

A new sauropod dinosaur from the Albian of Le Havre (Normandy, France)

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Abstract - A sauropod from the Albian of Normandy (northwestern France) is described as a new genus and species of basal Titanosauria, *Normanniasaurus genceyi*. *N. genceyi* shares several primitive characters with slightly younger basal Titanosauria such as *Epachthosaurus* and *Andesaurus*. It can be distinguished from other Albian sauropods of Western Europe. The late Early Cretaceous radiation of basal Titanosauria in South America, Europe and Africa is discussed.

Key-words: Sauropoda, Titanosauria, Albian, Cretaceous, France, *Normanniasaurus*

Un nouveau dinosaure sauropode dans l'Albien du Havre (Normandie, France) - Un nouveau sauropode de l'Albien de Normandie est décrit, *Normanniasaurus genceyi* n. g., n. sp. *N. genceyi* partage plusieurs caractères primitifs avec des Titanosauria basaux un peu plus récents comme *Epachthosaurus* ou *Andesaurus* et peut être distingué des rares sauropodes albiens d'Europe occidentale. La radiation des Titanosauria basaux à la fin du Crétacé inférieur en Amérique du Sud, en Europe ou en Afrique est évoquée.

Mots-clés: Sauropoda, Titanosauria, Albien, Crétacé, France, *Normanniasaurus*.

INTRODUCTION

Albian sauropods are still poorly known in Europe. Isolated discoveries from Cambridgeshire (Seeley, 1869, 1876), northern France (Lapparent, 1946; Buffetaut, 1984; Martin *et al.*, 1993; Buffetaut & Nori, 2012) and southern France (Gervais, 1848-52) indicate that titanosaurs coexisted in the Albian of Europe with other sauropods of enigmatic affinities (Le Loeuff, 1993). Titanosauria, as defined by Salgado *et al.* (1997), are the most recent common ancestor of *Andesaurus delgadoi* and Titanosauridae and all its descendants. Eutitanosauria were originally defined by Sanz *et al.* (1999) as the most recent common ancestor of *Saltasaurus*, *Argyrosaurus*, *Lirainosaurus*, plus the Peiropolis titanosaur (i.e. *Trigonosaurus* Campos *et al.*, 2005) and all its descendants. Salgado (2003) redefined this clade as all titanosaurs closer to *Saltasaurus* than to *Epachthosaurus*. Although different phylogenies of Titanosauria have been published in recent years our discussion is based on Calvo *et al.* (2007).

Macrurosaurus semnus Seeley, 1869 is likely a chimera composed of at least two different sauropods, including a possible eutitanosaur with procoelous mid-caudals and a second form with amphiplatyan caudals (Le Loeuff, 1993).

The material of *M. semnus* was found in the lower Cenomanian Cambridge Greensand Formation and is considered as reworked from upper Albian levels (see a recent discussion by Unwin, 2001). Lapparent (1946) described 10 amphicoelous middle caudal vertebrae of a sauropod found at a quarry at Villers-Saint-Barthelemy (Oise, NW of Paris). This material (also known as the sauropod from the Pays de Bray) is well dated from the middle Albian. In eastern France, other caudal vertebrae were also found in middle Albian marine deposits at Pargny-sur-Saulx near Saint-Dizier (Haute-Marne). This material was described by Martin *et al.* in 1993 and referred to an undetermined sauropod. Sauropod caudal vertebrae are also known from the lower Albian Sables verts of the Argonne region of eastern France (Buffetaut & Nori, 2012). Poorly preserved sauropod material described by Vullo *et al.* (2012) from the Early Cretaceous of Saint-Agnant in Western France may be of Albian age.

Prior to these discoveries Gervais (1848-52) had named *Aepisaurus elephantinus* on the basis of an isolated humerus found at Bédoin in the surroundings of the Mont Ventoux in southern France (Vaucluse) in Albian deposits.

GEOGRAPHICAL AND GEOLOGICAL SETTING

The new material described here was recovered in 1990 by Pierre Gencey inside blocks fallen from the sea-cliffs at Bléville, formerly a separate village, now a district of Le Havre (Seine-Maritime), on the northern side of the Cap de La Hève (Fig. 1). This specimen was briefly mentioned and partly illustrated by Buffetaut (1995). The observation of the conglomeratic matrix has shown that the fossils came from lower to middle Albian levels of the Poudingue Ferrugineux Formation (Breton, 1998).

