

**A primitive pachycephalosaurid from the Cretaceous of Anhui,
China, *Wannanosaurus yansiensis* gen. et sp. nov**

by

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Introduction

The Pachycephalosauria is a rare autapomorphic lineage of later ornithischian dinosaurs characterized by a thickening of the skull cap (frontoparietal) as either flattened or domed, and suffusion of the cranial surface (particularly the circumference) with numerous ossified tuberosities. On those taxa with a domed cranium, the supratemporal fenestra is closed. A premaxillary dentition is present and some taxa have a uniserial heterodont dentition. To date, phylogenetic relationships are still not precisely clear and there are currently only 6 genera and 12 species known initiating with the study of Leidy (1856).

In 1970, the Anwei Provincial Survey, a contingent of the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) South China Redbeds Survey, discovered several specimens belonging to the Pachycephalosauria in the Cretaceous sediments of Yansi, Shexian Co. In addition to a skull cap were a complete left mandible and some torso elements. This represents not only the most abundant data for the infraorder since the establishment of the People's Republic, but moreover a successful result of the Proletarian Cultural Revolution. The locality of Yansi, Shexian Co. is new for Mesozoic reptiles and represents some of the only reliable data for the determination of regional stratigraphic age.

Ornithischia

Pachycephalosauria (Maryanska and Osmolska, 1974)

Pachycephalosauridae (Troodontidae Gilmore, 1925)

Wannanosaurus Gen. nov.

Wannanosaurus yansiensis sp. nov

Type: Right posterior skull cap, left jugal, complete left mandible with seven relatively complete teeth, left humerus, pair of femora, right tibia, a portion of ilium, and a single cervical vertebra. Field No. 70101.2; IVPP V4447.

Paratype: A pair of femora, single left tibia and fibula, partial pelvic girdle, a portion of right pes with three claws, and six caudal vertebrae. Field No. 70101.1; IVPP V4447.1.

Locality and stratigraphic position: Red sandstones of the Late Cretaceous upper member of the Xiaoyan Fm. at the town of Yansi, Shexian Co., Anhui Province.

Diagnosis: A relatively small and primitive pachycephalosaurid with a well-developed supratemporal fenestra. The cranial roof is completely flattened, the thickest portion of the top of the frontoparietal is most posterior where it is also relatively well projected, osseous tuberosities are small and densely packed, the parietal and squamosal are not posteriorly projected, and the occiput and quadrate are slightly anteroventrally oblique. Mandibular dentition is long, exceeding half the length of the mandible, the posterior mandible is thin and weak, maintains ventral curvature, a broad and low surface, and a distinct retroarticular process. Dentition is denticulated. The forelimb is short and the humerus is half the length of the femur or shorter.

Description:

From the right posterior half of the skull that is preserved, it may be determined that it is distinctly primitive, as the supratemporal fenestra is conspicuous, large, and elliptical in outline, and it has an anteroposterior diameter of 15 mm, and a transverse diameter of 12 mm. The anterior

portion and ventral margin of the postorbital are incompletely preserved, but the bone appears to be an asymmetrically elongated rhomboid with a lateral crest, and it forms the anterolateral wall of the supratemporal fenestra. These elements are relatively thick, and the lateral osseous tuberosities are larger than those on the parietal. The boundary between the parietal and frontal is inconspicuous, as only a portion is visible in the temporal fenestra, and the osseous tuberosities are small and densely packed.

Two additional cranial bones are present. A relatively large left postorbital has a rugose surface texture, tuberosities, and a very slight crest. Another element is probably the corner of a squamosal with a high and large dorsal process.

A left jugal is present with an incomplete anterior end and ventral margin. It is typically triangular in morphology with irregular lateral surficial tuberosities. At its midsection, there is a large long process and there is a crest on the posterodorsal ramus. It is 31 mm in length and 23 mm in height.

