

A Basal Titanosauriform from the Early Cretaceous of Guangxi, China

MO Jinyou^{1,2,*}, WANG Wei^{1,2}, HUANG Zhitao², HUANG Xin³ and XU Xing⁴

1 Faculty of Earth Sciences, China University of Geosciences, Wuhan, Hubei 430074

2 Natural History Museum of Guangxi, Nanning, Guangxi 530012

3 Museum of Baise City, Baise, Guangxi 533000

4 Institute of Vertebrate Paleontology and Paleoanthropology, Beijing 100044

Abstract: Based on a partial postcranial skeleton collected from the Lower Cretaceous Napai Formation of Guangxi, China, we erect a new sauropod taxon, *Fusuisaurus zhaoi* gen. et sp. nov. The holotype specimen consists of the left ilium, left pubis, anterior caudals, most of the dorsal ribs and distal end of the left femur. *Fusuisaurus zhaoi* is diagnosed by a unique combination of character states among the known sauropods. It displays several synapomorphies of Titanosauriformes but lacks many derived features seen in other titanosauriforms, suggesting that the new taxon represents the basalmost known titanosauriform and providing new evidence that Titanosauriformes originated from Asia. A size comparison suggests that *Fusuisaurus zhaoi* is among the largest Early Cretaceous sauropods, providing an important addition to the Early Cretaceous Chinese sauropod diversity.

Key words: Titanosauriformes, Early Cretaceous, Fusui County, Guangxi, China

1 Introduction

In the summer of 2001, we collected a partial sauropod skeleton from the purple-red muddy siltstone of the Napai Formation at the Liubang site of Fusui County, Guangxi, China. Although incomplete, the specimen preserves significant phylogenetic signals, suggesting the presence of a new basal titanosauriform sauropod taxon in the Napai Basin. The Napai Formation has produced numerous vertebrate fossils, including fish, turtles, plesiosaurs, and two dinosaurs: the theropod *Prodeinodon kwangshiensis* and the sauropod *Asiatosaurus kwangshiensis* (Hou et al., 1975). Based on a multitude of criteria from tectonic, stratigraphic, paleontological evidence, the age of the redbeds in the Napai Basin is believed to be of Early Cretaceous (Hou et al., 1975; Bureau of Geology and Mineral Resources of Guangxi Zhuang Autonomous Region, 1985). Here we describe the specimen and erect a new taxon based on the recovered information.

2 Systematic Paleontology

Order Saurischia Seeley, 1888

Suborder Sauropoda Marsh, 1878

Titanosauriformes Salgado, Coria et Calvo, 1997

Family Incertae sedis

Fusuisaurus zhaoi gen. et sp. nov.

Etymology: Fusui, after the fossil-producing Fusui County; The specific name is dedicated to Professor Zhao Xijin for his contribution to the dinosaur research in Guangxi.

Locality and horizon: Liubang village, Fusui County, Guangxi Zhuang Autonomous Region; Napai Formation, Early Cretaceous.

Holotype: NHMG6729 (Natural History Museum of Guangxi), a relatively complete left ilium, a complete left pubis, 3 incomplete articulated anterior caudals, most of dorsal ribs and distal end of the left femur are preserved.

Diagnosis: A large sauropod distinguished from all other taxa in having a combination of the following character states: anterior dorsal ribs non-pneumatic, presence of a prominent, pointed anteroventral process of the ilium, the preacetabular blade strongly expanded dorsoventrally, posterior margin of the ilium notched, and transverse process of the anterior caudal vertebrae dorsoventrally flattened.

Description

Dorsal ribs: Most dorsal ribs are preserved. The longest one is about 230 cm in preserved length. The anterior dorsal ribs have widely separated capitulum and tuberculum, suggesting that the dorsal vertebrae are extremely large in

* Corresponding author. E-mail: mjj66925@163.com.

size. For example, one anterior dorsal rib shows a capitulum-tuberculum distance of about 60 cm. The articular facet of tuberculum is large and elongated quadrangular in outline and the capitular articulation is much smaller and oval in outline. Although the posterior margin of the proximal dorsal rib is deeply concave, no pneumatic opening is present (Fig. 1a, b). A prominent ridge extends from the tuberculum down the shaft along the anterior margin and a deep groove on the posterior surface. The anterior dorsal ribs are plank-like but the posterior ones are slender, with an oval cross-section.

Caudal vertebrae: Three incomplete anterior caudal vertebrae are preserved (Fig. 1c, d). One vertebra has a posterior central diameter of about 40 cm. The posterior articular surface is sub-circular in outline and only slightly concave, suggesting an amphicoelous central articulation. The neural arch is low and about half the central height (excluding the neural spinal height). The transverse process is short and dorsoventrally flattened. It extends ventrolaterally and also posteriorly to be slightly beyond the posterior margin of the centrum. The neural spine is low and markedly expanded at the distal end.