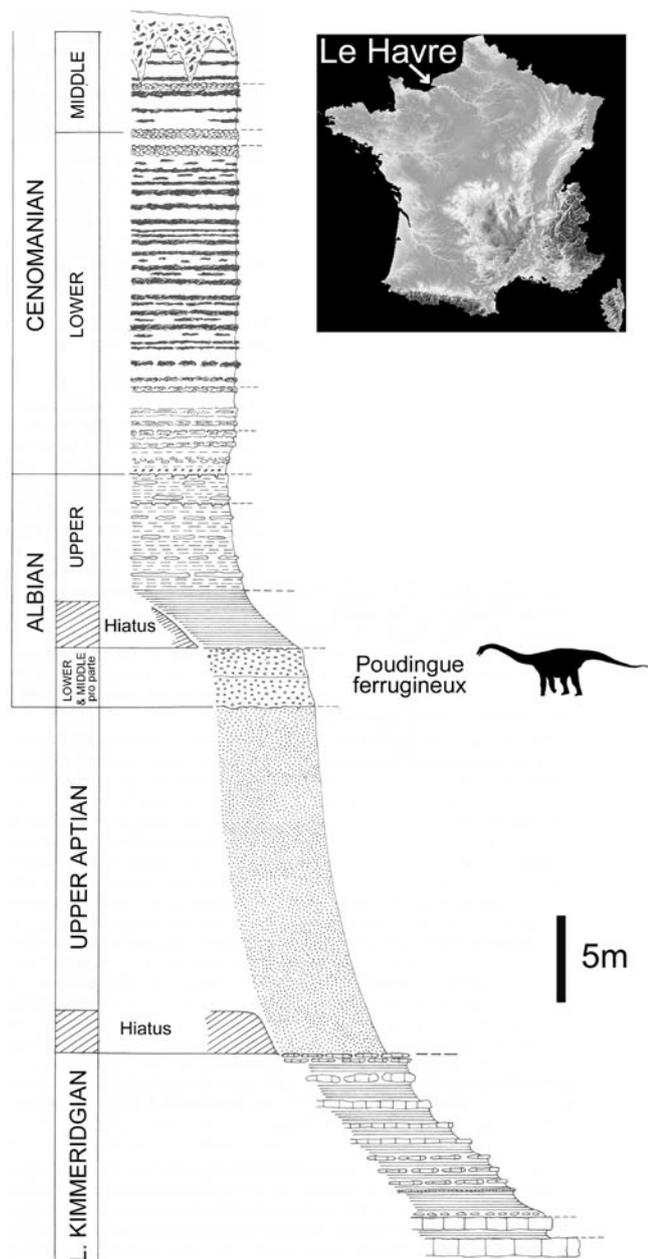


Fig. 1 - Location map and stratigraphic section of the Cap de la Hève at Le Havre, showing the position of the Poudingue ferrugineux (3 to 4 m thick), which has yielded the remains of *Normanniasaurus genceyi*. Section modified after Doré *et al.* (1977).

According to Juignet (1980), the Poudingue Ferrugineux is a coarsely detritic formation, consisting of material derived from the Armorican Massif of Lower Normandy (in the West) and carried by strong currents to a shallow littoral area. It contains ammonites and abundant plant remains. Few vertebrate remains have been reported from the Poudingue ferrugineux, although a catalogue of the geological exhibition held in Le Havre in 1877 lists “part of the head of a crocodylian” from the Poudingue ferrugineux, then considered as Aptian (Anonymous, 1880). Lennier (1904) listed a crocodylian vertebra from the Poudingue ferrugineux in the collection of the Le Havre museum. None of these specimens were ever described and the collections of the Le Havre museum were destroyed by Allied bombings in 1944 (Buffetaut, 2011).

The isolated posterior caudal centrum of a sauropod dinosaur, found in the 19th century and described by Buffetaut (1984), also comes from Bléville, but matrix remains on the specimen suggest that it comes from glauconitic levels of the upper Albian, rather than from the Poudingue Ferrugineux (Buffetaut, 1984). It is thus slightly younger than the partial skeleton described here, but can probably be referred to the same taxon, as shown below.

