

THE EARLY CRETACEOUS BRACHIOSAURID DINOSAURS *ORNITHOPSIS* AND *EUCAMEROTUS* FROM THE ISLE OF WIGHT, ENGLAND

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ABSTRACT. The lectotype of *Ornithopsis* is usually placed within the Brachiosauridae, but is unlike any other material that has been referred to the genus. This referred material is also brachiosaurid but is regarded as belonging to the genus *Eucamerotus* which was originally established without a type species. *Eucamerotus foxi* sp. nov. is erected for this material, and a holotype and five paratypes are designated. *Eucamerotus* is placed within the Brachiosauridae. Several genera of sauropod dinosaurs, previously established from the Lower Cretaceous Wealden formation of the Isle of Wight, are *nomina vana* as they are based on inadequate type material. All described Wealden sauropod material other than dorsal vertebrae should be described as Sauropoda *Incertae Sedis* or Brachiosauridae *Incertae Sedis*.

SEVERAL Lower Cretaceous sauropod genera were established by Owen, Seeley, Hulke and others, mostly based on inadequate material. *Cetiosaurus brevis* Owen, 1842 was founded on some vertebrae from Sussex with other vertebrae also referred to it. These referred specimens were made the type of *Cetiosaurus conybeari* by Melville (1849). A large humerus from Sussex was used by Mantell (1850) to establish the name *Pelorosaurus conybeari*. *Ornithopsis hulkei* Seeley, 1870 was based on two dorsal centra, one from Sussex, the other from the Isle of Wight, both of which were subsequently renamed by Owen (1875): the Sussex specimen as *Bothriospondylus elongatus* and the Isle of Wight specimen as *Bothriospondylus magnus*. Hulke (1870, 1871) described a dorsal neural arch from the Isle of Wight as *Eucamerotus* without giving it a species name. *Chondrosteosaurus gigas* Owen, 1876 and *C. magnus* Owen, 1876 were established for Isle of Wight vertebrae, cervical and dorsal respectively. Owen (1876) also proposed the synonymy of *Chondrosteosaurus magnus* with *Bothriospondylus magnus*. Lydekker proposed the presence of two American genera in the Weald, a new species of *Pleurocoelus* (*P. valdensis* Lydekker, 1889), based on vertebrae, and *Morosaurus* (*Camarasaurus*) (Lydekker, 1892), based on foot bones.

The name *Ornithopsis hulkei* has been much used for sauropod material, both Lower Cretaceous and Upper Jurassic, despite the type specimen being an isolated dorsal centrum, which offers little for comparison with other vertebrate specimens. *Ornithopsis* would be considered as a *nomen vanum* but for the fact that dorsal vertebrae are 'very diagnostic among the sauropods' (Berman and McIntosh 1978, p. 33), and the name remains widely used in dinosaur literature for Wealden sauropods. A brief systematic review and discussion of the species are included here.

Abbreviations. BMNH, Natural History Museum, London; MIWG, Museum of Isle of Wight Geology, Sandown, Isle of Wight.

SYSTEMATIC PALAEOLOGY

Class REPTILIA Linnaeus, 1758

Order SAURISCHIA Seeley, 1888

Suborder SAUROPODOMORPHA Huene, 1932

Infraorder SAUROPODA Marsh, 1878

Family BRACHIOSAURIDAE Riggs, 1904

Diagnosis. Following McIntosh (1990a, 1990b) and Riggs (1904): large sauropods with forelimbs longer than hind limbs; vertebrae with deep, complex pleurocoels; strong opisthocoely

throughout the dorsal series; short simple massive neural spines throughout, tallest over the shoulder region.

Genus ORNITHOPSIS Seeley, 1870

Type species. O. hulkei Seeley, 1870

Ornithopsis hulkei Seeley, 1870

Text-figure 1A–B

- 1870 *Ornithopsis hulkei* Seeley, p. 279.
- 1875 *Bothriospondylus magnus* Owen, p. 24, pls. 8–9.
- 1879 *Ornithopsis* Seeley; Hulke, p. 754.
- 1882 *Ornithopsis* Seeley; Hulke, p. 375.

Lectotype. BMNH 28632, posterior dorsal vertebra, chosen from syntypes of Seeley 1870, from Brook, Isle of Wight, England. Figured in Text-figure 1A–B.

