

内蒙古上白垩统二连组发现一新镰刀龙类¹⁾

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摘要 镰刀龙类化石主要分布于亚洲白垩纪地层 (Russell and Dong, 1993; Xu et al., 1999a; Kirkland and Wolfe, 2001)。最近发现于内蒙古上白垩统二连组的杨氏内蒙古龙 (*Neimongosaurus yangi*) 代表这一类群中较为原始的属种 (张晓虹等, 2001)。通过研究产自同一化石地点的镰刀龙类新材料, 我们鉴定出一个不同于杨氏内蒙古龙的新属种, 美掌二连龙 (*Eriansaurus bellamanus* gen. et sp. nov.)。

依据以下特征将 *Eriansaurus bellamanus* 归入镰刀龙超科: 肩胛骨干远端狭窄、肱骨近端角状、肱骨有后转子、肱骨的尺骨髁和桡骨髁位于肱骨干前部、肠骨髁白后支远端加厚、距骨髁小和腓骨近端后缘窄。 *Eriansaurus bellamanus* 的以下自近裔特征区别于其他镰刀龙类: 前部尾椎具加大的滋养孔、肱骨后转子峭状、肱骨后转子内侧有一卵形凹陷、肠骨外侧面坐骨柄上方有一多皱的肿状突起、腓骨近端后缘明显高于前缘以及腓骨前转子大、位置靠远端。

本文对镰刀龙类的系统关系进行了初步的分析, 结论如下: 北票龙 (*Beipiaosaurus*) 代表除 *Eshanosaurus* 外最原始的属种, 它没有以下一些其他镰刀龙类的进步性状: 掌爪近端深、胫骨短于股骨、非常短的趾骨以及第一趾骨关连附骨。 *Eriansaurus*、*Alxasaurus*、*Neimongosaurus* 和 *Nothronychus* 比 *Beipiaosaurus* 和 *Eshanosaurus* 进步, 但比镰刀龙科原始, 它们没有镰刀龙科的一些进步特征: 肠骨的髁白前支深而后卷、肠骨背缘平直和极其狭窄的足爪。 *Eriansaurus* 的肱骨也有一些原始特征, 比如较平的尺骨髁和桡骨髁之间的槽较宽。相比而言, *Eriansaurus* 比 *Alxasaurus*、*Neimongosaurus* 以及 *Nothronychus* 要进步一些, 它具有以下一些进步特征: 背椎和尾椎侧凹缺失、肱骨有后转子、肠骨髁白后支短。但是其他一些特征的分析则支持 *Eriansaurus* 的系统位置可能和 *Neimongosaurus* 较为接近的假说, 二者共享一些独特的性状, 比如肱骨干中部有一卵形凹陷、肠骨髁白上峭侧向发育以及腓骨峭长。 *Eriansaurus* 同时和其他一些镰刀龙类的属种也共享一些进步特征: *Eriansaurus* 腓骨的前转子侧向延伸, 这一特征类似于 *Beipiaosaurus* 和 *Nothronychus*; *Eriansaurus* 和 *Nothronychus* 以及 *Segnosaurus* 也共享一些进步的相似性, 比如腓骨前转子的位置在腓骨干中部。

有关 *Eriansaurus* 准确系统位置的确定有待于一个定量的分支系统学分析。但初步的结论表明它的系统位置处于原始的镰刀龙类和进步的镰刀龙科的成员之间。 *Eriansaurus* 的发现为镰刀龙类的分异提供了重要信息。

关键词 内蒙古苏尼特左旗, 上白垩统, 镰刀龙类

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A NEW THERIZINOSAUROID (DINOSAURIA, THEROPODA) FROM THE UPPER CRETACEOUS IREN DABASU FORMATION OF NEI MONGOL

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Abstract A partial skeleton is described from the Upper Cretaceous Iren Dabasu Formation of Nei Mongol that represents a new therizinosauroid theropod, *Erliansaurus bellamanus* gen. et sp. nov. Distinctive characteristics of the new species include enlarged nutritional foramen on anterior caudals, prominent crest-like posterior trochanter on the humerus bordered medially by an oval depression, rugose swelling located dorsal to the ischiadic peduncle on the lateral surface of the ilium, posterior margin significantly higher than anterior margin on the fibular proximal end, and distally located hypertrophied anterior trochanter on the fibula. Preliminary analysis suggests that *E. bellamanus* represents an intermediate taxon between the primitive therizinosauroids and the advanced Therizinosauroidae. The discovery of *E. bellamanus* provides important information regarding the diversity within Therizinosauroidae.

Key words Sunitezuoqi, Nei Mongol, Upper Cretaceous, Therizinosauroidae

1 Introduction

Therizinosauroids are a group of theropod dinosaurs that have an unusual combination of characters (Perle, 1979, 1980, 1982; Barsbold, 1983; Barsbold and Perle, 1980; Clark et al., 1994; Xu et al., 1999a). The fossil records are distributed in the Jurassic and Cretaceous of China, the Upper Cretaceous of Mongolia, and the Lower Cretaceous of North America (Zhao and Xu, 1998; Xu et al., 2001; Zhang et al., 2001; Kirkland and Wolfe, 2001). The recovered fossil remains are limited and mostly fragmentary. In 1999, an expedition team from the Department of Land Resources of Nei Mongol excavated at Sanhangobi in Nei Mongol Autonomous Region. We have reported a new therizinosauroid taxon, *Neimongosaurus yangi*, from a locality in this area, which provides important data for determining the phylogenetic relationships of this derived subgroup within Coelurosauria (Zhang et al., 2001). Recent work suggests that a second therizinosauroid species is present together with *N. yangi* at the same locality. In present paper we will describe this new taxon based on a partial skeleton which includes five vertebrae, left forelimb lacking the carpus (humerus, ulna, radius, manus), partial right ilium and fragments of the ischium and pubis, right femur, both tibiae, right fibula, and some partial metatarsals. Most of the manus and hind limb were found in articulation and other bones were isolatedly preserved in the quarry; however, the proportions of the elements recovered suggest that the materials represent a single individual.