Like many of the dinosaurs whose remains are found in Mesozoic marine sediments in Normandy, the sauropod from the Poudingue ferrugineux of Bléville probably lived on an emergent area corresponding to the Armorican Massif of present-day Brittany and Lower Normandy, a relatively long distance (some 60 km) to the West of the locality where it was found (see Buffetaut, 1984, for a discussion of this topic).

Acronyms: MHNH Museum d’histoire naturelle du Havre, France; MHNH Muséum d’Histoire Naturelle de Rouen, France.

SYSTEMATICS

Sauropoda Marsh, 1878

Titanosauria Bonaparte & Coria, 1993

***Normanniasaurus* nov. gen.**

Etymology: from *Normannia*, the Latin name of Normandy, the region where the bones were discovered.

Type species: *Normanniasaurus genceyi* nov. sp.

Diagnosis: the same as the type species

***Normanniasaurus genceyi* nov. sp.**

Etymology: species dedicated to the discoverer, Mr. Pierre Gencey.

Holotype: a partial skeleton including presacral vertebrae fragments (MHNH-2013.2.1.8, 2013.2.1.9), a partial sacrum (MHNH-2013.2.1.12), an anterior caudal vertebra (MHNH-2013.2.1.1), a middle caudal vertebra

(MHNH-2013.2.1.2), a right scapula (MHNH-2013.2.1.7), parts of both ilia (MHNH-2013.2.1.3, 2013.2.1.4) and ischia (MHNH-2013.2.1.5, 2013.2.1.6), the proximal extremity of a femur (MHNH-2013.2.1.11), the proximal part of a fibula (MHNH-2013.2.1.10).

Referred material: a posterior caudal centrum (MHNH-coll. Bucaille), also from Bléville but apparently from a more recent level of the Albian (Buffetaut, 1984).

Provenance: Bléville, Le Havre (Seine-Maritime, France), Poudingue Ferrugineux Formation.

Age: early to middle Albian (Juignet, 1980; Breton, 1998).

Diagnosis: presacral vertebrae with hyposphenepantrum articulation; internal texture of presacral vertebrae cancellous; anterior caudal vertebrae deeply procoelous, with antepostzygapophysial foramen, deep postspinal and prespinal fossae and axially elongated neural spine; middle caudal vertebrae amphicoelous with cranially inserted neural arch; dorsal projection of the spinoprezygapophysial lamina in mid-caudals; ilium with a craniolaterally expanded blade.

Description:

Presacral vertebrae (MHNH-2013.2.1.8, 2013.2.1.9; see Fig. 2).

Only fragments of presacral vertebrae have been preserved: two large isolated prezygapophyses show a well preserved hypantrum facet, at right angle to the prezygapophysial facet. The internal texture of the neural arch consists of very large cells, reminiscent of the condition found in Titanosauria (Calvo *et al.*, 2007), and in several Asian sauropods such as *Mamenchisaurus* and *Euhelopus* (Wedel, 2003; Suteethorn *et al.*, 2013).

Sacrum (MHNH-2013.2.1.12)

The ventral part of a strongly eroded sacrum is preserved. It consists of three coalescent centra with no trace of

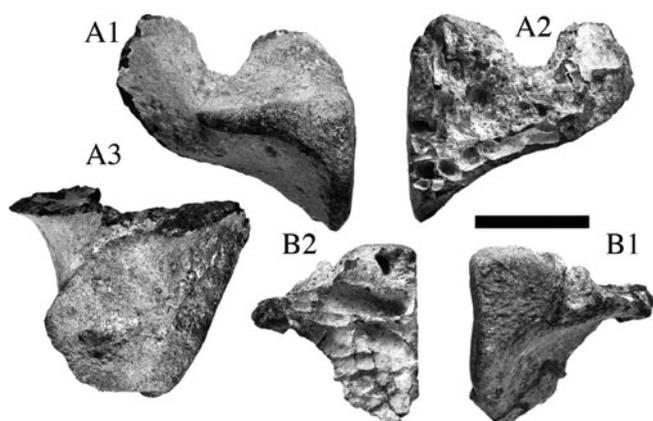


Fig. 2 - *Normanniasaurus genceyi* presacral vertebra showing a cancellous internal structure. A, right prezygapophysis (MHNH-2013.2.1.9) and B, left prezygapophysis (MHNH-2013.2.1.8) in anterior (A1-B1), posterior (A2-B2), and dorsal (A3) views. Scale bar 5 cm.

pleurocoels. The ventral surface is not flat, the sacrum having a V-shape cross-section.

