

**A new species of sauropod from Zigong, Sichuan,
*Mamenchisaurus youngi***

by

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Introduction

In December of 1988, Mr. Renfa Song, a resident of the rural village of Xinminxiang, Zigong Municipality, was quarrying stone at Wujiba dam near the village of Jiujiingbacun where he uncovered a dinosaur specimen. Subsequently, in January of the following year, Xunli Wen of the Zigong Dinosaur Museum organized an excavation team to collect the specimen as soon as possible before it was subjected to damage. The specimen represented an isolated skeleton of a sauropod in Late Jurassic sediments.

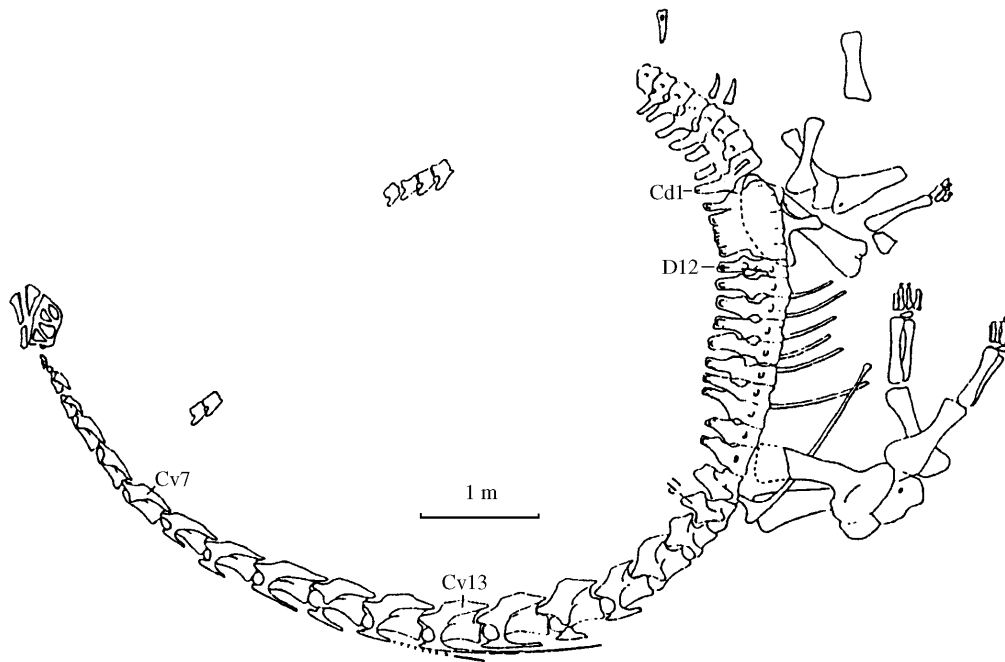


Figure 1. Quarry map illustrating the burial condition of *Mamenchisaurus youngi* sp. nov.

Sauropoda Marsh, 1877

Mamenchisauridae Young and Chao, 1972

***Mamenchisaurus* Young, 1954**

***Mamenchisaurus youngi* sp. nov.**

Etymology: In commemoration of the outstanding Chinese vertebrate paleontologist C.C. Young.

Diagnosis: A relatively small species with a length of approximately 14 m. Cranial size is moderate, lateral cranial fenestrae are all conspicuously large, external nares represent the largest fenestrae, and all cranial elements are relatively light and thin, composing a particularly gracile cranium. The dorsal surface of the skull is inclined obliquely to the posteriorly and the quadrate is angled obliquely to the anteriorly. The dentary is elongated with a deep anterior end, teeth are spoon-shaped, relatively narrow and long, and wear facets are conspicuous. On unworn teeth the anterior margins possess numerous denticles. Dental formula is Pm-4, M-18, D-22-24. Anterior sacral centrum is opisthocoelous, sacral plate morphology is simple, posterior cervical and anterior dorsal neural spines are bifid, cervical count is 18, consisting of relatively long centra lacking a

ventral keel, and cervical pleurocoels are not well developed. Cervical ribs are slender and elongated with a portion of the capitula bifurcated. Dorsal vertebral count is 12 with relatively well developed pleurocoels and neural spines are high. Sacral centra are 5 in count with fused centra and the anterior four neural spines are fused. Anterior caudals are procoelous but the medial and posterior series are amphiplatyan. Scapula is large and elongated with a rather expanded distal end and sternum is small and subcircular in morphology. Ilium is relatively low and elongated, pubic peduncle is particularly robust, ischium and pubis are equivalent in length. Limbs are relatively slender and long, humerus length is nearly $4/5$ the length of the femur, ulna is approximately $2/3$ the length of the humerus, and tibia is approximately $3/5$ the length of the femur. Manus and pes are relatively small.

