THE FOSSIL FISHES OF THE ENGLISH CHALK.

INTRODUCTION.

FISHES of the Cretaceous period are now known from many parts of the world. Materials are rapidly accumulating, indeed, for a tolerably complete account of the last of the Mesozoic fish-faunas. Some of the fossils, like those from the Lebanon, Dalmatia, and Westphalia, are whole fishes in a crushed state, displaying the vertebral column, fins, and scales, in undisturbed position, but showing almost nothing of the cranial osteology. Others, like those from the Chalk of England and Kansas, are usually more fragmentary, but are often little crushed, and exhibit the essential details of their osteology as well as modern skeletons. The specimens in these two conditions must therefore be carefully compared to obtain a complete knowledge of the various genera and species represented; and, as a basis for this comparison, it is necessary to prepare detailed descriptions and illustrations of each series of remains. So far as the fishes of the English Chalk are concerned, it is now proposed to attempt this preliminary work.

Fossil fishes seem to have been first noticed in the Chalk of this country by Dr. Gideon A. Mantell, who published general descriptions and figures of many specimens in his 'Fossils of the South Downs' in 1822. His collection was subsequently described with greater success by Agassiz in his 'Recherches sur les Poissons Fossiles' (1833–44). The writings of Mantell and Agassiz aroused so much interest in the south-east of England, that other collectors soon began to obtain important series of specimens, notably Dixon, Bowerbank, Willett (at that time named Catt), Coombe, Egerton, and Mrs. Smith, of Tunbridge Wells. Fine illustrations and brief notices of the Chalk fishes were then issued in Frederic Dixon's 'Geology and Fossils of Sussex' in 1850. A new edition of this work, with notes on the fossil fishes by E. T. Newton, appeared in 1878. Miscellaneous papers on certain genera were also published by Egerton, Günther, E. T. Newton, and W. Davies. More recently the present writer has made several contributions to the subject, including a preliminary "Synopsis" in the Proceedings of the Geologists' Association in 1888. Finally, there is a revised summary of all the known genera and

species from the English Chalk in the British Museum 'Catalogue of Fossil Fishes,' which was completed last year. All these writings will be referred to in due course.

The unique series of Chalk fishes collected by Mr. Henry Willett has been generously presented by him to the Brighton Museum; but all the other collections mentioned have been eventually acquired by the British Museum. To the latter are now added the fine collections made by S. H. Beckles, J. R. Capron, Frederick Harford, and S. J. Hawkins, besides smaller contributions from others. The Forbes-Young collection in the Woodwardian Museum, Cambridge, must also be specially mentioned; and the series of specimens obtained by the Right Hon. Lord Ashcombe from the Chalk near Dorking, is likewise of importance.

A large proportion of the fishes in some of these collections are unfortunately not labelled with the exact horizon and locality. The stratigraphical range of the various species and varieties, therefore, cannot yet be fixed so precisely as is desirable. The researches of Dr. Arthur W. Rowe [1] and Mr. G. E. Dibley [2] have contributed much towards our knowledge of the distribution of some forms; and the wide experience they have gained of the Chalk in the south of England enables them to determine with much probability of correctness the horizons of many specimens which lack exact labels. The writer is especially indebted to Mr. Dibley for his advice concerning the probable stratigraphical position of the fossils described from inland chalk-pits. Dr. Barrois [3] has already expressed his opinion that most of the specimens from the neighbourhood of Lewes described by Mantell and Agassiz, were obtained from the Turonian zones of *Terebratulina gracilis* and *Rhynchonella Cuvieri*.

Finally, it must be noted that in these fossil fishes the outer face of the bones and scales is often destroyed by flaking or by some solvent percolating through the chalk. Differences in the degree of external ornamentation need thus to be examined very critically with an experienced eye before they can be relied upon for the discrimination of species or races.

It is hoped that the fragmentary fossils will be rendered more easily comprehensible by the series of restored sketches in the text, which have been executed under the author's direction by Miss G. M. Woodward.

