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First nonavian dinosaur from Lebanon: a brachiosaurid sauropod from the Lower Cretaceous of the Jezzine District

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Abstract Two sauropod teeth from an Early Cretaceous (Neocomian) fluviodeltaic sandstone near Jezzine (Southern Lebanon) are the first nonavian dinosaur remains to be reported from Lebanon. Their distinctive character places them within Brachiosauridae. The sauropod teeth from Lebanon are a significant addition to the very scanty dinosaur record from the Levant, which hitherto consisted mainly of very poorly preserved and not easily identifiable specimens. The Basal Cretaceous Sandstone of Lebanon, thus, appears to be a potentially important source of fossil vertebrate material.

Introduction

The published record of dinosaurs (*sensu lato*) from the Levant (Lebanon, Syria, Israel, Palestine, and Jordan) is

extremely scanty, being based mostly on specimens that cannot be determined with any accuracy, so that this area, like the Middle East as a whole, is still largely a terra incognita in terms of dinosaur biogeography. The record includes theropod footprints from the Cenomanian of the vicinity of Jerusalem, Israel (Avnimelech 1966), a fragmentary theropod tibia from the Late Cretaceous of the vicinity of Damascus, Syria (Hooijer 1968), a small fragment of a tibia, probably from an ornithopod, from the Maastrichtian phosphates of Roseifa, Jordan (Martill et al. 1996), and feathers from the Early Cretaceous amber of Wadi Zerqa, Jordan (Kaddumi 2005, pp 36–39). In Lebanon, birds are among the various tetrapods known from the Cenomanian sublithographic limestones of Nammoura (Dalla Vecchia and Chiappe 2002), and feathers have been found in the Early Cretaceous amber of Jezzine (Schlee 1973; Schlee and Glöckner 1978) and Hammana, but no nonavian dinosaurs had so far been reported. We describe, in this study, sauropod teeth from the Lower Cretaceous of Southern Lebanon which are the first nonavian dinosaur remains from that country and, being identifiable to the family level, considerably improve our knowledge of the Cretaceous dinosaur faunas of the Middle East.

The material has been found in the Neocomian sandstone of Southern Lebanon (Mouhafazit Loubnan El-Janoubi), District of Jezzine (Caza Jezzine), in the locality of Jouâr Es-Souss, and at the entrance of the villages of Jezzine and Bkassine (Figs. 1 and 2). The same outcrop contains amber-bearing beds. This Basal Cretaceous Sandstone (also known as “Grès de Base”) is considered to have been deposited in a fluviodeltaic environment (Maasaad 1976).

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Description and comparisons

The material comprises two teeth (Fig. 3), one of which, found in August 2005 by André Nel, is well preserved while the other one, found in 1969 by Aftim Acra, is incomplete. Both specimens are in the Natural History Museum of the Lebanese University at Fonar, Lebanon.



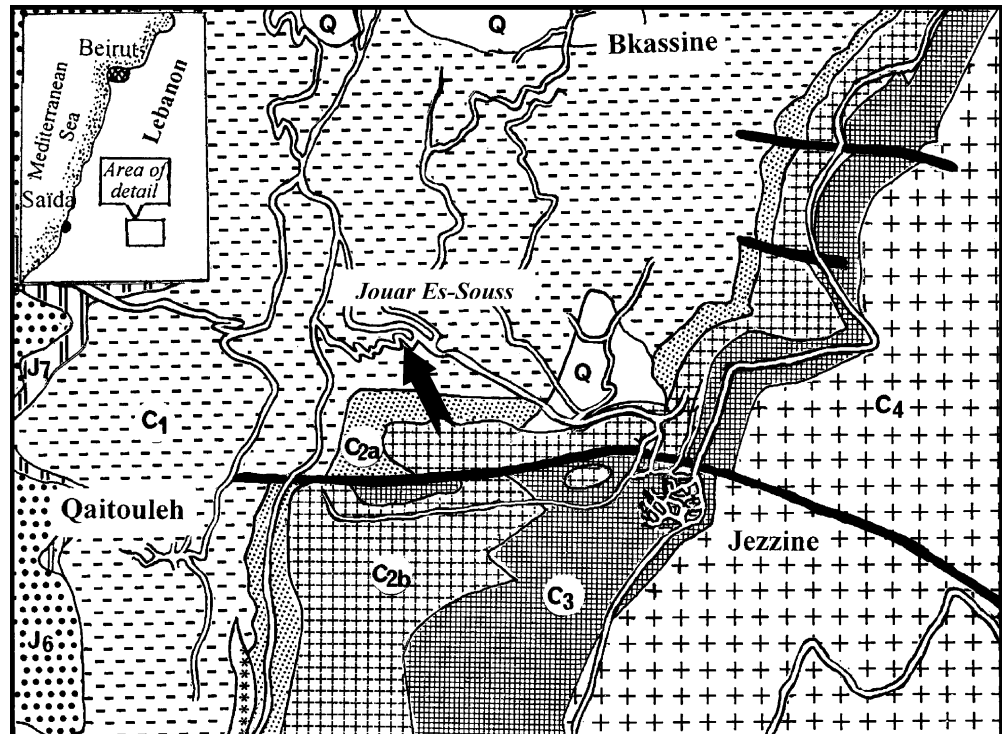
Fig. 1 The outcrop of Neocomian sandstone at Jouâr Es-Souss, Jezzine District, Southern Lebanon, where the sauropod teeth described in the present paper have been found

