

New material of the plesiosaur *Kimmerosaurus langhami* Brown from the Kimmeridge Clay of Dorset

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Synopsis

New specimens of the Kimmeridgian cryptoclidid plesiosauroid *Kimmerosaurus langhami* Brown provide additional data on the morphology and ontogeny of the skull, and the anterior cervical vertebrae are newly described. An emended diagnosis is given and the possibility of the synonymy of *Kimmerosaurus* with the 'elasmosaur' *Colymbosaurus*, the only other British Kimmeridgian plesiosauroid, is considered.

Introduction

Kimmerosaurus langhami was described by Brown (1981) on the basis of a single partial skull, Department of Palaeontology, British Museum (Natural History) register no. R.8431. A second specimen, consisting of a braincase, mandible and anterior cervical vertebrae, collected by P. A. Langham in 1976 and at that time in the private collection of R. A. & P. A. Langham, was referred to *K. langhami* by Brown, but was not available for description. This material has subsequently been presented to the Department by R. A. Langham, where it is registered as R.10042. A third specimen (R.1798), a previously unidentified fragmentary skull purchased from the executors of R. Damon in 1890, also belongs to *K. langhami*. These two additional specimens provide further data on skull morphology, ontogenetic changes of the skull and the first record of vertebrae in *Kimmerosaurus*.

The material described herein is housed in the collections of the British Museum (Natural History) (specimen numbers prefixed by R or without prefix), the Sedgwick Museum, Cambridge (SMC) and the Hunterian Museum, University of Glasgow (GLAHM).

Description

Order PLESIOSAURIA de Blainville, 1835

Superfamily PLESIOSAUROIDEA (Gray, 1825) Welles, 1943

Family CRYPTOCLIDIDAE Williston, 1925

Genus *KIMMEROSAURUS* Brown, 1981

TYPE SPECIES. *Kimmerosaurus langhami* Brown, 1981 (monotypic genus).

EMENDED DIAGNOSIS. Tooth ornament absent; teeth greatly recurved, sharply pointed and labiolingually compressed; premaxilla bears at least eight teeth; dentary bears 36 teeth; parietals do not form a sagittal crest; quadrate overlaps quadrate ramus of pterygoid anterolaterally; paroccipital process of exoccipital-opisthotic is relatively short and massive; occipital condyle not ringed by a groove and extends onto pedicels of the exoccipitals; vertebrae have relatively amphicoelous centra, the shape of a cross section of the articular face being a double sigmoid curve; length of anterior cervical centra less than height. (The postcranial skeleton is known only from anterior cervical vertebrae.)

Kimmerosaurus langhami Brown, 1981

HOLOTYPE. Partial skull and mandible (R.8431).

TYPE LOCALITY. 250–270 m west of Freshwater Steps, to the west of Egmont Bight, Isle of Purbeck, Dorset (National Grid reference SY 942773).

REVISED HORIZON. The specimen was recovered from a detached block of shale coming from about 2 m above the Middle White Stone Band, and is therefore from the upper part of the *eastlecottensis* Subzone, *pectinatus* Zone, Upper Kimmeridge Clay, Kimmeridgian Stage, Upper Jurassic (Cope *et al.* 1980; Cox & Gallois 1981). The horizon was incorrectly given as *rotunda* Zone by Brown (1981: 301).

REFERRED SPECIMENS. R.1798: partial skull and mandible; Kimmeridge Clay; Weymouth (no detailed data available but the specimen almost certainly came from a cliff exposure between Sandsfoot Castle and the old Portland Ferry Bridge described by Damon, 1884).

R.10042: partial skull and mandible, atlas-axis and five cervical vertebrae; from the type locality and horizon, *in situ* about 3 m east of the site of R.8431; collected P. A. Langham, 1976.

Description of skull material

The skull of R.10042. The preserved parts of this skull are the posterior region of the left mandibular ramus including the sockets for the last 15 teeth; a smaller portion of the right mandibular ramus posterior to the tooth row; and a part of the braincase comprising the basioccipital, both exoccipital-opisthotics, the supraoccipital and the basisphenoid.

