, 6 form a row in front of the ventral fins (Pl. I, fig. 3, 1—6), connected ventrally with the unpaired row; a 7th (*s*) lies more dorsally, inserted above 2 and 3, close to the gill-opening. The largest plates, 3, 4 and 5 are the most apparent and have therefore often been seen; their upper margin is somewhat lobed and a central lobe especially is larger and more distinct than the others. Alongside the groove for the ventral fins there is a shorter row of 3 plates, nos. 7—9, the last of which is the largest (plates 6, 7, 8 do not seem however to be always distinctly developed). On the outer side the paired ventral plates have a sharp, longitudinal ridge with other, shorter ribs radiating out from its centre; one of these runs out into the above-mentioned marginal lobe on the large plates. On the hindmost plate, 9, the median rib forms an oblique spine.

(b). The median unpaired row is composed in front of the ventral fins of 5 narrow, compressed and sharply keeled, symmetrical plates (*I—V*); with exception of the first they alternate with the paired plates in the row above; as in the latter the inner surface is smooth and concave, the outer provided with ribs which radiate out from the centre of the base of the keel. Behind the groove for the ventral fins there is a strongly keeled or almost spiny plate (VI). In contrast to the dorsal cuirass the components of the ventral armour are not mutually connected by sutures, but overlap each other at the margins; the keeled scales of the belly overlap the ventral margins of the paired plates of both sides.

It seems certain that the whole ventral armour of *Centriscus* may be regarded as corresponding to that in *Amphisile*. One of the paired plates, at any rate, namely the small plate *s* in Pl. I, fig. 3, seems from its whole position between the clavicle and the other plates in the ventral armour to correspond with the small plate indicated by the same sign in *Amphisile* (*s* in Pl. I, fig. 1), but in the case of the other plates I am unable to carry out a detailed comparison. Starting from the position, however, that the more primitive features are to be found in *Centriscus*, I should imagine that the condition in *Amphisile* has arisen in one of three ways, as already indicated earlier (p. 50 (12)). The characteristic rachis on the ventral plates of *Amphisile* together with the faint indications of ridges connected with their lower ends, can also without difficulty be considered as having arisen from the ridges on the plates in *Centriscus*[9].

(2). The true scales in *Centriscus* have been described by L. Agassiz (1*a*), Kner (21 b), Vaillant (33) and more especially by O. Hertwig (16). They consist typically of a bony plate ("Basalplatte" Hertwig) imbedded in the cutis, from which there issues a short, median stalk or keel, which again broadens out into the scaly plate ("blattartige Knochenlammelle", Hrtw.), which is seen through the epidermis as the true scale; this is provided on its upper surface with at least one median keel, or with a smaller or larger number parallel to the first, all according to the size of the scale; the posterior margin is more or less toothed. The basal plate is typically rhomboidal, with angles drawn out into longer or shorter points; in many cases however the regular type is changed, as the number of the points may be increased or one or two may even disappear. The scale plate also varies a good deal. The simplest scales are the small ones found on the eye and at the base of the pectoral fins or the unpaired fins; some of these small scales have preserved the original form as found in the young (see below), others present almost all possible transitions to the complicated scale which Hertwig figures (16, Pl. I, figs. 15, 16). The largest scales of the type represented in the figure cited are found on the sides of the trunk. Immediately above the ventral plates the larger scales are oblong, with basal plates which are likewise oblong but with the margins between the anterior and posterior angles provided with more or fewer teeth. Still longer and narrower scales, but of a fairly regular, rhomboidal shape and with quite regular rhomboidal basal plate are found above and in front of the eyes; those on the snout are even longer, almost linear in form, with likewise linear basal plates, more than 3 mm. long.

We find the original form of the scale in the young fishes. The Copenhagen Museum possesses a number of the developmental stages of *Centriscus*, which have been described and partly figured by Lütken (24 b); most of them are referred by him to *C. gracilis*, which differs but little, in the dermal structures not at all, from *scolopax*; some also belong to this species. In the youngest specimens, ca. 7—9 mm. (cf. Lütken (24 b), Pl. I, fig. 6), both the scales and the armour are very distinct. All the scales show the same form; they consist of the future basal plate, which is rhomboid with the angles drawn out into fine points; on their antero-posterior diagonal there is a thin, vertical keel or comb which terminates posteriorly as an oblique, hooked and compressed point. The scales are large in proportion to the size of the fish and give it a spiny appearance.

The components of the dorsal and ventral armour are quite of similar type; apart from their larger size they only differ from the other scales in that a comb rises from each half transverse diagonal and is connected with the vertical comb; this transverse comb can also be detected on some of the other scales, e. g. near to the ventral plates; it is also found on many of the small scales in the adult. It is thus quite clear that the large plates in the dorsal and ventral armour are simply greatly enlarged scales. The plates in the dorsal armour are not yet connected by sutures and those of the ventral armour do not yet overlap. As development proceeds, the basal plates gradually become very large in proportion to their comb, and in the adult the latter merely appears as part of the sculpture. The sculpture is indeed somewhat different on the elements of the dorsal and ventral armour, but in both it is easy to trace the common ground-plan found in the young.

The case is quite different with the other scales; in most of these the comb on the scale of the young fish develops the scale plate, described above, with its ridges on the upper side, its marginal teeth etc. The basal plate and the scale plate may grow equally, or the one or the other may develop more strongly. In order to follow the different stages in the transformation from the original common type in the young to the different forms in the adult, it is not necessary to examine a number of young stages of different age and size; in the adult itself a comparison of a series of the smallest and the small scales with the larger and more complicated gives a correct picture of the process of development.

It appears from the above, that HERTWIG was wrong in his view, that the large bony structures of the skin in *Centriscus* arose from fusion of the smaller[10].

The endoskeleton.

Vertebral column (Pl. II, fig. 2 and text-fig. 24). This consists of 24 vertebræ, of which I refer 9 to the abdominal and 15 to the caudal region. The first 5 vertebræ are elongated and much stouter than the others, especially the first 4; further, they are immovable owing to the manner in which their arches are connected and because their spinous processes are bound to the greatly enlarged, anterior interspinous bones, as also from their connection with the dorsal armour; it is only between the head and the 1st vertebra that there can be some movement, in the direction up and down. Two fairly large lateral processes (*a*) from the anterior end of the 1st vertebra are placed in deep, transverse grooves in the exoccipital (cf. fig. 24); they seem at first glance to be transverse processes, serially homologous with those on the following vertebræ; on closer examination however it seems to me that they must correspond rather to the anterior articular processes on these; their position on the anterior end of the vertebra and their connection with the skull is in favour of this; to the groove on the exoccipital corresponds on each of the 5 elongated vertebræ a triangular facet posteriorly on the basal part of the arches, into which the strongly developed, anterior articulating process is firmly wedged, without permitting any movement. Thus, a true transverse process would seem to be absent on the 1st vertebra, just as in *Amphisile* and many other bony fishes. The transverse processes on the 2nd, 3rd and 4th vertebræ are very strong, with a flat extension at the base; their ends are firmly bound by tight connective tissue to three of the plates in the dorsal armour, as we have already seen above.

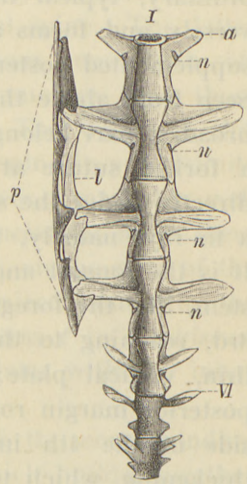

Fig. 24.
Centriscus scolopax. The 7 anterior abdominal vertebræ, seen from below; the exoskeleton removed from the left side; on the right side the lateral plates *I—VI* (*p*) are seen with their ridge *l*. *a*: articular process of first vertebra, I; *n*: openings for nerves (cfr. fig. 1, p. 46 (8)).

The spinous processes of the first to third vertebræ are greatly developed (cf. Pl. II, fig. 2), quite filling the spaces between the likewise enlarged anterior 4 interspinous bones; in the 4th vertebra only the base of the spinous process is enlarged, its upper end tapering to a slender point behind the basal part of the 4th interspinal. The 5th vertebra, the smallest of the enlarged group, has the transverse processes shorter and more slender, pointing forwards but not reaching the armour and connected only by connective tissue with the posterior end of the ridge on the third scutum; the base of the spinous process is somewhat enlarged, the remainder slender like those of the following vertebræ. In the 6th vertebra the transverse process divides distally into an inner and an outer branch; on the 7th the inner branch bends down vertically, on the 8th and 9th it meets its fellow from the other side, forming basally a narrow canal but still bifurcating distally; first in the 10th vertebra do the distal ends merge into one long inferior spine; I therefore take this vertebra as the first caudal (cf. above). The outer branch persists as an outwards directed transverse process (absorbing a smaller, posterior process which in some specimens is developed on the 6th and 7th vertebræ); gradually decreasing in length this process eventually disappears on the caudals (generally about the 8th caudal or 17th vertebra). The inferior faces of the last three abdominal vertebræ are deeply hollowed out to lodge the posterior part of the kidney. The 6th vertebra is movably articulated to the 5th, and the following as is usual in teleosts are movably connected by articular processes. The upper and lower spines of the last caudal vertebræ, behind the dorsal and anal fins, are distally flattened and somewhat enlarged. Between the penultimate upper spine and the last (containing the urostyle) an independent piece of bone is intercalated.

Ribs are wanting.

Interspinous bones (Pl. II, fig. 2). As in *Amphisile* the interspinous bones of the dorsal fin fall into two groups, an anterior consisting of 4, well-developed, with the lower ends placed in front of the spinous processes of the 1st to the 4th vertebræ, and a posterior, including the remaining interspinals, beginning behind the spinous process of the 6th vertebra; just as in *Amphisile* there are thus no interspinous bones in front of the 5th and 6th vertebræ.

In the first group the first two members have no fin-rays; the lower end of their stem or main part (i. e. the part containing the cartilaginous axis) reaches right down to the base of the spinous processes; at the tips of these the interspinous bones broaden out into a thin vertical plate (= the "dagger-blade" of an ordinary, typical interspinous bone); the upper margin of this is dilated transversely and forms a kind of narrow roof along the middle line of the dorsum, supplemented posteriorly by the corresponding part of the 3rd interspinous bone. Seen from above this roof appears broadest in the centre; the central, longest and broadest part belongs to the 2nd interspinous bone and is connected by means of a forked suture at each end with the other two members; the roof, which is directly under the skin, is covered with scales. The 3rd interspinous bone supports a fin-ray, namely, the quite small dorsal spine (*R'* in Pl. I, fig. 3 and Pl. II, fig. 2). It is the longest and stoutest interspinous bone in the whole group; its thickened stem, like the foregoing, is wedged in between two spinous processes, the 2nd and 3rd, reaching to their bases; at their upper end it likewise broadens out into a thin, vertical plate; the hindmost part of this is somewhat thicker and has its posterior margin rounded and fitted into a longitudinal furrow along the anterior side of the 4th interspinal; the upper end of the hind margin forms a small thickening, which terminates in a short, slightly hooked spine. Upwards the stem becomes thicker and immediately under the skin forms a kind of longitudinal protuberance (*l*), longitudinally grooved; the upper pointed end of the posterior plate in the upper row of the dorsal armour is firmly connected with this. The 4th interspinous bone bears the enormous dorsal spine, the 2nd fin-ray (*R*), and seems at first glance to be more like the common type of interspinous bone in bony fishes; its lower end is wedged in between the spinous processes of the 3rd and 4th vertebræ but does not go so far down as the previous. Closer examination shows the same parts as on these; the stem is here very strong, especially at the upper end; the anterior blade is here represented by a low, longitudinal ridge, with a deep furrow for the reception of the posterior edge of the 3rd interspinal; the posterior blade is low and thin (it separates the two musculi depressores for the large spine, just as the anterior blade along with the hindmost blade of no. 3 separates the M. erectores); it is only at its upper end that it becomes heavier and forms there a considerable, compressed process (*t* in fig. 2, Pl. II), the point of which is received into a deep furrow on the anterior face of the following, the 5th interspinal. On each side of the upper end of the broad and heavy stem there is a small, independent piece, oval above, triangular below, *l* in fig. 2, Pl. II. In position this corresponds well with the thickening (*l'*) on the 3rd interspinal, with which the 3rd dorsal plate is connected; but here it (*l*) is connected by suture with the interspinous bone; the sutures may often be very difficult to see, but by means of cross-sections it is always possible to make sure that the piece is independent; externally it covers the base of the ray and extends forward under the skin uncovered by scales as a striped, sculptured surface (like a "ganoin" bone (cfr. Pl. I, fig. 3 *l*)), resembling the spine itself. On the inner surface towards the base of the spine it has some few, semicircular ridges, which fit into some corresponding ridges on the base of the ray. The base of the dorsal spine is forked and sits directly on the upper end of the interspinous bone; both lateral surfaces of the latter are also provided with semicircular ridges, which fit in between corresponding ridges on the inner surfaces of the fork of the dorsal spine. The latter however form much longer curves than those on the interspinous bone; both sets are very sharply cut with shining surfaces; they are more numerous than those on the small bone *l* or those on the outer side of the ray. The whole of this highly elaborate apparatus is obviously able to fix the dorsal spine in any definite position (cf. W. Sørensen 32, pp. 65—66). In all details it agrees remarkably well with the corresponding apparatus in *Amphisile strigata* and *punctulata*; as in these the elaborate articulation belongs to the 4th interspinous bone; on the sides of the articulation there are the same paired bones *l*, and the unpaired bone *t* in the *Amphisile* species quite corresponds in position with the process *t* in *Centriscus*; this is probably an independent piece originally, which fuses later with the interspinous bone.

