A new crested theropod dinosaur from the Early Jurassic of Yunnan Province, China Postprint

Authors: WANG Guo-Fu, YOU Hai-Lu, PAN Shi-Gang, WANG Tao

Date: 2017-11-07T00:00:00+00:00

Abstract

A new crested theropod, Shuangbaisaurus anlongbaoensis gen. et sp. nov., is reported. The new taxon is recovered from the Lower Jurassic Fengjiahe Formation of Shuangbai County, Chuxiong Yi Autonomous Prefecture, Yunnan Province, and is represented by a partial cranium. Shuangbaisaurus is unique in possessing parasagittal crests along the orbital dorsal rims. It is also distinguishable from the other two lager-bodied parasagittal crested Early Jurassic theropods (Dilophosaurus and Sinosaurus) by a unique combination of features, such as higher than long premaxillary body, elevated ventral edge of the premaxilla, and small upper temporal fenestra. Comparative morphological study indicates that "Dilophosaurus" sinensis could potentially be assigned to Sinosaurus, but probably not to the type species. The discovery of Shuangbaisaurus will help elucidate the evolution of basal theropods, especially the role of various bony cranial ornamentations had played in the differentiation of early theropods.

Full Text

Preamble

A New Crested Theropod Dinosaur from the Early Jurassic of Yunnan Province, China

WANG Guo-Fu[1],[2], YOU Hai-Lu[3],[4]*, PAN Shi-Gang[5], WANG Tao[5]

[1] Fossil Research Center of Chuxiong Prefecture, Yunnan Province, Chuxiong, Yunnan 675000
[2] Chuxiong Prefectural Museum, Chuxiong, Yunnan 675000
[3] Key Laboratory of Vertebrate Evolution and Human Origins of Chinese Academy of Sciences, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044
[4] College of Earth Sciences, University of Chinese Academy of Sciences, Beijing

100049
[5] Bureau of Land and Resources of Lufeng County, Lufeng, Yunnan 650031

Corresponding author: youhailu@ivpp.ac.cn

Abstract

A new crested theropod, *Shuangbaisaurus anlongbaoensis* gen. et sp. nov., is reported from the Lower Jurassic Fengjiahe Formation of Shuangbai County, Chuxiong Yi Autonomous Prefecture, Yunnan Province, represented by a partial cranium. *Shuangbaisaurus* is unique in possessing parasagittal crests along the orbital dorsal rims. It is also distinguishable from the other two large-bodied parasagittal crested Early Jurassic theropods (*Dilophosaurus* and *Sinosaurus*) by a unique combination of features, such as a premaxillary body that is taller than long, an elevated ventral edge of the premaxilla, and a small upper temporal fenestra. Comparative morphological study indicates that "*Dilophosaurus*" *sinensis* could potentially be assigned to *Sinosaurus*, but probably not to the type species. The discovery of *Shuangbaisaurus* will help elucidate the evolution of basal theropods, especially the role that various bony cranial ornamentations played in the differentiation of early theropods.

Key words: Chuxiong, Yunnan; Early Jurassic; dinosaur; theropod; crest

Citation: Wang G F, You H L, Pan S G et al., 2017. A new crested theropod dinosaur from the Early Jurassic of Yunnan Province, China. *Vertebrata PalAsiatica*, 55(2): 177-186

1 Introduction

Bony cranial ornamentations, such as crests and horns, play important roles in visual communication and physical interactions within and between animal species. In theropod dinosaurs, a correlation has been documented between the presence of these ornamentations and rapid evolution of gigantism in basal theropods (Gates et al., 2016). Among various bony cranial ornamentation forms, tall sheet-like parasagittal crests formed mainly by the dorsal extension of the nasals are only known in two Early Jurassic taxa: the North American *Dilophosaurus* and Chinese *Sinosaurus* (Welles, 1984; Hu, 1993; Xing, 2012). These two taxa represent the first appearance of large theropods in dinosaur evolution, with femur lengths of 552 mm and 587 mm and body masses of 362 kg and 429 kg, respectively (Gates et al., 2016).

