

A NEW FOSSIL BIRD FROM LOWER CRETACEOUS OF GANSU AND EARLY EVOLUTION OF BIRDS

HOU LIANHAI (侯连海) AND LIU ZHICHENG (刘智成)

(Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica, Beijing)

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ABSTRACT

The new order of aves, Gansuiformes, is established on the basis of the fossil specimens, including a tibiotarsus and a tarsometatarsus with four complete digits derived from the Lower Cretaceous of Yumen, Gansu Province. The new bird probably represents the oldest one in continental deposits. As *Archaeopteryx* is now considered as the ancestor of all landbirds, *Gansus*, the new bird is supposed to be the ancestor of shorebirds and waterbirds. Gansuiformes is similar to Charadriiformes and some waterbirds in certain characters.

In the summer of 1981, Ma Fenzhen, Liu Zhicheng, Huang Shaochu and Niu Shawu found the distal end of a left tibiotarsus, a left tarsometatarsus with four complete digits in the Xiagou Formation, Yumen, Gansu Province. It is a bird of an early age in avian history and new to science. The fossil bird is described in the present paper.

A description of the Xiagou Formation of Shenjiawan has been made by the Gansu Regional Geological Survey Team. The fossil bird associated with some teleost remains has been found in the third layer of the Formation which is considered to be of lower Cretaceous in age.

I. DESCRIPTION

Gansus, gen. nov.

Type of Genus: Gansus yumenensis, sp. nov.

Diagnosis: Same characters with the new species.

Gansus yumenensis, sp. nov. (Fig. 1)

Type: Distal left tibiotarsus (9.5 mm) and left tarsometatarsus (31.6 mm) with four complete digits, V 6862, are found from the Xiagou Formation, Lower Cretaceous, Yumen, Gansu Province.

Only distal end of tibiotarsus is preserved. Its external shaft is preserved longer, internal condyle and external condyle are well formed. Supratendinal bridge of the distal end is observed in anterior view. Internal condyle and external condyle are greatly different from each other. In anterior view, external condyle is obviously larger than internal condyle, but the distal end of articular surface of external condyle is contract, and its edge is more round and does not expand outwards. Internal condyle ex-

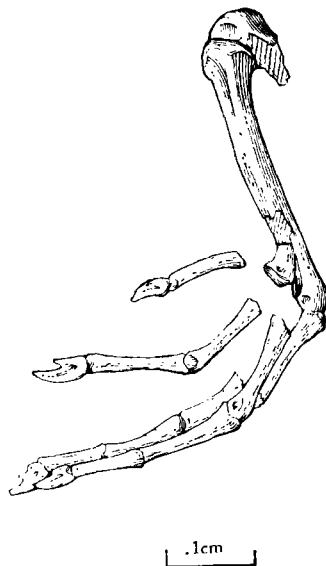


Fig. 1. *Gansus yumenensis*, gen. et sp. nov.

Distal end of left tibiotarsus and left tarsometatarsus with pes.

tends downward and is longer than the lower border of external condyle. The internal condyle is narrow inclining gently internally, anterior edge is projected forward, and internal condyle extends to anterior shaft margin. The internal condyle and external condyle form an angle trending inward, assuming a "V" form. Intercondylar fossa is deep, and inclines external in posterior of the tibiotarsus. Posterior margin of internal condyle is very short, and only extends slightly to posterior shaft margin. Distal edge of tibiotarsus is deeply incised. In inner lateral view, there is a crescent fossa in the centre of internal condyle; in outer lateral view, there is a crest in the centre of external condyle.

The bone wall of tibiotarsus is thick.

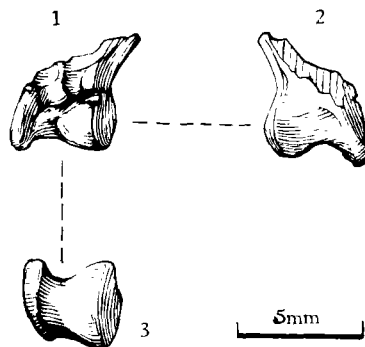


Fig. 2. *Gansus yumenensis*, gen. et sp. nov.