Taken as a whole, the 4 anterior interspinous bones and the corresponding spinous processes in *Centriscus* form a vertical bony plate which builds, together with the lateral pillars or buttresses formed by the dorsal armour, a kind of tripos-stand for the support of the large dorsal spine.

Of the interspinous bones of the second group the first (no. 5) lies behind the point of the 6th spinous process, the following 5 (nos. 6—10) each in front of its spinous process of the vertebræ 7—11. The distal portion of the first three (nos. 5, 6, 7) is enclosed in the membrane of the anterior dorsal fin. The first (5) bears a fin-ray, as a rule movable, the third spinous ray; but in many specimens I find that the spinous ray is fused with the interspinous bone, but so that the original articulation can easily be detected. The front surface of this interspinous bone has a deep longitudinal furrow in which the point of the process *t* of the 4th interspinal is placed.

The two following interspinous bones (6 and 7) are always, so far as I have seen, fused with their spinous rays 4 and 5; the next two interspinals (8 and 9) protrude through the skin as short, slightly irregularly shaped, shining points; these also represent, very probably, rudimentary spinous rays (but may possibly also be only modified scales?). The 10th interspinous bone usually has a very small spine movably articulated to it (Pl. II, fig. 2, *r'*); it is the first ray in the second dorsal fin. I sometimes find however that this also is fused with the interspinal. All the interspinous bones hitherto mentioned belong to the type denoted by Bridge (4) as "unisegmented", as is the rule indeed for interspinous bones which bear spinous rays. All the succeeding interspinous bones, as also those of the anal fin, are "bisegmented"; there is, namely, at their distal cartilaginous ends an independent cartilage with an osseous centre; this segment is embraced by the basal part of the ray. The rays are composed of two lateral halves, articulated but not branched. These interspinous bones show nothing of special interest; they are formed like ordinary interspinous bones and are for the most part grouped in pairs between two spinous processes (some variation in this regard occurs in different specimens).

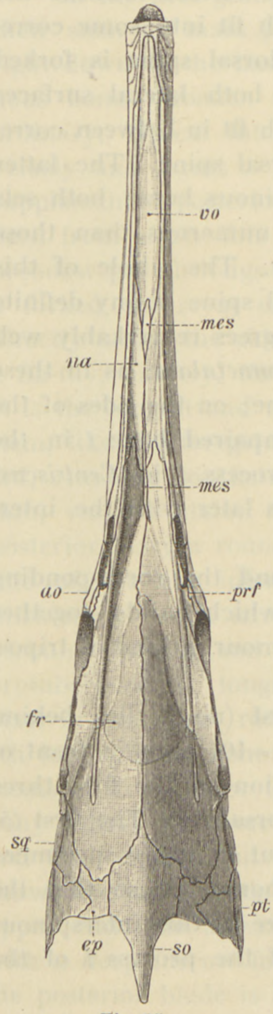

Fig. 25.
Centriscus scolopax. Skull, seen from above. *so*: supraoccipital; *ep*: epiotic; *pt*: posttemporal; *sq*: pterotic; *fr*: frontal; *prf*: prefrontal; *ao*: antorbital; *mes*: mesethmoid; *na*: nasal; *vo*: vomer.

The same holds good for the interspinous bones of the anal fin; the first of these is the largest and is placed behind the long hæmal spine of the first caudal vertebra[11].

The most frequent number of rays I find to be the following: D_2: 12; C: n + 4 + 5 + n'; A: 19—20. (n often = 6, n' often = 8). It is remarkable that the long rays in the caudal fin agree with the number and grouping of those in *Amphisile*; they are articulated as in that genus, whilst the shortest of the small marginal rays are unarticulated.

Cranial skeleton (Pl. II, fig. 2 and text-figs. 25—29). The head has a similar appearance to that of *Amphisile* but is less compressed and the lower margin of the preoperculum is not developed to a thin, transparent plate. Regarding the skull from above (fig. 25) more of the separate bones can be seen than was the case in *Amphisile,* as the posterior part of the skull especially is here less compressed: namely: supraoccipital (*so*), epiotic (*ep*) (posttemporal or suprascapular *pt*), pterotic (squamosum) (*sq*), frontals (*fr*), a quite small part of the postfrontals and prefrontals (*prf*), mesethmoid (*mes*) as also the vomer (*vo*); in addition, the nasals (*na*) and preorbitals (*ao*). As in *Amphisile* the parietals and opisthotics are wanting. In front the supraoccipital meets the frontals, between which it sends in a fairly long process; posteriorly it runs out into a fairly large process, which as in *Amphisile* is connected by a ligament with the first interspinous bone. The frontals do not reach so far forward at their anterior ends as in *Amphisile.* The mesethmoid (as in the figure) may appear between the frontals and the nasals with a quite small part, then be covered by the latter, appearing again as a short, slightly broader piece between the nasals and behind the vomer. The posttemporal bears laterally a sharp, prominent edge which is continued on to the pterotic; after a short break several sharp ridges appear again on the orbital margin of the frontals; they collect into one ridge which anteriorly runs out on the nasal towards the tip of the snout and posteriorly spreads over the broad part of the frontal. Essentially the same bones are seen from the lateral aspect of the skull (Pl. II, fig. 2); the postfrontals (*pf*) are naturally more distinct, provided with a fairly long postorbital process, which at its end (almost) meets the hyomandibular; of the prefrontals (*prf*) only quite a small part is seen between the posterior margin of the nasal opening and the orbit, bounded above by the frontals, below by the preorbitals (*ao*). The last (*ao*) overlaps it on the outer side and forms the part seen of the front and lower boundary of the orbit, reaching back to the preoperculum; in front the preorbital forms the thin bridge under the nasal opening and joins on to the nasal a little in front of this. The nasal is very long; posteriorly it forms the anterior margin of the nasal opening and somewhat further forward it projects up on to the upper side of the snout in order to meet the nasal of the opposite side in a suture, then separates again from this and follows its side of the vomer nearly to the tip of the snout.

The posterior surface of the skull (fig. 26) shows as in *Amphisile* the two exoccipitals (*eo*) meeting one another round the foramen (this has not been made very clear in the figure); though under their margins the supraoccipital also reaches to the foramen; in each exoccipital there is a deep groove (*gr*) for articulation with the articular process on the first vertebra. About half the epiotics (*ep*) are seen on this surface. The posttemporal (*pt*) forms a groove for the supraclavicle (II) at its junction with the exoccipital. The characteristic hollows on the posterior surface, present especially in *A. strigata*, are also faintly indicated here.

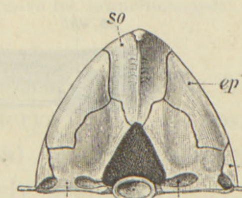

Fig. 26.
C. scolopax. Skull from behind. *so*: supraoccipital; *eo*: exoccipital; *gr*: groove for articulation of first vertebra; *ep*: epiotic; *pt*: posttemporal.

Viewed from the under surface the skull is broader than in *Amphisile* but as in this the under surface is distinctly angular anteriorly and the parasphenoid forms a similar, blunt angle under the posterior part of the orbit; it is also hollowed out ventrally in front of this in a similar manner. The pterotic is also the most prominent bone on the cranial surface in *Centriscus* and likewise separates the exoccipitals from the prootic, forming ventrally a suture with the basioccipital. The prootic forms with its front portion the lower part of the orbital wall of the cranium; here the prootics of the two sides meet in the middle line and roof over a deep canal for the eye muscles (myodoma), which is bounded laterally and below by the parasphenoid and continues posteriorly for a good distance into the basioccipital. (A basisphenoid, as given by Starks, I have not been able to find). Above the prootic the posterior wall of the orbit is formed by a small alisphenoid and a quite insignificant orbitosphenoid as well as by the postfrontal.

The vomer as in *Amphisile* is thread-like posteriorly under the middle of the parasphenoid's orbital part, then broadens out evenly and forms the roof of the long, tube-like mouth; here its margin is thickened (with a lateral furrow in the thickening) and along the margin are sutured the upper borders of the ento- and metapterygoid, and, towards the tip of the snout, the palatine.

The intermaxillary (*i*) has a weak, but distinct ascending part; as in the majority of bony fishes it forms the upper margin of the mouth and like the under jaw has no teeth. The maxillary (*mx*) is fairly broad, especially below; the mandible is composed of the usual three parts; its ascending process is also composed here of the dental (*d*) and the articular (*ar*). The angular (*ang*) is small, but distinct and as elsewhere in connection with the front end of the interoperculum (*io*) by means of a short ligament. A slight indication of the prominent hook on the dental in *Amphisile* can also often be detected here.

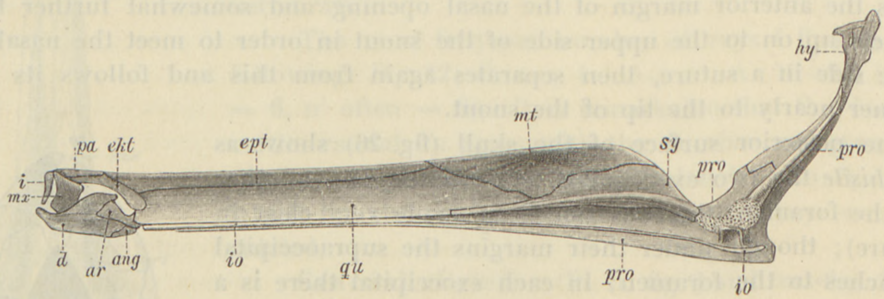

Fig. 27.
Centriscus scolopax. Right mandibulary suspensorium, seen from within. Letters as in fig. 13 and 14 (p. 61 (23)).

Of the parts of the suspensorium (fig. 27) the hyomandibular (*hy*) is long and slender, directed obliquely forwards so that its lower end lies under the front part of the orbit; its upper end is as usually connected with the postfrontal and the pterotic, especially with a cartilaginous process on the latter as in *Amphisile* and also as in this obviously but little movable. The upper part of the inner margin spreads out wing-like and almost touches the prootic and the portion of the parasphenoid ascending laterally on the skull. The outer margin touches the lower end of the postfrontal. The lower end of the hyomandibular is cartilaginous and has the same position as in *Amphisile*. The symplectic (*sy*) is connected proximally by means of connective tissue with the lower cartilaginous end of the hyomandibular and by a longer ligament with the inner surface of the epihyal of the hyoid arch; above the symplectic is connected with the metapterygoid, below with the preoperculum, anteriorly with the quadrate; the symplectic sends on to the inner side of the posterior, lowest point of the last a long, thin process which contains a permanent cartilaginous axis. The quadrate (*qu*) is exceedingly elongated, a half-cylinder, outwardly convex, with almost parallel upper and lower margins;

the preoperculum is attached to the lower margin almost to the mandibular articulation; from this on the outer side a longitudinal ridge runs almost the whole length of the quadrate parallel to its lower edge and immediately above the margin of the preoperculum. The short anterior margin, above the articulation for the under jaw, is attached at its upper part to the small ectopterygoid (*ekt*). Connected with the posterior margin of the latter lies the long, thin and narrow entopterygoid (*ept*), almost completely covered externally by the upper margin of the quadrate; as in *Amphisile* the upper margin of the entopterygoid is connected with the vomer in under the projecting margin of the nasal; posteriorly the entopterygoid joins on to the anterior end of the metapterygoid (*mt*), the upper end of which continues the attachment to the beak by means of a connection with the lower, outer margin of the mesethmoid. The last is ossified to a much greater extent in *Centriscus* than in *Amphisile*.

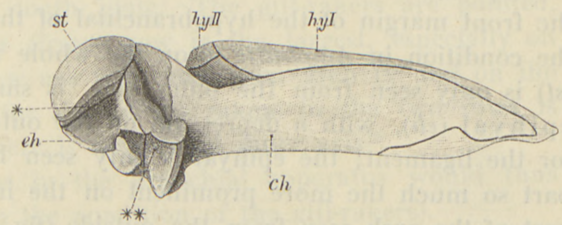

Fig. 28.
C. scolopax. Right hyoid arch, from the outer side. *st*: stylohyal; *eh*: epihyal; *ch*: ceratohyal; *hyI*, *hyII*: hypohyals; * groove for ligament; ** groove for branchiostegals.

The palatine (*pa*) is narrow and slender, connected anteriorly with the front end of the vomer and also with the ectopterygoid and entopterygoid; at its posterior end it touches the anterior point of the nasal; the normal process which projects forward over the upper jaw is very distinct and relatively prominent.

The preoperculum along its narrow ascending portion covers the outer side of the hyomandibular from the articulating cup for the operculum; under the eye its anterior margin spreads out somewhat and passes over into the horizontal part; this is on the whole fairly narrow and very long; a toothed ridge along the ascending portion is continued at a blunt angle along the horizontal portion.

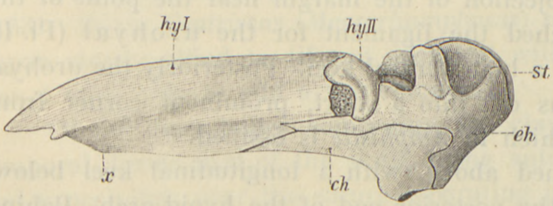

Fig. 29.
C. scolopax. Right hyoid arch, from the inner side. Letters as in fig. 28. At *x* is fixed the ligament for urohyal.

All 3 bones of the gill-cover are present; the operculum — as already mentioned — has a toothed ridge, which sends out a short branch backwards at the projection near the articulation with the hyomandibular. The interoperculum (*io*, fig. 27) is long and thin, its posterior end broadened out slightly to a small plate on the inner side of the suboperculum; it also extends along the inner side of the preoperculum and quadrate, reaching distally to the end of the latter at the mandibular joint.