Here we report the discovery of a new theropod with previously unknown parasagittal crests along the orbital dorsal rims. The specimen was recovered from the Lower Jurassic Fengjiahe Formation in Shuangbai County, Yunnan Province [Figure 1: see original paper] and is represented by a partial skull with lower jaw. The fossil site lies approximately 100 km south of Lufeng County, where the famous Lufeng dinosaur fauna has been recovered since the 1930s (Young, 1951; You et al., 2014; Wang et al., 2017). The only other dinosaur reported from Shuangbai County is a juvenile specimen of *Yunnanosaurus robustus*, though its assignment to either the Early or Middle Jurassic remains uncertain (Sekiya et al., 2013).

This paper briefly describes the major anatomical features of the new specimen and compares it with other relevant taxa. Based on this analysis, we establish a new taxon, *Shuangbaisaurus anlongbaoensis* gen. et sp. nov., which is most distinguished from all other known theropods by possessing parasagittal crests that extend at least along the orbital dorsal rims.

Institutional abbreviations: CPM, Chuxiong Prefectural Museum (Chuxiong, Yunnan); KM, Kunming Museum (Kunming, Yunnan); LFGT, Bureau of Land and Resources of Lufeng County (Lufeng, Yunnan).

Fig. 1 Localities of *Shuangbaisaurus anlongbaoensis* (CPM C2140ZA245) and *Sinosaurus* in Yunnan, China. Note that the holotype and LFGT LDM-L10 of *Sinosaurus triassicus* were recovered from Lufeng County, while *Sinosaurus sinensis* (= "*Dilophosaurus*" sinensis) KMV 8701 is from Jinning County (Xing, 2012).

---

2 Systematic Paleontology

Dinosauria Owen, 1842
Saurischia Seeley, 1887
Theropoda Marsh, 1881

***Shuangbaisaurus* gen. nov.**

Etymology: "Shuangbai" is the Chinese name of the county where the holotype was recovered, first established in the Western Han Dynasty (AD 109). "Sauros" is Greek for lizard.

Type species: *Shuangbaisaurus anlongbaoensis* sp. nov.

Diagnosis: As for type and only known species (see below).

***Shuangbaisaurus anlongbaoensis* gen. et sp. nov.**

Etymology: "Anlongbao" is the Chinese name of the town where the holotype was recovered, literally meaning "dragon-placing fort."

Holotype: CPM C2140ZA245, a partial skull with lower jaw.

Type locality and horizon: Liuna Village, Anlongbao Town, Shuangbai County, Chuxiong Yi Autonomous Prefecture, Yunnan Province. The specimen was recovered from dark purple muddy siltstones in the lower part of the Lower Jurassic Fengjiahe Formation.

Diagnosis: Basal theropod distinguished by having parasagittal crests at least along the orbital dorsal rims. *Shuangbaisaurus* also possesses a unique combination of features, including an elevated ventral edge of the premaxilla (also present in *Dilophosaurus* and LFGT LDM-L10 of *Sinosaurus*), a premaxillary body that is taller than long (also present in LFGT LDM-L10 of *Sinosaurus*, but longer than tall in *Dilophosaurus* and KMV 8701 of *Sinosaurus*), and a small upper temporal fenestra with its diameter shorter than the transverse width of the parietals between them and about half the length of the skull table posterior to the orbit.

Description

A partial skull is preserved, missing the nasals and dorsal portions of the premaxillae, maxillae, and lacrimals (Figs. 2, 3). The anterior half and posterior end of the lower jaw are associated with the skull. Due to deformation, the anterior portion of the rostrum is bent to the left. This brief description is based primarily on the right lateral and dorsal views of the cranium, highlighting its key features. Because *Dilophosaurus* and the two specimens of *Sinosaurus* (KMV 8701 and LFGT LDM-L10) represent the only three specimens with parasagittal skull crests of comparable size (Welles, 1984; Hu, 1993; Xing, 2012), we focus on similarities and differences among them. The total skull length is 540 mm along the ventral margin from the anterior tip to the posterior end of the quadrate. The skull height along the ventral process of the postorbital is 190 mm, not including the crests. Therefore, the skull is relatively low, with a length/height ratio of 2.84.

