A new sauropod from Dashanpu, Zigong Co. Sichuan Province (*Abrosaurus dongpoensis* gen. et sp. nov.)

by

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Introduction

To date, there were three genera and species of Middle Jurassic sauropods documented from the locality of Dashanpu, Zigong Co., Sichuan Province: *Shunosaurus lii*, *Datousaurus bashanensis*, and *Omeisaurus tianfuensis.* In 1984 an exceptionally complete sauropod skull was collected from the central excavation chamber of the Zigong Dinosaur Museum that was quite distinct from the aforementioned taxa. This text provides a brief description of the specimen and erects a new genus and species. Postcranial specimens have still not been excavated and will be described in a future publication with a more detailed description of the skull.

Specimen description

Sauropoda Marsh, 1878

Camarasauridae Cope, 1877

Cetiosaurinae Jenensch, 1929

Abrosaurus Gen. Nov.

Diagnosis: As for species.

Abrosaurus dongpoensis gen. et sp. nov.

Etymology: The prefix "Abr" indicating delicate or graceful, which is basically the main character of the skull. Species nomenclature Dongpo is the stylized name of the distinguished Northern Sung Dynasty literary scholar from Sichuan named Sushi (1037-1101).

Diagnosis: A moderate sized sauropod with a delicately constructed skull and extremely large lateral cranial fenestrae. Height/length index is 1:1.8, ventral region is elongated, nasal crest is high, quadrate is nearly perpendicular, dorsal premaxillary process and the dorsal branch of the maxilla are equivalently long and are exceptionally slender and elongated. External nares are larger than the orbits, and antorbital fenestra is triangular. Parietal is narrow and the two supratemporal fenestra are in relatively close proximity. The mandible is thin with the midportion of the dentary being dorsoventrally constricted. Dentition with numerous basically spoon-shaped teeth, a lingual medial crest on the teeth is not well developed, labial striations are dense but pinnate striations are absent. Premaxillary teeth lack serrations, maxillary teeth possess only a few serrations, and mandibular replacement teeth possess a small amount of anterior and posterior serrations in addition to an extremely weak medial crest.

Type specimen: An exceptionally complete skull. Zigong Dinosaur Museum specimen # ZDM5038.

Hypodigm: A fragmentary skull preserving only the post orbital region. Zigong Dinosaur Museum specimen # ZDM5033.

Locality and stratigraphic position: Lower Jurassic Xiaximiao Fm., Dashanpu, Zigong Co., Sichuan Province.

Description: The type specimen is exceptionally well preserved and has been exquisitely prepared, clearly defining the cranial outline, external and internal cranial elements, and fenestra (including the cranial nerve complex). The skull has been subjected to a very slight degree of lateral compressional distortion, the left lacrimal is not preserved, the left jugal and quadrate have

been partially displaced, and only the posterior half of the left mandible is preserved. Among all the cranial elements, only the vomer is absent and the right lateral side of the skull is not completely exposed (see plates I-III).

In lateral perspective the skull is a right angle trapezoid with the right angle represented by the intersection of the occiput and the parietal, the latter of which is parallel to the dentition. Skull height/length index (including mandible) is 1:1.8, indicating a longer and lower skull than other camarasaurids (Table I). In both dorsal and ventral perspective the skull is wedge shaped, and relatively laterally compressed. The highest point on the skull is at the posterior margin of the orbit, and the rostrum is slightly acute. In posterior perspective the skull is square with the occipital located in the midsection.

The description of cranial elements is given for the type specimen. The inter-occipital suture line is vague, the trough on the ventral surface of the basioccipital is shallow, the basioccipital processes are not well developed, and the occipital condyle is relatively small. The exoccipitals form the dorsal and lateral walls of the foramen magnum and the paroccipital processes are moderately developed. The supraoccipital is small, at its midsection it is rounded, and the occipital crest is low and gently rounded.

The morphology of the parietal resembles the prosauropod condition, with an extremely narrow and flat midsection and an anterior and posterior vertical process. The posterior process is relatively well developed, constituting the dorsal occipital surface. The parietal-occipital suture resembles the unossified crevice on the prosauropods.

