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A New Eusauropod Dinosaur from the Lower Cretaceous of Guangxi Province, Southern China

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Abstract: A new sauropod dinosaur, *Liubangosaurus hei* gen. et sp. nov., is erected based on a specimen represented by five articulated middle-caudal dorsal vertebrae, which was discovered in the Lower Cretaceous Napai Formation of Guangxi Province, southern China. This new taxon is diagnosed by a unique combination of derived features: prezygapophysis closely contacts with parapophysis, with the prdl and prpl absent; presence of cavity on the dorsal surface of the diapophysis; neural spine very low, with its distal end level with that of diapophysis; distal end of the neural spine strongly expanded laterally to form a platform; marked fossa formed between the infradiapophyseal lamina and the parapophysis; broad, flat area of featureless bone on lateral surface of neural arch; vertically directed infradiapophyseal lamina expands or bifurcates ventrally to form a inverted "Y"; highly positioned parapophyses large and tear-drop in shape. The discovery of this new taxon increases the diversity of sauropods in China during the Early Cretaceous.

Key words: Eusauropoda, *Liubangosaurus hei*, Napai Formation, Early Cretaceous, Guangxi, China

1 Introduction

In 2001, a large number of sauropod dinosaur bones were recovered from the Liubang quarry of Fusui County, Guangxi Province (Fig. 1). On the basis of size and morphological differences among the ilia found in the quarry, at least three individuals of sauropods are present: a very large one (described as *Fusuisaurus zhaoi* by Mo et al., 2006) and two smaller ones. The two smaller sauropods were represented by disarticulated postcranial skeletons which are difficult to differentiate from each other. Here we describe five articulated middle-caudal dorsal vertebrae which preserve many phylogenetically informative characters that allow it to be confidently identified as a new taxon. It is highly distinctive, possessing several autapomorphies. The Napai Formation has yielded a small vertebrate assemblage, including spinosaurid and megalosaurid theropods, brachiosaurid and basal titanosauriform sauropods (Hou et al., 1975; Mo et al., 2006; Buffetaut et al., 2008). Description of the new taxon indicates that several basal neosauropod dinosaurs coexisted in the Napai Basin during the Early Cretaceous. For the description of the neural arch, we follow the vertebral lamina nomenclature of Wilson (1999).

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2 Systematic Paleontology

Dinosauria Owen, 1842
Saurischia Seeley, 1888
Sauropodomorpha Huene, 1932
Sauropoda Marsh, 1878
Eusauropoda Upchurch, 1995
***Liubangosaurus* gen. nov.**

Etymology: "*Liubang*" (Chinese): name of the fossil site.

Type Species: *L. hei* sp. nov.

Diagnosis: As for the type and only species, *L. hei.*

Liubangosaurus hei sp. nov.

Etymology: "*he*" (Chinese): the specific name is dedicated to He Wenjian, who first reported the fossil site to us.

Holotype: NHMG8152, the Natural History Museum of

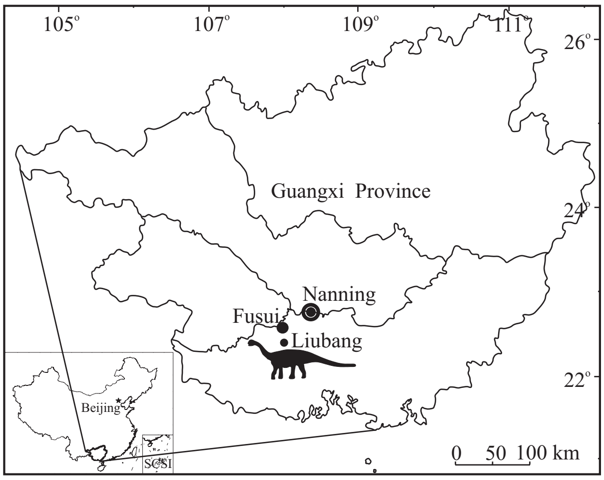

Fig. 1. Locality of *Liubangosaurus hei.*

Guangxi. Nearly complete five articulated dorsal vertebrae.

Type locality and horizon: Liubang village, Fusui County, Guangxi Province, southern China. Napai Formation, Early Cretaceous (Hou et al., 1975; Bureau of Geology and Mineral Resources of Guangxi Zhuang Autonomous Region, 1985).