Of the lateral line canals one is very distinct, arising in the frontal over the posterior margin of the orbit and continuing above the nasal openings right to the front end of the nasal; further, a quite short canal pierces the anterior end of the prominent lateral ridge on the pterotic; one seems to pass through the postfrontal. There is also a canal in the preoperculum in under the above-mentioned ridge; this is continued as is usual on to the mandible. On the other hand, there is no canal on the antorbital nor on any of the other cranial bones, and I have not been able to find a lateral line on any part of the body.

The hyoid arch (fig. 28 and 29) consists of the typical number of bones; as in *Amphisile* it is short and extends posteriorly here also only as far as almost to the front margin of the hypobranchial of the first gill-arch; the resemblance with the condition in *Amphisile* is on the whole very great; here also the stylohyal (*sl*) is only seen from the outer side, is small, rounded and articulated into the epihyal (*eh*), with a depression on the outer side, supplemented by the epihyal, for the ligament; the epihyal is only seen but little from this side, but forms a part so much the more prominent on the inner side (fig. 29). By far the greater part of the arch seen from the outside (fig. 28) is composed of the ceratohyal (*ch*), which in contrast to *Amphisile* here overlaps most of the hypohyal I, and a small part of the hypohyal II (*hy II*) is here seen from the outer side. The branchiostegal rays are also fastened here in a deep groove (**) formed by the epi- and ceratohyal and overhung above by a prominent ridge. Viewing the hyoid arch from the inner side (fig. 29) the stylohyal is seen to be covered by the large epihyal, which here appears as the second largest piece, whilst the hypohyal I is by far the largest; the hypohyal II has a similar size as in *Amphisile*, as also the ceratohyal. Both genera are thus remarkable for the great development of the lower hypohyal and the great shortening of the stylohyal. The branchiostegals are 4 in number, the first short and much thinner than the others, the last the longest and broadest. In a projection of the margin near the point of the lower hypohyal (at x, fig. 29) is attached the ligament for the urohyal (Pl. II, fig. 2, *u*), which is of good size and has a high ventral keel. Posteriorly the urohyal becomes broader and on each side runs out into a short, prominent corner from which springs the muscular tendon, which in *Amphisile* is ossified.

The glossohyal is long, flattened above, with a longitudinal keel below, and extends backward a little behind the posterior end of the hyoid arch. Behind this comes a long basibranchial, which extends to the hind end of the hypobranchial on arch II; then comes a short and thin basibranchial lying between the hypobranchials of arch III which are arched somewhat over it; as in *Amphisile* there is no basibranchial for arch IV, the two sides of which meet in the middle line, but immediately behind there is here also a small cartilage.

The whole region of the gill-arches is less elongated than in *Amphisile*, the part lying above the gullet especially is shortened, and more like the condition in most of the bony fishes. The upper three pharyngobranchials II—IV bear teeth, but corresponding to the relatively much shorter skeletal structure than in *Amphisile* the tooth-plate is placed transversely, pear-shaped in circumference, with the broad end towards the middle line; the posterior as in *Amphisile* is the smallest; the pharyngobranchial I is present as in *Amphisile* but does not seem to be ossified here; the lower pharyngobranchial V has an oval tooth plate on the upper surface. For the rest, all the essential features are quite the same as in *Amphisile*; epibranchial I broad (with stronger process than in A.), epibranchials II and III short and heavy, epibranchial IV narrower and more slender, epibranchials III and IV connected by processes etc. Gill-rakers are present here on all the arches, 2 rows on each with exception naturally of V, which has only the outer row, as in *Amphisile*, above the tooth plate. The gill-rakers are pointed, triangular with ossified axis; the outer (front) row is the largest, especially on arch I where the rakers of the inner row are very small; on arch IV and on the ceratobranchial of III the difference in the size of the rakers in the two rows is not great. In each branchial lamella there is an ossified inner axis[12].

In tabular form the main features in the branchial apparatus would thus be the same as in *Amphisile* (apart from the condition of the gill-rakers).

Gill-arch	Basibranchials	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.	Gill-rakers 1st row	Gill-rakers 2nd row
I	+	+	+	+	(+)	+	+
II	+	+	+	+	+	+	+
III		+	+	+	+	+	+
IV	(+)		+	+	+	+	+
V			+			+	

The pectoral girdle has been very accurately described by STARKS (30 p. 631—32) in *Centriscus* (*Macrorhamphosus*) *sagifue* Jordan & Starks, a species from Japan closely allied to (if not identical with?) *C. scolopax* L. To Starks' description I have only to add a few remarks.

Of the three bones composing the clavicular arch the uppermost, the posttemporal, forms part of the skull, being suturally united with the epiotic, pterotic and exoccipital; near the suture separating it from the latter, on the posterior face of the skull, it carries a fossa, in which the next member, the supraclavicle, is firmly fixed by dense connective tissue. The supraclavicle has one face forwards, looking into the gill chamber, another narrower looking sidewards; the latter carries the sculptured ridge, mentioned above, the thickened upper edge of which forms a continuation of the ridge on the posttemporal and pterotic. The upper part of the clavicula forms a broad plate bordered below by an arched sculptured ridge (Pl. II, fig. 2 *cl*) seen through the skin; compared with *Amphisile* the first part corresponds to the lighter shaded part, the latter to *cl* of Pl. II, fig. 1. While in *Amphisile* the first part is on the outer face wholly concealed by the dorsal armour and with its upper margin only touches the tip of the transverse process on the second vertebra, it is in *Centriscus* only partially covered by the cuirass and with its upper margin firmly fastened to the end of the corresponding transverse process, this besides being lodged in a flat pit on the inner face, as already mentioned.

As to the scapular part I need only remark that the front end of the coracoid (hypocoracoid Starks) remains unossified as in *Amphisile*, and that the foramen of the scapula (hypercoracoid Starks) is enclosed by this bone alone, as in *Amphisile*.

Of the 4 basalia the lowest as in *Amphisile* is very large and here also takes part in the boundary of an opening *o*, which however is more fissure-like[13].

The number of fin-rays in the pectorals I find to be most frequently 15, with in addition as in *Amphisile* a rudimentary ray on the upper border; this is however somewhat more developed than in *Amphisile*. As in the latter the rays decrease in size towards the lower edge of the fin; they are all articulated and unbranched.

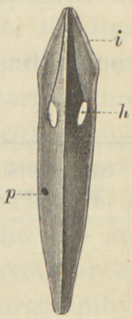

Fig. 30.
Centr. scolopax. Pubic arch from above. *i*: crista superior; *h*: foramen for the tendons of the upper muscles of the fin-rays; *p*: horizontal process.

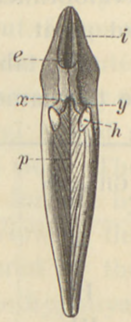

Fig. 31.
Centr. scolopax. Pubic arch from below. Letters as in fig. 30. *x*: opening for the tendons of the ventral muscles of the fin-rays; *y*: articulation for the fin-rays.

Pubic arch (figs. 30, 31). The characteristics of the pubic arch are: (1) that its main part, i. e. that which corresponds to the arch in other bony fishes, is directed obliquely upwards and forwards (Pl. II, fig. 2, *i*), parallel with the lower end of the postclavicle which lies immediately to the outside; in most other bony fishes the pubic bones lie more horizontally in the abdominal wall; (2) that a long horizontal process proceeds from the posterior end of the main part, longer than the pubic arch itself (Pl. II, fig. 2, *p*); this process along with its fellow forms the roof of a groove into which the ventral fins can be folded.

If we compare this with the pubic arch in such spinous-rayed fishes as *Sebastes*, *Labrax*, *Trigla*, *Cottus* etc. it is easy to see that the essential features of the arch in them are repeated in the anterior erect portion in *Centriscus*; it is exclusively on this portion that the muscles of the ventral fin rays are attached. The thin, very prominent, lateral projection *i* corresponds to what Winther (35) has called Crista superior in *Trigla*, *Cottus* etc.; the process *e* projecting ventrally, which bends inwards posteriorly and becomes suturally connected in the middle line with its fellow of the opposite side is Winther's crista inferior. The arrangement of the muscles is in agreement with this (so far as I have been able to determine from my badly preserved material); the dorsal muscles for the fin-rays (i. e. Adductores and Abductores superiores, Winther, minus the Abductor for the outermost ray) take up the space between the median suture of the pubic arch and the crista superior *i* and pass through the hole *h* to the base of the fin-rays; the lateral muscle (Abductor superior Wthr. for the outermost ray, the spinous ray) occupies the space between the two cristæ *i* and *e*; and finally the ventral muscles (Adductores and Abductores inferiores Wthr.) occupy the space between the pubic arch and the cristæ inferiores *e* of the two sides, so that they pass out to the fin-rays through the opening *x* in fig. 31. The long horizontal process *p* corresponds to the one which projects from the corresponding position in the above-mentioned spinous-rayed fishes, short in *Sebastes* and the Cottoids, long in *Trigla*, and here also lies in the musculature of the abdominal wall; but in *Centriscus* it has obtained a much more considerable size in comparison with the true pubic bones, corresponding to the new function of covering the ventral fins; in addition to this, the crista superior has become connected with it and contributes to its formation, thus producing the hollow *h*. The articulating surface for the rays of the ventral fin lies in front of this hollow, at *y* in fig. 31.

Compared with *Amphisile*, it is evident, that the pubic arch in the latter corresponds to the main portion of the arch in *Centriscus*, the process *p* not being developed at all. In both genera the arch is directed upwards in a similar manner, but the much greater compression of the abdomen in *Amphisile* has influenced the pubic arch to a much greater extent both with regard to form and position[14].

The number of rays in the ventral fins is 5; the outermost ray is a perfectly typical spinous ray, shorter than the others and without the covering of rows of dermal teeth (scales), which are characteristic of the remaining rays, especially on the proximal part; the spinous ray may be pressed close up against the considerably longer 2nd ray and is thus easily overlooked. The other four rays are double, articulated and dichotomously branched. The ventral fins are situated quite close together but do not seem to be fused[15].

Remaining anatomical features.

Musculature. The stiffness of the anterior portion of the trunk also has a certain influence in *Centriscus*. Of the dorsal part of the lateral muscles of the trunk the portion lying under the dorsal armour, along the elongated, immovable vertebræ, shows some amount of transformation, recalling that in *Amphisile*. The whole of this has in fact become one mass, in which the segmentation can only be seen with difficulty; towards the back part only can the myomeres be seen. In front this muscular mass is firmly attached to the postoccipital surface of the skull, especially above by means of strong tendinous ends to the ridge along the side of the supraoccipital; the lower margin further back is strongly tendinous and the tendons run back to become attached to the transverse processes of the movable abdominal vertebræ. The remaining part of the dorso-lateral musculature is segmented as usual, likewise the ventral portion on the tail and the sides of the body; but a part of the latter is extremely thin and becomes weaker and thinner forwards; all musculature is lacking on a triangular area between the broad upper portion of the clavicle, at the base of the postclavicle, and the weak intermuscular ligament which springs from the transverse process of the 4th vertebra; the area in question is partly covered over by the portion of the dorsal armour which lies below the ridge and corresponds to the non-muscular area in *Amphisile* through which the swim-bladder can be seen. The musculature of the 2nd dorsal fin, the caudal fin and the anal fin shows nothing remarkable; as in *Amphisile* the muscles are large which move the two rays of the caudal fin towards one another, which are situated on the boundary respectively of the upper and lower hypural bones. With regard to the first dorsal, the muscles for the first spinous ray, on the 3rd interspinous bone, are weak; of those to the 2nd, the large dorsal spine on the 4th interspinal, the anterior, M. erector, is very powerful; its muscular mass fills the whole of the space between the interspinous bones 3 and 4; it is pennate with a distinct tendinous strip in the middle, which increasing in thickness is continued into a tendon attached in front of the base of the ray. The posterior, M. depressor, is much weaker and lies practically hidden under the projecting lateral ridge of the interspinous bone. Very weak muscles are present round the 3 following interspinous bones, but they have no tendon for the spinous rays, which with exception of the first are immovably fixed to the interspinous bones. I have not been able to find any muscular fibres round the posterior interspinous bones for the 1st dorsal fin.

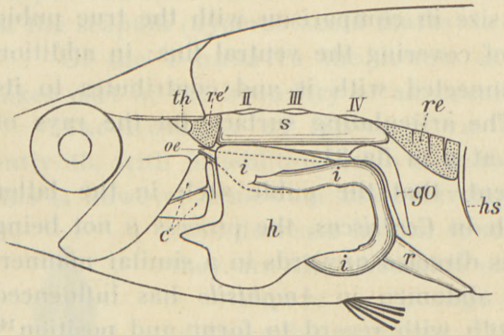

Fig. 32.
C. scolopax. Viscera seen from the left side. *II—IV*: transverse processes of 2nd—4th vertebra; *hs*: hæmal spine; *oe*: oesophagus; *i*: intestine; *r*: rectum; *h*: liver; *c*: heart; *th*: thymus; *re'*: head-kidney; *re*: kidney; *s*: swim-bladder; *go*: ovary.