The best specimen (Jazar 1), shows the well preserved crown and part of the root. It is 23 mm in height and 8 mm mesiodistally. The crown is hardly broader than the root and there is no significant constriction between them. The root, which is oval in cross-section, can be distinguished from the crown mainly because its surface is smooth, unlike the distinctly wrinkled enamel of the crown. The enamel wrinkles form low irregular ridges which become fainter toward the apex (probably because of wear, as described by Janensch (1935) in *Brachiosaurus*). The crown is strongly convex labially, both mesiodistally and apicobasally. The lingual face is markedly concave apicobasally and convex mesiodistally. Thus, the crown cannot be described as spoon-shaped or spatulate, as its lingual face is neither concave mesiodistally nor signifi-

cantly broadened relatively to the root. The mesial margin of the crown is slightly concave at the base and slightly convex near the apex. The distal margin is convex at the base and slightly concave closer to the apex. As a result, when seen in labial or lingual view, the crown appears twisted. The lingual and labial faces of the crown are separated by blunt carinae. The mesial one is only faintly marked, especially in the basal part. The distal carina is more distinct, being separated from the convex labial face by a well-marked groove, which extends from the base to the apex. A mesial groove is also present, but much fainter than the distal one. Close to the apex, the distal carina bears faint, heavily worn serrations. The apex of the tooth bears a large oval wear facet, sloping markedly in a mesiolingual direction, which has completely removed the enamel and exposes the underlying dentine.

The second specimen, (JAcra 1), is a fragment of a broader tooth (14 mm mesiodistally), consisting of the apical portion of a crown, broken above the base, and damaged at the apex. The labial face is convex mesiodistally and apicobasally, while the lingual face is convex mesiodistally and slightly concave apicobasally. The whole surface of the tooth is much abraded and pitted, the enamel being largely worn away, especially on the lingual face, so that no wrinkling is apparent. Both the mesial and distal carinae are worn and blunt. At the level of the break, the fragment is subcircular, with a small pulp cavity. The apex is irregularly broken, so it is uncertain whether a wear facet was present. On the lingual side, there is a more or less circular and rather deep pit, probably corresponding to a wear facet, as facets in a similar position occur, for instance, in *Brachiosaurus* (Janensch 1935).

Fig. 2 Geological map of the Jezzine area (Southern Lebanon) showing the location of the Neocomian sauropod locality at Jouâr Es-Souss (adapted from Dubertret 1950). J6 Kimmeridgian; J7 Tithonian; C1 Neocomian; C2a Barremian (?)–Early Aptian; C2b Late Aptian; C3 Albian; C4 Cenomanian; Q Quaternary. Scale bar represents 1 km