The left mandibular ramus has undergone some post-mortem straightening, the ventral margin being now almost straight, whereas this is seen in the undistorted holotype skull (R.8431; Brown 1981: figs 28, 38) to show a substantial curvature. In all other features it agrees with the holotype. The angular has fused with the always fused surangular-articular, and posteriorly the position of the closed suture is harder to trace. When the tooth row is laid against that of R.8431 it is found that the 15 tooth sockets of R.10042 occupy the same length as the posterior 17 sockets of R.8431, indicating that the new specimen was a slightly larger individual. Unlike the holotype, the dentary is preserved in full articulation with the posterior elements (Fig. 1). In lateral view the posterior margin of the dentary lies posterior to the highest elevation of the coronoid process, and the most posterior tooth socket is only just in advance of the coronoid process. Brown's lateral reconstruction of the holotype (1981: fig. 29) shows the coronoid process about 15 mm posterior to its true position.

The braincase was preserved compressed around the posterior end of the right mandibular ramus. During preparation the mandible was separated, and only a small fragment of the end



Fig. 1 *Kimmerosaurus langhami* Brown, R.10042. Posterior part of left ramus of mandible in dorso-lateral aspect, $\times 0.6$. A, angular; ART, articular; D, dentary; SA, surangular.

of the retroarticular process now remains attached to the braincase floor (Fig. 2). The elements are somewhat distorted by crushing, and on the right side the basiptyergoid process of the basioccipital has been displaced upwards and outwards so that part of the base now covers the jugular foramen of the right exoccipital-opisthotic. On the left side these fused elements and the basiptyergoid process are much better preserved.

The basioccipital and exoccipital-opisthotics are fully fused, and the line of fusion cannot be traced. However, the edge of the articular surface of the occipital condyle shown in Fig. 2 extends dorsolaterally to form a lip running onto the assumed region of the pedicles of the exoccipitals, indicating that those elements have a role in the formation of the condyle, a feature of taxonomic importance. The condyle is thus not ringed by a groove. However, it shows two differences from that of the holotype: there is no notochordal pit, so that the condyle has a more spherical shape; and the dorsal edge of the condyle is convex, being slightly elevated above the level of the floor of the foramen magnum (whereas in R.8431 the concave floor of the foramen forms its dorsal margin).

The general shape and orientation of the basiptyergoid process of the basioccipital are as in the holotype, but the cartilage-covered area associated with the articular surface for the pterygoid is elliptical in shape and extends further anteromedially than in R.8431. It is separated from the basisphenoid only by a very narrow strip of periosteal bone, whereas in R.8431 the articular surface is more nearly circular and separated from the basisphenoid facet by 8 mm on the right and 11 mm on the left. All other features of the basioccipital and exoccipital-opisthotic are extremely similar to those of the holotype, and in particular the taxonomically important paroccipital process, complete on the left side, agrees in all details.

The basisphenoid and supraoccipital (Fig. 2) have not been described previously as they are absent from R.8431. The basisphenoid is fused to the basioccipital, the position of the sphenoccipital synchondrosis being still discernible dorsally on the floor of the braincase as a transverse shallow groove (partly hidden by the mandibular fragment) but obliterated ventrally. It differs slightly from those of *Muraenosaurus* and *Tricleidus* (described and figured by Andrews 1910: text-figs 44, 73) in the relative proportions of the body to the hypophyseal ('pituitary') fossa. The body appears to be very short in the axial dimension, and the hypo-

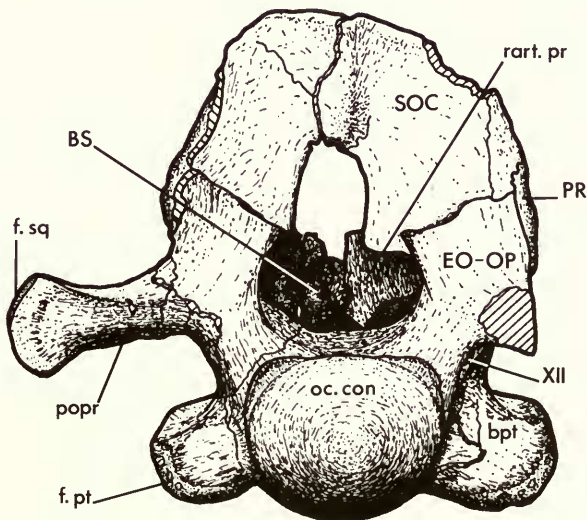


Fig. 2 *Kimmerosaurus langhami* Brown, R.10042. Occipital view of braincase, natural size. bpt, basiptyergoid process of basioccipital; BS, basisphenoid; EO-OP, exoccipital-opisthotic; f.pt, facet for pterygoid; f.sq, facet for squamosal; oc. con, occipital condyle; popr, paroccipital process of exoccipital-opisthotic; PR, prootic; rart. pr, retroarticular process of mandible; SOC, supraoccipital; XII, foramen for hypoglossal nerve (hypoglossal canal).

