A new Middle Jurassic sauropod subfamily (Klamelisaurinae subfam. nov.) from Xinjiang Autonomous Region, China

by

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Abstract

The text describes a new Middle Jurassic sauropod from Xinjiang Autonomous Region: *Klamelisaurus gobiensis* gen. et sp. nov. The new subfamily Klamelisaurinae is erected and its geologic age is discussed.

Introduction

Between 1981-1985, the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) cooperated with the National Academy of Sciences (Academia Sinica) and the Xinjiang Office of Petroleum in a joint research endeavor entitled "Evolution of the Junggar Basin and the formation of petroleum." In 1984, the IVPP field crew continued the systematic collection and excavation of a sauropod found two years previously in the Jiangjunmiao region.

Generally speaking, large sauropods are rather poorly preserved and the excavation of complete skeletons poses extreme difficulties. The entire sauropod skeleton in the Jiangjunmiao region has been subjected to weathering but still represents an extremely valuable scientific specimen.

In 1985, after its transportation to Beijing, preparation and restoration commenced but the specimen deteriorated further due to extreme fluctuation in ambient temperature and humidity. Thus the skeleton was merely layed out for a simple description. A more detailed published description is forthcoming.

Description

Saurischia Seeley, 1878

Sauropoda Marsh, 1878

Bothrosauropodea Young, 1958

Klamelisaurinae subfam. nov.

Diagnosis: A relatively large early to middle stage sauropod. Five sacral vertebrae are fused, there are over 60 caudal vertebrae that are procoelous to gently amphicoelous, cervical and dorsal vertebrae are opisthocoelous, pleurocoels on the dorsal series are slightly developed, neural spines on the anterior dorsal and posterior cervicals are bifid, those on the dorsals are low, caudals neural spines are thick and rounded, and cervical centra average one-and-a-half to two times the length of the dorsals. Forelimb is 3/4 the length of the hind limb. Scapula-coracoid index is 4.3-4.5:1. Ulna-humerus and tibia-femur indices are both 2:3. Femur head is not conspicuous and the fourth trochanter is positioned dorsally. Only a single genus and species is assigned to the subfamily with an age of Middle Jurassic.

Klamelisaurus gen. nov.

Diagnosis: As for species.

Klamelisaurus gobiensis gen. et sp. nov.

Etymology: Klameli being Pinyin romanization for the fossil locality near the Kelameilishan Mts. Gobi refers to the town of Jiangjun being in the Gobi desert.

Diagnosis: This is a relatively large sauropod with 16(?) cervical, 13, dorsal, 5 sacral, and 60 caudal vertebrae. Cervicals are distinctly opisthocoelous, anterior caudals are procoelous but mid- and posterior caudals are gently amphicoelous. Cervical neural spines are relatively high, dorsal pleurocoels are relatively shallow, and laminae between the neural arch and centrum are simple in morphology but thick. On the posterior dorsals, the apices of the neural spines are expanded. Sacral centra are fused to the extent that centrum boundaries are not visible and the four anterior neural spines are fused. Caudal neural spines are claviform and extremely posteriorly oblique. The scapula is thin and elongated, and coracoid is slender and small. Ilium is robust but a dorsal laminar ridge is indistinct, pubic peduncle is positioned anteriorly, ischium is relatively slender, pubis is robust, thin, flat, and lacks strong curvature. Proximal humerus is thick and broad with slight curvature. The ulna is longer than the radius, the latter being relatively straight. Femur is relatively thick and flat, and tibia is not well developed, being shorter than the fibula.

Locality and age: 35 km north of the town of Jiangjunmiao, south of the Kelameilishan Mts., Jiangjun Gebi, eastern Junggar Basin, Xinjiang Autonomous Region. Specimen occurs in gray-brown, purple-red sandy mudstones at the top of the late Middle Jurassic Wucaiwan Fm.