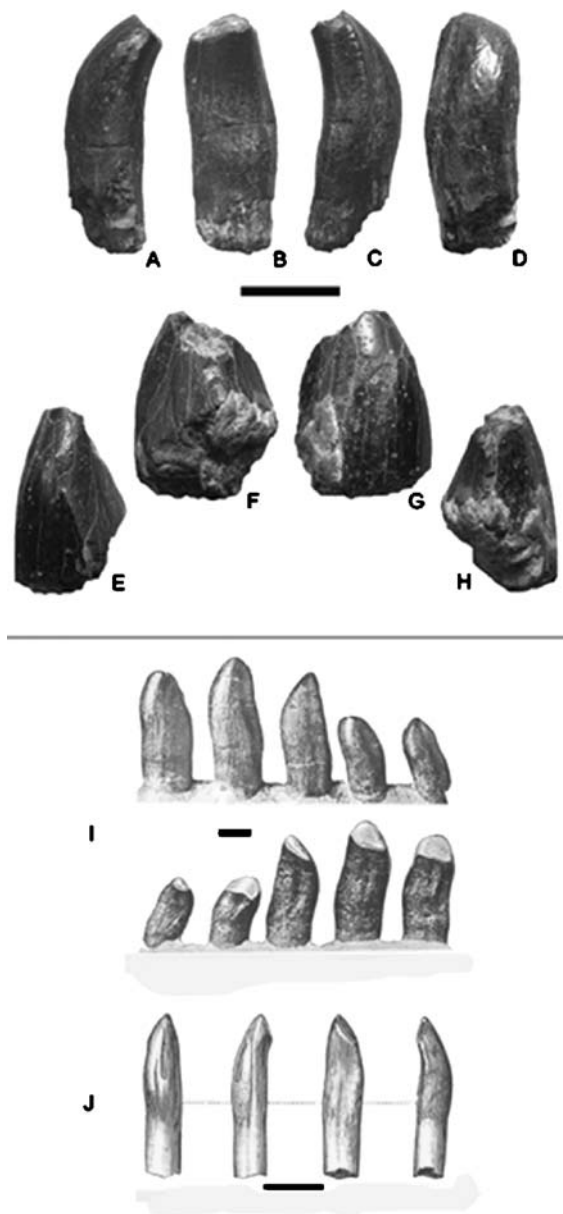


Fig. 3 Sauropod teeth from the Neocomian of Jouâr Es-Souss, Southern Lebanon in the collection of the Natural History Museum of the Lebanese University, compared with brachiosaurid teeth. JAzar1 in mesial (a), lingual (b), distal (c), and labial (d) views. JAcral in mesial (e), lingual (f), labial (g), and distal (h) views. *I* The five posteriormost teeth of the right upper tooth row of *Brachiosaurus brancai* from the Late Jurassic of Tendaguru (Tanzania) in labial (above) and lingual (below) views, after Janensch (1935, pl.XII, Fig. 1). *J* Isolated tooth of *Astrodon johnsoni* from the Early Cretaceous of Maryland (USA) in (from left to right) labial, mesial, lingual, and distal views, after Lull (1911, pl.XIV, Fig. 8). All scale bars represent 10 mm

The teeth from Jouâr Es-Souss are different in size and shape, but this may be the result of different positions in the tooth row. The better preserved slender specimen is used in this study for comparisons. The tooth can be described as a rather simple, somewhat flattened and twisted cylinder, indicating that it belongs to a sauropod dinosaur, a conclusion supported by the wrinkled surface of the

enamel (a sauropod synapomorphy: Wilson and Sereno 1998). Although the tooth cannot be described as spoon-shaped or spatulate, it differs from the typical peg-like teeth of diplodocoids and titanosaurs, which are straighter and more slender, with less strongly wrinkled enamel, and the affinities of the Lebanese sauropod must be sought among the “broad-toothed” sauropods. The “twisted” shape of the crown indicates that the tooth is from the posterior part of the jaw, as more anterior teeth have more symmetrical crowns. The narrow and convex lingual face of the crown distinguishes this tooth from the posterior teeth of most broad-toothed sauropods, such as camarasaurids and euhelopodids, in which the posterior tooth crowns are broad and have a concave lingual face. The tooth from Lebanon is strongly reminiscent of the posterior teeth of brachiosaurids. In *Brachiosaurus brancai* from the Upper Jurassic of Tanzania, the posterior teeth of the upper jaw show the same twisted shape and their crown is not spatulate (Janensch 1935, pl.XII, Fig. 1). Their enamel shows a similar wrinkling and when worn, they bear an oblique apical wear facet (Janensch’s “Terminal-Usurfläche”), as on the Lebanese tooth. The main difference is that on the tooth from Jezzine the distal groove on the labial face appears to be much more distinct than in *B. brancai*. The dentition of other brachiosaurids is poorly known. Isolated teeth from the Early Cretaceous Arundel Formation of Maryland (USA), for which the name *Astrodon johnsoni* must be used (Carpenter and Tidwell 2005), were described by Marsh (1888, p. 90) as having crowns which are “mainly compressed cones, and not spoon-shaped”. Some of them closely resemble the tooth from Jezzine (Lull 1911, pl.XIV, Fig. 8). *Astrodon* is usually placed among the Brachiosauridae (McIntosh 1990; Weishampel and Young 1996; Naish and Martill 2001), although Carpenter and Tidwell (2005) referred it to a family incertae sedis of the Titanosauriformes (a group which includes brachiosaurids).

