

**The first discovery of a pterosaur from western Liaoning Province
(*Eosipterus yangi* gen. et sp. nov.)**

by

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Abstract

Eosipterus yangi gen et sp. nov. is a moderate sized archaic member of the suborder Pterodactyloidea produced from the Yixian Fm. of Beipiao Municipality, western Liaoning Province. It is diagnosed as a pterodactyl based upon its short tail, presence of gastralium, and robust forelimb. The radius and ulna are longer than the wing metacarpal, the metatarsals are extremely slender and long, and pedal digit five is reduced but not completely lost. The species represents the first discovery of the Pterosauria in western Liaoning Province and provides new data for the interpretation of the faunal characteristics, age, paleogeography, and paleoecology of the Jehol Fauna.

Introduction*

Abundant fossil reptiles have been discovered and described from the Late Mesozoic sediments of western Liaoning including turtles, sphenodont and squamate reptiles, saurischian and ornithomimid dinosaurs, and footprints. These are extremely valuable toward understanding western Liaoning's Late Mesozoic faunal succession, facilitating the study of regional paleogeographical and paleoecological changes, and determining the Jurassic-Cretaceous boundary. Most recently a specimen representing the Pterosauria has been discovered in the Yixian Fm., representing the first documentation of the order in northeast China, and being of extreme significance biostratigraphically and biogeographically. In China, pterosaurs have also been documented in Xinjiang Autonomous Region, Gansu, Sichuan, and Zhejiang provinces.

Description

Pterosauria Kaup, 1834

Pterodactyloidea Plieninger, 1901

Eosipterus gen. nov.

Eosipterus yangi gen et sp. nov.

Etymology: Eos - Greek for dawn or early and east,** pteryx - Greek for wing, the nomenclature thus alludes to the pterosaur being produced from eastern China.

Type: An incomplete skeleton lacking head and cervical vertebrae. Chinese Geological Museum specimen #GMV2117.

Locality and stratigraphic position: Lower Yixian Fm. at Jinggangshan, Beipiao Municipality, Liaoning Province.

Diagnosis: A moderate sized pterosaur with a wing span of approximately 1.2 m, short tail, and slender and weak gastralium; forelimb is relatively robust, and the radius and ulna are 1.3 times as long as of the wing metacarpal; articular surfaces on all wing finger phalanges are distinctly expanded, femur is relatively straight and two-thirds as long as the tibia, lengths of the ulna, tibia, and first phalanx of the wing finger are equivalent. Metatarsals I-IV are slender and elongated. Digit V is reduced but not completely lost.

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** Translator's note: The authors have erroneously translated "eos" as east.