Distal end of left tibiotarsus, 1. anterior view, 2. posterior view, 3. distal view.

Tarsometatarsus is relatively complete, tarsals are healed, and shaft is straight.

In anterior view, it is slightly hollow, but in posterior view, it is prominent.

In proximal view of tarsometatarsus, internal cotyla and external cotyla are very clear; internal cotyla lies in higher position than external cotyla, and is larger and shallower than the external cotyla of the latter. Crackle is extending downward in the centre of internal cotyla. External cotyla lies somewhat lower, articular cotyla is gentle and shallow, and outer margin is straight and extends far to shaft margin. The intercotyla area is high, so articular surface is very deep.

The shaft is gently or slightly concave in anterior view, although the infracotylaris fossa is small and shallow. It does not appear to have foramina vascularia proximalia, or not clear in distal from anterior view. Internally a tuberositas M. tiberanilis appears in lower position of the shaft. Internal cotyla is situated further proximally than external cotyla.

Above the trochleae, the distal end of the tarsometatarsus shaft is not hollow and slightly arched at the distal end. All trochleae do not extend. Marked by broad articular surface, a groove in the centre of distal end and relatively well-developed ligamental fovea laterally, the trochlea III is the longest, while the shortest trochlea including posteriorly with a higher position as compared with that of all known birds, extends only to the base of trochlea III. Laterally, the trochlea II develops relatively small ligamental fovea. The trochlea IV is narrow and slender, and shorter than trochlea III.

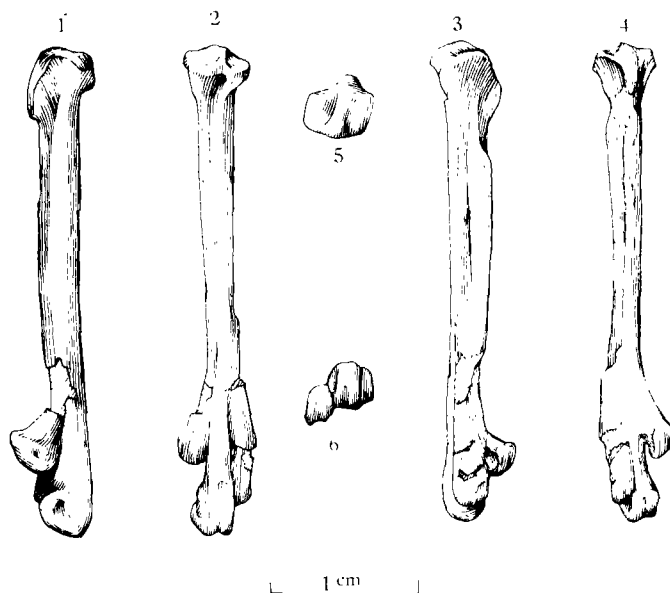


Fig. 3. *Gansus yumenensis*, gen. et sp. nov.

Left tarsometatarsus. 1. left view, 2. anterior view, 3. right view, 4. posterior view, 5. proximal view, 6. distal view.

Phalanges: The digits of the pes in *Gansus* are 1:2:3:4 (claws are not included). As compared with the tarsometatarsus digits are longer and slender; digit 3 and digit 4 are respectively longer than tarsometatarsus. The digit 4 is the longest. Claws have

well-developed groove on each side and present hook-shape downward; there are well-developed flexor tubercles at the base of the claws.