The external naris is not preserved. The internal antorbital fenestra is relatively large, occupying about one-third of the total skull length based on its preserved ventral portion bordered by the maxilla and lacrimal. The posterior edge of the antorbital fenestra inclines posterodorsally as in LFGT LDM-L10 and *Dilophosaurus*, but not as in KMV 8701, where it is vertical. The orbit is keyhole-shaped, tapering ventrally and slightly anteriorly, with a horizontal dorsal rim and a shorter anterior than posterior rim. The lower temporal fenestra is somewhat trapezoidal with a relatively long ventral border, while its long axis is not vertically oriented but directed anteroventral-posterodorsally. Slightly above its mid-height, the tip of the ventral process of the squamosal protrudes anteriorly and slightly constricts the width of the lower temporal fenestra. The upper temporal fenestra is not completely preserved but is clearly small and round, with its diameter shorter than the transverse width of the parietals between and about half the length of the skull table posterior to the orbit.

Fig. 2 Cranium of *Shuangbaisaurus anlongbaoensis* (CPM C2140ZA245) in right lateral view. Abbreviations: f. frontal; j. jugal; l. lacrimal; lj. lower jaw; lsoc. left supraorbital crest; m. maxilla; p. parietal; pl. palatine; pm. premaxilla; po. postorbital; q. quadrate; qj. quadratojugal; rsoc. right supraorbital crest; sq. squamosal

Fig. 3 Cranium of *Shuangbaisaurus anlongbaoensis* (CPM C2140ZA245) in dorsal view. Abbreviations: f. frontal; lpo. left postorbital; lsoc. left supraorbital crest; lsq. left squamosal; lutf. left upper temporal fenestra; m. maxilla; p. parietal; pm. premaxilla; rpo. right postorbital; rsoc. right supraorbital crest; rsq. right squamosal; rutf. right upper temporal fenestra

The major portion of the premaxillary body is preserved, missing its dorsal edge and both nasal and maxillary processes. There appears to be a vertical groove separating the premaxilla and maxilla, which Carrano et al. (2012) listed as an autapomorphy of *Sinosaurus*. The preserved dorsal rim of the premaxillary body should be very close to the ventral border of the external naris, which is aligned at about the same level as the ventral border of the antorbital fenestra, indicating that the premaxillary body is taller than long. This differs from the condition in both KMV 8701 and *Dilophosaurus*, where it is longer than tall, but resembles that in LFGT LDM-L10. The ventral margin of the premaxilla is notably elevated and higher than that of the maxilla, so the preserved last two premaxillary teeth are situated above the ventral edge of the maxilla. This resembles the condition in LFGT LDM-L10, although no teeth are preserved in the latter. In contrast, in KMV 8701 the ventral borders of the premaxilla and maxilla are aligned at the same level, while in *Dilophosaurus*, although the ventral border of the premaxilla is higher than that of the maxilla, they are not parallel but form an angle so that the premaxillary teeth point posteroventrally.

The maxilla is largely preserved, missing most of its ascending process. An inclined low ridge separates the main body of the maxilla from its anterior ramus. The ventral edge of the anterior ramus is upturned anterodorsally, so that the first maxillary tooth points anteroventrally. This first maxillary tooth is situated immediately posterior to the relatively small, ventrally pointing last premaxillary tooth, without a diastema between them. The anterior margin of the maxilla is high, a key feature noted by Young (1948) in his original paper naming *Sinosaurus*. Carrano et al. (2012) treated a vertical anterior border of the maxilla as an autapomorphy shared by KMV 8701 and LFGT LDM-L10, which is also the case in *Shuangbaisaurus*. In contrast, in *Dilophosaurus* the anterior border of the maxilla is dorsoventrally low and pointed.