Ilium: The left ilium is mostly preserved, missing only the distal part of the pubic peduncle and central part of the iliac blade (Fig. 1e). The iliac blade is massive anteriorly, but tapers posteriorly, thickening at both anterior and posterior end of the ilium. In dorsal view, the preacetabular blade of the ilium flares about 40° laterally from the body of the ilium. In lateral view the preacetabular blade strongly expands dorsoventrally, causing the ilium to appear asymmetrical, with its dorsal margin rising to its highest point anterior to the pubic peduncle. A prominent anteroventral process is present and it is somewhat pointed. A small anteroventral process is seen in some neosauropod such as *Diplodocus carnegii* and *Camarasaurus grandis* (McIntosh, 1990) and some titanosauriforms (Xu et al., 2006). The shallow postacetabular process of the ilium is transversely expanded and rugose along its dorsal margin for the origin of the iliocaudalis muscle (Borsuk-bialynicka, 1977). As in *Brachiosaurus*, it has small notch posteriorly in lateral view. Also similar to *Brachiosaurus*, a distinct notch between the ischial peduncle and the postacetabular process is present. The midlength of the ilium is located at the caudal face of the pubic peduncle contributing significantly to the acetabular surface. The distal part of the pubic peduncle is not well preserved, but the pubic peduncle is apparently more developed than the ischial articulation.

Pubis: The left pubis is completely preserved, measuring about 110 cm in length (Fig. 1f, g). It is extremely compressed transversely, with thickened proximal articular surface and moderately expanded distal end. The anterior

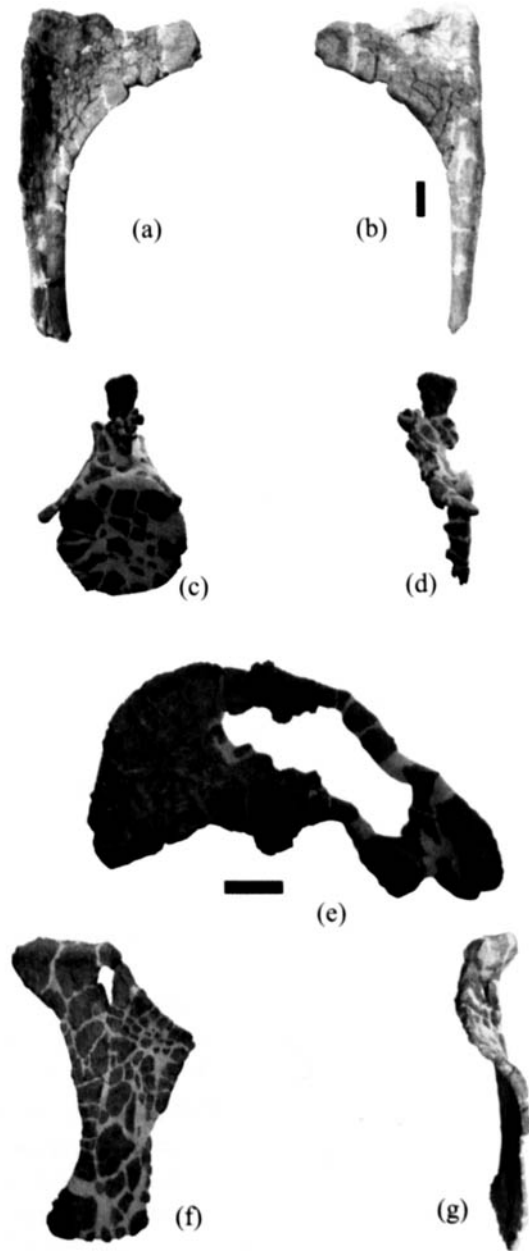


Fig. 1. Left anterior dorsal rib (a, b), anterior caudal (c, d), left ilium (e), and left pubis (f, g) of *Fusuisaurus zhaoi* gen. et sp. nov. in anterior (b), posterior (a, c and g) and lateral (d, e and f) views.

Scale bar = 10 cm in a–d, and 20 cm in e–g.

margin of pubic shaft is thin for most of its length but proximally and distally. The iliac peduncle is shallowly concave centrally and moderately expanded mediolaterally, while the pubic acetabular surface is prominently expanded medially. The middle and distal portion of pubis lie in approximately the same plane as the proximal end except the ischial articulation. The latter is a thin sheet, the proximal half of which extends posteriorly as a flange, while the distal half curves medially and aligns with the

long-axis of the pubic shaft. Viewed posteriorly, the articular margin resembles a stretched letter "S". The length of the ischial articulation is 43% of the total length of the pubis, which is similar to the condition in Camarasauromorph sauropods (Salgado et al., 1997; Wilson and Sereno, 1998). The acetabular and ischial surfaces meet in obtuse angle in lateral view.