Material: Fragmentary teeth, vertebral column (lacking anterior [7?] cervicals and a portion of the posterior caudals), ribs, right scapula and coracoid, right humerus, ulna, radius, phalanges, pelvic girdle, femur, tibia, fibula, and astragalus (IVVP # V9492).

Description of specimens: The dentition is spoon-shaped typical of many sauropods, although specimens are fragmentary, crowns are relatively thin with smooth and glossy enamel that is dark brown whereas wear facets are gray-white and a medial ridge is indistinct. Denticles are well developed on the slender and weak margins.

The vertebral column is relatively well preserved with characters that fit within the parameters of primitive to moderately derived sauropods. The cervical series is represented from the middle to posterior sequence by Cv8 to Cv16. It is estimated that there were a total of 16 cervicals including the atlas and axis for a total length of 6.7 m. The opisthocoelus centra are thin and elongated (as exemplified by Cv11 which is 47 cm) (Table 1), the ventral surface is distinctly flat, the lateral surfaces are concave, the anterior articular surfaces are circular, and two of the centra are fused. In the midsection they are thin and narrow with low neural arches. The three most posterior neural spines are bifid.

Table 1. Lengths of *Klamelisaurus gobiensis* gen. et sp. nov. preserved cervical centra (cm).

Sequence #	8	9	10	11	12	13	14	15	16
Length	42	43	43	47	42	45	44	43	35

The cervical ribs are relatively short with proximal ends that articulate with both the parapophyses and diapophyses of the vertebrae. A portion of the ribs are fused to the centra. The proximal ends are extremely short, arrowhead-shaped, shafts are relatively long, and gradually attenuate posteriorly. Each rib is slightly longer than its corresponding centrum and contacts the head of its succeeding rib.

There are 13 completely preserved dorsal vertebrae with robust opisthocoelous centra, slightly well developed but shallow pleurocoels, a ventral keel is present, neural arch laminae are thick but simple in construction, anterior articular surfaces are semicircular, neural arches are relatively high with the five anterior arches bifid and apices of posterior arches expanded. Centra become shortened and neural spines increase in height along the column posteriorly (Table 2). Total length of the sequence is 2.55 m.

Few dorsal ribs are preserved but on the sixth dorsal rib the distance between capitulum and tuberculum is 23 cm, tuberculum breadth is 6 cm and length is 8 cm, capitulum breadth is 6.5 cm and length is 7 cm. The fourth dorsal rib on the right side is well developed with a capitulum breadth of 8 cm and length of 6.5 cm and tuberculum length and breadth of 8 cm. The tuberculum articular surface is coarsened but on the capitulum it is smooth and the two heads lie 28 cm apart. The third right dorsal rib is robust with a preserved length of 80 cm, the tuberculum length is 7 cm, breadth is 8 cm, shaft is v-shaped in cross-section with its anterior surface laterally convex, posterior surface concave, and lateral surface flat and smooth.

Five fused sacral vertebrae have a length of 60 cm with boundaries indistinguishable, the anterior four neural spines are fused into a single 50 cm high robust plate with an apex that has faint boundary lines. The neural spine on the fifth sacral is posteriorly oblique appearing like an anteriorly bowed posteriorly concave baton. Ventrally the sacral centra are roughened, lateral diapophyses and sacral ribs are fused and contact the ilium at four unaligned tuberosities.

The caudal series preserves two complete anterior vertebrae, ten medial centra, and ten anterior caudal neural spines. Cd3 neural spine is 30 cm high and centrum height is 20 cm. Cd4 height is 46 cm with well developed ventrally-oriented 6 cm long diapophyses, and laterally it is pock-marked. Anterior caudals are procoelous and posteriorlythey gradually become gently amphicoelous, ventral keels become lost, and neural spines become gradually modified from claviform to plate-shaped. It is estimated there were a total of 60 vertebrae for a total length of 6.55 m.