There are 4 complete gills on each side and a large pseudobranch with numerous well-developed laminæ. As in *Amphisile* there is a slit between the hindmost, gill-bearing arch and the lower pharyngeals, surrounded by short gill-rakers. The first part of the alimentary canal (*oe*, fig. 32) is tubelike and provided internally with high and numerous longitudinal folds, just as in *Amphisile*; but in contrast to the latter, the oesophageal part is short; it passes over with abrupt cessation of the longitudinal folds into the succeeding, considerably wider, thin-walled portion (*i*), which is clothed inwardly with much weaker folds arranged in a net-work; this continues posteriorly, decreasing slightly and quite evenly in diameter. The biliary duct (*bd*) opens as in *Amphisile* into the ventral side of the first part of this section of the canal, but at a fairly con-

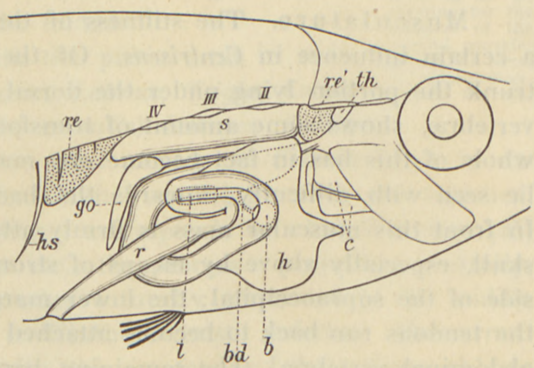

Fig. 33.
C. scolopax. Viscera from right side. *b*: gall-bladder; *bd*: bile-duct; *l*: spleen. Other letters as in fig. 32.

siderable distance from the termination of the tube-like oesophagus; in some specimens there is outwardly a slight constriction immediately in front of the place where the biliary duct enters, which might seem to be the natural boundary for the stomach; internally, however, no boundary can be seen, so that this constriction is probably quite accidental, produced by the contents of the intestine. A true pyloric constriction is likewise just as little developed here as in *Amphisile*, and even if the part corresponding to the stomach is somewhat larger in *Centriscus* yet it may be said that a true stomach is not developed here either. There is no trace of appendices pyloricæ. The abdominal cavity is relatively shorter than in *Amphisile*, and this is probably the reason for some small difference from the latter form in regard to the position of the remaining part of the canal. Seen from the left side (fig. 32) the position of the intestines is quite similar; thus the small intestine runs backwards in the abdominal cavity, bends over in a sling towards the right side and runs forwards almost as far as the entrance of the biliary duct; here it bends upwards and again runs backwards a short distance, again turns forwards in a sling round the spleen (*l*) then bends round again and runs almost straight backwards to end at a distinct boundary in the rectum which is here fairly long. Seen from the right side (fig. 33) the windings of the gut differ a good deal seemingly from the condition in *Amphisile*; more closely seen, however, the difference is small; if the whole sling embracing the spleen is turned forwards, we have exactly the same condition as in *Amphisile*.

The contents of the intestine in 2 specimens I examined consisted of large masses of Mysidæ, in a 3rd of Cumaceæ, Copepoda and small Annelids.

The liver (*h*) has two main portions, a large left part divided into a larger, lower and a smaller, upper lobe, and a small, undivided right part. The gall-bladder (*b*) lies on the concave surface facing backwards where the right part joins on to the common part connecting the lobes.

In contrast to the condition in *Amphisile* the liver lies quite close behind the heart (*c*) and the hepatic vein is thus exceedingly short.

The heart (*c*) is also far removed from the ventral margin here and lies obliquely with the bulb pointing forward and downward. The aorta lies on the right side of the elongated vertebræ; it is accompanied by 2 cardinal veins, of which the right is by far the larger. The large arteries to the pectoral fins are given off from the aorta close behind the junction of the aortic roots, and the A. coeliaca arises a little in front ventrally and somewhat to the right; the A. coeliaca runs on the right side of the oesophagus and also further just as in *Amphisile*; here also a branch is given off to the under side of the swim-bladder, destined for the "rete mirabile".

The venous system is in the main just as in *Amphisile*; but as already mentioned the trunk for the vena hepatica is extremely short, in fact is not present; it can be seen, however, that the branches from the lobes of the liver meet in a common opening in the sinus venosus; quite close to this on the sinus venosus we find the opening of the two large veins from the pectoral fins, which in *Amphisile* ran into the large trunk of the V. hepatica.

The swim-bladder (*s*) extends from over the oesophagus to over the anterior end of the genital organs; it is provided with a very similar horseshoe-shaped "rete mirabile" to that found in *Amphisile*, asymmetrical as in that form with the right horn a little shorter than the left.

The kidneys (*re*) are fused together posteriorly to a fairly large, triangular, compressed mass, which is bounded behind by the long, hæmal spine of the first caudal vertebra; it is penetrated by the short, hæmal spines on the last two abdominal vertebræ; anteriorly, dorsally to the swim-bladder, it divides into two thinner tracts along each of the cardinal veins, broadening somewhat in the interspaces between the transverse processes of the elongated vertebræ; above the anterior end of the swim-bladder it widens out on each side into a considerable "head-kidney" (*re'*), which even extends forward beyond the trunk under the skull; it is pierced by the nerves for the pectoral fins. The narrow part of the kidney lying under the spinal column here contains canaliculi; these are wanting however in the front portion, so far as I have seen. A urinary bladder seems also to be wanting here.

Genital organs. The ovaries (*go*) are only confluent in the posterior half, the first half being free; the common oviduct lies as usual dorsally to the rectum. The ovarial lamellæ are placed transversely. From the anterior end of the ovary a large vein runs along the free margin of the mesoarium to the Ductus Cuvieri.

I have not seen the testes; the 4 specimens dissected by me were all females[16].

Notes.

Amphisile.

[1]; p. 51 (13):

The exoskeleton in *Amphisile* has been mentioned, it need hardly be said, in all descriptions of the species right from the earliest; hitherto, however, all the statements regarding it have kept to what could be seen directly from the outside of the fish and even the most complete descriptions contain errors. Whilst the dorsal armour could hardly escape attention, the ventral armour with its much thinner and weaker parts has often been quite overlooked or — not least in recent years — quite misunderstood. Linné (23a, p. 336) brought together in concise form the essential points known in his time regarding this genus; for the genus *Centriscus* (= *Amphisile*(*n*) Klein) he names only the dorsal armour: "Corpus dorso loricatum", for the species *C. scutatus* likewise: "Singularis piscis loricatus testa ossea longitudinali postice in spinam terminata, sub qua cauda". This is repeated in Ed. XII (23b, p. 415) (where however the diagnosis of the genus is altered owing to the inclusion of the species *C. scolopax*). In GMELIN's edition of the Systema Naturæ, Ed. XIII (23c, p. 1460) the ventral plates are also mentioned: "Dorsum scutis glaberrimis, auratis, arctissime inter se conjunctis tectum, posterius longa cuspide armatum; abdomen scutis 10—12, in margine inferiori membrana tenui laxius ambinatis". LACÉPÈDE (22, p. 114 et seq.) in his detailed description compares *Amphisile* with a turtle, especially with "la tortue luth", which is said to lack the ventral shield. It is stated however, p. 118: "Chaque côté du corps est garni de dix ou onze pièces écailleuses, minces, et placées transversalement. Elles sont relevées dans leur milieu par une arête horizontale; et la suite de toutes les arêtes qui aboutissent l'une à l'autre, forme une ligne latérale assez saillante. Ces lames sont un peu arrondies dans leur partie inférieure, et réunies avec les lames du côté opposé par une portion membraneuse, très-mince, qui fait paraître le dessous du corps très-carené". This description shows on the one hand, that Lacépède has noticed the plates of the ventral armour, but on the other hand that he has quite misunderstood these; he obviously unites them with the part of the dorsal armour which lies ventral to the connection with the spinal column; only in this way can he make them divided at the continuous horizontal ridge, which is obviously due to the lower margin of the dorsal armour. CUVIER (7a, p. 269) states: "Le dos est cuirassé de larges pièces écailleuses, dont l'épine antérieure de la première dorsale a l'air d'être une continuation (he thus considers the dorsal spine as a spinous ray). Les uns ont mêmes d'autres pièces écailleuses sur les flancs". In the 2nd edition of CUVIER's "Leçons d'Anat. comp." (7b) the following is added (by LAURILLARD), after some remarks on the spinal column, Vol. I, p. 229: "Les apophyses transverses semblent manquer; mais peut-être la cuirasse qui recouvre le corps de ces poissons et que l'on a prise jusqu'à présent pour un composé d'écailles, est elle formée par ces apophyses, comme la carapace des tortues l'est par les côtes et les apophyses épineuses des vertèbres".

AGASSIZ (1b, p. 274) gives a short description of the genus *Amphisile*, most probably made from *A. strigata*, as he mentions that the dorsal spine "se termine par un rayon articulé". The description is correct in all essentials — except that AGASSIZ like most other authors considers the bones in the first dorsal fin simply as rays. The ventral armour is not mentioned the first time (1a, Vol. I, p. 90) when he characterises the dermal plates in *Amphisile* in the following manner: "Les Amphysiles ont de véritables écussons ganoidiques, c'est-à-dire recouverts d'une couche d'émail, au-dessous de laquelle des canaux médullaires rayonnent en avant et en arrière. Ces écussons sont engrénés les uns avec les autres par des bords sciés en peignes". In the later description cited, Vol. IV, AGASSIZ seems however to have become aware of the ventral armour, as he says: "Des plaques très-comprimées, plus nombreuses que celles du dos, forment, tout le long du ventre, une quille tranchante qui est embrassée, dans sa partie antérieure, par deux lames tranchantes appartenant au préopercule". "Tout le long des côtés, on remarque un espace étroit qui n'est point recouvert par les plaques écailleuses". But as he states (ibid., p. 275—276), in the special description of the skeleton in *A. scutata*: "Des arceaux cornés, semblables aux pièces sternales du hareng, ceignent les cavités abdominale et interpectorale, et tiennent lieu de côtes, qui manquent complètement", AGASSIZ cannot have been quite clear as to the ventral armour. HECKEL (15 pp. 223 and 225) calls them "Kielrippen (côtes sternales Agass.)" and believes that similar formations are lacking in *Centriscus*. The same view of parts of the ventral armour as replacing ribs appears again, though in more definite form, in GÜNTHER; the latter has perhaps taken the idea from AGASSIZ, and from LACÉPÈDE or CUVIER (LAURILLARD) the comparison with the turtle, which has had a very unfortunate influence on his and more recent views of the exoskeleton in this fish. His views of this and of its relation to the inner skeleton are summed up by GÜNTHER both in the Catalogue (14a, p. 527) and in the "Introduction" (14b, p. 510) in the following sentences: "*Amphisile* may be considered as a Chelonian form among fishes", a conclusion found throughout a series of misinterpretations. Apart from these, which I shall point out directly, and from various other, less correct data which will be dealt with later, Günther has described this form in a more detailed manner than most of the other authors, not excepting Agassiz, and on many points Günther's account is good and correct so far as it goes. The dorsal cuirass is described (p. 526) correctly in all essentials; that G. counts 6 plates in the lower row (the lateral) has arisen from the fact that he has not recognised the supraclavicle as such but takes it to be a plate of the cuirass. On the other hand, he has rightly recognised the part of the clavicle as such (*cl* in my fig. 1, Pl. I) and keeps it distinct from the true dorsal armour. It may be specially mentioned that G. was the first who suspected the true nature of the dorsal spine, as he says: "The long moveable (should be immoveable!) spine in which the cuirass terminates is evidently an interneural, since, in the second species, the first spine of the dorsal fin is joined to it". It is only the dorsal cuirass that G. regards as true armour; this is shown already in his diagnosis of the genus (p. 524) where it is only stated: "Body — provided with a dorsal cuirass which is formed by portions of the skeleton"; and later under the description of *A. scutata* (p. 525) it is said: "The whole head and back are cuirassed with smooth bony plates, whilst the abdomen is covered with a very tough skin", and in more detail on p. 526: "The inferior half of the side of the trunk is covered by a transparent tough covering, which passes into a broad cutting fringe inferiorly; this fringe extends the whole length of the abdomen, and the whole covering is supported by the coracoid and by seven or eight ribs". G. has thus in the first place not noticed the boundaries of the plates from one another and in the second quite misunderstood their structure; his coracoid and the 7 or 8 ribs are in fact merely the rachides on the lateral plates (the "coracoid" is the rachis on the 5th plate; see later). This misinterpretation is in complete agreement with the whole of Günther's incorrect views on the morphology of the dorsal armour, expressed (l. c., p. 527*) in the following words: "I am of opinion that the dorsal cuirass is not a dermal production, but formed by modified parts of the endoskeleton; its composition, the number and position of its single parts, and, finally, the first dorsal spine, which in *A. punctulata* is so singularly attached to it, favour this opinion. The plates which occupy the vertebral line would correspond to the neural spines, and the lateral plates on which the ribs are suspended, to the parapophyses. *Amphisile* may be considered as a Chelonian form among fishes". It appears quite extraordinary, that the position of the musculature in under the supposed spinous processes, covered by these (which may be seen indeed without preparation) and a "coracoid" (i. e. postclavicle) in front of the pectorals etc., did not raise some doubt in Günther's mind as to the correctness of such an interpretation; it is obviously the Chelonian idea which has controlled and confused the account.

In a notice by Steindachner (31) of about the same time we find the following remark: "Bleeker und andere Ichthyologen unterscheiden in der Beschreibung von *Amphisile* nur Bauch- und Rückenschilde, während doch Bauch-, Seiten- und Rückenschilder vorhanden sind, welche durch wahre Naht mit einander verbunden sind". No further explanation is given, but S.'s "Seitenschilder" must be the lower row of plates in the dorsal cuirass, just as with Hilgendorf. Lütken (24a) speaks of sutures between the ventral plates of this and that number, but at the same time of the number of "ribs" occurring in the different species, from which we may suppose that he agrees with Günther's views. The only protest against this that I have found anywhere occurs in Hilgendorf (17, p. 54) in the following words: "Die Bauchplatten und deren knöcherne Verstärkungslisten können nicht, wie dies wohl geschehen, mit Rippen in Verbindung gebracht werden, dazu ist ihre Zahl schon zu gross, während die knöchernen Seitenplatten in der Zahl mit den Wirbeln correspondiren und auch, mit Ausnahme der letzten, mit ihnen in continuirlicher Verbindung stehen". This protest seems to

* The same is repeated in the "Introduction" (14b) practically in the same words.

have been quite overlooked hitherto; even in 1903 we find in Jordan and Starks (20, p. 71) under the family diagnosis for *Amphisile*: "Ribs developed", and under the description of *A. strigata*: "There are 11 lower ventral plates (ribs), 2 in front of the pectoral and 9 behind". And the supposed identity of the dorsal cuirass with inner skeletal parts — against which however Hilgendorf does not protest — is found again both in 1902 and 1903 in Starks (30, p. 625; where the presence of ribs is also mentioned) and in Jordan and Starks (l. c. p. 70).