II. MEASUREMENTS (in mm)

Tibiotarsus

Maximum depth, internal condyle	4.4
Maximum depth, external condyle	4.2
Maximum length, internal condyle (ant.)	2.7
Maximum length, external condyle (ant.)	3.4
Maximum width	4.5

Tarsometatarsus

Maximum length	31.5
Proximal width	4.3
Proximal depth	4.2
Width of trochlea III	1.8
Depth of trochlea III	3.1
Width of trochlea IV	
Depth of trochlea IV	

Phanges

Digit I	
Phalanx 1 length	8.4
Phalanx 2 length	4.1
Digit II	
Phalanx 1 length	10.1
Phalanx 2 length	11.5
Phalanx 3 length	4.8
Digit III	
Phalanx 1 length	12.3
Phalanx 2 length	10.8
Phalanx 3 length	7.9
Phalanx 4 length	4.5
Digit IV	
Phalanx 1 length	11.1
Phalanx 2 length	8.6
Phalanx 3 length	8.4
Phalanx 4 length	8.

Gansuidae, fam. nov.

Diagnosis: A smaller Cretaceous shorebird. Claws are only slightly curved with flexor tubercles. Phalanges are slender and have attachment channel for M. flexor tendons cligitorum longus along each side. Digit IV is the longest. Tarsometatarsus is shorter than digits III and IV and laterally compressed, and is not fused completely in posterior view, and distal foramen large and prominent. Trochlea IV is shorter than trochlea III. Trochlea II is broad and in higher position. Calcaneal ridges and tendinal canals are not developed. Tibiotarsus is not supratendinal, highly compressed internal, and intercondylar fossa is deep. Internal condyle is slightly shorter than external condyle; internal condyle is extremely mediolaterally compressed.

Gansuiformes, order, nov.

Diagnosis: Same characters with the only known family, Gansuidae.

Discussion: We have argued that *Gansus* is a good form of innovations in the evolution of Early Cretaceous birds. It probably lies on a phylogenetic line leading to modern birds.

The *Gansus* has the following characters in common with the modern birds:

- (1) Tibia is specialized to be the form of tibiotarsus of the bird.
- (2) Metatarsus is fused into one tarsometatarsus; in the proximal view there are internal and external cotylas and its end has a distal foramen.
- (3) Digit 1 is opposed to other three digits.

The *Gansus* has the following primitive characters:

- (1) Tibiolaris does not appear to have a supratendinal.
- (2) Tarsometatarsus proximal foramen, tuberositas M. tiboecranialis and calcaneal ridges and tendinal conas are not developed.
- (3) The distal end of tarsometatarsus is fused incompletely.

The *Gansus* shares the following character with the other birds:

(1) At the distal end of the tibiotarsus the external condyle is much larger than internal one in surface area, with internal one being highly compressed mediolaterally. Internal condyle is decidedly shorter (anteroposteriorly) than external condyle, and has an elongate narrow crest on external margin.

(2) The distal end of tibiotarsus is gently flat in anterior and internal condyle has a tuberosity externally.

(3) The tarsometatarsus is shorter than digits III and IV. In proximal view the internal cotyla is deeper and larger than external cotyla. Intercotylar prominence continues posteriorly as a high ridge to the base of hypotarsus.

(4) In anterior view the distal end of tarsometatarsus with trochlea III is round (circular), which is different from that of Anseriformes and some shorebirds, but similar to Charadriiformes.

(5) Trochlea II is elevated far up the shaft and up to the Trochlea III.

(6) The digit I is long, and digit IV is longer than digit III.

The other known Early Cretaceous birds are *Enaliornis barretti*, *E. scelgwicki* Seeley, 1864 from England, *Gallornis straeleni* Lambrecht, 1931 from France, Ambioriiiformes Kurochkin 1982 from Mongolia, and indeterminate feathers from Australia. The age of *Gansus* is about 1.35 m.y., the earliest known shorebird.

Gansus is a small bird, but the differences between *Gansus* and Passeriformes are clear in tibiotarsus, tarsometatarsus and digits. *Gansus* is similar to Charadriiformes and other shorebirds in many characters, and this indicates that it may be an ancestor

form of shorebirds.

Gansus is similar to *Ichthyornis* in having the short tarsometatarsus. As A. Feduccia suggested that "... , while the ichthyornithiform birds may possibly be allied with the shorebirds." (1980), and the former may be the ancestor of the latter.