Table 2. Dorsal vertebra lengths and neural spine heights of *Klamelisaurus gobiensis* gen. et sp. nov. (cm)

D1		D2		D3		D4		D5		D6		D7	
L	H	L	H	L	H	L	H	L	H	L	H	L	H
29.0	25.0	28.0	35.0	21.0	36.0	19.5	43.0	18.0	51.0	18.0	44.0	17.0	47.0

D8		D9		D10		D11		D12		D13	
L	H	L	H	L	H	L	H	L	H	L	H
13.5	55.0	20.0	50.0	16.0	53.0	18.5	53.0	14.0	55.0	15.0	56.0

The right scapula is slender and elongated, its midsection is conspicuously narrow, and there is very little curvature, although it is still laterally convex and medially concave. The proximal end is narrow (35 cm), distal end is broad (70 cm), it has a total length of 130 cm, and at the point of distal curvature is only 17 cm in breadth.

The right coracoid is an irregular trapezoid with a length of 30 cm, breadth of 39 cm, the lateral side at its midsection is concave, a coracoid foramen is not well developed, and the glenoid fossa forms a blunt angle.

The right humerus is robust and curved, anteroposteriorly thin and flat with both sides thickly rounded, proximal end is expanded (38 cm), humeral head is well developed, deltopectoral crest is inconspicuous, distal end is narrow (27 cm), distomedial and lateral condyles are not distinctly separated, and total length is 92 cm, representing 3/4 the length of the femur.

The right ulna is columnar with slight curvature, proximal end is autapomorphic in its degree of expansion, its olecranon process is thin and weak, the radial groove on the shaft is a long longitudinal depression, proximal end is 22 cm in breadth, distal end is 11 cm in breadth, and length is 60 cm. Contemporaneous sauropods do not show a proximal expansion such as on this specimen.

The right radius is shorter than the ulna at 56 cm, the proximal end is 14 cm wide, distal end is 12 cm wide, shaft is straight, midshaft is somewhat thin, radial crest is not visible, and both articular facets are smooth and flat.

Two carpals are preserved: the lateral one is large, slender, and elongated with distolateral curvature and is trapezoidal in cross section, proximal end is uneven and is quadratic, the dorsal and lateral surfaces are flat, and the proximoventral surface is deeply concave. Its length is 15 cm, proximal breadth is 9 cm, and distal end is 7.5 cm with a minimum measurement of 4.5 cm. The second carpal is short and thick, with a slight degree of curvature, its length is 12.5 cm, distal breadth is 9 cm, height is 9 cm, proximal breadth is 7 cm, dorsal surface is roughened, lateral surface is smooth and flat, and the two articular facets possess small pits and tuberosities.

Seven phalanges are preserved which are determined to be manual based upon their size and morphology. Two are relatively large, two are relatively small, and ungual phalanges are present (Table 3). Phalangeal surfaces are all roughened and there is a large range of variation in outline morphology, dorsal surfaces are projected, ventral surfaces are concave, anterior articular facets have a longitudinal groove, posterior articular facets are concave, a medial lamina is not visible and lateral sides are concave.

Table 3. Phalangeal measurements of *Klamelisaurus gobiensis* gen. et sp. nov. (cm)

Sequence by size	1	2	3	4	5	6
L	8.0	7.0	5.5	6.0	4.0	5.0
W	10.0	10.0	7.0	6.5	6.0	4.5

The unguals are either pedal or manual elements and are damaged. The most complete is from digit I, being robust with intense curvature, an acute apex and a blunt thick proximal end. It is determined to be from the left side based upon the obliquity of its articular surface. Its dorsal surface is a gently curved brim, ventrally it has oblique concave curvature, the transverse medial ligament groove initiates above the highest point of the midline and extends to the distal end, whereas the lateral ligament groove initiates below the highpoint of the midline and only extends to the ventral surface. Length is 20 cm and proximal thickness is 5.5 cm.