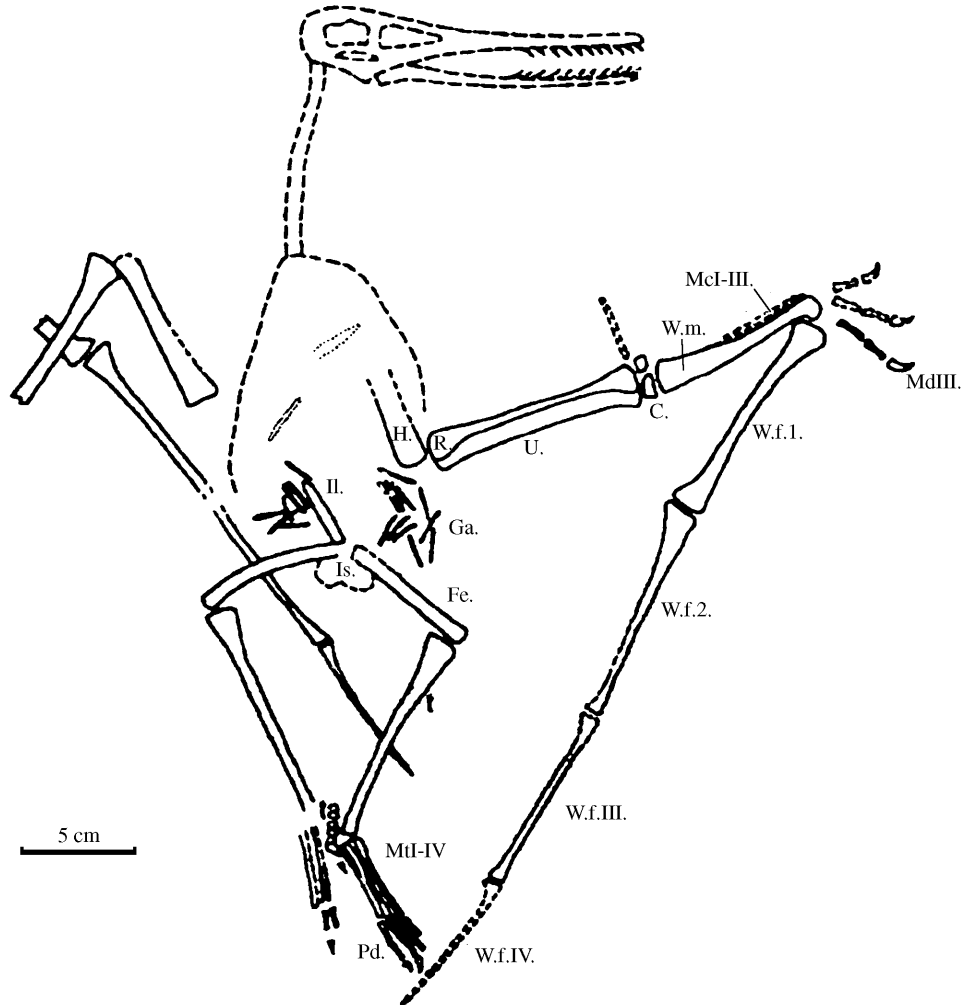


Figure 1. Drawing of *Eosipterus yangi* gen. et sp. nov (GMV2117).

C.-carpal; Fe.-femur; Ga.-gastralia; H.-humerus; II.-ilium; Is.-ischium; MdIII-manus digit III; McI-III.-metacarpal I-III; Mt.I-IV-metatarsal I-IV; Pd.-pedal digits; R.-radius; T.-tibia; Ta.-tarsals; U.-ulna; W.f.1-IV- phalanx I-IV of wing finger; Wm.-wing metacarpal.

Description: Cervical vertebrae are not preserved and the remaining vertebrae are very poorly preserved. Size, morphology, and count of the ribs, dorsal vertebrae, sacral, and caudal vertebrae are indeterminate, although it may be discerned that the caudal sequence is short. In the dorsal and sacral region 18 gastralia are scattered rather randomly in the matrix, so their sequential alignment is indeterminate. Each of the gastralia is 22-25 mm in length and is approximately 1.2 mm broad. Only a single element is rather broadened; the rest are slender, thin, straight or slightly curved, and the two ends do not attenuate.

The scapula and coracoid are not preserved, but most of the forelimb is well preserved. On the right side the length of the forelimb from the humerus to the end of the wing finger exceeds 55.0 cm. Thus the wingspan is at least 1.2 m (Fig. 1). The humerus is relatively robust with a preserved length of 34 mm, although the proximal end is missing. The distal end is slightly convex with a breadth of 13 mm.

The radius and ulna are equivalent in size and morphology. They are straight, pneumaticized, and parallel. They are both 95 mm long; their distal ends are both distinctly expanded and slightly laterally convex. The distal radius is 11 mm broad but at the midshaft the diameter constricts to only 3.5 mm whereas the ulna is 6.5 mm at its midshaft. The radius and ulna are 1.3 times the length of the wing metacarpal. Two relatively large but incomplete juxtaposed carpals are present; their lengths and breadths are 6-8 mm.

Metacarpals I-III are indistinct but still discernable as slender and elongated elements. The wing metacarpal (IV) is modified into a large and thickened element. The left wing metacarpal's distal end is missing but its preserved length is 64 mm. The proximal end is 13 mm broad, rather flat, and its midshaft is relatively constricted. The proximal morphology of the right wing metacarpal is indistinct, but the entire length is 73 mm, the midshaft is 5 mm in diameter, and the distal end is greatly inflated to form a nearly rounded and distinctly posteriorly projected process for articulation with the first phalanx.

Digits I and II are not preserved, but digit III is quite distinct, represented as three slender and elongated phalanges with slightly expanded termini and an ungual that is a hooked talon with an inflated basal articulation. The wing finger is well preserved on both sides of the specimen. The first and second phalanges are relatively flattened and pneumaticized, but the third and fourth phalanges are more columnar and not pneumaticized. All phalanges are virtually straight and their lengths diminish successively very slightly (Table I). On the right side the proximal end of phalanx 1 is distinctly convex and laterally expanded, whereas the distal end is very slightly convex and medially expanded. On the left side, phalanx 1 is preserved in two pieces. Their termini resemble the condition of the right counterpart, and they have a combined length of 97 mm. Phalanx 2 has a constricted midshaft; its proximal end is medially expanded and very slightly concave, providing an exceptional articular surface. Phalanx 3 has a poorly preserved proximal end; the distal end is slightly medially expanded and is nearly flat, but still slightly laterally convex. Phalanx 4 is preserved only on the left side. Its proximal end is slightly concave and medially expanded, and its shaft rapidly attenuates.

