Dinosaurs from the Cretaceous of South China

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From
Mesozoic and Cenozoic Red Beds of South China
Selected Papers from the "Cretaceous-Tertiary Workshop,"
Nanxiong, Guangdong Province

Edited by
Institute of Vertebrate Paleontology, Paleoanthropology
&
Nanjing Institute of Paleontology
Science Press, 1979
pp. 342-350

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August, 2002

Introduction

In 1961, the Guangdong Provincial Office of Geology conducted field work in the Nanxiong Basin where they collected a partial pes that was diagnosed by Young et al. (1962) to belong to the ?Coelurosauria. This represented the first documentation of dinosaurs in the "Red Beds" of South China and indicated that they represented the Mesozoic, attracting much attention from geologists and paleontologists. Following the initial survey of the Red Beds, continuous regional reports of fragmentary dinosaurs were published, although systematic excavations were not conducted, and consequently the distribution and precise age were left unknown.

Under the great Proletarian Cultural Revolution, the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) formed the South China Red Beds Survey with associates from related departments, conducting consecutive research in the provinces of Guangdong, Anwei, Henan, Zhejiang, Guangxi, Hubei, and Jiangxi. In addition to an abundant collection of Early Tertiary mammals, several dinosaur specimens were collected. In 1974, IVPP geologists continued research in the Nanxiong Basin, where they collected a set of relatively good specimens. This text is based upon these specimens and is an introduction to the dinosaurs from the South China Red Beds.

The Nanxiong Basin is one of the numerous basins that produces dinosaurs from the South China Red Beds. In addition to the material collected in 1974, this text describes additional specimens that have been collected during the several years of Nanxiong fieldwork. All specimens were collected from the Nanxiong Fm.

Specimen descriptions

Theropoda

Carnosauria

Tyrannosauridae

Tarbosaurus sp.

(Plate I, Figures 1 and 2)

Material: Two relatively complete teeth, a dorsal vertebra, and several fragmentary foot bones. Specimens were not collected from the same locality but they are provisionally assigned the same genus based upon morphology.

Description: The teeth are large and robust with serrated anterior and posterior margins. The largest tooth is a 72 mm in length but has lost its apex. It is relatively laterally compressed, laterally convex, and medially flat. Anterior serrations extend to the midpoint of the tooth with seven to eight serrations every five millimeters. Posterior serrations may reach the tooth base with eleven serrations every five millimeter span. Serration count, tooth morphology, and size approach *Tarbosaurus.*

Another tooth is relatively thickly rounded and elliptical in cross-section. The anterior and posterior serrations are asymmetrical, as on the anterior margin they occur more proximomedially and on the posterior margin occur more distomedially. The serrations reach the base of the crown on both sides. Because the serrations are asymmetrical this tooth is undoubtedly a third right premaxillary tooth.

There is only a single platycoelous dorsal vertebra which is medially constricted with shallow pleurocoels and resembles that of a large theropod.

Discussion: Coelurosaur specimens were described by Young (1962) from the Nanxiong Basin, although theropods are currently rare. The specimens described above undoubtedly represent a large carnosaur species with characters leading to the diagnosis of the family Tyrannosauridae. The Nanxiong teeth are smaller than *Tyrannosaurus* from the Lance Fm. of North America and cf. *T. rex* from the Wangshi Group, of Shandong Province. Lateral compression, size, and condition of serrations approach *Tarbosaurus* from the Late Cretaceous of Mongolia. Thus, the Nanxiong specimens are provisionally assigned to this genus based upon their morphology and biogeography.

Sauropoda

Homalosauropodidae

Atlantosauridae

Titanosaurinae

***Nanshiungosaurus* gen. nov.**

Diagnosis: As for species.

***Nanshiungosaurus brevispinus* sp. nov.**

(Plate II, Figure 1)

Diagnosis: A short neck with platycoelous anterior cervicals and opisthocoelous posterior cervicals, pleurocoels are undeveloped, neural spines are low, and the posterior series is not distinctly bifid. Cervical count is 12 and centra length is 2.5 times that of the dorsal centra. Dorsal count is 10 with platycoelous centra of equivalent height and length that have shallow pleurocoels. Neural spines are low and transversely broadened with a broad apex. Five well-fused sacral centra are present that have short unified neural spines with inflated apices and saddle-shaped depressions. The ilium is low with an extremely well-developed narrow and elongated preacetabular process, and the pubic peduncle is straight and robust. Pubis is linear with a thick lateral margin and closed obturator foramen. The ischium is thinly plate-shaped with expansive and fused distal ends. The acetabulum is large and circular.

Material: A string of articulated cervical, dorsal, and sacral vertebrae. Pelvic girdle is basically complete with the exception of the right ilium and pubis (V4731).

Locality and stratigraphic position: Upper Cretaceous Nanxiong Fm. at the village of Dapingcun, Shuikou Commune (Loc. 74015).