The right iliac plate is relatively flat and robust with a concave lateral surface, dorsal margin is straight, medial side is roughened, the midsection is slightly projected and vestiges of sacral rib contacts are visible. The anterior end is extended, bluntly rounded, and its ventral margin forms an obtuse angle with the pubic peduncle. The pubic peduncle is robust and its posterior margin lies anterior to the midline of the ilium. The ischiac peduncle is not well developed. Ilium length is 87 cm, and from dorsal margin of the pubic peduncle to its ventral end is 53 cm.

The right pubis is missing both ends but its shaft from the midsection to the distal end is thin and flat, its medial surface is slightly concave and relatively smooth and glossy, but the lateral side is roughened. Near the obturator foramen it becomes relatively thin and medially concave. The entire element is distinctly robust. The right ischium is missing its proximal end, its midshaft is broad and flattened, the distal end is relatively flat, medial side is very slightly concave, lateral side is convex and roughened, and approaching the distal end it becomes curved.

The right femur is robust, anteroposteriorly thin and flat with a slight amount of curvature, its anterior surface is laterally projected, and is concave at its distal end. The posterior surface is gently concave. Distal condyles are well developed with coarsened articular surfaces. The proximal end is robust with a spaciously flattened head but its articular surface is not distinctly defined and its neck is short. The fourth trochanter is well developed (24 cm) and positioned

dorsally (21.5 cm from the proximal end). Length is 120 cm, proximal breadth is 40 cm, distal breadth is 30 cm and femur-fibula index is 5:3.

The right tibia is relatively robust, slightly curved, the proximal end is thick (24 cm), distal end is slender (19 cm), a cnemial crest is inconspicuous, proximal cross-section is elliptical while medial to ventral sections are shaped like isosceles triangles. It is 74 cm in length.

The right fibula is slender and long, the proximal end is broad, compressed (19 cm), surficially smooth, and slightly projected for articulation with the femur. The distally it is slender and rounded (17 cm), elliptical in cross-section, the distal section maintains curvature, anterior surface is concave, and posterior shaft is laterally projected to form a gentle lamina. Lateral margin is thin, medial margin is thick, a fibular crest is not conspicuous, and it length is 77 cm.

The right astragalus is irregularly rectangular with a roughened surface, a length of 27 cm, breadth of 14 cm, a ventral surface to astragalar process of 13 cm, the ventral surface is laterally projected, the anterior surface is concave, the posterior side is uneven, the medial side is gently rounded, and the dorsal astragalar process surrounds a depression with its lateral side articulating with the calcaneum.

The right calcaneum is small and irregular in morphology. Only a portion of it is preserved lateral to the astragalus, the remainder being weathered away.

Diagnosis and discussion: The Jiangjunmiao sauropod displays transitional characters for the Sauropoda both in dental and postcranial morphology. The Sauropoda contains two superfamilies: the Homolosauropodoidea has a pedicilate dentition lacking denticles on its margins and extremely well developed pleurocoels. The Bothrosauropodoidea maintains a brachydont, spoon-shaped dentition with denticles on its margins, relatively well developed pleurocoels, pubic peduncle on the ilium it positioned anteriorly, and fibula is longer than the tibia. The Homolosauropodea diverged from the Bothrosauropodea in the Middle Jurassic. From an evolutionary perspective, the bothrosauropods are primitive whereas the homolosauropods are derived, the primitive stage being represented by the Early to Middle Jurassic taxa and the derived by the Late Jurassic to Late Cretaceous taxa. The Bothrosauropodea are documented in the Early Jurassic to Early Cretaceous while the Homolosauropodea descended from the former in the Middle Jurassic and persisted until the terminal Cretaceous.