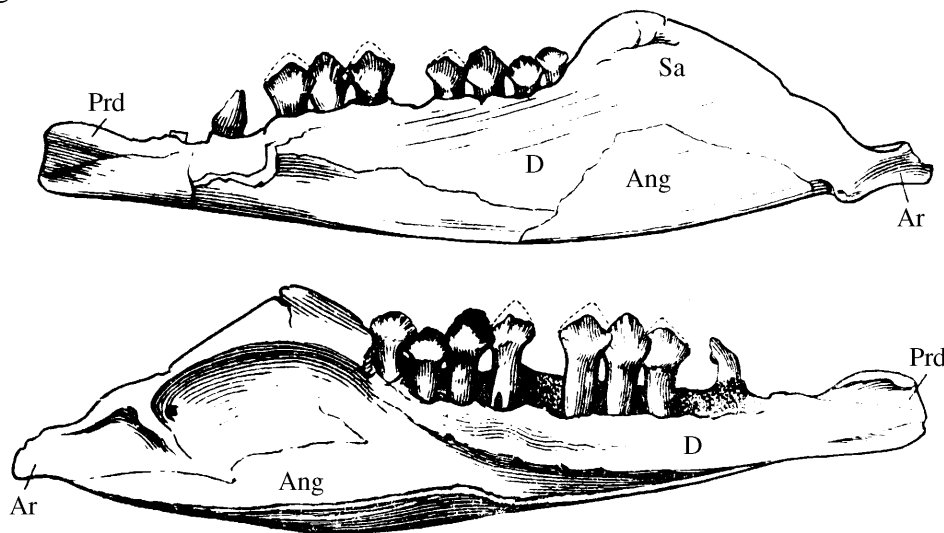


Figure 1. Left mandible of *Wannanosaurus yansiensis* gen et sp. nov.

A. Medial view; B. Lateral view (x 2).

Ang. Angular; Ar. Articular; D. Dentary; Prd. Prementary; Sa. Surangular.

The mandible resembles those already described in the literature, being relatively short with a length of 59 mm, and posteriorly it is high but extremely thin and weak. The anterior end is slightly more gracile than on *Stegoceras*. The lateral surface, and particularly the posterior portion, is ornamented with small tuberosities and its medial side has longitudinal striations. The entire dorsal margin is extremely thin, and the ventral margin is expanded into a stable and low plane. The maximum breadth posteriorly is 5.5 mm, and the anterior and posterior ends are dorsally curved. The medial dentition margin has an approximately 1 mm deep longitudinal trough that extends and expands anteriorly. The Meckelian groove is exposed and a splenial is not present, which is quite distinct from the vast majority of Ornithischia. There is a posterodorsolateral embayment on the dentary which may be due to post-depositional deformation, and the medial side is inflated. In lateral view, the greatest depth of the dentary is at its posterior end, where it is approximately 12 mm, and from this point anteriorly its dorsal margin gradually descends. The symphysis is ventrally inflated, deep, and long.

The prementary is extremely small, triangular, lies dorsal to the dentary, and is edentulous. The coronoid is the highest point on the mandible but does not form a particularly projected process. The angular is well-developed laterally, elliptical in morphology, and projects ventrally,

which is a character shared with *Stegoceras*, but it is not as highly projected as on the latter. The angular is positioned posteriorly, or posterior to the midsection, and is a principle component of the posterior mandible. The surangular is high, large, lies anterior to the articular and dorsal to the angular as the thinnest element of the mandible, and represents the highest point on the mandible with a thick and posteriorly oblique dorsal margin. Its ventral margin maintains an expansive contact with the angular.

A large, deep medial fossa constitutes the majority of the region posterior to the dentition. The articular is small and forms the ventral angle of the mandibule. The retroarticular process is extremely well developed, a medial process extends posteriorly and slightly obliquely, and there is also a lateral process that is short and projects obliquely anterolateral to the medial process with its anterior end contacting the angular. The glenoid fossa is shallow and small.

The dentition is uniserial with a low tooth count and conspicuous enamel. Eight teeth are preserved. Anteroposteriorly they consist first of a single incomplete tooth with matrix still adhered to the apex, which is possibly caniniform. Next is a 8.5 mm series of three teeth that are in overlying contact with small vacuities between them. After another small gap there is a 10 mm series of four teeth that are also in contact. Each of the two gaps may represent the presence of a tooth. At the most anterior end of the dentary it is possible to recognize the presence of at least one broken tooth, such that there may be a total of 10-11 teeth in the series. These teeth differ from other members of the family in being proportionally larger, the mandible is more robust and not distinctly curved, and interdental vacuities are conspicuous. The tooth crowns are greatly swollen, or palmate, and differ from the medially embayed crowns on *S. validus* by being laterally convex and possessing a longitudinal median crest that reaches the apex of the tooth. As in other members of the family there are seven denticles on each side. On the posterior dentition the lateral sides of the crowns are embayed but anteriorly they are relatively flat. Tooth bases (roots) are tightly locked into the dentary and the posterior four bases have a medial fenestra that the remaining teeth lack. These fenestra facilitate replacement teeth and thus the specimen represents an adult.