Type horizon. Wealden Marls (Wessex Formation) Lower Cretaceous (Barremian).

Diagnosis. Medium-sized brachiosaurid sauropod; posterior dorsal vertebrae are opisthocoelian with tall narrow centra; pleurocoels extend over the posterior two-thirds of the centrum near the base of the neural arch; the centrum has a basal ridge; parapophyses occur high on the neural arch.

Remarks. BMNH 28632 is the lectotype of *Ornithopsis hulkei* (Text fig. 1A–B) and was originally proposed as the syntype together with a vertebra from Sussex (BMNH 2239). There is no justification for linking these two vertebrae together as the syntypes, and Lydekker (1888) noted Seeley's approval for making the Isle of Wight specimen the type of *Ornithopsis hulkei*. The other specimen is here regarded as Sauropoda *Incertae Sedis* and Owen's binomen, *Bothriospondylus elongatus*, is a *nomen vanum* restricted to the type specimen. BMNH 28632 is very different to all other specimens referred to *Ornithopsis hulkei*. On this basis, the binomen can only be retained for this specimen, until such time as new vertebrae referable to *Ornithopsis hulkei* are found in association with other bones.

Since BMNH 28632 is restricted to a centrum only, precise family affinities cannot be established, but the following features are suggestive of a brachiosaurid origin. The centrum is tall and narrow and has a prominently ridged base. The deep pleurocoel is sub-triangular to round, occupying the posterior two-thirds of the centrum close to the neural arch. This is distinct from the other dorsal vertebrae currently referred to *O. hulkei*, where the pleurocoels are more anterior or extend nearly the length of the centrum, and the base is flat. The opisthocoelous nature of the centrum is well developed with a prominent anterior ball, and the parapophyses appear to have been high on the neural arch beyond that portion of the vertebra preserved. The combination of a high parapophysis position with strong opisthocoely suggests that this is a dorsal centrum from the caudal end of the sequence. Strong opisthocoely occurs only in the first four anterior dorsals in diplodocids where the parapophysis is sited on the centrum (dorsals 1–3 in *Diplodocus* and *Apatosaurus excelsus*), the centra becoming more amphiplatyan towards the posterior of the series. Middle and posterior dorsals of brachiosaurids, camarasaurids and titanosaurids have strong opisthocoely. Posterior camarasaurid centra appear short in length relative to height, whilst brachiosaurid centra are more elongate and become progressively more so anteriorly. The increased length of BMNH 28632 relative to height is suggestive of a brachiosaurid origin. The neural and lateral processes are missing, and thus the specimen lacks most of the parts which bear the features cited by McIntosh (1990a) as titanosaurid, except for the pleurocoel which is regular, deep and distinct in the specimen,



TEXT-FIG. 1. A–B, *Ornithopsis hulkei*, lectotype, BMNH 28632, dorsal vertebral centrum. A, anterior view; B, left lateral view. C, *Eucamerotus foxi* sp. nov., holotype, BMNH R2522, neural arch in anterior view. Both from the Lower Cretaceous Wessex Formation of Brook, Isle of Wight. All $\times 0.33$.

not moderate and irregular as in titanosaurids. The internal bone structure incorporates large, coarse cavitations, a brachiosaurid feature, unlike the fine cancellous bone structure of cetiosaurids and other sauropods (J. McIntosh, pers. comm.).

Genus *EUCAMEROTUS* Hulke, 1871

Type species. Eucamerotus foxi sp. nov.

Eucamerotus foxi sp. nov.

Plate 1, figures 1–6; Text-figures 1c, 2, 5

Derivation of name. After William Fox who collected most of the paratypes.

1871 *Eucamerotus* Hulke, p. 36.

Holotype. BMNH R2522, vertebral neural arch, Text-figure 1c.

Type horizon and locality. Wealden Marls (Wessex Formation), Lower Cretaceous (Barremian) of Brook, Isle of Wight, England.

Range. Wealden Marls (Wessex Formation) Lower Cretaceous.

Paratypes. BMNH R89, two dorsal vertebrae; BMNH R90, two dorsal vertebrae; BMNH R2524, juvenile dorsal vertebrae.

