Memoir of the Fukui Prefectural Dinosaur Museum 10 : 1–54 (2011)

ARTICLE

RE-EXAMINATION OF *CHUANJIESAURUS ANAENSIS* (DINOSAURIA: SAUROPODA) FROM THE MIDDLE JURASSIC CHUANJIE FORMATION, LUFENG COUNTY, YUNNAN PROVINCE, SOUTHWEST CHINA

Toru SEKIYA

Zigong Dinosaur Museum, No. 238, Dashanpu, Zigong City, 643013,
Sichuan Province, P.R. China

ABSTRACT

The present study re-evaluates *Chuanjiesaurus anaensis* Fang et al., 2000 from the Middle Jurassic of Lufeng, Yunnan, Southwest China. The holotype and a new referred specimen are described in detail, and re-examined osteologically and phylogenetically. In this report, the author proposes several emended diagnoses based on close observations and comparisons of the specimens. Some osteological features reveal that *Chuanjiesaurus* belongs to Mamenchisauridae. Compared to other mamenchisaurid dinosaurs, *C. anaensis* possesses relatively primitive characters. The phylogenetic position of *C. anaensis* was determined according to the present analysis. In addition, the data sets of some taxa of Mamenchisauridae from southwestern China are modified in the present research. The present analysis reveals that *C. anaensis*, *Mamenchisaurus*, *Tienshanosaurus* and *Yuanmousaurus* constitute a monophyletic group that belongs to relatively derived Eusauropoda. This suggests that Mamenchisauridae could be positioned at a more derived part of Eusauropoda than previously thought. This study confirms that *C. anaensis* is a member of Mamenchisauridae.

Key words: *Chuanjiesaurus anaensis*, Mamenchisauridae, sauropod, Middle Jurassic, Chuanjie Formation, Lufeng County, Yunnan Province, Southwest China

関谷 透（2011）中国雲南省禄豊県の中部ジュラ系川街層より産出した竜脚類恐竜 *Chuanjiesaurus anaensis* の再検討．福井県立恐竜博物館紀要 10：1 – 54.

中国雲南省の中部ジュラ系川街層から産出した竜脚類恐竜 *Chuanjiesaurus anaensis* Fang et al., 2000を再検討した．模式標本と新たな参考標本を詳細に記載し，本種の形態的特徴を再定義すると共に，本種をマメンチサウルス科に分類した．他のマメンチサウルス類恐竜と比較して，本種は比較的原始的な特徴をもつ．本種の分岐分析にあたっては，中国南西部から報告されているマメンチサウルス科恐竜について，先行研究のデータマトリックスを補充・修正した．分析の結果，Eusauropodaの比較的派生的な位置に属し，*Mamenchisaurus constructus, M. hochuanensis, M. youngi, Tienshanosaurus* および *Yuanmousaurus* とともに単系統群を形成することがわかった．これはマメンチサウルス科の系統的位置が以前考えられていたよりも派生的であることを示し，より派生的な分類群の共有派生形質をもつことが明らかとなった．

INTRODUCTION

Sauropods are gigantic, quadrupedal, and herbivorous saurischian dinosaurs with long necks and tails. More than 150 genera have been identified since 1840s and they were widely distributed in the world during the Mesozoic era (Mannion et al., 2011). The oldest known sauropods were discovered from the Upper Triassic of South Africa (Galton and Heerden, 1985) and northeastern Thailand (Buffetaut et al., 2000), while the latest members were discovered from the uppermost Cretaceous of India (Wilson and Upchurch, 2003). In China, over twenty sauropod genera have been reported from the Triassic (Young, 1937; Dong, 1992) to Upper Jurassic periods (Upchurch et al., 2004a). Numerous sauropod fossils have been discovered over the past several decades, especially in Yunnan and Sichuan of southwest China. In addition to sauropod species, many other vertebrate fossils have been found from Jurassic of southwestern China, particularly from the Lufeng County of Yunnan Province

Received June 17, 2011. Accepted November 22, 2011.
E-mail: t.sekiya.jlu*gmail.com
（The asterisk should be replaced by @）

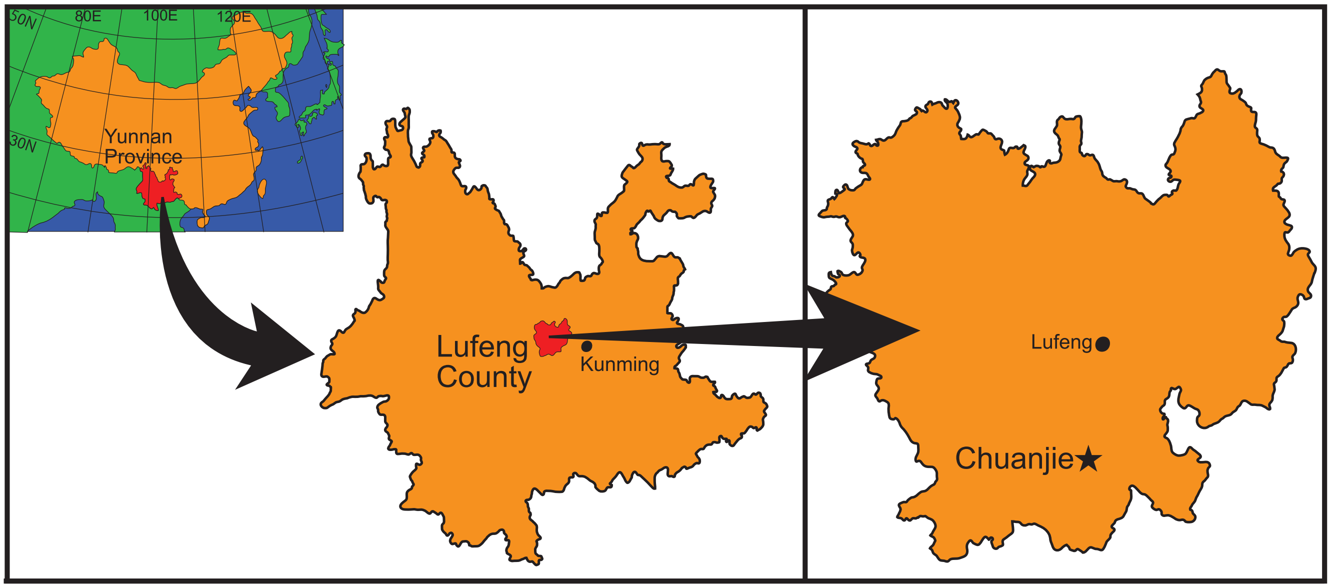

FIGURE 1. Geographical position of Chuanjie of Lufeng, Yunnan Province.

(Young, 1951; Sun et al., 1992).

Chuanjiesaurus anaensis was first named by Fang et al. (2000) based on postcranial specimens from the Middle Jurassic Chuanjie Formation in Ana Village of Chuanjie Town, Lufeng County, Yunnan Province (Fig. 1). The almost complete postcranial specimen of *C. anaensis* allows it to be coded for most phylogenetic characters. This data set will contribute to the study of early evolution in eusauropod dinosaurs. Although numerous materials have been discovered and are well-preserved, they were not fully described in any published report including the original paper. Also, its phylogenetic position has not been well discussed and there is great confusion about the taxonomical position of *C. anaensis. C. anaensis* was originally placed in Cetiosauridae without evaluating the classification (Fang et al., 2000). Furthermore, Upchurch et al. (2004a) regarded *C. anaensis* as Sauropoda *incertae sedis* as a result of a lack of detailed description of the holotype specimens. Detailed descriptions of *C. anaensis* and comparisons with other sauropod species are essential to analyze the phylogeny. Furthermore, the phylogeny is important for further studies about the development of early eusauropod dinosaurs.

In the present study, osteological characters of the holotype specimen and referred specimens of *C. anaensis* are described in detail. Furthermore, the phylogenetic position of *C. anaensis* is analyzed based on comparisons to other sauropods from Yunnan and Sichuan provinces.

Institutional abbreviations

BGMRY: Bureau of Geology and Mineral Resources of Yunnan Province, China; **EPLENEA**: Key-Lab of Evolution of Past Life and Environment in NE Asia, Ministry of Education, China (Jilin University); **FPDM**: Fukui Prefectural Dinosaur Museum of Japan; **IG-CAGS**: Institute of Geology, Chinese Academy of Geological Sciences; **IVPP**: Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences; **NIGPAS**: Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences; **PISNU**: Paleontological Institute of Shenyang Normal University; **PMOL**: Paleontological Museum of Liaoning, China; **RCPS.JU**: Research Center of Paleontology and Stratigraphy, Jilin University, China; **WDV**: World Dinosaur Valley, Lufeng County, Yunnan Province, China; **ZDM**: Zigong Dinosaur Museum, Sichuan, China.

GEOLOGICAL SETTINGS AND AGE

The fossil specimens of *Chuanjiesaurus anaensis* were first discovered by Mr. Tao Wang (Lufeng Dinosaur Museum) in 1995 in the Chuanjie Village of Lufeng County, Yunnan Province, China (Fig. 1). The local researchers built a small house to protect the specimen, and preserved them *in situ* for some years. Then the World Dinosaur Valley was built in 2008 and repaired as the natural fossil locality exhibition. The materials are preserved in massive dark red siltstone, (i.e., "Red Beds") of the Lufeng Series in the Lufeng Basin. The strata are widely distributed in Lufeng County, which is about 60 km west of Kunming City. The geological and paleontological significance of this area has attracted researchers' attention since the end of 1930s (Bien, 1940, 1941; Young, 1940). Bien (1941) described the Red Beds, i.e., the Lufeng Series and named the overlying strata as the Shimen Series. The age of the two series were assigned to Rhaetian and Jurassic–Cretaceous separately. The saurischian and mammal faunas found from the Lufeng Series are similar to those of Karoo Series (e.g., *Gyposaurus*) and Stormberg Series (Triassic–Early Jurassic) in those of Upper Elliot Formation in South Africa and Knollenmergel in Germany (e.g., *Dibothrosuchus, Oligokyphus*) (Luo and Wu, 1995).

The "Red Beds" strata in the Lufeng Basin unconformably overlie the Kunyang Group (Meso-Proterozoic) that is composed of crystalline schist (Qiu et al., 2003). Sheng et al. (1962) suggested that the Lower and Upper Lufeng Formation were Early and Middle Jurassic, respectively. Furthermore, they discovered sauropod fossils and doubted the Lufeng Formation belonging to the Rhaetian. They concluded that the horizon yielding *Ptilozamites* could be Lower Jurassic in age though the base of the Lower Lufeng Formation yields *Ptilozamites chinensis*, the index fossil of the Rhaetian, and *Cladophlebis raciborskii* was found from the base of the Lias (Lower Jurassic) in Europe. They also found the ostracods *Darwinula sarytirmensis* and *D. impudica* that are commonly found from the Middle Jurassic in Russia in the Upper Lufeng Formation. Based on these fossil evidences, the Upper Lufeng Formation was considered to be the Middle Jurassic in age (Sheng et al., 1962).

The Bureau of Geology and Mineral Resources of Yunnan Province (BGMRY, 1990) described detailed sedimentary facies of the Upper and Lower Lufeng formations. The lower part of the Lower Lufeng Formation is mainly composed of dark orange and purple siltstone. Towards its upper part, the frequency of dark red siltstone increases. The boundary of the Lower and Upper Lufeng formations shows an unconformity. The Upper Lufeng Formation is divided into two parts. The lower part is called the "varicolored layer", and the upper part is the Anning Formation, which includes the conchostracan *Nestoria–Keratastheria* assemblage. The formation is composed of dark red sandstone and siltstone, and could be correlated to the Jurassic strata in Sichuan Province. According to the research on mammal fossils (*Oligolyphus, Yunnania*, etc.) from the Lower Lufeng Formation, the formation was considered Early Jurassic in age. Moreover, the Upper Lufeng Formation yields abundant invertebrate fossils as well as vertebrate fossils such as fish and turtles. These findings also suggested that the formation was Middle Jurassic in age (BGMRY, 1990).

Zhang and Li (1999) reported a series of strata near Chuanjie Village that includes the basal conglomerate of Lower Lufeng Formation (Early Jurassic) through the uppermost part of the Upper Lufeng Formation (Middle Jurassic). The Lower Lufeng Formation is divided into two parts. The lower part is mainly composed of dark purple siltstone, the so-called "Dull Purplish Bed" (Bien, 1941: 158). The Upper Lufeng Formation is further subdivided into four lithological units that differ subtly and have conformable boundaries. Based on the fossils of *Darwinula lufengensis*, bivalves and fish scales found in the Upper Lufeng Formation, the formation was considered as Middle Jurassic in age (Zhang and Li, 1999).

Fang et al. (2000) re-studied the Lufeng Formation mainly in litho-stratigraphy (Fig. 2) and named the Shawan Member (mainly dark purplish red in color) and the Zhangjiaao Member (dark red and orange mudstone) in ascending order, instead of the lower and upper parts of the Lower Lufeng Formation. At the same time, they reclassified the four members of the Upper Lufeng Formation as four different formations, including in ascending order: the Chuanjie, Laoluocun, Madishan, and Anning formations. The Chuanjie Formation unconformably overlies the Lufeng Formation, whereas it is overlain conformably by the Laoluocun Formation. Based on the conchostracans studied by Jiang (1984), the Madishan and Anning formations are considered as Late Jurassic in age (Figs. 2, 3).

In conclusion, since the present dinosaur materials of *Chuanjiesaurus anaensis* are collected from the Chuanjie Formation, this study has generally accepted the idea of Fang et al. (2000) in stratigraphy, and considered the Chuanjie Formation yielding the present dinosaur described here as the Middle Jurassic in age. Although the paleoenvironment of the Middle Jurassic of Lufeng County has not been studied well, the correlated strata of Sichuan Province are estimated as subtropical warm-moist to semiarid climate (Wang et al., 2005).

SYSTEMATICS

Chuanjiesaurus was originally considered as belonging to the Cetiosauridae (Fang et al., 2000). However, it seems to belong to the Mamenchisauridae based on several key characters, such as four sacral vertebrae, weakly developed pneumaticity in dorsal centra, procoelous proximal caudal centra, anteroposteriorly depressed tibia and fibula (Young and Zhao, 1972), and fused posterior dorsal centra (Lü et al., 2008).

Classification

DINOSAURIA Owen, 1842
SAURISCHIA Seeley, 1887
SAUROPODOMORPHA Huene, 1932
SAUROPODA Marsh, 1878
EUSAUROPODA Upchurch, 1995
Family MAMENCHISAURIDAE Young and Zhao, 1972
Genus *CHUANJIESAURUS* Fang et al., 2000

Type Species.— *CHUANJIESAURUS ANAENSIS* Fang et al., 2000

Included Species.— Type species only.

Diagnosis.— as for type and only known species.

CHUANJIESAURUS ANAENSIS Fang et al., 2000

Emended Diagnoses.—Although Fang et al. (2000) listed several characters in their diagnosis of *C. anaensis*, most of these are present in other sauropod dinosaurs. For example, opisthocoelous elongated cervical vertebrae, and procoelous caudal centra that are reduced posteriorly, are also observed in *Mamenchisaurus* (Young and Zhao, 1972; Ouyang and Ye,

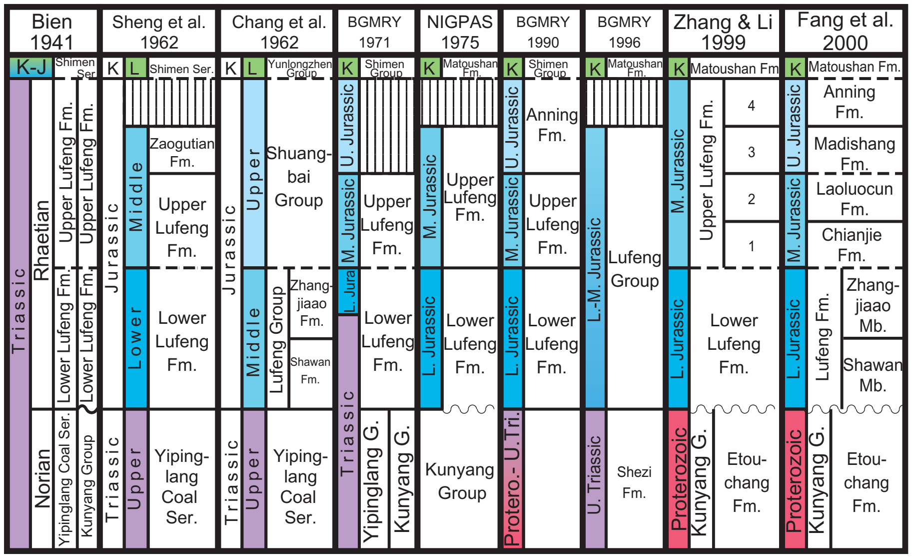

FIGURE 2. The previous stratigraphical correlation in Chuanjie of Lufeng, Yunnan Province (after Fang et al., 2000).

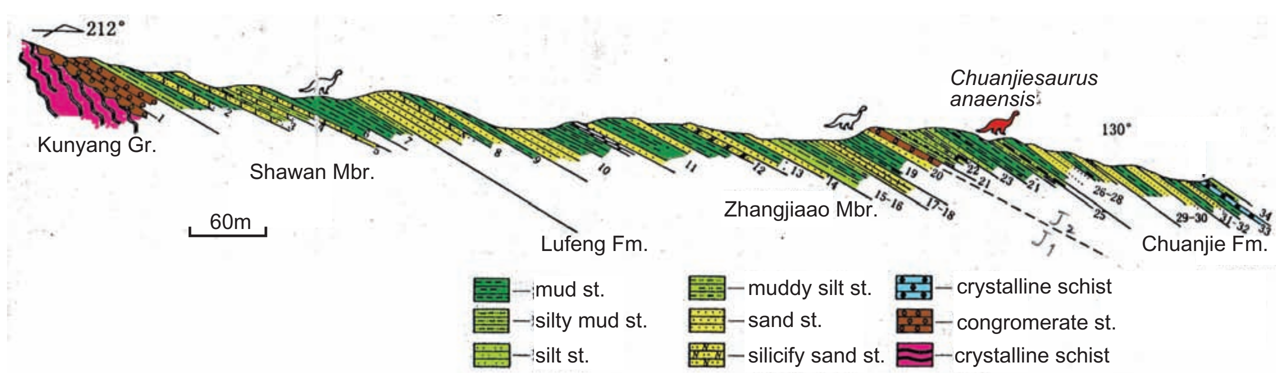

FIGURE 3. Lithological section of the Chuanjie Formation and its related strata (modified from Fang et al., 2000).

2002). Here, based on new observations of the holotype and referred specimen, an emended diagnosis for *Chuanjiesaurus anaensis* is proposed: three laminae support the infra-hyposphenal cavity of the dorsal neural arch; knob-like fused neural spines in posterior dorsal and sacral vertebrae; V-shaped shelf-like hyposphene in posterior dorsal vertebrae; anterior ridge on the proximal caudal rib; ratio of length to midshaft width of metacarpal II less than 0.2; fibular condyles of femur divided, with the medial crest wider than the sulcus between tibial condyle.

Material

Comments.—The fossil specimens are still in situ, preserved in the bone bed exhibition of the World Dinosaur Valley, Yunnan Province. As a result of this, the right lateral aspect of caudal vertebrae of the holotype and cervical, dorsal, sacral and caudal vertebrae of the referred specimen are unable to be studied. About the appendicular skeletons, buried aspects are shown in figures. In the bone bed, several kinds of vertebrate fossils are preserved, including at least four individuals of large sauropods, the theropod *Shidaisaurus jinae* (Wu et al., 2009), four turtles, and other fossils.

Holotype.—The holotype skeleton of *Chuanjiesaurus anaensis* originally included “nine cervical vertebrae, 17 caudal vertebrae, 2 ribs (one of them is complete), a chevron, left and right scapulae and coracoids, a humerus, left and right radii, left and right ulnae, right ilium, left pubis, an ischium, left and right femora and tibiae, a distal phalanx and so on” (translated from the Chinese, Fang et al., 2000: 213; Plate II, fig. 3, the specimen

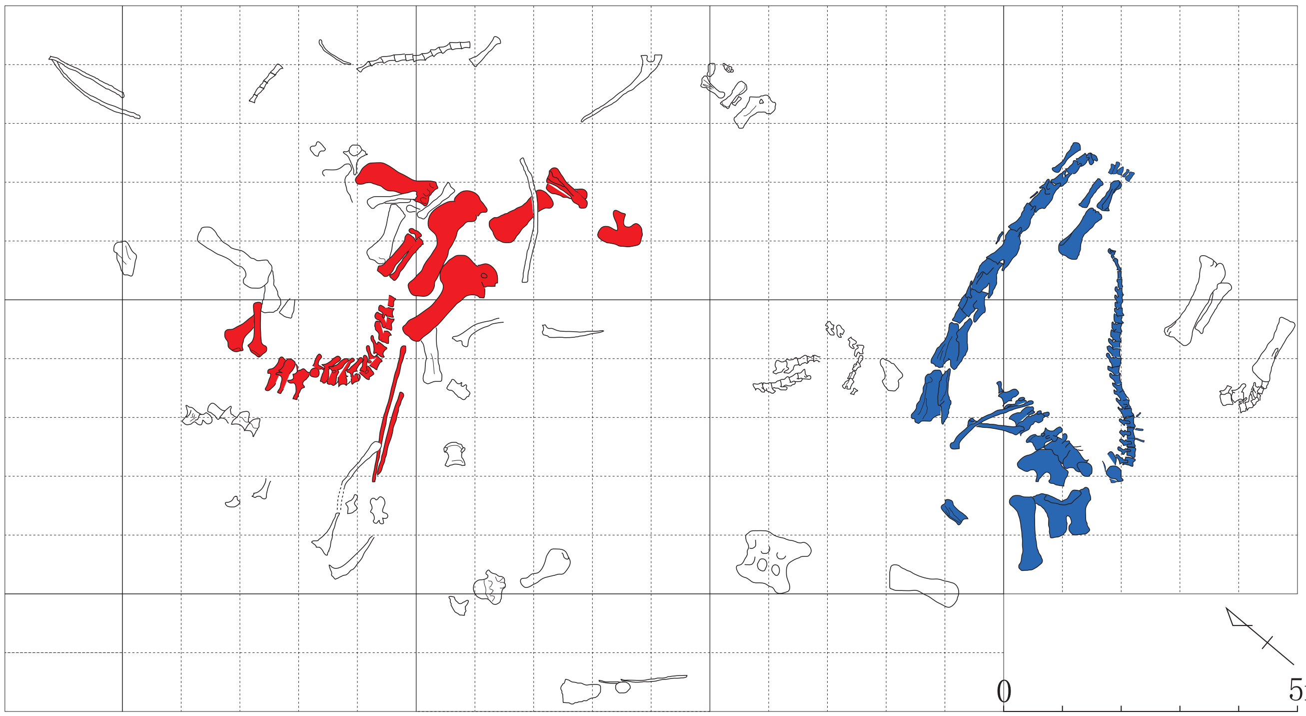

FIGURE 4. Preserved bone bed map of *Chuanjiesaurus anaensis*. Red colored materials are holotype, and blue colored are referred specimen (LCD9701-I). LCD: Lufeng Chuanjie Dinosaur.

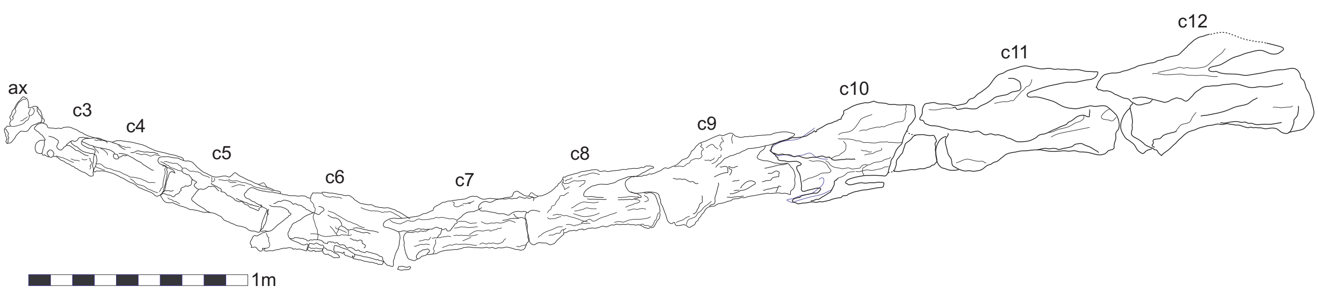

FIGURE 5. Cervical vertebrae series of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1.

No. is Lfch1001). Fang et al. (2000) showed only one bird's eye view of the fossil site, which they captioned "holotype (Fang et al., 2000: 214)." They did not specify which material belongs to the holotype specimen. Contrary to the original description of Fang et al. (2000), the picture does not include cervical vertebral elements.

This author would determine the holotype specimen based on the original enumeration of preserved regions and photograph referred in Fang et al. (2000) and available fossil materials in the bone bed. The red colored specimens in Figure 4 are the emended holotype materials in the present research, which include a series of caudal vertebrae (both scapulocoracoids and humeri), a left ulna and radius, a right femur, tibia, fibula and astragalus. The pelvic girdle and forelimb are preserved in natural articulated condition, as well as the right hind limb (femur, tibia, fibula and astragalus). Their length ratio with caudal series is similar to eusauropod dinosaurs from the Middle and Late Jurassic of southwestern China. Based on the presence of articulated joints and general length ratio of each bone, these specimens are regarded as belonging to one individual in the present study.

Referred specimen.—An almost complete postcranial skeleton (LCD9701-I) is preserved beside the holotype in the same site (Fig. 4). LCD9701-I is composed of a series of 11

TABLE 1. The measurements of cervical vertebrae of *C. anaensis* (referred specimen: LCD9701-I) in mm.
Abbreviations: **ArchH**, height of neural arch (measured from the top of the centrum to the upper margin of the postzygapophysis); **EI**, elongation index (anteroposterior length divided by width of posterior face); **H**, total height of vertebra; Hca: height of anterior surface of the centrum; **Hcp**, height of posterior surface of the centrum; **Hsp**, height of the neural spine (measured from the lower margin of the postzygapophysis to the top of the neural spine); **Lc**, length of centrum; **Lsp**, length of the neural spine; **TotH**, total height of centra; **Wca**, width of centrum across its anterior surface; **Wcp**, width of centrum across its posterior surface; **Wsp**, width across the top of the neural spine; **—**, un-applicable or not preserved.

Cervical vt	**Lc**	**Hca**	**Hcp**	**Wca**	**Hca/Wca**	**Lc/Hcp**	**EI**	**Lsp**	**TotH**	**H**	**ArchH**	**Wsp**	**Hsp**
Axis	172	70?	80?	—	—	—	—	127	83	155	79	—	—
3rd	228	—	88	46	1.91	2.59	4.96	85	105	160	65	—	30?
4th	316	85	120	—	—	2.63	—	174	—	200	90?	—	45
5th	430	—	—	—	—	—	—	—	120	215	98	—	13
6th	515	—	128+	—	—	—	—	148	128	270	106	22	30
7th	554	—	150	—	—	3.69	—	—	150	245	119	—	33
8th	610	—	—	—	—	—	—	215	160+	315	150	19+	32
9th	631	—	160	—	—	3.94	—	181	160	330	138	20	33
10th	625	—	155+	—	—	—	—	174	163	390	150	—	38
11th	677	—	220	—	—	3.08	—	140	220	390	—	—	28
12th	—	—	—	—	—	—	—	—	—	450?	—	—	—

TABLE 2. The measurements of posterior dorsal vertebrae of *C. anaensis* (referred specimen: LCD9701-I) in mm. Abbreviations are shown in Table 1.

Dorsal vt.	Lc	Hcp	H	ArchH	Wsp	Hsp
1	172?	—	—	—	—	—
2	165	210+	—	—	—	—
3	160	217	—	—	—	—
4	160	—	—	—	—	—
5	168	250	690	240	81+	210
6	160+	225	710	200	60+	265

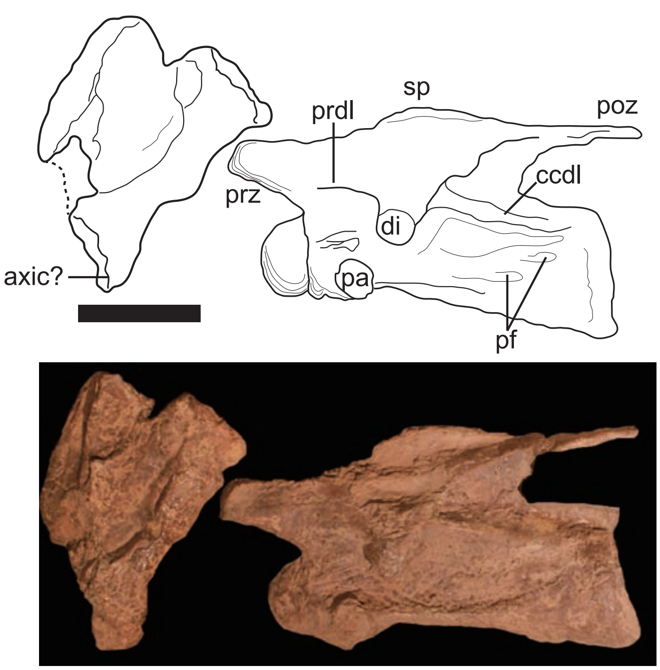

FIGURE 6. Line drawing and photograph of the axis and the third cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

cervical, 6 posterior dorsal, 4 sacral and 25 caudal vertebrae and chevrons; some dorsal ribs; left humerus, ulna, radius and metacarpals; left ilium; left and right fused pubes; and left femur. LCD9701-I is one of the four individuals mentioned above and the others are too poorly preserved to identify if they belong to *Chuanjiesaurus* or not. LCD9701-I has the anterior ridge on the proximal caudal rib, which is common in the holotype specimen. LCD9701-I is identifiable as the same species as *C. anaensis* based on the combination of the following characters: procoelous anterior caudal centra, absence of pleurocoels in anterior caudal centra, wing-like transverse process of anterior caudal vertebrae and anteroposteriorly compressed anterior caudal neural spine.

DESCRIPTION

Axial Skeletons

Cervical vertebrae.—The referred specimen possesses 11 (axis to twelfth) articulated cervical vertebrae (Figs. 4, 5; Table 1). They are preserved in situ with the left side exposed. The postaxial cervical centra are opisthocoelous (Figs. 6–15). The ventral surfaces of the centra are almost flat, without ventral midline keel. The lateral surface has some small pneumatic fossae which are divided by accessory laminae (Figs. 6, 11–14). The proximal half of the axial neural arch is broken and its large pneumatic cancellous openings are visible. The centroprezygapophyseal laminae are single laminae. The centrodiapophyseal lamina system is well developed on the anterior and middle cervical vertebrae (Figs. 6, 9–12, 15). The cervical neural spines are low and unbifurcated at least in the preserved anterior and middle cervical vertebrae (Figs. 6, 7, 9–13). The cervical ribs are poorly preserved and heavily damaged, and at least one

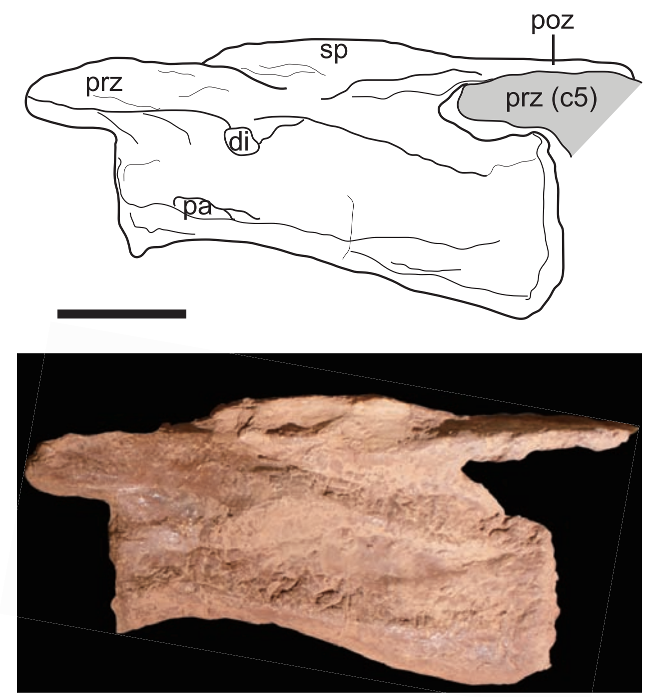

FIGURE 7. Line drawing and photograph of the fourth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

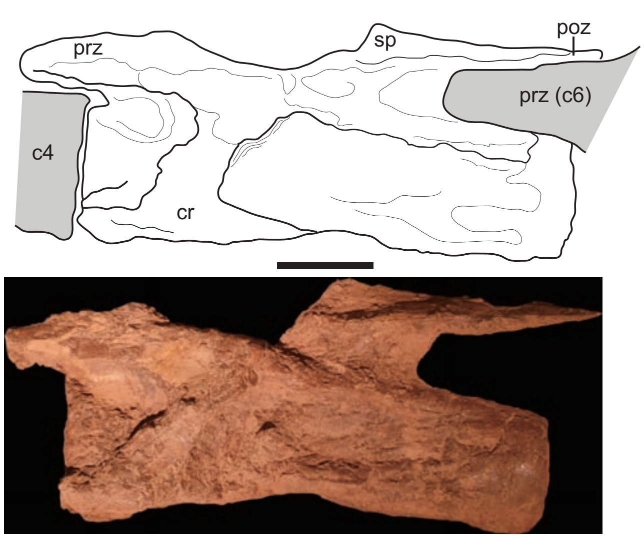

FIGURE 8. Line drawing and photograph of the fifth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm

of them, the 6th, projects very slightly beyond the end of the centrum (Fig. 9). The angle between capitulum and tuberculum of the cervical ribs is less than 90 degrees in anterior view, and the rib shaft lies below the ventral margin of the centrum (Figs. 8, 9 and 11–13).

Dorsal vertebrae.—The holotype does not preserve dorsal vertebrae (Fang et al., 2000), and the referred specimen has at least seven (the last one might be a dorsosacral vertebra) relatively well preserved posterior dorsal vertebrae (Fig. 16). The measurements are shown in Table 2; because accurate numbers are unknown, the dorsal vertebrae are numbered from anterior to posterior in the Table. The articular surfaces of centra are opisthocoelous with deep posterior concavities (Figs. 16, 17). The ventral surfaces of centra are convex transversely. The centrum pleurocoels are simple pits without opening through the neural canal. They have acute anterior and posterior margins similar to those in *Phuwiangosaurus* (Martin et al., 1999) and *Opisthocoelicaudia* (Borsuk-Bialynicka, 1977), respectively (Figs. 16, 17). The heights of the neural arches of the last two dorsal vertebrae are lower than the heights of their centra (Table 2). The anterior centroparapophyseal lamina is a thin plate, and the posterior one is a low ridge. The centroprezygapophyseal laminae are simple single plates on posterior dorsal vertebrae. The anterior surfaces of the dorsal neural arches are almost flat. The transverse process is directed laterally and lies slightly caudodorsally to the parapophysis (Fig. 17); and its distal end is set off from the dorsal surface by an acute inflection. The ventral tip of the posterior centrodiapophyseal lamina is slightly expanded but not bifurcated. Weak accessory laminae in the infrapostzygapophyseal cavity are visible in posterior dorsal vertebrae. There are deep cavities under the transverse process and supported by some accessory lamina. The typical hyposphene-hypantrum system seems to be absent, though there is a V-shaped platelike element under the postzygapophysis. The dorsal neural spines are knob-like quadrate elements. There is a thin plate as a prespinal lamina between the spinoprezygapophyseal laminae. The spinopostzygapophyseal laminae are relatively thick single plates. The spinodiapophyseal laminae are thin and weakly developed plates in posterior dorsal vertebra.