Institutional abbreviations: LH, Long Hao Geologic and Paleontological Research Center, Department of Land Resources of Nei Mongol, Hohhot.

2 Systematic paleontology

Theropoda Marsh, 1881
Coelurosauria Huene, 1914
Therizinosauroidae (Maleev, 1954)

The superfamily Therizinosauroidae is defined here as: all coelurosaurs closer to *Therizinosaurus*

than to either *Ornithomimus*, *Oviraptor*, *Velociraptor* or Neornithes. Therizinosauridae is redefined here as: common ancestor of *Segnosaurus*, *Erlikosaurus*, *Nanshiungosaurus*, *Therizinosaurus* and all descendants.

Genus *Erliansaurus* **nov.**

Type species by monotype *Erliansaurus bellamanus* sp. n.

Diagnosis As for the species.

Etymology “Erlian”, the larger geographical area that includes the type locality; “saurus”, meaning “lizard” (Greek).

Erliansaurus bellamanus **gen. et sp. nov.**

(Figs. 1~2)

Holotype A partial skeleton preserving much postcranial (LH V 0002).

Type locality and horizon Sanhangobi, Sunitezuoqi, Nei Mongol Autonomous Region (20km southwest of Erlian city); Iren Dabasu Formation (Senonian). The fossils were collected in fluvial sandstones of the Upper Cretaceous Iren Dabasu Formation, which has yielded a diverse dinosaurian fauna, including the hadrosaurids *Bactrosaurus* and *Gilmoresaurus* and the theropods *Archaeornithomimus*, *Avimimus*, and *Alectrosaurus*. This formation is now regarded Late Cretaceous (Senonian) in age (Currie and Eberth, 1993).

Etymology “bellamanus” (bellus, beautiful; manus, hand; Latin), for the well preserved manus of the holotype.

Material Only the holotype (LH V 0002) is known, including five vertebrae, left forelimb lacking the carpus, partial right ilium and fragments of the ischium and pubis, right femur, both tibiae, right fibula, and some partial metatarsals.

Diagnosis Differs from all other therizinosauroids in having enlarged nutritional foramen on anterior caudals, crest-like posterior trochanter on humerus bordered medially by an oval depression, rugose swelling located dorsal to ischiadic peduncle on lateral surface of ilium, posterior margin significantly higher than anterior margin on fibular proximal end, and distally located hypertrophied anterior trochanter on the fibula.

Description *E. bellamanus* represents a small sized therizinosauroid, with a femur length of 412mm. It is slightly larger in size than *N. yangi*, a therizinosauroid from the same fauna. However, extremely weak suture between the centrum and arch on one of the anterior caudals suggests the holotype of *E. bellamanus* might be ontogenetically younger than that of *N. yangi* in which the centrum and arch are completely fused on all preserved vertebrae, thus the size difference of the fully grown individual of *E. bellamanus* and *N. yangi* might be even bigger.

The axial column is represented by five vertebrae. Two represent cervical vertebrae, one is an anterior dorsal vertebra, and the last two are anterior caudal vertebrae. The posterior cervical centrum is trapezoidal and has a large pleurocoel that occupies much of the lateral surface of the centrum. Robust parapophyses project from the centrum ventral to the pleurocoel. The oval articular surface for the rib is large, measuring 14mm dorsoventrally and 17mm anteroposteriorly and located ventral to the pleurocoel. As in *N. yangi*, a hypapophysis is developed as a median keel, which becomes more robust toward the anterior end of the centrum, projecting 8mm below the rim. The anterior dorsal vertebra is incomplete anteriorly. The posterior face is more strongly concave. When the posterior face is held in a vertical plane, the centrum angles anterodorsally at about 30 degrees. The lateral surface of the centrum has a shallow depression, but there is no development of a pleurocoel. This appears to be quite different from that in *N. yangi*, where the pleurocoel is maintained as a deep pocket at least as far posteriorly as the middle dorsals. There is some possibility that the centrum belongs to an anterior caudal, in which case the absence of the pleurocoel

would not be unusual. The two anterior caudals (Figs. 1A ,B) numbered as Cd1 and Cd2 here. Cd1 is larger than Cd2 in size. Its centrum is amphicoelous ,the anterior face more strongly concave than the posterior one. A large ,oval ,sharp-rimmed nutritional foramen is present ,measuring 5mm in length and positioned just anterior to the middle of the centrum (Fig. 3A) . A weak ventral groove appears to be present on