Description: The vertebral count may be accurately determined as: cervicals 11, dorsals 10, and sacrals 5. A single caudal is articulated with the sacral series. The atlas has been lost, but the axis is complete, represented by a platycoelous centrum that is 13.5 cm in length, medially constricted, has a relatiively circular posterior end, and pleurocoels that are shallow and located anteriorly, dorsal to the parapophyses. The odontoid process is firmly fused to the anterior centrum and has a semicircular depression ventrally to facilitate the atlas centrum. The neural arch is relatively low, with circular facets that articulate with the atlantal postzygapophyses. The neural spine ascends posteriorly. The axis centrum morphology resembles that of *Apatosaurus.*

Posterior to the axis, the cervical vertebrae gradually increase in length, the longest being Cv7-8 with a centrum length of 18 cm. Posterior to this point the centra again reduce in length. The anterior cervicals are platycoelus with shallow pleurocoels, but there is also an additional small ridge or angle. The ventral centrum is flat, slightly medially constricted, and there are two longitudinal crests on the margins causing the centrum to be nearly rectangular. The thick but flattened anterior parapophyses extend ventrolaterally to fuse tightly with the capitulum on the ribs. The neural arches are low, the prezygapophyses extend anteriorly, and the anterior lobes of the diapophyses extend ventrally and also obliquely laterally to form a plate for articulation with the tuberculum. This morphology is frequently noted in the Sauropoda. The postzygapophyses are short, the neural spines are low and thin, and the most posterior centra are opisthocoelous, although the posterior sulcus is extremely shallow. The neural spines are transversely broadened and are not distinctly bifid.

Ten relatively well-preserved dorsal vertebrae are present, with the exception of the eighth through tenth which have damaged centra. The centra are short, platycoelous, 7 cm in length, and have shallow pleurocoels, but the several most posterior pleurocoels have been lost. The parapophyses have been lost, and replaced only by vestigial circular facets on the anterior centrum. The neural spines extend high, the pre- and postzygapophyses are within the bounds of the centrum, the neural spines are particularly low, transversely broadened, and thick; and the apices have a thick tuberosity. The morphology and configuration of all the processes conform to the general condition of the Sauropoda. A ventral keel is present that becomes more prominent posteriorly. The several most posterior dorsal vertebrae are platycoelous, approaching the sacral morphology. The centra (including the neural arch) are well pneumatized, such that in cross-section they are honeycombed and infilled with matrix, which is another generalized sauropod character.

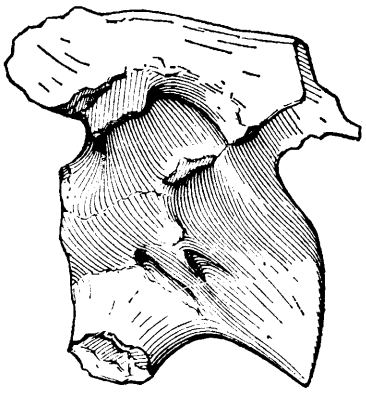

Figure 1. Cervical vertebra of *Nanshiungosaurus brevispinus* (x 1/4)

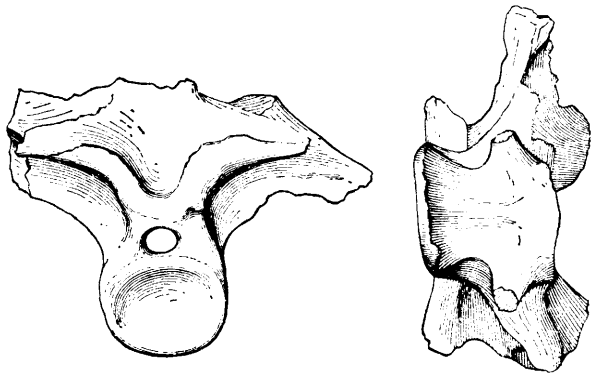

Figure 2. Cervical vertebra XII of *Nanshiungosaurus brevispinus* (x 1/4).

Five solidly fused sacral vertebrae are present that are longer than the dorsals, ventrally inflated, and have low, transversely broadened neural spines with thick apices bearing a depression. All five neural spines are fused in into a single longitudinal plate.

There is only a single gently amphicoelous caudal preserved which lacks its neural spine. Its height and length are equivalent.

Of the pelvic girdle, the right ilium and pubis are lost, and although the remaining is completely preserved, compressional distortion has caused lateral curvature of the left ilium. The ilium is long and low with an extremely well-developed preacetabular process that resembles the condition of the Stegosauria. The pubic peduncle is well developed, being broad and straight. The

pubis is linear with a thick lateral margin, and the ischial plate is relatively thin, expanded, and fused distally. The pubis and ischium are well fused, become compressed, and then extend posteriorly. The acetabulum is large and circular.