Diagnosis: Differs from all other sauropods in the following combination of character states: (1) prezygapophysis closely contacts with parapophysis, with the prdl and prpl absent; (2) presence of cavity on the dorsal surface of the diapophysis; (3) neural spine very low, with its distal end level with that of diapophysis; (4) distal end of the neural spine strongly expanded laterally to form a platform; (5) marked fossa formed between the infradiapophyseal lamina and the parapophysis; (6) broad, flat area of featureless bone on lateral surface of neural arch; (7) vertically directed infradiapophyseal lamina expands or bifurcates ventrally to form a inverted "Y"; (8) highly positioned parapophyses large and tear-drop in shape.

3 Description

The high position of the parapophyses indicates that five articulated dorsal vertebrae are from the middle and caudal portions of the dorsal column (probably D.5-D.9). The dorsals are nearly complete on their right side, while the left sides of the neural arches are not well-preserved (Figs. 2 and 3). These dorsals retain approximately the same height and length. Measurements are summarized in Table 1. The dorsal features described below are mainly from the right side of the vertebrae.

The centra are strongly opisthocoelous with prominent anterior convexities. In anterior view, the articular surface of the convexity is pear-shaped, with its ventral half strongly expanded ventrally and laterally. The elongation indices (centrum length, excluding the anterior articular ball, divided by posterior centrum height) are approximately 1.0. The centra are markedly compressed transversely, and their width: height ratio is approximately 0.7, partly because of the result of the mediolateral distortion. This ratio is greater than 1.0 in most other sauropods (Upchurch et al., 2004). The ventral surfaces of the centra are gently concave longitudinally and convex transversely. In lateral view, the lateral surfaces of the centra are mildly convex dorsoventrally. The pleurocoels are positioned dorsally and anteriorly on the centra. They are very roughly triangular in shape, with acute anterior and posterior margins. The pleurocoels are deep, ramifying through the centra and into the base of the neural arches, leaving only a thin septum on the midline of their centra. Deep and roughly triangular pleurocoels are also present in *Camarasaurus lewisi* (McIntosh et al., 1996). Dorsal to the pleurocoels, the lateral surface of the neural arch is slightly convex dorsoventrally.

The neural arches are extremely high, exceeding the height of their centra, as in most other sauropods, and are approximately twice the width of their centra. In lateral view, all the vertebrae develop marked, vertically oriented laminae from the distal end of the diapophyses to about the mid-height of the vertebrae. These laminae bifurcate

Table 1 Measurements of the fifth-ninth dorsal vertebrae of *Liubangosaurus hei* gen. et sp. nov. (holotype, NHMG8152)

Vert.	Lc	Lc-b	Hcp	Wcp	ArcH	ToHs	ToHd	Lsp	Wspb	Hpre	Hpos	MaLp	MaWp	Ddp
D.5	300	230	230e	150e	300	650e	710	140e	130e	490	530	160	60	330
D.6	310e	240	240	150	300	660	700	180e	130e	530	540	150	70	310
D.7	315	245	240	150	260	630	660	210e	140e	520	510	125	65	290
D.8	310	235	230	170	260	620	630	170e	120e	490	490	110	52	280
D.9	290	210	240	190e	240	650	620	120e	110e	480	480	105	50	270

Abbreviations: ArcH, height of neural arch (measured from the top of the centrum to the upper margin of the postzygapophysis); Ddp, distance between diapophysis and parapophysis; e, estimate; Hcp, height of posterior surface of the centrum; Hpos, height of the postzygapophysis; Hpre, height of the prezygapophysis; Lc, length of centrum (including articular ball); Lc-b, length of centrum (excluding articular ball); Lsp, anteroposterior length of the dorsal surface of the neural spine; MaLp, maximum length of parapophysis; MaWp, maximum width of parapophysis; ToHd, total height of vertebra (measured from the top of diapophysis); ToHs, total height of vertebra (measured from the top of neural spine); Vert. position in vertebral column; Wcp, width of centrum across its posterior surface; Wspb, width of the neural spine bifurcation (i.e., the distance between the tops of the metapophyses or width of the top of the neural spine without bifurcation). Measurements are in mm.

Fig. 2. Articulated fifth-ninth dorsal vertebrae of *Liubangosaurus hei* gen. et sp. nov. (holotype, NHMG 8152) in: a-d, right lateral views; e and f, ninth dorsal in anterior and posterior views; g, sixth dorsal in posterior view; h, fifth dorsal in anterior view; and i, seventh dorsal in dorsal view. Scale bar equals 10 cm.

ventrally and merge with the lateral surface of the neural arches, as in *Camarasaurus* (Wilson and Sereno, 1998, fig. 13). The anterior branch is shorter but more robust than the posterior one. This is presumably homologous with acdl and pcdl, but cannot be so named as it does not approach the centrum, unlike the condition in *Camarasaurus*. Below this bifurcate lamina and above the dorsal margin of the pleurocoel, the lateral surface of the neural arch is a nearly flat, featureless area. This feature is only observed in *Xenoposeidon proneneukos* (Taylor and Naish, 2007), but the anterior centroparapophyseal lamina is more marked and extends ventrally to the anterodorsal margin of the pleurocoel in *Xenoposeidon* in lateral view. In *Liubangosaurus*, the ventrally extended acpl extends along the anterolateral margin of the neural arch.