Sacral vertebrae.—The sacral vertebrae are not preserved in the holotype specimen. The referred specimen possesses four (or five, the most anterior one might be dorsosacral vertebra) sacral vertebrae, but the pelvic elements are depressed and squashed (Figs. 4, 18). The neural spines of the sacral vertebrae are expanded knob-like quadrate shaped and fused to each other. The posterior articular surface of the last sacral is visible, which is significantly convex. The last sacral rib is expanded dorsoventrally and its dorsal surface seems to lie below the dorsal margin of the ilium. Recently, Pol et al. (2011) discussed the evolutionary changes in the sacrum development of basal sauropodomorphs dinosaurs. The incorporation of a dorsosacral vertebra in *C. anaensis* could reveal the acquiring step of the fifth sacral vertebra.

Caudal vertebrae.—The holotype preserves 16 articulated caudal vertebrae (Fig. 19). Since the holotype lacks sacral vertebrae, precise positions of the caudal vertebrae are unknown; the most proximally preserved caudal vertebrae seems to come

TABLE 3. Measurements of caudal vertebrae of *C. anaensis* (holotype) in mm. Abbreviations: **Wdip**, transverse width between both side of diapophyses; **Ldip**, anteroposterior length of diapophysis; **Lprz**, anteroposterior length of prezygapophysis; **parchL**, length of neural arch; **Lch**, length of chevron. Other abbreviations are same as Table 1.

Caudal vt.	Lc	Hca	Hcp	Lc/Hca	Lc/Hcp	Lsp	Wdip	Ldip	H	ArchH	Lprz	parchL	Wsp	Hsp	Lch
1st	—	—	—	—	—	38	—	—	—	—	70	—	49	270	—
2nd	130	—	226	0.58	0.58	48	—	—	615	150	60	94	—	246	—
3rd	125	220	—	0.57	—	—	30+	30+	544	140	80	100	—	242	—
4th	—	—	230	—	—	—	85	85	560	—	—	—	—	228	—
5th	106	—	—	—	—	40?	—	—	535	—	60	70?	—	130?	—
6th	117	—	195+	0.6	—	45+	—	—	516?	—	75	69?	—	225?	220
7th	124	—	188+	0.66	—	60	—	—	435	65-	47	72	—	175	210
8th	116	180+	160+	0.64	—	45	53	53	408	—	57	72	33	170	—
9th	121	184+	168	—	0.72	56	—	—	410	67	60	85	—	180	—
10th	120	159	—	0.75	—	—	38	38	362?	—	60	—	—	188?	—
11th	128	—	148+	—	—	53	—	—	379	62-	43	—	—	167	—
12th	130	157	—	0.83	—	—	—	—	—	—	34	—	—	—	—
13th	140	141+	—	—	—	90	—	—	357	—	37	72	—	155	—
14th	140	—	145	—	0.97	100	—	—	346	58	58	80	—	133	—
15th	147	144	132+	1.02	—	—	—	—	—	—	40	—	—	—	—
16th	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 4. Measurements of caudal vertebrae of *C. anaensis* (referred specimen: LCD9701-I) in mm. Abbreviations: **dig sp**, incline degree of neural spine; **Lpr**, anteroposterior length of the proximal end of the chevron; **Ldis**, anteroposterior length of the distal end of the chevron. Other abbreviations are shown in Table 1.

Caudal vt.	Lc	Hca	Hcp	Lc/Hca	Lc/Hcp	Lsp	Wdip	Ldip	H	ArchH	Lprz	dig sp	parchL	Wsp	Hsp	Lch	Lpr	Ldis
1st	—	272	—	—	—	—	—	—	—	—	—	—	—	—	—			
2nd	133	—	—	—	—	45	64	67	—	—	—	56	30?	68	190			
3rd	119	190+	—	—	—	53	62	50	433	52-	73	50	—	65	214			
4th	115	182	—	0.63	—	55	52	63	424	80-	83	66	78	65	157	178	50	63
5th	115	165	—	0.7	—	61	65	53	437	58	90	56	80	63	170	240	45	70
6th	122	150	—	0.81	—	55	66	55	388	72	55	42	90	63	168	216	43	52
7th	112	135	—	0.83	—	50	—	—	345	51	70	60	67	45	155			
8th	132	—	120	—	1.1	—	51	40	—	50	60	50	64	—	—			
9th	120	138	130?	0.87	—	57	26	50?	298	30	60	42	67?	37	152			
10th	120	152	136	0.79	0.88	60	—	—	328	30	63	46	73	47	190			
11th	140	155	130	0.9	1.08	95	121	—	291	15	53	35	82	43	133			
12th	132	152	130	0.87	1.02	97	—	—	302	60	42	—	62	21	117			
13th	143	146	138	0.98	1.04	—	—	—	302	45	—	—	68	29	125			
14th	137	135	135	1.01	1.01	95	—	—	285	47	—	—	75	27	110	—	—	138
15th	144	131	128	1.1	1.13	123	—	—	270	—	44	—	70	22	—	—	—	145
16th	145	125	120	1.16	1.21	91	—	—	262	—	42	—	82	20	—			
17th	153	125	117	1.22	1.31	119	—	—	250	23?	35	—	83	20+	115			
18th	152	120	115	1.27	1.32	120	—	—	240	—	35	—	86	11+	85			
19th	155	120	104	1.29	1.49	121	—	—	225	32	42	—	85	16+	90			
20th	152	110	106	1.38	1.43	135	—	—	215	—	25	—	85	17+	—			
21st	152	100+	107	—	1.42	120	—	—	202+	25?	—	—	87	13+	73			
22nd	150	90+	95	—	1.58	100+	—	—	168	30?	70?	—	95	12+	—			
23rd	146	—	87?	—	—	57?	88	—	163	—	30?	—	—	—	—			
24th	148	80	—	1.85	—	—	—	—	—	—	—	—	105+	—	—			

from the proximal portion of the tail. The referred specimen (LCD9701-I) preserves 24 articulated caudal vertebrae (Fig. 20). Though the referred specimen is disarticulated from the sacral vertebrae, the preserved condition presumably shows the first element is the most proximal procoelous caudal centrum, which is heavily damaged. The measurements of holotype and referred specimens are shown in Tables 3 and 4 respectively.

The proximal and middle caudal centra are circular in anterior view (Figs. 19, 21–24 and 27–29). The articulations of the first to tenth caudal centra are procoelous (Figs. 27–29), and turn to amphicoelous or slightly amphiplatyan distally (Figs. 30–35). There are no pleurocoels in proximal caudal centra. The ventral surface of the proximal caudal centra is convex transversely.

The eleventh to fourteenth caudal centra of the referred specimen have blunt ridges on the ventrolateral surfaces of the centra; while the holotype lacks these ridges. The positions of the neural arches are closer to the anterior half, though they still cover the midpoints of the centra. The neural arches are relatively low contrary to that of *Mamenchisaurus youngi* (Ouyang and Ye, 2002). The referred specimen has weak spinoprezygapophyseal lamina on anterior caudal vertebrae, but the prespinal and postspinal laminae are absent. The neural spines are anteroposteriorly compressed rod-like and direct perpendicular to the anteroposterior longitudinal axis of the centra in proximal caudal vertebrae, which turn to a transversely compressed plate-like shape and are inclined caudodorsally gradually towards the posterior end of the tail. The neural spine of the holotype possesses lateral ridges on its anterolateral and posterolateral surfaces along its length. In the referred specimen, wing-like transverse process are present in the second to ninth

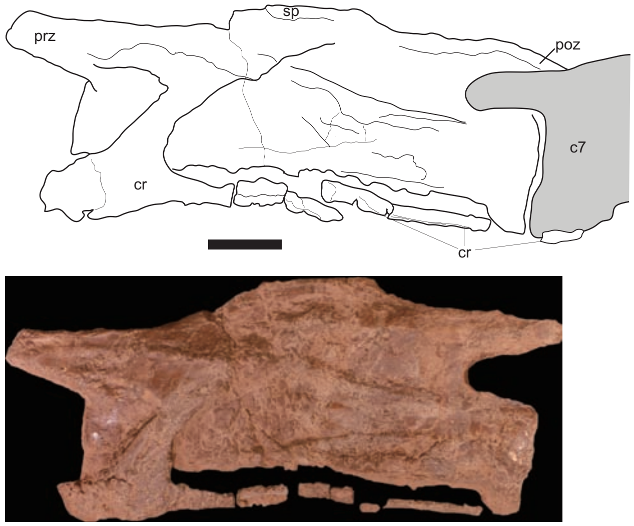

FIGURE 9. Line drawing and photograph of the sixth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

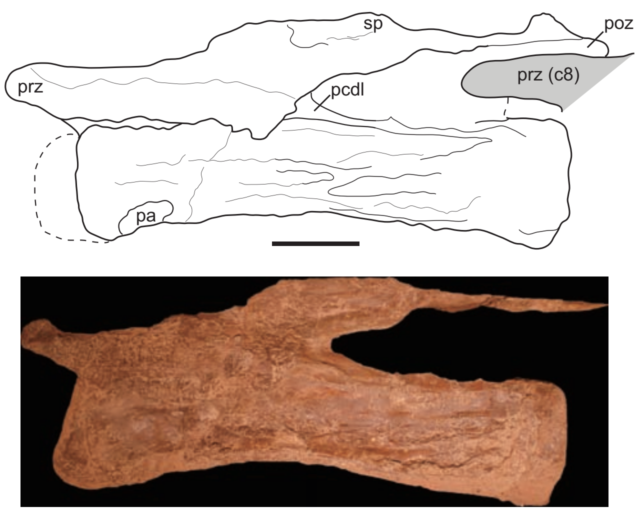

FIGURE 10. Line drawing and photograph of the seventh cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

caudal centra, and turn to low blunt processes in the tenth and eleventh caudal centra, then the transverse process disappear posteriorly. The proximal caudal transverse processes are deep and extend from the centrum to neural arch. The caudal rib of the holotype is semi-circular in its cross section and has a low thin ridge on its proximal surface, which might be diagnostic of this taxon (Fig. 22).

Chevrons.—Two chevrons are preserved near the middle caudal vertebrae in the holotype, whereas the referred specimen preserves four anterior (the second and fourth to sixth) and three

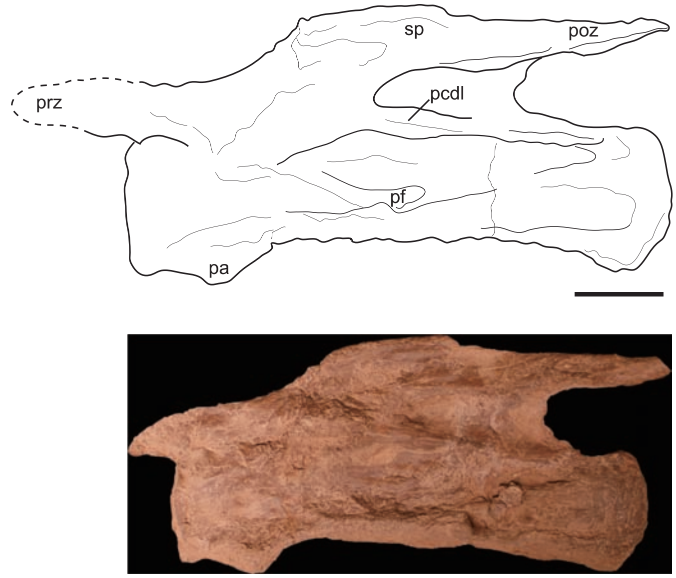

FIGURE 11. Line drawing and photograph of the eighth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

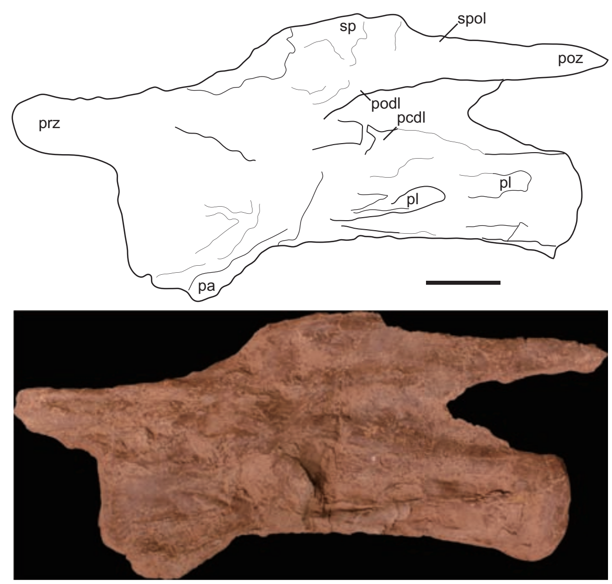

FIGURE 12. Line drawing and photograph of the ninth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

distal (the fourteenth to sixteenth) chevrons. The measurements are shown in Table 4.

The anterior chevrons are dorsoventrally elongated, thin stick-like elements. The proximal articular surface is bridged by a bar of bone, so the canal is not open dorsally. The haemal canal is relatively low, the ratio of dorsoventral height to chevron length is less than 0.3. The mid-shaft of the chevron blade is almost

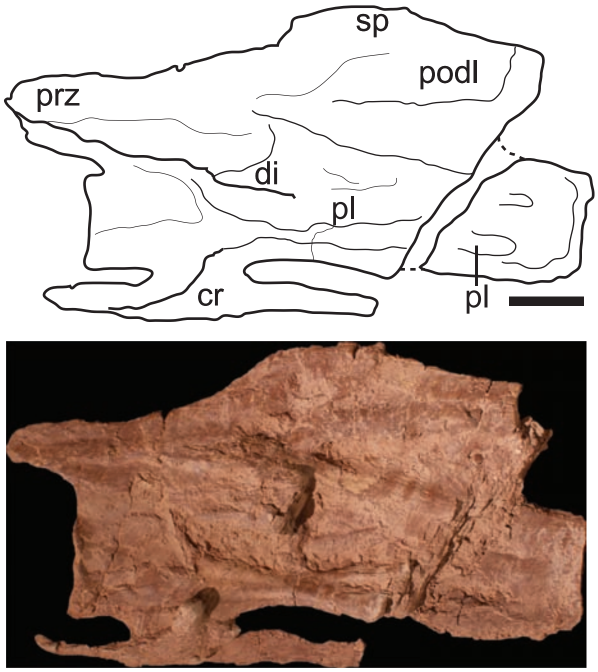

FIGURE 13. Line drawing and photograph of the tenth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm

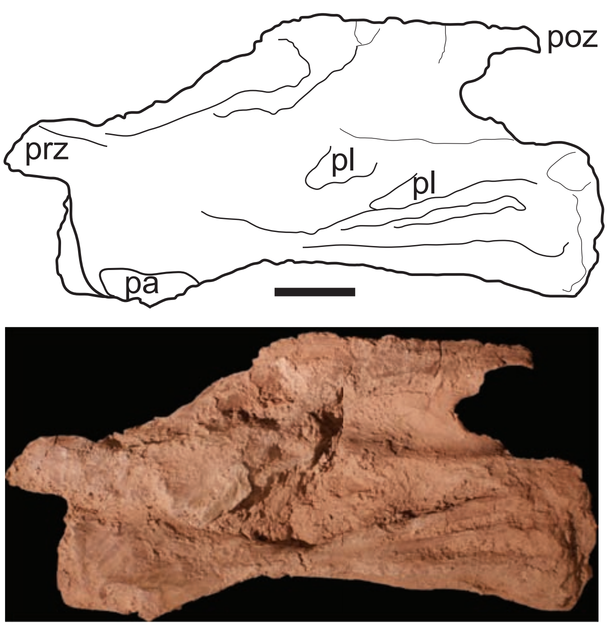

FIGURE 14. Line drawing and photograph of the eleventh cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

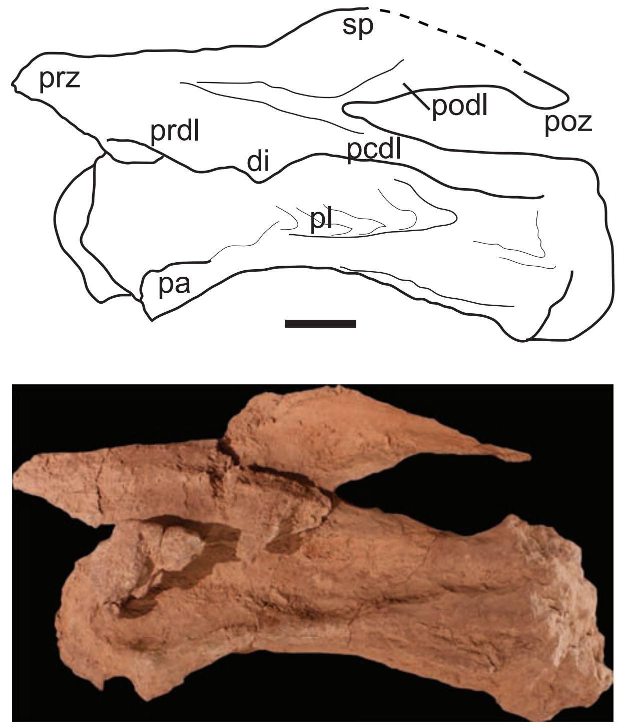

FIGURE 15. Line drawing and photograph of the twelfth cervical vertebra of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

straight in lateral view. The ventral end is expanded anteroposteriorly and slightly directed posteroventrally, except in the first chevron, which is straight throughout the whole length.

There are two chevrons near the middle series of the caudal vertebrae in the holotype. The middle shaft is straight and compressed laterally. The ventral end is expanded anteroposteriorly but not bifurcated into anterior or posterior processes.

The proximal articular surface is transversely wider than its anteroposterior length. The middle and ventral part is transversely compressed. The ventral end is bifurcated in lateral view, and the branches are directs anteriorly and posteriorly, respectively. The ventral ends of those projections turn to curve ventrally. The ventral slit is absent (Figs. 26, 32).

Appendicular Skeleton

Several appendicular elements are preserved along with the holotype caudal vertebrae: a pair of left and right scapulocoracoids; two left humeri; left radius and ulna; right femur; right tibia, fibula and astragalus (Fig. 4). The referred specimen possesses a left ischium and fused pubes, left scapula, ulna and radius, five metacarpals, and left femur.

Pectoral girdle.—Both scapulocoracoids are preserved in situ near the holotype caudal vertebrae (Figs. 4, 36, 37). The measurements of the appendicular skeleton are shown in Table 5.

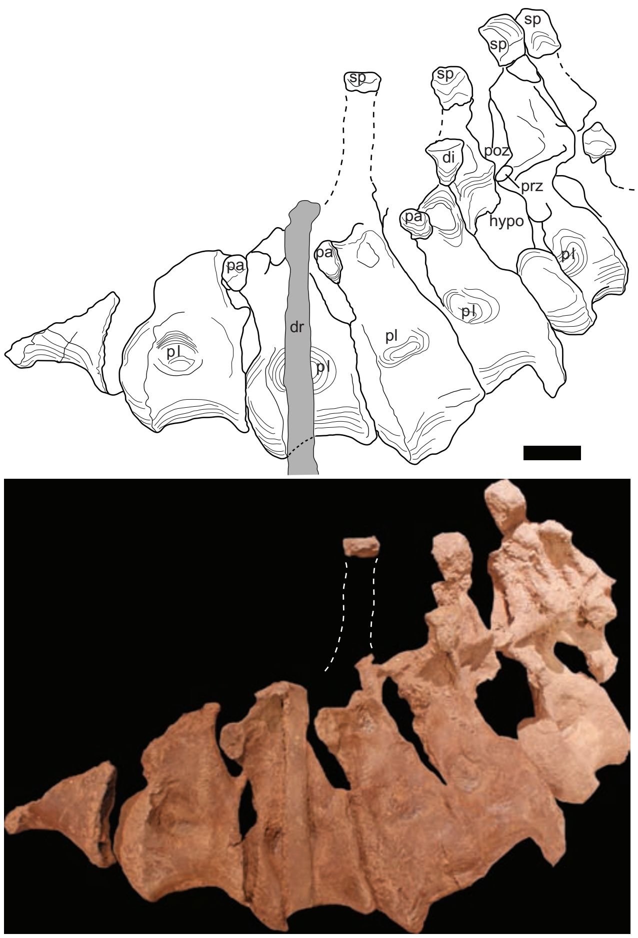

FIGURE 16. Line drawing and photograph of the posterior dorsal vertebrae of *C. anaensis* (LCD9701-I). Abbreviations are shown in Appendix 1. Bar = 10 cm.

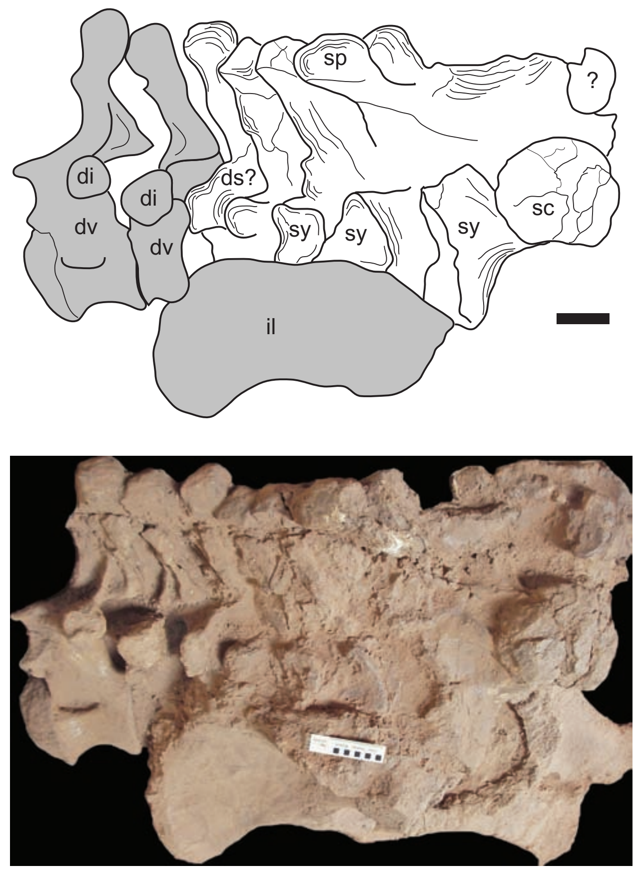

FIGURE 18. Line drawing and photograph of the sacral vertebrae of *C. anaensis* (LCD9701-I) in caudodorsal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

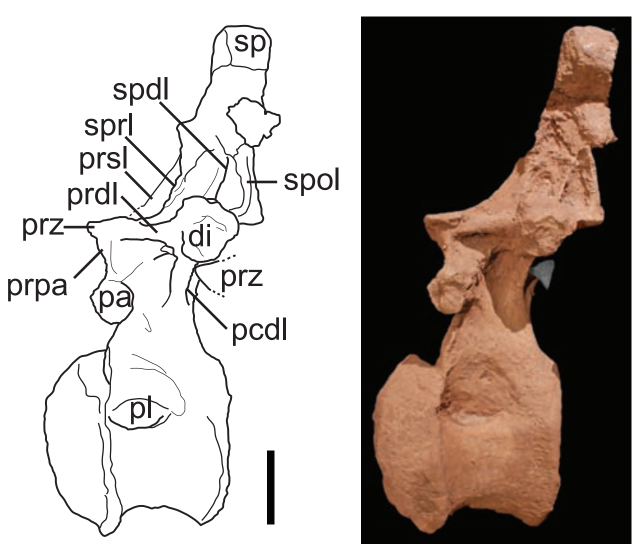

FIGURE 17. Line drawing and photograph of the last dorsal vertebra of *C. anaensis* (LCD9701-I) in left lateral view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

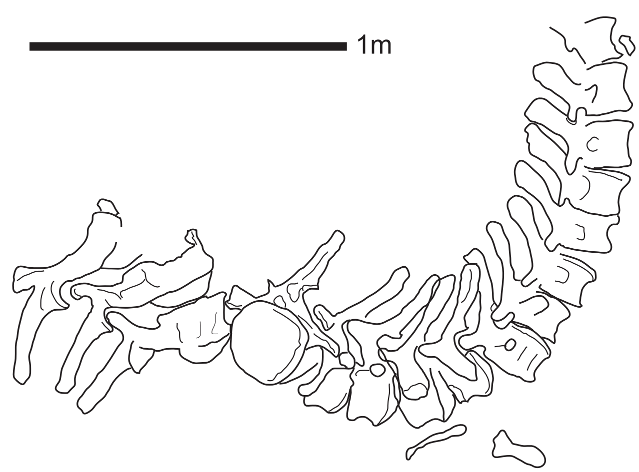

FIGURE 19. The series of 16 articulated caudal vertebrae of *C. anaensis* (holotype) preserved *in situ*.

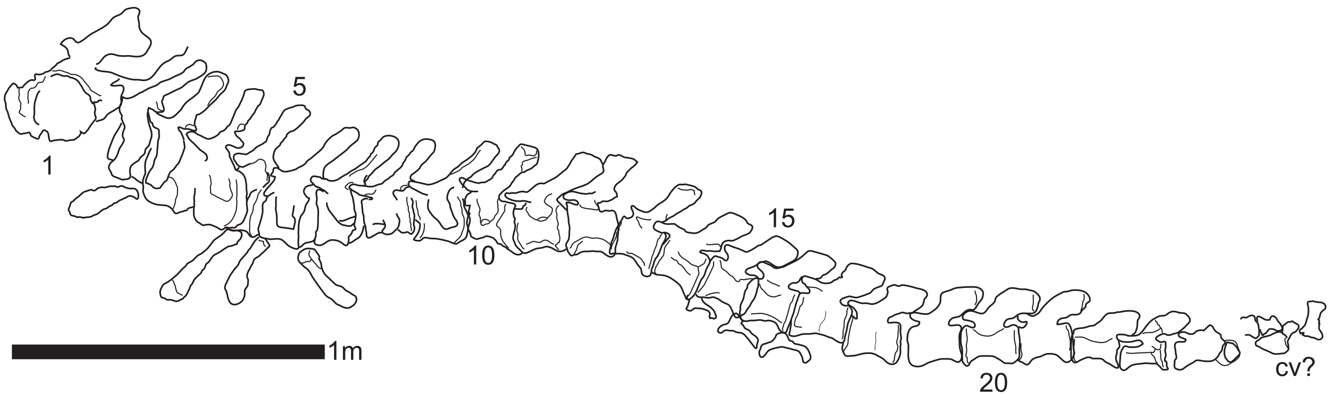

FIGURE 20. The series of 24 articulated caudal vertebrae of *C. anaensis* (LCD9701-I) preserved *in situ.*

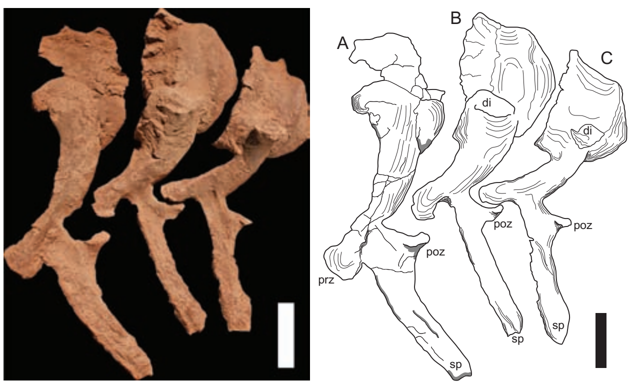

FIGURE 21. Line drawing and photograph of the line drawing of caudal vertebrae 1 to 3 of *C. anaensis* (holotype). **A**, right lateral view of the first; **B**, the second; and **C**, the third caudal vertebra. Abbreviations are shown in Appendix 1. Bar = 10 cm.

The referred specimen does not preserve scapulae.

Scapulae.—The left scapula exposes its medial side and the right one exposes the lateral surface. Both materials are completely preserved. The acromion process is a dorsally expanded round plate, and the acromial ridge is well developed on the lateral surface of the acromion process. The medial surface of the acromion process is flat. There is a small excavated area behind the acromial edge on the dorsal part of the acromion process in the right scapula. The scapular glenoid surface is slightly excavated and faces anteroventrally. The medial surface of the scapular blade is flat and lacks any ridge on the dorsal and ventral margins. The distal end of the scapular blade is just slightly expanded.

Coracoids.—The coracoids are rounded and rectangular in shape, and they are almost fused to the anterior surface of the scapulae (Figs. 36, 37). The dorsal margin lies below the proximal expansion of the scapula. The outlines of the coracoids are rectangular, but the anterior and dorsal margins meet at a relatively rounded corner. The anteroventral margin has a blunt

TABLE 5. The measurements of left and right scapulocoracoid of *C. anaensis* (holotype) in mm.

pectral girdle	Length of scapuloc oracoid	Length of scapula	Length of articular surface with	Least with of scapula blade	Distal height of scapula blade
Left	1785	1490	342	235	390
Right	1845	1495	360	223	390

TABLE 6. The measurements of the forelimb (humerus, ulna and radius) of *C. anaensis* (holotype and referred specimen) in mm.

forelimb		length	Proximal width	Middle least transverse width	Middle least anteroposterior width	Distal width
Holotype	L. humerus	1065	435	167	80+	330
	L ulna	720	284	97	48	124
	L. radius	655	140	95	—	180
Referred specimen	L. humerus	1042	420	320	80+	153.4
	L ulna	703	244	73.8	—	180
	L. radius	665	161	88.6	—	127

beak-like process, and its lateral surface has low infraglenoid lip. The coracoid foramen is circular, which is positioned at the posterior half of the coracoids (Figs. 36, 37).

Forelimb.—The forelimb of the holotype, i.e., the humerus, ulna and radius are preserved in an almost articulated original position (Fig. 4), while an isolated right humerus is relatively far from the holotype materials (Fig. 4). The referred specimen also possesses left humerus, ulna and radius. Though the humerus and ulna are almost articulated in situ, the radius seems to be removed and is isolated. The measurements are shown in Table 6.

Humerus.—The left humeri in both the holotype and the referred specimen expose anterior surfaces (Figs. 38, 39). The lateral and proximal surfaces merge smoothly with each other to produce a transversely rounded proximal end as non-titanosaur

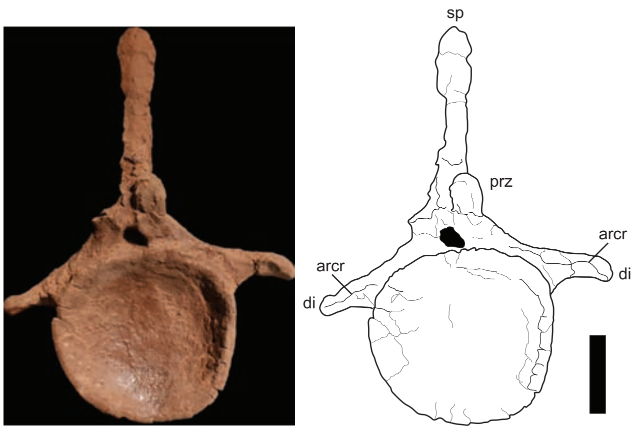

FIGURE 22. Line drawing and photograph of anterior view of the fourth caudal vertebra of *C. anaensis* (holotype). Bar = 10 cm. Abbreviations are shown in Appendix 1.

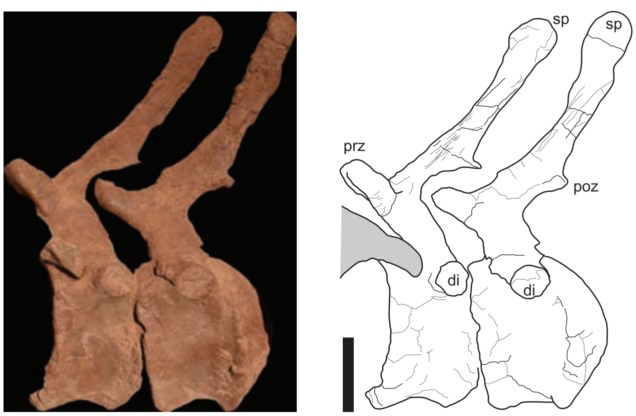

FIGURE 23. Line drawing and photograph of left lateral view of the fifth and sixth caudal vertebrae of *C. anaensis* (holotype) *in situ*. **A**, the fifth; and **B**, sixth caudal vertebra. Abbreviations are shown in Appendix 1. Bar = 10 cm.

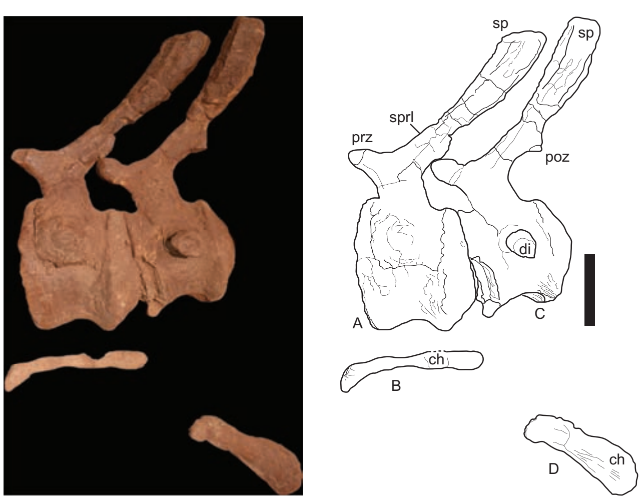

FIGURE 24. Line drawing and photograph of left lateral view of the caudal vertebrae of *C. anaensis* (holotype). **A**, seventh caudal vertebra; **B**, seventh chevron; **C**, eighth caudal vertebra; **D**, eighth chevron *in situ*. Bar = 10 cm. Abbreviations are shown in Appendix 1.