There is only a single vertebra preserved on the type and its large neural arch distinctly indicates that it is a cervical. The centrum is gently platycoelous, short, and broad. It is 9 mm in length and 11 mm in breadth. On each side lies a large pleurocoel and ventrally there is a large keel. Diapophyses are small, the neural spine is not preserved, and the neural arch is short. A cervical rib head is still attached to the right diapophysis.

A single 43 mm long left humerus is present, being one-half the length of the femur. The entire element is medially curved, and it is thin and flat from the proximal end to the deltoid crest. The proximal end is incomplete, but on its ventral side there is a depression, and the deltoid crest is small, undeveloped and located on the proximal half of the shaft. The distal section is relatively thick and there is a shallow trochlea between the radial and ulnar condyles. The ulnar condyle is large, nearly twice the size of the radial condyle, although the latter is slightly more distally extended. There is a small fossa at the distoventral end.

Of the pelvic girdle, only a left 31 mm ilium is preserved with an incomplete anterior end, although in morphology it appears typical for the family. The ventral border is nearly a horizontal shaft, dorsal margin is thin, high at its midpoint, curved medially, and the posterior portion is prismatic. The acetabulum, pubic, and ischiac peduncles are all lost.

A pair of incomplete femora is preserved on the Type. The proximal ends have suffered compressional distortion although the fundamental characters are discernable, the most conspicuous of which is the triangular cross-section of the proximal end, which is due to the extremely deep incision (puboischio-femoral notch) on the proximodorsal side which gradually attenuates distally. Secondly, there is a small fourth trochanter at the midpoint of the shaft. The walls of this pair of femora are exceptionally thin. The right femur is longer at 90 mm, and left

femur is 72 mm. The right femur is slender and long, whereas the left femur is distinctly robust, and thus they probably belong to different individuals.

A right tibia is documented on the Type but it is missing its proximal and distal articular surfaces. In overall morphology it resembles the general ornithischian condition, being expanded at its termini and particularly the proximal end where the maximum breadth is 23 mm. Maximum constriction is approximately at the midshaft where the shaft is prismatic. The distal end is slender and there is a shallow fossa ventrally. The length is 87 mm, nearly equivalent to the femur.

A nearly complete articulated left pes is preserved with complete digits and distinctly acute unguals, but the metatarsals are incomplete. Phalangeal formula is 1:2:3. It appears the metatarsals were elongate with the longest being MtV at 19 mm.

The Paratype specimen 70101.1 was collected only approximately 20 m from the Type specimen and from the same stratigraphic horizon. Thus it is ascribed to the same species.

Seven articulated caudal vertebrae are present exposed in lateral view. The remaining are still unprepared in a calcareous red sandstone. The centra are gently platycoelous, the neural spines are vague, the neural arches are relatively long, and the haemal arches are unpreserved. The ventral centra are prismatic and medially concave. The length of this series is 61 mm.

A pair of femora are complete and maintain characters consistent with the Type, only they are a little smaller. On the Paratype there is an articulated tibia and fibula that may supplement description of the Type. Tibia characters are completely consistent. The fibula is exceptionally gracile, the proximal end is laterally compressed, and the maximum breadth is only 8.5 mm. A small longitudinal groove is present anteromedially. Distally it gradually attenuates and articulates with the medial tibia. Its length is 67 mm.

Comparison and discussion: This small dinosaur from Yansi unquestionably belongs to the Infraorder Pachycephalosauria due to the presence of a prefrontal, and its frontoparietal is particularly thickened with densely packed osseous tuberosities, which is consistent with the family Pachycephalosauridae.