Referred specimens. BMNH R91, three dorsal vertebrae; BMNH R2523 (in part), three dorsal vertebrae; BMNH R406, anterior of dorsal centrum; BMNH R708, dorsal centrum; BMNH R94 (in part), dorsal vertebral pieces; MIWG 5314, juvenile dorsal centrum; MIWG 5125, anterior dorsal centrum; MIWG (BP001), new and undescribed partial skeleton.

Diagnosis. Medium-sized sauropod; dorsal vertebrae with broad, rounded centra, flattened bases, strongly opisthocoelian; deep lateral pleurocoels mostly placed anteriorly and becoming shallower posteriorly; shallow depth of bone below pleurocoel; tall neural arch with large anterior and posterior supra-neural concavities; strongly ridged neural and lateral spines; broad termination on the neural spine.

Remarks. The holotype (BMNH R2522, Text-fig. 1c) differs from the lectotype of *Ornithopsis* and cannot be referred to it (as has been the usual practice). The two genera are therefore not synonymous. All the material previously referred to *Ornithopsis* can be referred either to *Eucamerotus* (the dorsal vertebrae listed here) or to Sauropoda *Incertae Sedis*. No species was founded for *Eucamerotus* by Hulke, and *E. foxi* sp. nov. is erected here. Five paratypes, mostly from the Fox collection are also designated. Article 11(c) section (i) of the International Code of Zoological Nomenclature (ICZN 1985) states: 'A work published before 1931 and containing uninominal genus-group names without associated nominal species is accepted as consistent with the Principle of Binominal Nomenclature in the absence of evidence to the contrary'. ICZN Article 12(a) states: 'To be available every new scientific name published before 1931 must satisfy the

EXPLANATION OF PLATE 1

Figs 1–6. *Eucamerotus foxi* sp. nov., paratypes, all are single dorsal vertebrae. 1, anterior view. 2, left lateral view. 3, left lateral view. 4, anterior view. 5, anterior view. 6, left lateral view. All from the Lower Cretaceous Wessex Formation of the Isle of Wight. 1–4 (BMNH R89 in part) are $\times 0.14$; 5 and 6 (BMNH R90 in part) are $\times 0.16$.



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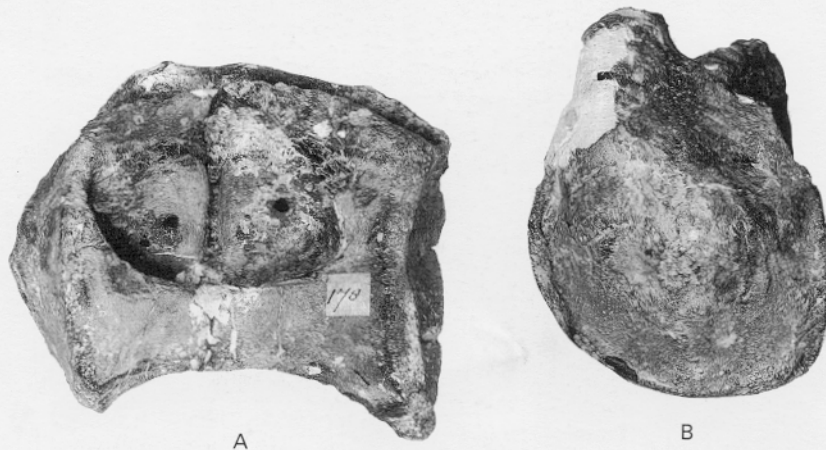
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BLOWS, *Eucamerotus foxi*

provisions of Article 11 and must have been accompanied by a description or a definition of the taxon that it denotes, or by an indication.' The 'indication' is referred to in ICZN Article 12(b) (7): 'the proposal of a new genus-group name or of a new species-group name in association with an illustration of the taxon being named...even if contained in a work...that is not consistently binominal'.

Four of the new paratypes of *E. foxi* (BMNH R89 and R90) may be part of a single skeleton, perhaps including four cervical vertebrae (BMNH R87, R87a, R173) described by Hulke (1880), although Fox gave no indication of any association (Blows 1983). These cervical vertebrae are regarded as Sauropoda *Incertae Sedis*.