The prefrontal is relatively long with a beak-shaped process that overlies the lacrimal. Nasals are narrow and elongated, constituting approximately one-third the length of the skull. They each have a short lateral process that contacts the maxilla and an extremely well developed anterior process that contacts the premaxilla. The anteriorly oblique lacrimal is extremely thin, elongated, and constricted at its midsection.

Table 1. Cranial measurements for *Abrosaurus dongpoensis* gen. et sp. nov. (ZDM5038) (cm).

Maximum length	45.6
Breadth between lateral frontal processes	17.2
Breadth between jugals	13.0
Breadth between first maxillary teeth	7.2
Maximum height (including mandible with restored articular)	25.2
Height from parietal to quadrate terminus	18.0
Height from skull roof to ventral occipital condyle	12.2
Maximum length of mandible	41.6
Anterior height of mandible	7.8
Mandibular fenestra to anterior end	27.4
Mandibular fenestra diameter (L/H)	2.3/1.0
Adductor fossa length	11.0
Adductor fossa height	3.5

The quadrate is nearly perpendicular with a large portion of its dorsolateral surface obscured by the squamosal, its ventrolateral surface is obscured by the quadratojugal, and there is only a hooked-shaped portion of it visible posteriorly. The articular condyle is not very robust.

The stapes is a small slender claviform element, one end of which penetrates the stapedial canal and the other which is in contact with the quadrate.

The quadratojugal is a thin, narrow, and L-shaped element with its horizontal arm longer than its vertical arm. The jugal is relatively small with a weak dorsal process in contact with the lacrimal, it has a relatively well developed posterior process in contact with the postorbital, and a relatively well developed ventral process in contact with the quadratojugal.

The maxillary ramus is low and long, the dental margin is long, and on the medial side there is a distinct shallow row of replacement alveoli. The dorsal process is thin, long and ascends posteriorly from the midsection of the ramus at a 40° angle, dividing the nasal and prefrontal and terminating in a contact with anterior margin of the lacrimal. The dorsal process of the premaxilla is thin and long, ascends to the midpoint, or highest point of the external nares, to form an arched crest with the nasals. The midline between the premaxillae is sutured to form an acute rostrum.

The pterygoids are the largest pair of elements on the palate, extending from the posterior end of the cranium to the anterior end of the maxilla. The ventral quadrate process thickens to compose an acute laminar projection which reaches the posterior margin of the quadrate. Its dorsal margin is a thin, concave, spoon-shaped element that fuses with the medial side of the quadrate's pterygoid process. The angle between the anterior and transverse pterygoid processes is approximately 70°. The anterior process is long, thin, and acute. The roofs of both anterior processes are sutured within the interpterygoid vacuity. The ectopterygoids are small, thin, fan-shaped elements that are posteriorly broadened and anteriorly claviform. They contact the medial jugal and maxilla and are overlain by the transverse processes of the pterygoids.

The palatine is a single claviform projection that contacts the palatal process of the maxilla. Posteriorly it is fan-shaped and fused to the ventral ectopterygoid, its thin anterior process traverses the anterolateral pterygoid process and would ultimately contact the vomer, which is missing. These three elements compose an extremely narrow bar that divides the extremely large internal nares.

The postorbital, squamosal, basipterygoid, laterosphenoid, and orbitosphenoid are typically saurischian in morphology. Worthy of note is that the lamina composed of the orbitosphenoid and alisphenoid, which constitutes the posterior wall of the orbit, is positioned rather posteriorly, thereupon compressing the braincase into a short but slightly deep cavity.

Lateral cranial fenestrae are all extremely large, representing one of the principle characters for the genus. The subtemporal fenestra is nearly an equilateral triangle in shape and equivalent in size to the orbit. The orbit is oval with its long axis anteriorly oblique. It is positioned rather posteriorly (midpoint is 34.0 cm from rostrum) and thus the facial region is spacious whereas the postorbital region is compressed. The elliptical external nares are the largest fenestrae on the skull, are 1.5 times the size of the orbit, and are divided only by an extremely thin medial nasal crest. The isosceles-triangle-shaped antorbital fenestra is extremely large, or one-half the size of the orbit, and is surrounded by the maxilla and lacrimal.

The supratemporal fenestrae are in close proximity, and are shaped as laterally broad-medially narrow, opposing triangles. Their anterior margin is composed of the frontal and the anterior process of the parietal, but their posterior wall is composed entirely of the posterior parietal.