Caudal vertebrae (Figs 3, 4)

The cranial caudal vertebra (MHNH-2013.2.1.1) has a dorsoventrally compressed centrum. The centrum is procoelous, with a deep anterior concavity. The ventral face of the centrum is concave transversally, with two lateral ridges arising from the posterior facets for the hemapophyses. The transverse processes of this vertebra are well developed; they are hook-shaped and posteriorly directed. The cranially placed neural arch is preserved (the neural spine and prezygapophyses are broken). The posterior part of the neural arch is well preserved and shows very peculiar characteristics: in lateral view, a large foramen opens cranial to the postzygapophyses in the same position as the interzygapophyseal fossa of *Mendozasaurus*, *Malawisaurus*, *Adamantisaurus* and *Aelosaurus* (González-Riga, 2003; Gomani, 2005; Santucci & Bertini, 2006; Powell, 2003). In caudal view, the postzygapophyses join ventrally above the neural canal. Dorsally, they diverge and are separated by a deep postspinal fossa, delimited by the spinopostzygapophysial laminae. Dorsal to this fossa, a strong postspinal lamina arises. The cranial part of the neural arch is less well preserved; there is a deep prespinal fossa between the spinoprezygapophysial laminae. The preserved basis of the neural spine is laterally compressed.

Measurements of MHNH-2013.2.1.1: anterior width of centrum: 168 mm; anterior height of centrum: 135 mm; total length of centrum: 141 mm; length of centrum excluding condyle: 101 mm; posterior height of centrum: 118 mm; posterior width of centrum: 150 mm.

A middle caudal centrum (MHNH-2013.2.1.2) is preserved with a partial neural arch. The centrum is amphicoelous with subrectangular anterior and posterior outlines. The ventral face is flat, with two well-developed posterior hemapophysial facets directed ventrally and posteriorly. The lateral faces of the centrum are anterodorsally concave. At the top of the centrum, a sharp ridge is all that remains of a transverse process. The neural arch is situated on the anterior half of the centrum; the postzygapophyses are unfortunately broken, and it is not possible to decide whether an antepostzygapophysial foramen existed or not. The prezygapophyses are thin and extend well beyond the anterior border of the centrum (about 74 mm). The spinoprezygapophysial laminae present a dorsal projection near the base of the neural spine as in some caudals of *Brachiosaurus*, *Mendozasaurus* and *Adamantisaurus*. There is another horizontal ridge on the lateral side of the prezygapophyses. The pedicels of the neural arch are bulbous, and form a ridge above the transverse processes.

Measurements of MHNH-2013.2.1.2: anterior width of centrum: 113 mm; anterior height of centrum: 107 mm; total length of centrum: 101 mm; posterior height of centrum: 114 mm; posterior width of centrum: 111 mm.

The middle caudal centrum described by Buffetaut (1984) from slightly younger Albian levels at Bléville also