The outline of each pelvic element is vague, however, the iliac preacetabular process is visible anterior to the proximal femur. It is a thin, slender, elongated element and is approximately 30 mm long and 4-5 mm broad. Posterior to the proximal femur are two relatively large elements that should represent the ischium; they are thin, flat plates and only a portion of their margins are discernable.

The proximal femur is damaged; its distal end is very slightly convex, and what is preserved indicates that it has a minimum length of 60 mm. Its diameter is consistent along the shaft, it is pneumaticized and thin-walled, and the right femur is straight whereas the left femur maintains a slight amount of posterior curvature.

Table I. *Eosipterus yangi* gen et sp. nov. wing finger measurements (mm).

		Length	Proximal breadth	Distal breadth	Shaft diameter	Preservation
Phalanx 1	L	97	14	13	5.5	Two pieces
	R	96	14	13	6	
Phalanx 2	L	80 (preserved)	12		5	Distal missing
	R	~95	14		~5	Distal end poor
Phalanx 3	L	68 (preserved)		6	3 (narrowest)	Distal missing
	R	~80		6	3 (narrowest)	Prox. end poor
Phalanx 4	L	73	6		>1	Not preserved
	R					

The right tibia is extremely well preserved as an extremely straight element 96 mm long and 12 mm wide at its convex proximal end. The distal end is relatively flat and 7 mm broad, and the midshaft constricts to 4 mm. It is 1.6 times as long as the femur and as long as the radius, ulna, and wing phalanx 1. There appears to be a vestigial remnant of the fibula on its proximolateral side.

The right tarsals, metatarsals, and phalanges are extremely distinct. Four oval and relatively tightly aligned metatarsals are preserved in longitudinal orientation. The length of this series is 16 mm and breadth is 7 mm. Metatarsals I-IV are extremely slender, elongated, and pneumaticized with a columnar midshaft. Their termini are laterally compressed but slightly broadened; their proximal ends are in close association with a combined breadth of 10 mm, and distal ends are flat and smooth. MtI-IV lengths are 42.0, 42.5, 38.5, and 36.0 mm respectively. The digits are relatively slender and long. Digits I and II are missing phalanges but III and IV are completely preserved with three phalanges. Unguals are laterally compressed, slightly curved talons. Digit V is reduced but not completely lost and the only remnant is a relatively sharp talon.

Discussion and comparison: The Pterosauria first appear in the Late Triassic and persist until the terminal Cretaceous, represented by specimens from portions of Asia, Europe, North, and South America. There are currently two suborders recognized: the primitive Late Triassic to Late Jurassic long-tailed Rhamphorhynchoidea and the derived Late Jurassic to Late Cretaceous short-tailed Pterodactyloidea (Wellnhofer, 1991; Sun et al., 1992; Benton et al., 1993).

The Pterodactyloidea is rather taxonomically diverse. In the Late Jurassic to Early Cretaceous species, the dorsal vertebrae are generally not fused and the radius and ulna are both longer than the wing metacarpal. On more derived Cretaceous species the dorsal vertebrae are generally fused and the radius and ulna are distinctly shorter than the wing metacarpal. The western Liaoning specimen is thus distinct from the more derived genera including *Dsungaripterus* (Young, 1964, 1973), *Noriopterus* (Young, 1973), *Zhejiangopterus* (Cai and Wei, 1994); *Pteranodon*, and *Ornithodemus*, because it is relatively small and its radius and ulna are distinctly longer, or 1.3 times the length of the wing metacarpal.

The western Liaoning specimen approaches several Late Jurassic Western European taxa in size such as *Pterodactylus*, *Ctenochasma* from Germany and France, and the German *Germanodactylus* (Wellnhofer, 1991). However, it is impossible to make a detailed comparison between the Liaoning specimen and the three aforementioned genera because it lacks cranial, dorsal vertebrae, and sternal data. But the robusticity of the limbs and length indices of *Eosipterus* are extremely distinct, and because the distance between the localities is extreme, it is determined that the Liaoning specimen is a distinct genus, although it is still difficult to provide a family assignment.