physial fossa relatively large. The bone of the floor of the fossa probably consists of basisphenoid with the parasphenoid fused beneath, as very clearly shown in Andrews' figure of *Tricleidus*. The internal carotid foramen is visible on both sides and, on account of the shortness of the basisphenoid body, appears relatively close to the base of the basiptyergoid process. On the right side, in advance of the internal carotid foramen, a process of bone ascends to form a contact with the anterior prolongation of the prootic as was described by Andrews (1910) for *Tricleidus* and *Cryptoclidus*.

The supraoccipital resembles in its general shape those of *Muraenosaurus* and *Cryptoclidus* (Andrews 1910: text-fig. 45; pl. 9). It encloses the upper half of the foramen magnum, which is somewhat restricted in diameter at the position of the supraoccipital-exoccipital union. Thus an aperture of almost circular shape is two-thirds surrounded by the basioccipital and exoccipitals but is then extended upwards between the arches of the supraoccipital so that the final shape is irregular, with the greatest diameter in the sagittal plane (see Fig. 2). A ridge or low crest is present in the midline of the occipital surface above the foramen magnum, similar to that seen in *Muraenosaurus* (Andrews 1910: text-fig. 45A). Andrews suggested that the end of this ridge may have projected into the foramen magnum, but his figure is incorrectly orientated, and by tilting the upper edge of the supraoccipital forwards, this 'apparent' projection is eliminated. In R.10042 the supraoccipital is still orientated in approximately the correct plane with reference to the basioccipital.

The supraoccipital itself is rather thin and flat. Dorsally it forms a single facet for the parietal which is slightly crescentic and very elongated transversely (transverse length 37 mm, greatest width 7 mm). As in *Cryptoclidus* (Andrews 1910: pl. 9; text-figs 1, 4) the parietal facet is separated by an area of convex periosteal bone margin (5 mm in the present specimen) from the anteroventrally-directed area of union with the prootic. The latter region is broken on both sides; but the appearance, especially on the right side where the remains of a closed suture may be visible, suggests that the supraoccipital and prootic were fused in this specimen.

The skull of R.1798. This specimen consists of an incomplete mandible in several pieces together with the squamosals and associated fragments of the quadrates, jugals and post-orbitals.

The mandibular tooth row is preserved intact on the right side from the symphysis to the back of the 24th tooth socket. The distance from the median posterior surface of the symphysis to the lingual surface of the back of the right tooth row is 135 mm. On the left side, the ventral margin of the mandible is preserved but there is a large gap in the middle of the tooth row. However, by measuring 135 mm from the symphysis the position of the 24th socket can be determined, and behind this are a further 11 sockets to the back of the tooth row as preserved, bringing the observable count to 35. The dentary behind this point is missing, but on the deep surface of the posterior part of the dentary is seen a shallow depression for the squamous overlap of the surangular. When this same shallow depression is examined in the holotype disarticulated dentary and its relationship to the tooth row noted, the posterior last few sockets of both specimens may be compared, and it appears probable that only one or at the most two further sockets are needed to complete the mandibular tooth row. This gives a count of 36 or 37 in R.1798 which compares with 36 in R.8431.

The posterior elements of the mandible (angular and fused surangular-articular) are preserved on the right side, and are about the same size as in R.10042, being again a little larger than the holotype. The surangular extends 30 mm further anterior to that of R.10042, but its lateral surface bears a shallow depression showing the posterior extent of the dentary, which confirms that the relative positions of the back of the tooth row and of the jaw joint were exactly as in the other two specimens. Similarly, the angular and surangular-articular are fully fused.