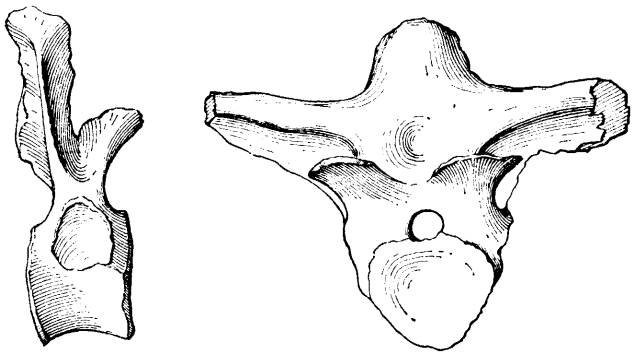

Figure 3. Third dorsal vertebra of *Nanshiungosaurus brevispinus* (x 1/4)

Comparison and discussion: The Nanxiong specimen is diagnosed as a member of the Sauropoda based upon the triradiate pelvic girdle, honeycombed internal structure of the vertebral centra, long cervical series with parapophyses ventrolaterally extended and strongly fused to the cervical ribs, and the neural spine height and foliate morphology. However, it also expresses some extremely autapomorphic characters, including the platycoelous centra, undeveloped pleurocoels, low and transversely expanded neural spines, and low ilium with an extremely well-developed preacetabular process. The undeveloped pleurocoel condition occurs in the subfamily Titanosaurinae, which is also characterized by rather short centra, low cervical neural spines that are bifid posteriorly, extremely small pleurocoels on the dorsal vertebrae, relatively broad and inflated dorsal neural spines, the presence of up to six sacral vertebrae, and a platycoelous first caudal. Forelimb-hind limb ratio is 3/4 and the limbs are straight and robust. This subfamily includes several Late Cretaceous genera that are rather rare and fragmentarily known in addition to being extremely autapomorphic, and consequently direct comparisons are difficult. Three genera are documented in Asia: *Titanosaurus, Antarctosaurus,* and *Nemegtosaurus*. The former two are from the Lameta beds of India and the latter from the Nemegt sediments of Mongolia, all of which are late Late Cretaceous.

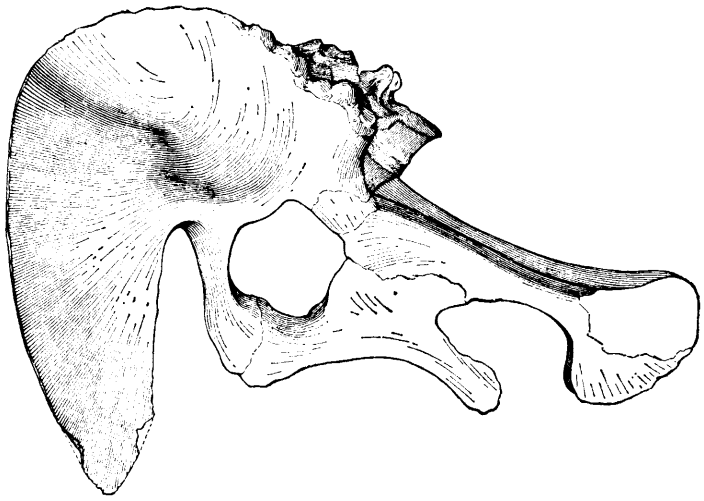

Figure 4. Pelvic girdle of *Nanshiungosaurus brevispinus* (x 1/10)

The authors who erected the genus *Nemegtosaurus* state that a complete skeleton is at hand, but because the details are still unpublished, further comparisons cannot be made here.

The two Indian genera are also documented from General Roca, Argentina, but detailed descriptions are also not available at this time, and abstracts state that the specimens are extremely depauperate, consisting principally of vertebral centra and several limb bones. A single titanosaur centrum is also recorded from southern France.

The genus *Titanosaurus* is rather close to the Nanxiong specimens. The description of this Indian genus was conducted rather long ago upon restricted specimens and the descriptions are brief. Regardless, the posterior cervical neural spines are bifid, the first caudal is amphicoelous, and the Type is larger than the Nanxiong specimen. The two are so distinct that it is obvious the Nanxiong specimen belongs to a new clade. However, due to the current lack of cranial and diagnostic apendicular material, the Nanxiong specimens are provisionally recognized in the subfamily Titanosaurinae, and erected as *Nanshiungosaurus brevispinus* gen. et sp. nov.

Appended description. Within the collections made previously is a massive humerus which is typically sauropod in morphology. Young, (1965) described a pedicellate tooth that undoubtedly belongs to a sauropod, or the superfamily Homalosauropodidae, with a morphology approaching the teeth of *Nemegtosaurus*. Thus, it may be determined that the Nanxiong Fm. produces a sauropod that has phylogenetic relationships with the Indian *Titanosaurus* and *Nemegtosaurus* from Mongolia and the Xinjiang Autonomous region.

Ornithischia

Ornithopoda

Hadrosauridae

***Microhadrosaurus* gen. nov.**

***Microhadrosaurus nanshiungensis* gen. et sp. nov.**

(Plate I, Figures 4 and 5)

Diagnosis: A rather small hadrosaur with a linear mandible, densely packed and planar dentition with vertical alveolae, and tooth count that does not exceed 45. The coronoid process is perpendicular to the mandible.