Specimen: A nearly complete skeleton including skull, with all vertebrae anterior to the eighth caudal articulated, pectoral girdle, pelvic girdle and all four limbs are nearly completely preserved basically in articulation. Specimen No ZDM0083 is housed at the Zigong Dinosaur Museum.

Locality and stratigraphic position: Upper Jurassic Shangshaximiao Fm. from the village of Xinminxiang, Zigong Municipality, Sichuan Province.

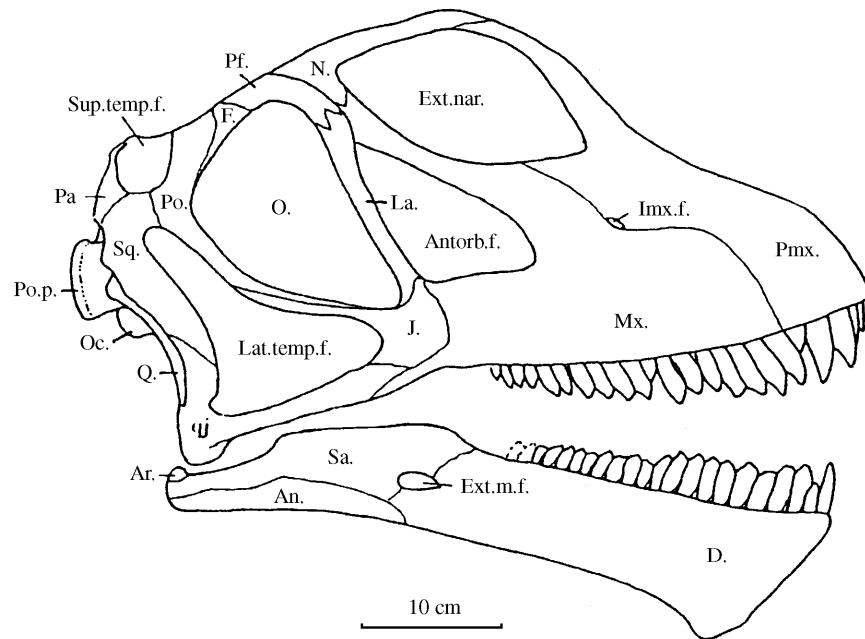


Figure 2. Skull restoration of *Mamenchisaurus youngi* sp. nov.

Description: The skull is relatively complete, with only a few elements on the posterior left side missing. The cranium is typically dinosaurian, superiorly rounded, particularly gracile in construction and moderately high and elongated with a length of 51.0 cm, breadth of 19.0 cm, and height of 31.0 cm.

In lateral perspective the cranial outline is a right angle trapezoid with the dorsal and ventral margins of the skull at right angles to the posterior margin and the rostral region composing a 40° gently rounded ascending angle. The highest point of the skull is at the midsection, represented by the apex of the nasal bridge. The dorsal cranium is posteriorly obliquely inclined and the quadrate is slightly anteriorly obliquely inclined. In dorsal perspective the cranium is wedge-shaped, being broadest at the posterodorsal margin of the orbit, and narrowest at the rostrum. The supraoccipital

is large, the occipital crest is well developed, the exoccipitals do not converge, the paroccipital processes are well developed, and in posterior perspective the occipital condyle is nearly triangular. The parietal, frontal, and nasal are relatively thin, and the maxilla is long, large, and thickened ventrally. The premaxilla is low and elongated with a well developed rostrum. The lacrimal, postorbital, and quadratojugal are narrow and elongated.

Cranial fenestra are all extremely spacious with the external nares larger than the orbits and placed dorsomedially. The orbit is pear-shaped, antorbital fenestra is triangular, and the lateral temporal fenestra is nearly triangular and almost equivalent in size to the orbit. The supratemporal fenestra is relatively small and quadratic in morphology.