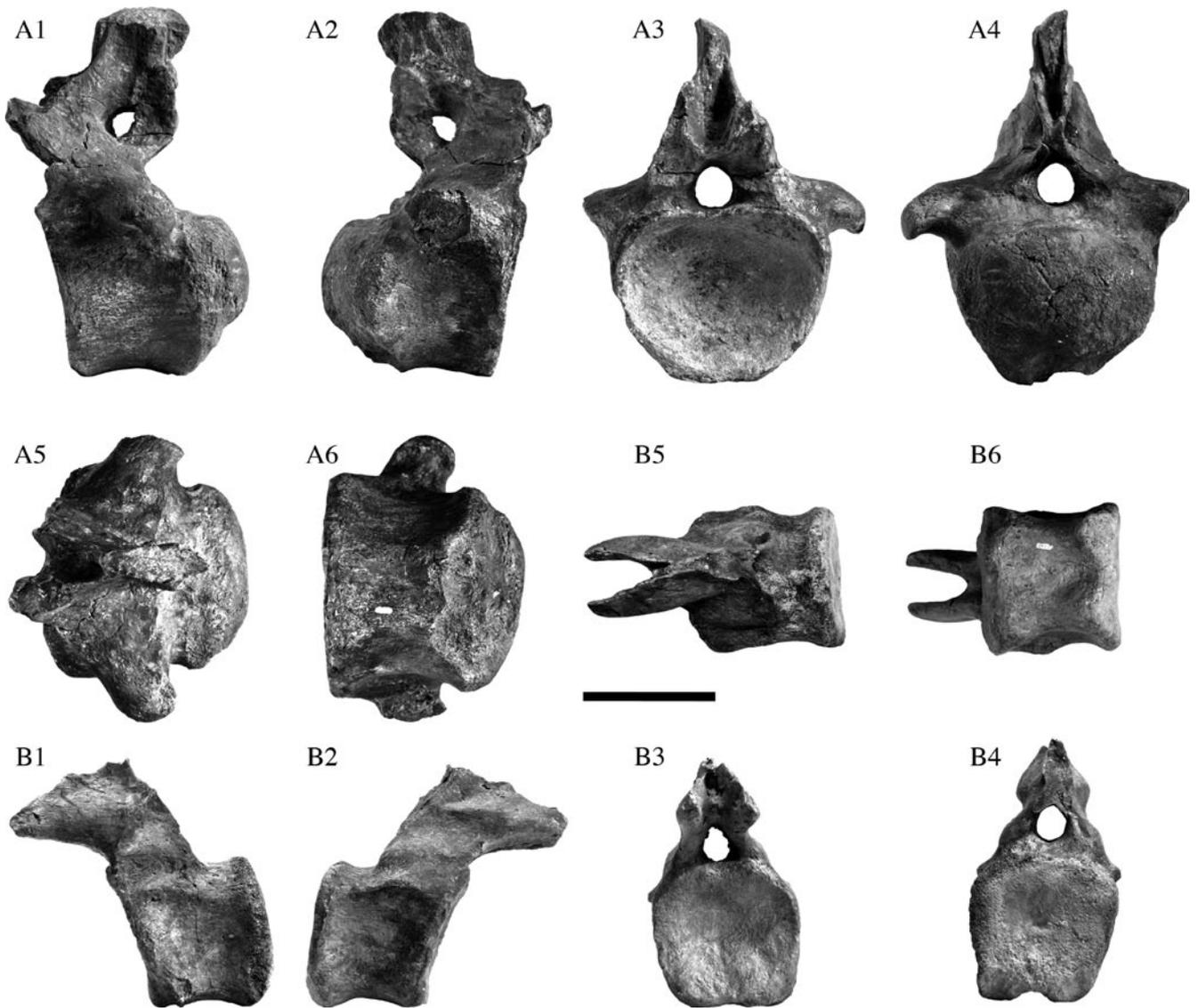


Fig. 3 - *Normanniasaurus genceyi* caudal vertebrae. A, anterior caudal vertebra (MHNH-2013.2.1.1) and B, middle caudal vertebra (MHNH-2013.2.1.2) in left lateral (A1-B1), right lateral (A2-B2), anterior (A3-B3), posterior (A4-B4), dorsal (A5-B5) and ventral (A6-B6) views. Scale bar 10 cm.