The parapophysis is situated at the anterodorsal margin of the D.5, just at the level with the prezygapophysis. It is teardrop-shaped with the long-axis extending vertically. In D.6-D.9, the parapophyses become higher than that of D.5, and are also tear-drop in shape, with acute dorsal margin and rounded ventral margin, and the long-axis extending anteroventrally. The parapophyseal articular surface of D.5 is mildly concave at the central part, facing laterally and a little posteriorly. In D.6-D.9, the parapophyseal articular surfaces are strongly concave, facing laterally and slightly dorsally. The acpl of D.5 is a sheet of thin bone which extends and gradually expands ventrally along the anterior margin of the neural arch to

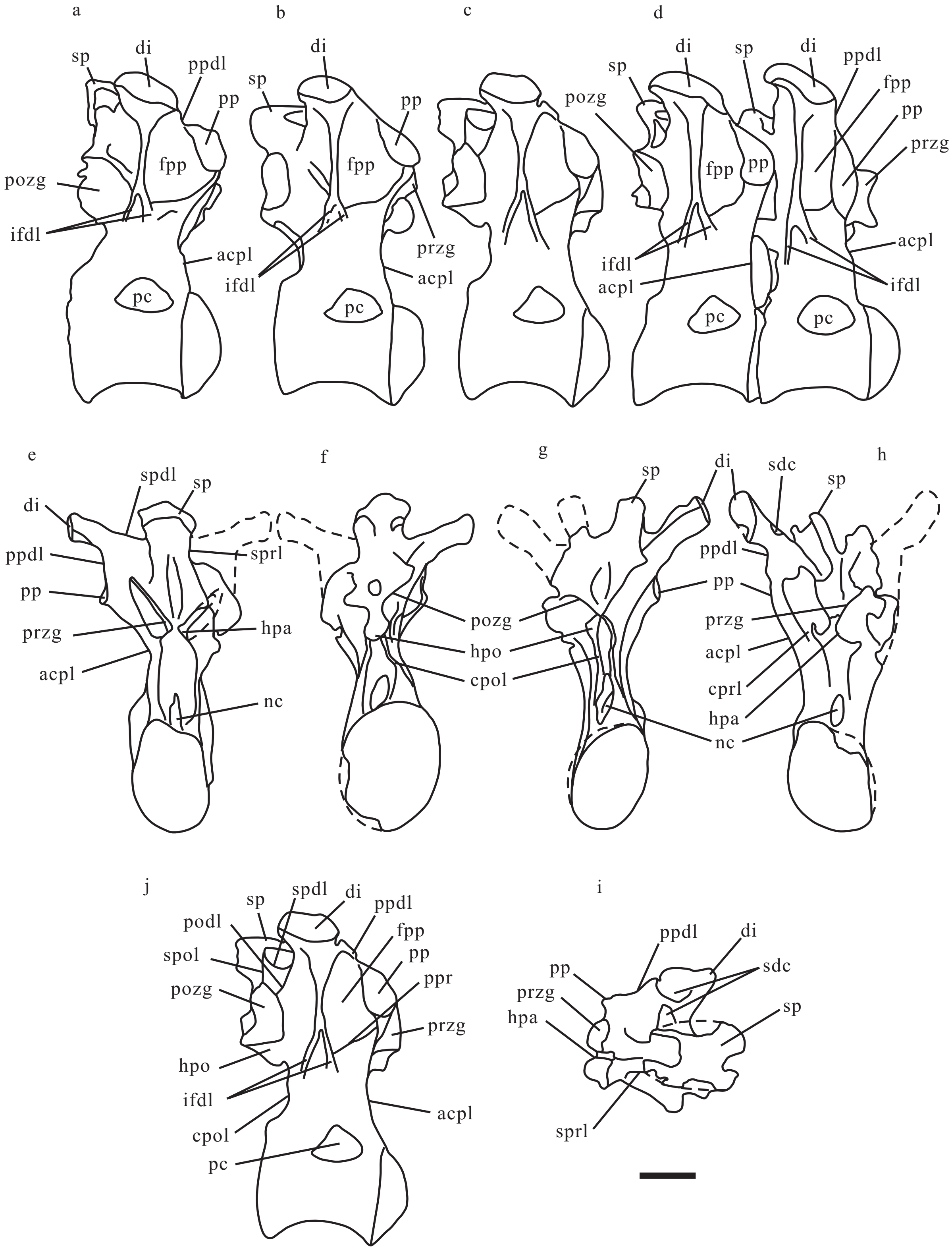

Fig. 3. Interpretive drawing of fifth-ninth dorsal vertebrae of *Liubangosaurus hei* gen. et sp. nov. (holotype, NHMG8152) in: a-d, right lateral views; e and f, ninth dorsal in anterior and posterior views; g, sixth dorsal in posterior view; h, fifth dorsal in anterior view; i and j, seventh dorsal in dorsal and lateral views. Scale bar equals 10 cm. Abbreviations: acpl, anterior centroparapophyseal lamina; cpol, centropostzygapophyseal lamina; cprl, centroprezygapophyseal lamina; di, diapophysis; hpa, hypantrum; hpo, hyposphene; fpp, postparapophyseal fossa; ifdl, infradiapophyseal lamina; nc, neural canal; pozg, postzygapophysis; podl, postzygodiapophyseal lamina; pp, parapophysis; ppdl, paradiapophyseal lamina; ppr, postparapophyseal ridge; przg, prezygapophysis; sdc, supradiapophyseal cavity; sp, spine; spdl, spinodiapophyseal lamina; spol, spinopostzygapophyseal lamina; sprl, spinoprezygapophyseal lamina.

contact the dorsal margin of the anterior articular ball. It decreases in thickness through the sequence. The paradiapophyseal lamina is very short and strongly developed, extending from the upper margin of the parapophysis to the anterior margin of the diapophysis. A stout ridge extends posteroventrally from the ventral margin of the parapophysis to contact the anterior branch of the infradiapophyseal lamina mentioned above. Between the parapophysis and the infradiapophyseal lamina, a large subtriangular cavity is present on the lateral surface of the neural arch. This cavity is deep at the posteroventral corner and ramifies somewhat into the base of the infradiapophyseal lamina, and becomes gradually shallow when extending to the upper margin of the spinodiapophyseal lamina. This cavity is designated as fpp by Bonaparte (1999), and also presents in *Ruyangosaurus giganteus* (Lü et al., 2009). In most other sauropods, this cavity is bordered ventrally by the pcpl. In D.6, the