Femur: Only the distal end of the left femur is preserved, which is about 60 cm in breadth. The distal end of the femur forms distinct articular condyles for the fibula and tibia that are separated from each other by a large, wide crural extensor fossa. The tibial condyle is moderately expanded, exceeding the fibular one in extent. Both condyles are shifted mediolaterally and are visible in anterior and posterior view. The articular surface is markedly rugose and convex anteroposteriorly.

3 Comparison and Discussion

Fusuisaurus displays several features suggesting a titanosauriform affinity. As in *Camarosaurus* and the known titanosauriforms, *Fusuisaurus* has a deep ischial articular surface on the pubis. Similar to other titanosauriforms, *Fusuisaurus* has plank-like anterior dorsal ribs. The ilium of *Fusuisaurus* is also similar to that of other titanosauriforms in several features. The preacetabular process of the ilium is strongly expanded dorsoventrally such that it is much deeper than the blade posterior to the pubic peduncle. Similar to the basal titanosauriform *Brachiosaurus*, a prominent lateral ridge is present along the dorsal margin and a distinctive notch on the posterior margin of the postacetabular blade. However, *Fusuisaurus* lacks many other titanosauriform synapomorphies. For example, the dorsal ribs seem to lack pneumatic features and the anterior caudal centra appear to be amphicoelous, and also the preacetabular blade is not lobe-like. Consequently *Fusuisaurus* might represent the basalmost known titanosauriform.

Several other titanosauriforms have been recently discovered from the Cretaceous of China. These include *Huabeisaurus* from Shanxi (Pang and Cheng, 2000), *Jiangshanosaurus lixianensis* (Tang et al., 2001) from Zhejiang, *Gobititan shenzhouensis* (You et al., 2003) from Gansu, *Borealosaurus wimani* (You et al., 2004) from Liaoning and *Sonidosaurus saihangaobiensis* (Xu et al., 2006) from Nei Mongol. In *Jiangshanosaurus*, the proximal caudal centra are procoelous and the dorsal ribs are pneumatized. These derived titanosaur characters do not occur in *Fusuisaurus*. Except for the distal half of the femur described in *Gobititan*, no girdle elements and proximal caudals and dorsal ribs are preserved in both *Gobititan* and *Borealosaurus*, thus their comparison with

Fusuisaurus is not possible. *Fusuisaurus* is similar to *Huabeisaurus* (Pang and Cheng, 2000) and *Sonidosaurus saihangaobiensis* (Xu et al., 2006) in several features. For example, they share the presence of an anteroventral process on the ilium, the pubic peduncle setting an acute angle with the ventral margin of the preacetabular blade, a relative narrow and long posterior process in lateral view, and the ventral margin of the ischiadic peduncles level with the chord across the anterior and posterior iliac spine. But in *Huabeisaurus*, the anteroventral process of the ilium is rounded and the ischial peduncle of the ilium is much more reduced; also in *Huabeisaurus* the pubis is more gracile with a slightly expanded proximal and distal end, different from the strongly expanded proximal and distal end of *Fusuisaurus*.

Fusuisaurus is also different from other basal titanosauriforms including *Brachiosaurus* (Riggs, 1904; Janensch, 1961), South American *Andesaurus* (Calvo and Bonaparte, 1991), Asian *Phuwiangosaurus* (Martin et al., 1999), and African *Malawisaurus* (Jacobs et al., 1993; Gomani, 1999) in a unique character combination. *Fusuisaurus* differs from *Brachiosaurus* in lacking pneumatic dorsal ribs, from *Malawisaurus* in lacking procoelous caudal vertebrae, and from *Phuwiangosaurus* in dorsoventrally deep preacetabular blade.

As discussed above, *Fusuisaurus* represents a new basal titanosauriform. The available information indicates a basalmost position within Titanosauriforms for this new taxon. You et al. (2003) suggested that Asia might be the origin place for Titanosauriformes and the discovery of *Fusuisaurus* provides further evidence for this hypothesis.

Fusuisaurus zhaoi is estimated to be more than 20 meters in length. Its ilium is 145 cm in length, compared to 135 cm in *Jobaria* (Sereno et al., 1999), 132 cm in *Haplocanthosaurus delfsi* (McIntosh and Williams, 1988), 116 cm in *Brachiosaurus brancai* (estimated from Janensch, 1961), 118 cm in *Huabeisaurus allocotus* (estimated from Pang and Cheng, 2000), and 86 cm in *Phuwiangosaurus sirindhornae* (Martin et al., 1999). These data suggest that *Fusuisaurus zhaoi* is one of the largest sauropod from the Early Cretaceous. The discovery of *Fusuisaurus* provides an important addition to the Early Cretaceous Chinese sauropod fauna.

4 Conclusions

A new titanosauriform sauropod dinosaur, *Fusuisaurus zhaoi* gen. et sp. nov., is described from the Early Cretaceous Napai Formation of Guangxi, China. Its primitive nature provide further supports for the Asian origin of Titanosauriformes.

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