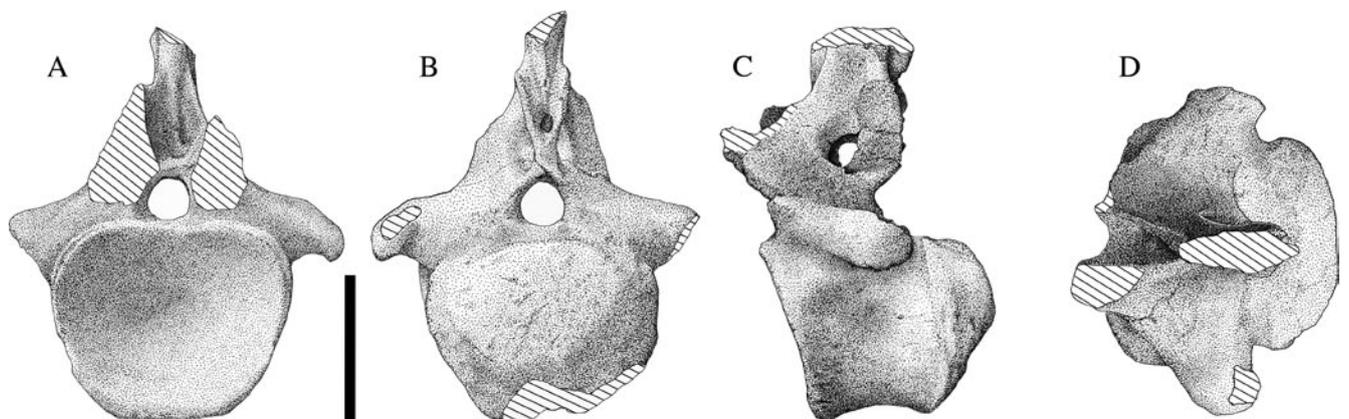


Fig. 4 - Schematic drawing of *Normanniasaurus genceyi* anterior caudal vertebra (MHNH-2013.2.1.1) in left lateral (A), right lateral (B), anterior (C) and dorsal (D) views (drawings by G. Le Roux). Scale bar 10 cm.

has an anteriorly inserted neural arch and well-developed hemapophysial facets, and it very probably belongs to *Normanniasaurus genceyi*. The articular faces of the centrum are slightly concave. The dimensions of this centrum are as follows: total length of centrum: 101 mm; anterior height of centrum: 87 mm; posterior width of centrum: 93 mm.

Appendicular skeleton

Scapula (Fig 5)

A partial right scapula (MHNH-2013.2.1.7) shows a thick ventral edge and a thinner dorsal edge.

Ilia (Fig 6)

Of the left ilium (MHNH-2013.2.1.4) only the posterior part of the pubic peduncle is preserved; the right ilium (MHNH-2013.2.1.3) preserves the pubic peduncle and a small part of a cranio-laterally expanded blade. In distal view the pubic peduncle is comma-shaped.

Ischia (Fig 7)

The proximal part of the right ischium (MHNH-2013.2.1.5) is preserved as well as a fragment of the left ischium (MHNH-2013.2.1.6). The iliac peduncle is robust; the pubic peduncle and the distal part of the bone are not preserved.

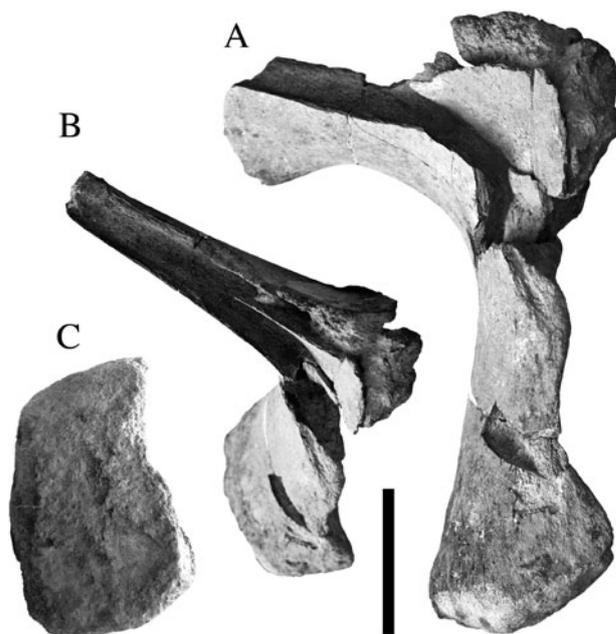


Fig. 6 - *Normanniasaurus genceyi* ilia. A, right ilium (MHNH-2013.2.1.3) in medial (A), dorsal (B), and ventral (C) views. Scale bar 10 cm.