[1] A. W. Rowe, "The Zones of the White Chalk of the English Coast. Part I.—Kent and Sussex," Proc. Geol. Assoc., vol. xvi, 1900, pp. 289—368.

[2] G. E. Dibley, "Zonal Features of the Chalk Pits in the Rochester, Gravesend, and Croydon Areas," *loc. cit.*, vol. xvi, 1900, pp. 484—496.

[3] C. Barrois, "Recherches sur le terrain crétacé supérieur de l'Angleterre et de l'Irlande," Mém. Soc. Géol. Nord., vol. i, no. 1, 1876, p. 30.

SYSTEMATIC DESCRIPTIONS.

Subclass TELEOSTOMI.

Order ACTINOPTERYGII.

Suborder ACANTHOPTERYGII.

Family CARANGIDÆ.

Genus **AIPICHTHYS,** Steindachner.

Aipichthys, F. Steindachner, Sitzungsb. k. Akad. Wiss., math.-naturw. Cl., vol. xxxviii, 1859, p. 763.

Generic Characters.—Trunk much deepened, and head short and deep, with a large supraoccipital crest. Eye rather small; cleft of mouth oblique and wide, the

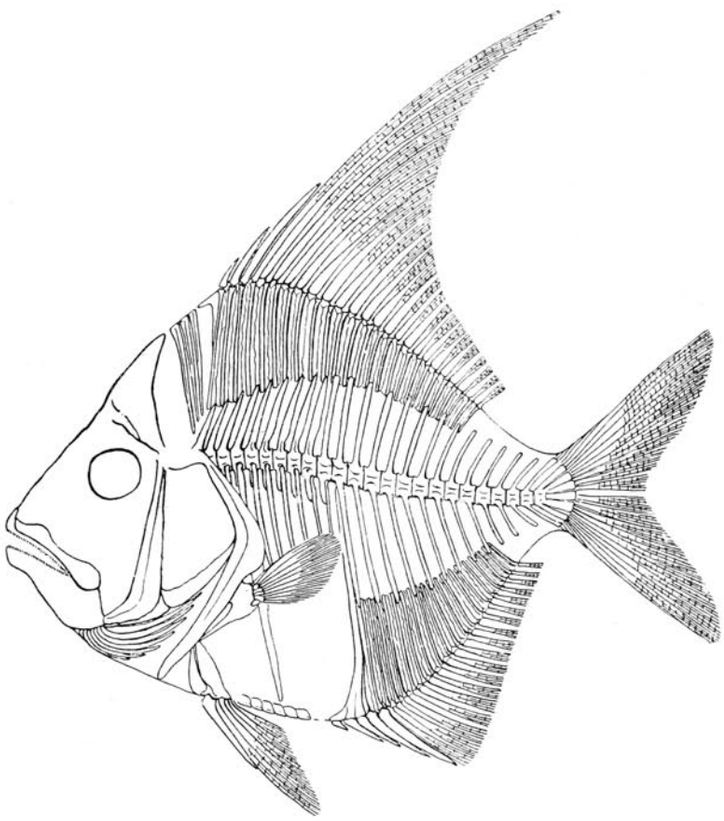

FIG. 1. *Aipichthys velifer*, A. S. Woodward; restoration of skeleton, without scales, about nat. size.—Upper Cretaceous; Hakel, Mt. Lebanon.

gape extending to the hinder border of the orbit; maxilla expanded behind; teeth minute but numerous. Pelvic fins inserted directly below the pectorals, somewhat

larger than the latter; dorsal fin much elevated and extending along nearly the whole of the back, with two to four very short and rather stout anterior spines; anal fin comparatively low, opposed to the hinder half of the dorsal, with three to five short and stout anterior spines; caudal fin deeply forked. Scales thin and small, except a series of ventral ridge-scales on the short abdominal region.

Type Species.—*Aipichthys pretiosus* (Steindachner, Sitzungsb. k. Akad. Wiss., math.-naturw. Cl., vol. xxxviii, 1859, p. 763, pl. i, fig. 1) from the Cretaceous (supposed Urgonian) of Comen, Istria.