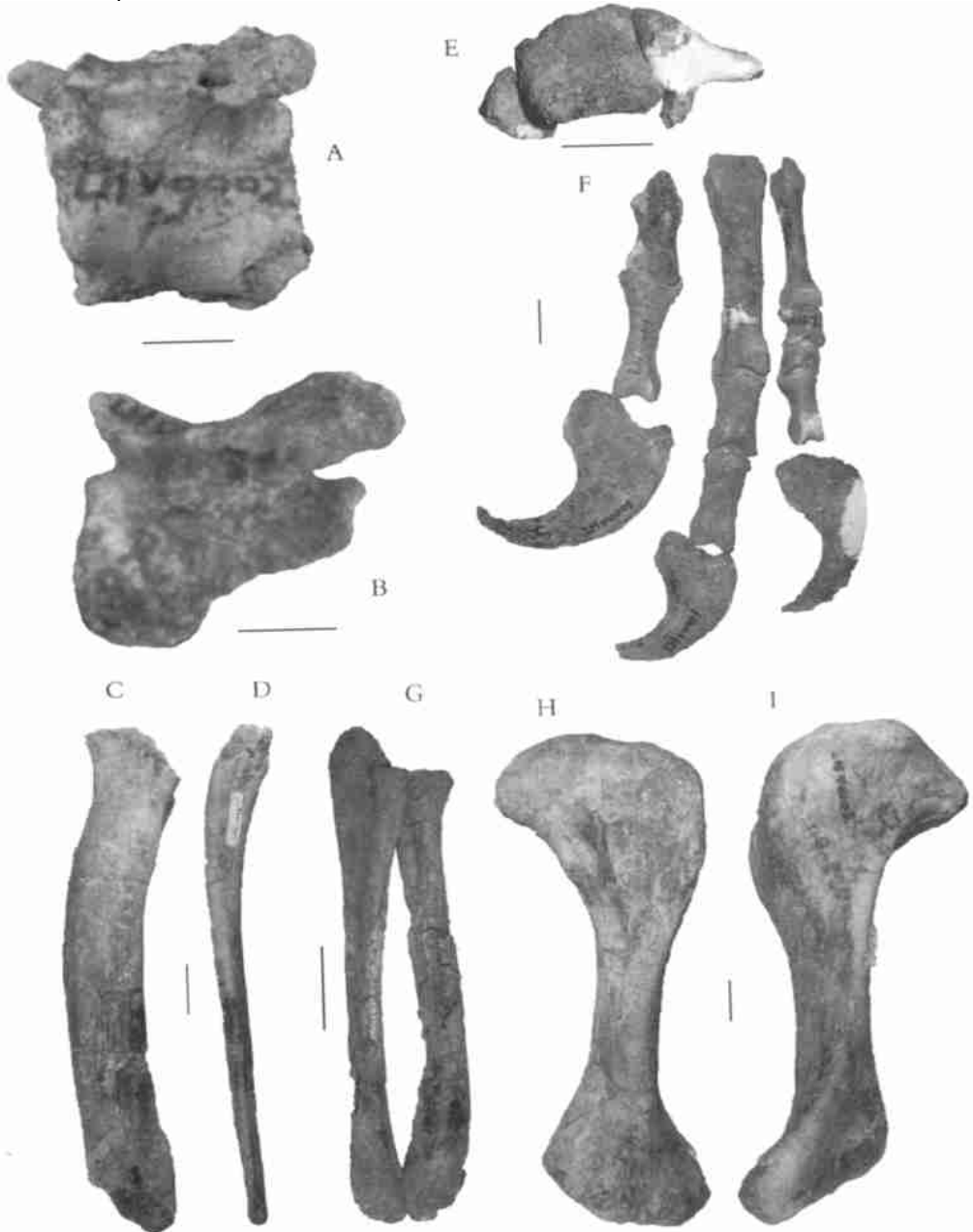


Fig. 1 *Eriansaurus bellamanus* gen. et sp. nov. (LH V 0002) ,scale bar 2cm

A ~ B. Two anterior caudal vertebrae in left lateral view ;C ~ D. Right scapula in lateral and ventral views ;
E ~ F. Left manus in proximal and dorsal views (unguals in side view) ;G. Left radius and ulna in anterior view ;
H ~ I. Left humerus in anterior and posterior views

the posterior half of the centrum. The broken base of the transverse process shows that it was robust, and a web of bone connects the anterior margin of the process with the prezygapophysis, as in other therizinosauroids. Cd2 is similar in morphology to Cd1 except that the transverse process is more ventrally located than that of Cd1.

The right scapular blade is preserved lacking only the distalmost corner (Figs. 1C,D,3C). It is strap-shaped and oval in cross-section. In lateral view the blade is gently arched; in dorsal or ventral view, the blade is straight. Just distal to the acromial expansion, the blade is constricted in lateral view, with a width of 33mm; distal to the constriction it is wider, with the parallel dorsal and ventral margins; further distally the blade becomes narrow, with a width of 33mm as in the proximalmost constricted portion; close to the distal end, the blade bears a ventral flange that makes the distal end appear dorsoventrally expanded (Fig. 3C); however, the distal end appears to be narrower than the preceding portion. In ventral view, the blade is wide and flat distal to the acromial expansion, and its ventrolateral edge is present as a sharp ridge (Fig. 1D). Near the distal end, the ventral margin is sharp.

The forelimb is nearly complete except for the carpus. The humerus shows some derived features common to other therizinosauroids, such as the hypertrophied medial tuberosity (Figs. 1H,I, 3E,F), an anterior tuberosity on the distal end of the humerus proximal to the ectepicondyle (Figs. 1H,3E), the ventrolateral angle of the distal end of the humerus (Figs. 1I,3F), and the ulnar and radial condyles located on the anterior aspect of the distal end. It differs from other therizinosauroids in some other features. The posterior trochanter is developed as a vertical crest 25mm in length with a wedge-shaped cross-section (Figs. 1I,3F), medial to which is a shallow depression. The ulnar and radial condyles is relatively flat and the flexor groove is shallow and wide (Figs. 1H,3E).

The ulna is primitive compared to that of advanced coelurosaurs such as dromaeosaurids. A stout triangular olecranon process projects proximally (Fig. 1G). The proximal articular surface of the ulna is divided between the olecranon process and a narrow coronoid process. The ulnar shaft is straight. The distal end gradually expands in width and is slightly compressed anteroposteriorly. There is about 30 degrees of rotation between a proximal axis running anteroposteriorly through the olecranon, coronoid process and a distal axis through the flattened distal end. A subtriangular articular surface is present distally for articulation with the radius.

The radius is approximately 80 percent the length of the humerus (Table 1). The proximal end is oval and the articular surface is concave. The distal third of the shaft is flattened on its posterolateral side, with a sharp margin on the shaft laterally and a more rounded margin medially.