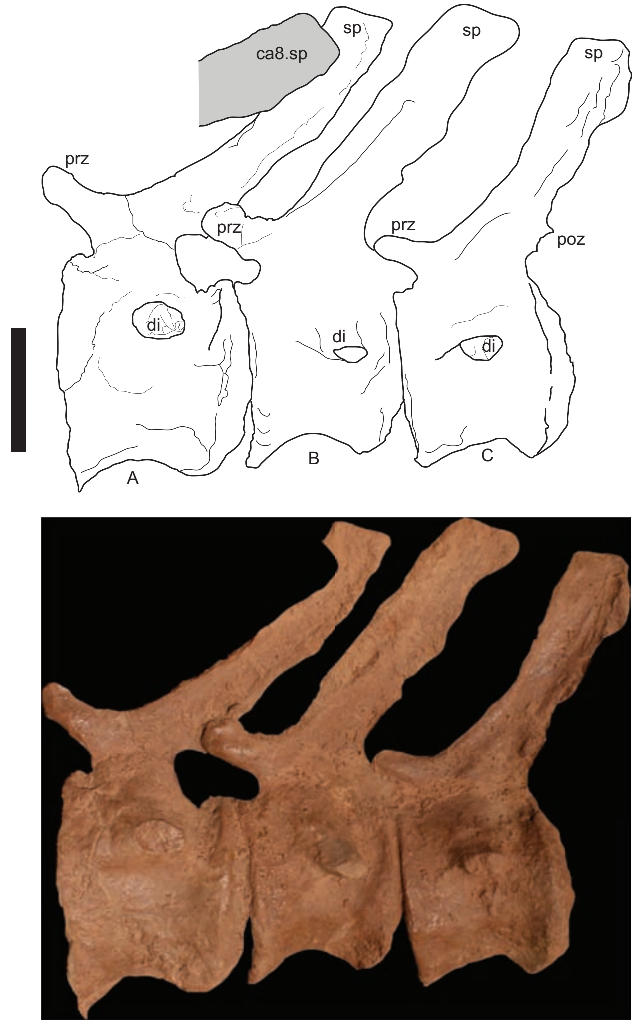

FIGURE 25. Line drawing and photograph of left lateral view of the caudal vertebrae of *C. anaensis* (holotype). **A**, ninth; **B**, tenth; and **C**, eleventh caudal vertebrae *in situ*. Bar = 10 cm. Abbreviations are shown in Appendix 1.

sauropods (Upchurch, 1998; Wilson, 2002; Mannion and Calvo, 2011), and the corner of the referred specimen is more rounded than the holotype. The anterior surface of the proximal edge is rugose. The proximal half of the anterior surface is slightly concave. The deltopectoral crest is a low narrow ridge and is restricted to the lateral edge of the humerus. The mid-shaft is relatively slender and the transverse cross-section is sub-circular. The distal part of the posterior surface is slightly concave and produces weak lateral and medial ridges. The distal articular surface is almost flat but faces anteriorly slightly, so that it is visible in anterior view. There are low ridges on the distal part of the anterior surface, and the lateral one is larger in holotype material. The mediolateral axes of the proximal and distal articular surfaces are twisted at about 20 degrees.

Ulna.—The left ulnae are preserved in both the holotype and

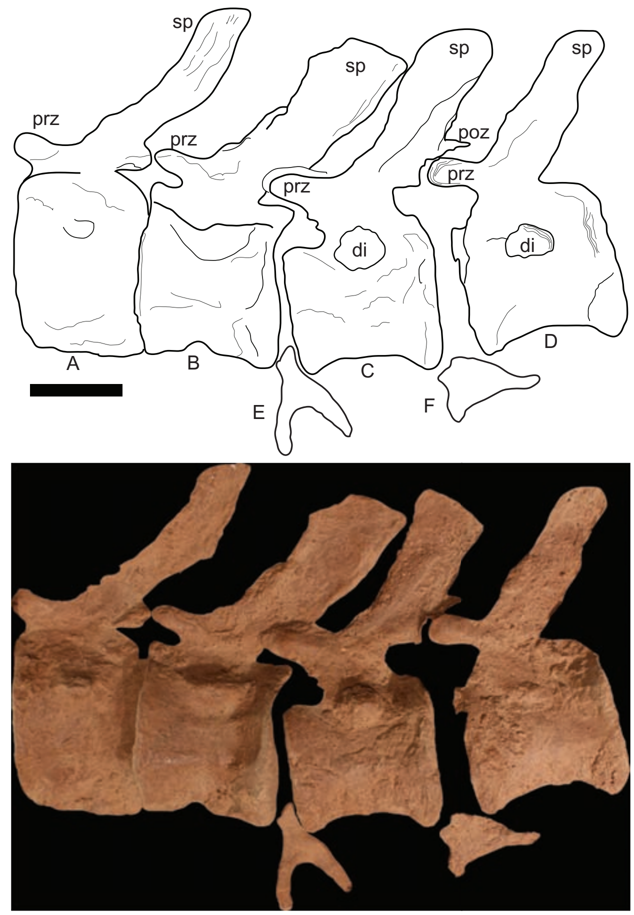

FIGURE 26. Line drawing and photograph of left lateral view of the caudal vertebrae of *C. anaensis* (holotype). **A**, twelfth; **B**, thirteenth; **C**, fourteenth; and **D**, fifteenth caudal vertebrae; **E**, thirteenth; and **F**, fourteenth chevrons *in situ*. Bar = 10 cm. Abbreviations are shown in Appendix 1.

TABLE 7. Measurements of metacarpals of *C. anaensis* (referred specimen: LCD9701-I) in mm.
Abbreviations: **L**, proximodistal length; **Wprox**, transverse width of the proximal articular surface; **Wmin**, middle least width of the shaft; **Wdist**, transverse width of the distal articular surface; **Lprox**, anteroposterior length of the proximal articular surface; **Ldist**, anteroposterior length of the distal articular surface.

	L	Wprox	Wmin	Wdist	Lprox	Ldist
Mtc. I	198	90.4	72.1	96.6	112	69.7
Mtc. II	172.4+	48.7	36.1	—	64.8	—
Mtc. III	168.4+	95.8	—	—	76.3	—
Mtc. IV	255	89.7	57.4	91.3	61.6+	72.8
Mtc. V	205	74.9	65	81.8	39.5+	63.8

TABLE 8. The measurements of left ilium of *C. anaensis* (referred specimen: LCD9701-I).

ilium	Totall ength	Total height	Length of the pubic	Width of the pubic	Length of the preacetabla	Height of the preacetabla	Height of the iliac blade
referred specimen	673	625	325	215	262	315	390

TABLE 9. Measurements of the pubes of *C. anaensis* (referred specimen: LCD9701-I) in mm.

Pubis	Length	Length of iliac articular surface	length of ischial articular surface	Length of the pubic blade	With of the distal end
Left	790	218	245	558	260
Right	815	—	—	—	330

TABLE 10. Measurements of the ischia of *C. anaensis* (holotype) in mm.

Ischium	Total length	Height of proximal main body	Least width of the middle shaft	Height of the distal end	Length of the iliac articular	Length of the pubic articular
Left	600+	411	79	?	166.6	141
Right	930	379	108	153	?	192

referred specimen. The ulna of holotype crosses the radius at its distal one-third in situ. The ulna is robust and relatively short (Fig. 40). The radial articular surface has a deep depression, so the proximal surface shows a triradiate shape. The olecranon process projects posteriorly and above the proximal articular surface. The articular surface of the anteromedial process of the ulna is concave gently along its length. On the distal one fourth of the anteromedial process, there is a significant low ridge which seems to contact with the radius. The distal articular surface that expands posteriorly is elliptical with its long axis directed anteroposteriorly. The anteromedial process of the holotype specimen is much longer than the anterolateral process, though these are almost same length in the referred specimen (Fig. 40).

Radius.—The radius is slender and rod-like shaped, and the transverse breadth is constant throughout the length. The distal half is bowed medially and just slightly sigmoid shape in medial view (Figs. 42, 43). The proximal and distal articular surfaces are elliptical and extended posteriorly. There is a sharp lower ulnar articular ridge at the distal one fourth of the posterolateral surface, and close to the posterior edge in both holotype and referred specimen.

Metacarpals.—The holotype lacks metacarpals, but the referred specimen possesses five metacarpals beside the left ulna *in situ* (Fig. 4). The ventral surfaces of metacarpals are still buried and not visible. Although the metacarpals are preserved in parallel to each other, the element is disarticulated and separated. Based on the proximal surface, the shape of articulation seems to be curved gently. Although the preservation is incomplete, the circumferences and lengths of the metacarpals are not similar. The measurements are shown in Table 7.

The metacarpal I is completely preserved. It is a robust and

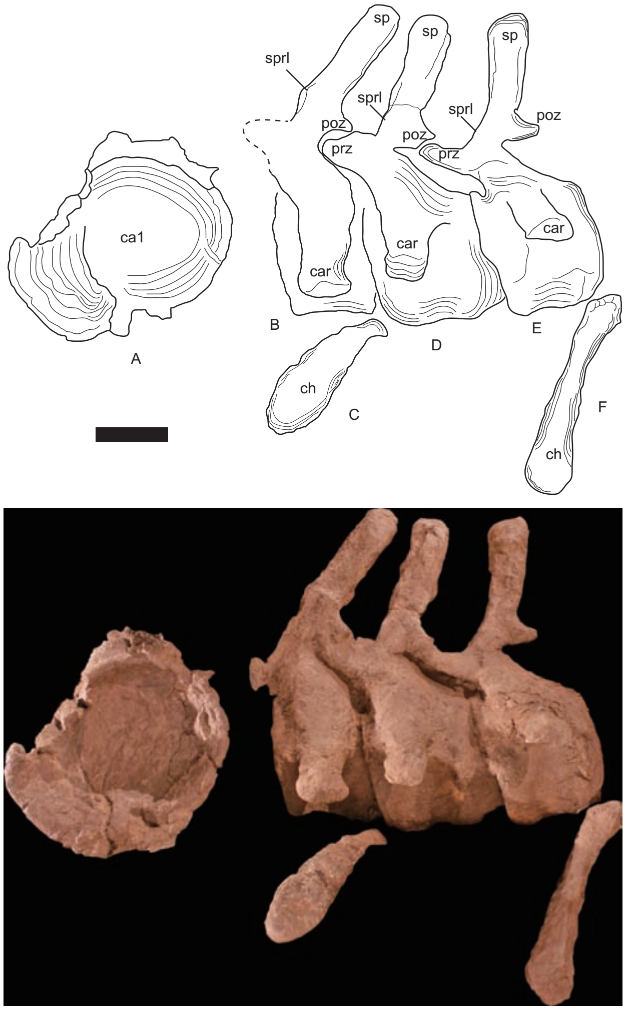

FIGURE 27. Line drawing and photograph of the caudal vertebrae of *C. anaensis* (LCD9701-I). **A**, anterior view of the first caudal centrum; **B**, left lateral view of the second caudal vertebra; **C**, left lateral view of the second chevron; **D**, left lateral view of the third caudal vertebra; **E**, left lateral view of the fourth caudal vertebrae; **F**, left lateral view of the fourth chevron. Abbreviations are shown in Appendix 1. Bar = 10 cm.

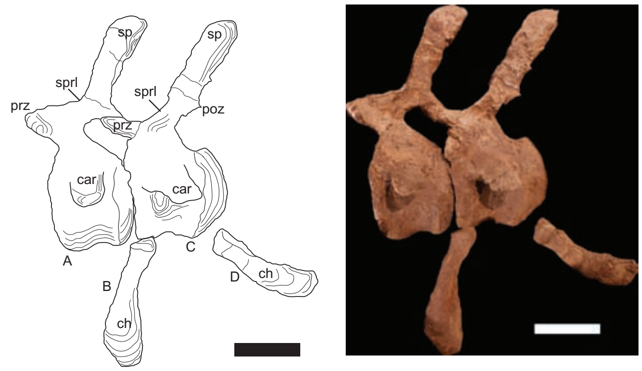

FIGURE 28. Line drawing and photograph of the caudal vertebrae of *C. anaensis* (LCD9701-I). **A**, left lateral view of the fifth caudal vertebra; **B**, left lateral view of the fifth chevron; **C**, left lateral view of the sixth caudal vertebra; **D**, left lateral view of the six chevron. Abbreviations are shown in Appendix 1. Bar = 10 cm.

short element. The proximal articular surface and medial surface are convex and rounded. The ventral part of the proximal end is expanded significantly (Fig. 44). The lateral surface is concave and contacts with metacarpal II. The dorsal surface is concave. The distal surface is elliptical with a flat dorsal edge and rounded ventral surface, which is almost flat and undivided.

The distal half of metacarpal II is broken and preserves only its proximal part. The metacarpal II has an extremely reduced thin shaft compared with other sauropod dinosaurs. The transverse cross section of the mid-shaft is subcircular. The proximal articular surface is semi-lunar with flat medial edge and convex (Fig. 45).

Metacarpal III also preserves only the proximal half. The dorsal surface is concave significantly. This is convex laterally and concave medially, contacting with metacarpal II and IV respectively (Fig. 46).

The metacarpal IV is completely preserved. The proximal articular surface is triangular. The dorsomedial surface is concave significantly, which seems to contact with metacarpal III. There is a small low knob at the middle part of the dorsal surface. The distal surface has a medial sulcus, which would probably contact with a phalanx, although there are no phalangeal materials (Fig. 47).

The metacarpal V is also completely preserved but the ventral half of the proximal part is buried and unobservable. The distal surface is similar to metacarpal IV and seems to articulate with a phalanx. The proximal half of the main shaft of the metacarpal V curves slightly medially (Fig. 48).

Pelvic girdle.—Although the original paper (Fang et al., 2000: 213) noted that the holotype is preserved with “right ilium, left pubis, and ischium,” only both sides of ischia are preserved beside the caudal series of the holotype. The referred specimen possesses a left ilium articulated to the sacrum and fused pair of pubes.

Ilium.—A complete left ilium is preserved in the referred specimen articulated to the sacral vertebrae. The measurements are shown in Table 8. The right side is invisible, which could be still buried. The projection of the anterior process lies in an approximately vertical plane and is directed anterolaterally (Fig. 49). The preacetabular process tapers anteroventrally and is rounded dorsally. The highest point of the dorsal margin lies anterior to the base of the pubic process. The dorsal margin is strongly convex dorsally and rounded in lateral view. The posterior part of the iliac blade has a caudolaterally facing surface. The pubic peduncle of the ilium is prominent and gains in width toward the distal end; the transverse cross-section is sub-triangular in shape. The ischial peduncle is reduced, so that the long axis of the main body of the ilium slopes caudoventrally,

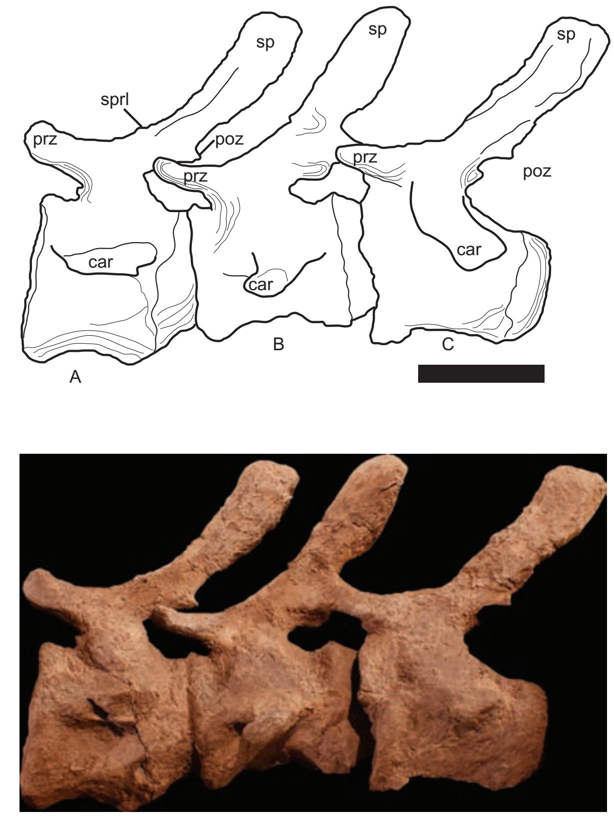

FIGURE 29. Line drawing and photograph of the caudal vertebrae of *C. anaensis* (LCD9701-I). **A**, left lateral view of the seventh; **B**, the eighth; and **C**, the ninth caudal vertebrae. Abbreviations are shown in Appendix 1. Bar = 10 cm.

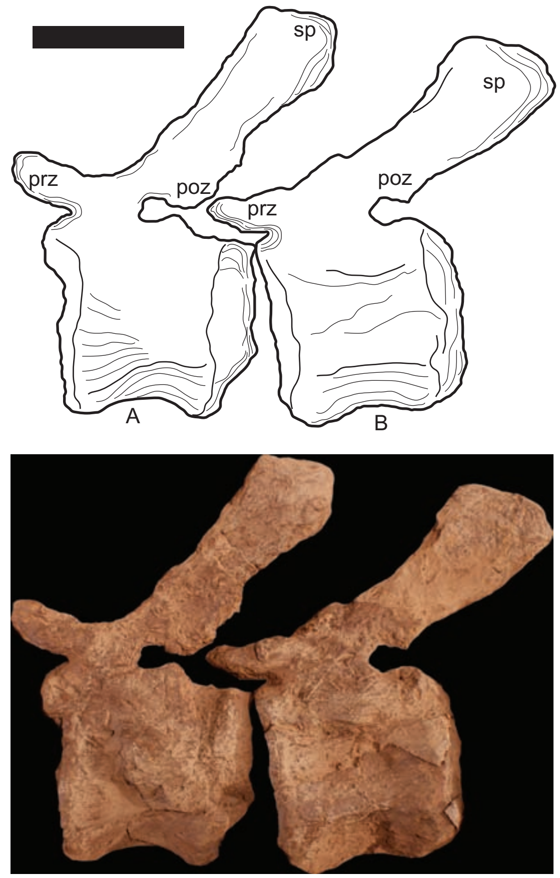

FIGURE 30. Line drawing and photograph of the caudal vertebrae of *C. anaensis* (LCD9701-I). **A**, left lateral view of the tenth; and **B**, the eleventh caudal vertebrae. Abbreviations are shown in Appendix 1. Bar = 10 cm.

but a chord through the articular surfaces of the pubic and ischial peduncles passes ventral to the posterior lobe of the ilium (Fig. 49).

Pubis.—The left and right pubes of the referred specimen are sutured to each other on the medial surfaces of the main body, and expose their ventrolateral surface in situ (Fig. 50). The measurements of them are shown in Table 9. The pubes of *C. anaensis* are relatively short and robust. The ventrolateral surface is almost smooth and lacks any process. The pubic blade is flat and wide transversely, and it is twisted slightly toward the main body. The distal end of the pubic blade is expended laterally with a rounded tip. The obturator foramen is circular and slightly expanded with a posterodorsally-anteroventrally directed long axis, and positioned just behind the ischial articular surface. The iliac articular surface is much shorter than the ischial ones, and slightly expanded mediolaterally (Fig. 50). The ischial articular surface is wide and rugose significantly, and fused to each other on their medial surfaces and forms a semi-circular articular surface together.

Ischium.—The holotypic left and right ischia are almost completely preserved and are not fused to one another (Fig. 51). They were preserved near the most proximal caudal vertebra (Fig. 4). The ischium is missing in the referred specimen. The measurements of the ischia are shown in the Table 10.

The left ischium exposes its flat medial surface and the distal end of the distal blade is still buried, while the right ischium exposes its lateral surface. The proximal main body is expanded dorsoventrally, and the left ischium is much taller than the right one. The distal shaft is slender and slightly expanded ventrally in the right ischium. Especially, the right hand side consists of a dorsolateral blunt ridge on its lateral surface. The ventral edge of the distal shaft is quite sharp and has a thin edge in the right side element. The distal end of the ischial blade is triangular; the acute angle directs laterally. The long axis of the ischial shaft passes through the middle part of the pubic articular surface. There is no tuberosity at the lateral side of the iliac articular process in anterior view. The iliac articular surface of the left ischium appears elliptical in outline in anterior view. The pubic articular surfaces reduce in mediolateral width and the left side one is much broader than the right one.

Hind limb.—In the original description Fang et al. (2000: translated from the Chinese, p. 213) stated that the holotype

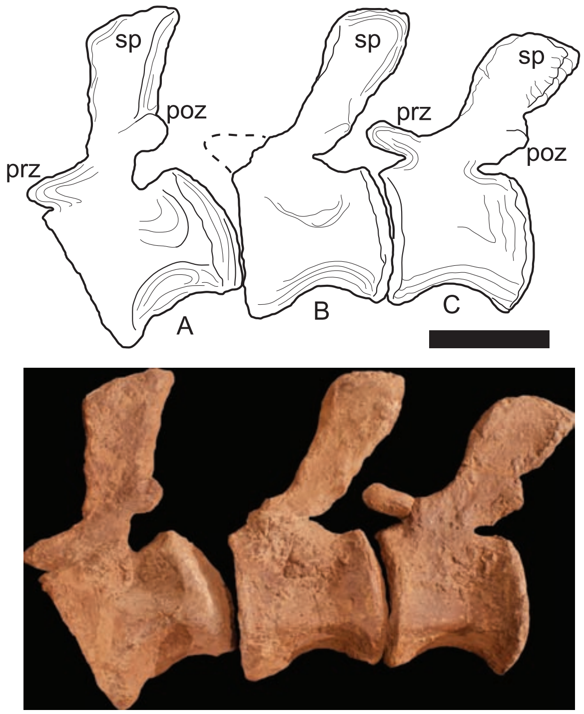

FIGURE 31. Line drawing and photograph of the caudal vertebrae of *C. anaensis* (LCD9701-I). **A**, left lateral view of the twelfth; **B**, the thirteenth; and **C**, the fourteenth caudal vertebrae. Abbreviations are shown in Appendix 1. Bar = 10 cm.

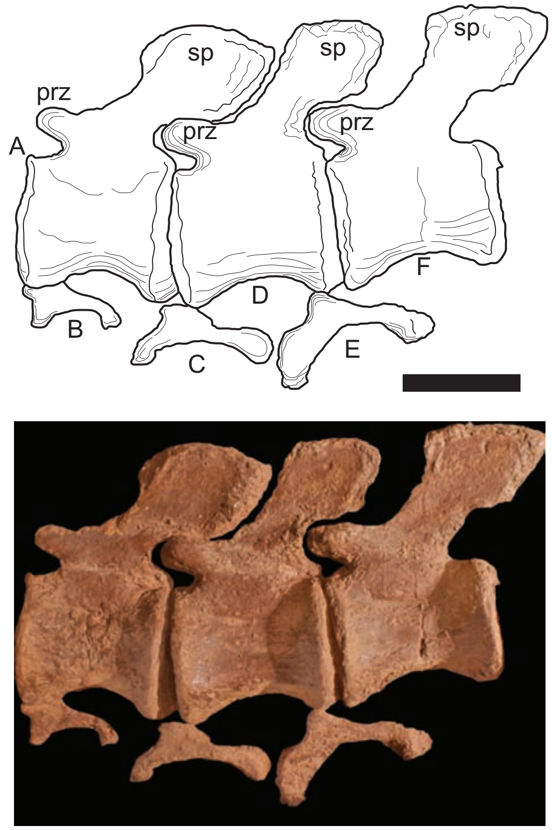

FIGURE 32. Line drawing and photograph of the caudal vertebrae and chevrons of *C. anaensis* (LCD9701-I). **A**, left lateral view of the fifteenth caudal vertebra; **B**, the fourteenth; and **C**, fifteenth chevron; **D**, the sixteenth caudal vertebra; **E**, the sixteenth chevron; **F**, the seventeenth caudal vertebra. Abbreviations are shown in Appendix 1. Bar = 10 cm.

possesses "the left and right femurs, tibia, fibula, and a distal phalange etc.," although, only one complete right femur, tibia, fibula and astragalus are preserved beside the caudal series. The ossified calcaneum might be absent in the holotype. The referred specimen has a complete left femur.

Femur.—A complete right femur is preserved in the holotype, the posterior surface is exposed and the anterior surface is unobservable in situ (Fig. 4). The measurements of the femora are shown in Table 11. The shaft is straight longitudinally in the holotype (Fig. 52), but with slightly reduced transverse width in the referred specimen (Fig. 53). The transverse cross section through the femoral shaft is compressed anteroposteriorly. The femoral shaft reduces its width downward, but turns to expand toward the distal articular surface. The lateral margin of the femoral shaft is slightly convex in the proximal one-third, and it turns to concave in the distal one-third. The femoral head is directed dorsomedially in the holotypic material and the referred specimen, which seems to be similar to the condition in titanosauriform sauropods, though the lateral bulge is not as expanded in *Chuanjiesaurus* as in titanosauriforms (Salgado et al., 1997). The fourth trochanter is a low rounded crest and positioned near the medial side of the posterior surface. The distal tip of the fourth trochanter lies slightly below the midshaft length. The distal condyles are oriented perpendicular to the axis of the femoral shaft. The tibial condyle is largest, and the fibular condyle is divided to the medial and lateral crests. The medial crest is transversely wider than the sulcus between the medial crest and the tibial condyle. Usually, only two distal condyles are present in basal sauropod dinosaurs, though *C. anaensis* possesses the third lateral articular condyle, which is similar to the second material of *Mamenchisaurus hochuanensis* (Ye et al., 2001). However, the sulcus between tibial and middle condyle are significantly deeper than the lateral sulcus in *C. anaensis*, which is contrary to *M. hochuanensis*. The articular surface of the femoral distal condyles curved upward at the posterior margins, so that the articular surface is partially visible in posterior view.

The smooth anterior surface is visible in the referred specimen in situ. The femoral shaft is also straight, but transversely narrower than the holotype material and slightly constricted in the one-third from the distal end. The anterior trochanter is absent in the referred specimen.

Tibia.—The holotypic right tibia, fibula and astragalus are preserved in articulation with each other and their anterior

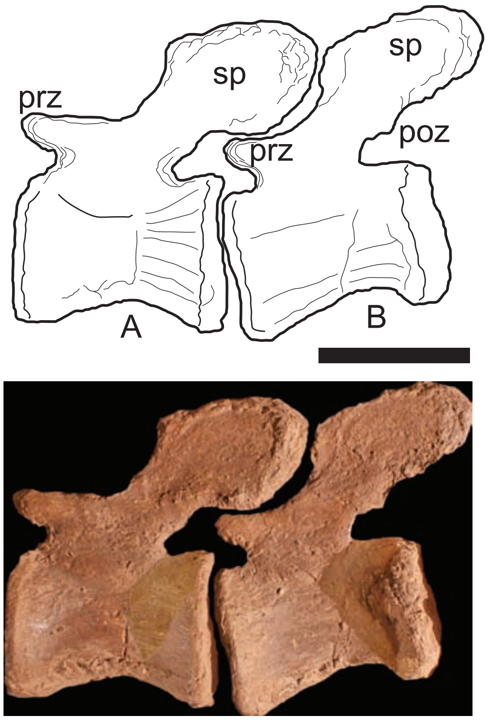

FIGURE 33. Line drawing and photograph of the caudal vertebrae of *C. anaensis* (LCD9701-I). **A**, left lateral view of the eighteenth; and **B**, the nineteenth caudal vertebrae. Abbreviations are shown in Appendix 1. Bar = 10 cm.

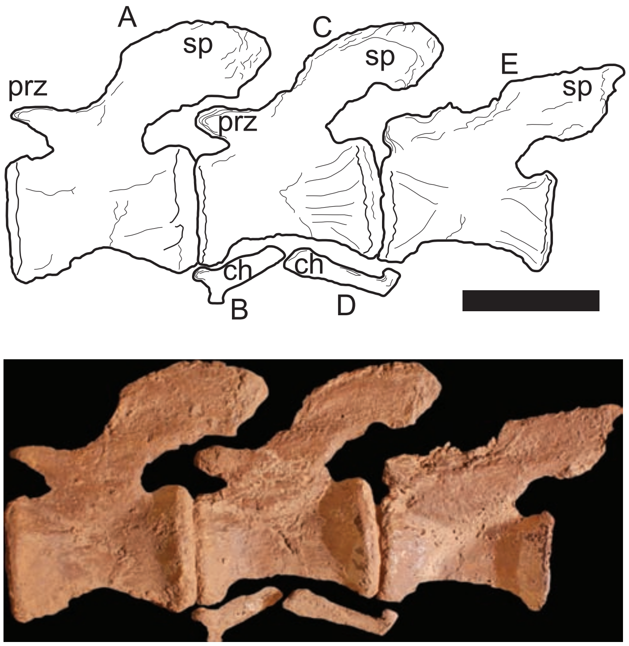

FIGURE 34. Line drawing and photograph of the caudal vertebrae and chevrons of *C. anaensis* (LCD9701-I). **A**, left lateral view of the twentieth caudal vertebra; **B**, the twentieth chevron; **C**, the twenty first caudal vertebra; **D**, the twenty first chevron; **E**, twenty second caudal vertebra. Abbreviations are shown in Appendix 1. Bar = 10 cm.

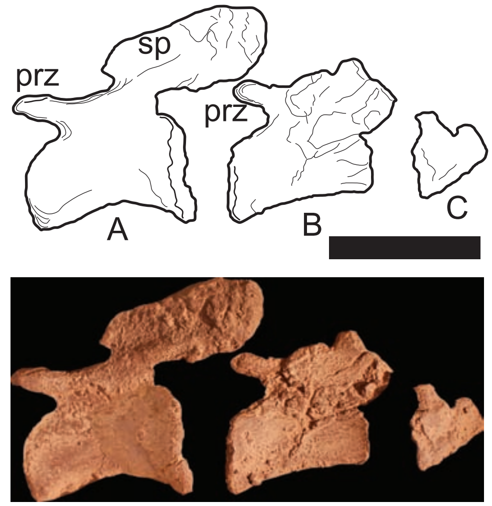

FIGURE 35. Line drawing and photograph of the caudal vertebrae and chevrons of *C. anaensis* (LCD9701-I). **A**, the twenty third; **B**, the twenty fourth; and **C**, ? twenty fifth caudal vertebra. Abbreviations are shown in Appendix 1. Bar = 10 cm.

surfaces are exposed. The measurements of the tibia are shown in Table 12.

The tibia is a relatively slender element and compressed anteroposteriorly. The proximal part is strongly compressed anteroposteriorly and expanded mediolaterally. The cnemial crest is a reduced low ridge and projects laterally. It reduces the width downward and reaches the least point at the distal two-thirds, and turns to expand mediolaterally toward its distal end. The distal articular surface is relatively smooth and convex. The distal end of the tibia is expanded transversely and compressed anteroposteriorly, and reduces its anteroposterior width laterally.

Fibula.—The right fibula is preserved with its medial side exposed, which lies beside the right tibia in the holotypic specimen (Fig. 54 and Table 13). The fibula is a slender rod-like element with a slightly sigmoid outline in medial view. There is a triangular tibial scar on the medial face of the proximal part of the fibula. The lateral muscle scar is hard to identify because of the damage from weathering. The distal end expands transversely and contacts with the lateral concavity of the astragalus. The distal end of the fibula is convex anteromedially to form the thick articular condyle.

Astragalus.—A right astragalus is partially articulated with the distal end of the right tibia in the holotypic material, with its anterior half and part of the proximal end exposed (Fig. 54). The TABLE 14. The measurements of astragalus of *C. anaensis* (holotype) in mm. is rounded in anterior and dorsal views. The dorsal ascending process is not so high, and fits into the posterior surface of the distal end of the tibia. The anterior surface of the dorsal process slopes toward the anterior surface and lacks anterodorsal cavity or neural foramen. The ventral surface is

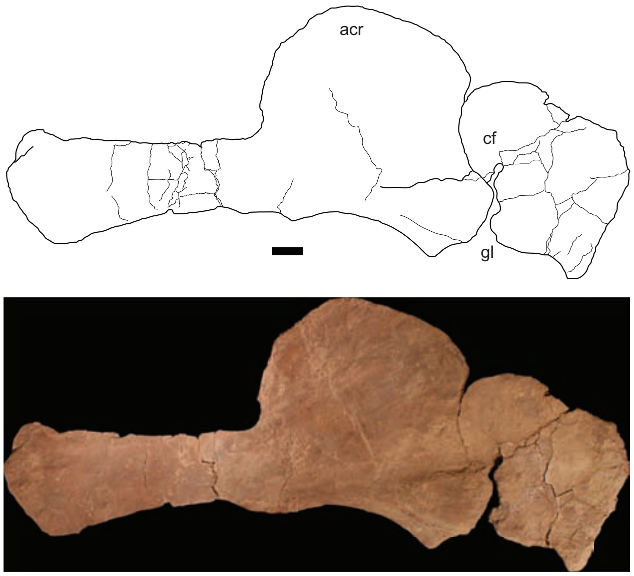

FIGURE 36. Line drawing and photograph of medial view of the left scapulocoracoid of *C. anaensis* (holotype). Abbreviations are shown in Appendix 1. Bar = 10 cm.

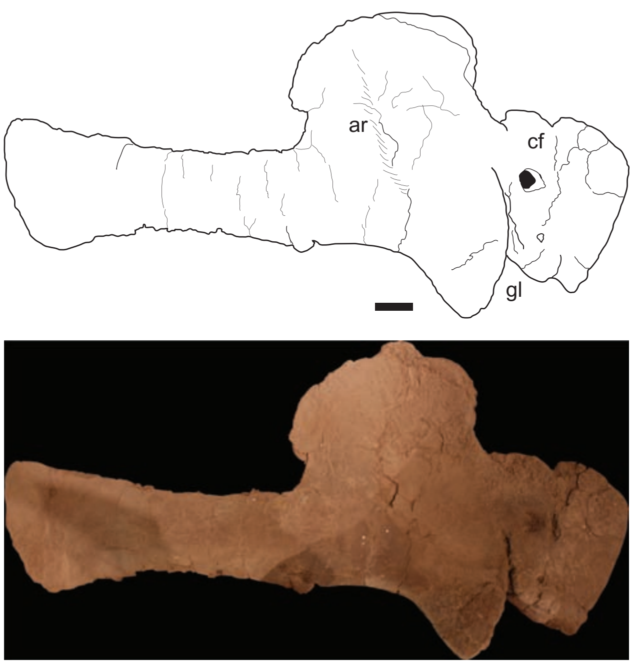

FIGURE 37. Line drawing and photograph of lateral view of the right scapulocoracoid of *C. anaensis* (holotype). Abbreviations are shown in Appendix 1. Bar = 10 cm.

slightly convex transversely and anteroposteriorly. The fibular distal condyle inserts into the lateral fossa of the astragalus.

COMPARISON

As mentioned above, based on four sacral vertebrae, weakly developed pneumaticity in dorsal centra, procoelous proximal caudal centra, anteroposteriorly depressed tibia and fibula (Young and Zhao, 1972), and fused posterior dorsal centra (Lü et al., 2008), *Chuanjiesaurus anaensis* belongs to Mamenchisauridae, which is a relatively basal group of Sauropoda. Compared to more derived taxa (i.e., Neosauropoda), *C. anaensis* lacks their autapomorphies, such as subcircular proximal end of tibia (Wilson and Sereno, 1998: Neosauropoda), transversely convex ventral surface of the astragalus, (Upchurch, 1998: Neosauropoda), shorter cervical ribs relative to their respective centra (Wilson and Sereno, 1998; Wilson, 2002: Diplodocoidea) and tall neural arch of the dorsal and anterior caudal vertebrae (Wilson and Sereno, 1998: Diplodocoidea).

In a recent classification, non-neosauropod Sauropoda generally include *Vulcanodon, Barapasaurus, Kotasaurus, Cetiosaurus, Patagosaurus* and *Tehuelchesaurus* (Wilson and Sereno, 1998; Wilson, 2002; Upchurch et al., 2004a), *Antetonitrus, Isanosaurus, Gongxianosaurus* and *Tazoudasaurus* (Wilson, 2005). So here we will consider the differences between *C. anaensis* and these taxa. Furthermore, Carballido et al. (2011) redescribed *Tehuelchesaurus*, and their phylogenetic analysis reveals *Tehuelchesaurus* is non-titanosauriform camarasauromorph. *C. anaensis* lacks their revised diagnostic characters, i.e., accessory laminae of infradiapophyseal fossae and anteroposterior expansion of the distal end of the humerus.