Remarks.—This is the highest type of fish to which any specimen hitherto discovered in the English Chalk can be referred. The genus comprises small species, none more than 10 cm. in length, which are known by nearly complete skeletons crushed between the laminæ of the fissile Cretaceous limestones of Comen (Istria), the Isle of Lesina (Dalmatia), and Hakel (Mt. Lebanon). The specimens from Hakel were for many years ascribed to the allied genus *Platax*, which survives in existing seas. The accompanying restoration (Text-fig. 1) of the skeleton of *Aipichthys velifer*, however, shows that the fish differs from *Platax* in having a larger mouth, a much less elevated anal fin, and a deeply forked caudal fin. The thickened ventral ridge-scales also distinguish the Cretaceous from the Tertiary and Recent genus.

1. **Aipichthys nuchalis** (Dixon).

1850. *Microdon nuchalis*, F. Dixon, Geol. Sussex, p. 369, pl. xxxii, fig. 7.
1887. *Platax* (?) *nuchalis*, A. S. Woodward, Ann. Mag. Nat. Hist. [5], vol. xx, p. 342.
1901. *Aipichthys nuchalis*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 429.

Type.—Imperfect fish, probably from zone of *Holaster subglobosus*; British Museum.

Specific Characters.—Not yet satisfactorily ascertained.

Description of Specimen.—This species is still known only by the unique type specimen, which is too incomplete to decide more than its generic relationships. Dixon's drawing of the fossil does not exhibit many of its essential features, but a study of the actual specimen reveals some of them. The supraoccipital bone of the cranium is shown to be raised into a large, laterally compressed, triangular crest. The vertebral centra, with their arches, are well ossified, and there seem to be only ten in the abdominal region. Of the pectoral fins no fragments remain, but each of the pelvic fins is represented by a single robust spine, though there are no traces of the articulated rays. Evidence of a much-elevated dorsal fin is seen in a series of large, wide-winged fin-supports above the vertebral column, just behind the supraoccipital crest. The anal fin is represented by its three small anterior spines. The total length of the fish cannot have exceeded 8 cm.

Horizon and Locality.—Probably zone of *Holaster subglobosus:* Washington, Sussex.

Family STROMATEIDÆ.

The Cretaceous genera provisionally assigned to this family are primitive Scombroid fishes of uncertain affinity.

Genus **BERYCOPSIS,** Dixon.

Berycopsis, F. Dixon, Geol. Sussex, 1850, p. 372.
Stenostoma, F. Dixon, *ibid.*, 1850, p. 373.

Generic Characters.—Trunk deepened and much laterally compressed. Cleft of mouth small and oblique, with minute clustered teeth; maxilla expanded behind, with relatively very large posterior supramaxilla; circumorbital plates small, except the foremost (antorbital), which is much expanded. Vertebræ about twelve in the abdominal, eighteen in the caudal region. Pectoral fins small and delicate; pelvic fins, with relatively large spine, inserted slightly behind the pectoral pair; dorsal and anal fins with a few very stout anterior spines, which gradually lengthen and are closely pressed together; caudal fin forked. Scales more or less feebly rugose and pectinated or ctenoid, extending over the operculum, occipital region, and cheek; none enlarged or thickened. Lateral line inconspicuous.

Type Species.—*Berycopsis elegans*, from the English Chalk.

Remarks.—This genus is most closely related to *Omosoma* and *Platycormus* from the Upper Cretaceous of the Lebanon and Westphalia. *Pycnosterinx*, from the Lebanon, may also perhaps prove to be an allied form when it is better known. *Omosoma* is distinguished by its cycloid scales, which seem to be less deepened on the flank than those of *Berycopsis;* while *Platycormus* appears to have about four more vertebræ and a much smaller pelvic fin-spine than the latter genus.

1. **Berycopsis elegans**, Dixon. Plate I; Plate II, fig. 1; Text-figure 2.