The maxillary body is robust. Its lateral surface ventral to the ascending process is shallowly depressed, while the portion ventral to the antorbital fenestra is dorsoventrally deep and narrows slightly posteriorly, with a flat or slightly convex lateral surface. The antorbital fossa appears to have only restricted lateral exposure. A fenestra located at the base of the ascending process probably represents the promaxillary fenestra, occupying a similar position as in *Sinosaurus* (KMV 8701 and LFGT LDM-L10). A notable elongate groove runs parallel to the tooth row on the lateral surface of the maxilla starting immediately posterior to the anterior ramus, though poor preservation makes it difficult to determine where it terminates posteriorly.

The maxilla-jugal articulation is located ventral to the preserved ventral portion of the ventral ramus of the lacrimal; therefore, the jugal does not reach the posteroventral corner of the antorbital fossa. The postorbital process of the jugal wraps around the jugal process of the postorbital and borders the lower half of the lower temporal fenestra anteriorly. A longitudinal ridge exists on the lateral surface of the jugal body. This ridge and the quadratojugal process direct posteroventrally as in *Zupaysaurus* (Ezcurra and Novas, 2006), unlike the horizontal condition in *Sinosaurus* and *Dilophosaurus*. Although the jugal process of the quadratojugal is not preserved, the preserved impression on the lateral surface of the jugal clearly indicates that it tapers until under the anteroventral corner of the lower temporal fenestra. The dorsal portion of the quadratojugal is not well preserved, but its dorsal contact with the quadrate can be traced, which lies slightly below the mid-height of the lower temporal fenestra. The quadrate articulates with the squamosal dorsally and contributes a small portion to the posterior border of the lower temporal fenestra.

The ventral process of the postorbital is long and slender. Its upper one-third is convex posteriorly, while the ventral two-thirds are almost straight and direct anteroventrally to the most ventral point of the orbit. In dorsal view, the anterior process of the postorbital is offset slightly from the skull table, leaving an embayment between it and the posterior ramus. The anterior process contributes to the posterior part of the dorsal rim of the orbit, though the boundary between it and the frontals is difficult to discern. The posterior process of the postorbital is not well preserved but should have a long suture line with the frontal and parietal medially and contribute to the lateral portion of the supratemporal fossa before forming the intertemporal bar with the squamosal.

The squamosal has three rami. The anteroventral ramus ends above the mid-height of the lower temporal fenestra and constricts the width of this fenestra. The other two rami direct anterodorsally and posteroventromedially, respectively; consequently, the upper temporal fenestra faces posterodorsally. In dorsal view, the small upper temporal fenestra is situated within the large supratemporal fossa. The fossa itself is divided by a raised transverse ridge, which is presumably along the parietal-frontal suture line. If so, the frontals should be long and large, contributing most to the skull table and bordering the dorsal rims of the orbits, although the exact articulation with the nasals and prefrontals is difficult to discern.

Most interesting is the presence of vertical crests extending dorsally along the entire dorsal rims of the orbits on both sides (here termed the supraorbital crests). The broken dorsal end is about 1 cm wide transversely along its entire length (Figs. 2, 3), so the crest should be higher than preserved. Indeed, it is difficult to determine the original shape of the whole crest.

The supraorbital crest appears to be formed mainly by the dorsal extension of the frontal, with possible contributions from the postorbital and prefrontal. It is difficult to discern whether the lacrimal contributes to the cranial crest at the anterodorsal corner of the orbit because the skull is broken at this position. Dorsal expansion of the lacrimal is common in theropods, and it is probable that the supraorbital crest continues anteriorly along the lacrimal. A reasonable hypothesis is that the supraorbital crests are part of much larger parasagittal crests and represent the posterior extension of the nasolacrimal crests.

---

3 Discussion

Theropod dinosaurs were the dominant predators in terrestrial ecosystems during the Age of Dinosaurs. They constitute a diverse clade including variously sized carnivores, secondarily herbivorous forms, and both extinct and living birds. Most theropods belong to Averostra, which first radiated around the Early–Middle Jurassic boundary and split into ceratosaurs and tetanurans (Carrano et al., 2012; Rauhut et al., 2016). However, the origin and early evolution of averostran theropods remain poorly understood, probably due mainly to a lack of relevant fossils, especially from the Early Jurassic. Therefore, our discovery of a new theropod provides valuable information that will help elucidate this evolutionary scenario. Here we focus on the taxonomy of this specimen and compare it with relevant taxa, leaving detailed description and phylogenetic analysis for future study.