Material: A 13.2 cm long midsection of a left mandible collected by the Guangdong Provincial Regional Survey. IVPP specimen #V4732.

Description: The specimen is principally represented by a posterior dentary with linear dorsal and ventral margins, its lateral midsection is inflated, dorsal margin is thin, medioventral margin is thick, and the Meckelian groove penetrates anteriorly and gradually attenuates. The medial side is flatter than the general hadrosaurian condition, the dentition is densely packed, 19 perpendicular and parallel aligned dental rows are preserved, and the apex of the coronoid process is slightly expanded into a shovel-shape.

Comparison and discussion: It is appropriate to assign the specimen to the subfamily Hadrosaurinae based upon the flat and straight mandible and relatively low dentary, indicating that the mandible is rather narrow and thus, the cranium is correspondingly elongated. This is a relatively small individual, being probably only three meters in length, and representing the smallest species of hadrosaur known. It resembles the North American *Hadrosaurus* and Canadian *Anatosaurus* in its planar dentition and relatively densely packed tooth grooves, however the

former are much larger. Despite there being only a single mandible, it is sufficient to recognize that it represents a new taxon and is thus erected as *Microhadrosaurus nanshiungensis* gen. et sp. nov.

Age of the Nanxiong Dinosaur Fauna

The Nanxiong Fauna records the following taxa:

Carnosauria
- Coelurosauridae
  - Tyrannosauridae
    - *Tarbosaruus* sp.

Sauropoda
- Titanosaurinae
  - *Nanshiungosaurus brevispinus*

Ornithopoda
- Hadrosauridae
  - *Microhadrosaurus nanshiungensis*

Chelonia
- *Nanshiungchelys wachingensis*

Eggs
- *Oölithes spheroides*
- *Oölithes rugustus*
- *Oölithes elongatus*

There is a rather extensive distribution of fossil egg taxa in China that may generally be recognized as typical for Late Cretaceous sediments. Young (1963) studied fossil eggs from the red beds of Guangdong and Jiangxi provinces and concluded that they were correlative to those from the Wangshi Fm. of Shandong Province and the Erlian Fm. of Inner Mongolia. Both latter units contain abundant eggs and are correlated with the North American Belly River Fm. (Campanian). Within the Nanxiong Fm., *Tarbosaurus* and *Microhadrosaurus* are considered typical for the Late Cretaceous although *Nanshiungosaurus brevispinus* is extremely autapomorphic and probably represents a member of the Titanosaurinae, approaching the genus *Titanosaurus* produced from India and the Late Cretaceous Senonian Stage of Argentina. *Nanshiungosaurus* may be related to the Mongolian *Nemegtosaurus* (based only on two teeth). In this manner the Nanxiong fauna is correlative with those from the Mongolian Nemegt Fm. and the Subashen Fm. in the Turpan Basin of Xinjiang. The former is recognized as Campanian-Maastrichtian. The Nanxiong Fm. is thus correlated to the Senonian or Campanian.

Chongren Co., Jiangxi Province

In 1973, dinosaurs were discovered by villagers at Shangang approximately 2.5 km south of Chongren County seat, who informed the IVPP Red Bed Survey and then assisted in making a collection. The specimens include a string of nine articulated caudal vertebrae that can only be diagnosed to the order Saurischia and were produced from coarse calcareous sandstones of the Nanxiong Fm. These vertebrae represent the midsection of a tail, as the centra are amphicoelous with their anterior ends more gently depressed, ventrally there is a shallow longitudinal trough, laterally there is a crest, and the neural arch lies on the anterior half of the centra. This morphology is consistent with the subfamily Titanosaurinae, but more complete diagnostic material is required prior to confirming whether or not it is conspecific with *Nanhsiungosaurus brevispinus.* However, these characters are also distinctly consistent with the Indian *Titanosaurus indicus* (Huene, 1933, Fig. 3) further confirming its subfamily diagnosis.

Luanchuan Co., Henan Province

In 1972, cadres and villagers from the Songping Brigade, Songba Commune, Luanchuan Co., Henan, were constructing a small reservoir in the Tantou Basin when they encountered fossil bone representing the first record of dinosaurs on the central China plane. The specimens were excavated from brown-red conglomerates bearing gravelly and muddy sandstones. Historically, this stratigraphic unit has been generally assigned to the Early Tertiary, and designated the Tantou Group. The dinosaurs now provide evidence that the Tantou Group includes Late Cretaceous sediments. In 1974, Renjie Zhai and colleagues conducted stratigraphic subdivisions and recognized the unit producing dinosaurs as basal Unit (Fm.) I. Five carnosaur teeth were collected and are described as follows (V4733).