1850. *Berycopsis elegans*, F. Dixon, Geol. Sussex, p. 372, pl. xxxv, fig. 8.
1888. *Berycopsis elegans*, A. S. Woodward, Proc. Geol. Assoc., vol. x, p. 328.
1901. *Berycopsis elegans*, A. S. Woodward, Catal. Foss. Fishes B. M., pt. iv, p. 423.

Type.—Imperfect head and trunk from zone of *Holaster subglobosus;* Willett Collection, Brighton Museum.

Specific Characters.—The type species attaining a length of about 30 cm. Length of head with opercular apparatus considerably exceeding two-thirds the

maximum depth of the trunk, which nearly equals the length from the pectoral arch to the base of the caudal fin. External head-bones only partially rugose, the hinder expanded portion of the frontals being quite smooth, and the front edge of the supraoccipital crest not thickened or ornamented. Antorbital cheek-plate slightly deeper than broad, its depth about equalling that of the orbit. Dorsal fin with 6 short and stout spines, which are nearly smooth; anal fin arising much nearer to the pectorals than to the caudal. Scales very feebly rugose, or sometimes quite smooth, with slightly bent, not regularly curved hinder margin; nearly 30 scales in each transverse series on the abdominal region.

Description of Specimens.—The type specimen in the Brighton Museum does not exhibit many of the essential characters of the fish. It is, however, sufficiently complete for generic and specific determination. The gently rounded frontal region of the skull is shown, and the large supraoccipital crest is observable in transverse section. The operculum is much flaked, but seems to have been smooth. The scales are well displayed, exhibiting their proportions and the typical rhombic exposed area, with a very slight rugosity at its hinder border. The front part of the anal fin is preserved, and its remains extend to the hinder fractured edge of the fossil.

The only other important known specimens of this species are contained in the collection of the British Museum. All these are very imperfect; but two afford an approximate idea of the general proportions of the fish, while the others exhibit most of the principal characters of its skeleton.

The general proportions are best shown in the small specimen from the Chalk of Sussex represented of the natural size in Pl. I, fig. 1. The frontal profile of the head is steep, and the back gradually rises to the origin of the dorsal fin, where the trunk is deepest. The ventral margin of the body forms a more gentle curve than the dorsal border. The jaws are slightly pressed forwards in fossilisation, but, allowing for this, the length of the head with opercular apparatus is seen to equal its maximum depth at the back of the occipital crest. Its length also somewhat exceeds two thirds that of the trunk from the pectoral arch to the base of the caudal fin.

The roof of the skull is sharply bent above the middle of the large orbit, and its short hinder portion is surmounted by a deep triangular supraoccipital crest (Pl. I, figs. 1, 3, *socc.*), which is strengthened by one oblique ridge. The muscles of the trunk must have extended forwards over this portion of the skull as far as a sharp ridge which is inclined backwards on each side from the middle point at the hinder border of the frontal region (fig. 3, *fr.*). The frontal bones (*fr.*) are smooth and a little tumid, impressed with a few reticulating grooves, and by a pair of lateral, longitudinal sensory canals. There is also a large supraorbital flange (*spb.*), apparently of the same element, which bears a finely rugose ornamentation. Anteriorly the frontals taper, and overlap the narrow mesethmoid, which is almost

destroyed in the original of fig. 3, but is shown in other specimens, *e. g.*, the original of fig. 2. Its exposed portion is longer than broad, and gradually widens in front, where its anterior margin is deeply excavated by a re-entering angle. Its vertical extent is also considerable, as shown by an imperfect small specimen, B. M., no. P. 6049. The basioccipital region, as exposed in one specimen (B. M., no. P. 5683), is much laterally compressed, and there is a basicranial canal. The prefrontal or ectethmoid element (fig. 2, *prf.*) is seen to be large and deepened. There are sometimes remains of an ossified sclerotic.