²; p. 58 (20):

Information on the inner skeleton is scarce in the earlier literature. Apart from Starks' investigations on the pectoral girdle and his few remarks on some of the bones of the skull (given below, see note 3 p. 96 (58)) we have information, based on personal investigations, from Cuvier (7b), Agassiz (1b, p. 275), Günther (14a, p. 527), Heckel (15, p. 223) and Hilgendorf (17). In the addition inserted by Laurillard in Cuvier's "Leçons" (2nd edition, Vol. I, p. 229), it is stated that the first 5 vertebræ are elongated without transverse processes and that the spinous processes are greatly inclined backwards, so much so that the dorsal fin projects out over the tail; the number of vertebræ is stated to be 15—16 in all. Both Agassiz and Günther give the correct number of vertebræ, 20, but whereas A. counts 8 to the abdominal and 12 to the caudal vertebræ, G. gives respectively 6 and 14. The information on the part of the spinal column lying outside the cuirass is — so far as it goes — in the main correct, most complete in Agassiz; on the other hand, the statements regarding the part enclosed within the cuirass are very imperfect. Both have seen that the first 6 vertebræ are much elongated, but we get no information regarding the connection with the armour, the relation of the interspinous bones etc. Agassiz has clearly not been able to distinguish between the spinous processes and the interspinous bones in this region, as he only mentions the interspinous bones which lie behind the dorsal spine; his words are:

"Les corps des six premières [vertèbres] sont tellement allongées, qu'ils forment à eux seuls toute la portion de la colonne qui est recouverte par la carapace. Leurs apophyses épineuses sont filiformes et démesurément longues, surtout les antérieures, qui se prolongent jusqu'à l'extrémité du tronc, ou plutôt jusque sous la grosse épine qui termine la carapace, en avant de l'insertion des osselets interapophysaires qui portent les rayons épineux ou la partie antérieure de la dorsale. Les deux dernières vertèbres abdominales sont courtes, semblables à celles de la portion caudale; celles-ci, au nombre de douze, ne forment pas, dans leur ensemble, un espace de la colonne qui égale en longueur plus du quart de celui qui est formé par les six vertèbres abdominales antérieures. C'est entre les deux dernières vertèbres abdominales, et en arrière de la première caudale, que se fixent les trois osselets interapophysaires qui portent les trois rayons épineux de la première dorsale; mais la longue pointe qui est au devant d'eux est produite par le prolongement de l'extrémité postérieure de la carapace, au bout de laquelle est articulé un rayon épineux". It is very probable that A. made his observations on a dried, shrivelled specimen, in which case it is impossible to see the details in question; perhaps the same and only specimen in the Paris Museum, concerning which Brühl (5b, p. 51) writes: ".... ein kaum ein halb Millim. breiter, vertrockneter, häutiger, derber Streifen .... ist der ganze Rest der Wirbelsäule, an dem Nichts zu erörtern möglich". That Günther cannot have seen anything of the spinous processes and interspinous bones in the region in question is quite obvious, otherwise his view of the dorsal cuirass would have been altered at once; he states: "These (six) abdominal vertebræ are extremely slender, the third alone being nearly as long as the whole caudal portion; they have a slight ridge superiorly and inferiorly and on each side; the whole portion lies in the uppermost concavity of the dorsal cuirass".

Heckel (15, p. 225) only says that in the fossil *A. heinrichi* the 6 anterior vertebræ lying under the dorsal cuirass are elongated, especially the first 4; and the figures only show their corpora preserved. After examination of recent *Amphisile* H. (l. c., p. 223) stated that all the rays in the first dorsal fin lacked interspinous bones, "sie verlängern sich nach unten zu und schieben sich unmittelbar selbst zwischen die Dornfortsätze der Wirbel ein, können sich daher ohne Articulation auch nicht nieder legen". The observation is indeed correct, but not the interpretation. He has so little knowledge of the skeletal parts lying under the dorsal cuirass and connected with this, that on comparing them with *Centriscus* he says: "An *Amphisile* dagegen fehlt der starke Rückenflossenstrahl sammt den Trägern und dem stützenden Gerüste; seine Stelle vertritt, sonderbar genug, ein analoger runder Dorn, der unmittelbar an der Spitze des letzten wagrechten, über das darunter abwärts gebogene Schwanzende hinaus verlängerten Rückenschildes ansitzt und daher n i c h t dem Skelete, sondern vielmehr der hornartigen Hautbedeckung angehört, durch welche beinahe der ganze Fisch wie in einer glatten halb durchsichtigen Scheide eingeschlossen ist". HILGENDORF says nothing about the spinal column, but his views regarding the dorsal spine are more correct than any previous; and he has seen — without knowing HECKEL's observations — that the "spinous rays" behind the dorsal spine had no articulation. His remarks (l. c., p. 54) are *in extenso*: "Morphologisch besteht der Stachel zwar, wie GÜNTHER angiebt, aus einem Flossenstrahlenträger, auf dem eben der (bei *punctulata* bewegliche) Stachel aufsitzt. Aber daneben ist wohl auch noch eine Bekleidung durch eine Hautplatte anzunehmen, und vielleicht ist selbst noch ein zweiter Strahlenträger in ihm enthalten; darauf deutet wenigstens die complicirte Querschnittsfigur, auch sieht man am Skelet zwei Knochenstäbchen sich nach vorn gegen die Rückenwirbel hinabziehen. An den drei zwischen der ersten und zweiten Dorsalis gelegenen Stacheln sehe ich keine Andeutung eines Gelenkes und es ist schwer zu sagen, ob sie nur den Flossenträgern oder diesen u n d den damit verwachsenen Strahlen gleichwerthig sind".

To complete the list of authors I may add that P. GERVAIS (11, p. 529) in mentioning the fossil *A. heinrichi* Hckl. gives a very poor text-figure (fig. 50) of the skeleton of a recent "*Amphisyle* de la mer des Indes". The note says: "La figure d'*Amphisyle* que nous donnons ici sous le no 50 est celle de l'*Amphisyle velitaris*, actuellement vivant dans la mer des Indes, dont M. Agassiz a déjà signalé les principales particularités ostéologiques. La plus curieuse de celles qu'elle présente est sans contredit le grand allongement des cinq premières vertèbres, qui dépassent considérablement ce que l'on voit chez les Centrines (sic!) et chez les autres poissons de la famille des Bouches en flûtes. On a enlevé sur l'individu ici représenté une partie des téguments du côté droit de manière à laisser voir la colonne vertébrale dont les premières vertèbres ont en effet une longueur insolite".

[3]; p. 63 (25):

Regarding the skeleton of the head the literature contains practically nothing; the most complete account is that given by AGASSIZ (l. c., p. 276), but this is altogether vague and contains various inaccuracies. Several authors naturally have noticed the large preoperculum with its thin plate covering the anterior ventral plates; but regarding the mandibular suspensorium, the composition of the long, tube-like snout etc. there is virtually nothing. Most recently STARKS (30, pp. 625, 633) has stated rightly that the parietal and opisthotic bones were lacking, that the posttemporal was attached to the skull and that the basioccipital (condylus) was concave (in contrast to *Fistularia* and *Aulostomum*). On the other hand, his view that a myodome was wanting may be disputed and his statement "pterotics normally placed" is incorrect, as also that a V-shaped process of the epiotic can be seen on the lateral aspect of the skull.

Some of STARKS' statements are repeated in JORDAN and STARKS (20, p. 71).

Concerning the bones of the gill-cover AGASSIZ (1 b, p. 276) wrongly states that: "l'opercule et le sous-opercule forment à eux seuls la partie mobile de l'appareil operculaire"; and GÜNTHER's statement (13a, p. 526) that "the pre- and interoperculum are united into one bone" is just as little correct.

Concerning the mandible we find in the diagnosis of the *Hemibranchii* by SMITH WOODWARD (36, p. 369): "Mandible simple, each ramus consisting only of two elements (dentary and articulo-angular)". This is however incorrect; there is an independent angular in all the forms which S. W. includes under *Hemibranchii*.

[4]; p. 66 (28):

COPE is — so far as I know — the only author who has given any information on the branchial apparatus in *Amphisile* (6, p. 457). After first characterising the group *Hemibranchii* in the following manner (l. c., p. 456): "Superior branchihyals and pharyngeals reduced in number (which as mentioned on p. 42 (4) is incorrect), inferiors separated", he states regarding *Amphisile*: "Fourth superior branchihyal (i. e. epibranchial IV) and all the superior pharyngeals wanting". That all these statements are likewise incorrect appears from the description and figures given by me here. GILL (1a, p. 156 and 164) repeats COPE's words regarding the branchial apparatus and STARKS in his diagnosis of the *Hemibranchii* (30, p. 623) again gives COPE's incorrect statements as follows: "superior pharyngeals and usually elements of branchial arches reduced in number" and p. 625 for the family "*Centriscoidea*" i. e. *Amphisile*: "branchial system feebly developed".

Concerning the gill-rakers in *A. punctulata* KNER (21a, p. 534) states: "Die Rechenzähne des ersten Bogens sind relativ starke nach vor- und einwärts gekrümmte Hakenzähne, die der folgenden Bögen stellen niedere Höckerreihen vor".

Regarding the hyoid I find the following in AGASSIZ (1b, p. 276): "Les cornes latérales de l'os hyoïde sont aussi démesurément longues". I am not sure what he means by this; perhaps the long ossified tendons which spring from the urohyal?

The number of the branchiostegal rays, which are often used by systematists, especially when they can be easily observed, is given as follows: AGASSIZ (l. c., p. 276) 5, PETERS (l. c., p. 335) 4; STEINDACHNER (l. c., p. 766) 3 (4?); GÜNTHER (l. c., p. 526) 3. KNER (21a, p. 534) states on the other hand that he has not been able to find any trace of branchiostegals (in *A. punctulata*)!

[5]; p. 67 (29):

STARKS cites no earlier account of the pectoral girdle than GÜNTHER's comparison of the external characters in *Amphisile punctulata* (not *A. strigata*, as STARKS says) with those in *A. scutata*, the latter of which is quite ignored by STARKS. Nor is there much to be found in the older literature; I know only the following. In AGASSIZ (1b, p. 276): "Les pectorales.... sont portées par la saillie postérieure du humérus (i. e.: clavicle), auxquels s'attachent les cubitus (i. e.: coracoid) qui se réunissent en avant, comme les apophyses antérieures des deux humérus le font sous la gorge. L'osselet styloïde (i. e.: postclavicle) est derrière l'insertion des pectorales". GÜNTHER (14a, p. 526; *A. scutata*) states: "The humerus (i. e.: clavicle) also contributes to the bony covering of the body; a long horizontal portion of it extends from the operculum to the base of the pectoral fin; it fits into the shallow notch of the dorsal cuirass mentioned, and is of a lanceolate shape, tapering into a point posteriorly". From the subsequent sentences, which describe the ventral armour (cf. citation above, p. 94 (56)), and the account of *A. punctulata* on p. 528, it is seen that G. has taken the rachis in the 5th ventral plate to be the "coracoid", i. e. the postclavicle, although this can often be seen lying deeper in through the abdominal wall.

HILGENDORF (17, p. 54), who rightly denies that the ventral plates have anything to do with ribs, is only partly right however in the following: "Auch die Ausdrücke Humerus und Coracoid, die man zur Bezeichnung der äusseren, zwischen Kiemenöffnung und Brustflosse sichtbaren Theile angewandt hat, sind morphologisch nicht zu rechtfertigen; es handelt sich hier um reine Hautbildungen; die wirklichen Knochen liegen unter der Haut verborgen an der Brustflossenbasis". Regarding the "true skeletal parts" he says nothing.

[6]; p. 69 (30):

Regarding the pubic arch I have not been able to find anything in the literature beyond GÜNTHER's statement (14a, p. 527), that "a rudimentary pubic bone is visible within the fringe".

[7]; p. 69 (30):

It has long been known that the ventral fins are united in *Amphisile*. LINNÉ in Ed. X, p. 336, states "Pinna ventralis unica"; LACÉPÈDE calls them "réunies". On the other hand, AGASSIZ (1c, p. 274) says: "celles des deux côtés du corps sont tellement rapprochées qu'on les croirait confondues, si un examen attentif ne permettait de reconnaître leur parité". Later, KNER again maintained their fusion (21a, p. 535), as also STEINDACHNER (31, p. 765). The sexual difference in the ventral fins, long in the males, short in the females, was observed by KNER (l. c.) in *A. strigata* (not *scutata*, as GÜNTHER believes), and it has been mentioned later by others, that some specimens of this species have long, others short ventral fins (e. g. by JORDAN and STARKS; 20 p. 72). When the number of rays is given differently and (with exception of LACÉPÈDE and AGASSIZ) as a rule too low, this is probably due to the spinous ray being overlooked. The only one who expressly mentions this is AGASSIZ (l. c., p. 276), who rightly says: "un premier, petit épineux, à peine perceptible à la loupe, suivi de cinq rayons simples articulés, successivement plus grands". His statement concerns probably *A. strigata* (cf. supra), but he calls his species *A. scutata*. There is indeed on the whole a certain amount of confusion in the use of the specific names. LINNÉ gives the number of rays as 6 (i. e. 3, as he only counted one fin); LACÉPÉDE: 5 (possibly *A. strigata*, as he speaks about the dorsal spine being divided longitudinally into an upper and a lower part); GÜNTHER: 3 (*A. scutata*), 4 for the other two species; PETERS: 4 (*A. punctulata*); KNER: 4 (*A. punctulata* and *strigata* *); STEINDACHNER: 4 (*A. scutata* (=*macrophthalma* Stdchr.) and *strigata* (= *scutata* Stdchr.)).