In so far as they are preserved, the squamosals and quadrates conform to the structure of those elements in the holotype. The facet for articulation with the paroccipital process of the opisthotic is well seen on the left side. The ventral extremities of the pterygoid facets of the quadrates are present, and on the left side the tip of the quadrate process of the pterygoid



Fig. 3 *Kimmerosaurus langhami* Brown, R.1798. Fragment of left cheek in lateral aspect, $\times \frac{2}{3}$. J, jugal; PO, postorbital; Q, quadrate; SQ, squamosal.

appears fused onto this surface, showing the diagnostic manner of union of these elements. In R.8431 the anterior ramus of the squamosal on both sides terminates at the sutural surface, but on R.1798 posterior fragments of the postorbital and jugal elements remain attached, and anteriorly between these elements, on both sides, a part of the margin of the orbit is preserved. The orbital margin is only 12 mm anterior to the middle of the suture on the squamosal.

The left jugal fragment is the better preserved (Fig. 3), and consists of a thin strap-like element which runs sharply downwards from the squamosal, the ventral margins of the elements forming an obtuse angle of about 100° . The jugal and postorbital are fused, but the outline of the once-discrete left jugal is still clearly visible on the lateral surface of the left side, occupying the lower four-fifths of the anterior end of the squamosal. The postorbital unites with the dorsal end of the jugal and the remaining one-fifth of the end of the squamosal, then extends posteriorly above the squamosal for a distance of 25 mm. In medial aspect, the fused postorbital and jugal are seen to overlap the squamosal more extensively, running from the posterodorsal corner of the postorbital to the ventral obtuse angle between the squamosal and jugal in an almost straight line. On the medial aspect of the right side, the appearance of the broken upper end of the postorbital suggests that it probably continued towards the parietal as the posterior component of the postorbital bar. On the left side the appearance is similar, and in addition there is another process of bone, presumably of the postorbital, which passes anteriorly for about 7 mm and probably would have made contact with the postfrontal. The lower edge of this process forms part of the margin of the orbit, and meets the dorsal margin of the jugal at a rounded-out angle of rather less than 90° to form the posterolateral corner of the orbit.

Discussion. The skulls of R.10042 and R.1798 are of almost identical size, as is shown by the comparison of the mandibular fragments, the only parts to be preserved in both. They are very slightly larger than the holotype skull R.8431. Of the diagnostic characters of *Kimmerosaurus langhami* listed by Brown (1981) and above, the number of mandibular teeth (36 in R.8431) is fairly reliably estimated as 36 or 37 in R.1798, in which specimen also the quadrate is seen to overlap the quadrate ramus of the pterygoid anterolaterally. The paroccipital process of the exoccipital-opisthotic in R.10042 has exactly the same short and massive structure as in R.8431 (representing an extreme of development amongst the Plesiosauroidea). Although the basioccipital and exoccipital-opisthotic are fused in R.10042, their appearance in the specimen nevertheless confirms the formation of the occipital condyle in this genus and species from both elements. Thus the identification of the specimens is determined; there now remain, however, several differences between R.10042 and the holotype to be explained.