fpp is open anteriorly through a large canal formed between the parapophysis and the prezygapophysis, just at mid-length of the prezygapophysis. The dorsal end of the canal is formed by a prominent ridge which is homologous with the prpl, while the ventral end of the canal is formed by the cprl which merges ventrally with the acpl. This canal is not present in D.5, and D.7-9, and it seems to be an aberrant feature of this individual, not considered taxonomically significant.

The diapophyses are strongly directed dorsolaterally at an angle of about 45°, level with the dorsal margin of the neural spines, as in *Haplocanthosaurus* (Hatcher, 1903; McIntosh and Williams, 1988). The distal articular surface of the diapophysis of D.5 is teardrop-shaped, with a rounded anterior margin and acute posterior margin. Its articular surface directs dorsolaterally and slightly anteriorly. In D.6-9, these articular surfaces are oval in shape, directing laterally and slightly dorsally in D.6-7, and entirely laterally in D.8-9. All the diapophyseal articular surfaces are nearly flat, anteroposteriorly elongated, dorsoventrally compressed, and strongly expanded ventrally. The postzygodiapophyseal lamina is present and mildly developed. In dorsal view, the dorsal surface of the diapophysis forms an irregular-shaped cavity which opens externally. This cavity is large and covered by a sheet of bone in D.7 (Fig. 2 and 3i) and D.8, small in D.5 and D.6, and weakly developed in D.9. This feature is not observed in any other sauropod vertebra.

The prezygapophyses are in close contact with the parapophyses in all these five dorsals. It is positioned at the level of the parapophysis in D.5, and decreases in height relatively to the parapophysis through the sequence. All the prezygapophyses have flat elliptical articular surfaces, with their long axis directed dorsolaterally and their articular surfaces facing dorsomedially. The ventral margin of the prezygapophyses curve ventrolaterally to form the hypantral facets. The prezygapophysis is prominent in D.5 and D.6, extending anteriorly well beyond the parapophysis. The prdl and prpl are absent, due to the close contact between the prezygapophysis and the parapophysis. This close contact is more marked through the sequence. Ventrally, the prezygapophysis is supported by a very short ridge which is homologous with the cprl in D.5. It merges with the medial surface of the upper part of the acpl. The cprl becomes less developed through the sequence, and is absent in D.9. Large, deep concavities are present at the anterior face of the neural arches between the left and right acpls. The neural canals are large, oval in shape.

