

moderately long black hairs, the thorax and abdomen with longer and more sparsely distributed hairs. Antennæ black, thick; the scape covered with long black hairs, the flagellum with a microscopic down. Head large, wider than the thorax, developed behind the eyes to rather more than twice the length of the eyes; the mandibles sericeous and bearing some long black hairs. There is a black transverse band on the base of the mesonotum, one down the centre of the median segment and a narrower one down each of its sides. Abdomen not much longer than the thorax; its petiole short, obliquely raised from the bottom to the top. The ventral segments clothed, like the dorsal, with pale golden pubescence. Legs entirely black, sparsely clothed with longish black hairs.

S. myrmiciformis belongs to the group of *S. ocyroe*.

XXXV.—*A Contribution to the Osteology of the Mesozoic Amioid Fishes Caturus and Osteorachis.* By A. SMITH WOODWARD, F.L.S.

[Concluded from p. 297.]

II.—*OSTEORACHIS LEEDSI*, SP. N., FROM THE OXFORD CLAY OF PETERBOROUGH.

The unique specimen of *Osteorachis* in the Leeds Collection (Brit. Mus. no. P. 8388) comprises the hinder portion of the skull, fragments of the jaws, opercular apparatus, and pectoral arch, and part of the vertebral column, all undoubtedly belonging to one and the same individual. It is of interest not only on account of its gigantic size, but also as being the first known example of the genus of Upper Jurassic age. As its teeth are relatively larger and stouter than those of the typical species (*O. macrocephalus*) from the Lower Lias, while their enamelled apex seems to be shorter, the species it represents is evidently new, and may be named *O. Leedsi*, in honour of its discoverer. In the anterior half of the dentary in the Oxfordian fossil the length occupied by the bases of three consecutive teeth at least equals, and usually exceeds, the depth of the bone bearing them; whereas in *O. macrocephalus* the corresponding length is always less than the depth of the bone.

The following are some of the principal measurements obtainable :—

	m.
Width of occiput	0·20
Length from occiput to orbital rim.....	0·13
Maximum depth of hyomandibular.....	0·23
Width of upper end of ditto, about.....	0·09
Length of post-temporal	0·16
Depth of supraclavicle	0·20
Maximum width of ditto	0·05

Cranium.

The cranium has lost the rostral region, and the floor of the brain-case with the parasphenoid is broken into three pieces separate from the main mass. The hinder portion of the cranial roof is well-preserved and shown of two fifths the natural size in Pl. X. fig. 1. The right post-temporal (*p.t.*) and some of the vertebral elements (*h.c.*, *pl.c.*, *n.*) are crushed upon the occiput, which is thus a little obscured; but the characteristic narrow projecting portion of chondrocranium beyond the roofing membrane-bones is conspicuous. The parietals (*pa.*) are remarkably unsymmetrical, that of the right side being twice as broad as that of the left, and the former exhibiting only a small antero-lateral point, while the latter extends far forwards into the frontal by its corresponding process. Except on their overlapped hinder border these bones are entirely covered by a fine rugosity and tuberculation, but without any traces of enamel. The relatively large frontals (*fr.*) are approximately equal in maximum width, but that of the right side is narrowed behind, and their median suture is extremely wavy, with one large acute lobation just behind the interorbital region, and numerous small interdigitations in front, where the fossil is fragmentary and then terminates. Posteriorly the ornamentation is a little more sparse than that of the parietals, anteriorly it becomes much coarser, and there is a tendency to radiation towards the margin of the bone. The squamosals (*sq.*) are relatively large and form a symmetrical pair, each gradually tapering forwards as far as the exposed portion of the postfrontal (*pt.f.*), and then rapidly terminating in an anterior acute point. They are ornamented like the frontals, and exhibit a conspicuous narrow smooth area, widest behind and tapering forwards, close to the inner margin of the element. The postfrontal (*pt.f.*) is only exposed for a very small space on each side, and appearances suggest that the cartilaginous element itself is shown without any investing membrane-bone. There are no marks of regularly disposed sensory canals on any part of the roof.