The diagnoses of *Vulcanodon* (from Early Jurassic of Zimbabwe) include broadly articulated distal shaft of pubis, amphicoelous caudal vertebrae, the radius slightly longer than tibia, columnar femur (Cooper, 1984) and middle caudal centra with a ventral longitudinal hollow (Wilson, 2002), though *C. anaensis* possesses none of these features. Furthermore, there are several differences between *Vulcanodon* and *C. anaensis* as follows: the deltopectoral crest of the former is much more developed than the latter; the radius of *Vulcanodon* is anteroposteriorly thinner than that of *C. anaensis*; the latter lacks the ventral groove of caudal centra, while that is present in *Vulcanodon*. The distal shaft of the ischium of *Vulcanodon* is dorsoventrally shallower than *C. anaensis*. The fourth trochanter constitutes a prominent ridge in *Vulcanodon*, but that is low and blunt in *C. anaensis*. The diagnoses proposed by Upchurch et al. (2004a) are related to metatarsal and pedal unguals, those are not preserved in *C. anaensis*. The prosauropod-like pubic ‘apron’ mentioned in Upchurch et al. (2004a) seems much wider in *C. anaensis*.

Contrary to *Barapasaurus* (Jain et al., 1975), the deltopectoral crest of *C. anaensis* is not well developed. The pubic peduncle of the ilium of *Barapasaurus* is directed ventrally, but it is directed anteroventrally in *C. anaensis*. The distal end of the pubis is rounded in *Barapasaurus*, whereas that of *C. anaensis* is expanded transversely. The femoral shaft of *Barapasaurus* is

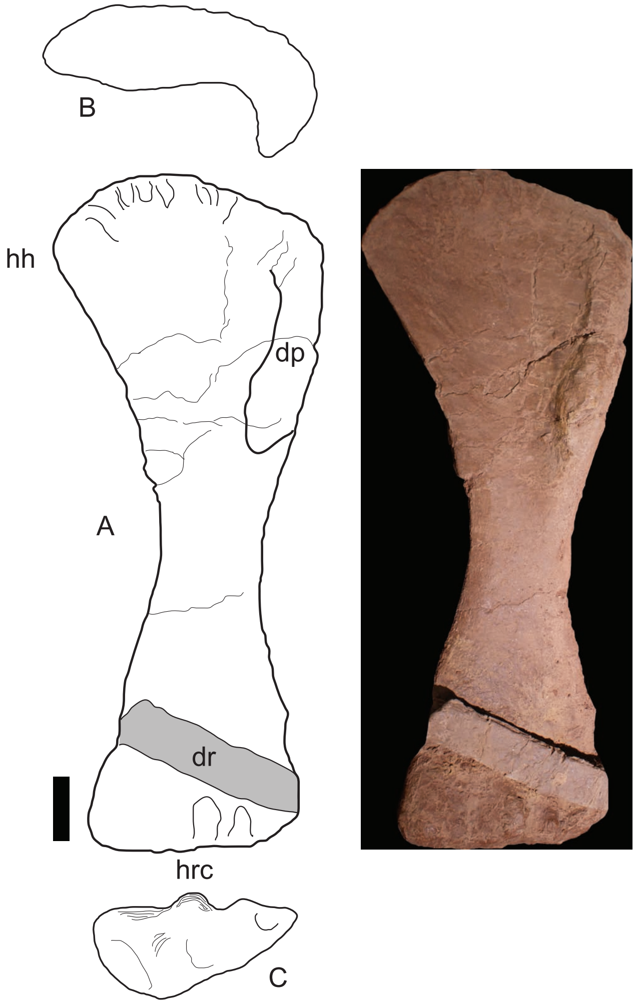

FIGURE 38. Line drawing and photograph of the left humerus of *C. anaensis* (holotype). **A**, anterior; **B**, proximal; and **C**, distal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

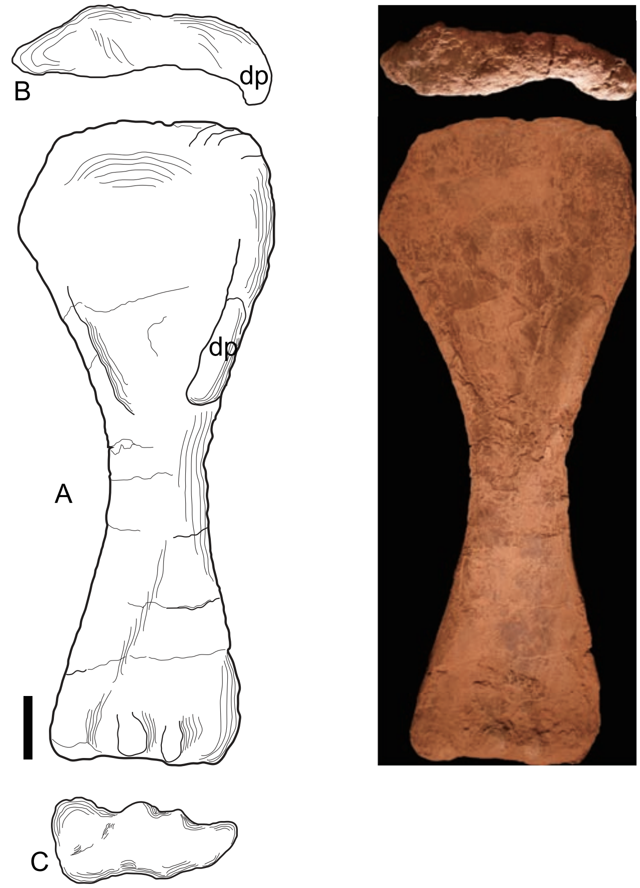

FIGURE 39. Line drawing and photograph of the left humerus of *C. anaensis* (LCD9701-I). **A**, anterior; **B**, proximal; and **C**, distal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

much more slender than *C. anaensis*, whereas it is expanded mediolaterally and the fourth trochanter is a low blunt crest in *C. anaensis*. Contrary to the autapomorphy of Wilson (2002), the fibular distal condyle is not wider than twice mid-shaft breadth. The presence of slitlike neural canal (Upchurch et al., 2004a) is uncertain in *C. anaensis*. Bandyopadhyay et al. (2010) proposed numerous amended diagnosis for *B. tagorei*. Compared to *C. anaensis*, some features are not referable as follows: the limb bones of *B. tagorei*, especially the radius and femur are much slender than *C. anaensis*; the caudal centra of *B. tagorei* is biconcave, but procoelous in *C. anaensis*; the sacral centra of *B. tagorei* is amphiplatyan, but the posterior surface of the last sacral centrum is convex in *C. anaensis*; the scapular acromion process of *C. anaensis* is rounded and much more developed than that of *B. tagorei*.

Upchurch and Martin (2003: 216) revised the diagnoses of *Cetiosaurus* as follow: "(1) symmetrical 'pyramid'-shaped neural spines on posterior cervical vertebrae and anterior dorsal vertebrae; (2) loss of the spinodiapophyseal lamina (or complete fusion of this lamina with the spinopostzygapophyseal lamina) on all dorsal neural spines; (3) distal caudal centra have 'tongue' -like projections on their articular faces which extend the floor of the neural canal anteroposteriorly; (4) distal shafts of anterior chevrons are anteroposteriorly compressed and do not taper to a transversely flattened distal end; (5) triangular hollow, bounded dorsally by a horizontal ridge, on the lateral surface of the base of the pubic process of the ilium. " Excluding the third character, none of them are present in *C. anaensis*. The posterior cervical neural spine of *C. anaensis* is a laterally compressed simple plate; *C. anaensis* possesses spinodiapophyseal lamina in its dorsal vertebrae; presence of the third diagnosis is uncertain because of the preserved condition; the distal shafts of anterior chevrons are laterally compressed; the ilium lacks any ridge as mentioned in *Cetiosaurus*.

There are several differences with the emended diagnosis of

TABLE 11. The measurements of the femur of *C. anaensis* (holotype and referred specimen) in mm. Abbreviations are same as Table 7.

Femur	L	Wprox	Wmin	Wdist
Holotype (right)	1375	400	225	365
LCD9701-I (left)	1360	440	197	390

TABLE 12. The measurements of the right tibia of *C. anaensis* (holotype) in mm. Abbreviations are same as Table 7.

	L	Wprox	Wmin	Wdist	Craniocaudal length of distal end
r. tibia of holotype	890	340	135	210	107

TABLE 13. The measurements of the right fibula of *C. anaensis* (holotype) in mm. Abbreviations are same as Table 7.

	L	Wprox	Wmin	Wdist
r. fibula	910	140	93	172

TABLE 14. The measurements of astragalus of *C. anaensis* (holotype) in mm.

	Dorsoventral height	mediolateral width	Craniocaudal length
r. astragalus	163	278	—

Kotasaurus (Yadagiri, 2001: 243). “Simple dorsal vertebral neural spines (without spinal laminae)”: *C. anaensis* possesses dorsal spinodiapophyseal, spinoprezygapophyseal, and spinopostzygapophyseal laminae system; “low iliac blade”: contrary to the *Kotasaurus* diagnosis, the iliac blade of *C. anaensis* is expanded dorsally; “a narrow proximal surface to the scapula” the condition in Kotasaurus is uncertain in his paper; the limb bones are relatively more slender than those of *C. anaensis*, and the lesser trochanter is almost completely absent in the referred specimen (LCD9701-I); and *C. anaensis* lacks “V-shaped chevrons with well developed articular facets on the dorsolateral corners”. Thus, several diagnostic characters of *Kotasaurus* are absent in *C. anaensis*, though, “a pneumatocoel on the base of the posterior dorsal neural arch that opens into the neural canal is not present”: this character is present in *C. anaensis*

C. anaensis is apparently different from *Patagosaurus* (Bonaparte, 1979, 1986) which has five sacral vertebrae, while the number of sacral vertebrae is four in the referred specimen of *C. anaensis*. The first sacral rib of *Patagosaurus* seems much more developed dorsoventrally than the dorsosacral rib of *C. anaensis*. The cervical centra of *Patagosaurus* lack pneumatic concavities, and the cervical neural arches are much higher and shorter than those of *C. anaensis*, furthermore the cervical prezygapophyses of *Patagosaurus* are directed anterodorsally whereas those of *C. anaensis* project anteriorly. The dorsal and caudal centra of *Patagosaurus* are amphicoelous, while those of *C. anaensis* are opisthocoelous and procoelous respectively. The proximal half of the humerus is more expanded transversely than *Patagosaurus*. The distal end of the ischium of *C. anaensis* is not expanded as greatly as in *Patagosaurus*. Contrary to *C. anaensis*, the fourth trochanter is positioned at the center of the posterior surface in *Patagosaurus*. Compared to *C. anaensis*, the tibial cnemial crest is well developed anteriorly in *Patagosaurus* (Wilson, 2002). The posterior cervical neural spines with well-developed dorsally directed process at their summit (Upchurch et al., 2004a) are absent.

The scapula shaft of *Tehuelchesaurus* (Rich et al., 1999) is shorter than *C. anaensis* and lacks distal expansion. The distal articular surface of the humerus of *Tehuelchesaurus* is much thicker (Upchurch et al., 2004a) than *C. anaensis*. The distal end of the ulna is significantly expanded anteroposteriorly in *Tehuelchesaurus*, but that of *C. anaensis* is subcircular. Compared to *C. anaensis*, the femoral distal articular surface of *Tehuelchesaurus* is expanded anteroposteriorly and the fibular condyle is narrower than the sulcus between tibial and fibular condyles.

From the Middle Jurassic of southwest China, the relatively basal sauropod, *Tienshanosaurus* (Young, 1937), *Shunosaurus* (Zhang, 1988), *Omeisaurus* (He et al., 1988) and *Yuanmousaurus* (Lü et al., 2006) were reported.

Tienshanosaurus was found from ?Jurassic of Xinjiang (Young, 1937). In contrast to *Chuanjiesaurus*, the cervical vertebra is much taller with anteroposteriorly compressed form, the caudal centra are amphicoelous or weakly procoelous, the pubic peduncle of ilium is directed ventrally, the deltopectoral crest is a relatively well developed sharp ridge and the lateral surface of the ilium has a shelf-like depression in *Tienshanosaurus* (Young, 1937).

Compared to *Shunosaurus*, *C. anaensis* is apparently different with its elongated cervical vertebrae, and the cervical neural spines are much lower dorsoventrally and shorter anteroposteriorly than those of *Shunosaurus*. The anterior portion of the axial neural spine is much developed in *Shunosaurus* (an autapomorphies mentioned by Wilson 2002), whereas the expansion is relatively weak in *C. anaensis. Shunosaurus* is highly unusual in its postparapophysis on the posterior dorsal vertebrae (Upchurch et al., 2004a), though *C. anaensis* does not have it (Figs. 16, 17). The anterior caudal centra of *Shunosaurus* are amphicoelous but that is procoelous in *C. anaensis*. Furthermore, the most unique feature of *Shunosaurus* is its tail club (Zhang, 1988), but because of the preservation condition, presence of it in *C. anaensis* is uncertain. The autapomorphic characters of *Shunosaurus* (Wilson, 2002)

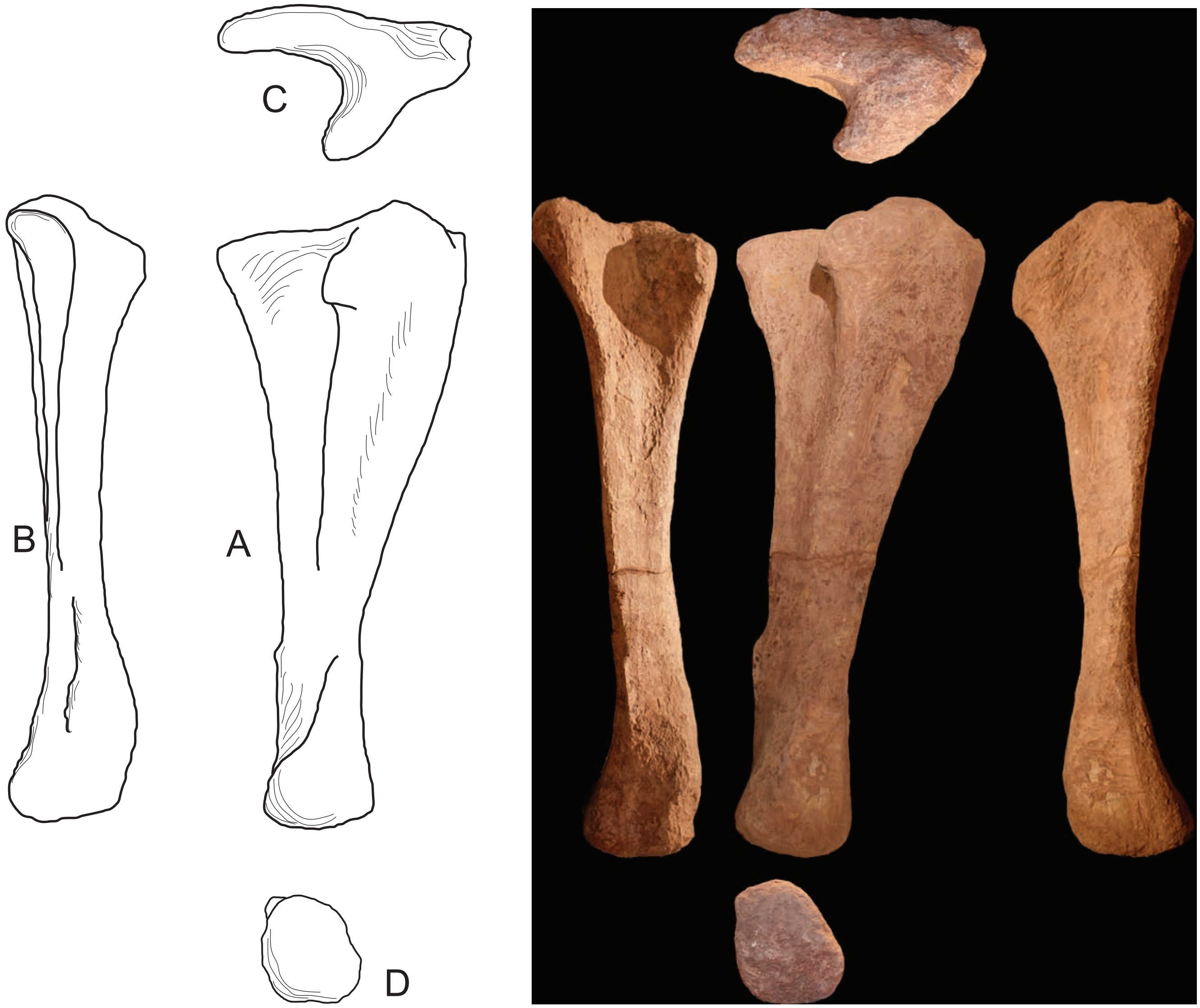

FIGURE 40. Line drawing and photograph of the left ulna of *C. anaensis* (holotype). **A**, anterior; **B**, medial; **C**, proximal; and **D**, distal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

are not present in *Chuanjiesaurus* as follows: the ulnar proximal condylar processes of the holotype of *C. anaensis* are quite different in length; however, those of the referred specimen are subequal in length (Fig. 41). The distal condyle of metacarpal I is perpendicular to the axis of shaft in *Shunosaurus*, though that is beveled about 20 degrees in *C. anaensis* (Fig. 44).

The general body plan of *Omeisaurus* is similar to *C. anaensis* with especially elongated neck and longtail, though; there are several differences between these two genera. Although the cervical vertebrae of *Omeisaurus* are elongated and low as in *C. anaensis*, the longitudinal ventral keel of the centrum is absent in *C. anaensis*. The articular surfaces of the posterior dorsal centra of *Omeisaurus* are amphicoelous; however, those of *C. anaensis* are strongly opisthocoelous. The caudal centra are amphicoelous in the former, but procoelous in the proximal caudal centra of the latter. Wilson (2002: 271) mentioned that "distalmost caudal chevrons fused to anteriormost portion of ventral centrum," those of *C. anaensis* are not fused. The dorsal margin of the ilium is weakly convex in *Omeisaurus*, whereas that of *C. anaensis* are strongly convex and almost semicircular (Fig. 49). The former has a relatively elongate radius with approximately more than 0.65 to 0.70 ratio to humerus, but less than 0.65 in *C. anaensis*. The fourth trochanter is positioned at the center of the posterior surface of the femur in *Omeisaurus*, but at nearly the caudomedial edge in *C. anaensis*.

Compared to other non-neosauropods, procoelous caudal centra occur only in *Bellusaurus* (Dong, 1990), *Klamelisaurus* (Zhao, 1993) and *Mamenchisaurus* in Jurassic age. So, the

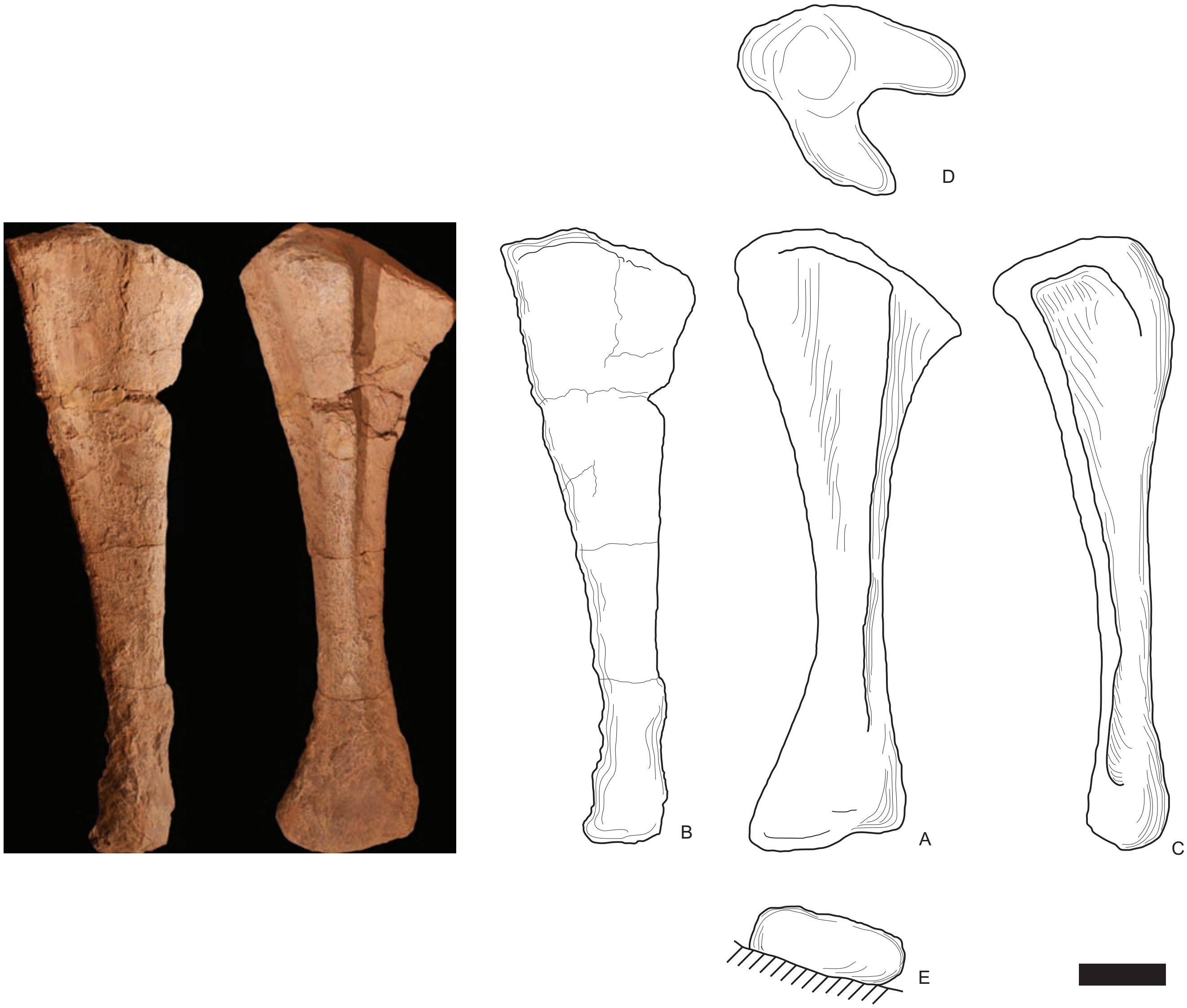

FIGURE 41. Line drawing and photograph of the left ulna of *C. anaensis* (LCD9701-I). **A**, anterior; **B**, lateral; **C**, medial; **D**, proximal; and **E**, distal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

present paper discusses differences between *Chuanjiesaurus* and these taxa.

Cervical neural spines of *Bellusaurus* are much higher than those of *C. anaensis*, and the cervical centra are much more elongated in *C. anaensis*. The height of the posterior dorsal neural arch of *C. anaensis* is much higher than that of *Bellusaurus*. The articular surface of the sacral centrum is amphiplatyan in *Bellusaurus*; however, the posterior articular surface of *C. anaensis* is moderately convex. The degree of procoely of the caudal centra of *Bellusaurus* is not as prominent as *C. anaensis*. The deltopectoral crest of *Bellusaurus* is relatively well developed, while it is low and blunt in *C. anaensis*. Contrary to *C. anaensis*, the lateral corner of the femur of *Bellusaurus* has a shelf-like concavity. The proximal end of the tibia is expanded in *Chuanjiesaurus*, but not in *Bellusaurus*. Furthermore, *Bellusaurus* lacks sacrocostal yoke.

Two cervical centra are fused and the ventral surface of dorsal centra have longitudinal ridges in *Klamelisaurus*, but such features are absent in *Chuanjiesaurus*. Furthermore, contrary to *C. anaensis,* the distal end of the scapular blade of *Klamelisaurus* is significantly expanded ventrally. The ulnar mid-shaft of *C. anaensis* is much more slender than that of *Klamelisaurus*. Contrary to *C. anaensis*, the ilium of *Klamelisaurus* is dorsoventrally low and possesses a lateral shelf on the dorsal part of the acetabulum. The fourth trochanter of *Klamelisaurus* lies on the proximal half of the posterior surface

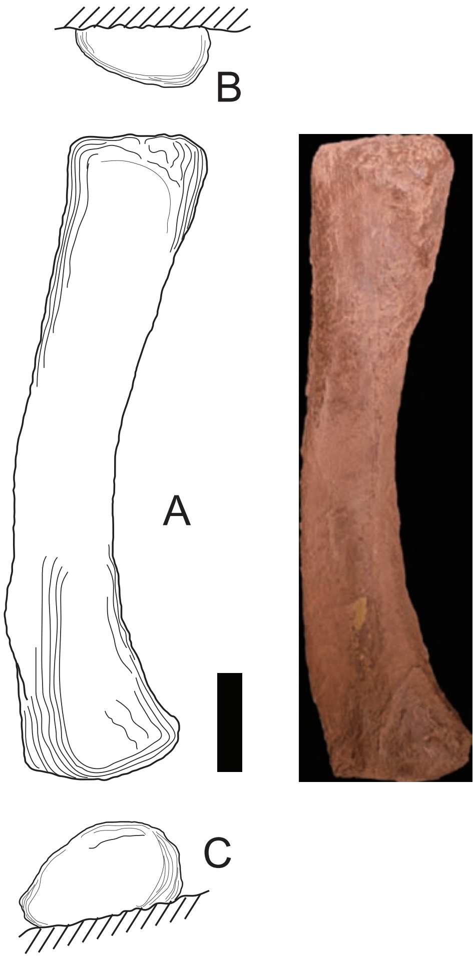

FIGURE 42. Line drawing and photograph of the left radius of *C. anaensis* (holotype). **A**, anterior; **B**, proximal; and **C**, distal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

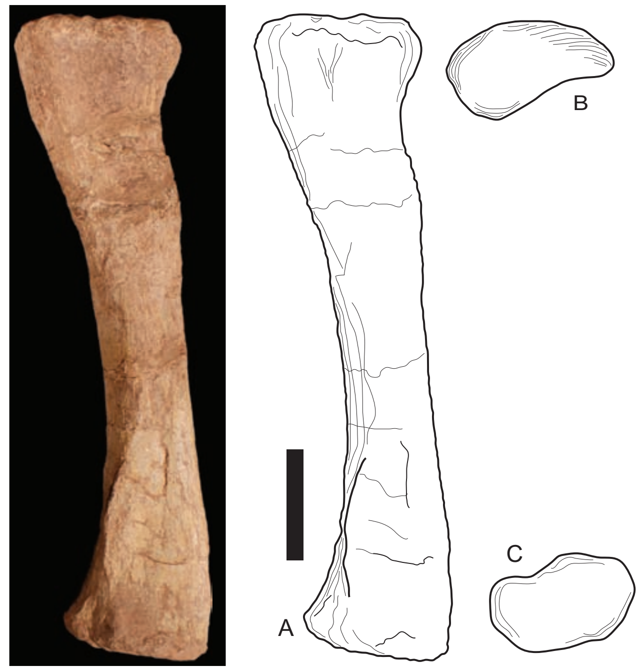

FIGURE 43. Line drawing and photograph of the left radius of *C. anaensis* (LCD9701-I). **A**, anterior; **B**, proximal; and **C**, distal view. Abbreviations are shown in Appendix 1. Bar = 10 cm.

of the femur, while it is at midshaft in *C. anaensis*. Zhao (1993) classified *Klamelisaurus* as Brachiosauridae, though the diagnoses of this clade (ratio of humerus length to femur is 1.0 and prominent deltopectoral crest of humerus) reported by Upchurch et al. (2004a) are absent.

The first described mamenchisaurid dinosaur is *Mamenchisaurus constructus* (Young, 1954). In the original description, no diagnostic characters are mentioned. Compared to the pneumatic cavities of cervical centra of *M. constructus*, those of *C. anaensis* are much developed. As mentioned by Wilson (2002), the distal end of the mid-caudal chevron is divided into anterior and posterior processes by less than 45 degrees angle. The thirteenth chevron of holotype of *C. anaensis* seems similar to this feature (Fig. 26). The proximal end of the tibia is not expanded compared to that of *C. anaensis*, and its distal end contacts with the dorsal margin of the astragalus in *M. constructus*, but with the lateral concavity in *C. anaensis*.

The second species is *M. hochuanensis* (Young and Zhao, 1972). The diagnosis of this species is as follows: deep lateral excavation in dorsal vertebrae, transverse section of caudal centra are circular, posterior process of scapula expanded dorsoventrally, main body of ilium very high, and astragalus lacks excavated area in front of dorsal process (Young and Zhao, 1972). *C. anaensis* lacks these diagnoses. Furthermore, there are more differences between *M. hochuanensis* and *C. anaensis*, For instance, the anterolateral process of ulna is very short as a blunt ridge in *M. hochuanensis*, though that is prominent in *C. anaensis*; the proximal end of radius is rectangular in *M. hochuanensis*, while that is sub-crescentic in the *C. anaensis* holotype; the sulcus of *C. anaensis* between tibial and fibular condyles of femur is deeper than that of *M. hochuanensis*.

Besides the holotype, Ye et al. (2001) reported the second specimen of this species (ZDM0126), which preserved so many parts that are not preserved in the holotype. Compared with that, the anterolateral process of the ulna is quite short in the second specimen (ZDM 0126), though that is as long as its anteromedial process in both individuals of *C. anaensis*. The transverse with of the ulnar proximal end is nearly half length of the ulnar shaft in ZDM0126. The transverse width is much shorter in *C. anaensis*. The posterior margin of the acromion process of the scapula is ascending perpendicular to the long axis of the scapula in *M. hochuanensis*, while that is inclined anteriorly about 70 degree in *C. anaensis*. The posterior surface of the distal end of the femur has a low third crest in *M. hochuanensis*, but the medial crest is much shallower than that of *C. anaensis*. The distalmost caudal vertebrae are fused together and the neural spines constitute a laterally compressed plate. This feature is

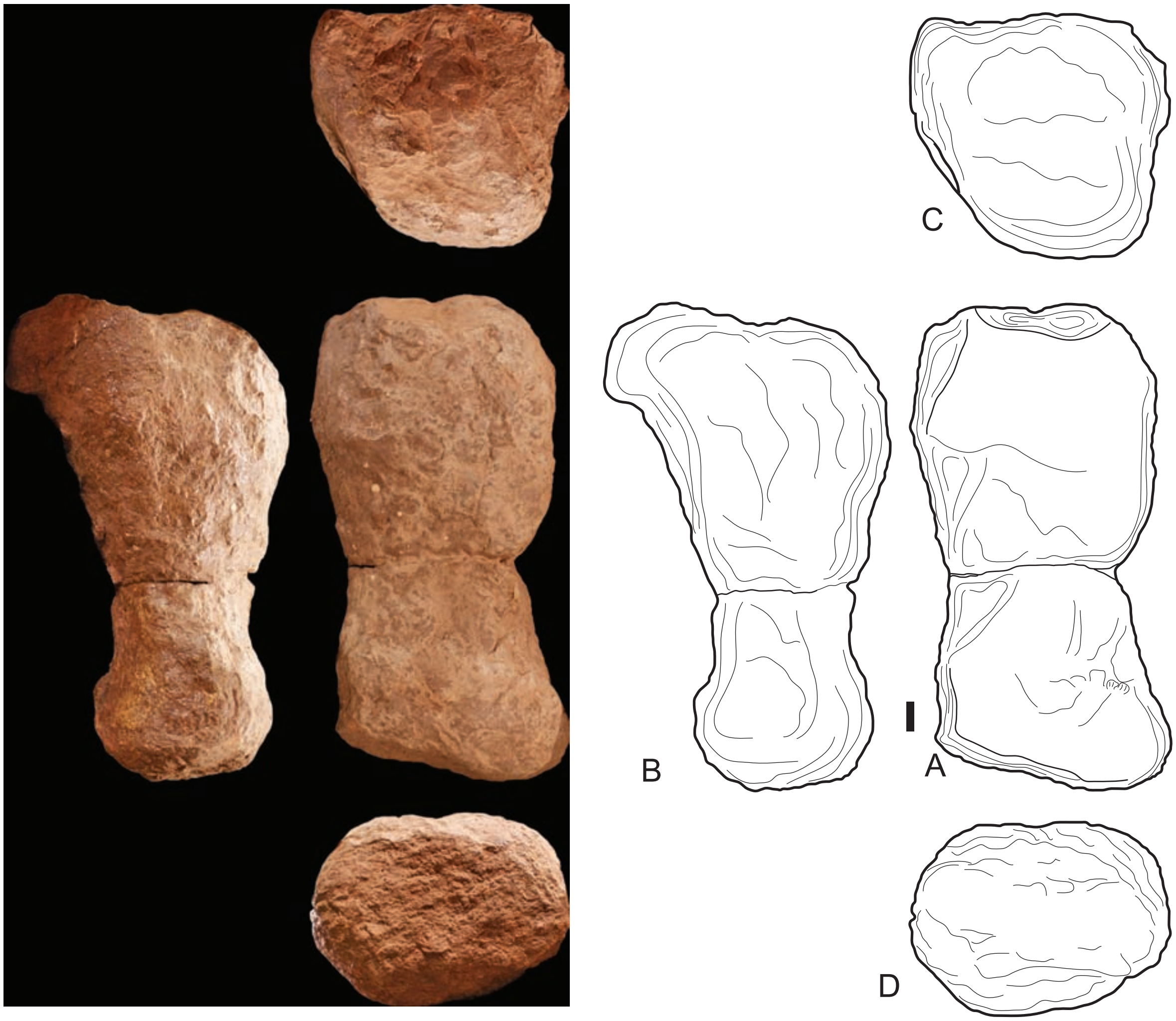

FIGURE 44. Line drawing and photograph of metacarpal I of *C. anaensis* (referred specimen). **A**, dorsal; **B**, medial; **C**, proximal; and **D**, distal view. Bar = 10 cm.

different from the tail club of *Shunosaurus*, and a unique feature of this specimen.

M. sinocanadorum was erected by Russell and Zheng in 1993. The diagnosis is as follows: neural spine is lower than prezygapophysis, and atlantal postzygapophysis develops well (Russell and Zheng, 1993). The third cervical neural spine of *C. anaensis* is expanded more anteriorly than *M. sinocanadorum*. The parapophysis of the third cervical lies lower than the ventral margin of the centrum in *M. sinocanadorum*, while that of *C. anaensis* lies level with the ventral margin. Recently, Buffetaut (2005) reported *Archaeodontosaurus* from its right dentary from the Middle Jurassic of Madagascar. The 'prosauropod-like' features of the teeth mentioned by him (distinct lingual median ridge and probably larger number of denticles) seem similar to those of *M. sinocanadorum*.

Pi et al. (1996) coined *Mamenchisaurus youngi*, and Ouyang and Ye (2002) described its almost complete skull and postcranial elements in detail. Compared to *M. youngi*, pneumatic cavities of cervical centra are developed in *C. anaensis*. The anterior surface of the proximal half of the humerus is almost flat in *C. anaensis*, while that is concave in *M. youngi*. The general body plan of femur of *M. youngi* is more slender than *C. anaensis*, the proximal and distal ends are transversely expanded in the latter. The fourth trochanter of *M. youngi* is positioned at the center of the posterior surface, though that of *C. anaensis* is at the medialmost part of posterior surface. The ilium of *C. anaensis* is more rounded than that of *M. youngi*. The tibia is apparently different in the anterior view. The lateral edge of the tibia of *M. youngi* is concave immediately under the proximal end, while that is convex laterally in *C. anaensis*. Furthermore, the distal end of *M. youngi* directs ventrolaterally, but the expansion directs laterally and is very

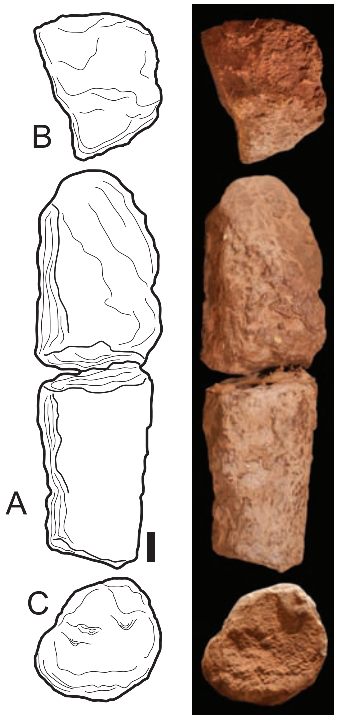

FIGURE 45. Line drawing and photograph of metacarpal II of *C. anaensis* (LCD9701-I). **A**, dorsal; **B**, proximal; and **C**, distal view. Bar = 1 cm.