Six genera and 12 species are known in the family: *Stegoceras* (*Troödon*) *edmontonensis*, *S. sternbergi*, *S. validus*, ?*S. formosus*, *S. bexelli*, *Pachycephalosaurus grangeri*, *P. reinheimeri*, *P. wyomingensis*, *Yaverlandia bitholus*, *Tylocephale gilmorei*, *Prenocephale prenes*, and *Homalocephale calathocercos*. Among the two former genera, with the exception of *S. bexelli*, the remaining species are all produced from the North American Late Cretaceous Belly River, Judith River, Edmonton, and Lance Fms. *Yaverlandia* is produced from the Early Cretaceous Wealden beds of the United Kingdom, and the latter three genera are from the Mongolian Late Cretaceous Khulsan and Nemegt Fms.

The principle characters of the genus *Stegoceras* are: small to moderate in size; frontoparietal region is moderate to extremely thick and generally developed to form a large, broad, spherical dome; osseous tuberosities superficially circumvent the cranium; supratemporal fenestra is small or completely sealed; facial region is short and deep; dentition is extremely acute; and the postcoronoid region of the mandible is short.

Pachycephalosaurus is produced exclusively from the Lance Fm. of North America. Its principle characters include being large with a thickened frontoparietal, osseous tuberosities are particularly well developed on the posterior cranium, supratemporal fenestra is completely sealed, and the facial aspect is shallow and narrow.

The characters for *Yaverlandia* include a thick but flattened cranium, a v-shaped groove on the cranial apex separates the cranium into two domes, the frontal participates in a portion of the orbit, and the supratemporal fenestra is reduced by the invasion of the postorbital.

Among the three genera produced from Mongolia, the former two genera have thickened and high crania with their apices on the posterior cranium, large osseous tuberosities are present, supratemporal fenestra is absent, infratemporal fenestra is short and broad, an antorbital fenestra is present, and the orbit is relatively long.

The cranium of *Homalocaphale* is thickened but completely flat, the apical surface is rugose but at its midpoint there is a smooth and flat surface, the supratemporal fenestra is large, there is a distinct parietal-frontal suture, and orbits are large and nearly circular.

From the characters and stratigraphic ranges of the genera above, the Yansi specimen most closely resembles *Yaverlandia* and *Homalocaphale*, and particularly the latter. Sympleiomorphies include an undomed cranium and relatively large supratemporal fenestra. But there are also numerous distinctions between these two genera and the Chinese specimen, as the latter is small, cranial tuberosities are distinct and densely packed, the postorbital is in contact with the frontal, the median crest is very slightly elevated, and the cranium lacks a v-shaped groove or a flat, smooth, apical surface. These characters thus justify the erection of *Wannanosaurus yansiensis* gen. et sp. nov.

With regard to the phylogenetic relationships of the Pachycephalosauria, Hulke (1881) regarded the closest taxon to *Stegoceras* to be *Hypsilophodon* based upon the morphology of the dentition. Subsequently, Gilmore (1924), recognizing the postcranial skeleton of *Protoceratops* to be typically ornithischian, also noted the resemblance of the skull to the Pachycephalosauria, and believed the two shared a relatively close relationship. Nopsca (1929) believed the pachycephalosaurian pelvic girdle resembled the primitive nature of the Ankylosauria, after which Brown and Schlaikjer (1943) thought the pachycephalosaur postcranial skeleton was closest to the Ceratopsia. Bohlin (1953) posited whether the Pachycephalosauria were related to the Nodosauria or other armored dinosaurs.

Galton (1971), in his description *Yaverlandia* from the Early Cretaceous of England, concluded that all taxa in the infraorder were primitive based upon the low cranial cap and large supratemporal fenestra, and consequently they more closely approached *Hypsilophodon*. However, Coombs (1972), based upon the presence of a palpebral, proposed that the pachycephalosaurs had a distinct relationship to the Middle Jurassic stegosaur *Scelidosaurus*. After a study of Mongolian specimens, Maryanska and Osmolska (1974) concurred with the conclusions of both Hulke and Galton, stating that because of the presence of premaxillary dentition and other shared cranial characters, the Pachycephalosauria perhaps represented the earliest lineage (Triassic) ancestral to the hypsilophodontids. And based upon the pubis not participating in the construction of the acetabulum, they erected a new infraorder for the family.