The mandibular suspensorium is nearly vertical, only slightly inclined forwards; and the mandibular articulation is below the hinder margin of the orbit. The

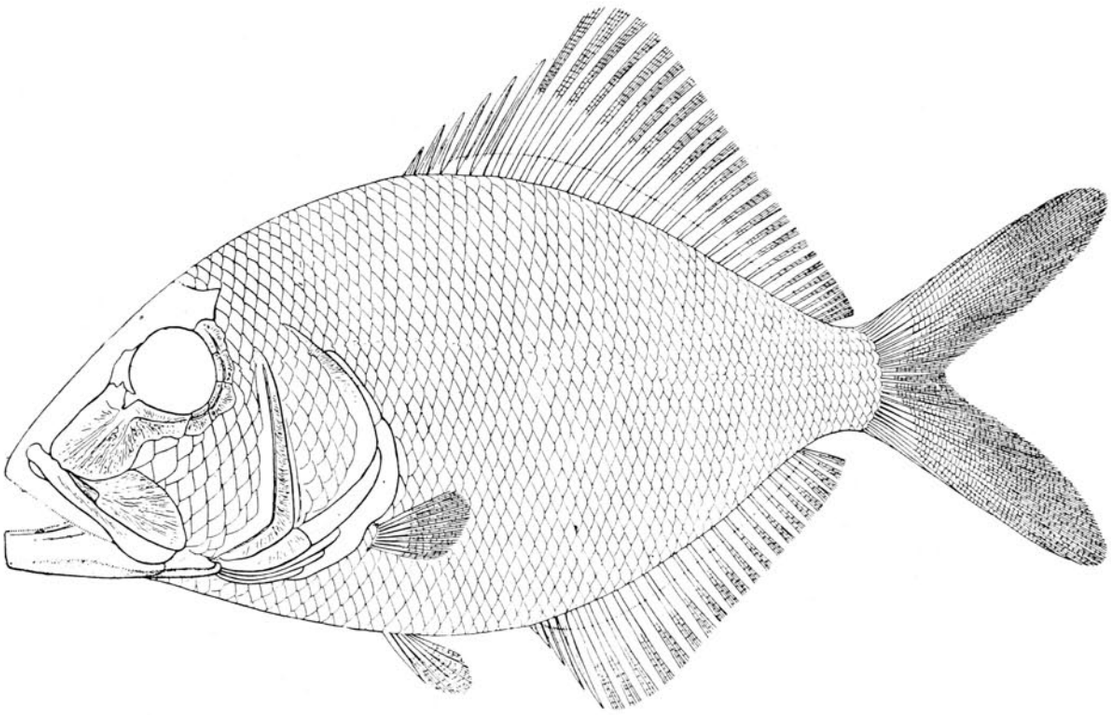

FIG. 2. *Berycopsis elegans*, Dixon; restoration, about one half nat. size.—English Chalk. The pelvic fins and the greater part of the anal and caudal fins are based on probabilities. The extent of the squamation over the rays of the dorsal and anal fins is indicated by a dotted line.

hyomandibular (fig. 2, *hm.*) is a long and narrow lamina, strengthened on the upper part of its outer face by three radiating ridges, one ending in the point of suspension (*s.*) for the operculum, the other two diverging respectively to the postero-superior and antero-superior angle of the bone. Its truncated lower end meets the symplectic and the hinder half of the upper margin of the quadrate. The latter element (*qu.*) is deeply notched for the reception of a rather large symplectic, and has the usual thickened articular prominence for the mandible below. The large and delicate laminar metapterygoid (*mpt.*) adjoins the anterior margin of the hyomandibular and the anterior half of the upper margin of the