Besides the well-recognized clade of coelophysoid theropods, which existed exclusively in the Late Triassic and Early Jurassic and includes mainly small-bodied members (Tykoski, 2005; You et al., 2014; Martill et al., 2016), only two small theropods (*Eshanosaurus* and *Tachiraptor*) (Zhao and Xu, 1998; Xu et al., 2001; Barrett, 2009; Langer et al., 2014) and five large ones (*Sinosaurus*, *Dilophosaurus*, *Cryolophosaurus*, *Berberosaurus*, and *Dracovenator*) have been known from the Early Jurassic (Young, 1948; Welles, 1984; Hu, 1993; Yates, 2006; Allain et al., 2007; Smith et al., 2007; Xing, 2012); note that *Dilophosaurus* has alternatively been considered a member of Coelophysoidea (Carrano et al., 2012). Among the five large taxa, only *Dilophosaurus* and *Sinosaurus* possess tall parasagittal crests, while *Cryolophosaurus* bears a unique transversely oriented, curved midline lacrimal crest and the conditions in the other two taxa are unknown. Therefore, the new specimen represents the third definitive theropod genus bearing parasagittal crests, and we focus our comparison on the other two similar-sized taxa (*Sinosaurus* and *Dilophosaurus*); note that the coelophysoid "*Syntarsus*" *kayentakatae* also has parasagittal crests (Rowe, 1989; Tykoski, 1998), but they are low and this taxon is small, with a femur length of 272 mm and body mass of 35.98 kg (Gates et al., 2016).

Both the new specimen and *Sinosaurus* were recovered from the Lower Jurassic of the Chuxiong Basin in central Yunnan Province (Fig. 1), and they share general features of the skull, particularly the possession of parasagittal skull crests. However, in *Sinosaurus* the crests are formed by dorsal extension of the nasals and lacrimals, never extending posteriorly along the orbital dorsal rims. In contrast, in the new specimen, although the crests could possibly extend anteriorly as in *Sinosaurus*, they certainly span the entire orbital dorsal rims. Furthermore, the posterior process of the jugal directs posteroventrally in the new specimen, whereas it is horizontal or bends slightly ventrally in KMV 8701 and LFGT LDM-L10, respectively. The new skull is more robust than that of *Sinosaurus*, as indicated by the dimensions of the maxillary body, although their skulls are similar in length (54.0 cm in CPM C2140ZA245; 52.2 cm in KMV 8701; 63.3 cm in LFGT LDM-L10 based on Xing et al., 2012). We consider these differences sufficient to differentiate them at the generic level.

However, Carrano et al. (2012) recognized that *Sinosaurus* can be diagnosed by a vertical groove or channel on the lateral premaxilla adjacent to its contact with the maxilla, and the new specimen appears to possess this feature, though preservation prevents certainty.

It is notable that all specimens assigned to *Sinosaurus* have not been well studied, especially KMV 8701 (= "*Dilophosaurus*" *sinensis*) (Hu, 1993; Xing, 2012). We agree with Xing (2012) that LFGT LDM-L10 and LFGT ZLJT01 belong to *Sinosaurus triassicus*, although description of the well-preserved LFGT LDM-L10 is still pending. We also agree with Xing (2012) that "*Dilophosaurus*" *sinensis* should not be assigned to the North American genus *Dilophosaurus*, but whether it can be assigned to the same species as *S. triassicus* requires further investigation, especially considering that KMV 8701 has not received additional description beyond the original brief description with no photographs but only an illustration of the cranium. Note that Xing (2012) only cited "Currie et al. in progress recognized 'Dilophosaurus' sinensis as being the same as *Sinosaurus triassicus*," and this assignment has since been followed in recent works (Xing et al., 2013, 2014, 2015; Langer et al., 2014; Gates et al., 2016; Rauhut et al., 2016). Here we tentatively assign KMV 8701 to *Sinosaurus* but retain its specific epithet. We recognize that *S. triassicus* and *S. sinensis* differ at least in the premaxilla based on the illustration of Hu (1993) and photograph of LFGT LDM-L10 in Xing (2012). In *S. triassicus*, the premaxillary body is taller than long and its ventral edge is placed higher than that of the maxilla, whereas in *S. sinensis*, the premaxillary body is longer than tall and its ventral edge is aligned at the same level as that of the maxilla. As noted by Carrano et al. (2012), the skull proportions of *S. triassicus* (long and low) and *S. sinensis* (shorter and taller) are different. Interestingly, the premaxilla and skull proportions of *S. triassicus* are more similar to those of *Shuangbaisaurus* than to *S. sinensis*.