The postzygapophyses are prominent structures that do not project beyond the posterior margins of the centra. Their articular surfaces are concave transversely and face ventrolaterally. Marked diamond-shaped hyposphenes are present at the ventromedial end of the postzygapophyses. The hyposphenes are well developed, with the dorsal margins strongly expanded anteriorly in lateral view and laterally in posterior view. Ventrally, the hyposphenes are supported by stout centropostzygapophyseal laminae which extend ventrally along the posterior margin of the lateral surface of the neural arch. A relatively deep and elongated concavity is formed between two cpols. Dorsally, two short but stout ridges extend from the dorsolateral margin of the postzygapophysis to the posterolateral margin of the spine and the posterior margin of the diapophysis respectively. These two ridges are homologous with spinopostzygapophyseal lamina and podl which are less prominent through the sequence. In D.8 and D.9, a subsidiary lamina originates posterodorsally from the point where the infradiapophyseal lamina bifurcates to the anterodoral margin of the postzygapophysis. This subsidiary lamina, the podl, and the infrodiapophyseal lamina define marked depression.

The neural spines are extremely short, with their dorsal margins level with that of their diapophyses. Very short dorsal neural spines are also present in some titanosauriform sauropods from China (Lü et al., 2008; You, et al., 2008; Zhang et al., 2009). The caudal margins of the spines do not project beyond the caudal margins of the postzygapophyses. The spines of D.5 and D.6 are bifurcate, though the left sides of the spines are missing (Fig. 3g and h). The anterior and posterior margins of the spine in D.7 are slightly notched (Fig. 3i), while the spines of D.8 and D.9 are undivided (Fig. 3e and f). The anteroposterior length and transverse width of the spines decrease from D.5 onward. The distal end of the spine of

Table 2 Character codings for *Liubangosaurus* in the matrix used for the phylogenetic analysis in this paper

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Apart from the addition of *Liubangosaurus*, the matrix is identical to the revised matrix of Harris (2006) at Taylor (2009), which includes 31 taxa and 331 characters.

D.9 is transversely convex and longitudinally flat. The anterolateral margin of the spine is formed by a stout spinoprezygapophyseal lamina which extends anteroventrally from the anterolateral margin of the distal end of the spine to contact the medial surface of the ppdl. The ppdl is short, originating from the posterior margin of the diapophysis to contact the posterolateral margin of the spine. Spdl, podl, and spol are marked in D.5, and define a small triangular fossa which becomes less marked through the sequence and disappears in D.9, though this area is slightly broken. Between the spdl and sprl, a deep and vertically elongate concavity is formed on the lateral side of the spine. Dorsally, the lateral margin of the distal end of the spines in D.7, D.8, and D.9 strongly expands transversely to roof the lateral elongate concavity of the spines mentioned above. A strong transverse expansion of the distal end of the spine is only observed in the sacral vertebrae of *Huanghetitan* (You, et al., 2006; Lü, et al., 2007), the dorsal and the anterior caudal vertebrae of *Ruyangosaurus* (Lü et al., 2009).

4 Phylogenetic Analysis

A preliminary phylogenetic analysis was performed in order to elucidate the phylogenetic position of *Liubangosaurus*. We used the dataset of Taylor (2009) with the new taxon added in, yielding a matrix of 32 taxa (30 ingroups and two outgroups) and 331 characters. Because of the paucity of material, only 24 characters were scored in *Liubangosaurus* (Table 2). PAUP 4.0b10 (Swofford 2002) was used to perform a heuristic search using random stepwise addition with 50 replicates and with maximum trees = 500 000, and recovered 144 most parsimonious trees with a tree length of 794 steps, consistency index of 0.5176, and retention index of 0.6827. The strict and majority consensus of the 144 most parsimonious trees are presented in Fig. 4a and b, respectively, which show that *Liubangosaurus* is an eusauropod possibly closely related with *Haplocanthosaurus*.

5 Discussion

Liubangosaurus material is from the quarry that produced *Fusuisaurus zhaoi* holotype. The known material of the two taxa has no overlapping and is thus difficult to compare. Both specimens are probably adult individuals as indicated by fusion features of the dorsal or caudal vertebrae. However, they are significantly different in size (*Fusuisaurus* is probably more than 20 m in length with the anterior caudal centrum exceeding 40 cm in diameter (Mo et al., 2006), while the posterior dorsal centrum of *Liubangosaurus* is approximately 25 cm in diameter), suggesting that they are likely to be different taxon. Further more, the titanosauriform affinity of *Fusuisaurus zhaoi* (Mo et al., 2006) also provides evidence that they are two different taxa.