The chondrocranium itself is imperfectly ossified, but when

viewed from below in the fossil (Pl. X. fig. 1 *a*) some of its characteristic features can be distinguished. The opisthotic (*op.o.*) is a well-formed bone, with the usual large oval foramen for the exit of the vagus nerve, and in front it clearly articulates by a wavy suture with the equally well ossified pro-otic (*pr.o.*), which is broken away anteriorly. The postfrontal or sphenotic (*pt.f.*) is also massive and distinct, with a very well-defined hinder border for union with the rest of the upper part of the otic capsule, which seems to have remained unossified, as in *Amia*. There may have been a granular calcification of the cartilage here, but nothing more. The ossifications and calcifications in the interorbital region of the chondrocranium are almost entirely broken away, but there are just traces of the interorbital septum (*s.*), showing the anterior production of the cerebral cavity for the passage of the olfactory nerves. On the left side of the fossil there are also indications of a robust pre-frontal or ecto-ethmoidal ossification.

The imperfect separated basicranial axis cannot be fitted to the rest of the fossil, and the sutures between its component elements are not distinguishable. The robust parasphenoid is, indeed, firmly fused at least with the basioccipital. This basal membrane-bone exhibits a slight cleft behind and is expanded in front in the usual manner for squamous union with the vomers; it does not bear teeth, but there is an irregular bony excrescence a little behind the middle, where small teeth usually occur in allied fishes. The upper or cerebral aspect of the specimen is interesting on account of the configuration of the basioccipital. This bone is not curved upwards at the sides, but agrees exactly with the corresponding element of *Amia* in displaying a conspicuous median ridge, which looks like a distinct bone thrust into a cleft.

Jaws, Facial and Opercular Bones.

The hyomandibular is preserved on both sides, and one specimen is shown of two fifths the natural size from the inner aspect in Pl. XI. fig. 1. The bone is slightly more than twice as deep as its maximum width measured at the process (*p.*) for the support of the operculum; it is much laterally compressed, strengthened by a median longitudinal thickening, and by another extending from this along the base of the opercular process. The upper end was evidently capped with cartilage; the anterior margin, completely preserved in the fossil, is gently excavated, and below the opercular process behind there seems to have been an ex-

tremely delicate wing of bone probably of the form indicated by the dotted line in the figure. It is also interesting to note that the bone is pierced by a short vertical canal exactly as in *Amia*, the upper opening (*f.*) being on the inner, the lower opening on the outer face. The quadrate of the left side is nearly complete and is remarkable for the very large size of the articulation for the mandible, which is much elongated antero-posteriorly. The hinder margin is a little curved outwards and thickened, and remains of a tuberculated external plate are crushed upon this prominence. Of the pterygo-palatine arcade only fragments are preserved; but it may be said that these laminar bones bear clustered patches of teeth, which are small near the margin of the jaw and become merely minute tubercles or granulations beyond. One piece of bone, which seems to have been palatine, bears an irregular cluster of teeth as large as those of the splenial. The imperfect right maxilla (Pl. XI. fig. 2) shows that this element is very long and narrow, the dentigerous border being somewhat concavely arched and furnished with a single close series of large teeth, which are largest in the middle of the bone, and all seem to be approximately circular in transverse section. The outer face is very coarsely rugose and seems to have formed a little parapet outside the bases of the teeth, as indicated by a fragment behind, which is accidentally overlain by another piece of bone (*x*). There is some indication of a surface of overlap for the supramaxilla. The mandible is also remarkably long and slender, but is known only by the portion of the left ramus shown of two fifths the natural size from the outer and superior aspects in Pl. XI. figs. 3, 3*a*. The dentary (*d.*) bears a single close series of teeth still larger than those of the maxilla, but they are unfortunately only indicated by their bases, which are ovoid in shape, with the long axis coincident with that of the jaw. The outer face of the bone is coarsely and irregularly rugose, and its lower portion is a thin vertical lamina with an acute inferior border. The splenial (*spl.*) is comparatively robust and forms a broad ledge on which small teeth are irregularly clustered, but it is broken in front, and its precise extent is unknown.

Very few traces of the cheek-plates remain, and nothing is known of their arrangement. Like the other external bones, all are destitute of enamel on the tubercular or rugose ornament. A fragment of the anterior border of the left operculum is almost smooth, though with irregular surface.

Dentition.