quadrate; while the thin, arched, and tapering hinder portion of the ectopterygoid (*ecpt.*) borders the quadrate anteriorly and the metapterygoid inferiorly. As shown by B. M., no. P. 5683, the lower part of the inner face of the ectopterygoid bears a cluster of minute teeth. The premaxilla (figs. 1, 2, *pmx.*) completely excludes the maxilla from the upper border of the mouth on each side. It is remarkable for the great relative size of its anterior ascending process, which fits into the deep groove on the anterior face of the mesethmoid. It is constricted, though a little thickened, immediately behind the base of this process; and its oral face, when well preserved (*e. g.*, B. M., no. P. 5683), bears a broad cluster of minute teeth. The maxilla (figs. 1, 2, *mx.*) is a slender bar for the greater part of its length, with a large upturned anterior end, which is partly shown in fig. 1, but better preserved on the left side of the original of fig. 2. It terminates behind in a considerable laminar expansion which is broken and incomplete in the original of fig. 2, but a little less fractured in that of fig. 1. When quite complete, this expansion is slightly deeper than in the latter, and its outer face is not ornamented. The maxilla is overlapped for the greater part of its length by a relatively enormous supramaxilla (figs. 1, 2, *smx.2*), of which the form is best shown in fig. 2. It seems to have been slightly convex, and it is covered with a very fine rugose ornament, which is often partly destroyed in fossilisation. Below its anterior pointed prolongation there is also a diminutive second supramaxilla (fig. 2, *smx.1*), which is similarly ornamented. The mandible is more or less broken in all the known specimens, but its general shape is indicated in fig. 1. It is short and deep, with a truncated symphysis, and the oral border gradually rising to the coronoid region, of which the highest point is just in front of the articulation for the quadrate bone. The lower portion of the mandible is much bent inwards, so that its complete depth is not seen in direct side-view (figs. 1, 2). The dentary (*d.*) is quite smooth, but the articulo-angular (*ag.*) exhibits a horizontally-extended flattened ridge immediately below and in front of the articulation, covered with a fine rugose ornament. Below this ridge there is a deep groove, which may have been occupied by the slime-apparatus of the sensory canal. The thickened oral margin of the dentary bears clustered minute teeth like those of the premaxilla.

The cheek is covered partly by circumorbital plates, partly by scales. Most of the circumorbital plates (figs. 1, 2, *co.*) are small, and form a very narrow rim round the orbit; but the foremost element of the series, which may be termed antorbital (*ao.*), is excessively expanded. All these plates are covered with a very fine rugose ornament, and the sensory canal which traverses them is marked by a deep groove. The original outline of the large antorbital plate is best shown in fig. 2, where it is only destroyed by an accidental indent near the upper end of its hinder margin. Its maximum depth somewhat exceeds its width, and about equals the vertical diameter of the orbit. Its longer axis is slightly inclined

forwards, but its inclination is increased by crushing in the original of fig. 1. The sensory canal is abruptly bent downwards when it reaches the middle of this plate and spreads in a few radiating branches. When the cheek is well preserved it is seen to be completely covered with scales behind and below the circumorbital ring, and remains of these are observable in fig. 1. As shown by B. M. no. P. 6049, these scales are large and deeply overlapping, less conspicuously rugose than the circumorbital plates, and not serrated.

The opercular apparatus is complete. The preoperculum (figs. 1, 2, *pop.*) is very deep and narrow, and not much expanded at the angle, which is greater than a right angle. Its straight ascending limb tapers to its pointed upper end at the hyomandibular suspension of the operculum; its short lower limb is more bluntly pointed below. Its thickened anterior border overhangs the deep groove for the sensory canal; its narrow hinder wing, when well preserved, is covered with a fine rugose ornament but not serrated. The exact form of the operculum (*op.*) is difficult to determine, but it only seems to lack an insignificant fragment of the hinder border in fig. 1, and the postero-superior angle in fig. 2. In the former specimen it is completely exposed and exhibits only remains of a radiating rugose ornament in its hinder half. In better preserved specimens, however, as in the original of fig. 2, it is always covered with scales like those of the cheek, and its hinder ornamented portion is very little exposed. The suboperculum (*sop.*) and interoperculum (*iop.*) are narrow, antero-posteriorly extended bony plates, displaying a fine rugose ornament when well preserved, never covered with scales. The outline of these two elements seems to be complete in fig. 1, but the lower margin of the interoperculum is accidentally indented in fig. 2. Fragments of branchiostegal rays (*br.*) are seen in fig. 2, but these are imperfectly known. Three or perhaps four of them are shown on the right side in B. M. no. P. 6465. The branchial arches seem to bear a few large pointed gill-rakers (B. M. no. P. 5695).