Whilst the number of rays given by the different authors for the pectoral fins in recent species agrees with that found by me (or may vary by 1 more or fewer), HECKEL (15, p. 225) gives only 2 for the fossil *A. heinrichi*, "die im Gegensatz zu den völlig ungetheilten Strahlen der *Amphisyle scutata* gespalten und so lang sind als die halbe Mundröhre vom Auge angefangen"; and SAUVAGE also states (28, p. 402): "La pectorale n'est composée que de deux rayons aussi longs que la moitié de la hauteur du corps à ce niveau". There is no doubt, however, from the figures of both authors, that what they have taken as the 2 rays of the pectoral are the postclavicles of the two sides! Of the true pectorals there is no trace in their figures.

[8]; p. 73 (35):

Concerning the anatomy of the soft parts I have only found the following, in GÜNTHER (14a, p. 525) under the diagnosis of the genus: "Pyloric appendages none", and on p. 527, after remarks on the appearance of the swim-bladder (seen from outside): "The oesophagus passes gradually into the stomach, which is situated below the air-bladder; it does not appear to be much wider than the intestine following; the latter makes a single complete circumvolution and then proceeds to the vent. Ovaria and testicles are situated behind the air-bladder". What GÜNTHER considers the stomach is thus the anterior portion of the small intestine.

* What KNER in the male of this species ("*scutata*" Kner) calls "ein Paar sehr kurzer Stützstrahlen, die neben einander stehen" must be the spinous rays.

°; p. 77 (39):

Concerning the armoured portions of the exoskeleton I find the following information in earlier literature.

Cuvier (7a, p. 268): "Dans les Centrisques proprement dits. La dorsale antérieure situé fort en arrière, a sa première épine, longue et forte, supportée par un appareil qui tient à l'épaule et à la tête. Ils sont couverts de petites écailles, et ont de plus quelques plaques larges et dentelées sur l'appareil dont nous venons de parler".

The dorsal cuirass of *Centriscus* is figured by Rosenthal (27, Plate X, fig. 11), but very imperfectly. The explanation of the figure (l. c., p. 37) states sub II. Rumpf. C. "Die Gürtelknochen (i. e. the clavicular arch) bestehn aus zwei Stücken, von denen das obere sehr klein ist. Sie erhalten durch die Verbindung mit dem Rückenschilde (my dorsal cuirass) *z.*, welcher den ersten starken Rückenstachel aufnimmt, eine vorzügliche Festigkeit". Nothing is said about the connection with vertebræ; all that is noted about the vertebræ is that "die vier ersten sich durch einen verlängerten Körper auszeichnen".

L. Agassiz (1a, Vol. IV, p. 272) in describing the skeleton of *C. scolopax* only mentions the cuirass as "la plaque osseuse qui va de l'humérus au premier rayon de la dorsale".

Kner (21b, p. 258) comparing *Centriscus* with *Zeus*, says: "Die Lage des Seitencanales bezeichnen 3—4 grosse, schief stehende Schilder, ähnlich denen der Carangen, die am hinteren Rande fein gezähnelt und längs der Mitte gekielt sind. Dieser Kiel setzt sich über der Kiemenspalte vorne bis zum Auge fort, verschwindet aber nach rückwärts. Beiderseits des Bauchkieles liegen vom Isthmus an ebenfalls drei längliche, schwach gekielte Schilder, mit erhobener, centraler Spitze und radiär auslaufenden Furchen. Hinter den Bauchflossent welche in der durch den jederseits vorstehenden Bauchkiel gebildeten Furche eingesenk, liegen, folgen bis zum Anus noch zwei mediane gekielte Schilder mit gezähneltem Rande".

Günther (14a, p. 520): "Several bony strips are visible on the side of the back: one arises from the side of the nape and proceeds towards the first dorsal spine, where it meets its fellow of the other side. Another strip commences from the scapulary region and represents a sort of lateral line; it is composed of three bones, each bone having a horizontal and an oblique portion, which cross each other. The margins of the thorax and of the abdomen are covered with several bony plates which have a cutting longitudinal ridge along the middle". Later (ibid. p. 521) describing the vertebral column, G. says: "The bony strips, which are visible externally,.... are the modified ribs with their epipleurals". Of the real mode of connection with the vertebræ G. has no clear apprehension. In his "Introduction (p. 509) G. in characterizing the genus only says: „... some bony strips on the side of the back, and on the margin of the thorax and abdomen; the former in one species are confluent and form a shield". The species alluded to is of course *C. humerosus*.

O. Hertwig (16, p. 105—108) in describing the dermal structures of *Centriscus* only mentions the plates of the cuirass in the following way (p. 107): "Dagegen haben sich in der Seitenlinie von der Scapularregion an drei umfangreichere Knochenplatten entwickelt, die mit vorspringenden Blättern und Stacheln in grösserer Zahl bedeckt sind. Knochenplatten mit ähnlichen Rauhigkeiten sind am Bauchkiel und am Kopf nachweisbar". In his concluding remarks ("Vergleichung", p. 108) he states: "Die umfangreicheren Knochenstücke am Kopf, in der Seitenlinie und am Bauch erklären sich aus stattgehabter Verschmelzung ursprünglicher discreter Ossificationen, worauf die zahlreichen Vorsprünge, die als Leisten, Kämme oder Stacheln verschieden modificirt sind, hinweisen". That this view is erroneous is shown by an examination of quite young stages (cf. p. 77 (39)).

W. Sørensen (32, p. 64) in his description of the anterior vertebræ says: ".... the large processus transversi of the 2nd to the 4th vertebræ are connected by dense connective tissue with some keeled scales, which are considerably larger and especially longer than the rest of the dermal covering"; adding in a foot-note that he has not devoted any further attention to these scales.

Jordan and Evermann (19, p. 758): "Some bony strips on the side of the back and on the margin of the thorax and abdomen, the former sometimes confluent into a shield". Quite the same is said by Jordan and Starks (20, p. 68 and 69).

Goode and Bean (13, p. 483) characterize the family Macrorhamphosidæ as: "Hemibranchiates with compressed body, armed with bony plates on belly and anterior parts of body".

[10]; p. 78 (40):

L. Agassiz (1 a, Vol. 1, p. 90) was the first to recognize the peculiarities of the scales. As his description seems to have been totally overlooked by all later authors, I quote it here *in extenso*: "Les Bécasses de mer (Centriscus) ont un type d'écailles tout particulier. Ce sont de petites esquilles lisses, cachées dans la peau, surmontées d'une tige cylindrique et courte qui s'étale de nouveau à la surface de la peau en un écusson de forme trapézoide. Cet écusson montre plusieurs carènes qui rayonnent en arrière et qui se terminent par des pointes assez effilées".

Later Kner (21 b, p. 258 (27)) pointed out the main feature of the scale, viz. that it is composed of a basal part ("Wurzeln") and a scale-plate ("Flächenausbreitung der Schuppe").

O. Hertwig has given a detailed description of their form and relation to the dermal layers, including also some of the simpler forms, e. g. those of the eye, the base of the pectoral fin, and of the fin-rays. In addition, he has examined "eine zweite sehr kleine Art, den *Centriscus brevispinis*", in which he finds a much simpler type of scale; hence he concludes: "Alles macht den Eindruck, als ob das Hautskelet vom Centriscus brevispinis sich rückzubilden im Begriffe stände". According to Lütken, however, (24 b, pp. 586, 610), this "species" is a young stage of *C. gracilis* Lowe*; Hertwig's description therefore, and his figure (Pl. 1, fig. 26) do not concern stages of reduction but stages of development of the scales, such as will be found also in the other species of the genus.

L. Vaillant (33 a, p. 126 and 33 b, p. 338) describes the scales anew and gives one figure (Pl. XXVII, fig. 3); apparently without knowing Hertwig's much more detailed description. The plates as well as the different forms of the scales are not mentioned.

[11]; p. 82 (44):

Information regarding the inner skeleton is given by Rosenthal (27), Agassiz (1 b), Heckel (15), Brühl (5 a and b), Günther (14 a) and W. Sørensen (32); and in recent years by Starks (30) and Siebenrock (29) for the pectoral girdle and some points in the skull. Apart from Rosenthal's statement (quoted above under 9) regarding the elongation of the 4 anterior vertebræ, Agassiz (l. c., p. 272) was the first, so far as I am aware, to give any information regarding the spinal column and the interspinous bones. He states that there are 9 abdominal and 14 caudal vertebræ. He further says, regarding the anterior vertebræ:

"Les cinq premières vertèbres abdominales sont remarquables en ce que leur corps est très-allongé, saillant en forme de double cône dans la cavité abdominale, et que les deuxième troisième et quatrième ont de très-grosses et larges apophyses transverses qui s'étendent horizontalement jusqu'à la plaque osseuse qui va de l'humérus au premier rayon de la dor-

* Lütken's statement (24 b, p. 586 (178)), that young individuals of *C. gracilis* of 17 mm. and below are without ventral fins, is incorrect. I find the ventrals quite conspicuous, with the fin-rays discernible, in the smallest specimens of 7—8 mm. length. They might also perhaps be found (e. g. through suitable staining) in stages of *C. scolopax*, corresponding to those of 10 mm. length, figured by Emery (8, Pl. I, fig. 12) and said by him to lack ventrals (8, p. 12.)

sale". "Le premier épineux, de la dorsale qui est petit, et le second, qui est très-grand sont articulés sur d'immenses osselets interapophysaires, dont l'extrémité s'etend jusqu' au corps des vertèbres".

In the addition made by LAURILLARD in the 2nd edition of CUVIER's Leçons (7b, p. 228) it is only said, that the first four vertebræ have the bodies swollen at both ends, with very long and broad transverse processes, and that the extremely high, posteriorly directed spinous processes cause the dorsal fin to lie on the posterior part of the body. BRÜHL (5b, p. 51), who has only seen an imperfect specimen in the Paris Museum, probably the one that served for the notes in CUVIER and possibly for AGASSIZ, gives only 4 abdominal vertebræ with biconical bodies and large transverse processes. HECKEL (15, p. 223) noticed that the last 4 "rays" in the anterior dorsal fin extend in between the spinous processes without showing any articulation, from which he concludes that they lack interspinous bones, like the corresponding parts in *Amphisile*. The same observation with the same interpretation was made by KNER (21 b, p. 26 (257), Note 2). Regarding the large spinous ray of this fin HECKEL observed that it "sich bei einer gewissen Wendung so weit nieder legen lässt, dass er die nachfolgenden steifen gelenklosen Strahlen zum Theile unter seine rinnenförmige Aushöhlung aufnehmen kann. Ferner wird der sehr schief liegende Träger dieses Strahles, welcher sich zwischen die Dornfortsätze der vorderen mitsammen verwachsenen Wirbelkörper einschiebt, durch eine feste Membrane mit einem voranstehenden noch stärkeren Träger verbunden. Diese letztere Hauptstütze, auf welcher auch der sehr kleine erste Rückenflossenstrahl sitzt, dient zugleich dem beinahe leistenförmigen Rückenschilde als Auflage, wird aber selbst wieder an jeder Seite von zwei kräftigen Endspitzen festgehalten, welche ein, mit den drei ersten breiten Querfortsätzen verwachsenes aufrichtes Gerüste, gleich Strebepfeiler ihm entgegen sendet".

What HECKEL here calls "Rückenschild" must be the upper expanded margin of the first two interspinous bones (see fig. 2, Pl. II) and his "aufrechte Gerüste" is the dorsal armour, the structure and other relations of which he thus does not seem to have understood. The same may also be said regarding GÜNTHER, whose description (14 a, p. 521) is *in extenso* as follows:

"The vertebral column is composed of eight abdominal and sixteen caudal vertebræ; the former are distinguished by their strength and large size, a peculiarity which is in intimate connexion with the circumstance that they form the base of other strongly developed bones; their parapophyses are strong, rather long, and those of the first four vertebræ have their extremities united. The bony strips, which are visible externally, and which we have mentioned in the description of the outward characters, are modified ribs with their epipleurals. The neural spines of the three anterior vertebræ are strong, especially that of the third, which corresponds to the interneural of the second dorsal spine. This interneural is situated behind the third neural, and ends in three articular processes which receive two others of the dorsal spine between them".

By far the most complete information on the anterior part of the vertebral column is given by W. SORENSEN (32, p. 63 etc.); it is not only correct in all essentials, but likewise complete. As his paper is written in Danish and therefore not so readily accessible, I may give here a full translation of his remarks.