Metacarpals F III are preserved. A fossa is present on the lateral side of the base of metacarpal III. Metacarpal I has a triangular proximal articular surface (Fig. 1E). A trough on the posterior side of the base was probably continuous with the trough of the semilunate carpal, as in other tetanurans. The flattened facet for articulation with metacarpal II extends for about 20mm along the lateral aspect of the base, or approximately 40 percent of the length of the metacarpal (Fig. 1F). The distal condyles are rotated approximately 25 degrees from the horizontal, when the articular facet for metacarpal II is held vertically. The medial distal condyle is larger than the lateral distal condyle, which is offset dorsally and distally. Medial and lateral collateral ligament pits are very shallow, and the dorsal extensor pit is very poorly developed (Fig. 1F). Metacarpal II has a large subrectangular proximal articular surface (Fig. 1E). Distally, the medial condyle is slightly larger than the lateral condyle. Although there is no development of a dorsal extensor pit, the proximal phalanx can extend to an angle of about 45 degrees above the horizontal. Metacarpal III articulates on the posterolateral corner of metacarpal II and has a small subtriangular proximal articular surface (Fig. 1E). The medial aspect of the shaft contacts metacarpal II for 20mm, or about 25 percent of its length. The medial distal condyle is broader and deeper than the lateral distal condyle. The collateral ligament pits are shallow, the lateral one the deepest on any of the metacarpals. In general, the metacarpus in *Erliansaurus* is remarkably similar to that described for *Therizinosaurus*, despite the very flattened

and extremely elongate form of the manual unguals in the latter (Barsbold, 1976).

Table 1 Measurements of the holotypic specimen of *Eriiansaurus bellamanus* gen. et sp. nov. (LH V 0002) (mm)

Mid cervical centrum length	61	Posterior cervical centrum length	50
Anterior dorsal centrum length	45	Cd1 centrum length	50
Cd2 centrum length	47	Scapular blade length (right)	227
Scapular blade maximum distal width	37.5	Scapular blade minimum width	33
Humeral deltopectoral crest (head to apex)	110	Humerus length (left)	276
Humeral proximal end width	110	Humeral head to posterior trochanter	128
Humeral minimum shaft diameter	33	Humeral distal end width	89
Ulna proximal anteroposterior depth	42	Ulna length (left)	237
Ulna mid shaft transverse width	13	Ulna mid shaft anteroposterior depth	22
Ulna distal anteroposterior depth	22	Ulna distal transverse width	34
Radius proximal anteroposterior depth	29	Radius length (left)	220
Radius mid shaft transverse width	17	Radius mid shaft anteroposterior depth	22
Metacarpal I minimum shaft width	21	Metacarpal I length (left manus)	57
Metacarpal II minimum shaft width	19	Metacarpal II length	116
Metacarpal III minimum shaft width	10	Metacarpal III length	79
Phalanx IF1 length	40	Phalanx F1 length (mid socket to condyle)	58
Phalanx IF1 length	17	Phalanx IF2 length	45
Phalanx IF3 length	33	Phalanx IF2 length	14
Digit II-ungual length	76 *	Digit I-ungual length	91
Femur proximal transverse width I	14	Femur length (right)	412
Femur proximal end to fourth trochanter	179	Femur distal transverse width	101
Tibia proximal transverse width	78 *	Tibia length (right)	373
Tibia distal transverse width (right)	106 *	Tibia proximal anteroposterior length	103 *
Fibula proximal transverse width	75	Fibula length (right)	350 *
Fibula distal shaft width	15	Fibula distal transverse width	156

* indicates estimation.

The proximal phalanges of the manus all have prominent heels. Phalanx F1 is the only manual phalanx with collateral ligament pits, the medial pit deeper than the lateral pit. The other non-ungual phalanges in the manus are deeply socketed proximally to accommodate well developed, divided distal condyles (Fig. 1F). These well fitted surfaces permit limited flexion and almost no extension along each series in digits II and III. The penultimate phalanges in digits II and III are the longest, that in digit II only slightly longer than phalanx IF1. The manual unguals are well preserved. The largest one is interpreted to pertain to digit I. It has a small lip dorsal to the articulation. The unguals of digit II and III are smaller in size. All unguals are flat-sided, strongly curved, proximally deep, with massive pyramidal flexor tubercles located near the proximal articulation (Fig. 1F). They are enlarged relative to the corresponding digital phalanges.

The partial right ilium is somewhat flattened transversely (Figs. 2A, B, 4A). In lateral view, the postacetabular process is very short and deep; the posterodorsal end of the blade curves ventrally; the ventral margin of the blade is smoothly transiting from the posterior margin of the ischial peduncle. A rugose swelling is located dorsal to the ischial peduncle, close to the dorsal margin of the ilium. Posterior to this swelling is a heavy crest dorsal to the posterodistal end of the ilium (Figs. 2A, 4A, B). The ischial peduncle has a clearly marked, teardrop-shaped antitrochanteric articular surface. The supraacetabular crest is well developed and flares beyond the lateral margin of the blade (Fig. 4B). Only fragments of the ischium and pubis are preserved.

The femur and tibia (Figs. 2C~E, 4E) are similar to those of *N. yangi*. The femur is straight in both anterior and lateral views. A round femoral head is separated from the trochanteric crest by

a well developed neck. A fourth trochanter, if present, must be very weak. The medial and lateral distal condyles are similar in size, though this may be partially caused by crushment. The tibia is slightly longer relative to the femur in *E. bellamanus* (90%) than in *N. yangi* (85%) (Table 1). As in *N. yangi*, the fibular crest is long, extending distally at the level of the mid-shaft of the tibia (Figs. 2E, 4E). The fibula shows some derived features seen in other therizinosaurids. In proximal view, the large head of the fibula tapers posteriorly, as in *Alxasaurus* (Russell and Dong, 1993) but unlike most other theropods where the reverse shape obtains (e. g., *Allosaurus*, Madsen, 1976. pl. 52, fig. D). Unlike most other coelurosaurs, there is no development of a fibular fossa on the medial side of the proximal end (Fig. 2F). The slender distal shaft is transversely concave on its medial