The vertebral column is imperfectly known, but it comprises at least 26, perhaps as many as 30 vertebræ. The centra are much constricted cylinders, and most of them seem to be strengthened by a stout, lateral, longitudinal ridge. The arches are all very stout and large. The neural arches are fused with the centra in the abdominal, as well as in the caudal region. The anterior ribs articulate directly with the centra, but there may have been small transverse processes. There are expanded hypural bones (B. M. no. P. 6465).

The pectoral arch is suspended from the cranium by a small supratemporal (Pl. II, fig. 1, *st.*), and by a larger, forked post-temporal (*ptt.*). The supratemporal is an irregularly crescentic lamina, its concave border smooth and turned forwards, its convex border marked with a rugose ornament and turned backwards. Its antero-superior angle overlaps the epiotic, while its postero-inferior portion is in contact with the exposed laminar part of the post-temporal. This plate (*ptt.*) tapers a little above, but is truncated below where it articulates with the supra-

clavicle. The greater part of its outer face is smooth, but behind and below a deep vertical groove which traverses two thirds of its depth, it exhibits a rugose ornament. From its antero-inferior angle there extends forwards a smooth rod-like process (*p.*), which articulates with the pterotic. The supraclavicle (*scl.*) is more than three times as deep as broad, truncated above, tapering below, and with a thickened anterior margin. Its outer face is very feebly rugose. The clavicle (Pl. I, fig. 2, *cl.*) is much sigmoidally bent, with a large external lamina, which is as feebly ornamented as the supraclavicle. Its hinder margin is notched just above the attachment of the coraco-scapular mass (*c.*); and at the angle there is sometimes a trace of a post-clavicle (*pcl.*). There is a persistent suture between the coracoid and scapula, as shown on the left side of the original of Pl. I, fig. 2; and the scapula is pierced by a large oval foramen (*f.*). The basal bones of the pectoral fin are unknown, and the fin itself has never been well observed. As indicated by B. M. no. P. 6465, it is very small, comprising from eight to ten rays, of which the uppermost and longest cannot have exceeded the premaxilla in length. Only scattered fragments of its delicate fin-rays are shown in Pl. I, fig. 1, *p.* The pelvic fins are unknown, but a trace apparently of one of the supports in B. M. no. 37751, seems to show that their insertion was slightly behind that of the pectoral fins.

The median fins are always imperfect in the fossils, but some of their characters are observable. The dorsal fin seems to arise opposite the insertion of the pelvic pair, and is much extended. There are traces of free fin-supports in advance of it (Pl. I, fig. 1, *n.*); and its low anterior portion consists of very stout, nearly smooth, closely arranged spines (Pl. I, fig. 4). These spines, six in number, gradually increase in length, and are followed by much longer rays, which are closely articulated distally but only represented by their bases in the specimens figured (Pl. I, figs. 1, 4). The articulated dorsal rays must have been at least twenty-five in number, as shown by B. M. no. P. 6535. The anal fin must also have been considerably extended, arising in advance of the middle point between the pectorals and the caudal, and reaching at least as far back as the seventh vertebra from the caudal extremity. Its foremost support (Pl. I, fig. 1, *a*) exhibits at its lower end a large triangular expansion, evidently for the attachment of powerful spines. The caudal fin must have been delicate, and was probably forked. Only fragmentary remains of it are shown in Pl. I, fig. 1.

The aspect of the scales varies much in the different specimens, but this circumstance seems to be due to accidents in preservation. When they are undisturbed and complete, as in the front part of Pl. I, fig. 1, their exposed portion is observed to be almost rhombic in shape, the hinder border being not gently curved but rather sharply bent at its middle. When the surface is well preserved it is distinctly rugose, and some of the delicate markings at the hinder margin radiate in such a manner as to give it a pectinated appearance. The smoothness of the scales in the originals of Pl. I, figs. 1, 4, and in similar specimens, is almost certainly