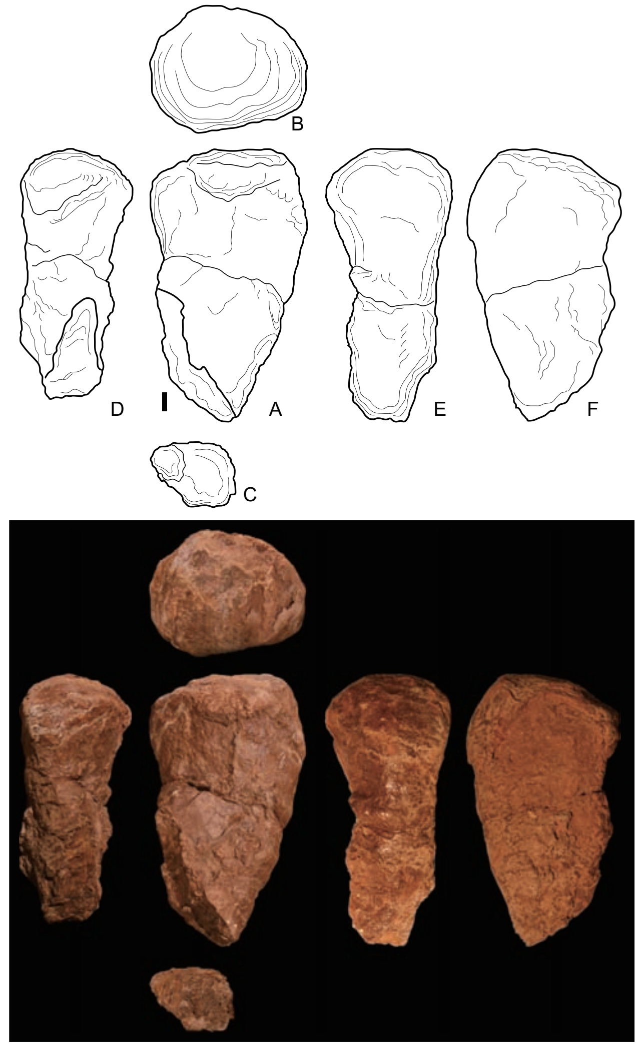

FIGURE 46. Line drawing and photograph of metacarpal III of *C. anaensis* (LCD9701-I). **A**, dorsal; **B**, proximal; **C**, distal; **D**, medial; **E**, lateral; and **F**, ventral view. Bar = 1 cm.

weak in *C. anaensis.*

Lü et al. (2008) coined a new mamenchisaurid, *Eomamenchisaurus yuanmouensis*. *Chuanjiesaurus* does not possess any of the diagnostic features of this taxon as follows: the pleurocoels are present in dorsal centra of *C. anaensis*; the anterior articular surfaces of dorsal vertebrae are strongly convex, and the posterior surfaces are deeply concave in *C. anaensis*; neural spines of the third and fourth sacral vertebrae are weakly fused in *Eomamenchisaurus* (Lü et al., 2008), while whole sacral neural spines are fused tightly in *Chuanjiesaurus*; the postacetabular process of the ilium is extremely reduced or almost absent in *C. anaensis*; although the ratio of ischial and pubic shaft length are unknown, the cross-section of the mid-shaft of the ischium is triangular in *Chuanjiesaurus*; the posteromedial position of femoral fourth trochanter is a common character among Sauropoda; length ratio of tibia to femur (= 0.64) is not uncommon either.

He et al. (1998) named *Gongxianosaurus shibeiensis* from the Early Jurassic of China. Contrary to *C. anaensis*, *G. shibeiensis* possesses much more primitive features as follows: platycoelous to weak amphicoelous presacral centra, absence of distinct lamina system and lateral pneumatic fossa on the dorsal vertebrae, three sacral vertebrae, well developed humeral deltopectoral crest, equivalent developing of ischial and pubic articular processes of the ilium. Wilson (2005) proposed an autapomorphy for *Gongxianosaurus*: absence of coracoid foramen. This feature is not shared with *C. anaensis*.

Compared to *Yuanmousaurus* (Lü et al., 2006), *C. anaensis* has the following differences: the posterior dorsal centra are amphiplatyan in the former, but these are strongly opisthocoelous in the latter; the caudal centra are amphicoelous in the former but procoelous in the latter. The transverse width of the femur is sub-equal in its proximal and distal half in *Yuanmousaurus*. Lü et al. (2006) proposed the length ratio of tibia to femur as 0.72, but the ratio is about 0.64 in *C. anaensis*. The fibular condyle of *Yuanmousaurus* is not divided to the medial and distal crests. The distal one-fourth of the fibula is much more robust than that of *C. anaensis*.

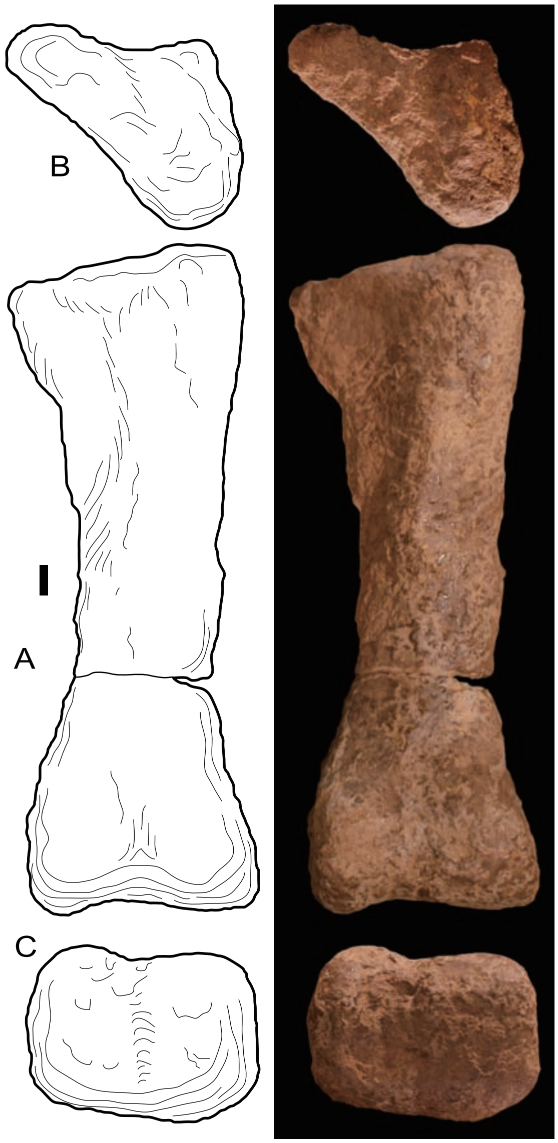

FIGURE 47. Line drawing and photograph of metacarpal IV of *C. anaensis* (referred specimen). **A**, dorsal; **B**, proximal; **C**, distal view. Bar = 1 cm.

PHYLOGENETIC ANALYSIS

Data Matrix

The present analysis tries to resolve the phylogenetic position of *Chuanjiesaurus anaensis* with some Chinese sauropod taxa including *Mamenchisaurus constructus* (Young, 1954), *M. hochuanensis* (Young and Zhao, 1972), *M. youngi* (Ouyang and Ye, 2002), *Yuanmousaurus jiangyiensis* (Lü et al., 2006), *Chinshakiangosaurus* (Upchurch et al., 2007b), *Gongxianosaurus* (He et al., 1998), *Datousaurus* (Dong and Tang, 1984) and *Tienshanosaurus* (Young, 1937). The data matrix and method of analysis are based on Upchurch et al. (2004a) and Wilson (2002).

Additional characters.—In order to reveal the phylogenetic relationship of eusauropod dinosaurs from China, the author added the following autapomorphies of *Mamenchisaurus, Shunosaurus, Omeisaurus and Gongxianosaurus* proposed by Wilson (2002) and *C. anaensis* by the author for the dataset of Upchurch et al. (2004a) and Wilson (2002). Bracketed numbers are additional character number for the data set of Upchurch et al. (2004a) and Wilson (2002). **[U310, W235]** Accessory lamina in the infraprezygodiapophyseal cavity of anterior dorsal vertebrae: absent (0); present and parallel to the prezygodiapophyseal lamina (1) (Wilson, 2005: #147, modified); [U311, W236] 'Forked' chevrons in mid-caudal region with anterior and posterior projections oriented less than 45 degrees to each other: absent (0); present (1). (Wilson, 2005: #148); **[U 312, W237]** Ulna with anterior arm of proximal condyle: less than (0) or nearly one-half (1) the length of shaft. (Wilson, 2005: #149); **[U313, W238]** Tibial condyle of femur expanded: posteriorly (0) or medially (1) (Wilson, 2005: #150); **[U314, W 239]** Proximal half of femoral shaft: sub-equal or narrower (0); broader (1) than distal half. (Wilson, 2005: #151); **[U315, W 240]** Three laminae support the infra-hyposphenal cavity of the dorsal neural arch: absent (0); present (1); **[U316, W241]** Neural spines in posterior dorsal and sacral vertebrae: sticklike (0) or knob-like and fused (1); **[U317, W242]** V-shaped shelf-like hyposphene in posterior dorsal vertebrae: absent (0) or present (1); **[U318, W243]** Anterior ridge on the proximal caudal rib: absent (0); present (1); **[U319, W244]** Metacarpal II: ratio of minimum transverse width to length: larger (0) or less (1) than 0.2 (1); **[U320, W245]** Fibular condyle of the femur: undivided (0) divided to medial and lateral condyle narrower (1); the medial condyle is wider than sulcus between tibial and fibular condyles (2), unordered; **[U321, W246]** Pterygoid: dorsoventrally higher than anteroposterior length (0); anteroposteriorly elongated strap-shaped (1). (Wilson, 2005: # 136, modified); **[U322, W247]** Anterior portion of the axial neural spine: smoothly slopes posterodorsally (0); prominently developed (1). (Wilson, 2005: #137); **[U323, W248]** 'Postparapophyses' on posterior dorsal vertebrae: absent (0); present (1). (Wilson, 2005: #138); **[U324, W249]** Terminal tail club : absent (0); composed of at least three enlarged, co-ossified caudal vertebrae with two dermal spines (1); co-ossified centra and spines without transverse expansion (2), unordered. (Wilson, 2005: #139, modified); **[U325, W250]** Maxillary ascending ramus dorsoventrally expanded distal end: absent (0); present (1). (Wilson, 2005: #145); **[U326, W251]** Distalmost caudal chevrons fused to anterior most portion of ventral centrum: absent (0); present (1). (Wilson, 2005: #146); **[U327, W252]** Coracoid foramen: present (0); absent (1). (Wilson, 2005: #162).

The character scorings of *C. anaensis* and other taxa are shown in appendix 2-1 and 2-2; they are based on character

TABLE 15. Data resources of tailored character codings.

Marasuchus	Bonaparte, 1975; Sereno and Arcucci, 1994
Herrerasaurus	Novas, 1993; Sereno, 1993; Sereno and Novas, 1993
Prosauropoda	Galton, 1985; Galton, 2000; Young, 1941; pers. obs.
Apatosaurus	Berman and McIntosh, 1978; Gilmore, 1936; Upchurch et al., 2004b
Barapasaurus	Bandyopadhyay et al., 2010; Jain et al., 1975; Jain et al., 1979
Bellusaurus	Dong, 1990; pers. obs.
Brachiosaurus	Bonnan and Wedel, 2004; Carpenter and Tidwell, 1998; Riggs, 1903
Camarasaurus	McIntosh et al., 1996a; McIntosh et al., 1996b
Cetiosaurus	Upchurch and Martin, 2002, 2003
Chinshakiangosaurus	Dong, 1992; Upchurch et al., 2007b
Chuanjiesaurus	pers.obs.
Datousaurus	Dong and Tang, 1984; pers. obs.
Dicraeosaurus	Janensch, 1914, 1929a, b, 1935-36
Diplodocus	Hatcher, 1901; Holland, 1906; McIntosh and Berman, 1975; Mook, 1917; Osborn, 1899
Euhelopus	Wilson and Upchurch, 2009; pers. obs.
Gongxianosaurus	He et al., 1998; Luo and Wang, 2000
Jobaria	Sereno et al., 1999
Kotasaurus	Yadagiri, 1988, 2001
Mamenchisaurus constructus	Young, 1954
M . hochuanensis (holotype)	Upchurch et al., 2004a; Young and Zhao, 1972; pers. obs.
M. sinocanadorum	Upchurch et al., 2004a; Russell and Zheng, 1993
M. youngi	Ouyang and Ye, 2002; pers. obs.
M. hochuanensis (ZDM0126)	Ye et al., 2001; pers. obs.
Omeisaurus	He et al., 1988; pers. obs.
Patagosaurus	Bonaparte, 1986
Phuwiangosaurus	Martin et al., 1994; Martin et al., 1999; Suteethorn et al., 2009
Saltasaurus	Powell, 1992
Shunosaurus	Zhang, 1988; pers. obs.
Tienshanosaurus	Young, 1937
Vulcanodon	Cooper, 1984; Raath, 1972
Yuanmousaurus	Lü et al., 2006; pers. obs.

descriptions of Upchurch et al. (2004a) and Wilson (2002), respectively. The data of *M. hochuanensis* is collected by author based on the publication of holotype (Young and Zhao, 1972) and personal observation of the second specimen ZDM0126 (Ye et al., 2001) which are exhibited and stored in the Zigong Dinosaur Museum, Sichuan, China. The data of *Y. jiangyiensis* is also collected by this author on my personal observation of holotype specimen displayed in the exhibition hall of the World Dinosaur Valley, Yunnan Province, China. The publication by Lü et al. (2006) is also referred to the data scoring. The data of *Gongxianosaurus* is based on the original publications (He et al., 1998; Luo and Wang, 2000) and data set by Wilson (2005), Allain and Aquesbi (2008) and Ezcurra (2010). The other data resources are shown in the Table 15. Considerable amount of character scores are modified in data matrix of *Euhelopus* by Wilson and Upchurch (2009). The current analysis adopted these modifications.

In the original data matrix of Upchurch et al. (2004a), character 277 of *Omeisaurus* and *Shunosaurus* are scored as "?"s. In the recent analysis, these gaps are filled based on the personal observation at the Zigong Dinosaur Museum. The character no.277 of *Omeisaurus* is corded as '1' and *Shunosaurus* is '0' based on the comparison of tibial proximal articular surface of them. The data set of *Omeisaurus* for Wilson (2002) is imported from Harris and Dodson (2004: supplement).

Methods

The phylogenetic position of *C. anaensis* was analyzed by heuristic search program of PAUP 4.0b (Swofford, 2002). In the analysis based on Upchurch et al. (2004a), the relationship of the outgroups is constrained reflecting the current opinions on dinosaur phylogeny as follows: (*Marasuchus*, (*Herrerasaurus*, (Prosauropoda, ingroup))). Following Upchurch et al. (2004a), *Andesaurus*, *Argentinosaurus*, *Lapparentosaurus, Nigersaurus*, and "*Pleurocoelus-tex*" were posteriorly removed from the data matrix. Furthermore, *Aragosaurus* is also removed from current analysis, though this was not done in Upchurch et al. (2004a).

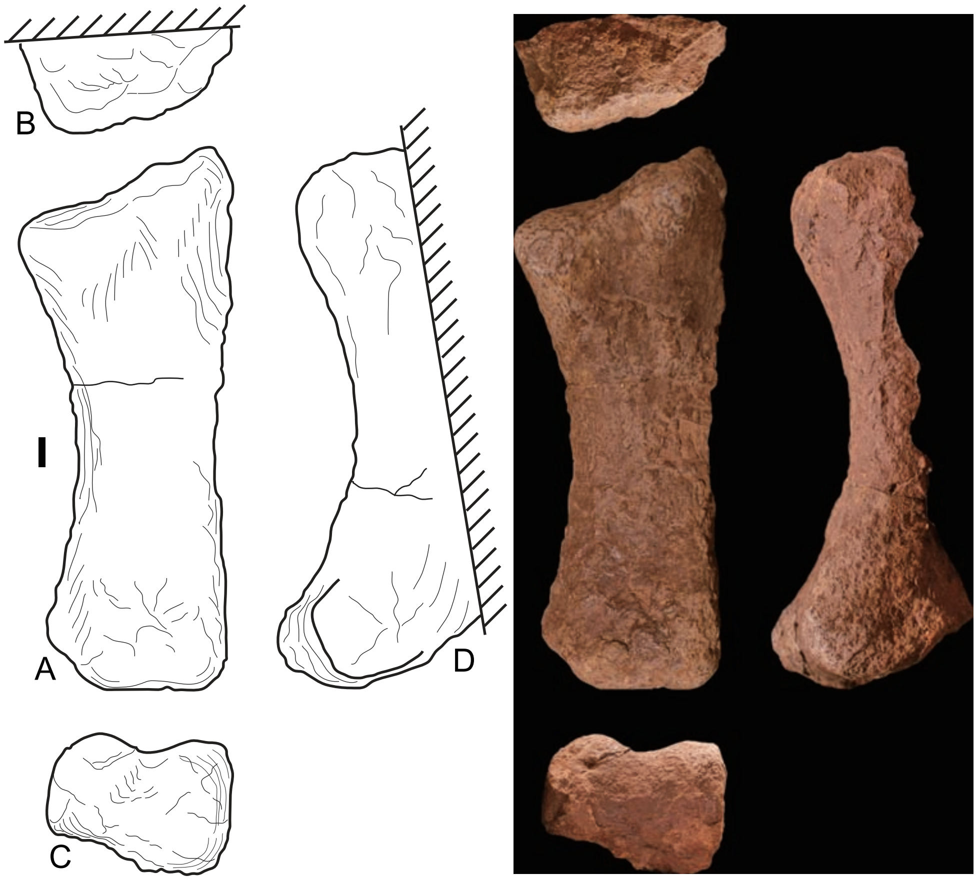

FIGURE 48. Line drawing and photograph of metacarpal V of *C. anaensis* (referred specimen). **A**, dorsal; **B**, proximal; **C**, distal; and **D**, lateral view. Bar = 1 cm.

Finally, in consideration of the purpose of current analysis, derived taxa among Neosauropoda are restricted to a few major taxa (Table 15).

In the analysis based on Wilson (2002), according to the original analysis, some characters (numbered 8, 37, 64, 66, and 198) are set as ordered. Prosauropoda and Theropoda are defined as outgroups. In this analysis also, derived taxa are restricted.

Results and Interpretation

Upchurch et al. (2004a).—Based on the modified data matrix of Upchurch et al. (2004a), the current analysis produced 30 most parsimonious trees of tree length 647, consistency index (CI) =0.504, retention index (RI) = 0.673, rescaled consistency index (RC) = 0.339, homoplasy index (HI) = 0.496. The bootstrap test was held with 2,000 replicates by heuristic search program. The strict consensus tree of them is shown in Figure 55.

In the result of this analysis, *C. anaensis* comprises a mono phyletic group with several Chinese taxa, i.e., *Omeisaurus, M. constructus, M. hochuanensis* (holotype), *M. sinocanadorum, M. youngi, Yuanmousaurus, Tienshanosaurus* and ZDM0126 (*M. hochuanensis*) at a relatively derived part in Eusauropoda.

Synapomorphies of each node are determined by accelerated transformation optimization (ACTRAN) and delayed transform optimization (DELTRAN) of PAUP 4.0 (Swofford, 2002). Some characters are unequivocal between these two strategies, and the synapomorphies (CI = 1.0) are shown in Table 16. In this article, "C#:*" means the character numbers and its states described in the analysis of Upchurch et al. (2004a). See Appendix 3 for the comments on each node.

Wilson (2002).—The analysis based on the modified data matrix of Wilson (2002) generated 21 MPTs with following scores: Tree length = 425; CI = 0.614; RI = 0.703; RC = 0.432; HI = 0.386. The synapomorphies for each node are shown in Table 17. The strict consensus tree is showed in Figure 56.

As similar to the topology shown in Figure 55, *C. anaensis* constitutes a monophyletic group with mamenchisaurid dinosaurs (*M. constructus, M. hochuanensis, M. youngi*), *Tienshanosaurus* and *Yuanmousaurus*. Unfortunately, none of the diagnostic character supports this clade, but some synapomorphies are common to more derived taxa as follows

TABLE 16. Synapomorphies based on two optimization strategies in PAUP (Swofford, 2002), ACCTRAN and DELTRAN. Positions of each node are shown in Fig. 55. Character numbers are based on Upchurch et al. (2004a).

Node no.	Taxon	Synapomorphies (ACCTRAN)	Synapomorphies (DELLTRAN)	bootstrap value	decay index
Node 1	Sauropoda	2:1, 9:1, 16:1, 17:1, 21:1, 23:1, 32:1, 34:1, 35:1, 37:1, 38:1, 58:1, 61:1, 76:1, 79:1, 96:1, 115:1, 133:1, 168:1, 187:1, 214:1, 223:1, 227:1, 234:1, 235:1, 236:1, 238:1, 261:1, 264:1, 267:1, 270:1, 273:1, 275:1, 296:1	9:1, 79:1	78%	8
Node 2		none	2:1, 261:1, 264:1, 270:1, 273:1,	64%	10
Node 3		161:1, 286:1, 289:1, 290:1, 298:1, 299:1	115:1,161:1, 187:1, 214:1, 223:1, 234:1, 236:1, 267:1, 275:1, 286:1, 289:1, 290:1, 298:1		9
Node 4		247:1, 248:1, 252:1, 302:1, 304:1,	133:1, 279:1		7
Node 5	Eusauropoda	237:1, 279:1, 291:1, 280:1, 291:1, 305:1, 307:1	16:1, 17:1, 21:1, 23:1, 32:1, 35:1, 37:1, 38:1, 58:1, 76:1, 96:1, 168:1, 227:1, 235:1, 237:1, 238:1, 247:1, 248:1, 252:1, 280:1, 291:1, 299:1, 302:1, 304:1, 305:1, 307:1	55%	6
Node 6		40:1, 147:1, 169:1, 200:1	none		6
Node 7		none	147:1, 200:1		6
Node 8		156:1, 202:1	156:1		8
Node 9		none	169:1		7
Node 10		none	34:1, 40:1, 61:1, 202:1		7
Node 11		none	none		6
Node 12	Mamenchisauridae	311:1, 324:1	311:1	9.8%	6
Node 13		73:1	none	11%	6
Node 14		none	none	15.3%	7
Node 15	Neosauropoda	20:1, 28:1, 65:1, 164:1, 283:1, 300:1	20:1, 28:1, 65:1,164:1, 283:1, 300:1	32.4%	8
Node 16	Flagellicaudata	3:1, 4:1, 7:1, 11:2, 12:1, 13:1, 14:1, 22:1, 27:1, 41:1, 53:1, 56:1, 59:1, 60:1, 62:1, 63:1, 68:1, 90:1, 95:1, 120:1, 134:1, 170:1, 180:1, 257:1,	7:1, 12:1, 13:1, 14:1, 41:1, 53:1, 63:1, 95:1, 120:1, 134:1, 257:1	100%	16
Node 17	Diplodocidae	42:1, 51:1, 124:1, 125:1	3:1, 4:1, 11:2, 22:1, 27:1, 42:1, 51:1, 56:1, 59:1, 60:1, 62:1, 68:1, 90:1, 124:1, 125:1, 170:1, 180:1,	99%	14
Node 18		74:1, 75:1, 231:1, 253:1, 258:1	none		16
Node 19	Camarasauromorpha	11:1, 31:1, 72:1	11:1, 31:1, 72:1, 74:1, 75:1, 231:1, 253:1, 258:1	56%	13
Node 20	Titanosauriformes	48:1, 160:1, 185:1, 240:1, 265:1	48:1, 160:1, 185:1, 265:1	61%	11
Node 21	Titanosauria	142:1, 163:1, 225:1, 254:1	225:1	57%	9
Node 22		184:1, 196:1, 243:1	142:1, 163:1	60%	8

TABLE 17. Synapomorphies based on DELTRAN optimization strategies in PAUP (Swofford, 2002). Positions of each node are shown in Fig. 56. Character numbers are based on Wilson (2002).

	Taxon	Synapomorphies (DELLTRAN: CI=1.000)	bootstrap value	decay index
node 1	Sauropoda	71:1	79%	6
node 2		8:1, 160:1, 172:1, 196:1, 198:1, 206:1, 222:1	81%	7
node 3		127:1, 149:1, 165:1, 185:1, 211:1, 216:1, 219:1, 225:1,	56%	7
node 4	Eusauropoda	3:1, 7:1, 10:1, 20:1, 28:1, 29:1, 30:1, 33:1, 37:1, 40:1, 41:1, 54:1, 61:1, 65:1, 66:1, 67:1, 70:1, 115:1, 143:1, 174:1, 181:1, 183:1, 186:1, 217:1, 223:1, 226:1, 227:1,	59%	6
node 5		none		6
node 6		18:1, 26:1, 96:1, 99:1, 101:1, 139:1, 207:1		6
node 7	Mamenchisauridae	none	29.5%	6
node 8		235:1	46.5%	6
node 9		236:1		6
node 10		none	43.8%	6
node 11		21:1, 109:1, 228:1		6
node 12		none		6
node 13		none		6
node 14	Neosauropoda	4:1, 12:1, 16:1, 39:1, 60:1, 123:1, 124:1, 176:1, 184:1	56%	8
node 15	Flagellicaudata	5:1, 22:1, 53:1, 65:2, 66:2, 68:2, 70:2, 79:1, 111:1, 137:1, 140:1, 189:1	98%	10
node 16		6:1, 8:2, 13:1, 14:1, 37:2, 129:1, 130:1	99%	11
node 17	Camarasauromorpha	59:1, 62:1, 64:1, 191:1	63%	8
node 18	Titanosauriformes	50:1, 77:1, 141:1, 142:1,	72%	8
node 19		none	81%	8

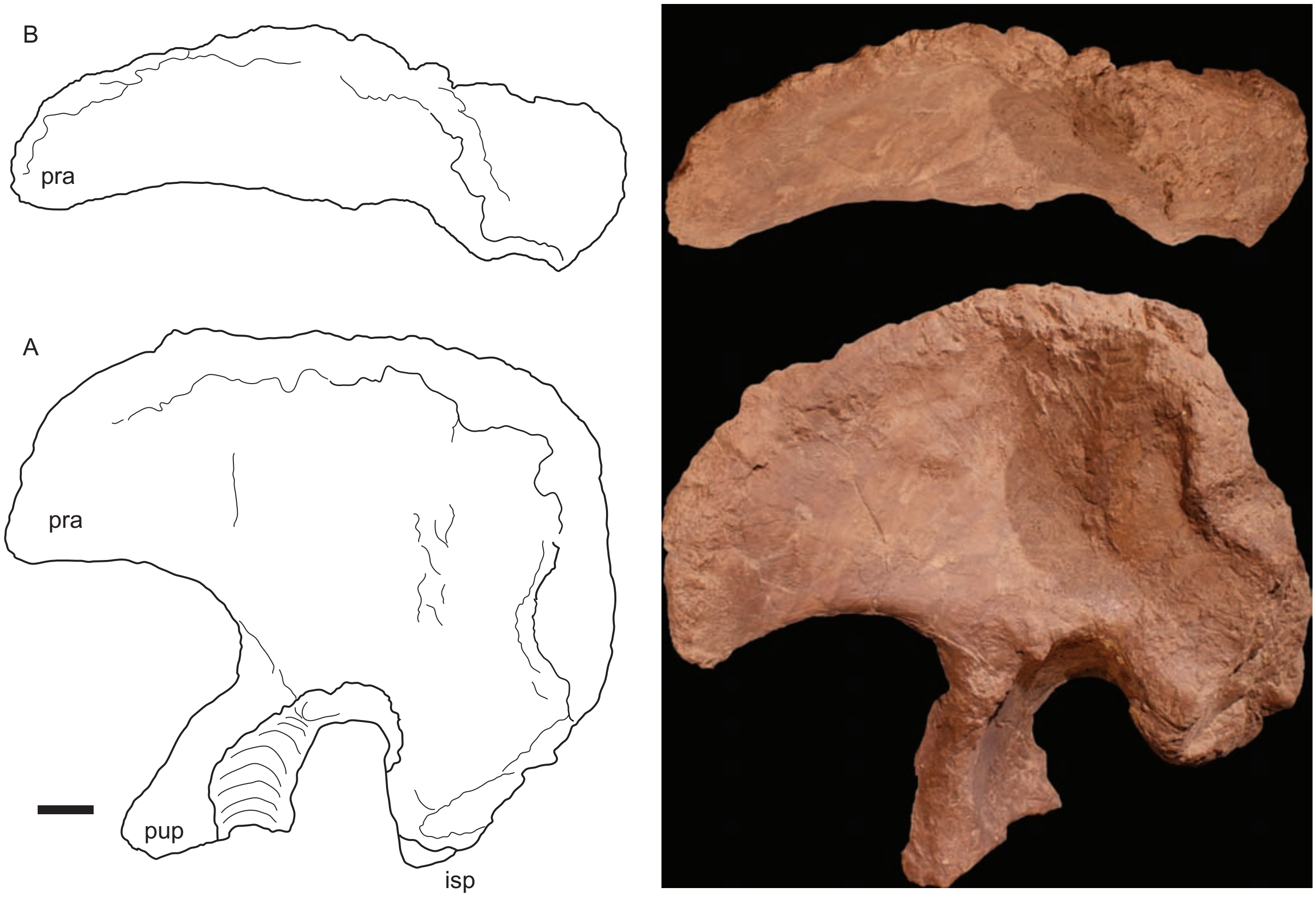

FIGURE 49. Line drawing and photograph of left ilium of *C. anaensis* (LCD9701-I). **A**, left lateral; **B**, dorsal view. Bar = 10 cm. See abbreviations in Appendix 1

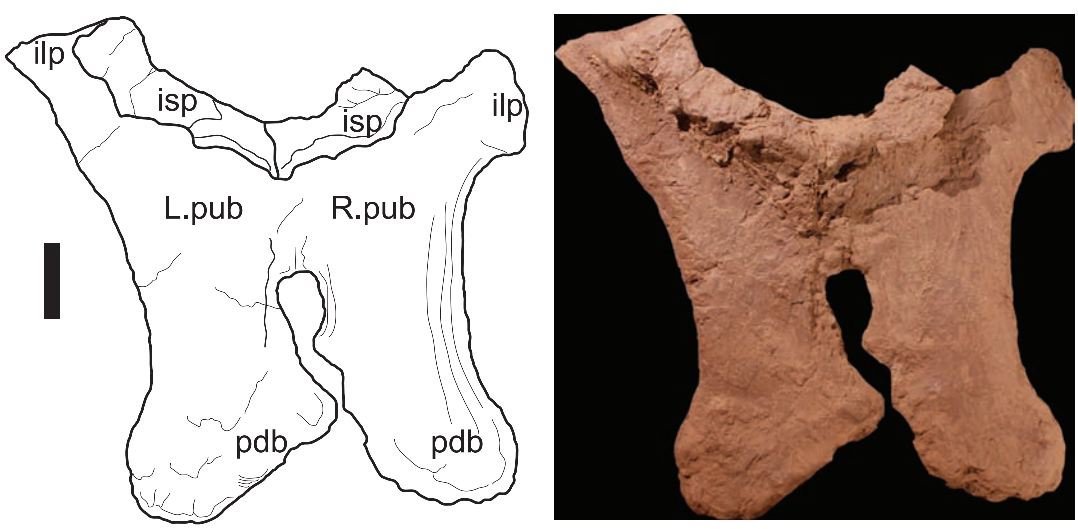

FIGURE 50. Line drawing and photograph of left and right pubes of *C. anaensis* (LCD9701-I) in ventral view. Bar = 10 cm. See abbreviations in Appendix 1.

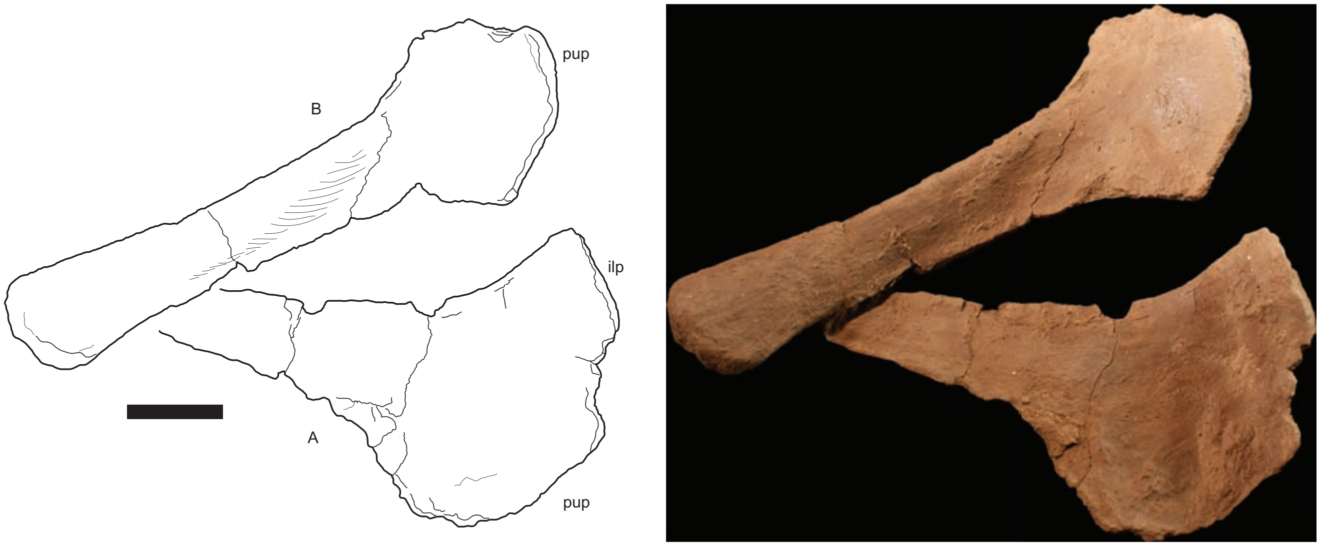

FIGURE 51. Line drawing and photograph of left and right ischia of *C. anaensis* (holotype) *in situ.* **A**, left ischium in medial view; and **B**, right ischium in lateral view. Bar = 10 cm. See abbreviations in Appendix 1.

FIGURE 52. Line drawing and photograph of the right femur of *C. anaensis* (holotype). **A**, posterior; and **B**, distal view. Bar = 10 cm. See abbreviations in Appendix 1.

(parenthetic number means the character number and the coding, and the taxon name): opisthocoelous posterior dorsal centra (105:1, Camarasauromorpha); fan-like proximal caudal rib (128: 1, Flagellicaudata); presence of coracoid infraglenoid lip (157:1, *Saltasaurus*); rectangular distal end of radius (169: 1); expanded tibial distal end (203:1, Neosauropoda); absence of calcaneum (215:1, Diplodocoidea). The last one character is common to the result analyzed with modified dataset of Upchurch et al. (2004a); however, the inter-relationships of mamenchisaurid dinosaurs are quite different from the foregoing result (Fig. 55). A more detailed classification will be held in my future studies.