With regard to the pterosaurs from China (Young, 1964; 1973, Cai and Wei, 1994; Dong, 1982; and He et al., 1983), the Liaoning specimen most closely approaches *Huanhepterus* (Dong 1982) from Qingyang Co., Gansu Province, because in both the radius and ulna are longer than the wing metacarpal and the metatarsals are relatively slender and long. However, there are large discrepancies between the two, for the Liaoning specimen is smaller with an approximate wing span of 1.2 m whereas *Huanhepterus* has a wingspan of up to 2 m. The former possesses numerous robust and weak gastralia that are absent on the latter. The tarsals and tibia are unfused in *Eosipterus* and pedal digit V is reduced but not lost; but in *Huanhepterus* the tibia and tarsals are fused and digit V is completely lost. The radius-ulna length in Liaoning specimen is 1.3 times that of the wing metacarpal but on the Gansu specimen this index is 1.6. The *Eosipterus* femur is robust and nearly straight, and slightly less than two-thirds as long as the tibia, whereas in *Huanhepterus* the femur is rather slender and distinctly curved, and is nearly half as long as the tibia. On the former the lengths of the ulna, wing phalanx 1, and tibia are equivalent but in the latter these corresponding elements have progressively diminishing lengths. The metatarsals in

Eosipterus are slender, elongated, and .44 the length of the tibia, but on the latter this index is over .26. All these characters justify the erection of a new genus for the Liaoning specimen.

Table 2. Geographic and stratigraphic distribution of the Pterosauria in China.

Taxon	Locality	Stratigraphic age	Reference
<i>Dsungaripterus weii</i>	Wuerho, Junggar Basin, Xinjiang	Early Cretaceous, Upper Tugulu Group	Young, 1964, 1973
<i>Noripterus complicidens</i>	Wuerho, Junggar Basin, Xinjiang	Early Cretaceous, Upper Tugulu Group	Young, 1973
<i>Huanhepterus quingyangensis</i>	Shansilipu, Qingyang, Gansu	Late Jurassic-Early Cretaceous Zidan Group	Dong, 1982
<i>Angusinairipterus longicephalus</i>	Dashanpu, Zigong, Sichuan	Middle Jurassic, Lower Shaximiao Fm.	He et al., 1983
<i>Zhejiangopterus linhaiensis</i>	Shangpanzhen, Linhai, Zhejiang	early Late Cretaceous, Tangshan Fm.	Cai and Wei, 1994
<i>Eosipterus yangi</i> gen et sp. nov.	Jingangshi, Beipiao, Liaoning	Early Cretaceous, Lower Yixian Fm.	This text
Pterosauria indet.	Lushan, Laiyang, Shandong	Early Cretaceous Qingshan beds,	Young, 1958, 1964
Pterosauria indet.	“Amajiahan,” Inner Mongolia	Cretaceous	Young, 1964

Significance of the specimen: The first authentic documentation of the Pterosauria in China was the description of *Dsungaripterus weii* (Young, 1964) from the Early Cretaceous of the Wuerho region, Junggar Basin, Xinjiang, although prior to this there was a small quantity of limb bones provisionally assigned to the order from the Cretaceous Qingshan sediments of Laiyang Co., Shandong Province (Young, 1958). Subsequently, several taxa were described ranging from Middle Jurassic to Late Cretaceous (Young, 1973; Cai and Wei, 1994; Dong, 1982; and He et al., 1983) (Table 1).

The documentation of a pterosaur in the Yixian Fm. of western Liaoning is significant toward advancing the study of faunas, biostratigraphy, paleobiogeography, paleoecology, and paleoclimatology. (1) *Eosipterus* represents the sixth pterosaur genus documented in China and the first documentation in the diverse Jehol Fauna of western Liaoning and Hebei provinces. (2) *Eosipterus* has several derived characters, including the reduced caudal series, but it also retains several relatively plesiomorphic characters such as the radius-ulna that is longer than the wing metacarpal; this indicates that the age of the Yixian Fm. should not postdate the Early Cretaceous. (3) Initially, European and Western Hemisphere pterosaurs were produced from marine sediments and consequently it was long thought that pterosaurs only inhabited marine littoral habitats. The pterosaurs currently documented in China are all produced from terrestrial sediments and the western Liaoning specimen co-occurs with terrestrial and fresh water faunas, further substantiating the expansive habitat range of pterosaurs to include inner continental lacustrine littoral habitats. (4) The documentation of pterosaurs from the Late Jurassic to Early Cretaceous of North China, including Xinjiang, Gansu, Inner Mongolia, Liaoning, and Shandong, indicates that North China was an important pterosaur habitat. (5) Stratigraphically, *Eosipterus* occurs slightly higher than *Confuciusornis*, the oldest bird in China, which also occurs in the Yixian Fm. (Hou et al., 1995).

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