The Jiangjunmiao specimen maintains characters allowing its assignment to the Bothrosauropodea, which in the early stage contains the family Brachiosauridae, containing the four subfamilies Cetiosaurinae, Brachiosaurinae, Camarasaurinae, and Euhelopodinae. The Junggar specimen shares characters with all these subfamilies but is closer to the camarasaurines with characters including cervical vertebrae are all longer than dorsals, low neural spines that are bifid on the posterior cervicals and anterior dorsals, slightly well developed pleurocoels, forelimbs short, and fibula 2/3 the length of the femur. However, the Junggar specimen is also quite distinct in its cervical count exceeding 12, presence of 13 dorsal vertebrae, and five sacrals. with the four anterior sacral neural spines fused. Caudal centra are relatively long with conspicuously high neural spines, cervical ribs slightly exceed the length of the centra, scapula is narrow and elongated, coracoid is thin and weak, proximal ulna is relatively slender, pubic peduncle on the ilium is positioned forward, femur is robust, thin, and flat with a non-rounded head, fourth trochanter is dorsally positioned, and tibia is slender, weak and relatively straight. Camarasaurinae lack these characters and the other three brachiosaurid subfamilies are even more distinct such as the Cetiosaurinae which possess vertebrae that are not distinctly opisthocoelous, pleurocoels are undeveloped, neural spines are not bifid, they possess 13 cervical vertebrae, the ilium is low, and tibia is over half the length of the femur. Brachiosaurinae also lack bifid neural spines, their anterior neural spines are high, posterior neural spine apices are not distinctly expanded, lengths of the cervicals are three times those of the dorsals, and forelimb is longer than

hind limb. The Euhelpodinae possess 14 dorsals and cervical centra are twice the length of dorsals.

Thus the Xinjiang specimen represents a new subfamily within the Brachiosauridae and is hereby erected as Klamelisaurinae subfam. nov. containing a single genus and species *Klamelisaurus gobiensis* gen. et sp. nov. In general, its characters represent the middle to late stage of sauropod evolution and its age is recognized as Middle Jurassic. Obviously, this is an important element of the Wucaiwan Fm. fauna of the Junggar Basin and is further evidence for a Middle Jurassic age for the Wucaiwan Fm.

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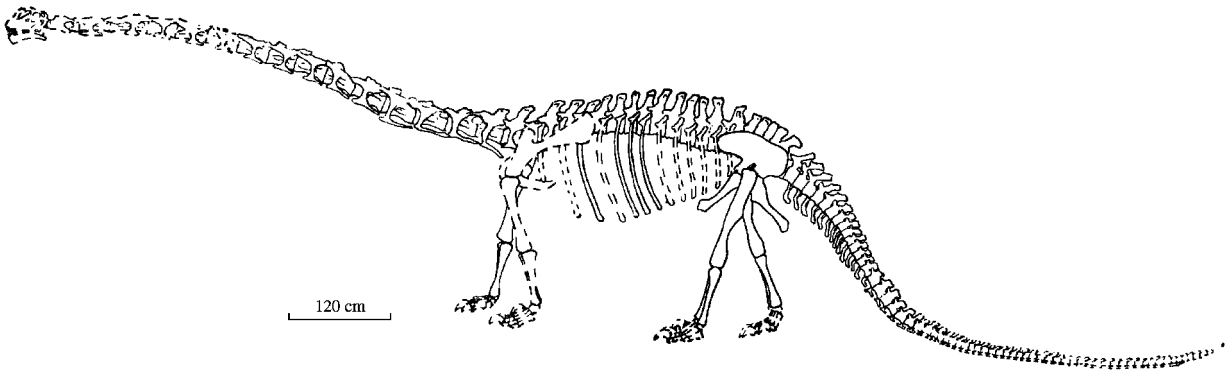

Figure 1. Skeletal restoration of *Klamelisaurus gobiensis* gen. et sp. nov.

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Explanation of plates

1. Lateral view of cervical vertebrae 15 and 16; X 1/10.
2. Medial view of right scapula, X 1/19.
3. Anterior view of right humerus, X 1/11.
4. Anterior view of right radius and ulna, X 1/10.
5. Lateral view of right ischium, X 1/10.
6. Medial view of right pubis, X 1/8.
7. Lateral view of left ilium; X 1/10.