"The necessary support for the interspinous bone (of the large spine) is obtained in a very complicated manner. The transverse processes of the first vertebra, which are not a little shorter than those of the following vertebræ, fit into a pair of transverse depressions on the side of the foramen magnum; these depressions are formed chiefly by a prominent transverse ridge on the lateral occipitals which lies under the transverse processes of the first vertebra. Movement in the articulation formed in this manner arises for a very small part from articulating surfaces, mostly from ligamentous connective tissue. The articulation permits some movement up and down, but very little from side to side, the latter being rendered even more difficult by the stout transverse processes on the 2nd to the 4th vertebræ being bound by means of dense connective tissue with some keeled scales, which are considerably larger and especially longer than the remainder of the external covering. In this way movement between the first 4 vertebræ is also considerably reduced. The interspinous bone of the long spine is not so long and scarcely so stout as the spine itself; it is a dagger-shaped, almost rounded bone, with two grooves, in front and behind, for muscular tendons. It is well-supported at the base owing to the fact, that the part which extends up over the spinous process of the 3rd vertebra is connected with a (rayless) interspinous bone, which is provided laterally with a pair of low muscular crests in the form of a rounded ridge, the lower end of which is wedged in between the spinous processes of the 2nd and 3rd vertebræ and even reaches to the vertebral arches. A similar, but slightly weaker (rayless) interspinous bone is found between the 1st and 2nd vertebræ, and a similar, but much weaker interspinal rests against the anterior face of the spinous process of the 1st vertebra and above sends forwards a process, which is connected by means of a short and tough, ligamentous connective tissue with a similar process on the supraoccipital. The whole of this narrow bony plate formed by the rayless interspinous bones is flexible, but the single pieces are not articulated together; the interspinous bones themselves are connected by a kind of "harmonia" and their upper, thickened margins are united by a kind of suture. — In agreement with this, the connections between the first 4 vertebræ are but little movable, as their arches (and articulating surfaces) are kept in place over a fairly long distance by a kind of "harmonia". — The vertebral centra are, as is usually the case where the connections are immovable, slender and of the ordinary hour-glass shape. The interspinous bone ends above in 3 compressed elevations, one medially and one weaker on each side. The central elevation is thickened at the middle of its upper edge into a knot, which is raised somewhat and has on the sides a small pit, into which fits a protuberance or button on the inner side of the deeply cleft base of the ray. In this way is formed the articulation between the ray and interspinous bone. — On the lateral faces of the central elevation on the interspinous bone and on the inner surfaces of the deeply cleft base of the ray there are about ten circular, sharp-edged keels (fig. 16), which fit into one another and are shiny (as if polished) at the margin and on the one side: the keels of the interspinous bone on the surface directed upwards, those on the ray on the downward surface. On the outer sides of the deeply cleft base of the spine and on the inner side of the two outer elevations on the interspinous bone there are similar keels, but only a few and much weaker.

Musculature. For the long spine there are the usual 2 pairs of muscles; the M. anteriores, which are much stronger than the M. posteriores, fill the space between the interspinous bone and the rounded muscular ridge on the preceding (rayless) interspinous bone. Both pairs are provided with long tendons, which are attached somewhat high up on the ray.

In the dead fish the long spine is so fixed that it cannot be moved, neither by means of its muscles nor by the fingers without using force. After I had observed the above described, circular keels and their nature, and thus learnt that the fixing depends on the downward pressure of the ray on the interspinous bone, I was able to unfix the joint by raising the ray and at the same time giving it a circular turn, just as was the case with the earlier described Triacanthus. The ray is most probably fixed by the simultaneous action of the M. anteriores and posteriores. — The specimens were too small to determine whether the portions of connective tissue, which occur between the spine and the interspinous bone, either the front part or that at the joint, serve to undo the latter, similar to what occurs in Triacanthus; how the fish itself unlocks the joint is thus unknown".

In different recent authors, such as Cope, Jordan and Evermann, Bean and Goode, Starks, Jordan and Starks, the diagnoses state that the anterior vertebræ are elongated, but nothing is added to what has been observed by the earlier, above-named authors.

The fact alone, that ribs occur and that the anterior vertebræ are not elongated in the fossil genus *Rhamphosus* Ag. shows that this cannot be nearly related to *Centriscus.* This has been generally accepted hitherto (cf. Smith Woodward (36, p. 377)), since Blainville brought the oldest known specimen even into the genus *Centriscus* as *C. aculeatus.* Agassiz retained this alliance, but believed that there were "différences assez marquantes pour constituer un petit genre à part" (1 b, p. 271). On reading through Agassiz' description of the, at that time, only species *Rh. aculeatus*, we very soon see, however, that the resemblances to be found with *Centriscus* are on the whole quite superficial. The long dorsal spine, for example, shows quite different relations to the skeleton; it seems to be placed far forward just behind the head and is not followed by other "spines"; the snout has nothing like the characteristic tube-form with terminal mouth; the mouth lies in under a prolonged snout ("Le museau est très-saillant, en forme de rostre dépassant de beaucoup les mâchoires; celles-ci s'ouvrent peu et sont placées immédiatement au-dessous l'orbite"; p. 270); the ventral fins are large and are placed on the thorax etc. I may add to this that, according to Agassiz' figure (Pl. 32, fig. 7), the rays in the dorsal, anal and caudal fins are branched or divided; the same is the case in the species *Rh. biserratus*, later described by Bassani (2). Every trace of the ventral armour is absent and the external bony plates connected with the large, postoccipital spine have not the least resemblance to the dorsal armour in *Centriscus.*

It is stated, certainly, by Vaillant (33 a, p. 127; 33 b, p. 339) that he had found quite similar small scales in *Rh. aculeatus* to those in *Centriscus*, and — if I understand him rightly — he is not disinclined to make one genus of those two; he writes: "Il me paraît donc hors de doute que dans ce genre fossile, si tant est qu'il doive être conservé, la structure des écailles était la même que dans le genre actuellement existant".

In spite of this and though I have not had the opportunity to examine specimens of this form personally, I venture to say, that *Ramphosus* cannot be related to *Centriscus*, and indeed that it can by no means be placed anywhere within the group of families, which I have provisionally called "Hemibranchii" + "Lophobranchii" in the Introduction to this communication.

[12]; p. 87 (49):

Regarding the skeleton of the head the earlier literature gives us just as little as for *Amphisile.* Rosenthal has given the only figure known to me of the skeleton in *Centriscus*; but it is practically useless (l. c. Pl. X, fig. 11); the few statements in the explanation to the figure (pp. 36, 37) only serve to show that he has understood very little of the structure of the head. Nor do Agassiz and Günther give anything more than what is superficially quite obvious; Günther rightly remarks, however, that "The interoperculum is extremely narrow and elongate". Recently Siebenrock has figured the posterior portion of the skull in *Centriscus* and remarks that the parietals are wanting (29, p. 131); and Starks (30, p. 624) notes the same thing, as also that the opisthotic is wanting, that the articulating surface on the basioccipital is concave (in contrast to *Aulostomidæ*, as Brühl however had already remarked), that the uppermost portion of the pectoral girdle, the posttemporal, is suturally connected with the cranium, and that there is a well-developed "myodome". His statements "pterotic normal in position" and "basisphenoid small" are however incorrect.

Cope was the first, so far as known to me, to give information regarding the branchial arches in *Centriscus* (6, p. 457), namely: "Fourth superior branchihyal and first and fourth superior pharyngeals only wanting". This is however quite wrong. It is repeated nevertheless by Gill (12 a, pp. 156 and 163), Jordan and Evermann (19, p. 742) and Jordan and Starks (20, p. 68), and by Goode and Bean (13, p. 483).

Regarding the hyoid I only find the following in Günther (14a, p. 520): "the glossohyal is long, feeble, gradually lost in the membrane which forms the bottom of the ventral tube", which is only partly right.

13; p. 88 (50):

Several previous authors have endeavoured to describe the pectoral girdle in *Centriscus*; as they are not mentioned by Starks, I may give here what I have been able to find in the literature.

Geoffroy St. Hilaire (10a, Pl. 29) gives an incomplete and very imperfect figure of the shoulder girdle in *C. scolopax*. The upper broad part of the clavicle is called omoplate (*o*), the lower the clavicle (*c*); scapula + coracoid + basalia are included under one name humerus (*h*); postclavicle: furculaire (*f*). According to the note (p. 372, explanation of Plate) the form and apparent (but misunderstood) relation of the latter bone to its fellow in *Centriscus* seems to have induced the comparison with the furcula of birds. In 10b (p. 424) we find some further remarks on this bone (postclavicle) and its relation to a bone on the ventral margin, which so far as I can understand the description must be the pubic bone. Rosenthal (27; Pl. X, figs. 11 and 12, Text pp. 36 and 37) states: "Die Gürtelknochen (i. e. Clavicle) bestehn aus zwei Stücken, von denen das obere sehr klein ist.... *x*. Eine breite, unten wie ein Schiffskiel zusammenlaufende Lamelle, die diesem Fisch eigenthümlich ist (i. e. coracoid; a note adds: "Diese als ein Stück des Flossengliedes anzunehmen ist man wohl um so weniger berechtiget, da beide dem *radius* und der *ulna* entsprechenden Stücke, wie in den übrigen Fischen auch hier vorhanden sind". This means possibly the 2 bones *a* and *b* in fig. 12) *s*. Der stielförmige Beckenknochen (i. e. postclavicle), der hier mit dem Bauchflossengliede *l*. sehr fest verbunden ist". His interpretation of this bone as the pubic is further explained in the note. It is seen from the explanation to fig. 12, which represents the separated parts of the pectoral girdle, that Rosenthal has correctly seen the suprascapular "(1) das obere" and the clavicle "(2) das untere Stück der Gürtelknochen"; *a* and *b* "Stücke des Brustflossengliedes" are the scapula and the lowermost (4th) large basal.

Agassiz (1b, p. 272) makes the following remark: "Le cubitus (i. e. coracoid) est une large plaque dont le bord inférieur forme une longue carêne le long du ventre".

Brühl (5a) has copied (on Plate XII, fig. 23) Geoffroy's figure, which has not been improved on reproduction; and Brühl does not seem to have closely investigated the structure himself. The clavicle is called the "vorderes Schlüsselbein" (v. Schl.), the postclavicle the "hinteres Schl." (h. Schl.); regarding the latter we find, p. 176, *c* "bei einigen Fischen stossen sie wirklich durch Symphyse zusammen, so bei.... Centriscus"; but this does not apply to *Centriscus*, nor does the following: "Beim letzteren.... tragen die so unten verbundenen hintern Schlüsselbeine sogar die Beckenknochen". The remaining parts of the pectoral girdle are not specially mentioned, but the lettering on the figures, VA, compared with the text p. 176, 3, a, shows that they are together included under "Ober- und Vorderarmknochen", of which 1 is given as "Humerus", 2 as "Radius" without the figure showing any boundary between two bones, just as little as in Geoffroy's original.

Günther (14a, p. 521) writes: "Another peculiarity is the great breadth of the radius (i. e. the coracoid), this bone forming with its fellow a suture which is as long as the bone is high; there is an oval free space between the radius and the humerus (i. e. clavicle). The coracoid (i. e. postclavicle) is very strong, straight, sabre-shaped, extending backwards to the pubic bones, which, however, are not fixed to it and quite small".

Gegenbaur (9, p. 128) writes: "Bei Centriscus stellt das Schulterstück einen breiten Knochen dar, der durch zwei von oben nach abwärts (con) vergirende Leisten, die eine rundliche Oeffnung zwischen sich fassen, ausgezeichnet ist. Der Vorderrand des Knochens lehnt an eine Lamelle der Clavicula; am ganzen Hinterrande sitzen die Basalstücke der Brustflosse. Eine Zusammensetzung dieses Knochens aus mehreren aufzufinden, habe ich vergeblich mich bemüht".

SIEBENROCK (29), who has only investigated the nature of the connection of the pectoral girdle to the skull, includes *Centriscus* in his Group *d*, in which all 3 elements of the pectoral girdle are present; on p. 123 he states, that in this the uppermost element, suprascapular (i. e. my posttemporal), is not forked, but broad and short; p. 130 he says: "Das Suprascapulare bildet die äussere Ecke des Hinterhauptes und hat eine grubenförmige Vertiefung zu Anlenkung des Scapulare (my supraclavicle), die bei *C.* immer noch vom Pleurooccipitale (my epiotic) begrenzt wird". On Pl. V, fig. 9, he gives a figure of the posterior portion of the skull and the upper end of the pectoral arch; on p. 131, it is said, that ROSENTHAL does not seem to have known the "suprascapulare", which is attached to the skull, but only the other two elements.

[14]; p. 89 (51):

Regarding the pubic arch itself I have not found any remarks in the literature beyond the following by AGASSIZ (1 b, p. 272):

"Les nageoires ventrales n'offrent rien de particulier. Mais ce qu'il y a de remarquable, c'est que l'os du bassin auquel s'attache la petite ventrale, est fixé entre les deux osselets styloides de la ceinture thoracique; ce qui confirme pleinement l'opinion de Carus, que cet osselet doit être envisagé comme appartenant aux extrémités posterieures, dont il serait une espèce d'iléon".

[15]; p. 89 (51):

Whilst the number of rays in the ventral fins is correctly given by many authors, amongst them by LINNÉ (in the formula; but later he says: "Pinnæ ventrales binæ, 4-radiatæ"), LACÉPÈDE, GÜNTHER, it has not been noticed as a rule, that the outermost is a spinous ray; GÜNTHER even maintains the contrary, as he has in his diagnosis of the genus *Centriscus* (14 a, p. 518): "Ventrals.... composed of five soft rays" and regarding the species *C. scolopax* (p. 520) "apparently without spine". On the other hand, a number of American authors credit the ventral fins with a spinous ray, but with too many soft rays; thus GILL (12 a, p. 163): "a spine and several rays", GOODE and BEAN (13, p. 487) "one spine and seven rays", JORDAN and EVERMANN (19, p. 758) "1 spine and 5 soft rays", JORDAN and STARKS (20, p. 68) "1 spine and 4 or 5 soft rays".

[16]; p. 92 (54):

Concerning the internal organs I find in GÜNTHER (14 a, p. 518) for the genus *Centriscus*: "Air-bladder large; pyloric appendages none". With regard to the branchiæ in the family *Centriscidæ*, which with Günther also includes *Amphisile*, it is stated correctly: "four gills and pseudobranchiæ".