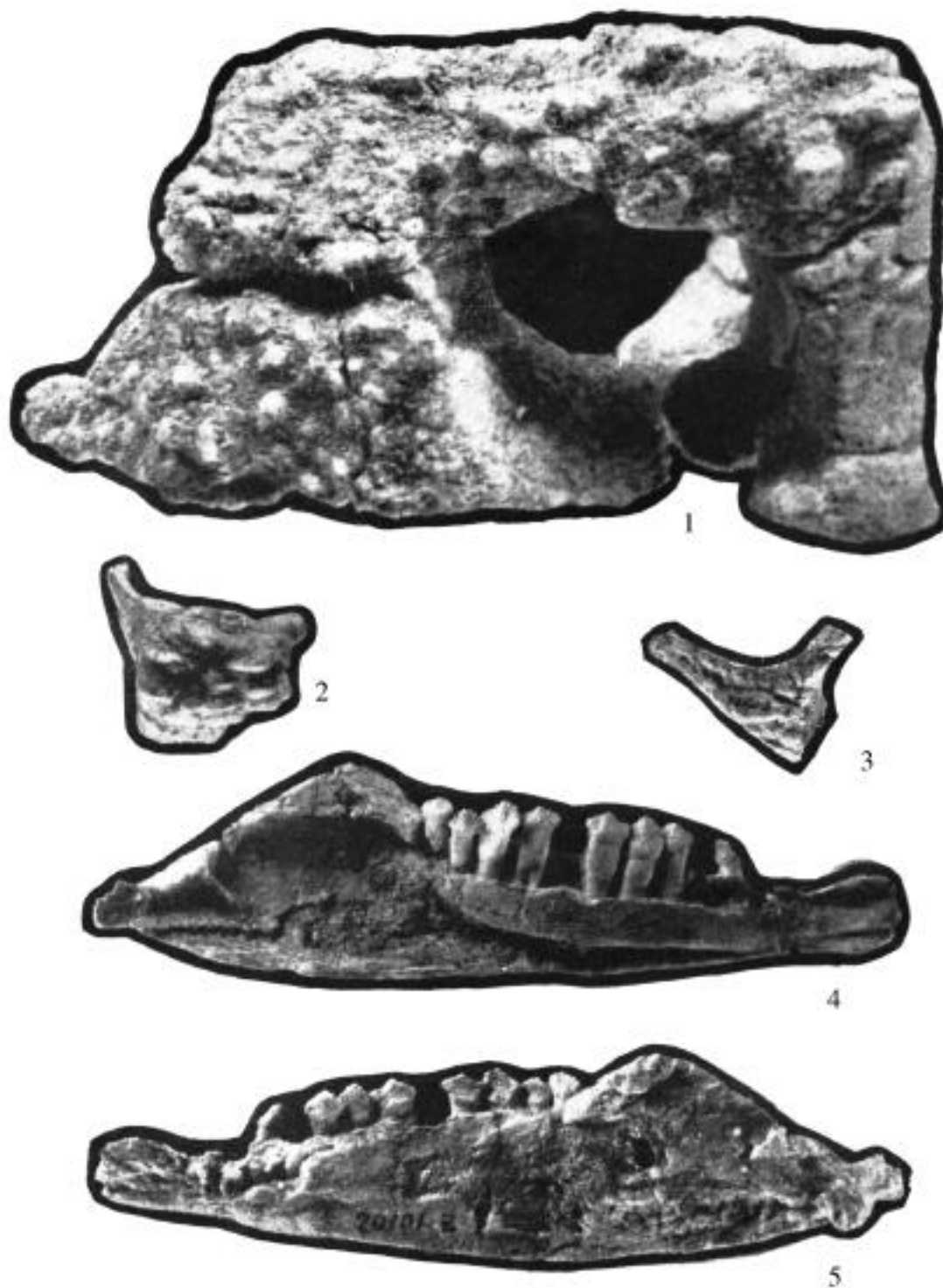
The Yansi pachycephalosaur is primitive, suggesting an intimate relationship to *Psittacosaurus* in its relatively high and thickened cranium, the presence of a large supratemporal fenestrae, a slightly laterally extended jugal, and relatively close morphology of the vertebral centra and limb bones.

Currently, geologists usually correlate the age of the Yansi Fm. to the Qujiang Fm. in Jiangxi Province, which produces theropod dinosaurs. In addition to the specimens described in this text, the Yansi Fm. has produced sauropod cervical vertebrae and portions of a pelvic girdle that are too fragmentary for a more precise diagnosis. Thus, based upon comparisons to the English and Mongolian specimens, the age of the Xiaoyan Fm. should be early Late Cretaceous.