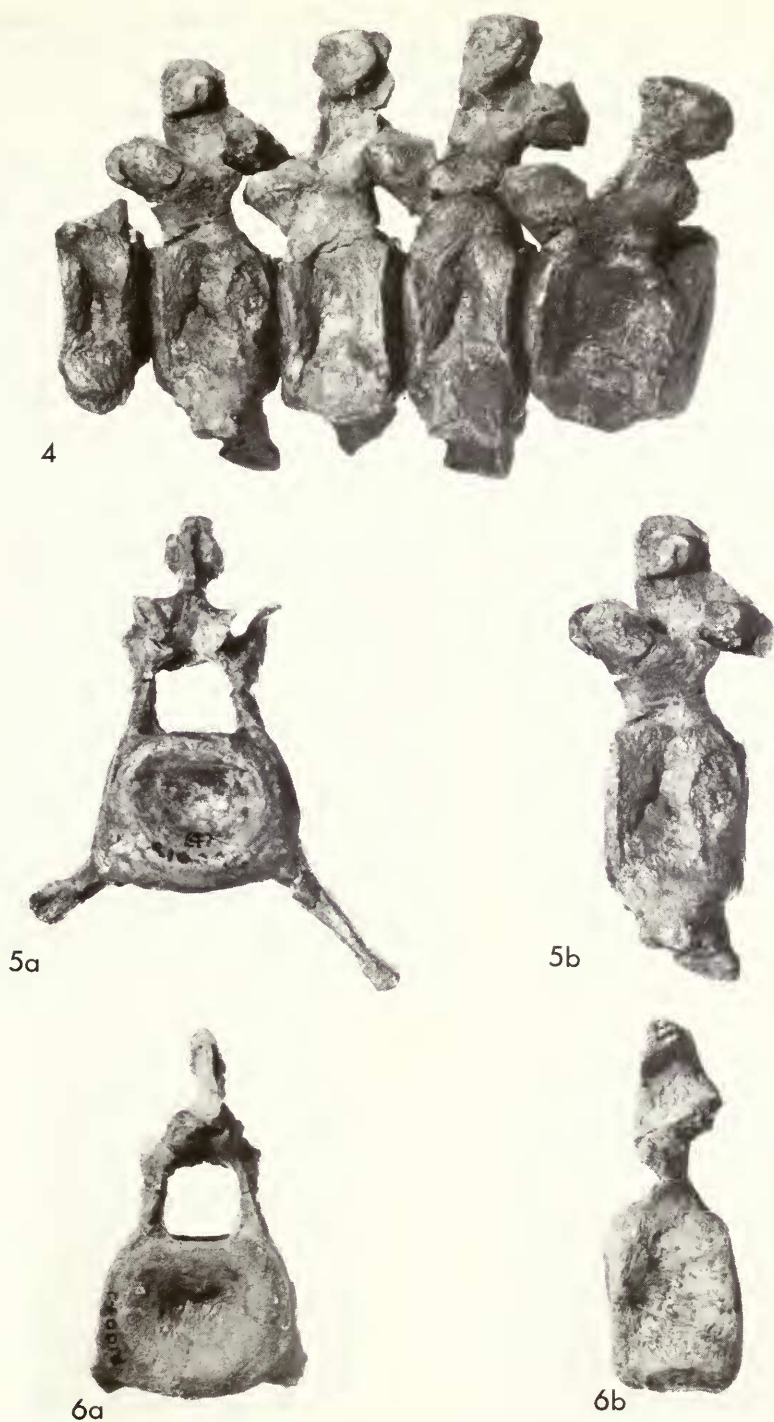
Almost all the differences are accounted for by reference to ontogeny. R.10042 is not only slightly larger than the holotype R.8431 but also ontogenetically a little older because it shows a greater degree of fusion between the elements. The suture between the angular and the surangular-articular is harder to trace; the dentary is preserved in full articulation with the posterior mandibular elements, whereas in R.8431 it was more loosely attached and was preserved disarticulated. The basioccipital and exoccipital-opisthotic are fully fused with complete obliteration of the synchondrosis and, similarly, the sphenoccipital synchondrosis is largely closed, whereas all the braincase elements recovered in R.8431 were disarticulated. In view of this weight of evidence that R.10042 represents an individual older than R.8431, it seems reasonable to suppose that the lack of a notochordal pit in the occipital condyle of R.10042 is also an ontogenetic difference, the late-lingering embryonic remnant seen in R.8431 being eventually eliminated.

One other difference between R.10042 and R.8431, the greater extent of cartilage-covered surface on the basiptyergoid process of the former, still requires explanation. The condition in R.10042 more closely resembles that seen in the genera *Cryptoclidus*, *Muraenosaurus* and *Tricleidus*, in which the pterygoid and basisphenoid facets of the basioccipital show confluence of cartilage in all but the most fully-ossified 'old adult' specimens (Brown 1981). The difference between the specimens is thus contrary to expectations based upon ontogeny, and it may therefore be that the holotype is atypical in this regard.

Finally, the preservation of fragments of the jugal and postorbital associated with the squamosal in R.1798 (the relationship of the orbital margin can be seen in Fig. 3) demonstrates that the arrangement of this region of the skull as tentatively reconstructed by Brown (1981: fig. 29) is broadly correct. In particular, the orientation of the jugal as a narrow near-vertical bar forming parts of both the orbit margin and the ventral margin of the cheek, not typical of plesiosaurs generally, is confirmed by this specimen.