Both mandibles are preserved, with only the midportions slightly damaged. Restored length is 47. cm. The deepest portion is at the anterior end, the glenoid fossa is situated ventral to the dentition, and a mandibular fenestra penetrates the element in its posteromedial section. The dentary is extremely elongated with a strong precipitous anterior end that has a medial curvature. The symphysis composes a well developed angle, or chin. Angular, surangular and splenial are all extremely thin.

The upper dentition is complete and the lower dentition is nearly complete with relatively high-crowned and narrow spoon-shaped teeth that maintain a well developed lingual medial ridge. On the anterior dentition, wear facets are conspicuous and denticles are well developed on the anterior margin of unworn teeth. Teeth erupt obliquely with both the upper and lower teeth inclined anteriorly. Upper and lower dentitions are long with numerous teeth in dense alignment. Dental count is Pm.:4, M.:18, D.:22-24. The four premaxillary teeth are thick, large, and relatively shallowly concave. The lingual embayment of the 18 maxillary teeth is slightly deeper than on the premaxillary teeth. On the labial medial surface of the entire upper dentition there are small elliptical wear facets. There are 20 consecutive teeth on the right mandible but they do not represent the complete sequence. The anterior mandibular dentition resembles that on the premaxilla and posterior dentition resembles that of the maxilla. The mandibular teeth are slightly smaller than their opposing counterparts and are in tighter alignment with the posterior margin of each tooth overlapping the labial side of its succeeding tooth. It is estimated the mandibular tooth count is 22-24.

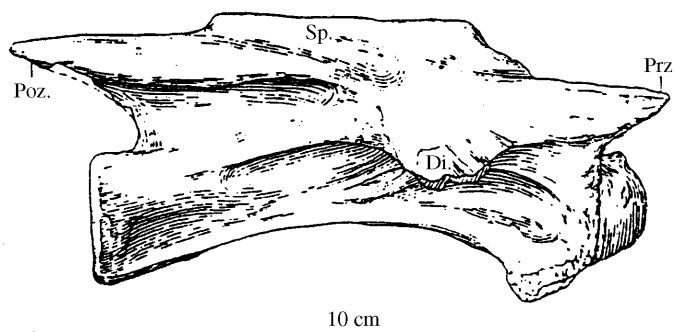


Figure 3. Right lateral view of *Mamenchisaurus youngi* sp. nov. seventh cervical vertebra.

There are 18 cervical and 12 dorsal vertebrae. The beginning of the dorsal series is recognized at the vertebra post Cv18 based upon its closer resemblance to the vertebra posterior to it rather than the one anterior to it and because its ribs have the morphology of the dorsal series. All presacral centra are opisthocelous and resemble the morphology of *M. hochuanensis*, except the cervical centra are distinctly shorter, with the longest cervical being 2.5 times the length of the longest dorsal or 3.2 times the average length of the dorsals. The longest cervical is Cv14 with a length of 48 cm. The longest cervical neural spine is on Cv9 at 23.5 cm which exceeds one-half

the length of its centrum. Anteriorly, the claviform cervical ribs are thin and elongated, but the cervical ribs in the midseries have bifurcated capitula. Pleurocoels on the dorsal vertebrae are more well developed than on *M. hochuanensis* and dorsal ribs are relatively elongated, as exemplified by D3 which is 170 cm along its arc, indicating *M. youngi* had a relatively expansive body.

There are five fused sacral centra which lack pleurocoels, the four anterior neural spines are fused, the fifth sacral resembles the morphology of the caudals, and lateral troughs are absent. Distal sacral ribs are anteroposteriorly expanded and fused to compose the sacral yoke. Sacral rib plates are also relatively well developed.

Anterior caudals are typically procoelous with well developed semi-rounded postzygapophyses. Centra are laterally compressed, strongly constricted ventrally, and there is a conspicuous ridge that represents the boundary between the postzygapophyses and the centrum. Neural spines are extremely high and rectangular club-shaped with their distal ends becoming slender. Ribs on the first caudal are large, broad, slightly fan-shaped, and extend from the neural arch angled dorsally. Posteriorly, caudal ribs become dorsoventrally thin and flattened with slightly thickened termini. Medial and posterior caudals are amphiplatyan with plate-shaped neural spines that extend posteriorly and display weakly developed postzygapophyses.