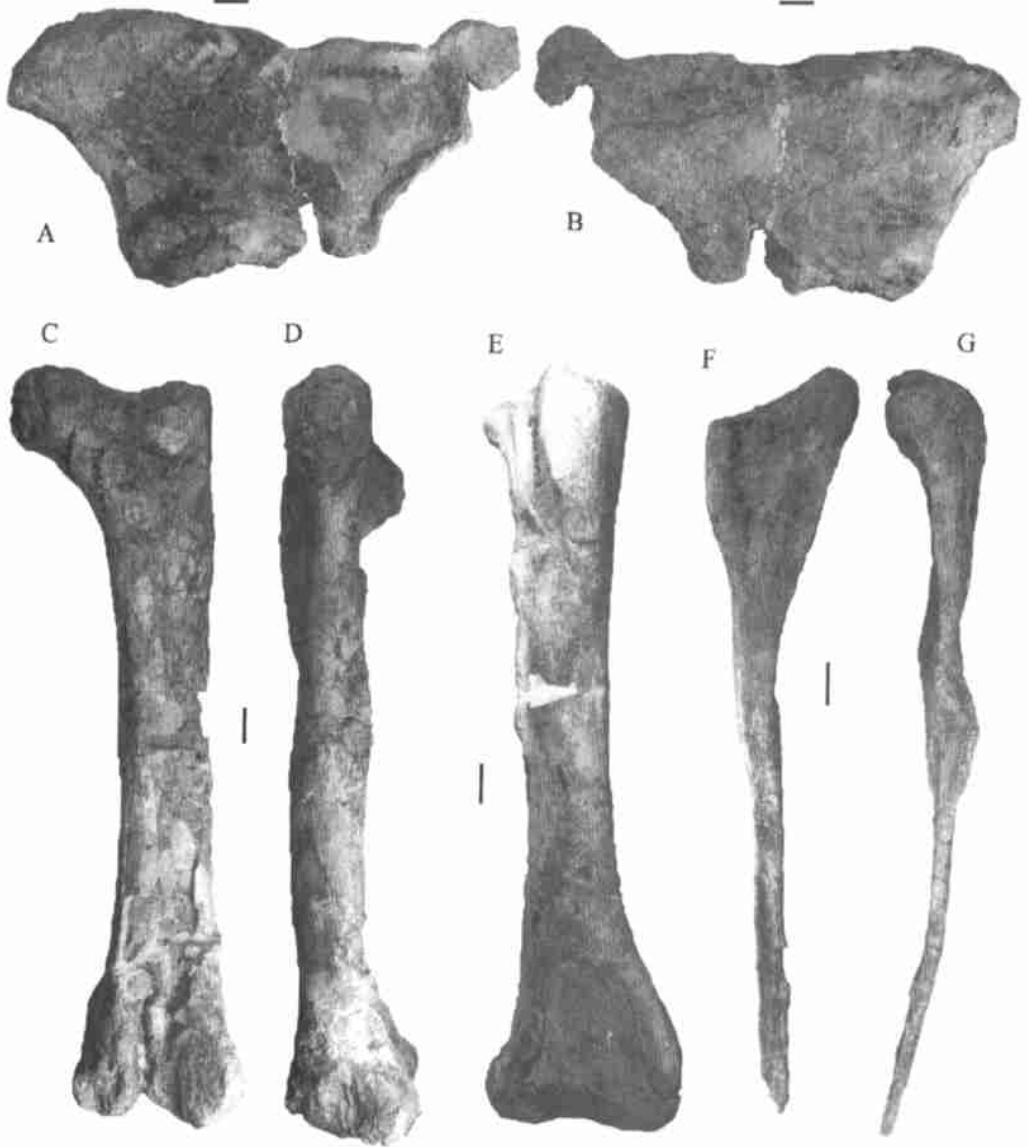


Fig. 2 *Ertiansaurus bellamanus* gen. et sp. nov. (LH V 0002), scale bar 2cm
A~B. Right ilium in lateral and medial views; C~D. Right femur in posterior and medial views;
E. Right tibia in anterior view; F~G. Right fibula in medial and anterior views

side to accommodate the lateral edge of the shaft of the tibia. However, the fibula shows some differences from that of other therizinosauroids. In medial or lateral views, the posterior margin of the proximal head is elevated, significantly higher than the anterior margin, thus making a slightly concave, sloping dorsal margin in medial or lateral views (Fig. 2F). In most theropods including other therizinosauroids the dorsal margin of the fibular head is nearly horizontal or slightly convex in medial or lateral views. The anterior trochanter is hypertrophied and located at mid-shaft. It projects laterally rather than anteriorly, as in most other theropods (Fig. 2G). The distal end of the fibula is only slightly expanded.

Discussions As described above, *E. bellamanus* displays combinations of primitive and derived characters and might represent an intermediate taxon between primitive and derived therizinosauroids. Although a numerical phylogenetic analysis of *E. bellamanus* is beyond the scope of the present paper, some preliminary analysis can be made. We will discuss below some characters informative for determining the phylogenetic position of *E. bellamanus*.

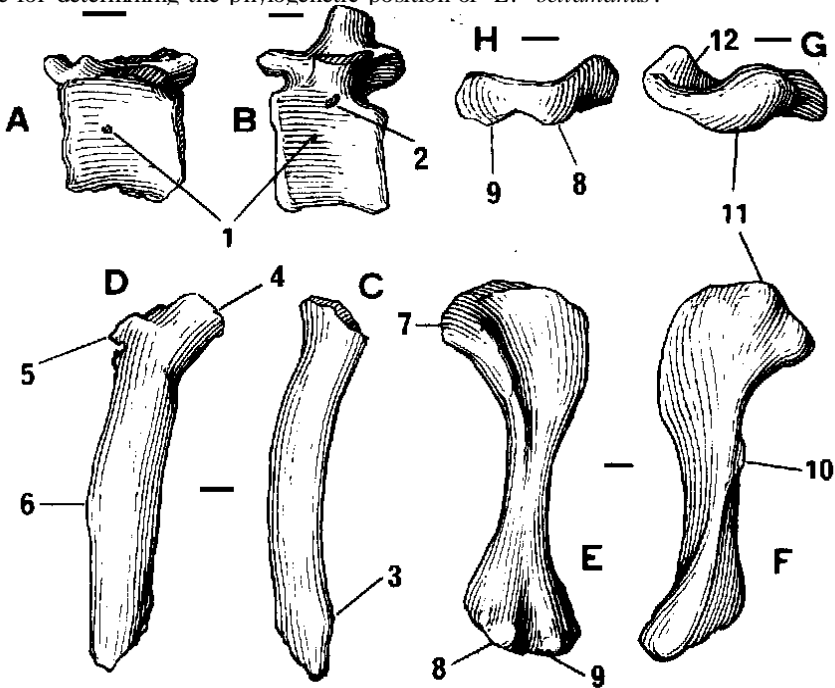


Fig. 3 Line drawings of selected elements of *Eriiansaurus bellamanus* gen. et sp. nov. (LH V 0002) and *Neimongosaurus yangi* (LH V 0001), scale bar 2cm