HYRTL includes *Centriscus* (18, p. 33) amongst the fishes, in which the right cardinal vein is obviously much larger than the left.

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EXPLANATION OF THE PLATES.

Plate I.

Fig. 1: *Amphisile scutata* (L.) Gthr. × 2.

Head. pt: posttemporal (supraclavicular I).
sq: pterotic (squamosal).
Dorsal cuirass. 1—5: upper, dorsal row of plates.
I—V: lower, lateral row. The line on which the numbers stand corresponds to the inner ridge connected with the vertebral column.
T: dorsal spine.
scl: supraclavicular (II).
cl: clavicular.
The dotted lines indicate the canals for the lateral line.
Dorsal fin. r: interspinous bones forming stays for the membrane of first dorsal fin.
Ventral cuirass. 1—14: ventral plates.
l: thickened stripe or rachis of the same.
s: separate plate between (the fifth) ventral plate and the clavicle.
**: upper boundary line of the transparent ventral keel.

Fig. 2: Posterior part of *Amphisile punctulata* Bianc. × 2.

Dorsal fin. l: lateral bony piece of dorsal spine T.
t: ventral bony piece of the same.
R: spinous ray supported by the fourth interspinous bone.
Other letters as in Fig. 1.

Fig. 3: *Centriscus scolopax* L., not fully grown specimen. × ca. 2.

The scales are omitted; only the larger scutes forming the armour, and the crests on the head are shown.

Ventral armour. 1—9: row of paired scutes.
I—VI: row of unpaired, keeled scutes.
Dorsal fin. R': first spinous ray of the foremost dorsal (absent in *Amphisile punctulata*).
r': first ray (spinous) of second dorsal (absent in *Amphisile*).
Other letters as in Figs. 1 and 2.

Plate II.

Fig. 1: *Amphisile scutata*. Skeleton. × 2.

Branchial skeleton, except the urohyal, removed; further the left mandibular suspensorium and bones of the gill-cover, and left supraclavicular (II). Of the dermal skeleton parts of the ventral scutes (the transparent keel) and of the upper row of dorsal plates as well as the dorsal spine are preserved. Through the latter are seen the cartilaginous axes of the interspinous bones 3 and 4.

Head. so: supraoccipital.
pt: posttemporal (supraclavicular I).
sq: pterotic (squamosal).
fr: frontal.
prf: prefrontal.
pf: postfrontal.
na: nasal.
ao: preorbital (antorbital).
pro: preopercular.
u: urohyal.

Trunk. 1—4: foremost group of interspinous bones.
5—7: the following interspinous bones, forming stays for first dorsal.
*: first interspinous bone of second dorsal.
I—VI: the six elongated anterior abdominal vertebræ.
a, b: anterior and posterior part of vertebral arch.

Shoulder girdle. cl: clavicle (the part covered by the cuirass is shown by the lighter shading).
sc: scapula.
co: coracoid.
pcl: postclavicle.
o: foramen.

Pubic arch. i: "pubic" bone or "pelvis".

Fig. 2: *Centriscus scolopax*. Skeleton. × ca. 2.

Head. pa: palatine.
ekt: ectopterygoid.
qu: quadratum.
mt: metapterygoid.
sy: symplectic.
hy: hyoid.

Dorsal fin and Trunk. R': first spinous ray } of first dorsal.
R: second spinous ray } of first dorsal.
r': first ray (spinous) of second dorsal.
l': lateral thickening of the upper end of third interspinous bone.
l: lateral bony piece of the upper end of fourth interspinous bone.
t: unpaired upper prolongation of the same interspinal (cfr. t figs. 2 and 3 on Plate I).
5—9: interspinous bones, coalesced with more or less reduced spinous rays, forming stays for the membrane of first dorsal.
I—V: five anterior elongated abdominal vertebræ.

Shoulder girdle. scl: supraclavicular (II).

Pubic arch. i: part of "pelvis" corresponding to i in Fig. 1.
p: posterior part of pelvis, roofing over the ventrals when pressed to the body.

Other letters as in Fig. 1.

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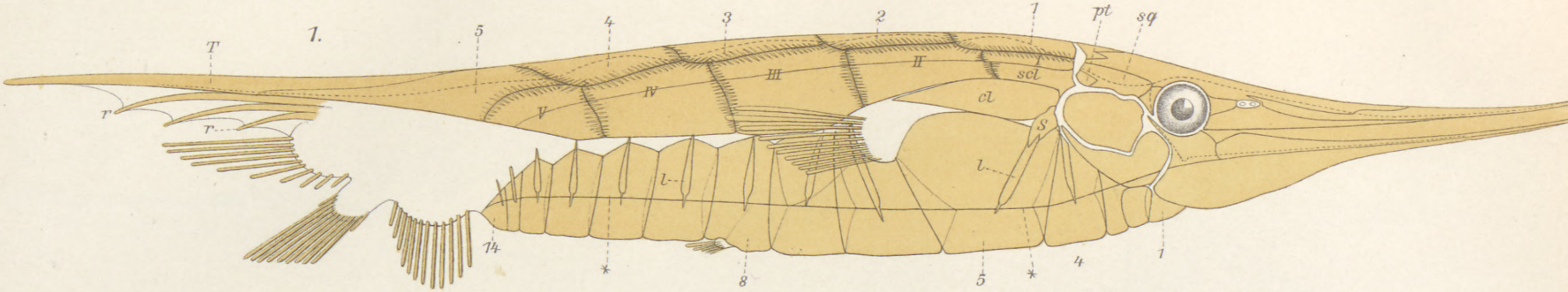

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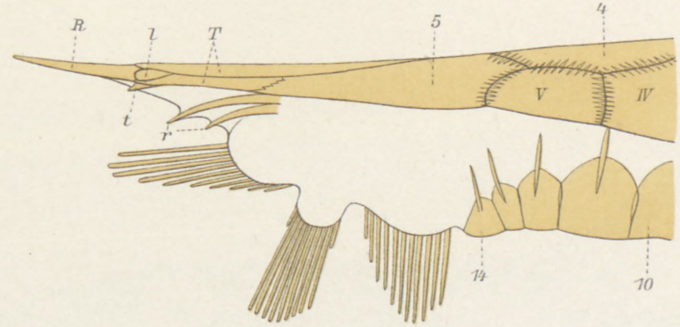

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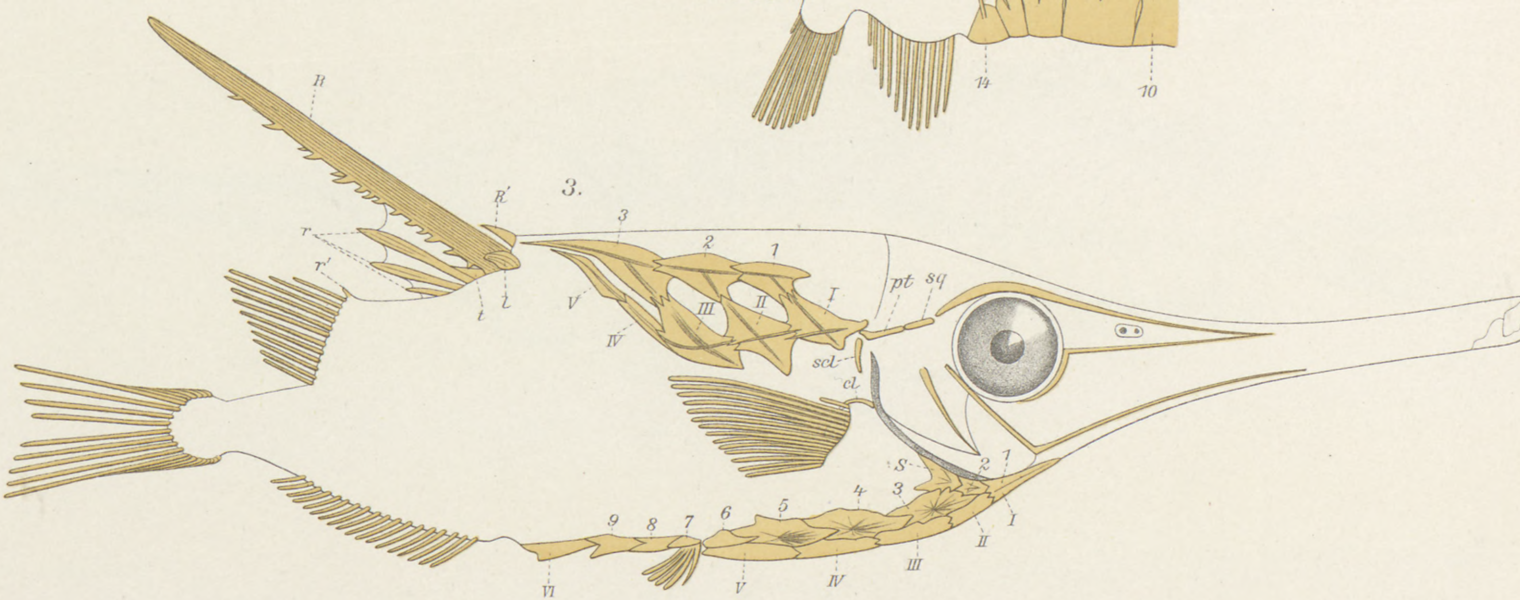

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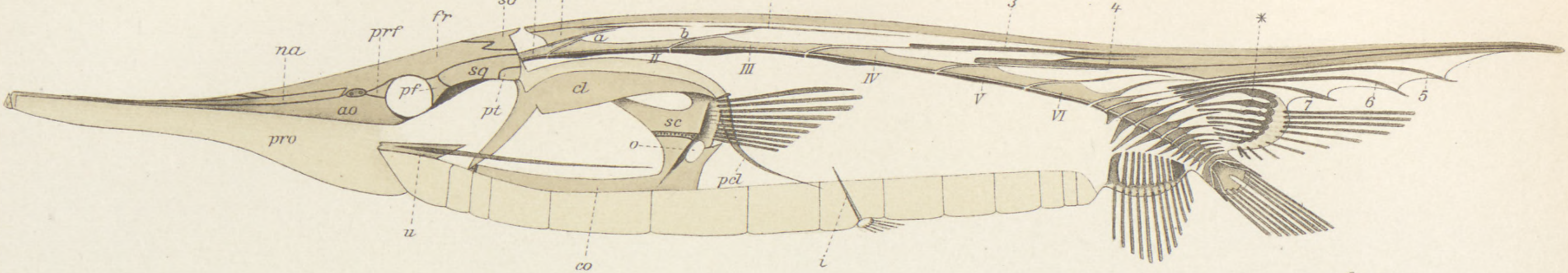

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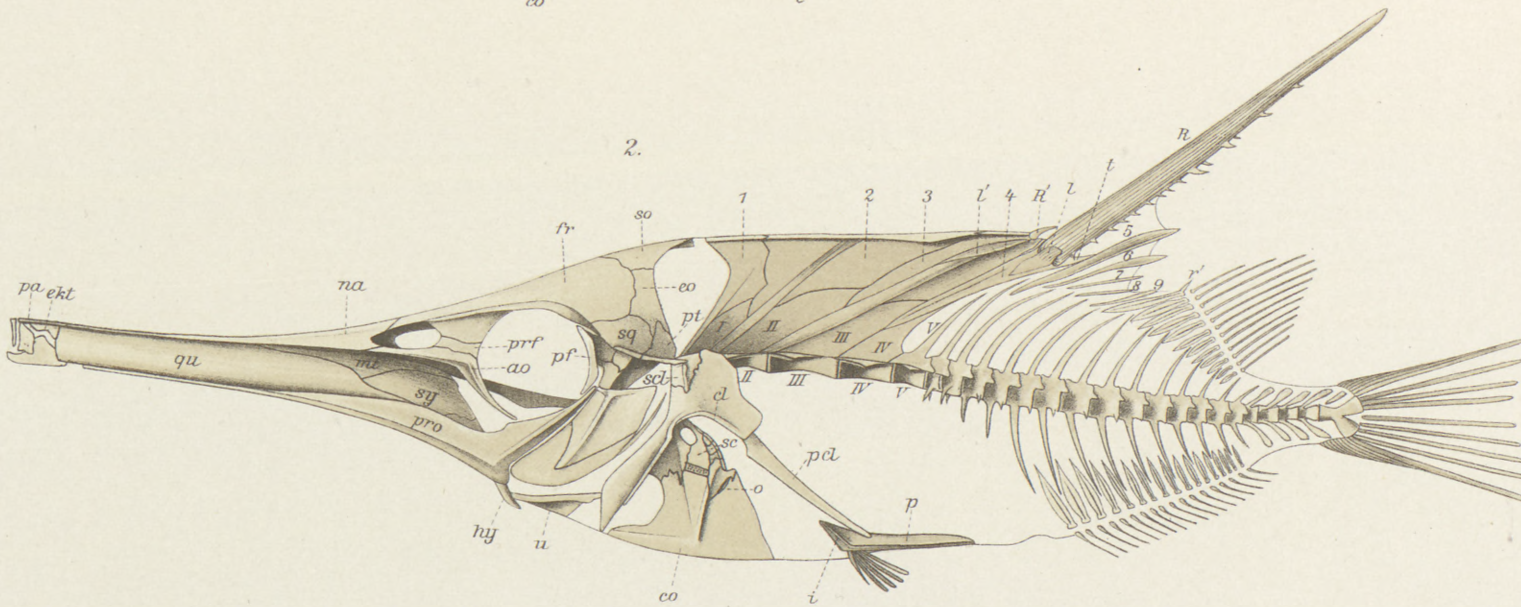

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