BMNH R89 (Pl. 1, figs 1-4) comprises two dorsal vertebrae, one of which was described and illustrated by Hulke (1880). They are tall with long lateral pleurocoels divided into two or three separate depths, with the deepest cavities being anterior. Large deep supra-neural concavities exist above the neural canals within the neural arch, and the bases of the centra are broad and flat, with less bone below the pleurocoel compared with *Ornithopsis*. BMNH R90 (Pl. 1, figs 5-6; Text-fig. 5A) comprises similar, less complete vertebrae than R89, having lower and longer centra. A juvenile centrum (BMNH R2524, Text-fig. 2) described by Hulke (1879) is also included with the paratypes.



TEXT-FIG. 2. *Eucamerotus foxi* sp. nov., paratype, BMNH R2524, juvenile dorsal vertebra. A, left lateral view; B, anterior view. From the Lower Cretaceous Wessex Formation of the Isle of Wight, $\times 0.5$.

It is similar to the adult forms, being smaller with pleurocoels proportionately larger and deeper, and occupying a larger surface area of the lateral centrum than in the adult. The opisthocoelian nature of the centrum is less well developed than in the adult.

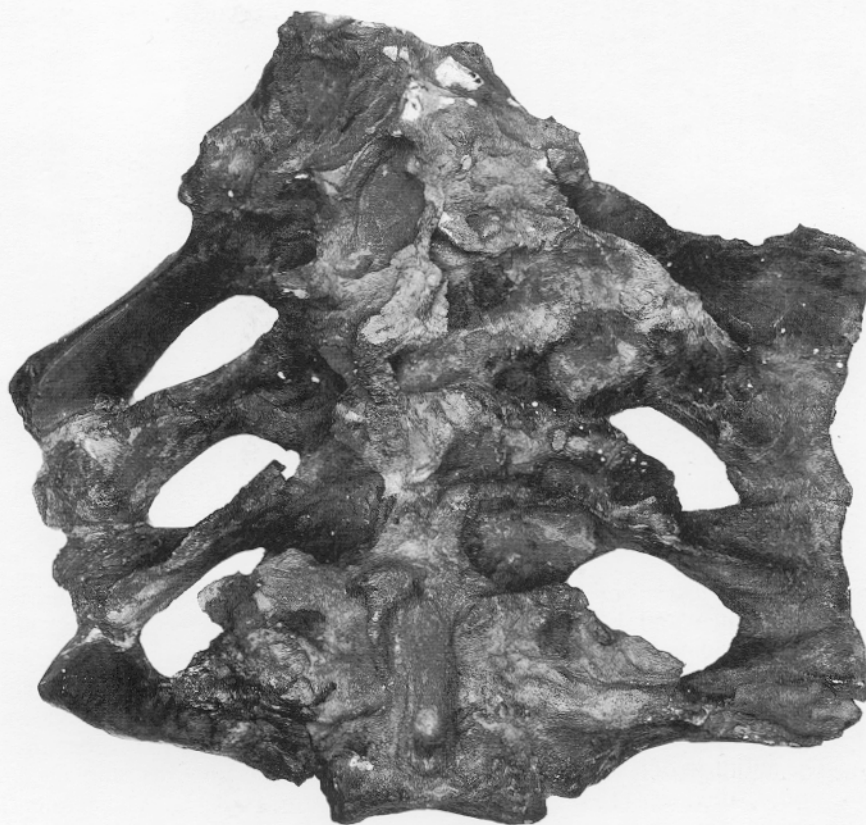
The brachiosaurid dorsal vertebral characteristics described by Riggs (1904) and Bonaparte (1986) are: more than ten vertebrae with simple, non-bifurcated neural spines which increase in length from sacrum to mid-dorsal region; large, elongated centra; axially elongated neural arch and base of spine. To this, McIntosh (1990a, 1990b) has not added familial dorsal vertebral characters, but noted that *Brachiosaurus* shows the highest neural arches and spines over the shoulders and the lowest over the sacrum. This corresponds with limb length. The pleurocoels are deep and clearly defined within a strongly opisthocoelous centrum. In *Eucamerotus*, the dorsals correspond with those features indicated for a single vertebra. The neural arches and spines are tall (especially in R89) which suggests a possible anterior presacral position. If this is correct, the absence of neural spine bifurcation precludes a camarasaurid and diplodocid origin, and the lack of posterior slope

to the neural spine excludes them from a titanosaurid origin. The top of the neural spine expands laterally and has a gently rounded crest, when viewed anteriorly, which is very similar to *Brachiosaurus*.