Here, the relationship with *Omeisaurus* is different in each topology (Figs. 55, 56). In the former result, Mamenchisauridae is a sister taxon of *Omeisaurus*. Whereas, in the latter, Mamenchisauridae is positioned as a sister taxon of a clade composed of *Omeisaurus* and more derived taxa (Fig. 56). If Mamenchisauridae was moved to the sister taxon of *Omeisaurus*, three additional steps are needed.

Furthermore, as in the case with Figure 56, this clade is positioned at a more basal part than *Barapasaurus* and *Patagosaurus*, contrary to the derived position in the previous result (Wilson, 2002).

CONCLUSION

In this research, *Chuanjiesaurus anaensis* Fang et al., 2000 was re-evaluated morphologically and phylogenetically.

As for the holotype and referred specimen, osteological features are re-described in detail and the emended diagnostic characters are proposed, which include three laminae; supporting the infra-hyposphenal cavity of the dorsal neural arch; knob-like

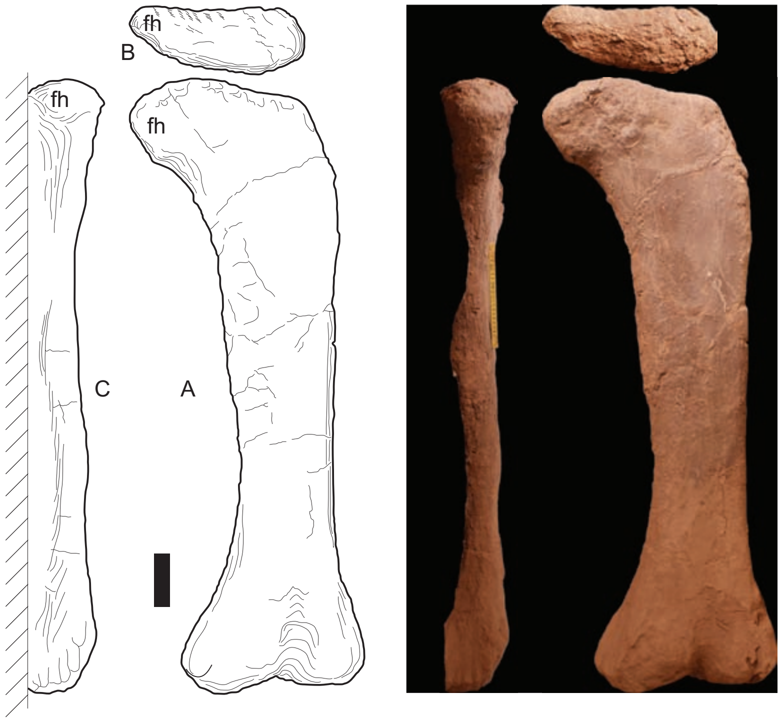

FIGURE 53. Line drawing and photograph of the left femur of *C. anaensis* (LCD9701-I). **A**, anterior; **B**, proximal; and **C**, medial view. Bar = 10 cm. See abbreviations in Appendix 1.

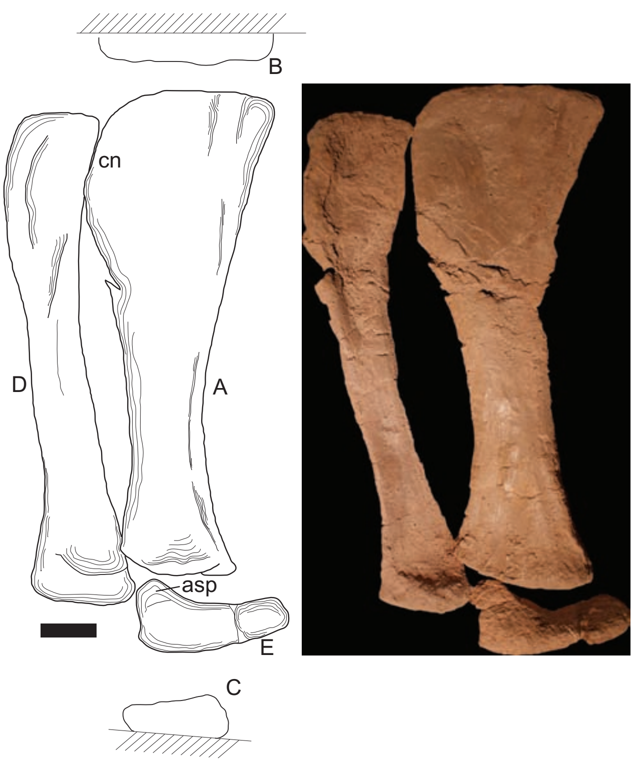

FIGURE 54. Line drawing and photograph of the distal hind limb of *C. anaensis* (holotype) *in situ.* **A**, anterior, **B**, proximal, and **C**, distal view of the tibia; **D**, anteromedial view of the fibula; and **E**, anterior view of the astragalus. Bar = 10 cm. Abbreviations are shown in Appendix 1.

fused neural spines in posterior dorsal and sacral vertebrae; V-shaped shelf-like hyposphene in posterior dorsal vertebrae; anterior ridge on the proximal caudal rib; the extremely slender metacarpal II; fibular condyles of femur divided, with the medial crest wider than the sulcus between tibial condyle.

Phylogenetically, *C. anaensis* constitute a monophyletic clade within Mamenchisauridae with *Tienshanosaurus, Yuanmousaurus* and previously named mamenchisaurid taxa. This clade is positioned at a relatively derived part within Eusauropoda. The character optimization of the present analysis reveals some characteristic features of Mamenchisauridae, which is common to more derived taxa.

ACKNOWLEDGMENTS

This volume is modified from the PhD dissertation of the author. First of all, the author would express profound gratitude to the co-supervisors Prof. DONG Zhiming (RCPS-JU and IVPP) and Prof. SUN Ge (RCPS.JU, EPLENEA, PISNU and PMOL) for their dedicated advices and kind help during the author's study in China from 2005 to 2010. Dr. Yoichi AZUMA (FPDM) also gave the author numerous very useful advices about dinosaur paleontology and evolution; furthermore he invited the author to join several excavation programs in China and Thailand while the author's studying in JLU, China. Mrs.

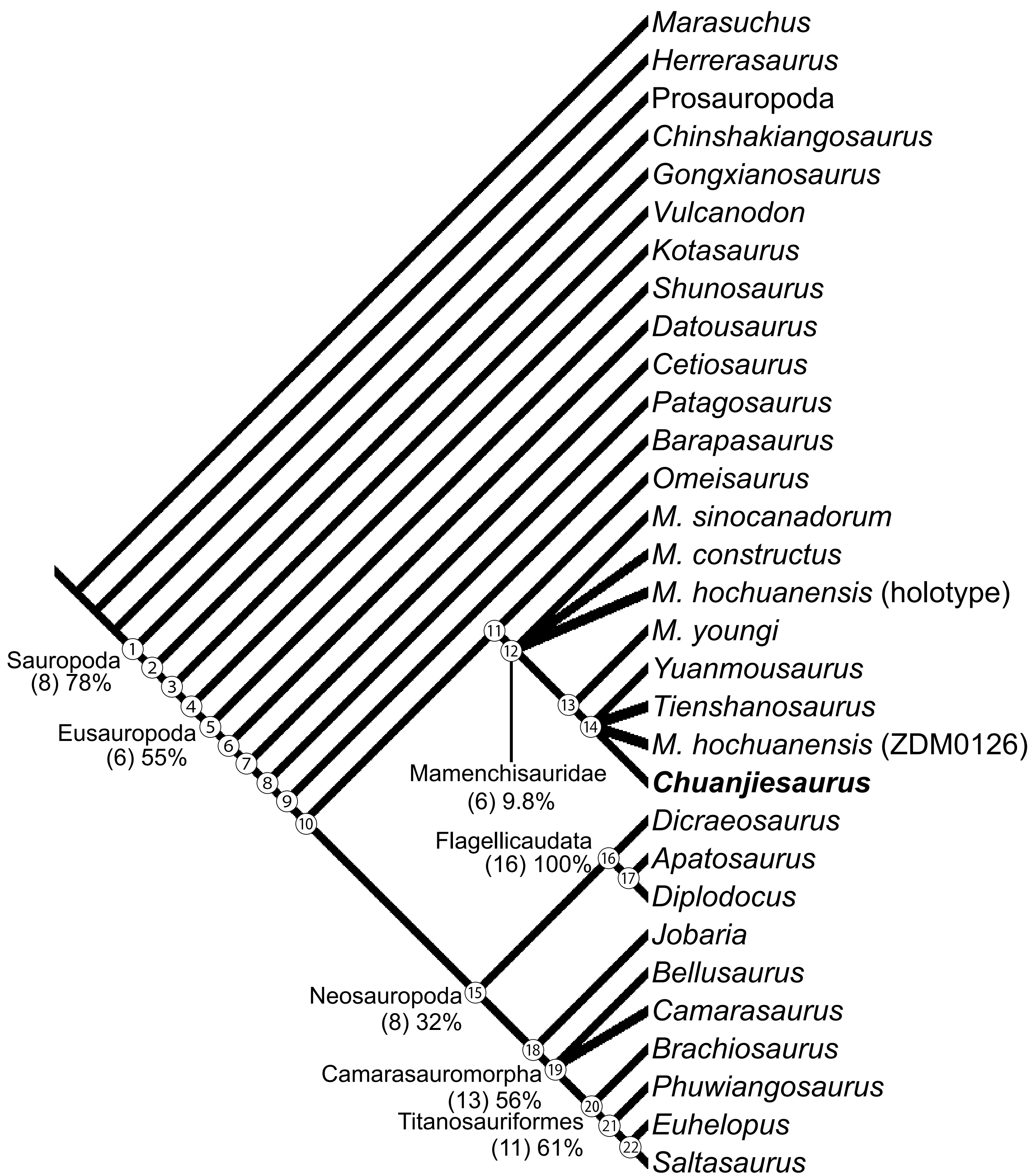

FIGURE 55. The strict consensus tree of 30 MPTs with data matrix modified from Upchurch et al. (2004a). The numbers in circles represent the number of each node. The percentage beside node show the boot strap support values. The decay indexes are shown in parenthesis for major taxa.

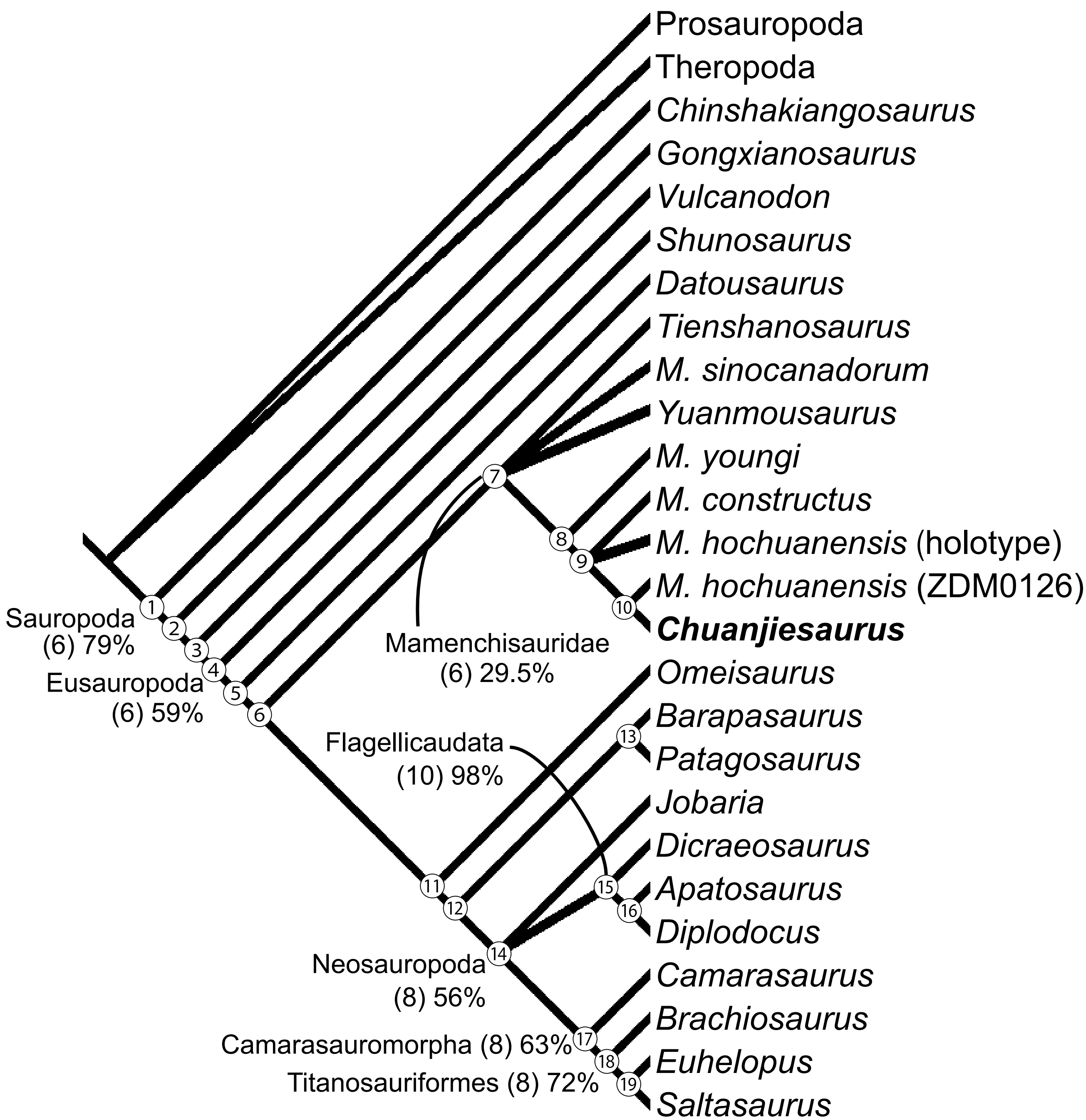

FIGURE 56. The strict consensus tree of 21 MPTs with the data matrix modified from Wilson (2002). The numbers beside node show the percentages of each node. The numbers in circles represent the number of each node. The percentage beside node show the boot strap support values. The decay indexes are shown in parenthesis for major taxa.

ZHOU Yuanming, Mr. PENG Guangzhao, and Mr. YE Yong (ZDM) helped the author in observation and comparison of their excellent mamenchisaurid materials in ZDM, Sichuan. Drs. LÜ Junchang and YOU Hailu (IG-CAGS) helped the author correct the manuscript of this thesis, and gave a lot of useful advices. Mr. PANG Shigang and Mr. WANG Tao (WDV) and other colleagues of Jurassic World Investment Co. Ltd. kindly supported accommodations during my field research in Lufeng. Dr. XU Xing and Ms. ZHENG Fang (IVPP) helped to arrange the precious specimen for comparison and measurement in order to observe material of *Bellusaurus sui*. Mr. Masateru SHIBATA (FPDM) helped the author in various ways during my field research and preparing the materials with his friendship. Drs. WU Wenhao, YANG Tao, LANG Jiabing, Miss DONG Man, and other graduate students of RCPS, Jilin University have helped the author for this graduate school life and several interpretations. Drs. Jeffrey A. Wilson (University of Michigan) and Philip D. Mannion (University College London), kindly reviewed the manuscript and provided numerous useful suggestions. The author wishes to thank Dr. Hiroto. Ichishima (FPDM) for his assistance from the preparation of my first draft to the final editing works. Mr. Syunya YAGI (Arts and Science at Kent State University) kindly helped the author to improve the quality of English manuscript and gave very useful suggestions for scientific writing. Finally, the author would express deepest gratitude to his parents and sisters, who supported the author's five year overseas study in China by understanding as well as financial support.

REFERENCES

Allain, R., and N. Aquesbi. 2008. Anatomy and phylogenetic relationships of *Tazoudasaurus naimi* (Dinosauria, Sauropoda) from the late Early Jurassic of Morocco. Geodiversitas 30: 345−424.

Bandyopadhyay, S., D. D. Gillette, S. Ray. 2010. Osteology of *Barapasaurus tagorei* (Dinosauria: Sauropoda) from the Early Jurassic of India. Palaeontology 53: 533−569.

Barrett, P. M., and P. Upchurch. 1995. Sauropod feeding mechanisms: their bearing on palaeoecology; pp. 107−110 *in* A-L. Sun and Y. Wang (eds.), 6th Symposium on Mesozoic Terrestrial Ecosystems and Biotas Short Papers. China Ocean Press, Beijing.

Berman, D. S., and J. S. McIntosh. 1978. Skull and relationships of the Upper Jurassic Sauropod *Apatosaurus* (Reptilia, Saurischia). Bulletin of Carnegie Museum of Natural History 8: 1−35.

Bien, M. 1940. Preliminary observation on the Cenozoic geology of Yunnan. Bulletin of the Geological Society of China 20: 180−204.

Bien, M. 1941. "Red Beds" of Yunnan. Bulletin of the Geological Society of China 21: 157−198.

Bonaparte, J. F. 1975. Nuevos materiales de *Lagosuchus talampayensis* Romer (Thecodontia−Pseudosuchia) y su significado en el origen de los Saurischia. Acta Geologica Lilloana 13: 5−90. *

Bonaparte, J. F. 1979. Dinosaurs: A Jurassic assemblage from Patagonia. Science 205: 1377−1379.

Bonaparte, J. F. 1986. Les Dinosaures (*Carnosaures*, Allosauridés, Sauropodes, Cétiosauridés) du Jurassique Moyen de Cerro Cóndor (Chu but, Argentine). Annuales de Paléontologie (Vertébrés-Invertébrés) 72: 325−386.

Bonaparte, J. F., and R. A. Coria. 1993. Un nuevo y gigantesco sauropodo titanosaurio de la Formación Río Limay (Albiano −Cenomaniano) de la Provincia del Neuquén, Argentina. Ameghiniana 30: 271−282. *

Bonnan, M. F., and M. J. Wedel. 2004. First occurrence of *Brachiosaurus* (Dinosauria: Sauropoda) from the Upper Jurassic Morrison Formation of Oklahoma. Paleo Bios 24: 13 −21.

Borsuk−Bialynicka, M. 1977. A new Camarasaurid Sauropod *Opisthocoelicaudia sakarynskii* gen. n., sp. n. from the Upper Cretaceous of Mongolia. Palaeontologia Polonica 37: 5−64.

Buffetaut, E. 2005. A new sauropod dinosaur with prosauropod-like teeth from the Middle Jurassic of Madagascar. Bulletin de la Société Géologique de France 176: 467−473.

Buffetaut, E., V. Suteethorn, G. Cuny, H. Tong, J. L. Loeuff, S. Khansubha and S. Jongautchariyakul. 2000. The earliest known sauropod dinosaur. Nature 407: 72−74.

Bureau of Geology and Mineral Resources of Yunnan Province. 1990. Regional Geology of Yunnan Province, People's Republic of China Ministry of Geology and Mineral Resources, series 1, 21: 727 pp.

Carballido, J. L., O. W. M. Rauhut, D. Pol and L. Salgado. 2011. Osteology and phylogenetic relationships of *Tehuelchesaurus benitezii* (Dinosauria, Sauropoda) from the Upper Jurassic of Patagonia. Zoological Journal of the Linnean Society 163: 605−662.

Carpenter, K., and V. Tidwell. 1998. Preliminary description of a *Brachiosaurus* skull from Felch Querry 1, Garden Park, Colorado. Modern Geology 23: 69−84.

Cooper, M. R. 1984. A reassessment of *Vulcanodon karibaensis* Raath (Dinosauria: Saurischia) and the origin of the Sauropoda. Palaeontologia Africana 25: 203−231.

Curry, K. A. 2001. The Evolutionary History of the Titanosauria. Ph. D. dissertation, State University of New York, 552 pp.

Curry Rogers, K. 2005. Titanosauria: A phylogenetic overview; pp. 50−103 *in* K. C. Rogers and J. A. Wilson (eds.), The Sauropods Evolution and Paleobiology. University of California Press, London.

Dong, Z. 1990. On remains of the Sauropods from Kelamaili Region, Junggar Basin, Xinjiang, China. Vertebrata PalAsiatica 28: 43−58. ***

Dong, Z. 1992. Dinosaurian Faunas of China. China Ocean Press, 188 pp.

Dong, Z. and Z. Tang. 1984. Note on a new Mid-Jurassic

Sauropod (*Datousaurus bashanensis* gen. et sp. nov.) from Sichuan Basin, China. Vertebrata PalAsiatica 22: 69–75.

Ezcurra, M. D. 2010. A new early dinosaur (Saurischia: Sauropodomorpha) from the Late Triassic of Argentina: a reassessment of dinosaur origin and phylogeny. Journal of Systematic Palaeontology 8: 371–425.

Fang, X., Q. Long, L. Lü, Z. Zhang, S. Pan, Y. Wang, X. Li and Z. Cheng. 2000. Lower, Middle, and Upper Jurassic subdivision in the Lufeng region, Yunnan Province; pp. 208–214 *in* Proceedings of the Third National Stratigraphical Congress of China. Geological Publishing House, Beijing. **

Galton, P. M. 1985. Cranial anatomy of the prosauropod dinosaur *Plateosaurus* from the Knollenmergel (Middle Keuper, Upper Triassic) of Germany II. All the cranial material and details of soft-part anatomy. Geologica et Palaeontologica 19: 119–159.

Galton, P. M. 2000. The prosauropod dinosaur *Plateosaurus* MEYER, 1837 (Saurischia: Sauropodomorpha). I. The syntypes of *P. engelhardti* MEYER1837 (Upper Triassic, Germany), with notes on other European prosauropods with " distally straight" femora. Neues Jahrbuch fur Geologie und Palaontologie Abhandlungen 216: 233–275.

Galton, P. M., and J. van Heerden. 1985. Partial hindlimb of *Blikanasaurus cromptoni* n. gen. and n. sp., represeting a new family of prosauropod dinosaurs from the Upper Triassic of South Africa. Geobios 18: 509–516.

Gilmore, C. W. 1936. Osteology of *Apatosaurus*, with special reference to specimens in the Carnegie Museum. Memoir of the Carnegie Museum 9: 1–298.

Hatcher, J. B. 1901. *Diplodocus* (Marsh): its osteology, taxonomy, and probable habitatsm, with a restoration of the skeleton. Memoir of the Carnegie Museum 1: 1–63.

Harris, J. D., and P. Dodson. 2004. A new diplodocoid sauropod dinosaur from the Upper Jurassic Morrison Formation of Montana, USA. Acta Palaeontologica Polonica 49: 197–210.

He, X., K. Li and K. Cai. 1988. Sauropod dinosaur (2) *Omeisaurus tianfuensis*. The Middle Jurassic dinosaurian fauna from Dashanpu, Zigong, Sichuan 4, Sichuan Publishing House of Science and Technology, Chengdu, 143 pp. ****

He, X., C. Wang, S. Liu, Z. Fengyun, L. Tuqiang, C. Kaiji and D. Bing. 1998. [A new species of sauropod from the Early Jurassic of Gongxian County, Sichuan]. Acta Geologica Sichuan 18: 1–6. ***

Holland, W. J. 1906. The osteology of *Diplodocus* Marsh. Memoirs of the Carnegie Museum 2: 225–264.

Huene, F. von. 1932. Die fossile Reptil-Ordnung Saurischia, ihre Entwicklung und Geschichte. Monographien zur Geolgie und Palaeontologie series 1: 1–361.

Jain, S. L., T. S. Kutty, T. Roy-Chowdhury and S. Chatterjee. 1975. The sauropod dinosaur from the Lower Jurassic Kota Formation. Proceeding of the Royal Society of London, series A 188: 221–228.

Jain, S. L., T. S. Kutty, T. Roychowdhury and S. Chatterjee. 1979. Some characteristics of *Barapasaurus tagorei*, a sauropod dinosaur from the Lower Jurassic of Deccan, India; pp. 204–216 *in* Laskar, B., and Raja Rao, C. S. (eds.), Fourth International Gondwana Symposium. vol. 1. Hindustan Publishing Corporation, India. 1.

Janensch, W. 1914. Übersicht über die Wirbeltierfauna der Tendaguru-Schichten, nebst einer kurzen Charakterisierung der neu aufgeführten Arten von Sauropoden. Archiv für Biotologie 3: 81–110.

Janensch, W. 1929a. Material und Formengehalt der Sauropoden in der Ausbeute der Tendaguru-Expedition. Palaeontographica (supplement 7) 2: 1–34.

Janensch, W. 1929b. Die Wirbelsaule der Gattung *Dicraeosaurus*. Palaeontographica (supplement 7) 2: 39–133.

Janensch, W. 1935-36. Die schädel der Sauropoden *Brachiosaurus, Barosaurus* und *Dicraeosaurus* aus den Tendaguru-Schichten Deutsch-Ostafrikas. Palaeontographica (supplement 7) 2: 147–297.

Jiang, Z. 1984. [An essay on geological age of saline series of the Anning Basin]. Yunnan Geology 3: 187–196.

Lü, J., S. Li, Q. Ji, G. Wang, J. Zhang and Z. Dong. 2006. New eusauropod dinosaur from Yuanmou of Yunnan Province, China. Acta Geologica Sinica (English Edition) 80: 1–10.

Lü, J., T. Li, S. Zhong, Q. Ji and S. Li. 2008. A new Mamenchisaurid dinosaur from the Middle Jurassic of Yuanmou, Yunnan Province, China. Acta Geologica Sinica (English Edition) 82: 17–26.

Lü, J., L. Xu, X. Zhang, W. Hu, Y. Wu, S. Jia and Q. Ji. 2007. A new gigantic Sauropod dinosaur with the deepest known body cavity from the Cretaceous of Asia. Acta Geologica Sinica (English Edition) 81: 167–176.

Luo, Z., and X. Wu. 1995. Correlation of vertebrate assemblage of the Lower Lufeng Formation, Yunnan, China; pp. 83–88 *in* A. Sun and Y. Wang (eds.), 6th Symposium on Mesozoic Terrestrial Ecosystems and Biotas Short Papers. China Ocean Press, Beijing.

Luo, Y., and C. Wang. 2000. A new sauropod, *Gongxianosaurus*, from the Lower Jurassic of Sichuan, China. Acta Geologica Sinica (English Edition) 74: 132–136.

Mannion, P. D., and J. O. Calvo. 2011. Anatomy of the basal titanosaur (Dinosauria, Sauropoda) *Andesaurus delgadoi* from the mid-Cretaceous (Albian–early Cenomanian) Río Limay Formation, Neuquén Province, Argentina: implications for titanosaur systematics. Zoological Journal of the Linnean Society 163: 155–181.

Mannion, P. D., P. Upchurch, M. T. Carrano and P. M. Barrett. 2011. Testing the effect of the rock record on diversity: a multidisciplinary approach to elucidating the generic richness of sauropodomorph dinosaurs through time. Biological Reviews 86: 157–181.

Marsh, O. C. 1878. Principal characters of American Jurassic dinosaurs. American Journal of Science 16: 411–416.

Marsh, O. C. 1884. Principal characters of American Jurassic dinosaurs, Part VII. On the Diplodocidae, a new family of the Sauropoda. American Journal of Science, series 3 27: 161–167.

Martin, V., E. Buffetaut and V. Suteethorn. 1994. A new genus of sauropod dinosaur from the Sao Khua Formation (Late Jurassic or Early Cretaceous) of northeastern Thailand. Comptes rendus de l'Académie des sciences, series 2, 319: 1085–1092

Martin, V., V. Suteethorn and E. Buffetaut. 1999. Description of the type and referred material of *Phuwiangosaurus sirindhornae* Martin, Buffetaut and Suteethorn, 1994, a sauropod from the Lower Cretaceous of Thailand. Oryctos 2: 39–91.

McIntosh, J. S., and D. S. Berman. 1975. Description of the palate and lower jaw of the sauropod dinosaur *Diplodocus* (Reptilia: Saurischia) with remarks on the nature of the skull of *Apatosaurus*. Journal of Paleontolgy 49: 187–199.

McIntosh, J. S., C. A. Miles, K. C. Cloward and J. R. Parker. 1996a. A new nearly complete skeleton of *Camarasaurus*. Bulletin of Gunma Museum of Natural History 1: 1–87.

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

Mook, C. C. 1917. The fore and hind limbs of *Diplodocus*. Bulletin American Museum of Natural History 37: 355–358.

Novas, F. E. 1993. New information on the systematics and postcranial skeleton of *Herrerasaurus ischigualastensis* (Theropoda: Herrerasauridae) from the Ischigualasto Formation (Upper Triassic) of Argentina. Journal of Vertebrate Paleontology 16: 723–741.

Osborn, H. F. 1899. A skeleton of *Diplodocus*. Memoir of the American Museum Natural History 1: 191–214.

Ouyang, H., and Y. Ye. 2002. The first Mamenchisaurian skeleton with complete skull *Mamenchisaurus youngi*. Sichuan Science Technology Press, Chengdu, 111 pp. ****

Owen, R. 1842. Report on British Fossil Reptiles. Part II. Reports of the British Association for the Advancement of Science 11: 60–204.

Pi, L., H. Ouyang and Y. Ye. 1996. A new species of sauropod from Zigong, Sichuan, *Mamenchisaurus youngi*; pp. 87–91 *in* Department of Spatial Planning and Regional Economy (eds.). Papers on Geoscience Contributed to the 30th International Geological Congress. **

Pol, D., A. Garrido and I. A. Cerda. 2011. A new Sauropodomorph Dinosaur from the Early Jurassic of Patagonia and the origin and evolution of the Sauropod-type sacrum. PLoS one 6: 1–24

Powell, H. P. 1992. Osteologia de *Saltasaurus loricatus* (Sauropoda-Titanosauridae) del Cretacico superior des noroeste Argentino; pp. 165–230 *in* J. L. Sanz and A. D. Buscalioni (eds.), Los Dinosaurios y su Entornoe Biotico. Instituto 'Juan de Veldes', Cuenca. *

Qiu, H., J. R. Wijbrans and X. Li. 2003. 40Ar-39Ar mineralization ages of the Dongchuan-type layered copper deposits, Yunnan, China. Geochimica et Cosmochimica Acta Supplement 67: 306.

Raath, M. A. 1972. Fossil vertebrate studies in Rhodesia: an new dinosaur (Reptilia: Saurischia) from near the Trias–Jurassic boundary. Arnoldia (Rhodesia) 30: 1–37.

Rich, T. H., P. Vickers-Rich, O. Gimenez, R. Cuneo, P. Puerta and R. Vacca. 1999. A new sauropod dinosaur from Chubut Province, Argentina; pp. 61–84 *in* Y. Tomida, T. H. Rich and P. Vickers–Rich (eds.), Proceedings of the Second Gondwanan Dinosaur Symposium, National Science Museum Monographs 15.

Riggs, E. S. 1903. *Brachiosaurus altithorax*, the largest known dinosaur. American Journal of Science s4-15: 299–306.

Riggs, E. S. 1904. Structure and relationships of opisthocoelian dinosaurs. Part II. The Brachiosauridae. Field Columbian Museum Publication Geological Sereies 2: 229–247.

Russell, D. A., and Z. Zheng. 1993. A large mamenchisaurid from the Junggar Basin, Xinjiang, People's Republic of China. Canadian Journal of Earth Sciences 30: 2082–2095.

Salgado, L., R. A. Coria and J. O. Calvo. 1997. Evolution of titanosaurid sauropods. I: Phylogenetic analysis based on the postcranial evidence. Ameghiniana 34: 3–32.

Seeley, H. G. 1887. On the classification of the fossil animals commonly called Dinosauria. Proceedings of the Royal Society of London 43: 165–171.

Sereno, P. C. 1993. The pectral girdle and forelimb of the basal theropod *Herrerasaurus ischigualastensis*. Journal of Vertebrate Paleontology 13: 425–450.

Sereno, P. C., and A. B. Arcucci. 1994. Dinosaurian precursors from the Middle Triassic of Argentina: *Marasuchus lilloensis*, gen. nov. Journal of Vertebrate Paleontology 14: 53–73.

Sereno, P. C., A. L. Beck, D. B. Dutheil, H. C. E. Larsson, G. H. Lyon, B. Moussa, R. W. Sadleir, C. A. Sidor, D. J. Varricchio, G. P. Wilson and J. A. Wilson. 1999. Cretaceous Sauropods from the Sahara and the Uneven Rate of Skeletal Evolution Among Dinosaurs. Science 286: 1342–1347.

Sereno, P. C., and F. E. Novas. 1993. The skull and neck of the basal theropod. Journal of Vertebrate Paleontology 13: 451–476.

Sheng, S., L. Chang, S. Zhi and R. Shou. 1962. The problem of the age and correlation of the Red Beds and the coal series of Yunnan and Szechuan. Acta Geologica Sinica (Chinese Edition) 42: 32–56. ***

Sun, A., J. Li, X. Ye, Z. Dong and L. Hou. 1992. Tha Chinese Fossil Reptiles and Their Kins. Science Press, Beijing, New York, pp. 260.

Suteethorn, S., J. L. Loeuff, E. Buffetaut, V. Suteethorn, C. Talubmook and C. Chonglakmani. 2009. A new skeleton of *Phuwiangosaurus sirindhornae* (Dinosauria, Sauropoda) from NE Thailand; pp. 189–215 *in* E. Buffetaut, G. Cuny, J. L. Loueuff and V. Suteethorn (eds.), Late Palaeozoic and Mesozoic Ecosystems in SE Asia. The Geological Society, London, Special Publications.

Swofford, D. L. 2002. PAUP: Phylogenetic Analysis Using Parsimony, Version 4.0b 10.

Taylor, M. P., and D. Naish. 2005. The phylogenetic taxonomy of Diplodocoidea (Dinosauria: Sauropoda). Paleo Bios 25: 1–7.

Upchurch, P. 1995. The evolutionary history of sauropod dinosaurs. Philosophical Transactions: Biological Sciences 349: 365–390.

Upchurch, P. 1998. The phylogenetic relationships of sauropod dinosaurs. Zoological Journal of the Linnean Society 124: 43–103.

Upchurch, P., and J. Martin. 2002. The Rutland *Cetiosaurus*: the anatomy and relationships of a Middle Jurassic British sauropod dinosaur. Palaeontology 45: 1049–1074.

Upchurch, P., and J. Martin. 2003. The anatomy and taxonomy of *Cetiosaurus* (Saurischia, Sauropoda) from the Middle Jurassic of England. Journal of Vertebrate Paleontology 23: 208–231.

Upchurch, P., P. M. Barrett and P. Dodson. 2004a. Sauropoda; pp. 259–322 *in* D. B. Weishampel, P. Dodson and H. Osmolska (eds.), The Dinosauria (Second Edition). University of California Press, Berkley.

Upchurch, P., Y. Tomida and P. M. Barrett. 2004b. A new specimen of *Apatosaurus ajax* (Sauropoda: Diplodocidae) from the Morrison Formation (Upper Jurassic) of Wyoming, USA. National Science Museum Monographs 26: 1–108.

Upchurch, P., P. M. Barrett and P. M. Galton. 2007a. A phylogenetic analysis of basal sauropodomorph relationships: implications for the origin of sauropod dinosaurs. Special Papers in Palaeontology 77: 57–90.