Description of vertebrae

The fused atlas-axis and five anterior postaxial cervical vertebrae are preserved with R.10042. This is the only postcranial material yet discovered in association with diagnostic skull material of *Kimmerosaurus langhami*. There can be no proof that the disarticulated vertebrae are serial, but direct evidence that they are all from the very anterior end of the neck is provided by the neural spines. On the sides of the neural spines, just below their tips, are well-developed excrescences which arise behind the anterior edge of the spine and form oblique ridges which run posterodorsally and increase in elevation to terminate abruptly near the posterior margin of the spine. In the neotype of *Cryptoclidus eurymerus* (Phillips) (R.2860) and the holotype of *Muraenosaurus leedsii* Seeley (R.2421), which are adult specimens, have complete necks and represent distinct families (Cryptoclididae and Elasmosauridae respectively), these same excrescences occur only on the neural spines of the first five or six postaxial vertebrae. They were probably, therefore, associated with the attachment of muscles or slips of nuchal ligament involved in supporting the dorsal part of the occiput. When placed together the postaxial vertebrae appear to comprise a good series and have therefore been numbered 3-7 (Fig. 4).



Figs 4–5 *Kimmerosaurus langhami* Brown, R.10042. Fig. 4, postaxial cervical vertebrae placed in series 3–7 from left to right, $\times \frac{2}{3}$. Fig. 5, cervical vertebra 4, $\times \frac{3}{4}$: a, posterior; b, left lateral aspect.
Fig. 6 *Colymbosaurus trochanterius* Owen, R.10062. Anterior cervical vertebra, $\times \frac{3}{4}$: a, posterior; b, left lateral aspect.

The atlas-axis has the usual adult form, with all the component elements fused. The atlas-neural arch outline can still be distinguished, but the atlas intercentrum cannot. Both atlas and axis ribs were fused and are now broken off and missing. In all respects the complex is indistinguishable from the atlas-axis of *Cryptoclidus eurymerus*; fusion of component parts beyond that seen in R.2860 (Andrews 1910: text-fig. 78C, D) indicates again that this is an 'old adult' specimen.

The neural arches and cervical ribs of the postaxial vertebrae are fully fused. In addition to the excrescences on the neural spines, already described, a horizontal rugose ridge runs antero-posteriorly across the side of the anterior zygapophysis and neural arch pedicle, a feature which was also noticed in anterior vertebrae of *Cryptoclidus* and *Muraenosaurus*. All the cervical ribs are damaged and it is not possible to describe their exact shape or make comparisons.

The anterior cervical centra of plesiosaurs show three characters of importance in taxonomy: the presence or absence of a lateral keel (lateral longitudinal ridge, lateral crest *auctt.*); the shape of the anterior face; and the proportional length of the centrum. The latter character is, for comparative purposes, expressed as a vertebral length index (VLI), which is calculated as the vertebral length (l) divided by the average of posterior central width (w) and height (h), $\times 100$ (Brown 1981). In R.10042 the lateral keel is absent (Fig. 5), and the articular face is deeply concave, the shape of the transverse section being a double sigmoid curve because the margins of the face are convex. The measurements of the centra of R.10042 are given below. Also given are corresponding figures for three 'adult' specimens of *Colymbosaurus trochanterius* (Owen): 40106 (holotype of *Plesiosaurus manselii* Hulke, synonymized with *C. trochanterius* by Brown, 1981); SMC J.29596 etc. (syntype of *Plesiosaurus megadeirus* Seeley, also synonymized with *C. trochanterius* by Brown, 1981); and R.10062 (Fig. 6), a recently collected specimen from the Isle of Portland, reported by Brown, 1984.

In *Kimmerosaurus* R.10042 the length index of the atlas-axis is more than 20% less than in *Colymbosaurus* 40106 and SMC J.29596 etc. Similarly, the average vertebral length index for the first five postaxial vertebrae is only 66.6, and so these are proportionally 20% shorter than in SMC J.29596 etc. In *Colymbosaurus* 40106 there is a gap in the sequence of vertebrae preserved from the axis to about the twelfth cervical, and so comparison between the most anterior postaxial cervical vertebrae of that specimen and R.10042 cannot be made. In R.10062 the neck is very incomplete and only one very anterior cervical, showing lateral excrescences on the neural spines, has been found (Fig. 6). This vertebra has dimensions between those of cervicals 3 and 4 (Fig. 5) of R.10042, and its vertebral length index is only 67.9, almost exactly the same as the average (67.3) of those two vertebrae in R.10042.

Table 1 Measurements of anterior cervical vertebrae (mm). l = vertebral length; w = posterior central width; h = posterior central height. VLI = vertebral length index ($l \times 100 \div (w + h)/2$); see text. (E) = estimated.