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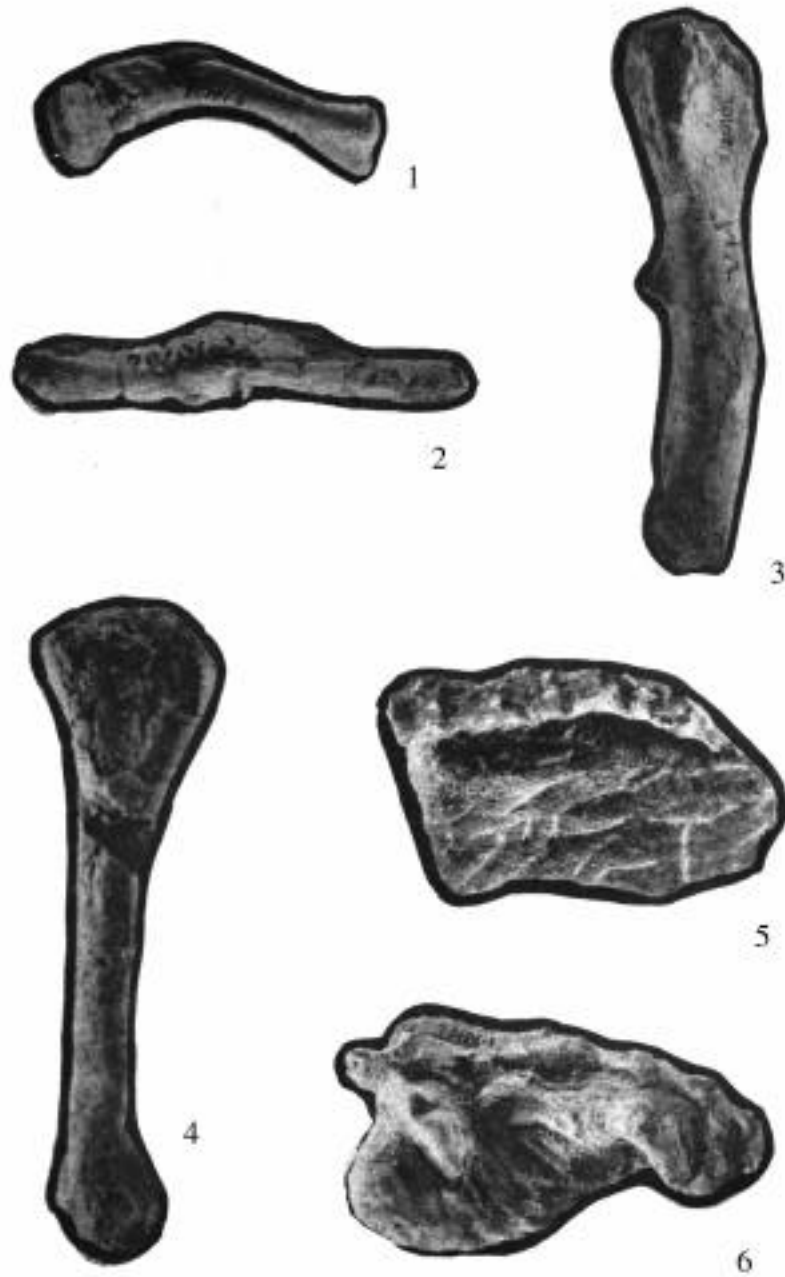
* Translator's note: Indicates the reference cannot be confirmed.



Wannanosaurus yansiensis gen. et sp. nov

1. Dorsal view of right posterior skull (x 3.5);
2. Dorsal view of left postorbital (x 2);
3. Dorsal view of left jugal (x 2);
4. Medial view of left mandible (x 2);
5. Lateral view of left mandible (x 2).

Plate II



Wannanosaurus yansiensis gen. et sp. nov

1. Lateral view of left humerus (x 1); 2. Lateral view of a portion of left ilium (x 2);
3. Lateral view of right femur (x 1); 4. Lateral view of right tibia (x 1); 5. Left lateral
view of caudal vertebra (x 1). 6. Lateral view of right pes with three claws (x 1).