The teeth are all simple hollow cones, and the internal cavity in the fossil is usually filled with calcite. They are rounded in section, without any longitudinal keels, and the slender apical portion alone is enamelled. The apex is more or less curved and usually marked only with very delicate striæ, though one splenial tooth is crimped in the lower part of the enamel. The smooth brown base seems to have had a relatively thin wall in the larger teeth, judging from fractures by crushing, and one of the supposed palatine teeth shows a natural indent of its outer face at the attached end. All the teeth are fixed in shallow depressions and fused with the supporting bone, and the only complete tooth of the maxillary series seems to be worn (during the life of the animal) at the apex. No successional teeth are observable.

Axial Skeleton of Trunk.

The vertebral column is represented by 12 of the pleurocentra, 15 of the hypocentra, and a few fragments of the arches. As already mentioned, one pleurocentrum (*pl.c.*), one hypocentrum (*h.c.*), and one neural-arch-shaped fragment (*n.*) are crushed in the matrix at the occiput; the others are all detached. A typical pleurocentrum is shown of two thirds the natural size in end view and from the superior and lateral aspects in Pl. XI. figs. 4, 4 *a*, 4 *b*.

All the specimens are crushed and some much distorted, but that here represented seems to retain approximately its original form. It is not quite bilaterally symmetrical, one side being longer than the other, and in this respect it differs from the remainder of the series, which have a more regular figure. In end view five distinct facettes are observed. Between the two branches of the bone there is the smooth saddle-shaped surface (*not.*) which would be directly in contact with the persistent notochord; above this is a pair of small ovoid facettes of finely granulated aspect (*n.a.*), to support the basal segment of the neural arch, and each divergent branch bears a great rugose flattened surface, which would be apposed to the corresponding surface of the hypocentrum. When viewed from above (fig. 4 *a*) the pair of facettes for the support of the neural arch is seen to occur on both ends of the bone, with a small intervening space, this indicating that the arches alternated with the vertebral bodies as in *Amia*. It is also noteworthy that a conspicuous little boss of variable development projects from the restricted area between each pair of these neural facettes. Inside view (fig. 4 *b*)

the pleurocentrum appears as a very short bone tapering to its pointed lower end. The hypocentra are larger and more massive than the pleurocentra. A typical example from the abdominal region is shown of two thirds the natural size from the anterior, inferior, and lateral aspects in Pl. XI. figs. 5, 5 *a*, 5 *b*. The smooth saddle-shaped surface (*not.*) originally in contact with the persistent notochord is again conspicuous, and the great rugose surface on each branch of the bone resembles that of the pleurocentrum which it meets. The stout lower portion of the element is often a little distorted by crushing during fossilization, but it always exhibits a pair of small rounded depressions (*x*) in front and behind, as if they were facettes for some relatively small intercalated parts which have disappeared. When viewed from below (fig. 5) *a* the hypocentrum is seen to be flattened in the middle of the inferior face and marked with a slit-like pair of longitudinal depressions, while between this flattening and the transverse processes (*tr.*) the surface of the bone exhibits a slight concavity. The processes, seen also in side view (fig. 5 *b*, *tr.*), are very short and stout, and there is always a small irregular bony boss (*y*) at their base antero-inferiorly; in the specimen figured they are placed on the hinder half of the bone, the disposition of parts doubtless indicating that it belongs to the posterior abdominal region. The end of the lateral branch of the hypocentrum is rather truncated than pointed (fig. 5 *b*). Two detached hypocentra are exceptional in being much stouter in every way than the others, and are remarkable as exhibiting a pair of deep depressions in place of the usual transverse processes. Comparison with the partially obscured example crushed upon the back of the skull suggests that these belong to the most anterior part of the vertebral column.

Among the remains of vertebral arches the only satisfactory specimens are some detached bases of the neural elements. One of these, imperfect at its upper end, is shown of two thirds the natural size from the anterior and externo-lateral aspects in Pl. XI. figs. 6, 6 *a*, and the first figure is rendered more instructive by an outline restoration of its fellow of the opposite side. The specimen obviously belongs to the abdominal region. The bone is comparatively massive at the proximal end, and shows very clearly the facettes (*c*) for articulation with two contiguous pleurocentra. It meets its fellow of the opposite side in another considerable articulation (*a*) above the neural canal (*n.c.*), which is shown to have been remarkably small, and there seems to have been even another slight meeting below this canal. On the outer side of its base the bone bears a prominent little boss (*p.*), which is directed upwards and almost pointed.