Carnosauria

Tyrannosauridae

Tyrannosaurus

***Tyrannosaurus luanchuanensis* sp. nov.**

(Plate III, Figure 3)

Description: Five extremely well-preserved teeth are represented that have black-red coloration and are massive with slight curvature. The largest specimen is 110 mm. Among the five specimens is a premaxillary tooth with two parallel serrated margins, tending to be incisiform. The remaining characters resemble those of the North American forms, thus their unqualified generic assignment. Despite the evidence consisting only of a few teeth, they undoubtedly belong to the Asian Tyrannosauridae and thus they are erected as *Tyrannosaurus luanchuanensis* sp. nov.

In 1974, during their work in western Henan, the Henan Regional Survey documented dinosaur eggs in the Xixia and Xichuan basins from a set of red sandstones that they erected as the Majiacun Fm. (previously, these sediments were provided with nomenclature from neighboring Hubei Province: the Paomagang Fm.). In addition to eggs, hadrosaurian cervical and caudal vertebrae were documented (Plate I, Figs. 6, 7). Although the material is restricted, it is enough to confirm a Late Cretaceous age for the Majiacun Fm.

Prior to 1972 there were no reliable dinosaur specimens found regionally. But in recent years there have been consecutive discoveries made in the western Henan and eastern Hubei regions, although systematic excavations have yet to be conducted. Indications suggest that abundant dinosaur eggs are present.

Anwei Province

The Xiaoyan Fm. in southern Anwei has produced a small pachycephalosaur that was described by Hou (1977) as *Wannanosaurus yansiensis* gen. et sp. nov. In North America, the pachycephalosaurs from the Lance, Edmonton, and Belly River Fms. are all Late Cretaceous. The earliest record of the suborder is *Yaverlandia* from the Wealden Stage of the United Kingdom. In more recent years, several well preserved specimens have been excavated from the Late Cretaceous of the Mongolian Nemegt Basin, but the closest form to the Anwei specimen is the genus *Homalocephale.* Although the cranium of this dinosaur is extremely autapomorphic, the postcrania is distinctly primitive, and this is also expressed in *Wannanosaurus.* Its age is also currently recognized as Late Cretaceous. The Xiaoyan Fm. also produces fragmentary sauropod cervical vertebrae.

Zhejiang Province

Young (1962) described dinosaur specimens from the Pujiang region of Zhejiang. But because the origin of the specimens is unknown, the locality and stratigraphic position are suspect.

In 1972, the Zhejiang Regional Survey discovered dinosaurs at Zhongdai Commune, Tangxi Co., in the Qujiang Basin. Subsequently, the Zhejiang Provincial Museum excavated a fragmentary right tibia and relatively complete hind foot from the second member of the Fangyan Fm. Although the specimens are not ideal, they provide an assignment to the Megalosauridae as described below.

Megalosauridae

Chilantaisaurus

Chilantaisaurus zheziangensis sp. nov.

Description: A right proximal tibia is preserved that is gray-white in coloration. The walls of the shaft are extremely thick, and the cnemial crest is laterally projected causing the triangular shape of the proximal end. Incomplete metatarsals II, III, and IV are preserved but are not fused as in the condition of the Tyrannosauridae, are also not modified in morphology, and the phalangeal formula is not completely reduced. The unguals are large, the first ungual is flattened, recurved, and morphologically resembles *Chilantaisaurus tashuikouensis* from Inner Mongolia in its robusticity, intense symmetrical curvature, extremely acute end, extreme lateral compression, distinct lateral ligament groove on each side, and its consistency in size.

Comparison and discussion: In general morphology, this large carnosaur is more robust than *Antrodemus valens* from North America. Its primitive (unfused) metatarsals allow a diagnosis to the Megalosauridae, and its massive laterally compressed unguals resemble the Asian genus *Chilantaisaurus* although these are slightly more robust than on the Inner Mongolian genus. Thus morphologically and biogeographically it probably represents a new species and is thus erected as *Chilantaisaurus zheziangensis.*

This genus is currently represented at two stratigraphic levels: the late Early Cretaceous *C. maortuensis* and the early Late Cretaceous *C. tashuikouensis*. Because of its primitive characters, *C. zheziangensis* indicates that the Fangyan Fm. is more appropriately recognized as late Early Cretaceous and is thus correlated with the Early Cretaceous Alashan Fauna, or Aptian-Albian Stage.

Hunan Province

Dinosaurs are still scarce in the extensively distributed red beds of Hunan. The first record was made by the Hunan Regional Survey, which documented two coelurosaurian teeth from Shexing, Hengyang Co. The teeth are extremely small, laterally compressed, and serrated on both the anterior and posterior margins. In addition to the teeth is a foot bone which should also belong to this family. Only a Cretaceous age can be determined at this time.

In 1974, the Hunan Brigade of the IVPP South China Red Bed Survey collected two dinosaur teeth and fossil eggshells from a measured cross-section in the Muheling region of the Chaling Basin from the Late Cretaceous Daijiaping Fm.

Additionally, the Qijiahe Fm. in Changde Co. produced carnosaur teeth and several fragmentary bones that are diagnosed to the Megalosauridae. More advanced stratigraphic study is required in these basins.