Brusatte et al. (2010) discussed the homology of cranial ornamentations and suggested that the parasagittal crest probably represents primary homology. Based on their alternative scoring strategy, Brusatte et al. (2010) favored three characters concerning the presence, shape, and pneumaticity of specific types of cranial crest. Substituting these three characters for the five original characters in the modified dataset of Smith et al. (2007) does not recover a clade of basal crested "dilophosaurids," but the individual genera in this group still fall into a polytomy with *Zupaysaurus* and the large clade Ceratosauria + Tetanurae, implying that the appearance of parasagittal crests could be homologous. However, a recent comprehensive study on the phylogeny of Tetanurae (Carrano et al., 2012) recovered *Dilophosaurus* as a member of Coelophysoidea while *Sinosaurus* was recovered as a basal member of Tetanurae, suggesting that parasagittal crests were convergently acquired in these two taxa. In their data matrix, *Sinosaurus* is coded as having an inflated nasal and forming a hollow midline crest as in *Monolophosaurus* and *Guanlong* (character 40, state 3), but not as having tall parasagittal crests (state 2). We have not tested the influence of this coding on the phylogenetic position of *Sinosaurus*, but another analysis largely based on Carrano et al.' s (2012) dataset and correctly coding *Sinosaurus* as having tall parasagittal crests recovered *Dilophosaurus*, *Cryolophosaurus*, and *Sinosaurus* as more advanced than coelophysoids and as successive taxa at the base of averostrans (ceratosaurs + tetanurans). It will be interesting to determine in future work the phylogenetic position of *Shuangbaisaurus* and its relationships to *Sinosaurus* and *Dilophosaurus*, and to reveal the evolution of tall parasagittal crests—whether they represent homology or convergence.

Acknowledgments

We are grateful to the personnel of the Chuxiong Prefectural Museum for excavating the specimen and to Wei Gao for taking photographs. Funding was provided by the National Natural Science Foundation of China (41472020) and the Chuxiong Prefectural Government.

References

Allain R, Tykoski R, Aquesbi N et al., 2007. An abelisauroid (Dinosauria: Theropoda) from the Early Jurassic of the High Atlas Mountains, Morocco, and the radiation of ceratosaurs. *J Vert Paleont*, 27: 610–624

Barrett P M, 2009. The affinities of the enigmatic dinosaur *Eshanosaurus deguchiianus* from the Early Jurassic of Yunnan Province, People' s Republic of China. *Palaeontology*, 52(4): 681–688

Brusatte S L, Benson R B J, Currie P J et al., 2010. The skull of *Monolophosaurus jiangi* (Dinosauria: Theropoda) and its implications for early theropod phylogeny and evolution. *Zool J Linn Soc*, 158: 573–607

Carrano M T, Benson R B J, Sampson S D, 2012. The phylogeny of Tetanurae (Dinosauria: Theropoda). *J Syst Palaeontol*, 10: 211–300

Ezcurra M D, Novas F E, 2006. Phylogenetic relationships of the Triassic theropod *Zupaysaurus rougieri* from NW Argentina. *Hist Biol*, 19: 35–72

Gates T A, Organ C, Zanno L E, 2016. Bony cranial ornamentation linked to rapid evolution of gigantic theropod dinosaurs. *Nat Commun*, 7: 12931

Hu S J, 1993. A new Theropoda (*Dilophosaurus sinensis* sp. nov.) from Yunnan China. *Vert PalAsiat*, 31: 65–69