Appendicular Skeleton.

Of the appendicular skeleton scarcely any parts are preserved, but the right post-temporal and supraclavicle are worthy of note. The post-temporal (Pl. X. fig. 1, *p.t.*) agrees in general characters with that of *Amia*, exhibiting the downward and forwardly directed process near the outer margin; but its hinder portion is relatively longer and narrower, with an almost spatulate end. There is an irregular rugose and tubercular ornament on its middle region. The supraclavicle is truncated above, with a concave facette about half its width. It is a gently arched laminar bone, about four times as deep as its maximum width, which is at the upper end. There is an irregular coarse rugosity on its exposed hinder half.

III.—*OSTEORACHIS MACROCEPHALUS*, FROM THE LOWER LIAS OF LYME REGIS.

The foregoing and other recent observations necessitate a few supplementary remarks on the fine example of *Osteorachis* from the Lower Lias of Lyme Regis originally described by Davis under the name of *Heterolepidotus grandis**. This specimen has lately been acquired by the British Museum, and its reference to the genus now under consideration can thus be verified by direct comparison with the type specimens.

The imperfect cranium in this unique fossil (Brit. Mus. no. P. 7797) is exposed from above, but the rostral end is wanting and the anterior half of the frontals is shown only in impression. The whole is much fractured, and is merely of interest as displaying the prominent tubercular ornament in the hinder region and the extremely wavy suture between the frontals where they begin to become smooth. The squamosal is lost on the right side, so that the original figure of Davis does not indicate the total width of the occiput. The jaws and facial bones are entirely wanting, and the appearances described by Davis as "lower jaws 5 inches in length" are better explained as a portion of clavicle crushed upon the branchial apparatus. Nearly all the remains below the skull, indeed, may be ascribed to the hyoid and branchial arches. The branchial bars are delicate and covered with the scattered gill-rakers in the form of minute enamelled denticles. These are especially interesting as being often clustered on

* J. W. Davis, "On *Heterolepidotus grandis*, a Fossil Fish from the Lias," Journ. Linn. Soc., Zool. vol. xviii. pp. 293-298, pl. vii. (1885). See also A. S. Woodward, "On the Liassic Fish, *Osteorachis macrocephalus*," Geol. Mag. [4] vol. ii. pp. 204-206, pl. vii. fig. 10 (1895).

little triangular plates of bone, much like those of *Caturus* and *Amia*. In the description by Davis they are erroneously ascribed to the jaws. Just below and behind the head (scarcely indicated in Davis's figure) there is a fragment of the vertebral column clearly segmented into wedge-shaped pleurocentra and hypocentra, and one of the latter displays the short transverse process for the rib. The remainder of the axis is obscured by pyrites as far as the middle of the tail, where the overlapping scales and crushing are also detrimental to precise observation; but the pleurocentral and hypocentral ossifications in the hinder half of the tail are either comparatively feeble or absent. The upper caudal lobe is atrophied as much as usual in the Protospondylic fishes, and the caudal fin is quite normal. The supposed "second series of intermediate bones to which the fin-rays are attached" (Davis) are merely the short unjointed bases of the rays themselves. The fulcra on the upper caudal lobe are also quite normal, the "five prong-like rootlets" depending upon an error of interpretation. The well-preserved dorsal fin seems to exhibit "smaller intermediate" rays between its principal rays as the result of a little distortion by crushing; the right and left halves of the rays in question are evidently somewhat displaced, and that of the right side becomes exposed in posterior view just behind its fellow of the left side. This often happens in fossilized fishes. The well-preserved pelvic fin is interesting as showing for the first time in *Osteorachis* the biserial character of its slender fulcra. There are remains of large finely ornamented post-clavicular plates, and the characteristic squamation is very well preserved over the greater part of the trunk.

EXPLANATION OF THE PLATES.

PLATE VIII.