Fusui Basin, Guangxi Province

Excavations have been conducted in the Fusui Basin, Guangxi, but the specimens are weathered and preservation is poor. *Asiatosaurus kwangshiensis, Prodeinodon kwangshiensis* and the plesiosaur *Sinopliosaurus fusuiensis* are documented. This fauna has been correlated with the *Psittacosaurus* Fauna in North China.

In 1975, during an agricultural development project, villagers of the Napai Brigade made a collection of relatively well-preserved fossils. Preliminary diagnosis indicates a primitive member of the Ornithopoda, advancing the age of the Napai Fm. to Early Cretaceous.

Conclusions

South China Cretaceous dinosaurs are extremely widely distributed, but due to the current absence of systematic collections, only preliminary work has been conducted. The following conclusions are made based upon the available data.

1. In the widely distributed South China Red Beds, there are two biochronologically distinct dinosaur faunas present. The first is the Early Cretaceous fauna from the Napai and Fangyan Fms. in Guangxi and Zhejiang provinces which approaches the *Psittacosaurus* Fauna that is extensively distributed in North China. Its age is Aptian-Albian or slightly younger. Despite the low quantity of data, it is sufficient to document the presence of Early Cretaceous sedimentation in South China.

2. The second is a Late Cretaceous dinosaur fauna that is rather extensively distributed in the red beds of South China although systematic research has yet to be undertaken. Preliminary indications are that elements share a distinct relationship with Late Cretaceous faunas on the southern continents. This differs markedly from the current generally accepted concepts.

3. The distribution of fossil eggs is extensive, they are easily collectible, and currently may be regarded as index fossils.

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Explanation of plates

Plate I

1. Premaxillary tooth of *Tarbosaurus* sp. from Nanxiong Co., Guangdong Province (x 1).
2. Tooth of *Tarbosaurus* sp. from Nanxiong Co., Guangdong Province (x 1).
3. Dorsal vertebra of Theropoda indet. from Nanxiong Co., Guangdong Province (x 1).
4. Medial view of *Microhadrosaurus nanshiungensis* gen. et sp. nov. mandible from Nanxiong Co., Guangdong Province (x 1/4).
5. Lateral view of *Microhadrosaurus nanshiungensis* gen. et sp. nov. mandible from Nanxiong Co., Guangdong Province (x 1/4).
6. Cervical vertebra of Ornithopoda indet. from Luanchuan Co., Henan Province (x 2/3).
7. Caudal vertebra of Ornithopoda indet. from Luanchuan Co., Henan Province (x 1)
8. Tooth of Coelurosauridae indet from Xingning Co., Guangdong Province (x 1).
9. Tooth of Pliosauria from Yuanma Co., Hunan Province (x 2).

Plate II

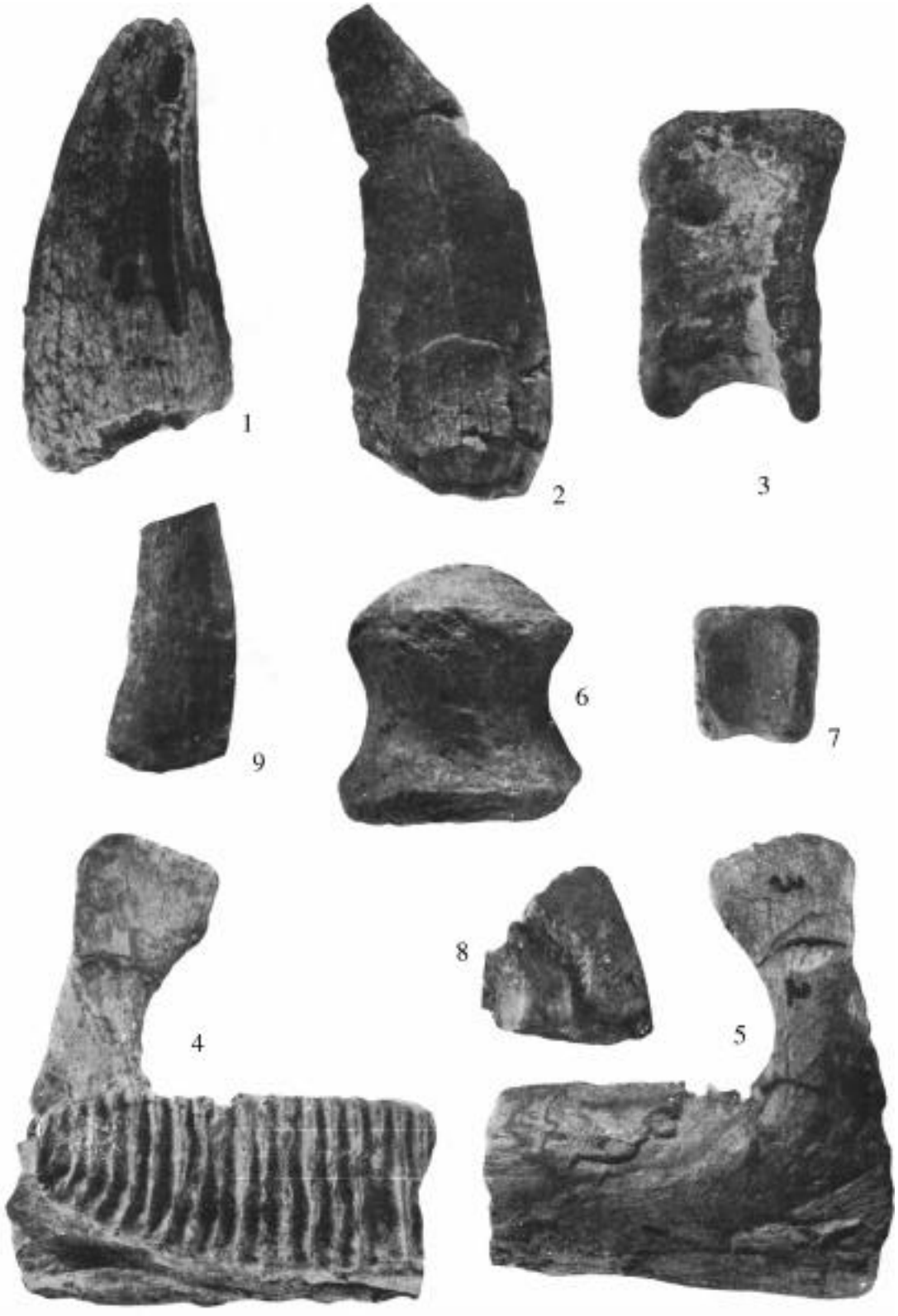
Nanshiungosaurus brevispinus gen. et sp. nov. from Nanxiong Co., Guangdong Province.