Upchurch, P., P. M. Barrett, X. Zhao and X. Xu. 2007b. A re-evaluation of *Chinshakiangosaurus chunghoensis* Ye vide Dong 1992 (Dinosauria, Sauropodomorpha): implications for cranial evolution in basal sauropod dinosaurs. Geological Magazine 144: 247–262.

Wang Q., B. Liang, Z. Kan, B. Zhu and X. Ji, 2005. Paleoenvironmental reconstruction of mesozoic dinosaurs fauna in Sichuan Basin, Geological Publishing House, Beijing, 189 pp. ***

Whitlock, J. A. 2011. A phylogenetic analysis of Diplodocoidea (Saurischia: Sauropoda). Zoological Journal of the Linnean Society 161: 872–915.

Wilson, J. A. 2002. Sauropod dinosaur phylogeny: Critique and cladistic analysis. Zool. J. Linn. Soc. London 136: 217–276.

Wilson, J. A. 2005. Integrating ichnofossil and body fossil records to estimate locomotor posture and spatiotemporal distribution of early sauropod dinosaurs: a stratocladistic approach. Paleobiology 31: 400–423.

Wilson, J. A., and P. C. Sereno. 1998. Early Evolution and Higher-Level Phylogeny of Sauropod Dinoaurs. Memoir of Sciety of Vertebrate Paleontology 5: 1–68.

Wilson, J. A., and P. Upchurch. 2003. A revision of *Titanosaurus* Lydekker (Dinosauria–Sauropoda), the first dinosaur genus with a 'Gondwanan' distribution. Journal of Systematic Palaeontology 1: 125–160.

Wilson, J. A., and P. Upchurch. 2009. Redescription and reassessment of the phylogenetic affinities of *Euhelopus zdanskyi* (Dinosauria: Sauropoda) from the Early Cretaceous of China. Journal of Systematic Palaeontology 7: 163–197.

Wu, X., P. J. Currie, Z. Dong, S. Pan and T. Wang. 2009. A new theropod dinosaur from the Middle Jurassic of Lufeng, Yunnan, China. Acta Geologica Sinica (English Edition) 83: 9–24.

Yadagiri, P. 1988. A new sauropod *Kotasaurus yamanpalliensis* from lower Jurassic Kota Formation of India. Records of the Geological Survey of India 11: 102–127.

Yadagiri, P. 2001. The osteology of *Kotasaurus yamanpalliensis*, a sauropod dinosaur from the Early Jurassic Kota Formation of India. Journal of Vertebrate Paleontology 21: 242–252.

Yates, A. M., and J. W. Kiching. 2003. The earliest known sauropod dinosaur and the first steps towards sauropod locomotion. Proceedings of the Royal Society of London Series B 270: 1753–1758.

Ye, Y., H. Ouyang and Q. Fu. 2001. New material of *Mamenchisaurus hochuanensis* from Zigong, Sizhuan. Vertebrata PalAsiatica 39: 266–271. ***

You, H., D. Li, L. Zhou and Q. Ji. 2006. *Huanghetitan liujiaxiaensis*, a new sauropod idnosaur from the Lower Cretaceous Hekou Group of Lanzhou Basin, Gansu Province, China. Geological Review 52: 668–674. ****

Young, C. 1937. A new dinosaurian from Sinkiang. Palaeontologia Sinica 105: 1–23.

Young, C. 1940. Preliminary notes on the Lufeng vertebrate fossils. Bulletin of the Geological Society of China 20: 235–239.

Young, C. 1941. A complete osteology of *Lufengosaurus huenei* Young (gen. et sp. Nov) from Lufeng, Yunnan, China. Palaeontologia Sinica New Series C. 7: 1–53.

Young, C. 1951. The Lufeng Saurischian Fauna in China. Palaeontologia Sinica New Series C 13: 1–96.

Young, C. 1954. [A new sauropod from Yiping, Suchian]. Acta Palaeontologica Sinica 2: 355–369. **

Young, C., and X. Zhao. 1972. *Mamenchisaurus hochuanensis*. Institute of Vertebrate Paleontology and Paleoanthropology monograph Series I 8: 1–30. **

Zhang, Y. 1988. Sauropod dinosaur (I) *Shunosaurus*. The Middle Jurassic dinosaurian fauna from Dashanpu, Zigong, Sichuan 3, Sichuan Publishing House of Science and Technology, Chengdu, 89 pp. ****

Zhang, Z., and X. Li. 1999. A study on the stratigraphic section bearing the new Sauropterygia fauna in Laochangjing, Lufeng. Yunnan Geology 18: 72–78. ***

Zhao, X. 1993. A new Mid–Jurassic Sauropod (*Klamelisaurus gobiensis* gen. et sp. nov.) from Xinjiang, China. Vertebrata PalAsiatica 31: 132–138. ***

* : in Spanish with English abstract
** : in Chinese
*** : in Chinese with English abstract
**** : in Chinese with English summary

Appendix 1. Abbreviations of osteological term

Axial Skeleton

arcr	anterior ridge on caudal rib
ax	axis
axic	axial intercentrum
c3, c4, c5,...	third, fourth, fifth cervical vertebra, etc.
ca1, ca2,...	first, second caudal vertebra, etc.
car	caudal rib
cedi	centrodiapophyseal lamina
ch	chevron
cr	cervical rib
cv	cervical vertebra(e
dl, d2, d3...	first, second, third dorsal vertebra, etc.
di	diapophysis
dr	dorsal rib
ds	dorsosacral vertebra(e)
dsl, ds2	dorsosacral vertebra 1,2
dv	dorsal vertebra(e)
hypo	hyposphene
pa	parapophysis
pcdl	posterior centrodiapophyseal lamina
pf	pneumatic foramen
pl	pleurocoel
podl	postzygodiapophyseal lamina
poz	postzygapophysis or postzygapophyseal facet
prdl	prezygodiapophyseal lamina
prpa	prezygoparapophyseal lamina
prsl	prespinal lamina
prz	prezygapophysis or prezygapophyseal facet
s1, s2…	first, second sacral vertebra, etc.
sc	sacral centrum
sp	neural spine
spdl	spinodiapophyseal lamina
spol	spinopostzygapophyseal lamina
sprl	spinoprezygapophyseal lamina
sy	sacral or sacrocostal yoke
vt	vertebra

Appendicular Skeleton

acr	acromion process
ar	acromial ridge
asp	ascending process of astragalus
cf	coracoid foramen
cn	cnemial crest
dp	deltopectoral crest
f4t	fourth trochanter of femur
ffc	fibular condyle of femur
fg	greater trochanter of femur
fh	femoral head
fmc	medial condyle of femur
gl	glenoid cavity
hh	humeral head
hrc	radial condyle of humerus
ilp	iliac articular process
isp	ischial articular process
pdb	pubic distal blade
pra	preacetabular process
pup	pubic articular process

Appendix 2-1. Upchurch et al. (2004a) The tailored data matrix of *Chuanjiesaurus anaensis* Fang et al., 2000 and the other additional Chinese taxa (see text), based on character descriptions of Upchurch et al. (2004a) and additional characters by author.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Marasuchus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	0	0	0	0	0	1	0
Apatosaurus	2	1	1	1	0	1	1	0	1	?	2	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1
Barapasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Bellusaurus	?	1	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Brachiosaurus	1	1	0	0	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1
Camarasaurus	1	1	0	0	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1
Cetiosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	1	0	?	?	?	?	1	?	1	0	0	?	?	0	1	?	?	?	0	?	0	?	0	?	?	?	?	1	0
Dicraeosaurus	2	1	?	?	?	1	1	0	1	0	?	1	1	1	?	1	1	1	?	1	1	?	?	?	?	?	?	1	1	?
Diplodocus	2	1	1	1	0	1	1	0	1	0	2	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1
Euhelopus	1	1	0	0	?	0	0	1	1	1	1	0	0	0	0	1	1	0	1	1	1	0	?	?	1	0	0	1	1	?
Gongxianosaurus	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Jobaria	1	1	0	0	1	1	0	1	?	1	0	0	0	0	1	1	?	?	1	?	1	0	1	?	1	0	0	?	?	?
Kotasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.sinocanadorum	1	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	0	?	?	?	?	?	?	?	1	1	0	0	?	?	0	?	?	?	1	0	1	?	?	?	?	?	0	0	?	?
M.youngi	1	1	0	{01}	1	?	0	1	1	1	0	0	0	0	0	1	1	1	1	0	?	0	1	1	0	0	0	?	1	1
Omeisaurus	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	1	0	1	0	1	0	1	0	0	0	1	0
Patagosaurus	1	1	0	0	?	0	0	0	1	?	?	0	0	0	1	1	1	?	1	0	1	0	?	?	?	?	?	?	?	?
Phuwiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Shunosaurus	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	1	0
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Appendix 2-1 (continued)

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Marasuchus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0	?	?	?	?	?
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	{01}	0	0	0	{01}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	0	1	1	1	1	0	1	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1
Barapasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Bellusaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	0	?	0	0	0	0	0	?	?	?	?	?	?
Brachiosaurus	1	1	0	1	1	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0
Camarasaurus	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0
Cetiosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Dicraeosaurus	?	?	0	?	1	1	1	1	1	1	1	0	1	0	?	0	1	0	1	1	0	1	1	1	1	?	?	?	?	?
Diplodocus	0	1	1	1	1	0	1	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1	1
Euhelopus	?	?	1	?	1	0	1	1	0	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	1	1	0	?
Gongxianosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Jobaria	0	1	0	1	1	0	1	1	0	1	0	?	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Kotasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0
M.hochuan (ZDM0126)	?	?	?	?	?	?	?	1	0	1	?	?	?	0	?	1	0	0	?	0	?	1	0	?	0	?	?	?	?	?
M.youngi	0	1	1	1	1	0	1	1	0	1	0	?	0	0	0	1	0	?	?	0	?	?	?	?	?	?	0	1	0	0
Omeisaurus	?	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	?	1	1	0	0
Patagosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Phuwiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Saltasaurus	?	?	?	?	1	0	1	1	1	1	?	?	0	?	?	0	1	1	0	1	0	1	0	?	0	?	?	?	?	?
Shunosaurus	0	1	1	?	1	0	1	1	0	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	?	1	1	0	0
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Appendix 2-1 (continued)

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Marasuchus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	?	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Apatosaurus	1	1	1	0	1	0	0	1	?	?	?	?	?	?	?	?	?	1	1	?	?	1	1	0	0	1	1	1	1	1
Barapasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	?	?	?	?	?
Bellusaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	?	1	1	?	0	0	0	?
Brachiosaurus	1	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0
Camarasaurus	1	0	0	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Cetiosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	1	1	1	1	1	0	0	0	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	0	0	1	?	?	?	?	?	?	?	1	?	?	0	0	1	1	1	?	?	?	0
Chuanjiesaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	?	?	?	1	1	0	?	?	?	0	?	1	0	?	?	{01}	1	{01}	1	1	1	?	?	?	0
Dicraeosaurus	1	?	1	1	?	?	?	?	1	1	0	0	?	?	?	?	?	?	1	?	?	1	1	1	0	1	1	1	1	?
Diplodocus	1	1	1	0	1	0	0	1	1	1	0	0	1	0	0	1	1	1	1	0	0	1	1	0	0	0	1	1	1	1
Euhelopus	1	?	?	?	?	1	1	0	1	?	0	?	?	?	?	1	1	1	1	1	1	1	1	1	1	1	0	0	0	?
Gongxianosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	1	1	1	?	0	0	0	?
Jobaria	?	?	?	?	?	?	?	?	0	1	?	0	?	?	?	?	?	0	?	?	?	0	0	1	1	?	0	0	0	?
Kotasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	1	1	1	0	0	0	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.sinocanadorum	1	0	0	0	?	1	1	?	1	0	0	0	1	0	0	1	0	?	1	1	1	0	0	1	1	1	0	0	0	?
M.hochuan (ZDM0126)	?	?	?	?	?	1	1	?	1	1	?	0	?	?	?	?	?	?	1	?	?	0	0	1	1	1	0	0	0	?
M.youngi	?	?	?	1	0	1	1	0	1	1	0	?	0	0	0	1	0	?	1	1	1	0	0	1	1	0	0	0	0	?
Omeisaurus	?	?	?	?	?	0	0	0	1	0	0	?	?	?	0	1	1	0	1	1	1	1	0	1	1	1	0	0	0	0
Patagosaurus	?	?	?	?	?	?	?	?	1	0	0	?	?	?	?	?	?	?	1	?	?	1	1	1	1	1	0	0	0	?
Phuwiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	1	1	0	0	?	1	1	1	?
Shunosaurus	?	?	?	1	0	1	0	0	1	0	0	?	?	?	0	1	0	0	1	1	1	0	0	1	1	1	1	0	0	?
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Appendix 2-1 (continued)

	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Marasuchus	?	?	?	?	?	0	0	0	0	0	0	0	0	0	0	?	0	?	0	0	0	0	0	0	0	0	0	0	0	?
Herrerasaurus	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	?	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	2	2	1	1	1	0	1	1	0	2	1	1
Barapasaurus	?	0	?	?	?	?	?	?	?	?	?	0	1	1	0	0	0	?	0	1	1	1	?	?	1	1	0	0	?	?
Bellusaurus	?	0	?	?	0	?	?	?	?	?	?	?	1	1	1	1	0	?	?	2	1	1	0	0	1	1	0	0	1	0
Brachiosaurus	1	1	0	1	0	1	?	0	0	0	0	0	1	1	1	1	1	0	2	2	1	1	1	0	1	1	0	0	1	0
Camarasaurus	1	0	1	1	0	1	0	0	0	0	0	0	1	1	1	1	0	0	2	2	1	1	0	0	1	1	0	1	1	0
Cetiosaurus	?	0	?	?	?	1	1	0	0	0	?	0	1	1	0	1	0	0	1	1	1	1	0	0	1	1	0	0	1	0
Chinshakiangosaurus	0	0	0	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	?	?	?	?	?	1	1	?	?	?	1	1	1	?	1	1	0	1	0	1	0	0	0	?	1	1	0	0	?	0
Datousaurus	1	0	0	1	0	?	?	?	?	?	?	?	1	0	0	1	0	?	?	?	?	?	?	?	?	?	?	0	?	?
Dicraeosaurus	1	1	?	1	1	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	1	1	1	0	1	1	1	2	1	1
Diplodocus	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	2	2	1	1	1	1	1	1	0	2	1	1
Euhelopus	1	1	1	0	0	1	1	1	1	1	?	1	1	1	1	1	1	1	0	0	1	1	0	0	1	1	0	2	1	0
Gongxianosaurus	1	0	1	?	?	?	?	?	?	?	?	?	0	0	0	?	?	0	?	?	?	?	?	?	?	?	?	0	?	?
Jobaria	0	0	1	1	0	1	0	0	0	0	?	?	1	?	0	?	?	?	?	2	1	1	?	0	1	1	0	0	1	0
Kotasaurus	?	0	?	?	?	?	?	?	?	?	?	0	1	1	0	?	0	0	?	0	1	0	?	0	1	0	0	0	?	?
M.constructus	?	?	?	?	?	1	1	1	1	?	?	?	1	1	1	?	?	?	?	0	0	0	?	?	1	0	0	?	?	0
M.hochuanensis (holotype)	?	?	?	?	?	1	1	1	1	1	?	1	1	1	1	0	0	1	?	0	1	1	0	0	1	0	0	1	1	0
M.sinocanadorum	1	0	1	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	0	0	1	?	?	1	1	?	?	?	?	?	1	1	1	?	?	?	{12}	?	?	?	?	?	1	0	0	1	?	?
M.youngi	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	{12}	0	0	0	1	1	1	0	1	1	0
Omeisaurus	1	0	1	1	0	1	1	1	1	1	0	1	1	1	0	0	0	1	?	2	1	1	0	0	1	1	0	0	1	0
Patagosaurus	?	0	?	?	0	?	?	?	?	?	?	0	1	1	0	0	0	?	1	1	1	1	0	0	1	1	0	0	1	?
Phuwiangosaurus	?	?	?	?	?	?	?	?	?	?	?	0	1	?	1	0	0	0	?	2	1	1	0	0	1	1	0	1	1	?
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	0	1	1	1	1	0	0	?	2	1	1	0	0	1	0	0	0	1	?
Shunosaurus	0	0	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	?	0	1	1	0	0	1	?
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	0	?	?	0	1	?	?	?	?	?	?	?	{01}	0	?
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	1	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	0	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Appendix 2-1 (continued)

	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
Marasuchus	?	1	0	0	0	0	?	0	0	?	0	0	0	0	0	0	0	0	?	?	?	?	0	0	1	0	0	0	0	?
Herrerasaurus	0	0	0	0	0	0	?	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	?	0	?	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	?	0	1	0	0	0	1	1	1	1
Barapasaurus	?	?	?	?	?	0	0	1	0	0	0	1	1	?	?	1	0	0	0	0	2	0	0	1	0	0	1	0	0	1
Bellusaurus	0	?	?	?	?	?	0	1	1	0	1	1	1	?	?	1	?	0	0	?	?	?	?	?	0	0	1	?	0	?
Brachiosaurus	1	1	1	?	0	2	1	1	1	0	1	1	1	0	1	1	1	0	0	0	?	0	1	0	0	0	1	0	1	1
Camarasaurus	1	1	1	0	0	0	1	1	1	0	0	1	1	0	1	1	0	0	0	0	1	0	1	0	0	0	1	0	0	1
Cetiosaurus	1	?	?	0	0	{02}	0	1	0	0	0	1	1	0	0	1	0	1	0	0	2	0	1	1	0	0	1	0	0	0
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	1	?	?	?	?	0	?	1	?	1	0	0	1	0	0	1	0	0	0	1	1	0	1	1	0	1	1	2	0	0
Datousaurus	?	0	0	0	0	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Dicraeosaurus	1	1	1	0	0	0	?	0	0	?	0	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	1	1	1	1
Diplodocus	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	0	1	1	1	1	1
Euhelopus	1	0	0	0	0	0	1	1	0	0	1	1	1	0	0	1	1	1	0	1	?	1	1	0	0	0	1	2	1	0
Gongxianosaurus	?	?	?	?	?	?	0	?	?	?	?	0	?	?	?	?	?	0	?	?	?	?	?	?	?	?	0	?	?	?
Jobaria	1	1	?	0	0	?	?	1	?	?	?	1	1	?	?	?	1	?	?	?	?	0	?	?	0	?	1	?	0	0
Kotasaurus	?	?	?	?	?	0	0	1	0	0	0	1	1	0	0	1	1	1	0	0	?	0	0	?	0	0	0	0	0	0
M.constructus	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	1	1	?	?	0	0	?	0	0	?	0	1	1	?	?	1	?	0	0	0	?	0	?	?	0	0	1	0	0	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	1	1	1	0	0	0	0	1	1	1	0	0	1	?	0	0	1	?	0	?	?	0	?	?	1	?	1	2	0	0
M.youngi	1	1	1	0	0	2	0	1	0	1	0	1	1	0	0	0	1	0	{01}	{01}	1	0	0	1	0	1	1	0	0	0
Omeisaurus	1	1	1	0	0	0	0	1	?	0	0	1	1	?	1	1	1	1	0	0	?	0	0	?	0	0	1	0	0	1
Patagosaurus	?	?	?	?	?	0	0	1	0	0	0	1	1	0	0	1	0	1	0	0	2	0	0	1	0	0	1	0	0	0
Phuwiangosaurus	1	?	?	?	?	1	1	1	?	1	?	1	?	?	?	?	1	1	0	?	?	?	?	?	0	0	1	0	0	?
Saltasaurus	?	?	?	?	?	1	1	1	?	1	1	1	1	0	1	1	1	1	1	1	?	1	1	1	1	?	1	2	1	1
Shunosaurus	0	1	0	0	0	0	?	0	0	?	0	1	1	0	0	0	1	1	0	0	?	0	?	?	0	?	0	0	?	?
Tienshanosaurus	?	?	?	?	?	?	?	1	0	1	?	1	1	?	?	0	0	?	0	?	1	0	?	1	?	?	?	?	0	?
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	{01}	0	1	0	0	0	0	1	?	1	0	0	0	0	?	1	0	0	1	0	1	1	0	0	?

Appendix 2-1 (continued)

	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Marasuchus	0	0	0	0	0	0	0	0	?	?	0	0	0	0	0	?	?	0	0	?	0	0	0	0	0	?	0	1	1	?
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	0	1	0	0	0	1	1	0	0	0	1	1	0	1	1	1	0	1	1	1	0	0	1	0	0	1	1	1	1	1
Barapasaurus	0	0	0	0	0	1	1	0	?	?	1	?	?	0	0	0	0	?	1	?	?	?	0	0	0	?	?	?	?	?
Bellusaurus	?	0	1	0	0	?	?	0	?	?	1	?	?	1	0	0	0	?	?	?	0	1	1	0	0	?	0	0	0	0
Brachiosaurus	0	0	1	1	0	1	0	0	1	1	1	1	0	1	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0
Camarasaurus	0	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Cetiosaurus	0	0	0	0	0	0	0	0	0	0	1	?	?	?	?	0	0	?	?	?	0	0	0	0	0	?	1	0	0	0
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	0	1	1	0	0	1	?	?	{01}	?	1	0	0	?	?	0	0	1	?	?	0	0	1	0	0	?	1	0	0	0
Datousaurus	?	?	?	?	?	?	?	?	?	?	1	0	0	?	?	?	?	?	?	?	0	0	0	0	0	?	?	?	?	?
Dicraeosaurus	0	1	0	0	1	1	1	0	?	0	1	1	0	1	0	1	1	1	1	?	0	0	1	0	0	1	1	0	1	?
Diplodocus	0	1	0	0	0	1	1	0	0	0	1	1	0	1	1	1	0	1	1	1	0	0	1	0	0	1	1	1	1	1
Euhelopus	0	0	1	0	0	1	1	0	1	1	1	1	1	1	?	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?
Gongxianosaurus	0	0	0	?	0	0	0	?	?	?	0	0	0	?	?	?	?	?	?	?	?	?	0	0	0	?	?	?	1	0
Jobaria	0	0	0	0	0	?	1	?	?	?	1	1	0	?	?	0	0	?	?	0	0	?	0	0	0	?	?	0	0	?
Kotasaurus	0	0	0	0	0	0	0	0	?	?	1	0	0	0	0	0	0	?	0	?	?	0	0	0	0	0	1	0	0	0
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	1	?	0	?	1	?	?	?
M.hochuanensis (holotype)	?	0	1	0	0	?	?	?	0	0	1	0	0	?	0	0	0	1	?	0	0	2	1	1	0	?	1	0	0	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	1	1	1	1	1	1	1	0	?	?	1	0	0	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?
M.youngi	0	0	1	1	0	1	0	1	1	?	1	1	0	0	1	0	?	?	1	?	0	2	1	1	0	?	1	?	0	?
Omeisaurus	0	0	0	0	0	1	1	0	?	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Patagosaurus	0	0	0	0	0	1	1	0	?	0	1	1	0	?	0	0	0	?	?	?	?	0	0	0	0	?	1	?	0	?
Phuwiangosaurus	?	0	0	0	0	?	?	?	?	?	1	1	?	?	1	0	0	?	?	?	?	0	0	0	0	0	1	?	0	0
Saltasaurus	0	0	1	0	0	1	?	0	?	?	1	1	1	1	0	0	0	1	1	?	0	1	1	1	1	1	0	?	1	0
Shunosaurus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0
Tienshanosaurus	1	?	0	?	0	1	?	?	?	0	?	?	?	?	?	0	0	1	?	?	?	?	0	0	0	0	0	0	0	0
Vulcanodon	?	?	?	?	?	?	?	?	?	?	1	0	0	?	0	?	?	?	0	?	0	0	0	0	?	?	1	0	?	?
Yuanmousaurus	1	1	1	0	1	1	?	?	?	?	?	?	?	?	0	0	0	1	?	?	?	0	0	0	0	?	1	?	?	?

Appendix 2-1 (continued)

	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210
Marasuchus	0	0	0	0	0	0	?	0	0	0	0	0	0	?	?	?	?	?	?	0	?	?	?	?	?	1	0	1	?	?
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	?	?	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	?	?	0	0	0	1	0	0	0	0
Apatosaurus	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1	?	1
Barapasaurus	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	?	?	?	?	0	?	?	0	?	0	?	?
Bellusaurus	0	0	?	?	?	?	?	0	0	1	0	0	1	?	?	?	?	?	?	1	?	?	?	?	?	1	?	0	?	2
Brachiosaurus	0	0	0	0	1	0	1	0	0	1	0	0	1	1	1	0	0	0	0	1	1	1	0	0	0	1	1	1	0	2
Camarasaurus	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0	1	0	0	1	1	1	0	0	0	1	1	1	0	0
Cetiosaurus	0	0	0	0	0	0	1	0	0	1	0	0	1	?	0	0	0	0	?	1	1	0	0	0	0	1	1	0	0	0
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	0	{01}	1	0	0	0	?	0	1	0	0	0	1	0	0	0	1	1	0	1	1	1	0	0	0	0	1	0	?	?
Datousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	?	?	?	?	?	?	?	?	?	0	?	?
Dicraeosaurus	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	?	?	?	?	?
Diplodocus	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	0	0	1
Euhelopus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	?	1	?	?	1	1	1	?	?
Gongxianosaurus	0	?	?	?	0	?	?	0	0	0	?	1	?	0	0	?	0	0	0	?	0	?	?	?	?	1	0	0	0	0
Jobaria	0	?	?	?	0	?	?	0	0	?	?	?	1	?	0	?	1	0	?	1	1	?	?	?	?	1	0	0	?	?
Kotasaurus	0	0	0	0	0	0	1	0	0	?	0	0	0	0	0	?	?	?	?	0	1	0	?	?	?	1	0	0	?	?
M.constructus	0	?	?	?	?	?	?	0	?	?	1	?	?	0	?	?	1	?	0	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	1	1	?	?	?	0	?	?	?	?	?	?	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	?	?	0	?	0	0	?	0	1	?	?	?	1	{01}	0	0	1	1	1	?	1	1	0	0	0	0	1	?	?	0
M.youngi	0	1	0	0	0	0	1	0	0	1	1	1	1	?	0	0	?	?	?	1	1	1	?	?	?	1	1	?	0	0
Omeisaurus	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	1	1	1	0	?	0	0	0	0	1	0	0	0
Patagosaurus	0	0	0	0	0	0	1	0	0	?	0	0	?	?	0	0	?	?	?	1	1	?	0	?	?	1	1	0	?	?
Phuwiangosaurus	0	0	1	0	1	0	1	0	0	1	0	0	1	1	1	0	?	?	?	1	1	1	?	?	?	1	?	0	?	2
Saltasaurus	0	1	1	1	1	?	1	1	1	1	0	0	?	1	1	1	0	0	0	1	1	1	1	?	?	0	0	1	?	2
Shunosaurus	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0
Tienshanosaurus	0	?	0	?	0	1	?	1	?	?	1	1	?	0	0	?	?	?	?	1	1	1	1	0	0	0	1	?	?	?
Vulcanodon	0	0	0	?	?	?	1	?	0	0	0	0	1	?	0	0	?	?	?	0	?	?	?	?	?	0	?	?	?	?
Yuanmousaurus	0	0	0	0	0	0	1	0	0	0	1	?	?	?	0	0	?	?	?	?	?	1	0	0	0	1	?	?	?	?

Appendix 2-1 (continued)

	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
Marasuchus	?	?	?	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	1	0
Barapasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Bellusaurus	0	?	?	?	?	?	0	0	1	0	0	0	1	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Brachiosaurus	0	0	0	1	1	1	0	1	0	0	0	0	1	0	0	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1
Camarasaurus	0	0	0	1	1	0	0	0	1	0	0	0	1	0	0	1	1	1	0	0	1	0	1	1	1	1	1	1	1	0
Cetiosaurus	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	?	?	?	?	?	?	?	0	1	1	1	?	?	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	?	?	?	?	?	0	0	0	1	0	0	0	1	0	0	0	?	?	?	?	0	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	?	?	?	?	?	1	?	1	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?
Dicraeosaurus	?	?	?	1	0	0	0	0	1	0	0	0	1	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Diplodocus	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Euhelopus	?	?	?	?	?	?	0	1	1	0	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Gongxianosaurus	1	?	?	?	?	0	?	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Jobaria	?	?	?	1	1	0	?	?	?	?	?	?	?	?	0	?	1	0	0	0	?	?	0	1	1	?	1	1	0	0
Kotasaurus	?	?	?	?	?	?	0	0	1	0	0	?	1	1	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	0	0	0	?	?	0	0	0	1	0	0	1	1	?	0	0	?	?	?	?	?	?	?	1	?	?	?	?	?	?
M.youngi	0	0	0	1	1	0	0	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	1	1	1	?	1	?	?	0
Omeisaurus	0	1	0	1	1	0	0	0	1	0	0	0	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0
Patagosaurus	?	?	?	?	?	?	0	0	1	0	?	0	1	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Phuwiangosaurus	1	?	?	1	1	0	0	0	?	?	0	0	1	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Saltasaurus	1	0	?	?	?	?	1	1	1	1	?	1	1	1	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Shunosaurus	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	0	0
Tienshanosaurus	?	?	?	?	?	?	0	0	1	0	1	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Vulcanodon	?	?	?	1	1	0	?	?	1	0	0	?	1	1	0	1	?	?	?	?	?	?	0	1	?	1	0	?	?	?
Yuanmousaurus	?	?	?	?	?	0	0	1	1	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

Appendix 2-1 (continued)

	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270
Marasuchus	?	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	{01}	0	0
Apatosaurus	0	1	0	0	0	1	1	1	1	0	1	1	0	0	0	0	1	0	0	1	1	1	1	1	0	?	1	1	1	1
Barapasaurus	?	0	0	0	0	?	?	1	0	0	?	1	0	?	0	0	0	?	0	?	1	1	1	1	0	1	1	?	0	1
Bellusaurus	?	1	0	0	0	?	1	1	1	0	?	1	1	?	0	0	0	1	0	?	1	1	1	1	0	1	1	1	1	1
Brachiosaurus	0	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Camarasaurus	0	1	0	0	0	1	1	1	1	0	1	1	1	0	0	0	0	1	0	1	1	1	1	1	0	1	1	1	1	1
Cetiosaurus	?	0	0	0	0	1	1	1	1	0	1	1	0	0	0	0	?	0	?	1	1	1	1	1	0	1	1	1	1	1
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	0	?
Chuanjiesaurus	?	1	0	0	0	1	1	1	0	0	?	1	0	?	0	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1
Datousaurus	0	?	?	0	0	?	1	1	0	?	?	?	?	?	?	?	0	?	0	?	?	?	?	1	?	?	?	?	?	?
Dicraeosaurus	?	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	0	0	1	1	1	1	1	0	1	1	1	1	1
Diplodocus	?	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	0	0	1	1	1	1	1	0	1	1	1	1	1
Euhelopus	?	?	?	?	1	?	1	1	1	0	?	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	0	1	1
Gongxianosaurus	?	?	?	0	?	?	0	0	0	?	?	?	?	?	?	?	?	?	?	?	1	1	0	1	0	?	?	1	1	1
Jobaria	0	?	0	0	0	?	1	1	1	0	?	?	?	?	?	0	?	?	0	?	?	?	1	1	?	1	1	?	1	?
Kotasaurus	?	0	0	?	0	?	0	0	0	0	1	0	0	0	0	0	?	?	0	?	1	0	1	1	0	1	1	1	1	1
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	0	0	1	0	1	1	1	0	?	?	?	?	0	0	0	0	0	0	1	?	?	1	1	0	1	1	0	?	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	0	0	0	0	?	1	?	1	0	?	?	?	?	?	?	?	?	?	?	?	1	1	1	1	?	1	1	1	1	1
M.youngi	0	?	?	0	0	?	1	1	0	0	1	1	0	?	0	0	0	0	0	1	1	1	1	1	0	0	1	0	1	1
Omeisaurus	0	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	1	1
Patagosaurus	?	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	?	0	1	1	1	1	1	0	1	1	0	1	1
Phuwiangosaurus	?	1	0	1	1	1	1	1	1	0	0	1	1	?	0	0	0	?	0	1	1	1	1	1	1	0	1	1	1	1
Saltasaurus	?	1	1	1	1	1	1	1	1	0	?	1	1	?	0	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Shunosaurus	0	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	1	1
Tienshanosaurus	?	1	0	0	1	1	1	1	0	?	?	?	?	?	0	1	0	?	0	0	1	1	0	?	?	?	?	?	?	?
Vulcanodon	0	?	?	?	?	?	?	?	?	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	1	0	1
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	0	1	1	1	1	1

Appendix 2-1 (continued)

	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
Marasuchus	?	?	0	0	0	0	?	?	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0
Herrerasaurus	0	0	0	0	0	0	1	0	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Barapasaurus	?	?	?	0	?	1	1	1	1	1	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?
Bellusaurus	1	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Brachiosaurus	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	1	?	?
Camarasaurus	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	1
Cetiosaurus	0	0	1	0	1	0	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	1	1	1	?	1	1	0	?	1	?	?	1	?	1	0	1	?	1	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Dicraeosaurus	?	?	1	1	1	1	1	1	1	1	0	1	?	?	1	1	1	?	?	?	?	1	1	?	?	?	?	?	?	?
Diplodocus	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Euhelopus	1	1	1	0	1	1	0	1	1	1	0	1	?	1	1	1	?	0	1	1	1	1	0	0	1	?	1	?	?	?
Gongxianosaurus	0	?	1	?	?	?	0	1	?	?	?	0	?	0	?	0	1	0	0	0	0	1	0	?	0	1	1	0	0	0
Jobaria	?	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	0	?	?	?	?	?
Kotasaurus	1	0	1	?	1	0	?	0	1	?	?	0	?	0	1	?	1	?	?	?	?	0	0	0	?	?	?	?	?	?
M.constructus	?	1	?	?	?	?	0	1	?	?	?	1	0	0	?	?	?	1	?	1	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	1	?	?	?	?	?	?	0	0	0	0	1	1	?	?	1	1	1	0	0	1	?	?	1	1	0
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	1	1	1	1	1	1	0	1	?	?	0	1	0	1	1	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	1	1	1	?	1	1	0	?	?	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?
Omeisaurus	0	0	1	0	1	?	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0
Patagosaurus	?	0	1	?	1	0	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Phuwiangosaurus	0	0	1	1	1	1	0	?	?	1	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Saltasaurus	1	1	1	?	1	0	?	?	?	1	1	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?
Shunosaurus	?	0	1	?	1	1	0	1	1	1	0	0	0	0	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Vulcanodon	?	?	1	0	1	0	?	?	0	0	?	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	0	1	?	?
Yuanmousaurus	1	1	1	1	1	1	0	1	1	?	0	1	?	1	?	1	0	1	1	?	?	?	?	?	?	?	?	?	?	?