A newly discovered partial skeleton, currently being prepared at Sandown Museum (MIWG BP001) can be referred to *Eucamerotus foxi* on the basis of the dorsal vertebral morphology, which is identical to that in the paratypes established here. This represents a future opportunity to extend the description of this genus to skeletal elements other than the dorsal vertebrae.

BRACHIOSAURIDAE INCERTAE SEDIS

Parts of a pelvis and sacrum of a large brachiosaurid sauropod from the cliff at Luccombe Chine, Isle of Wight, were briefly described by Swinton (1946) and Stroh (1949). The sacrum (BMNH R12713) comprises four vertebrae (Text-fig. 3), and since most sauropods have five or more, this



TEXT-FIG. 3. Sauropod sacrum, BMNH R12713, dorsal view, associated with the pelvic bones of Text-fig. 4. From the Cretaceous of Luccombe Chine, Isle of Wight, $\times 0.14$.

suggests that some vertebrae may be lost in this specimen. Four lateral sacral ribs extend from both sides and fuse distally at the ilio-sacral joint, but some of this joint has been artificially replaced.

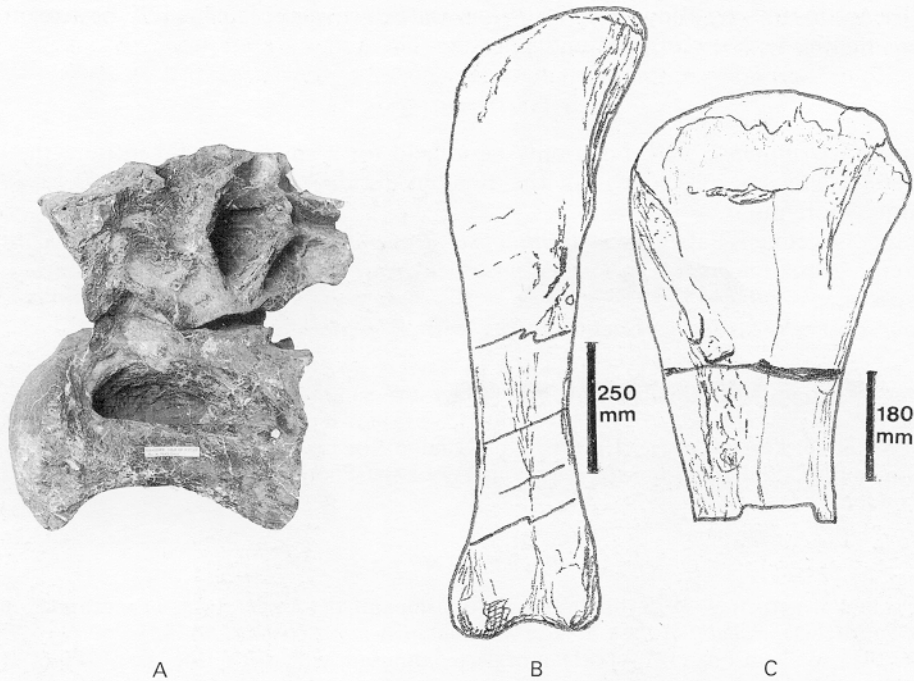
The associated pelvis consists of both ilia and both pubes. The two ilia are nearly complete (Text-fig. 4A) and are about 750 mm long and 630 mm deep. They are concave medially and slightly

convex laterally, with a ridge extending down centrally to the upper margin of the acetabulum. The iliac crest is high as in other brachiosaurid genera. The pubes are long, narrow and flat (Text-fig. 4B-C). Fox found a right ischium and pubis which together were described by Hulke (1882) as the



TEXT-FIG. 4. A, Sauropod right ilium, BMNH R12713, in lateral view; B, associated right pubis in medial view; C, associated left pubis in lateral view. From the Cretaceous of Luccombe Chine, Isle of Wight. All $\times 0.1$.