On the type specimen the foramen magnum is rhomboid due to compressional distortion, but on the hypodigm it is nearly circular and moderate in size with a diameter of 24 mm.

Smaller cranial foramina are visible on the type and particularly distinct on the hypodigm. These include foramina for the olfactory (I), optic (II), oculomotor (II), trigeminal (V), glossopharyngeal (IX), and hypoglossal (XII) nerves. Also visible are the oval foramen, the foramen for the internal carotid, and several foramina which have yet to be adequately identified.

Only the posterior half of the left mandible is preserved but the right mandible is completely preserved in articulation with the skull and, resembling the condition of the skull, is a relatively thin and gracile element. The anterior end is relatively deep but the deepest point on the mandible is at the coronoid process. Between these two points the dentary is distinctly dorsoventrally constricted. The ventral margin on the anterior half of the mandible is dorsally embayed, but on the posterior half, the mandible gradually descends ventrally. A small lateral mandibular fenestra is present. On the medial side there is a relatively large oval depression to facilitate adductor musculature. The coronoid process is relatively well developed although a retroarticular process is weak. The dentary is extremely elongated, constituting approximately two-thirds the length of the mandible and a Meckelian groove is conspicuous.

Table 2. Mandibular measurements for *Abrosaurus dongpoensis* gen. et sp. nov. (ZDM5038) (cm).

Mandible length	41.6
Anterior height	7.8
Distance from mandibular foramen to anterior end	27.4
Mandibular foramen diameter (L/W)	2.3/1.0
Length of adductor fossa	11.0
Height of adductor fossa	3.5

The relatively thin angular composes the posterior half of the mandible. The surangular is relatively large, overlies the dentary anterolaterally, and the articular posteriorly. The prearticular lies anterior to the articular and in medial view appears as a lineation between the angular and surangular that extends to the anterior margin of the mandibular foramen. The splenial is thin, smooth, and triangular. Its midsection obscures the medial dentary, angular, and prearticular. The articular fossa appears to be smaller than in any taxa taxon of sauropod known (see inside back cover plate).

The dentition is basically spoon-shaped with a relatively shallow lingual surface. Teeth in both upper and lower dentitions are abundant, represented by the following formula: PM: 5, M: 15-17, D: 16-18. The premaxillary count of 5 is not documented on any other sauropod. Tooth crowns are relatively long and acute with their broadest point approaching the base of the crown, a medial lingual ridge is absent as are pinnate striations, but longitudinal striations are densely packed, and serrations on both anterior and posterior margins are absent. Ten teeth are preserved on the left maxilla but on the right there are only four functional and two replacement teeth, There is distinct morphological variation between anterior and posterior teeth with the anterior being relatively large, symmetrical, and elliptical. Teeth in the mid-series are narrow, high crowned, and posteriorly oblique. The posterior series is small, crowns again resume being symmetrical, but are low and blunt. A few serrations are present only on the anterior margin, lingual longitudinal striations are well developed, but pinnate striations are absent. All the teeth on the mandible have dropped out and become lost with the exception of three replacement teeth which display an extremely weak lingual medial ridge and a small number of serrations anteriorly and posteriorly.

Comparison and discussion:

As mentioned above, there were three genera and three species of sauropods represented at the Dashanpu locality of Zigong Co. *Abrosaurus* was excavated from the same locality as the other taxa.

Shunosaurus lii is also represented by exceptionally complete cranial material and shares characters including an abundant basically spoon-shaped dentition and a vertical quadrate. But

Abrosaurus differs in its relatively low and elongated skull, being more gracile in construction, lateral cranial fenestrae are larger, antorbital fenestra is extremely distinct in size and morphology, maxillary and mandibular morphology are extremely distinct, and dental characters are not completely consistent. *Shunosaurus* cranial height/length index is 1:1.6, maxillary ramus is relatively high, coronoid process is short, ventral margin of the mandible does not descend, anterior end is very low, lateral mandibular foramen is relatively large, and teeth are all relatively long and acute with well developed lingual pinnate striations. These distinctions exceed the parameters for individual or intraspecific variation.

Table 3. Dental measurements for *Abrosaurus dongpoensis* gen. et sp. nov. (ZDM5038) mm.