- A. Anterior caudal in lateral view (LH V 0002); B. Anterior caudal in lateral view (LH V 0001);
 C. Right scapula in lateral view (LH V 0002); D. Right scapula in lateral view (LH V 0001);
 E~H. Left humerus in anterior, posterior, proximal and distal views (LH V 0002)
 Abbreviations: 1. nutritional foramen; 2. pleurocoel; 3. ventral flange; 4. glenoid fossa;
 5. acromion process; 6. dorsal flange; 7. medial tuberosity; 8. radial condyle; 9. ulnar condyle; 10. posterior trochanter; 11. humerus head; 12. deltopectoral crest

1) Dorsal pleurocoel absent. Similar to *Nanshiungosaurus brevispinus* and *Beipiaosaurus*, there is no pleurocoel on the lateral side of the dorsal centrum in *E. bellamanus*. Among therizinosauroids dorsal pleurocoels are reported in *Nothronychus* and *N. yangi*. Absence of pleurocoels on dorsal centra might represent a derived character state for Therizinosauroidea if a therizinosauroid-oviraptorosaur hypothesis (Makovicky and Sues, 1998; Xu et al., 1999a) is correct.

2) Enlarged nutritional foramen on anterior caudals. A small, oval, sharp-rimmed opening is

present on the lateral side of the caudal centra in *E. bellamanus* and a similar, but much smaller opening is also present in *N. yangi* (Figs. 3A, B) that has been identified as a reduced pleurocoel (Zhang et al., 2001). Compared with the pleurocoels in *Nothronychus* (Kirkland and Wolfe, 2001) and oviraptorosaurs (Sues, 1997; Barsbold et al., 2000) that are located immediately below the caudal rib, the openings in *E. bellamanus* and *N. yangi* are positioned much more lower and smaller on the centrum. We assume the openings in *E. bellamanus* represent the enlarged nutritional foramina rather than reduced pleurocoels. Such an enlarged nutritional foramen on anterior caudals are unknown in other theropods and here regarded as autapomorphy for *E. bellamanus*.

3) Caudal pleurocoel absent. There is no opening immediately below the caudal rib in *E. bellamanus* as seen in oviraptorosaurs and *Nothronychus* that represents the pleurocoel. *N. yangi* has a deep circular fossa in the same position, probably representing the pneumatic fossa. Similar to *E. bellamanus*, most other therizinosauroids have no pneumatic anterior caudals. Absence of pleurocoel on anterior caudals might represent derived character state for Therizinosauroidea if a therizinosauroid-oviraptorosaur hypothesis is correct.

4) A dorsal flange on the scapular blade absent. Among therizinosauroids *N. yangi* and *Therizinosaurus* bear a dorsal flange on the scapular blade (Fig. 3D; Barsbold, 1976). Most other therizinosauroids including *E. bellamanus* lack such a structure.

5) Distally narrow scapular blade. The scapular blade is wider distally in lateral view, with the proximalmost portion narrowest in most non-avian theropods. Therizinosauroids including *E. bellamanus* are different in that the scapular blade becomes narrower distally (Figs. 3C, D; Fig. 2 in Barsbold, 1976; Fig. 3 in Kirkland and Wolfe, 2001). However, no complete scapula is known among therizinosauroids, whether the distal end of the scapula is expanded as in non-avian theropods remains unknown.

6) Hypertrophied medial tuberosity on humerus (Figs. 1H, 1, 3E, F). A distinctive medial tuberosity is hypertrophied, and overhangs the shaft in therizinosauroids. This tuberosity is more prominent and further medially expanded in *N. yangi* and other derived therizinosauroids than in *E. bellamanus*.

7) Presence of anterior tuberosity on the distal end of the humerus proximal to the ectepicondyle. This feature is not known in other theropods and is probably a synapomorphy for Therizinosauridea.

8) Crest-like posterior trochanter on the humerus bordered medially by an oval depression. A posterior trochanter is present on the caudomedial surface of the mid-shaft of the humerus as the form of a crest-like structure in *E. bellamanus* (Figs. 1I, 3F). Derived therizinosauroids including *Therizinosaurus* (Barsbold, 1976), *Erlicosaurus andrewsi* and *Segnosaurus galbinesis* (Barsbold and Maryanska, 1990) develop a posterior trochanter on the humerus but differ in that the trochanter is represented by a sharply pointed tubercle. Primitive members of the group such as *Beipiaosaurus*, *N. yangi*, and *Nothronychus* lack a posterior trochanter (Kirkland and Wolfe, 2001). Interestingly in *N. yangi* an oval depression is present at the mid-shaft, which might be homologous to the depression medial to the posterior trochanter in *E. bellamanus*. The presence of the posterior trochanter on the humerus represents a derived character state uniting advanced therizinosauroids. Furthermore, the unusual shape of the trochanter in *E. bellamanus* distinguishes the taxon from all other therizinosauroids and makes an autapomorphy.

9) Hypertrophied entepicondyle. The presence of a hypertrophied entepicondyle is unique to therizinosauroids among theropods. *E. bellamanus* has a large entepicondyle but differs from other therizinosauroids such as *N. yangi* in that it is not as flattened anteroposteriorly. Hypertrophied entepicondyle is a synapomorphy for Therizinosauroidea and the anteroposteriorly flattened shape represents a derived character state for this subgroup.