Appendix 2-1 (continued)

	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327
Marasuchus	?	?	?	?	?	?	?	?	?	0	0	0	0	0	?	0	?	0	?	0	?	1	0	?	?	?	0
Herrerasaurus	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	0	0	1	0	0	1	0	?	0	?	0
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	0	0	0	0	0	0	0
Apatosaurus	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	?	0	0	0	0	0	0
Barapasaurus	?	?	?	?	?	1	?	?	0	0	0	0	0	0	0	0	0	?	?	?	?	?	0	?	?	0	0
Bellusaurus	?	?	?	?	?	?	?	?	?	0	?	0	0	0	?	0	?	0	?	0	?	1	0	?	?	?	0
Brachiosaurus	0	1	0	1	1	1	1	1	1	?	?	0	0	1	0	0	0	0	1	0	?	0	0	?	0	?	0
Camarasaurus	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cetiosaurus	?	?	?	?	?	?	?	?	0	0	?	0	0	0	0	?	0	0	?	0	?	?	0	?	?	0	0
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?
Chuanjiesaurus	?	?	?	?	?	?	?	?	1	?	{01}	0	0	1	1	1	1	1	1	1	?	1	0	?	?	?	0
Datousaurus	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	0
Dicraeosaurus	?	1	?	?	?	?	?	?	0	0	0	?	0	1	0	0	0	0	?	0	?	0	0	0	?	?	?
Diplodocus	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Euhelopus	?	1	?	1	?	?	?	1	1	0	?	?	0	0	?	0	?	?	?	0	0	0	0	?	0	?	0
Gongxianosaurus	?	0	0	{01}	0	?	0	0	?	?	0	0	0	1	?	?	?	?	0	?	?	?	?	?	?	0	1
Jobaria	?	?	?	?	?	?	?	?	?	0	0	0	0	0	?	0	?	?	?	0	?	?	0	?	0	0	0
Kotasaurus	?	0	?	0	?	?	?	?	?	0	?	0	0	0	0	0	0	0	?	0	?	?	0	?	?	?	0
M.constructus	?	?	?	1	?	0	?	?	?	?	1	?	?	?	?	0	?	?	?	?	?	?	?	?	?	0	?
M.hochuanensis (holotype)	0	1	?	?	?	?	?	?	?	1	1	?	?	?	0	1	0	0	?	0	?	0	0	?	?	0	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?
M.hochuan (ZDM0126)	?	?	?	?	?	?	?	?	?	?	1	0	0	0	0	1	0	?	?	0	?	?	0	2	1	0	0
M.youngi	0	?	?	1	1	0	?	1	?	1	?	0	0	0	0	0	0	0	1	0	?	?	0	?	0	?	0
Omeisaurus	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Patagosaurus	?	?	?	?	?	?	?	?	0	0	?	0	0	0	?	0	?	?	?	0	?	?	?	0	0	?	0
Phuwiangosaurus	?	?	?	?	?	?	?	?	?	0	?	0	0	0	0	0	0	?	?	0	?	0	0	0	?	0	?
Saltasaurus	?	?	?	?	?	?	?	?	1	0	?	0	0	1	0	?	0	{01}	?	0	?	1	0	?	?	?	0
Shunosaurus	0	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	0	?	?	?	0
Vulcanodon	0	0	0	0	0	0	0	0	?	?	?	0	0	?	?	?	?	0	?	?	?	?	?	?	?	0	0
Yuanmousaurus	?	?	?	?	?	?	?	0	?	0	?	0	1	0	?	0	?	0	?	0	?	?	0	?	?	?	?

Appendix 2-2. Wilson (2002) The tailored data matrix of *Chuanjiesaurus anaensis* Fang et al., 2000 and the other additional Chinese taxa (see text), based on character descriptions of Wilson (2002) and additional characters by author.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Theropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?
Barapasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Omeisaurus	1	1	1	0	0	0	1	1	0	1	1	0	0	0	0	?	0	1	0	1	1	0	0	0	0	1	0	1	1	1
Shunosaurus	0	1	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	1	?	?	0	0	0	0	0	1	1	1
Patagosaurus	1	?	1	0	0	?	1	1	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	1	1	?	0	?	?	1	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	1	?	?	1	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	1	1	?	0	?	?	?	1	1	?	1	0	0	?	1	?	?	1	0	1	?	?	0	?	?	1	0	?	1	1
Chuanjiesaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	0	1	?	0	?	?	?	1	?	?	1	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1
Gongxianosaurus	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Apatosaurus	0	0	1	1	1	1	1	2	0	1	1	?	1	1	1	?	0	1	0	1	1	1	?	1	0	1	0	1	1	1
Brachiosaurus	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	1	1	1
Camarasaurus	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1	1
Dicraeosaurus	0	0	?	1	1	?	?	?	?	?	0	?	?	0	0	?	0	1	1	1	1	1	1	1	0	1	1	1	1	1
Diplodocus	0	0	1	1	1	1	1	2	0	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	0	1	0	1	1	1
Euhelopus	0	1	1	1	0	?	1	1	?	?	1	?	?	?	?	1	0	?	?	?	?	?	?	?	0	?	?	?	?	?
Jobaria	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	1	1	1
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	0	0	?	?	1	0	1	?	0	0	1	0	1	?	?	?	?

Appendix 2-2 (continued)

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Prosauropoda	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Theropoda	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Barapasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Omeisaurus	?	1	1	?	0	?	1	?	?	1	1	1	0	0	?	0	?	0	?	0	?	0	0	1	1	0	0	0	0	?
Shunosaurus	0	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	?	0	0	0	1	1	0	0	0	0	?
Patagosaurus	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	?	?	1	1	?	?	?	?	?	?	?	?	?	?	?	1	?	0	?	?	0	?	0	?	1	1	?	?	?	?
M.sinocanadorum	?	?	1	1	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	0	0	0	?
M.youngi	0	1	1	1	?	2	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	1	1	0	0	0	?
Chuanjiesaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	0	1	?	?	?
Datousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	0	1	0	?
Gongxianosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Apatosaurus	1	1	1	0	0	0	2	0	?	1	?	0	0	0	0	1	0	0	0	0	0	0	1	1	?	?	?	?	?	?
Brachiosaurus	1	1	1	1	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	1	1	1
Camarasaurus	0	0	1	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	1	1
Dicraeosaurus	?	?	?	?	?	1	?	0	?	?	1	0	0	0	1	1	1	0	1	0	1	0	1	1	1	1	0	?	?	?
Diplodocus	1	1	1	0	0	0	2	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0	1	1	1	1	0	1	0	1
Euhelopus	?	?	1	1	?	?	?	0	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	0	1	?	?
Jobaria	0	1	1	1	0	?	1	0	?	1	1	?	0	0	0	?	?	0	0	0	?	0	0	1	0	0	0	?	?	?
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	?	0	1	0	0	0	1	0	1	?	?	?	1	?	?	?	?	?	?

Appendix 2-2 (continued)

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Prosauropoda	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	1	1	0	9	0	0	0	0	0	0	9
Theropoda	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	9	0	0	0	0	0	0	9
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	9	?	?	?	?	?	?	?
Barapasaurus	?	?	?	?	?	?	?	?	?	1	?	0	?	?	?	?	0	0	?	?	0	1	9	?	?	0	1	0	0	9
Omeisaurus	1	?	?	?	1	1	1	0	1	1	1	1	1	?	0	0	0	1	0	4	0	1	1	1	0	1	0	?	0	–
Shunosaurus	1	0	1	?	1	1	1	0	1	1	1	2	0	?	0	0	0	0	0	3	1	1	9	1	0	0	1	0	0	9
Patagosaurus	?	?	?	?	1	?	1	0	1	1	1	?	?	?	0	0	0	1	?	?	0	1	1	?	0	0	1	0	0	9
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	4	1	1	0	?	?	?	0	?	?	?
M.hochuanensis (holotype)	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	4	1	1	0	1	?	1	1	0	1	0
M.hochuan (ZDM0126)	?	?	?	?	{01}	?	?	?	?	?	1	0	0	?	1	?	?	1	?	{34}	1	1	?	?	?	?	?	?	?	?
M.sinocanadorum	?	0	1	?	1	1	?	?	1	?	1	0	1	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	?	0	0	?	1	1	?	?	1	?	1	0	0	?	1	?	?	1	?	4	0	1	1	0	?	1	0	0	1	0
Chuanjiesaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	{234}	0	1	1	1	0	1	0	0	?	?
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	1	0	0	0	0	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	1	?	?	?	?	?	2	1	0	0	?	?	1	?	?	?	1	?	?	?	?	?	?	0	0
Gongxianosaurus	?	?	?	?	?	?	?	?	?	?	1	2	1	?	1	?	?	1	?	?	?	0	?	0	?	?	?	?	0	0
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	0	1	1	?	?	0	0	?	1	0
Yuanmousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	0	?	?	?	?	?	?	?	?
Apatosaurus	?	?	?	?	2	2	1	2	0	2	1	2	1	?	?	?	0	1	1	4	0	1	1	0	1	0	1	1	1	1
Brachiosaurus	1	1	1	2	1	1	1	0	0	1	1	2	1	0	0	0	1	1	0	3	0	1	1	0	0	1	1	0	0	9
Camarasaurus	1	1	1	1	1	1	1	0	1	1	1	2	1	0	0	0	0	1	0	2	0	1	1	0	1	0	1	0	1	0
Dicraeosaurus	?	?	?	?	2	2	1	2	0	2	1	2	1	?	0	0	0	1	1	2	0	1	1	0	1	0	1	0	1	1
Diplodocus	1	0	1	?	2	2	1	2	0	2	1	2	1	1	1	0	0	1	1	4	0	1	1	0	1	1	1	1	1	1
Euhelopus	?	?	?	?	1	1	1	0	1	1	1	2	1	?	1	0	1	1	?	4	0	1	1	1	0	1	1	0	1	1
Jobaria	?	?	?	?	1	1	1	0	1	1	1	0	0	0	0	0	0	1	?	3	0	1	1	0	0	0	1	0	0	9
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	?	?	0	1	1	0	0	0	1	1	0	9

Appendix 2-2 (continued)

	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Prosauropoda	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
Theropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0
Vulcanodon	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	0	?	?	0	?	0	0	?
Barapasaurus	?	1	0	1	0	1	1	0	1	1	1	0	1	0	0	0	0	1	1	0	0	?	0	?	?	0	?	0	0	?
Omeisaurus	3	1	0	1	?	1	1	0	1	1	1	0	0	0	0	0	0	2	1	1	0	1	?	0	1	0	0	1	0	0
Shunosaurus	2	1	0	0	0	0	?	0	0	0	0	0	0	0	0	?	0	1	0	9	0	0	0	0	1	0	0	0	0	0
Patagosaurus	?	1	0	1	0	1	1	0	1	?	?	0	1	0	0	0	0	2	?	?	0	?	?	?	?	?	?	0	0	?
M.constructus	?	?	?	1	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	1	?	1	0	?
M.hochuanensis (holotype)	3	0	1	1	?	1	?	?	?	?	1	1	?	0	1	0	0	1	?	?	?	1	?	0	1	1	?	1	0	0
M.hochuan (ZDM0126)	3	1	0	1	?	1	?	1	1	0	1	1	?	0	1	1	1	1	?	?	?	?	?	?	1	?	?	?	?	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	3	0	1	1	?	1	?	1	1	0	1	1	1	0	1	0	0	2	?	?	?	?	?	?	1	1	?	1	0	?
Chuanjiesaurus	?	1	?	?	1	1	1	0	1	0	1	1	0	0	1	0	0	1	?	?	?	1	?	?	1	1	?	1	0	0
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	{012}	?	?	0	?	?	?	?	?	?	?	?	?	?	0	?	?	1	?	?	?	?	?	?	?	0	?	0	?	?
Gongxianosaurus	?	0	0	0	?	?	?	?	0	?	0	0	?	?	0	?	0	0	?	?	?	?	?	?	?	?	?	0	0	?
Tienshanosaurus	?	?	1	?	?	1	1	0	1	?	?	0	1	?	?	?	0	?	?	?	?	1	?	?	1	?	?	0	0	0
Yuanmousaurus	?	0	?	0	?	1	1	1	1	?	1	1	0	0	1	0	0	?	0	?	?	0	?	?	?	?	0	0	0	?
Apatosaurus	5	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	2	1	?	1	1	0	0	1	1	0	0	0	0
Brachiosaurus	3	1	0	1	0	1	1	1	1	1	1	1	0	0	1	0	0	2	1	1	0	1	0	?	1	0	0	0	0	0
Camarasaurus	3	1	0	1	0	1	1	0	1	1	1	1	0	0	1	0	0	2	1	1	0	1	0	0	1	0	0	0	0	0
Dicraeosaurus	3	1	1	1	1	1	0	0	1	1	1	0	0	0	0	0	1	2	1	?	1	?	0	?	1	1	0	0	0	0
Diplodocus	5	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	2	1	1	1	1	0	0	1	1	0	1	1	1
Euhelopus	2	1	0	1	0	1	1	1	1	0	1	1	0	0	1	?	0	3	?	?	0	1	?	?	?	?	?	?	?	?
Jobaria	3	1	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0	2	1	1	0	1	0	0	1	0	0	0	0	0
Saltasaurus	?	1	0	1	0	1	?	1	1	0	1	1	0	1	1	1	0	3	1	2	0	1	1	?	?	?	?	1	0	?

Appendix 2-2 (continued)

	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	0	0	0	0	0	9	0	0	0	0	0	0
Theropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	0	0	0	0	0	9	0	0	0	0	0	1
Vulcanodon	?	?	?	?	?	?	1	0	0	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	0	0	?	?	1	0
Barapasaurus	?	?	?	?	?	?	1	0	0	0	0	0	0	0	0	0	9	9	?	?	?	0	1	?	0	0	?	0	1	1
Omeisaurus	0	0	0	0	0	0	1	0	0	0	0	?	0	0	0	?	?	?	1	0	0	?	1	1	0	0	0	0	1	1
Shunosaurus	0	0	0	0	0	0	1	0	0	0	0	?	0	0	0	9	9	9	0	?	0	0	1	1	1	0	1	0	1	0
Patagosaurus	?	?	?	?	?	?	1	?	?	?	0	?	0	0	0	?	?	?	1	?	0	0	?	?	0	0	?	?	1	1
M.constructus	?	0	?	?	?	?	?	1	?	?	?	?	?	0	?	?	?	?	1	0	?	?	1	?	0	?	?	0	1	?
M.hochuanensis (holotype)	1	1	?	0	1	0	?	1	?	?	0	0	?	0	?	?	?	?	1	0	0	?	1	1	0	0	?	1	1	?
M.hochuan (ZDM0126)	1	0	0	0	0	1	?	?	?	?	?	0	?	1	?	?	?	?	1	?	?	?	1	1	1	0	?	1	1	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	0	0	0	0	0	0	?	1	?	?	0	1	?	0	?	?	?	?	1	0	?	?	?	?	0	0	?	?	1	1
Chuanjiesaurus	1	0	0	0	?	1	1	1	0	0	0	0	0	0	0	?	?	?	1	?	?	?	1	1	0	0	?	0	1	1
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	0	0	0	0	0	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	1	1	?	?	?	?	1	?
Gongxianosaurus	0	0	0	0	0	0	?	0	?	?	?	?	?	0	?	?	0	?	?	?	?	?	0	0	0	?	?	0	?	?
Tienshanosaurus	1	0	?	?	?	?	?	1	0	?	?	0	?	0	?	0	0	?	?	?	0	?	?	?	0	?	?	?	?	1
Yuanmousaurus	0	0	0	0	1	0	1	1	0	?	0	{01}	0	1	?	?	?	?	?	?	?	?	?	?	0	0	?	?	1	?
Apatosaurus	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1	1	0	0	1	0	1	1
Brachiosaurus	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	?	?	?	1	0	1	1	?	?	1	0	?	?	1	1
Camarasaurus	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	9	9	1	0	0	?	1	0	1	0	1	0	1	1
Dicraeosaurus	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	1	1	?	1	1	0	0	1	?	0	0	?	?	1	1
Diplodocus	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	1	1	0	0	1	0	1	1
Euhelopus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	1	1	?	?	?	?	?	?	1	1
Jobaria	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	?	?	?	1	0	0	0	1	?	0	0	1	0	1	1
Saltasaurus	0	0	1	1	1	1	1	0	0	0	0	1	0	1	1	1	0	?	1	?	?	?	?	?	1	1	?	0	1	1

Appendix 2-2 (continued)

	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Theropoda	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vulcanodon	?	?	?	?	?	?	?	?	?	1	0	1	0	?	1	1	1	0	1	0	0	1	?	?	?	?	0	?	?	?
Barapasaurus	0	0	0	0	0	0	0	?	0	1	0	1	0	1	1	1	1	0	1	0	0	?	?	?	?	?	?	?	?	?
Omeisaurus	0	0	0	?	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0
Shunosaurus	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	1
Patagosaurus	0	?	0	?	0	0	0	?	0	1	0	1	1	1	1	1	1	0	1	0	0	?	?	?	?	?	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuanensis (holotype)	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.hochuan (ZDM0126)	?	0	0	?	?	?	?	0	0	1	?	?	1	?	1	?	1	?	0	?	?	1	?	?	?	?	?	?	?	?
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	?	1	?	?	?	0	1	0	1	1	?	?	0	?	1	?	1	?	0	?	?	1	1	1	1	?	1	0	?	?
Chuanjiesaurus	0	0	0	1	{01}	0	1	?	0	1	0	1	0	0	1	0	1	0	0	0	1	1	?	?	?	?	?	0	1	1
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	0	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Gongxianosaurus	?	1	?	?	?	0	?	0	0	1	?	?	?	?	?	?	1	?	?	?	?	1	?	?	?	?	?	?	?	?
Tienshanosaurus	?	0	1	1	?	?	1	?	0	1	0	1	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	0	?	0	1	?	?	?	?	0	1	0	0	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Apatosaurus	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	1	0	1	0	0	1	1	1	1	1	0	0	0	0
Brachiosaurus	0	1	0	1	0	0	0	0	0	1	0	1	0	1	1	1	1	0	1	0	0	2	1	1	1	1	1	1	1	1
Camarasaurus	0	1	0	1	0	0	0	0	0	1	0	1	0	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	0	0
Dicraeosaurus	0	0	0	1	0	0	0	?	0	1	0	1	0	1	1	1	1	0	?	?	?	1	?	?	?	?	?	?	?	?
Diplodocus	0	0	0	1	0	0	0	0	0	1	0	1	0	1	1	1	1	0	1	0	0	1	?	?	?	?	?	?	?	?
Euhelopus	0	0	1	0	0	0	0	?	1	1	0	1	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Jobaria	0	1	0	1	0	0	0	0	0	1	0	1	0	1	1	1	1	0	1	0	0	1	0	1	1	1	0	0	0	0
Saltasaurus	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	?	?	?	?	?	?	?	?	?

Appendix 2-2 (continued)

	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Theropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vulcanodon	?	?	?	?	1	?	?	?	0	0	0	1	0	1	0	1	0	1	0	?	?	?	0	0	0	?	0	0	0	0
Barapasaurus	?	?	?	0	1	1	0	0	0	1	0	1	0	1	0	1	1	1	0	1	0	0	0	1	0	1	1	1	1	?
Omeisaurus	1	1	1	0	1	1	0	0	0	1	0	1	0	1	0	1	1	1	0	0	0	?	0	1	0	1	1	?	?	0
Shunosaurus	1	0	1	0	1	1	0	0	0	1	0	1	0	?	0	1	1	1	0	1	0	0	?	1	0	1	?	1	0	0
Patagosaurus	?	?	?	?	1	1	0	0	0	1	0	1	0	1	0	1	1	1	0	1	0	0	0	0	0	1	?	?	?	?
M.constructus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	0	1	?	?	?	0
M.hochuanensis (holotype)	?	?	?	?	1	1	0	1	?	?	?	?	0	1	0	?	?	?	0	?	?	?	?	?	?	?	?	?	?	0
M.hochuan (ZDM0126)	?	?	?	?	1	?	0	0	?	?	?	?	?	?	?	1	1	1	?	1	?	1	1	1	0	1	?	0	0	1
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	{01}	?	1	?	1	1	?	0	0	1	0	1	?	1	0	1	1	1	0	1	0	1	1	1	0	?	?	1	0	?
Chuanjiesaurus	?	?	?	?	1	1	0	0	0	0	0	?	?	0	?	1	1	1	0	1	0	1	1	1	0	?	1	?	0	1
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	1	1	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Gongxianosaurus	?	?	?	?	0	0	?	0	?	?	?	?	?	?	?	1	1	1	0	0	?	?	?	?	0	1	?	?	0	0
Tienshanosaurus	?	?	?	?	1	1	0	0	?	?	?	?	?	1	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	1	1	1	0	1	0	1	1	1	0	1	?	?	1	0
Apatosaurus	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1
Brachiosaurus	1	0	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	1	1
Camarasaurus	1	1	1	1	1	1	0	0	0	1	1	1	0	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1
Dicraeosaurus	?	?	?	1	1	1	0	0	1	1	0	1	0	0	0	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1
Diplodocus	?	?	?	1	1	1	0	0	1	1	0	1	0	0	0	1	1	1	0	1	0	1	1	1	0	1	?	1	0	1
Euhelopus	?	?	?	1	1	1	?	?	0	1	?	?	0	1	1	1	1	1	1	1	0	0	1	1	0	1	?	1	0	1
Jobaria	1	1	1	1	1	1	0	0	0	1	0	1	0	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1
Saltasaurus	?	?	?	1	1	1	1	1	0	1	1	0	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	0	?

Appendix 2-2 (continued)

	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?
Theropoda	0	0	0	0	0	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0
Vulcanodon	1	0	0	0	0	1	0	?	1	0	0	1	0	0	1	0	0	?	0	1	1	0	0	0	?	?	0	0	?	?
Barapasaurus	1	?	1	0	?	?	?	0	1	0	?	?	?	?	?	?	?	1	?	?	1	1	?	0	0	0	0	0	0	0
Omeisaurus	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Shunosaurus	1	0	?	0	0	1	1	1	1	0	1	1	1	0	1	1	1	?	1	1	1	1	1	0	0	0	0	0	0	0
Patagosaurus	?	?	?	?	?	?	1	0	1	0	1	1	?	?	?	?	?	?	?	?	?	?	?	0	0	?	0	0	0	?
M.constructus	?	0	?	?	1	?	?	?	?	?	?	?	1	?	?	1	?	0	?	?	?	?	?	?	?	1	?	?	?	?
M.hochuanensis (holotype)	1	0	1	?	?	?	1	?	?	0	1	?	1	?	1	?	?	?	?	?	?	?	?	0	1	1	?	?	?	0
M.hochuan (ZDM0126)	?	0	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	0	0	0
M.sinocanadorum	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
M.youngi	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	1	1	0	?	?	?	1	?	0	1	?	0	0	0	0
Chuanjiesaurus	1	?	?	0	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	{01}	0	0	1	1
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?
Datousaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?
Gongxianosaurus	0	?	1	?	0	0	0	?	?	0	1	1	0	1	0	{01}	0	?	?	0	?	0	?	?	?	0	0	0	1	?
Tienshanosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Yuanmousaurus	1	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	0	?	0	1	0	?
Apatosaurus	1	1	1	0	1	1	1	1	1	1	1	1	1	1	?	1	1	1	1	?	1	1	1	0	0	0	0	0	1	1
Brachiosaurus	1	1	1	0	0	1	1	1	1	0	1	1	1	?	1	1	?	1	?	?	1	1	?	0	?	?	0	0	1	0
Camarasaurus	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Dicraeosaurus	1	1	1	0	?	?	1	1	1	1	1	1	?	1	1	?	?	?	?	1	1	?	?	0	0	0	?	0	1	0
Diplodocus	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	?	1	1	1	1	0	0	0	0	0	0	0
Euhelopus	1	1	?	0	0	?	1	1	1	0	1	?	1	1	?	1	?	1	?	1	1	?	?	0	0	?	?	0	0	?
Jobaria	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	?	?	?	?	?	?	?	?	0	0	0	0	0	0	?
Saltasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	?	0	0	1	0

Appendix 2-2 (continued)

	241	242	243	244	245	246	247	248	249	250	251	252
Prosauropoda	0	0	0	0	0	0	0	0	0	0	0	0
Theropoda	0	0	0	1	0	0	1	0	?	0	?	0
Vulcanodon	?	?	0	?	?	?	?	?	?	?	0	0
Barapasaurus	0	0	?	?	?	?	?	0	?	?	0	0
Omeisaurus	0	0	0	0	0	0	0	0	0	1	1	0
Shunosaurus	0	0	0	0	0	1	1	1	1	0	0	0
Patagosaurus	0	?	?	?	0	?	?	?	0	0	?	0
M.constructus	0	?	?	?	?	?	?	?	?	?	0	?
M.hochuanensis (holotype)	1	0	0	?	0	?	0	0	?	?	0	?
M.hochuan (ZDM0126)	1	0	?	?	0	?	?	0	2	1	0	0
M.sinocanadorum	?	?	?	?	?	?	0	?	?	?	?	?
M.youngi	0	0	0	1	0	?	?	0	?	0	?	0
Chuanjiesaurus	1	1	1	1	1	?	1	0	?	?	?	0
Chinshakiangosaurus	?	?	?	?	?	?	?	?	?	?	?	?
Datousaurus	?	?	?	?	?	?	?	?	?	0	?	0
Gongxianosaurus	?	?	?	0	?	?	?	?	?	?	0	1
Tienshanosaurus	0	?	?	?	?	?	?	0	?	?	?	0
Yuanmousaurus	0	?	0	?	0	?	?	0	?	?	?	?
Apatosaurus	0	0	0	0	0	?	0	0	0	0	0	0
Brachiosaurus	0	0	0	1	0	?	0	0	?	0	?	0
Camarasaurus	0	0	0	0	0	0	0	0	0	0	0	0
Dicraeosaurus	0	0	0	?	0	?	0	0	0	?	?	?
Diplodocus	0	1	0	0	0	0	0	0	0	0	0	0
Euhelopus	0	?	?	?	0	0	0	0	?	0	?	0
Jobaria	0	?	?	?	0	?	?	0	?	0	0	0
Saltasaurus	?	0	{01}	?	0	?	1	0	?	?	?	0

Appendix 3. Comments for each node of phylogenetic tree analyzed with modified data of Upchurch et al. (2004a). The bootstrap values of 2,000 replicates are shown in parenthesis for the main nodes.

Node 1: Sauropoda Marsh, 1878 (78%)

Comments: Sauropoda can be defined as a stem-based taxon consisting of sauropodomorphs more closely related to *Saltasaurus* than to Prosauropoda. Following Upchurch et al. (2007b), this node was identified as the base of Sauropoda. They focused on the acquisition of feeding-related characters in basal sauropods. Recently, Buffetaut (2005) reported a partial dentary of sauropod from the Middle Jurassic of Madagascar. The retention of 'prosauropod-like' lingual ridges on teeth could be an intermediate character in the evolutionally linage. Upchurch et al. (2004a) proposed sixteen characters to diagnose Sauropoda. Although numerous of them are diagnostic characters for node 2 and 3 by DELTRAN, however, most of them are diagnostic by ACCTRAN in current analysis (Table 16). Data of *Chuanjiesaurus* remove C226 and C260 as synapomorphies of Sauropoda. The derived state of C2:1, C76:1 and C187:1 is consistent with the synapomorphies of Sauropoda in Upchurch et al. (2007a: C2, C7 and C147, respectively).

Node 2: Unnamed clade (64%)

Comments: *Gongxianosaurus* is the most basal taxon of this clade and its derived state is consistent with synapomorphies of Sauropoda proposed by Upchurch et al. (2004a: C261:1, C264:1 and C273:1). However, at the same time, about the other synapomorphies, *Gongxianosaurus* represents plesiomorphic feature (C161:0, C286:0, C289:0, C290:0 and 298:0).

Node 3 and 4: Unnamed clade

Comments: The strict consensus tree of the current analysis represents in a nesting relationship from this node, including *Vulcanodon, Kotasaurus* and Eusauropoda (Fig. 55). Most of synapomorphies in Sauropoda proposed by Upchurch et al. (2004a) supports this clade (Table 16). Absence of the ossified distal tarsals (C289:1) is a new diagnostic character by this analysis, which is not included in Upchurch et al. (2004a).

Node 5: Eusauropoda Upchurch, 1995 (55%)

Comments: Eusauropoda was named by Upchurch (1995), and Upchurch et al. (2004a) proposed several characters. Most of them remain in the current result, but wrinkled tooth enamel (C 79:1) appears in more basal steps (Node 1). Some characters are reversed in mamenchisaurid dinosaurs as follows: C25:0, C57:0 in *M. youngi*; C112:0 in *M. youngi, M. constructus and Chuanjiesaurus*.

Furthermore, some Chinese taxa represent inconsistent coding with the synapomorphies of Upchurch et al. (2004a) as follows: posterior cervical spine of *Tienshanosaurus* directs posterodorsally (C119:0; Young, 1937: fig. 1B); simple flattened first caudal rib (C190:0) in *Yuanmousaurus* and *Chuanjiesaurus*; absence of femoral cranial trochanter (C262:1), reduced tibial medial malleolus (C278:1), robust first metatarsal (C292:1) of *Gongxianosaurus*; unguals with sub-circular outline in *Yuanmousaurus* (C308:0).

Nodes 6 to 10: Unnamed clades

Comments: In Upchurch et al. (2004a), *Barapasaurus* is a sister taxon of *Cetiosaurus* and *Patagosaurus*. However, in the strict consensus tree of the current analysis, these taxa appear in a nesting relationship within the basal part of Eusauropoda (Fig. 55).

Node 11: Unnamed clade

Comments: No unique characters support this clade, however, there are some synapomorphies common with more derived taxon as follows: more than 17 cervical vertebrae (C100:1, common to *Euhelopus*); more than three ossified carpals (C228: 1, common to Neosauropoda); absence of ossified calcaneum (C 288:1, common to Diplodocidae); cancellous structure of presacral vertebrae (C309:1, Titanosauriformes).

Node 12: Mamenchisauridae Young and Zhao, 1972 (9.8%)

Comment: Interestingly, most of the newly added taxa in this analysis compose a monophyletic group. The diagnosis is 'forked' chevrons in mid-caudal region with anterior and posterior projections oriented less than 45 degrees to each other (C311:1). On the other hand, the external mandibular fenestra is present, reversely (C77:0). Although, the bootstrap value of this clade is relatively low (Table 16), the decay index does not show very weak support for this clade. For more reliable analysis, additional collecting of codings is required and more advanced research of mamenchisaurid classification will be studied in future.

Node 14: Unnamed clade (15.1%)

C. anaensis, Yuanmousaurus and *Tienshanosaurus* represent monophyletic clade with ZDM0126, which is regarded as the second specimen of *M. hochuanensis* by Ye et al. (2001). If ZDM0126 is moved to the sister position of *M. hochuanensis*, nine additional steps are needed.

Node 15: Neosauropoda Bonaparte, 1986 (32.4%)

Comments: Neosauropoda was originally proposed by Bonaparte (1986) as relatively derived group which is "considerably distinct from that of Eosauropods" in Sauropoda (Bonaparte, 1986). Since, several definitions and classifications have been proposed by Upchurch (1995, 1998), Wilson and Sereno (1998), Wilson (2002), and Upchurch et al. (2004a).

Two diagnoses of the present result are consistent with those of Upchurch (1995), and lack that about teeth in Upchurch (1998). Concerning the number of carpals, the present diagnoses are consistent with that of Wilson and Sereno (1998) and Wilson (2002); though, that is defined in more detail in the present result.

Eight diagnoses are proposed by Upchurch et al. (2004a). Four of them remain, but the others are excluded by rescoring of *Euhelopus* (C6:0, 18:0) by Wilson and Upchurch (2009) and *M. youngi* (24:1 and 30:1, see above) by this author.

Node 16: Flagellicaudata Harris and Dodson, 2004 (100%)

Comments: Based on the definition by Harris and Dodson (2004), this clade is regarded as Flagellicaudata. Compared to their synapomorphy, the following characters are common to the current analysis: elongate subnarial foramen (C7:1), length of tooth rows extends rostral to orbit but caudal to subnarial foramen (C95:1), distal shaft of the middle cervical ribs are short and do not project far beyond the end of the centrum (120:1).

Node 17: Diplodocidae Marsh, 1884 (99%)

Comments: Marsh (1884) did not comment about this family beyond *Diplodocus* itself, and his definition is phylogenetically uninformative (Taylor and Naish, 2005). Concerned with this old classification also there are various opinions on its definition and compositions. Taylor and Naish (2005) summarized three different ways. The result of current analysis supports the third way, i.e., including *Diplodocus, Barosaurus, Apatosaurus* and closely related forms, but not *Dicraeosaurus, Rebbachisaurus* and other more distantly related taxa. Whitlock (2011) presented phylogenetic relationships of Diplodocoidea. In his result, Diplodocidae is diagnosed by 20 characters. However, the classification of the derived taxa is beyond the viewpoint of this research. Here, considering with the diagnoses of Upchurch et al. (2004a), rounded distal expansion of paroccipital process (C46: 1) is excluded since the presence in *M. youngi* and *M. hochuanensis* (ZDM0126).

Node 18: Unnamed clades

Comments: In the reduced consensus tree of Upchurch et al. (2004a), a monophyletic group composed of *Jobaria, Bellusaurus* and *Atlasaurus* is included in Macronaria. However, in the current analysis, *Jobaria* is solely positioned as a sister taxon of Camarasauromorpha.

Node 19: Camarasauromorpha Salgado et al., 1997 (56%)

Comment: Although the original definition has six synapomorphies for this clade, character No.9 of Salgado et al. (1997) is present in *Chuanjiesaurus, M. hochuanensis* and *M. youngi*; No.10 and 12 are present in *Chuanjiesaurus*; No.11 is present in *Bellusaurus*. In the current result, this clade is trifurcated with *Bellusaurus*, *Camarasaurus* and Titanosauriformes (Fig. 55). Although the synapomorphies include most of the diagnosis proposed by Upchurch et al. (2004a), the elongated metacarpal against radius (233:1) is also present in *M. youngi* and that is excluded by the trifurcation with *Bellusaurus* (C231:0) also.

Node 20: Titanosauriformes Salgado et al., 1997 (61%)

Comments: Although this clade was originally established by Riggs (1904), the determination in this research is based on Wilson and Sereno (1998). Compared to their diagnosis, undivided distal condyle of the first metacarpal is present in the referred specimen of *C. anaensis* (Fig. 44). Whereas Upchurch et al. (2004a) suggested *M. hochuanensis* possesses one of the diagnoses of this clade with its rounded preacetabular process of the ilium (C244:1), this process points anteroventrally in *C. anaensis*.

Node 21: Titanosauria Bonaparte and Coria, 1993 (57%)

Comments: The original objective of this clade, Titanosauria, was a response to the increasing diversity of Titanosauridae (Bonaparte and Coria, 1993); however, the definitions included characters that make Titanosauridae a paraphyletic group, and some of them appear in different nodes (Wilson, 2002). Furthermore, numerous verification and various opinions have been suggested and there seems to be no consensus among them since this clade had been established (Curry, 2001; Curry Rogers, 2005; Upchurch et al., 2004a; Wilson and Upchurch, 2003).

Upchurch et al. (2004a) proposed two diagnoses for this clade. One of them, the prominent caudolateral expansion of the sternal plate seems present in *Gongxianosaurus* (He et al., 1998: fig. 4 d) from the Early Jurassic of Sichuan, China. However, definite determination of the presence of this feature awaits detailed observation of the type material.

According to the definition by Wilson and Upchurch (2003), this clade must not be regarded as Titanosauria. But the discussion of such derived taxon is beyond the purpose of the current research.

Node 22: Unnamed clade (60%)

Comments: Verified with the classification of *Euhelopus* by Wilson and Upchurch (2009), this clade could be regarded as Somphospondyli. However, because of the large exclusion of derived titanosauriforms taxa in the current analysis, the detailed discussion could not be useful here.