Sequence		Crown Height	Crown Breadth	Height/ breadth index
Left	Pm1	32	17	1.89
	Pm2	30	16	1.88
	Pm3	25+	15	1.67+
	Pm4	30	15	2
	Pm5	32	16	2
Right	Pm1	28+	17	1.65+
	Pm2	30	15	2
	Pm3	30+	15	2+
	Pm4	30+	15	2+
	Pm5	27+	15	1.8+
Left	M1	25+	17	1.47+
	M8	30	13	2.31
	M9	23	11	2.09
	M10	16	10	1.6
	M11	15	9	1.67
	M12	14	9	1.56
	M13	12	9	1.33
	M14	10	7	1.43
Right	M1	32+	20	1.6+
	M10	25	10	2.5
D11		20+	12	Replacement
D14		16+	10	Replacement

Omeisaurus tianfuensis lacks a complete skull but is still represented by relatively abundant cranial material. It shares characters with *Abrosaurus* in the morphology of the maxilla, jugal, postorbital, and anterior mandible. However, there are numerous distinctions, including the large and robust nature of the skull which is in direct contrast to the gracile construction of *Abrosaurus.* There are also either large or small discrepancies between the two skulls in cranial outline, location and size of fenestrae, and mandibular and dental morphology. In lateral perspective the *Omeisaurus* skull is wedge-shaped with a relatively low nasal crest. Furthermore, its quadrate is anteriorly oblique, the lateral cranial fenestrae are smaller, the mandible is thick and robust with an extremely high anterior end, dentition is much more reduced, teeth are robust and typically spoon-shaped with numerous anterior serrations, and there are extremely well developed lingual and pinnate striations. Another sauropod genus from the Dashanpu quarry, *Bashunosaurus*, is represented by a damaged skull. However, after restoration, it appears to be generally consistent with *Omeisaurus* although its maxillary morphology is more consistent with *Shunosaurus,* it lacks

a mandibular fenestra and has an even more reduced dentition, distinguishing it further from *Abrosaurus*.

Prior to the discovery of the Dashanpu quarry, cranial data for Chinese sauropods was deficient, being represented only by fragmentary remains of *Euhelopus zdanskyi* and *Zigongosaurus fuxiensis*, both of which represent stratigraphic intervals higher than *Abrosaurus* and are extremely distinct in morphology, representing more phylogenetically distant genera.

Among the taxa outside of China, *Camarasaurus* displays lateral cranial fenestrae that are all extremely large and basically consistent in morphology with *Abrosaurus* in addition to many cranial elements that are also consistent. However, the height and robustness of the *Camarasaurus* skull is distinct, its mandible is thick and lacks and a fenestra, dentition is extremely reduced, the parietal is relatively broad, the lateral quadrate is completely obscured by the quadratojugal, and the lateral cranial fenestrae are not as expanded as on *Abrosaurus*. Furthermore, as it is produced from the Upper Jurassic Morrison Fm. of North America, it is extremely distinct geochronologically.

Thus, *Abrosaurus* displays a plethora of characters that justifies its erection as a new genus and species.

Steel (1970) subdivides the suborder Sauropoda into the two families Camarasauridae Cope 1877 and Atlantosauridae Marsh 1877. *Abrosaurus* is assigned to the former family.

Abrosaurus shares several characters with the Prosauropoda including extremely large cranial fenestrae, cranial morphology being slightly low and elongated, high dental count, retention of a mandibular fenestra, and similar morphology and contact relationships of the parietal, quadratojugal, squamosal, and quadrate. Furthermore, as its age represents the early evolution of the sauropods, or the early Middle Jurassic, *Abrosaurus* is more appropriately provisionally assigned to the subfamily Cetiosaurinae. However, it is worth noting that this subfamily contains nearly all the taxa of Early to Middle Jurassic sauropods, and thus is obviously not a natural taxonomic rank. With the increase of fossil data, and particularly with the erection of more genera with skulls from the Dashanpu quarry, it will be necessary to elevate this subfamily to family status and the subsequently erected new subfamilies and the Cetiosauridae will have to be further revised and defined, and adjustments will have to be made to its phylogenetic status. Obviously, the scope of that work is outside the limitations of this short report. The author of this paper aspires to conclude research on the postcranial skeleton of *Abrosaurus*, will then conduct further discussions upon this subject, and further elaborate upon the evolutionary significance of *Abrosaurus dongpoensis*.

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