10) Ulnar and radial condyles located on the anterior aspect of the distal end of the humerus.

The ulnar and radial condyles are shifting proximally onto the anterior aspect of the distal end of the humerus in all known therizinosauroids including *E. bellamanus*. Some non-avian theropods also share this feature but not as proximally shifted as in therizinosauroids. This feature is potentially a synapomorphy for Therizinosauroidea if the intermediate state in some non-avian theropods is considered a different state.

11) Wide flexor groove between the ulnar and radial condyles. In most other therizinosauroids the ulnar and radial condyles are prominent and close to each other, making a narrow, deep flexor groove in between. The ulnar and radial condyles are not as prominently developed in *E. bellamanus*, and relatively widely located. Thus *E. bellamanus* has a relatively shallow and wide flexor groove as in most theropods.

12) Presence of a lip dorsal to articular surface of the manual unguals. *E. bellamanus* is similar to most other therizinosauroids, oviraptorosaurs, and some other maniraptorans such as dromaeosaurids in having a lip dorsal to the articular surface of the manual unguals (Xu et al., 1999b). The recently reported *Nothronychus*, however, lacks this feature.

13) Manual unguals proximally deep. *E. bellamanus* is similar to some therizinosauroids such as *Alxasaurus*, *Segnosaurus* and *Nothronychus* (Russell and Dong, 1993; Kirkland and Wolfe, 2001) in having proximally deep manual unguals (articulation depth more than 45% of ungual length). *Therizinosaurus*, *Beipiaosaurus* and most other theropods have a ratio less than 35%.

14) Short postacetabular process of the ilium. Derived therizinosauroids such as *Segnosaurus*, *Enigmosaurus mongoliensis*, and *Nanshiungosaurus brevispinus* have a short postacetabular process of the ilium. An associated feature is that the ventral margin of the ilium blade is confluent with the posterior margin of the ischial peduncle whereas in most other theropods there is distinct bending between the two margins. *E. bellamanus* is similar to derived therizinosauroids in this feature though the ventral margin is more strongly curved (Figs. 2A, 4A). *N. yangi*, *Beipiaosaurus*, and *Alxasaurus* are similar to most other theropods in having a long postacetabular process, the ventral margin of which diverges strongly from the posterior margin of the ischial peduncle (Fig. 4C), though in the latter taxon the postacetabular process is comparatively shorter than that of the former taxa.

15) Posterodorsal margin of ilium curving ventrally in lateral view. *E. bellamanus* is similar to *N. yangi* and most other maniraptorans in that the posterodorsal margin of ilium curves ventrally in

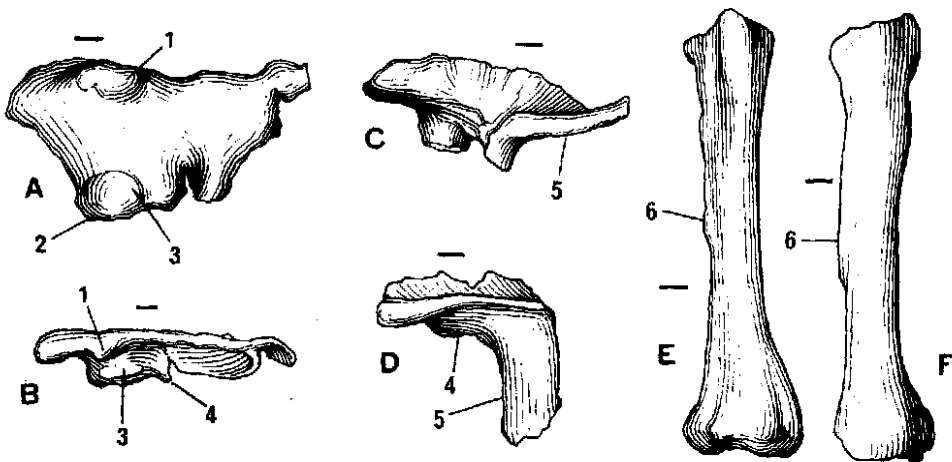


Fig. 4 Line drawings of selected elements of *Ertiansaurus bellamanus* gen. et sp. nov. (LH V 0002) and *Neimongosaurus yangi* (LH V 0001 and LH V 0008), scale bar 2.5cm
 A ~ B. Right ilium in lateral and dorsal views (LH V 0002); C ~ D. Right ilium in lateral and dorsal views (LH V 0008); E. Right tibia in anterior view (LH V 0002); F. Left tibia in posterior view (LH V 0001)
 Abbreviations: 1. rugose swelling; 2. ischiadic peduncle; 3. antitrochanter;
 4. supraacetabular crest; 5. preacetabular process; 6. fibular crest

lateral view, though in *N. yangi* the postacetabular process is shallower, with a somewhat tapered distal end (Figs. 4A, C). In some derived therizinosauroids such as *Segnosaurus* the dorsal margin is straight.

16) Thickened posterodistal end of ilium. A unique feature to most therizinosauroids is the presence of the large rugose area for muscle attachment on the caudolateral surface of the ilium, which is represented as the form of a raised welt at the posterodistal end in some therizinosauroids (Barsbold and Maryanska, 1990). Although lacking a prominent welt at the posterodistal end, *E. bellamanus*, *Alxasaurus* (Russell and Dang, 1993) and *N. yangi* (Figs. 4B, D) have a heavy crest in the same position, and this might be homologous to the welt in more derived therizinosauroids. *Beipiaosaurus* appears to lack this feature.

17) Rugose swelling located dorsal to the ischiadic peduncle on the lateral surface of ilium. A rugose swelling is located dorsal to the ischial peduncle and anterior to the heavy crest in *E. bellamanus*. This swelling represents a separate muscle attachment from the more posterior one.