The discovery of a eusauropod in the Early Cretaceous of China is significant given that all sauropods from the Cretaceous Asia are referred to the Titanosauriformes and this has been considered to be a perplexing distribution pattern (Wilson, 2005; Wilson and Upchurch, 2009). The discovery of *Liubangosaurus*, together with the diplodocoid material from Shandong Province, northern China (Upchurch and Mannion, 2009), suggest that this is probably due to sampling bias.

Although our analysis places *Liubangosaurus* at a relatively basal position within the Eusauropoda, it should be noted that the specimen is represented by limited material and thus its proposed systematic position is tentative. Noteworthy is that *Liubangosaurus* shares some derived features with some basal titanosauriforms, such as a low dorsal neural spine, not well-developed prezygaparapophyseal lamina, and a dorsolaterally directed diapophysis.

The discovery of *Liubangosaurus hei* adds a new element to the Early Cretaceous vertebrate fauna from the Napai Formation of Guangxi, the importance of which partly lies in its geographical location in one of the southernmost regions of China. By comparison with northern, western and central China, few Cretaceous vertebrate assemblages have yet been reported from southern China, which makes the assemblage from Guangxi all the more significant for palaeobiogeographical reconstructions. Sauropod diversity seems to be relatively high in the Napai Formation, with *Liubangosaurus hei* and *Fusuisaurus zhaoi*, represented by skeletal elements, and isolated teeth which cannot be attributed with any certainty to either of them, but also indicate the occurrence of more than one taxon. These