Langer M C, Rincón A D, Ramezani J et al., 2014. New dinosaur (Theropoda, stem-Averostra) from the earliest Jurassic of the La Quinta formation, Venezuelan Andes. *R Soc Open Sci*, 1, 10.1098/rsos.140184

Martill D M, Vidovic S U, Howells C et al., 2016. The oldest Jurassic dinosaur: a basal neotheropod from the Hettangian of Great Britain. *PLoS ONE*, 11: e0145713

Rauhut O W M, Hübner R T, Lanser K P, 2016. A new megalosaurid theropod dinosaur from the late Middle Jurassic (Callovian) of north-western Germany: implications for theropod evolution and faunal turnover in the Jurassic. *Palaeontol Electron*, 19.2.26A: 1–65

Rowe T, 1989. A new species of the theropod dinosaur *Syntarsus* from the Early Jurassic Kayenta Formation of Arizona. *J Vert Paleont*, 9: 125–136

Sekiya T, Jin X S, Zheng W J et al., 2013. A new juvenile specimen of *Yunnanosaurus robustus* (Dinosauria: Sauropodomorpha) from Early to Middle Jurassic of Chuxiong Autonomous Prefecture, Yunnan Province, China. *Hist Biol*, 26: 1–26

Smith N D, Makovicky P J, Hammer W R et al., 2007. Osteology of *Cryolophosaurus ellioti* (Dinosauria: Theropoda) from the Early Jurassic of Antarctica and implications for early theropod evolution. *Zool J Linn Soc*, 151: 377–421

Tykoski R S, 1998. The osteology of *Syntarsus kayentakatae* and its implications for ceratosaurid phylogeny. M. A. thesis. Austin: University of Texas. 1–217

Tykoski R S, 2005. Anatomy, ontogeny, and phylogeny of coelophysoid theropods. Ph. D thesis. Austin: University of Texas.

Wang Y M, You H L, Wang T, 2017. A new basal sauropodiform dinosaur from the Lower Jurassic of Yunnan Province, China. *Sci Rep*, 7: 41881

Welles S P, 1984. *Dilophosaurus wetherilli* (Dinosauria, Theropoda) osteology and comparisons. *Palaeontogr Abt A*, 185:

Xing L D, 2012. *Sinosaurus* from southwestern China. M. A. thesis. Edmonton: University of Alberta. 1–267

Xing L D, Bell P R, Rothschild B M et al., 2013. Tooth loss and alveolar remodeling in *Sinosaurus triassicus* (Dinosauria: Theropoda) from the Lower Jurassic strata of the Lufeng Basin, China. *Chin Sci Bull*, 58: 1931–1935

Xing L D, Paulina-Carabajal A, Currie P J et al., 2014. Braincase anatomy of the basal theropod *Sinosaurus* from the Early Jurassic of China. *Acta Geol Sin - Engl*, 88: 1653–1664

Xing L D, Wang Y K, Snively E et al., 2015. Model-based identification of mechanical characteristics of *Sinosaurus* (Theropoda) crests. *Acta Geol Sin - Engl*, 89: 1–11

Xu X, Zhao X J, Clark J M, 2001. A new therizinosaur from the Lower Jurassic Lower Lufeng Formation of Yunnan, China. *J Vert Paleont*, 21: 477-483

Yates A M, 2006. A new theropod dinosaur from the Early Jurassic of South Africa and its implications for the early evolution of theropods. *Palaeont Afr*, 41: 105-122

You H L, Azuma Y, Wang T et al., 2014. The first well-preserved coelophysoid theropod dinosaur from Asia. *Zootaxa*, 3873(3): 233-249

Young C C, 1948. On two new saurischians from Lufeng, Yunnan. *Bull Geol Soc China*, 28: 73-90

Young C C, 1951. The Lufeng saurischian fauna in China. *Palaeont Sin*, New Ser C, 13: 1-96

Zhao X J, Xu X, 1998. The oldest coelurosaurian. *Nature*, 394: 234-235

Note: Figure translations are in progress. See original paper for figures.