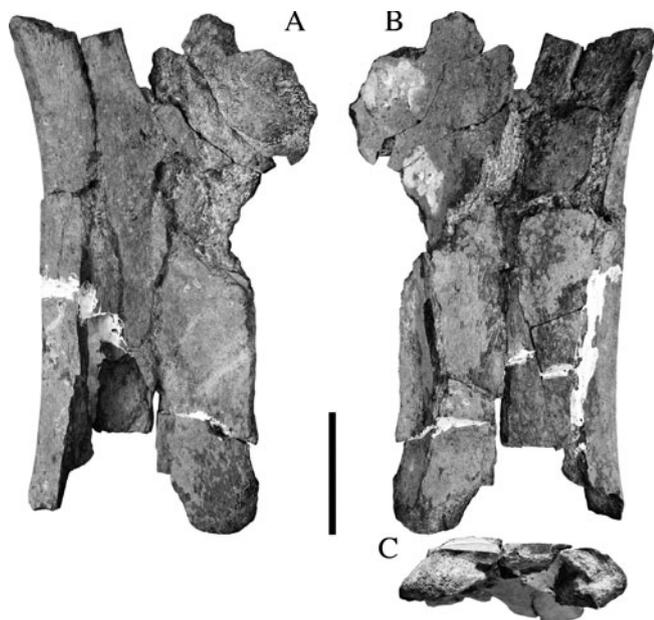


Fig. 5 - *Normanniasaurus genceyi* right scapula (MHNH-2013.2.1.7) in ventral (A) and dorsal (B) views. C, showing D-shaped cross section of the scapula shaft. Scale bar 10 cm.

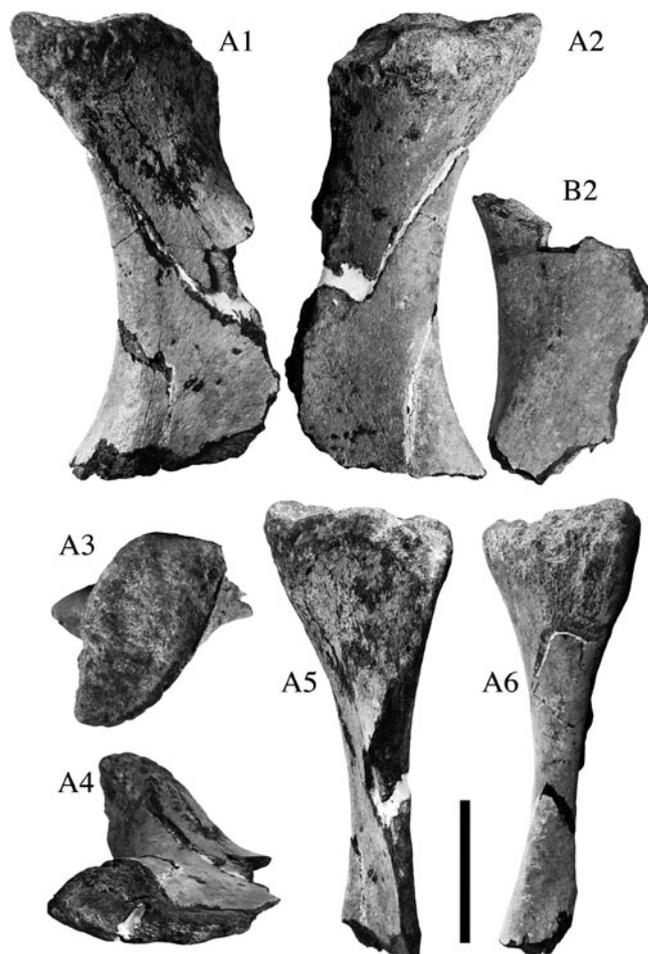


Fig. 7 - *Normanniasaurus genceyi* ischia. A, right ischium (MHNH-2013.2.1.5) and B, left ischium (MHNH-2013.2.1.6) in lateral (A1), medial (A2-B2), dorsal (A3), ventral (A4), anterior (A5) and posterior (A6) views. Scale bar 10 cm. ➔

COMPARISONS

Normanniasaurus can at first be compared with the poorly known Albian European sauropods. *Aepisaurus elephantinus* Gervais 1848-52 is known by a single humerus and cannot be compared with *Normanniasaurus*; it is considered as a nomen dubium (see Le Loeuff, 1993; Upchurch *et al.*, 2004).

The middle Albian sauropod from Pargny-sur-Saulx in eastern France was figured by Martin *et al.* (1993); it is represented by eight caudal vertebrae. In the middle caudals, centra are elongated, slightly constricted transversally; the hemapophysial facets are slightly marked. Articular surfaces are hexagonal in outline. These vertebrae are very different from those of *Normanniasaurus*.

Knoll *et al.* (2000) described an isolated caudal centrum from the Albian of eastern France as the caudal vertebra of a sauropod, however Buffetaut *et al.* (2005) have shown that this vertebra does not belong to a sauropod but to a plesiosaur.