Previously described specimens of *Mamenchisaurus* do not preserve a pectoral girdle or forelimb but on the Zigong specimen these are nearly completely preserved. The scapula is long and large, slightly longer than the femur, proximal and distal ends are both expanded, and the shaft is relatively narrow with its narrowest point one-half the breadth of the distal end. The sternum is relatively small and semi-circular.

The humerus is relatively short with a thick and large head, a conspicuous medial trochanter, and a constricted midshaft with the narrowest point only one-third the breadth of the proximal end. Both the deltopectoral crest and fossa for anterodorsal musculature are well developed. The radius and ulna resemble the morphology of *Omeisaurus* only they are distinctly thinner and more columnar.

The five metacarpals are contracted ventrally causing McI and McV to lie close together. In anterior perspective the metacarpals are dorsally arched. Among them McI is the shortest, McII and III are the longest, McV is the most robust but its distal end is constricted, and McII, III and IV are relatively slender, particularly McIV which has an extremely constricted anterior section and extremely thin anterior end. The proximal ends of the metacarpals are triangular, with the exception of McI which is elliptical. Digit morphology resembles the basic sauropod condition and is estimated to have a formula of 2,2,3,2,2.

The ilium is relatively low and elongated with a particularly elongated and robust pubic peduncle located at its midsection. Ischium and pubis morphology basically resembles that of *M. hochuanensis*, only on the Zigong specimen they are nearly equivalent in length which differs from the general sauropod condition in which the ischium is distinctly longer than the pubis.

On *M. hochuanensis* only the proximal end of the femur is preserved but on the Zigong specimen it is relatively complete, being relatively slender and long with a distinctly slender and columnar shaft, well developed head, and strong medial trochanter. The distomedial condyle is distinctly larger than the lateral condyle and the intercondylar groove is relatively deep. The tibia is short and robust, the fibula is relatively slender, and tibia is slightly longer than the fibula.

On *M. hochuanensis* only the right MtIV and MtV are preserved but the Zigong specimen preserves the right MtI, II and III. MtI is short, broad, and robust with expanded ends, and the height of the proximal end exceeds its breadth. Two phalanges lie anteriorly. MtII is longer and thinner than MtI with a square proximal end. Two phalanges lie anteriorly. Only the distal end of

MtIII is preserved with a relatively slender shaft, and two phalanges articulated to it. Unguals are relatively small, thin, flat, and triangular. The general condition of the sauropod pes is to possess three unguals but the Zigong specimen possesses only two. The estimated phalangeal formula is 2,2,2,?,?.

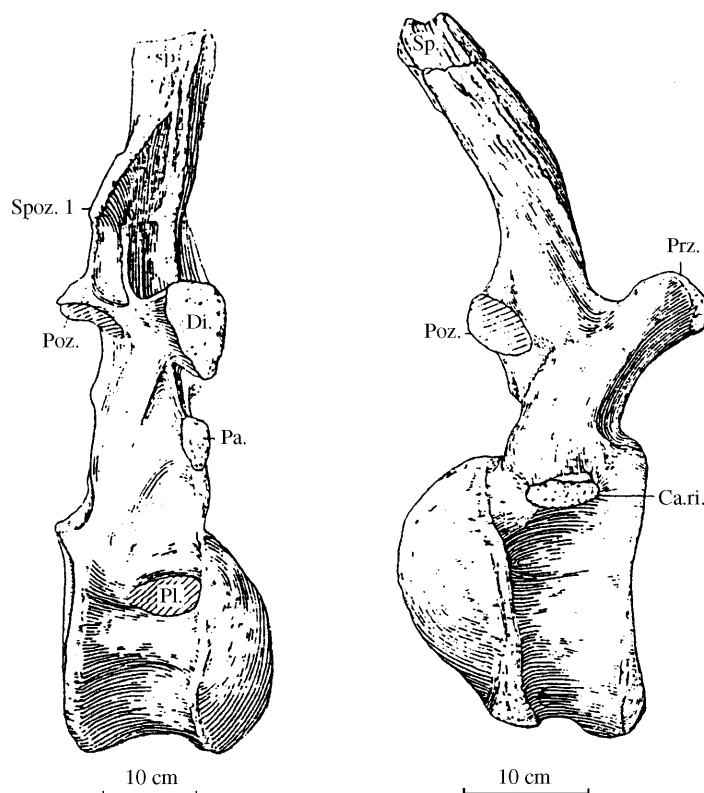


Figure 4. *Mamenchisaurus youngi* sp. nov. twelfth dorsal and fourth caudal vertebrae.