From these comparisons, the slender tooth from Jezzine, probably from the posterior part of a left upper tooth row, can be referred to the Brachiosauridae, although no identification at a lower taxonomic level is possible. The broader tooth, to judge from its apparently more symmetrical crown, is probably from a more anterior location in the tooth row, and both teeth may well belong to the same taxon.

Discussion

The teeth from Jezzine allow identification to the family level and are, thus, more informative than the previously reported dinosaur material from the Middle East. However, they do not provide much new information about the exact age of the Basal Cretaceous Sandstone of Lebanon, as brachiosaurids are known from both the Late Jurassic and the Early Cretaceous. All that can be said is that the occurrence of a brachiosaurid is in accordance with the Early Cretaceous (Neocomian) age of the Basal Cretaceous Sandstone of Lebanon.

The ascertained geographical distribution of brachiosaurids encompasses North America, Europe, and Africa

(Upchurch et al. 2004); in addition, an isolated tooth from the Lower Cretaceous of Korea has been referred to the Brachiosauridae (Lim et al. 2001). In the Early Cretaceous, the region of present-day Lebanon was in the northeastern part of Gondwana, on the Afro-Arabian plate. There is no well-ascertained record of brachiosaurids in the Early Cretaceous of Gondwana. The brachiosaurid “*Brachiosaurus*” *nougaredi* (Lapparent 1960) from Algeria, considered as Early Cretaceous by Upchurch et al. (2004) and Weishampel et al. (2004), in fact comes from beds which contain Late Jurassic plants (Boureau and Caillon 1958; Lapparent 1960). Early Cretaceous sauropods so far reported from Africa (see Weishampel et al. 2004) are either indeterminate or belong to other groups, including primitive eusauropods and rebacchisaurids from Niger (Sereno et al. 1999) and titanosaurs from Malawi (Jacobs et al. 1996), to which the teeth from Lebanon cannot be referred. By contrast, brachiosaurids are well represented in the Early Cretaceous of North America (Upchurch et al. 2004), with taxa such as *Cedarosaurus*, *Sauroposeidon*, and *Astrodon*, and are also present in Europe, with material from the Wealden of England that is mostly fragmentary, although a fairly complete skeleton still awaits description (Naish and Martill 2001). However, the record of Early Cretaceous sauropods from Gondwana is still too sparse to conclude that brachiosaurids were not present there, and it would be premature to suggest that the teeth from Lebanon indicate Euramerican rather than Gondwanan affinities.

Conclusion

The brachiosaurid teeth from the Early Cretaceous of Jezzine are the first nonavian dinosaur remains from Lebanon. The only vertebrates hitherto reported from the Basal Cretaceous Sandstone were small fishes from a dysodilic level (Janensch 1924) and feathers (Schlee 1973; Schlee and Glöckner 1978) and a lizard (Arnold et al. 2002) preserved in amber. The Lebanese brachiosaur is an important addition to the record of dinosaurs from the Levant, and more generally from the Middle East, which is still very scarce (see above). We fully concur with the remark of Martill et al. (1996, p.153), to the effect that “the apparent scarcity (of dinosaurs in the Middle East) is because so few vertebrate paleontologists have examined the Mesozoic in this part of the world”. The Basal Cretaceous Sandstone of Lebanon is one of the formations which are likely to provide more information about the elusive dinosaurs of the Middle East, a vast area which was part of the northern margin of Gondwana and for which continental biogeographical data for the Cretaceous are still extremely incomplete.

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