Macrurosaurus semnus, from the Albian of Cambridgeshire (reworked in Cenomanian Cambridge Greensand), is composed of mixed caudal vertebrae of two sauropods (Le Loeuff, 1993): a titanosaur with procoelous middle caudal vertebrae and an unknown sauropod, which has very flattened caudal vertebrae, different from those of *Normanniasaurus*.

The isolated sauropod caudal vertebrae from the lower Albian Sables verts of Argonne described by Buffetaut and Nori (2012) are generally similar to the posterior, amphicoelous caudal of *Normanniasaurus genceyi*, notably because of well-developed hemapophysial facets, but the largest one has a lower centrum. The observable differences may be linked to different positions in the vertebral column, and the Argonne specimens may belong to *Normanniasaurus* or a closely related form.

The middle Albian vertebrae from the Moru quarry (Villers Saint Barthélémy, Oise department) described in 1946 by Lapparent are the closest to *Normanniasaurus genceyi*; we tentatively refer them to this new species on the basis of the well-developed hemapophysial facets and the anteriorly inserted neural arch. It can be noted that the resemblance between one caudal centrum from saint-Agnant and the material from Moru was recently underlined by Vullo *et al.* (2012).

The strong procoely of anterior caudal vertebrae of *Normanniasaurus* is reminiscent of titanosaurs, but advanced titanosaurs (Eutitanosauria) also have procoelous middle and posterior caudals. The condition in *Normanniasaurus* (anterior caudals strongly procoelous, mid-caudals amphiplatyan) is shared with basal titanosaurs like *Andesaurus* (Albian of Argentina: Calvo & Bonaparte, 1991; Calvo *et al.*, 2007) or *Malawisaurus* (Early Cretaceous of Malawi according to Jacobs *et al.*, 1993, although Le Loeuff *et al.*, 2012 have suggested a Late Cretaceous age). The cancellous internal structure of the presacral vertebrae is also

reminiscent of the Titanosauria, as well as the cranially inserted neural arch and the hook-shaped transverse processes. The presence of a hyposphene-hypantrum structure in presacral vertebrae is unknown in advanced titanosaurs. It is worth noting that the Argentinian basal titanosaurs *Epachthosaurus* and *Andesaurus* had an accessory articulation of this type (Powell, 1990; Calvo *et al.*, 2007). Other characters of *Normanniasaurus genceyi* are shared with more advanced Eutitanosauria such as the strongly inclined anterior face of the mid-caudals or the very elongated prezygapophyses in mid-caudal vertebrae.

We thus consider *Normanniasaurus* as a basal member of the Titanosauria (anterior caudal deeply procoelous, anterior insertion of the neural arch, presacral vertebrae with cancellous bone), the loss of the hyposphene-hypantrum structure and the procoely of mid and posterior caudals being synapomorphies of more advanced titanosaurs (Eutitanosauria).

CONCLUSION

This discovery suggests that diverse sauropod lineages (including a possible eutitanosaur, basal titanosaurs such as *N. genceyi*, and sauropods of enigmatic affinities like the sauropod from Pargny-sur-Saulx and the non-titanosaurian vertebrae of “*Macrurosaurus*”) were present in Europe during the late Early Cretaceous. *Normanniasaurus genceyi* is only one element of this diverse sauropod fauna, which went extinct before the Campanian, when Eutitanosauria became the dominant sauropod group in Europe. More remains of the members of this “middle” Cretaceous sauropod radiation, their systematic affinities and the reasons for their extinction are to be sought in European Cretaceous strata. Basal Titanosauria are now known from South America (*Epachthosaurus*, *Andesaurus*, *Mendozasaurus*), Africa (*Malawisaurus*) and Europe (*Normanniasaurus*) in “mid-Cretaceous” deposits. Whether these primitive forms gave birth to the Late Cretaceous Eutitanosauria in their respective areas or were replaced by a new radiation of advanced titanosaurs is still unclear, although the probable existence of Eutitanosauria in the Barremian-Aptian and the Albian of Great Britain (Le Loeuff, 1993) would rather support the second hypothesis.

ACKNOWLEDGMENTS

We are indebted to Pierre Gencey who found the material and to Gérard Breton (then at the Natural History Museum, Le Havre) who allowed us to describe it. We thank the reviewers R. Vullo and T. Tortosa for their useful comments. S. Suteethorn’s research was supported by the Faculty of Science and Development Fund of Mahasarakham University and the Thailand Research Fund (MRG5480145).

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