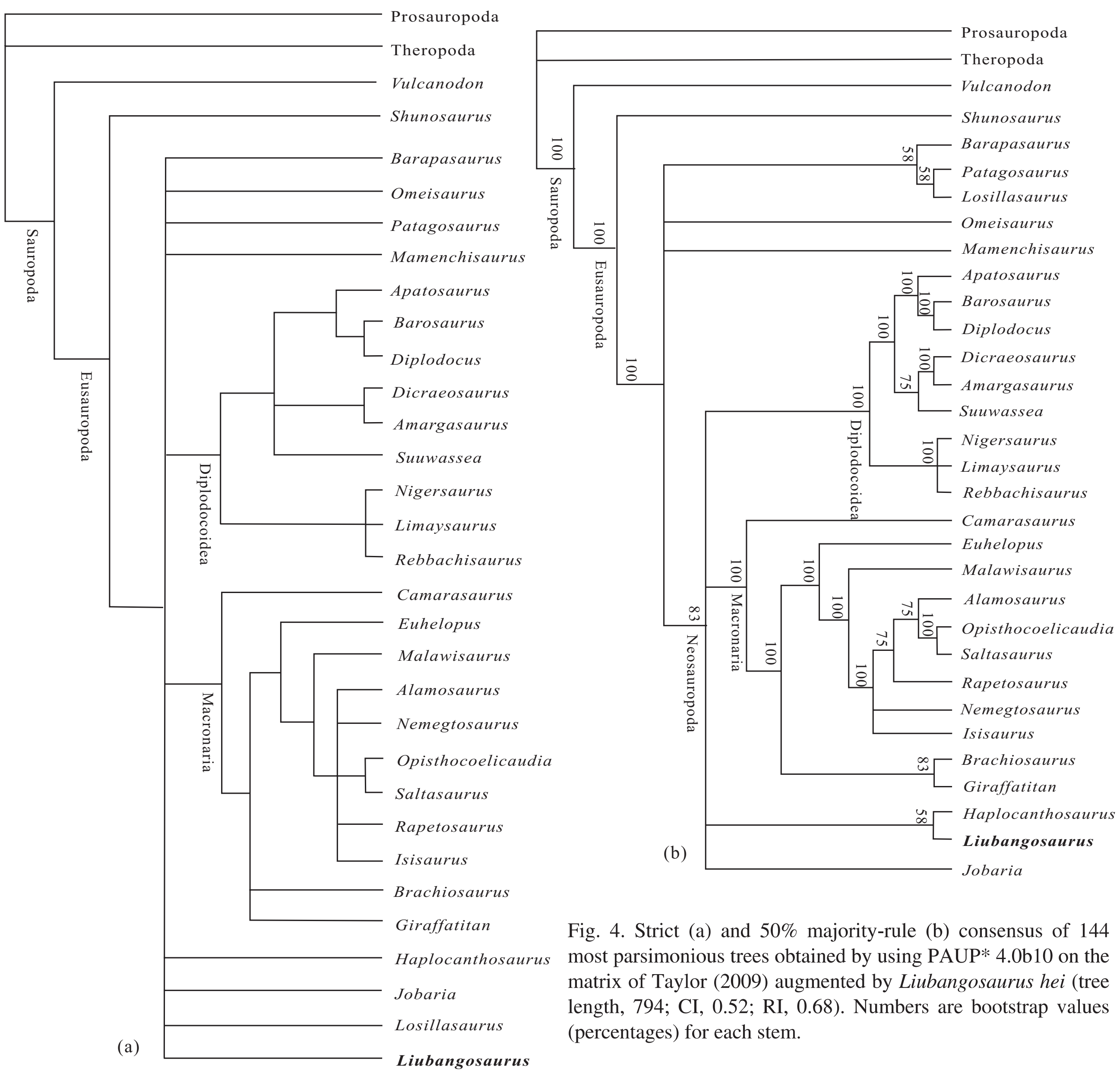

Fig. 4. Strict (a) and 50% majority-rule (b) consensus of 144 most parsimonious trees obtained by using PAUP* 4.0b10 on the matrix of Taylor (2009) augmented by *Liubangosaurus hei* (tree length, 794; CI, 0.52; RI, 0.68). Numbers are bootstrap values (percentages) for each stem.

isolated teeth include at least two distinct types of spoon-shaped teeth (including the tooth described as *Asiatosaurus kwangshiensis* by Hou et al., 1975) and one peg-like tooth.

The new sauropod from the Napai Formation also adds a new element to the already high diversity of Cretaceous sauropods from China. However, this diversity should not be overestimated, because the various sauropods reported from the Cretaceous of China come from different formations in various provinces, and apparently span a large part of both the Early and Late Cretaceous (although in many cases the exact geological age of these continental formations remains rather uncertain). Interestingly, although most the Cretaceous sauropods from China are now considered as belonging to the Titanosauriformes, *Liubangosaurus hei* apparently belongs to a more basal group, since the phylogenetic analysis places it very close to *Haplocanthosaurus*. The new form from Guangxi would thus appear to be one of the few non-titanosauriform sauropods currently known from the Cretaceous of China.

6 Conclusion

Liubangosaurus hei represents a new eusauropod dinosaur. It is diagnosed by a unique combination of derived features: prezygapophysis closely contacts with parapophysis, with the prdl and prpl absent; presence of cavity on the dorsal surface of the diapophysis; neural spine very low, with its distal end level with that of diapophysis; distal end of the neural spine strongly expanded laterally to form a platform; marked fossa formed between the infradiapophyseal lamina and the parapophysis; broad, flat area of featureless bone on lateral surface of neural arch; vertically directed infradiapophyseal lamina expands or bifurcates ventrally to form a inverted "Y"; highly positioned parapophyses large and tear-drop in shape. A preliminary phylogenetic analysis shows that it is a relatively basal eusauropod, in contrast to other Early Cretaceous sauropods from Asia which are more derived in systematic position.

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References

Bonaparte, J.F., 1999. Evolution de las vertebras presacras en Sauropodomorpha. *Ameghiniana*, 36 (2): 115–187.

Buffetaut, E., Suteethorn, V., Tong, H.Y., and Amiot, R., 2008. An Early Cretaceous spinosaurid theropod from southern China. *Geological Magazine*, 145 (5): 745–748.

Bureau of Geology and Mineral Resources of Guangxi Zhuang Autonomous Region, 1985. *Regional Geology of Guangxi Zhuang Autonomous Region*. Beijing: Geological Publishing House. 255–266 (in Chinese).

Harris, J.D., 2006. The significance of *Suuwassea emiliae* (Dinosauria: Sauropoda) for flagellicaudatan intrarelationships and evolution. *Journal of Systematic palaeontology*, 4 (2): 185–198.

Hatcher, J.B., 1903. Osteology of *Haplocanthosaurus*, with description of a new species, and remarks on the probable habits of the Sauropods and the age and origin of the *Atlantosaurus* Beds. *Mem. Carnegie Mus*. 2: 1–72.

Hou Lianhai, Ye Xiangkui and Zhao Xijin, 1975. Fossil reptiles from Fusui, Kwangshi. *Vertebrata PalAsiatica*, 13 (1): 24–33 (in Chinese with English abstract).

Lü Junchang, Xu Li, Zhang Xingliao, Hu Weiyong, Wu Yanhua, Jia Songhai and Ji Qiang, 2007. A new gigantic sauropod dinosaur with the deepest known body cavity from the Cretaceous of Asia. *Acta Geologica Sinica* (English Edition), 81 (2): 167–176.