1. R.10042		l	w	h	VLI
Atlas-axis	crushed laterally	35.9	*31.6	*25.2	126.4
Cervical 3	good condition	18.8	34.8	27.0	60.8
Cervical 4	posterior face chipped	24.7	38(E)	28.9	c. 73.8
Cervical 5	good condition	25.6	44.0	33.2	66.3
Cervical 6	crushed longitudinally	28(E)	46.5	40.4	c. 64.4
Cervical 7	crushed vertically	31.4	47.7	45(E)	c. 67.7
2. Specimens of <i>C. trochanterius</i>		l	w	h	VLI
40106	atlas-axis	45.8	33.0	26.8	152.3
SMC J.29596 etc.	atlas-axis	44.7	30.0	26.8	163.1
R.10062	'anterior' cervical	21.8	36.0	28.2	67.9
SMC J.29596 etc.	cervical 5	27.9	36.2	30.2	84.0

* w and h are anterior face of cervical 3.

Discussion. Brown (1981) recognized two species of Upper Jurassic plesiosauroids from the Kimmeridge Clay of England and referred them to two monotypic genera. One of those is *Kimmerosaurus langhami* Brown 1981, hitherto known only from cranial material; its skull is the most lightly built of all species in the Upper Jurassic. The other is *Colymbosaurus trochanterius* (Owen 1840) known only from five incomplete skeletons and a number of isolated propodials; it is the longest English plesiosauroid (>6 m) and the most massively built. Brown referred the two genera to different families, *Kimmerosaurus* to the Cryptoclididae of Williston and *Colymbosaurus* to the Elasmosauridae of Cope.

The only elements known in both genera are the anterior cervical vertebrae (in *Kimmerosaurus* only in specimen R.10042); they are closely similar, especially with regard to the posterior height and width of the centra and the form of the articular facet. *Colymbosaurus* and *Kimmerosaurus* might therefore be synonyms for a genus of plesiosauroid with a lightly built delicate skull and a specialized fine slender dentition. If that were true, it would affect the choice of criteria by which the families Cryptoclididae and Elasmosauridae might be distinguished.

The elasmosaurids are typified by elongated necks, produced by increases both in the number of cervical vertebrae and in the proportional lengths of the individual centra, especially the anterior cervicals. Further, according to Brown, their anterior cervical centra are generally equipped with a lateral keel and an articular face which has either a single shallow concavity or an open V-shape. The cryptoclidids, by contrast, do not have elongated necks (the number of cervical vertebrae remaining at the primitive figure of 30–32); their anterior cervical centra do not have lateral keels; and the articular faces of those centra show a deep concavity with a convex rim. They share certain characters of the dentition and occiput.

Of the plesiosauroid genera in the Middle and Upper Jurassic of England, *Muraenosaurus* is a typical elasmosaurid—though with its neck less elongated than in Cretaceous elasmosaurs. The anterior cervical vertebrae of *Tricleidus* and *Colymbosaurus*, though those genera are included by Brown (1981) in the Elasmosauridae, lack lateral keels and possess an articular face shape like those of cryptoclidids. Brown referred *Tricleidus* to the elasmosaurids only because of certain characters of the dentition and occiput, and *Colymbosaurus* was included only because of its augmented cervical count (42).

Measurement of the average VLI of cervical vertebrae 3–7 of the above plesiosauroids and of *Kimmerosaurus* R.10042 provides useful comparative data. Values, in descending order of relative length of centra, are as follows:

'adult' <i>Muraenosaurus</i> (R.2421)	95.1;
'adult' <i>Tricleidus</i> (R.3539)	93.7;
'old adult' <i>Cryptoclidus</i> (GLAHM V.1091)	88.8;
'adult' <i>Colymbosaurus</i> (SMC J.29596 etc.)	84;
'old adult' <i>Kimmerosaurus</i> (R.10042)	66.6 (VLI is increased with ontogeny).

These figures show that, with regard to proportional length of anterior cervical centra, *Colymbosaurus* falls within the same range as *Cryptoclidus*, whereas in *Kimmerosaurus* R.10042 these vertebrae are proportionally 20% shorter. A similar degree of difference is found between the VLI of the atlas-axis in *Colymbosaurus* and *Kimmerosaurus* R.10042. Since this difference is greater than the margin separating 'adult' *Muraenosaurus* and 'old adult' *Cryptoclidus*, the measurements suggest that *Colymbosaurus* and *Kimmerosaurus* are very distinct. However, the dimensions and VLI of the only known anterior cervical of *Colymbosaurus* R.10062 fall between the values for cervicals 3 and 4 of *Kimmerosaurus* R.10042, and those vertebrae of the two individuals are indistinguishable. Thus the evidence for synonymizing the genera is ambivalent.