18) Supraacetabular crest flaring beyond the lateral margin of the ilium blade. Unusually the supraacetabular crest flares beyond the lateral margin of the ilium blade in *E. bellamanus* and *N. yangi* such that the primitively lateral surface is twisted to face dorsally (Figs. 4B, D). In the latter taxon this feature develops to the extreme extent: the preacetabular process also flares laterally and its anatomically lateral surface is twisted to face dorsally (Fig. 4D). It should be pointed out that this differs from the condition in Therizinosauridae where the preacetabular process flares laterally and curves posteriorly.

19) Posterior margin significantly higher than anterior margin on the fibular proximal end. The posterior margin of the fibular proximal end is elevated relative to the anterior end, forming a concave, sloping dorsal margin in medial or lateral views in *E. bellamanus* (Fig. 2F). In most theropods including other therizinosauroids the dorsal margin of the fibular head is nearly horizontal or slightly convex in medial or lateral views.

20) Distally located hypertrophied anterior trochanter on fibula. The anterior trochanter on the fibula (M. iliofibularis tubercle) is located at mid-shaft in *E. bellamanus* (Fig. 2G), as in *Nothronychus* (Kirkland and Wolfe, 2001) and *Segnosaurus* (Perle, 1979). It is proximally located in most other theropods including other therizinosauroids such as *Beipiaosaurus*. *E. bellamanus* is different from *Nothronychus*, *Segnosaurus*, and most other theropods in that the anterior trochanter is prominently developed.

21) Anterior trochanter on fibula laterally projected. The anterior trochanter projects anteriorly in most other non-avian theropods including *Segnosaurus* (Perle, 1979). *E. bellamanus* has, however, a laterally projected anterior trochanter, as in *Beipiaosaurus* and *Nothronychus* (Kirkland and Wolfe, 2001) and some non-avian maniraptorans.

22) Tibia shorter than femur. As in most other therizinosauroids but unlike other coelurosaurians, the tibia is shorter than the femur in *E. bellamanus*. Among therizinosauroids only *Beipiaosaurus* has a longer tibia.

23) Long fibular crest of tibia. The fibular crest is long, extending distally at the level of the mid-shaft of the tibia in *E. bellamanus* (Figs. 2E, 4E). This is similar to the condition in *N. yangi* in which the fibular crest is even longer, extending further distally significantly beyond the mid-shaft (Fig. 4F). The fibular crest is much shorter in most other theropods including other therizinosauroids.

24) Astragalus with reduced astragalar condyles. The astragalar condyles are reduced in all known therizinosauroids including *E. bellamanus* whereas in most other theropods they are much more robust.

25) Proximal end of fibula tapering posteriorly. As in *Alxasaurus* (Russell and Dong, 1993), the proximal end of the fibula tapers posteriorly. In most other theropods, the proximal end is

transversely thicker at the posterior margin than at the anterior margin.

As discussed above, the therizinosauroid affinities of *E. bellamanus* are established by the following therizinosauroid synapomorphies: distally narrow scapular blade, hypertrophied medial tuberosity on humerus, presence of an anterior tuberosity on the distal end of the humerus proximal to the ectepicondyle, ulnar and radial condyles located on the anterior aspect of the distal end of the humerus, thickened posterodistal end of ilium (this needs be confirmed by examining the condition in *Beipiaosaurus*), astragalus with reduced astragalar condyles, and proximal end of the fibula tapering posteriorly.

Among therizinosauroids, *Beipiaosaurus* is the most basal taxon except *Eshanosaurus* (Xu et al., 2001) because of lacking the following derived characters that are seen in most other therizinosauroids including *E. bellamanus*: manual unguals proximally deep (the proximal articular surface of the manual unguals is also shallow in *Therizinosaurus*, but it may represent a reversal), tibia shorter than femur, shorter metatarsus, and metatarsal I participating in the articulation with the tarsus.

E. bellamanus, together with *Alxasaurus*, *N. yangi* and *Nothronychus*, are primitive members among the more advanced therizinosauroids than *Beipiaosaurus*; they lack the following derived features of Therizinosauroidae: deep, laterally and posteriorly curved preacetabular process of the ilium, straight dorsal margin of the ilium, and the extremely narrow, blade-shaped form of the pedal unguals. *E. bellamanus* is also primitive in some features of the humerus, such as the wide flexor groove between the relatively flat ulnar and radial condyles. Comparatively, *E. bellamanus* is more derived than *Alxasaurus*, *N. yangi* and *Nothronychus* in having the following derived characters: dorsal and caudal pleurocoel absent, the presence of the posterior trochanter on humerus, and short postacetabular process of the ilium, yet the first two character states may turn out to be primitive because the basal therizinosauroid *Beipiaosaurus* appears to share these features. However, *E. bellamanus* shares a few unusual derived features with *N. yangi*, suggesting a possible close relationship between the two taxa. These include: an oval depression at the mid-shaft of the humerus (it is located medial to the posterior trochanter in *E. bellamanus*), supraacetabular crest flaring beyond the lateral margin of the ilium blade, and long fibular crest of tibia. On the other hand, *E. bellamanus* also shares with some other therizinosauroids a few derived characters. The anterior trochanter on fibula projects laterally in *E. bellamanus*, a feature also seen in *Beipiaosaurus* and *Nothronychus*. *E. bellamanus* is also similar to *Nothronychus* and *Segnosaurus* in having this trochanter located at mid-shaft of the fibula. A precise phylogenetic position of *E. bellamanus* will be given elsewhere when a numerical cladistic analysis is done.

The discovery of *E. bellamanus* provides important information regarding diversity within Therizinosauroidea. Therizinosauroids are previously thought to be a very rare, exclusively Cretaceous group of aberrant dinosaurs. Recent discoveries extended both their geographical and stratigraphical distributions (Zhao and Xu, 1998; Xu et al., 2001; Kirkland and Wolfe, 2001). *E. bellamanus* co-exists with *N. yangi* as does *Segnosaurus* with *Erlikosaurus*. The available evidence suggests that therizinosauroids represent a group of dinosaurs with high diversity, and are more common elements than previously known.

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