- Fig. 1.* *Caturus*, sp.; cranial roof, two thirds nat. size.—Oxford Clay; Christian Malford, Wiltshire. [B. M. no. 29049.]
Fig. 2. *Caturus*, sp.; anterior end of cranium, two thirds nat. size.—Oxford Clay; Peterborough. [B. M. no. P. 6902.]
Fig. 3. *Caturus*, sp.; head, right lateral aspect, two thirds nat. size.—Ibid. [B. M. no. P. 6907.]
Figs. 4, 4 a. *Caturus*, sp.; right maxilla and palatine, outer and inferior aspects, two thirds nat. size.—Ibid. [B. M. no. P. 6910.]
Fig. 5. *Caturus*, sp.; portion of gill-arches, two thirds nat. size.—Ibid. [B. M. no. P. 6906.]

a.o., antorbital; *a.p.*, articular process of maxilla; *ag.*, angular; *br.*, branchiostegal rays; *c.o.*, circumorbital; *d.*, dentary; *fr.*, frontal; *gu.*, gular plate; *mx.*, maxilla; *na.*, nasal; *occ.*, occipital border; *pa.*, parietal; *pl.*, palatine; *pmx.*, premaxilla; *s.mx.*,

supramaxilla; *s.o.*, suborbitals; *scl.*, sclerotic; *sp.o.*, supra-orbitals; *sq.*, squamosal; *t.*, bony tesserae; *x*, dermal bone on ethmoid.

PLATE IX.

Figs. 1, 1 a. *Caturus*, sp.; suspensorium, mandibular, and hyoid arches, outer and inner aspect, two thirds nat. size.—Oxford Clay; Peterborough. [B. M. no. P. 6901.]

Fig. 2. Hypohyal of same specimen.

Fig. 3. Gular plate of same specimen, imperfect behind.

Figs. 4, 4 a. Nasal bones of same specimen, outer and inner aspects.

Figs. 5, 5 a, 5 b. *Caturus*, sp.; hypocentrum, anterior, lateral, and inferior aspects, nat. size.—Ibid.

ag., angular; *ar.*, articulation of mandible; *c.hy.*, ceratohyal; *c.o.*, circum-orbital; *cor.*, coronoid; *d.*, dentary; *ecpt.*, ectopterygoid; *enpt.*, entopterygoid; *ep.hy.*, epihyal; *g.r.*, gill-rakers; *hm.*, hyomandibular; *l.f.*, lower articular facette; *p.*, process of hyomandibular for operculum; *p.op.*, preoperculum; *qu.*, quadrate; *spl.*, splenial.

PLATE X.

Figs. 1, 1 a. *Osteorachis Leedsi*, sp. n.; hinder portion of cranium superior and inferior aspects, two fifths nat. size.—Oxford, Clay; Peterborough. [B. M. no. P. 8388.]

fr., frontal; *h.c.*, hypocentrum; *n.*, neural arch; *op.o.*, opisthotic; *p.t.*, post-temporal; *pa.*, parietal; *pl.c.*, pleurocentrum; *pr.o.*, prototic; *pt.f.*, postfrontal; *s.*, interorbital septum; *sq.*, squamosal.

PLATE XI.

Fig. 1. *Osteorachis Leedsi*, sp. n.; hyomandibular of type specimen, inner aspect, two fifths nat. size. *f.*, foramen; *p.*, process for support of operculum.

Fig. 2. Right maxilla of same specimen, outer aspect, two fifths nat. size. *x*, bone-fragment.

Figs. 3, 3 a. Portion of left mandibular ramus of same specimen, outer and oral aspects, two fifths nat. size. *d.*, dentary; *spl.*, splenial.

Figs. 4, 4 a, 4 b. Pleurocentrum of same specimen, anterior, superior, and lateral aspects, two thirds nat. size. *not.*, surface for notochord; *n.a.*, facette for neural arch.

Figs. 5, 5 a, 5 b. Hypocentrum of same specimen, anterior, inferior, and lateral aspects, two thirds nat. size. *not.*, surface for notochord; *tr.*, transverse process; *x*, depression; *y*, bony prominence.

Figs. 6, 6 a. Right half of neural arch of same specimen, anterior and externo-lateral aspects, two thirds nat. size, the left half restored in outline in fig. 6. *a*, median articulation; *c*, facettes for pleurocentra; *n.c.*, neural canal; *p.*, prominence.

The numbers in square brackets refer to the Register of the Department of Geology in the British Museum, where the original specimens are preserved.



Woodward, Arthur Smith. 1897. "XXXV.—A contribution to the Osteology of the mesozoic amioid fishes *Caturus* and *Osteorachis*." *The Annals and magazine of natural history; zoology, botany, and geology* 19, 379–387.

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