Comparison and discussion: The genus *Mamenchisaurus* was erected by Young (1954) based upon a specimen from Yibin Co. Sichuan Province, and diagnosed primarily as a sauropod with an elongated cervical series and procoelous anterior caudals with the species name *M. constructus*. Subsequently, Young and Zhao (1972) described a partial skeleton with a relatively complete series of dorsal vertebrae collected from Hechuan Co., Sichuan, which they erected as *M. hochuanensis*. They further reestablished this specimen and species as the type for the genus and erected the family Mamenchisauridae, which they placed in the superfamily Homalosauropodidae. In 1987, a sauropod specimen was collected from the Junggar Basin of Xinjiang Autonomous Region, which resembled *M. hochuanensis* but after study by Russell and Zhong (1993) was erected as the new species *M. sinocanadorum*. Thus, to date, there were three species of *Mamenchisaurus* recognized.

The Zigong specimen is undoubtedly assigned to the genus based upon the diagnostic characters including elongated cervical series, opisthocoelous presacrals, bifid neural spines on the posterior cervicals and anterior dorsals, and procoelous anterior caudals. A closer comparison to the other three species is as follows:

There are numerous characters shared with *M. hochuanensis* but also notable distinctions, as *M. hochuanensis* is a large species with 32 presacral vertebrae, 4 sacrals, and the cervical centra are particularly elongated with the longest being over three times the length of the longest dorsal. The capitula on the cervical ribs are dagger-shaped, pleurocoels on dorsal vertebrae are not well

developed, and the tibia is shorter than the fibula. The Zigong specimen is only two-thirds the size of *M. hochuanensis*, the presacral vertebral count is 30, and the sacral count is 5. Cervicals are moderately elongated with the longest being twice that of the longest dorsal, the capitula on the mid cervical series is bifurcated, dorsal vertebral pleurocoels are relatively well developed, and the tibia is longer than the fibula.

Specimens representing *M. constructus* are rather restricted, prohibiting a detailed comparison. Nevertheless, its cervical ribs are relatively short, tibia is shorter than fibula, distal tibia is expanded to nearly the breadth of the proximal end, and distal fibula is rather conspicuously medially inflated. On the Zigong specimen cervical ribs are slender and elongated, tibia is longer than fibula and lacks an expanded distal end, and the fibula lacks a distomedial inflation. Consequently, *M. constructus* has a tibia/body index that is distinctly larger than the Zigong specimen, indicating a proportionally longer hind limb.

Specimens referred to *M. sinocanadorum* are extremely restricted but the Zigong specimen is much smaller with an axis/Cv3 index being only 1.4, while on the former this index is 1.71. The Zigong mandible is conspicuously deep anteriorly, forming a distinct mandibular angle (chin) and the mandibular dentition of 22-24 teeth exceeds the count on the Xinjiang specimen. Furthermore, their type localities are over 2,000 km apart.

The Zigong specimen is recognized as the new species *Mamenchisaurus youngi* and represents significant supplementary data supporting the generic diagnosis including the confirmation that it has a high rounded skull, extremely well developed external nares, cranial construction is extremely gracile, and the dentition is spoon-shaped. The condition of dental wear facets indicates that members of this genus were not only adapted for a diet of soft succulent plants but also for more coarse fibrous diet reflected by the well developed labial dental morphology. The high crowns and dental margins reflect adaptations for nipping.

The Zigong specimen confirms the hypothesis of Dong et al. (1983) and He et al. (1984, 1998) where they surmised *Mamenchisaurus* has a spoon-shaped dentition. The postcrania of these species approach the Diplodocidae but the cranial construction resembles the Camarasauridae indicating that *Mamenchisaurus* along with the genera similar to it such as *Omeisaurus* and *Euhelopus* should be erected as an independent family. This text concurs with Russell et al. (1993) who stated the Diplodocidae were prevalent in the western hemisphere, Europe, and Africa but are absent in China, and instead are represented by sauropods resembling *Mamenchisaurus*. This indicates different centers of sauropod evolution between Asia and continents bounding the Atlantic Ocean.

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