1. Ventral view of cervical vertebrae VII or VIII (x 1/4)
2. Posterior view of cervical vertebrae XII (1/4).
3. Anterior view of dorsal vertebra (x 1/4)
4. Skeleton.

Plate III

1. Ungual phalanx of *Chilantaisaurus zheziangensis* sp. nov. (x 1/3).
2. Digits II and III of *Chilantaisaurus zheziangensis* sp. nov. (x 1/3).

3 - 5. Teeth of *Tyrannosaurus luanchuanensis* sp. nov. (x 1).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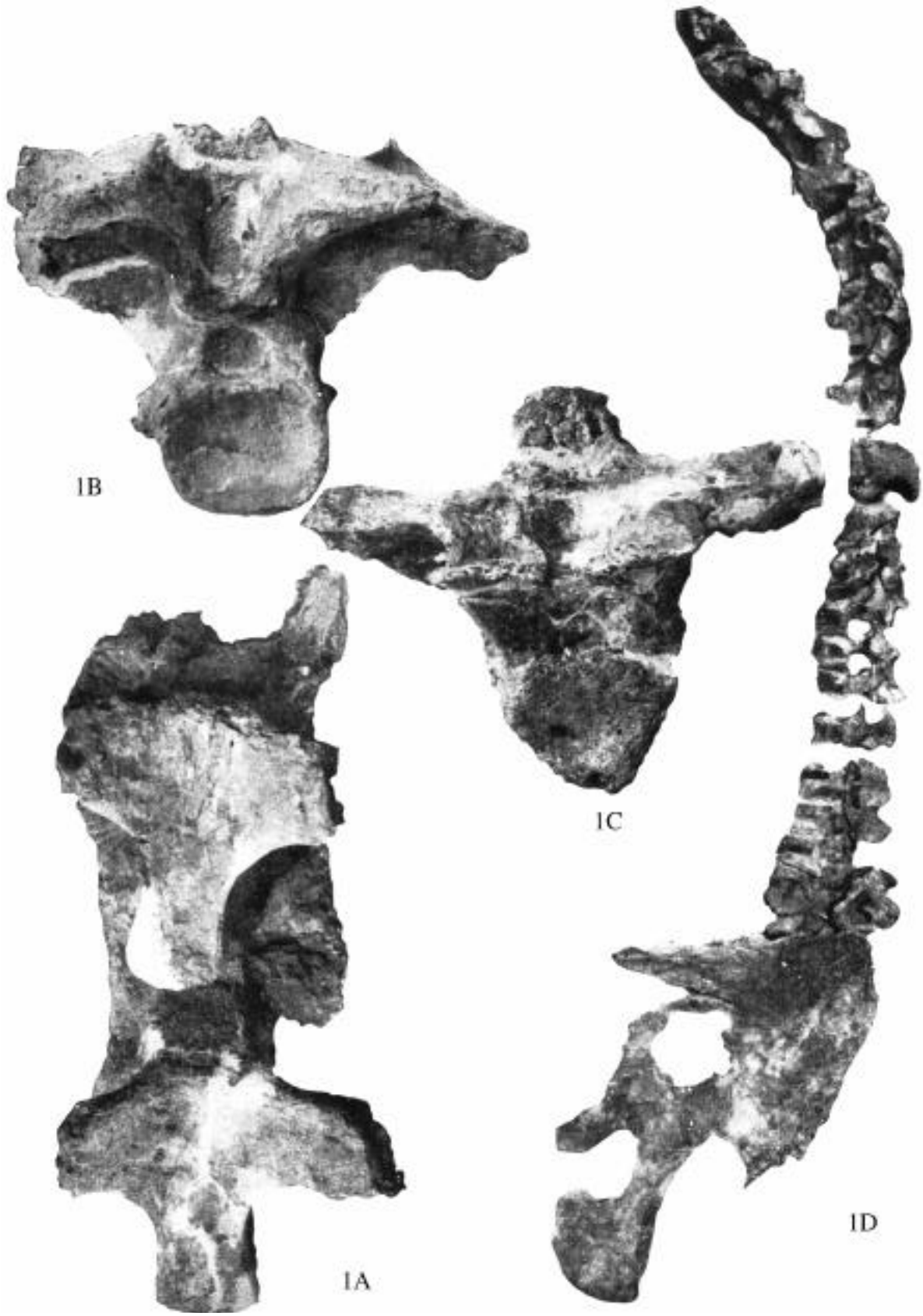
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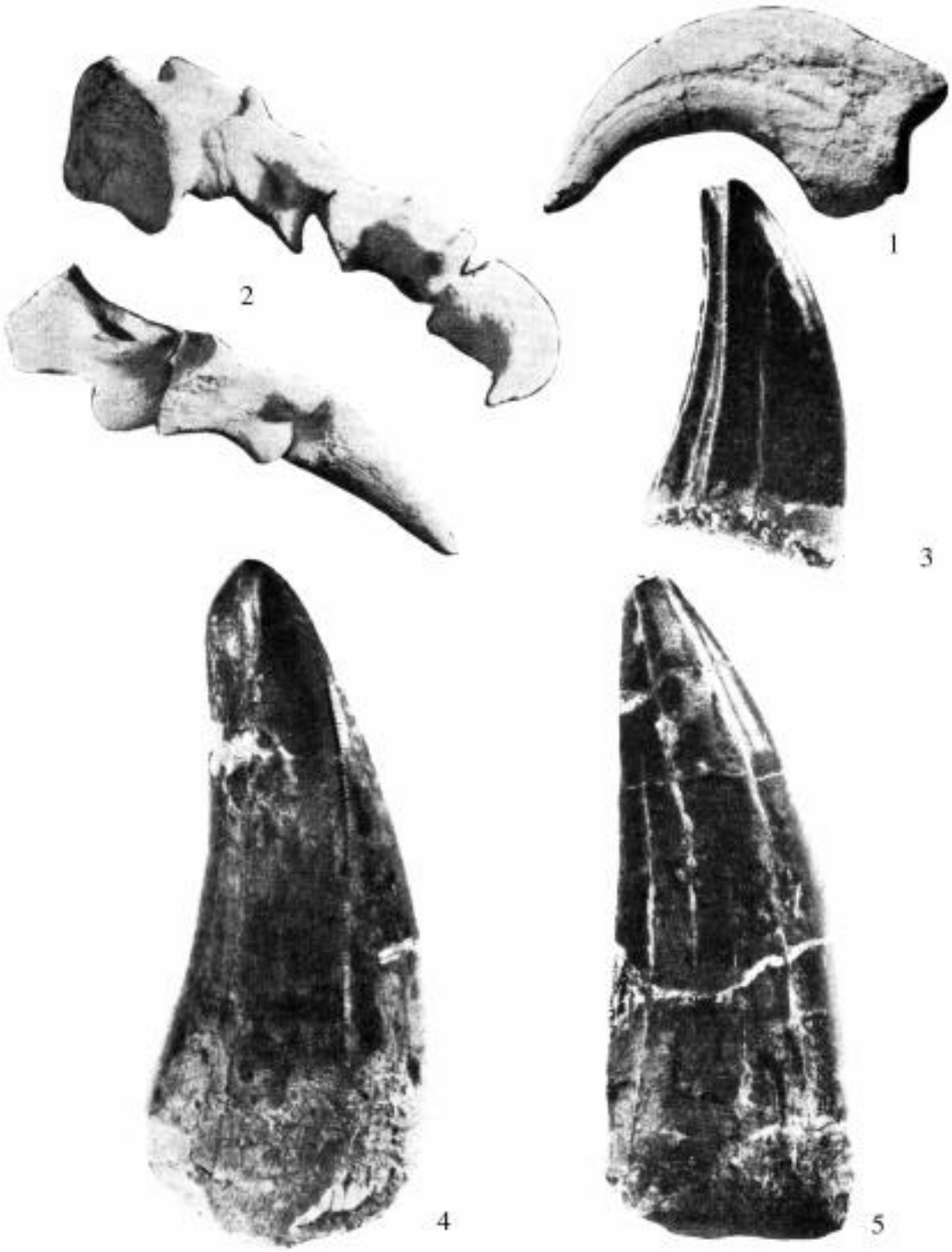
1A
1D


1
2
3
4
5