type specimen of '*Ornithopsis eucamerotus*' (BMNH R97). The pubis is slightly shorter than the Luccombe Chine specimen and is broader with a distinct rounded termination. The ischium, illustrated by Hulke articulated to the pubis, now consists of the proximal half only. I am unable to prove that this pubis and ischium are part of the same pelvis. Although Hulke gave a good description, he did not indicate if they were discovered together, and Fox left no evidence of their association *in situ*. The bones appear to be different in preservation and I consider them to be of separate origin. The addition of a second right ischium to the BMNH R97 assemblage confuses the picture further, and Lydekker (1888) catalogued one ischium as R97a. The name *Ornithopsis eucamerotus*, for which this is the type, is no longer valid, and the specimen is regarded as *Brachiosauridae Incertae Sedis*. A complete left femur (MIWG 6484; Text-fig. 5A) has a long slender shaft that narrows towards the distal epiphysis. The head is inclined obliquely upwards on broad trochanters and merges imperceptibly with the shaft rather than flattening at right angles to the shaft as it does in diplodocids. The fourth trochanter is placed about two-thirds up the length of the bone. It is possible that this femur may be part of the new partial skeleton (MIWG BP001, S. Hutt, pers. comm.). The head of a large right humerus (MIWG 5211; Text-fig. 5B) resembles those of brachiosaurids. It has a well preserved rounded articular end surface with a pronounced deltoid crest.



TEXT-FIG. 5. A, *Eucamerotus foxi* sp. nov. paratype dorsal vertebra, BMNH R90 in part, left lateral view, $\times 0.14$. B–C, Brachiosaurid sauropod; B, left femur, MIWG 6484, in posterior view, $\times 0.07$; C, proximal portion of a humerus, MIWG 5211, in anterior view, $\times 0.83$. All from the Lower Cretaceous of the Isle of Wight.

Taxonomic status of some British sauropods

Jurassic material attributed to the genus Ornithopsis. Delair (1959) indicated that sauropod remains from the Jurassic of Dorset were *Ornithopsis* but gave no supporting evidence for this. However, since the lectotype of *Ornithopsis* is a single dorsal centrum of Lower Cretaceous age and no Jurassic specimens are bones homologous with this lectotype, direct comparison and therefore referral is not possible. The name *Ornithopsis* is therefore confined at present to the Lower Cretaceous and all the Jurassic specimens listed by Delair (1959, pp. 81–83) are regarded as Brachiosauridae *Incertae Sedis* (McIntosh 1990a). These are: '*Ornithopsis humerocristatus*' Hulke, 1874 based on a humerus from the Kimmeridge Clay of Weymouth, Dorset (BMNH 44635); '*Ornithopsis manseli*' Lydekker, 1888 based on a humerus from the Kimmeridge Clay of Dorset (BMNH 41626); and '*Ornithopsis? leedsi*' Hulke, 1887 based on a proximal portion of a pubis from the Kimmeridgian of Weymouth, Dorset (BMNH 49165). '*Ornithopsis sp.*', based on a tooth from the Portland Stone of the Isle of Portland, Dorset (BMNH R5833), is regarded as Sauropoda *Incertae Sedis*.

The status of Pelorosaurus conybeari Mantell, 1850. *Ornithopsis* and *Eucamerotus* have been synonymized with the mainland genus *Pelorosaurus* by several authors (e.g. Romer 1966; Olshevsky 1978). McIntosh (1990a and pers. comm.) tentatively accepted the synonymy of all the English Lower Cretaceous brachiosaurs under *Pelorosaurus conybeari*, which he stated to be close to *Brachiosaurus* in most respects. However, the type of *Pelorosaurus* is a humerus which cannot be compared with dorsal vertebrae, or most of the other bones referred to the Brachiosauridae, and therefore the genera should be regarded as separate. *Pelorosaurus* is from the Tilgate Stone (Grinstead Clay) which is Valanginian and thus earlier than the Wealden Marls (Barremian) of the Isle of Wight. Between these two horizons, a hiatus occurs in the dinosaur faunas (Hauterivian) as

noted for the nodosaurs by Blows (1987). *Pelorosaurus conybeari* is probably best regarded as a *nomen vanum* as the type specimen is undiagnostic.

CONCLUSIONS

1. The binomen *Ornithopsis hulkei* can only be upheld for a single dorsal centrum, the lectotype (BMNH 28632) which is placed within the Brachiosauridae. *Ornithopsis* and *Eucamerotus* are therefore not synonymous.
2. All other specimens labelled as *Ornithopsis* are either 'Sauropoda *Incertae Sedis*' or are referable to the genus *Eucamerotus*. *Pelorosaurus conybeari* cannot safely be synonymized with Isle of Wight specimens.
3. *Eucamerotus* is regarded as brachiosaurid, with *E. foxi* sp. nov. established.

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