Lü Junchang, Yoichi Azuma, Chen Rongjun, Zheng Wenjie and Jin Xingsheng, 2008. A New Titanosauriform Sauropod from the Early Late Cretaceous of Dongyang, Zhejiang Province. *Acta Geologica Sinica* (English Edition), 82 (2): 225–235.

Lü Junchang, Xu Li, Jia Songhai, Zhang Xingliao, Zhang Jiming, Yang Lili, You Hailu, and Ji Qiang, 2009. A new gigantic sauropod dinosaur from the Cretaceous of Ruyang, Henan, China. *Geological Bulletin of China*, 28 (1): 1–10.

McIntosh, J.S., Miller, W.E., Stadtman, K.L., and Gillette, D.D., 1996. The osteology of *Camarasaurus lewisi* (Jenesh, 1988). *Brigham Young University Geology Studies*, 41: 73–115.

McIntosh, J.S., and Williams, M.E., 1988. A new species of sauropod dinosaur, *Haplocanthosaurus delfsi* sp. nov., from the Upper Jurassic Morrison Fm. of Colorado. *Kirtlandia*, 43: 3–26.

Mo Jinyou, Wang Wei, Huang Zhitao, Huang Xin and Xu Xing, 2006. A basal Titanosauriform from the Early Cretaceous of Guangxi, China. *Acta Geologica Sinica* (English Edition), 80 (4): 486–489.

Swofford, D.L., 2002. PAUP*: phylogenetic analysis using parsimony (* and other methods). Sinauer Associates, Sunderland, MA.

Taylor, M.P., and Naish, D., 2007. An unusual new Neosauropod dinosaur from the Lower Cretaceous Hastings Beds Group of east Sussex, England. *Palaeontology*, 50 (6): 1547–1564.

Taylor, M.P., 2009. A re-evaluation of *Brachiosaurus altithorax* Riggs 1903 (Dinosauria, Sauropoda) and its generic separation from *Giraffatitan brancai* (Janensch 1914). *Journal of Vertebrae Paleontology*, 29 (3): 787–806.

Upchurch, P., Barrett, P.M., and Doson, P., 2004. Sauropoda. In: Weishampel, D.B., Dodson, P., and Osmolska, H. (eds): *The Dinosauria* (second edition). Berkeley: University of California Press, 259–322

Upchurch, P., and Mannion, P.D., 2009. The first diplodocid from Asia and its implications for the evolutionary history of sauropod dinosaurs. *Palaeontology*, 52: 1195–1207

Wilson, J.A., and Sereno, P.C., 1998. Early evolution and higher-level phylogeny of sauropod dinosaurs. *Society of Vertebrate Paleontology, Memoir 5, Journal of Vertebrate Paleontology*, 18: 1–68.

Wilson, J.A., 1999. A nomenclature for vertebral laminae in sauropods and other saurischian dinosaurs. *Journal of Vertebrate Paleontology*, 19 (4): 639–653.

Wilson, J.A., 2005. Redescription of the Mongolian sauropod *Nemegtosaurus mongoliensis* Nowinski (Dinosaria: Saurischia) and comments on Late Createaceous sauropod diversity. *Journal of Systematic Palaeontology*, 3 (3): 283–318.

Wilson, J.A., and Upchurch, P., 2009. Redescription and reassessment of the phylogenetic affinities of *Euhelopus zdanskyi* (Dinosauria: Sauropoda) from the Early Cretaceous of China. *Journal of Systematic Palaeontology*, 7: 199–239.

You Hailu, Li Daqing, Zhou Lingqi and Ji Qiang, 2006. *Huanghetitan liujiaxiaensis*, a new sauropod dinosaur from the Lower Cretaceous Hekou Group of Lanzhou Basin, Gansu Province, China. *Geological Review*, 52 (5): 668–674 (In Chinese with English abstract).

You Hailu, Li Daqing, Zhou Lingqi, and Ji Qing, 2008. Dashatitan binglingi: a giant sauropod dinosaur from the Early Cretaceous of China. Gansu Geology, 17 (4): 1–10.

Zhang Xingliao, Lü Junchang, Xu Li, Li Jinhua, Yang Li, Hu Weiyong, Jia Songhai, Ji Qiang and Zhang Chengjun, 2009. A New Sauropod Dinosaur from the Late Cretaceous Gaogou Formation of Nanyang, Henan Province. *Acta Geologica Sinica* (English Edition), 83 (2): 212–221.