A full description of R.10062 might throw further light on the problem of the status of the genera, and it is possible that cranial material of this specimen may yet be found. Discovery of a single associated tooth, for example, would end the debate. If *Kimmerosaurus* should prove to be a junior synonym of *Colymbosaurus*, then the skull characters of the enlarged genus would still show it to be a cryptoclidid, albeit with an independently derived increase in the number of cervicals. If not, then *Kimmerosaurus* would simply remain a cryptoclidid; but *Colymbosaurus* might still be an elasmosaurid because of its longer neck. Until such time as diagnostic associated skull and postcranial material is found, it is in the interest of stability of nomenclature to retain both names.

Summary

Two additional specimens of the Kimmeridgian cryptoclidid plesiosauroid *Kimmerosaurus langhami* Brown, identified and described with reference to the hitherto unique holotype, provide new data on osteology and ontogenetic changes of the braincase and cheek. The only known postcranial elements of *Kimmerosaurus* are the atlas-axis and anterior cervical vertebrae; the vertebrae are closely comparable with those of *Colymbosaurus*, a contemporary elasmosaurid known only from postcranial material. The possibility that *Kimmerosaurus* might be synonymous with *Colymbosaurus* is discussed, in which case *Colymbosaurus* would have to be reassigned at family level as a long-necked cryptoclidid. However, the evidence for synonymy is ambivalent and both names are currently retained pending the description of more complete material.

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References

- Andrews, C. W. 1910. *A descriptive catalogue of the marine reptiles of the Oxford Clay*. 1. 205 pp., 10 pls. London, British Museum (Natural History).
- Blainville, H. D. de 1835. Description de quelques espèces de reptiles de la Californie, précédée de l'analyse d'un système général d'Erpetologie et d'Amphibiologie. *Nouv. Ann. Mus. Hist. nat. Paris* (3) 4: 232–296.
- Brown, D. S. 1981. The English Upper Jurassic Plesiosauroidea (Reptilia) and a review of the phylogeny and classification of the Plesiosauria. *Bull. Br. Mus. nat. Hist.*, London, (Geol.) 35 (4): 253–347. See Erratum below.
- 1984. Discovery of a specimen of the plesiosaur *Colymbosaurus trochanterius* (Owen) on the Island of Portland. *Proc. Dorset nat. Hist. archaeol. Soc.*, Dorchester, 105: 170.
- Cope, J. C. W., Duff, K. L., Parsons, C. F., Torrens, H. S., Wimbledon, W. A. & Wright, J. K. 1980. A correlation of Jurassic rocks in the British Isles. Part Two: Middle and Upper Jurassic. *Spec. Rep. geol. Soc. Lond.* 15. 109 pp.
- Cox, R. M. & Gallois, R. W. 1981. Stratigraphy of the Kimmeridge Clay of the Dorset type area and its correlation with some other Kimmeridgian sequences. *Rep. Inst. geol. Sci.*, London, 80/84: 1–44.
- Damon, R. 1884. *Geology of Weymouth, Portland, and the coast of Dorsetshire, from Swanage to Bridport-on-the-Sea: with natural history and archaeological notes*. 3rd edn. 250 pp., 61 figs. Weymouth.
- Gray, J. E. 1825. A synopsis of the genera of reptiles and Amphibia, with a description of some new species. *Ann. Phil.*, London, 26: 193–217.
- Owen, R. 1840. Report on British fossil reptiles. Part 1. *Rep. Br. Ass. Advmt Sci.*, London, 9: 43–126.
- Welles, S. P. 1943. Elasmosaurid plesiosaurs with a description of new material from California and Colorado. *Mem. Univ. Calif.*, Berkeley, 13 (3): 125–215.
- Williston, S. W. 1925. *The osteology of reptiles* (ed. Gregory, W. K.). 300 pp. Cambridge, Mass.

Erratum

In Brown (1981: 263) the caption to fig. 4 is unfortunately incomplete as printed. The last sentence should read 'Sites of fusion between the articular, angular and surangular (indicated by broken lines) are discernible from bone growth-lines.'