Gansus is almost coeval with *Archaeopteryx*, but the former is advanced in comparison with the latter.

According to known fossil birds there is a schematic representation of the evolution of avian orders.

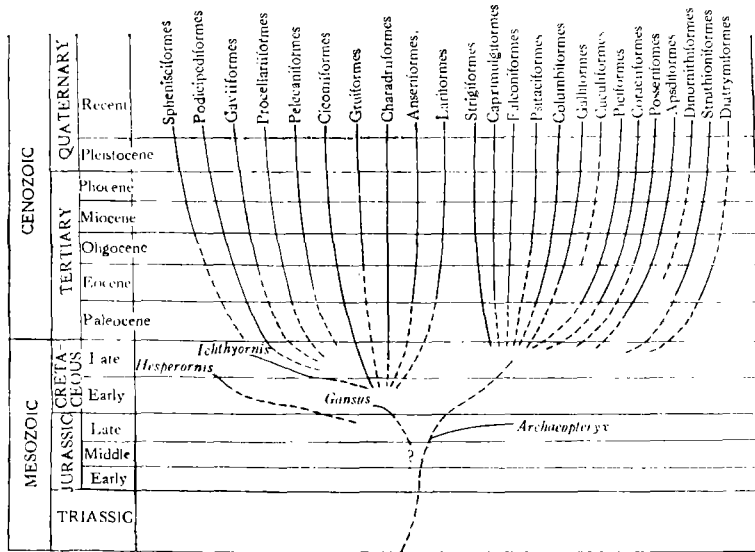


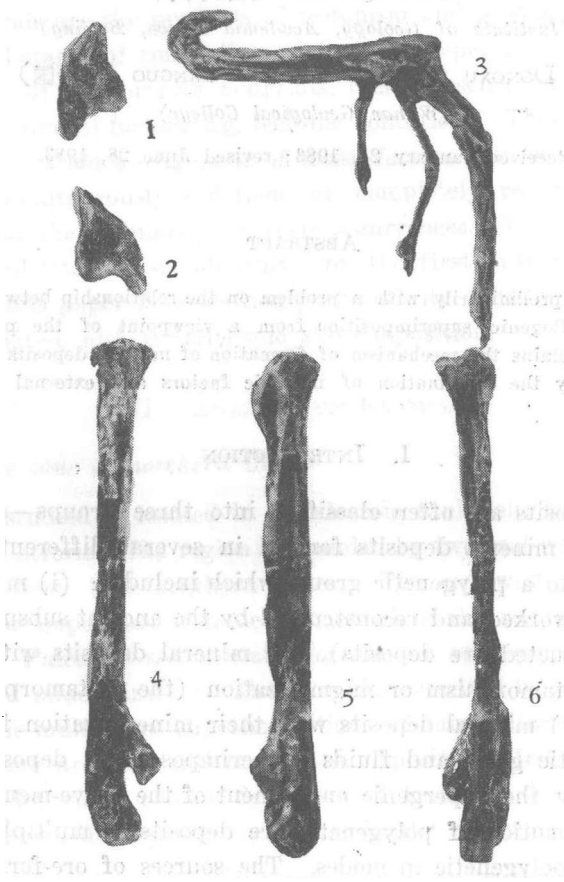
Fig. 4. Schematic representation of evolution of avian orders. Solid lines indicate the known fossil record. Dotted lines show postulated extension and relationship. (partly after T.J. Cade, 1979)

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L. Gansus yumenensis gen. et sp. nov.

1. Anterior view of distal end of left tibiotarsus. $\times 3$
2. Posterior view of distal end of left tibiotarsus. $\times 3$
3. Distal end of left tibiotarsus and left tarsometatarsus with pes. $\times 1.4$
4. Posterior view of left tarsometatarsus. $\times 3.1$
5. Left view of left tarsometatarsus. $\times 3.1$
6. Anterior view of left tarsometatarsus. $\times 3.1$