

A Miocene ostrich fossil from Gansu Province, northwest China

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A pelvic skeleton, recognized as a large terrestrial bird in the field, was recently collected by our paleomammalogist colleagues from the Institute of Vertebrate Paleontology and Paleoanthropology from the late Miocene sandy mudstones in the Linxia Basin in Gansu Province, northwest China. We have further referred this bird to as an early representative of ostrich. Ostrich fossils usually coexisted with the famous *Hipparion* Fauna from the Miocene to Pliocene. The Linxia Basin is well known for producing a continuous and complete sequence of Cenozoic sediments ranging from the Oligocene to Holocene^[1,2], with abundant mammals and a few birds. The fossil ostrich was believed to be living in an open grassland or wetland.

Ostrich is the largest living bird, represented by only one genus and species. It is a cursorial bird characterized by a reduced wing, sternum without a keel, loss of flight capability, running on two toes, etc. The earliest known record of ostrich (*Struthio*) is from the early Miocene of Africa. It has been known that ostriches were widely distributed in Africa and Eurasia in the Pliocene. Ostrich has been reported from the Miocene in Asia in the past. The new specimen represents one of the few relatively well-preserved ostrich skeletal fossils, pushing back the history of ostrich in China by several million years.

Struthioniformes

Struthionidae Vigors, 1825

Struthio Linnaeus, 1758

Struthio linxiaensis sp. nov.

Holotype: An incomplete pelvis and synsacrum (Hezheng Paleozoological Museum, Gansu HMV 1381).

Paratype: An incomplete pelvis and synsacrum (Institute of Vertebrate Paleontology and Paleoanthropology V 14399).

Locality and horizon: Yangwapuzijifang, Guanghe County, Gansu Province; upper Liushu Formation (late Miocene).

Diagnosis: A large sized ostrich fossil, differing from *Struthio camelus* in the following characteristics: rela-

tively large and deep concavity on the preacetabular wing of ilium, highest point of ilium far anterior to the acetabulum, a deep transverse groove present on the ventral margin of the acetabulum that separates the proximal ischium and the pubis.

Description: The fossil represents a bird that is slightly larger than living ostrich (Fig. 1). The preserved length of the pelvis is about 50cm. The pelvic bones are comparatively well preserved and thick walled. The pelvis comprises a nearly complete ilium, incomplete ischium and pubis, and is well fused with a nearly complete synsacrum (lacking the last two sacrals). The anterior part of the ilium bears a high crest, which becomes progressively lower and thicker posteriorly. The two ilia are projected laterally near the middle of the acetabulum and form distinctive dorso-lateral processes (processus supratrochantericus). The preacetabular wing of the ilium has a thick and rounded ventral margin, with a large and elongate concavity on its surface, and is fused with the transverse processes of at least 5 sacral vertebrae. The postacetabular wing of the ilium is lower and more dorso-ventrally compressed, with a relatively thin and straight ventral margin, and the posterior end of the ilium is missing. The preserved synsacrum comprises 19 sacrals and is estimated to have missed the last two sacrals (20th and 21th). The transverse processes of the 9th and 10th sacrals are crushed. The synsacrum is well fused with the ilium, with a well-developed dorsal crest.

The anterior, dorsal, and upper posterior margins of the acetabulum are formed by the thickened ventral margin of the ilium. A relatively deep transverse groove separates the antero-ventral margin of the acetabulum, which was formed by the pubis, and the postero-ventral margin of the acetabulum, which was formed by the ischium. The middle and lower parts of the posterior margin of the acetabulum are formed by the pubis. The antitrochanter is well developed, with a shallow fossa on its surface. The antitrochanter lies at the broadest part of the pelvis. The distance between the two incompletely preserved antitrochanters is approximately 17 cm.

Transverse processes of 6 sacrals are visible in the acetabular area in lateral view, and they are fused with the medial side of the ilium. Most of the sacral vertebrae are well preserved except the first, which is broken, and the last two, which are not preserved. The sacrals are robust, with deep and wide ventral groove in anterior sacrals, and low ventral processes in middle sacrals. The ventral processes form a continuous ridge. The ventral surfaces of sacrals 12th—14th form a narrow and shallow concavity. Low ventral processes are also present in sacrals behind sacral 14th. The synsacrum is generally straight, with the exception of protruding below the acetabulum. The most anterior sacrals have long and robust transverse processes, and consequently the preacetabular wing of the ilium ex-

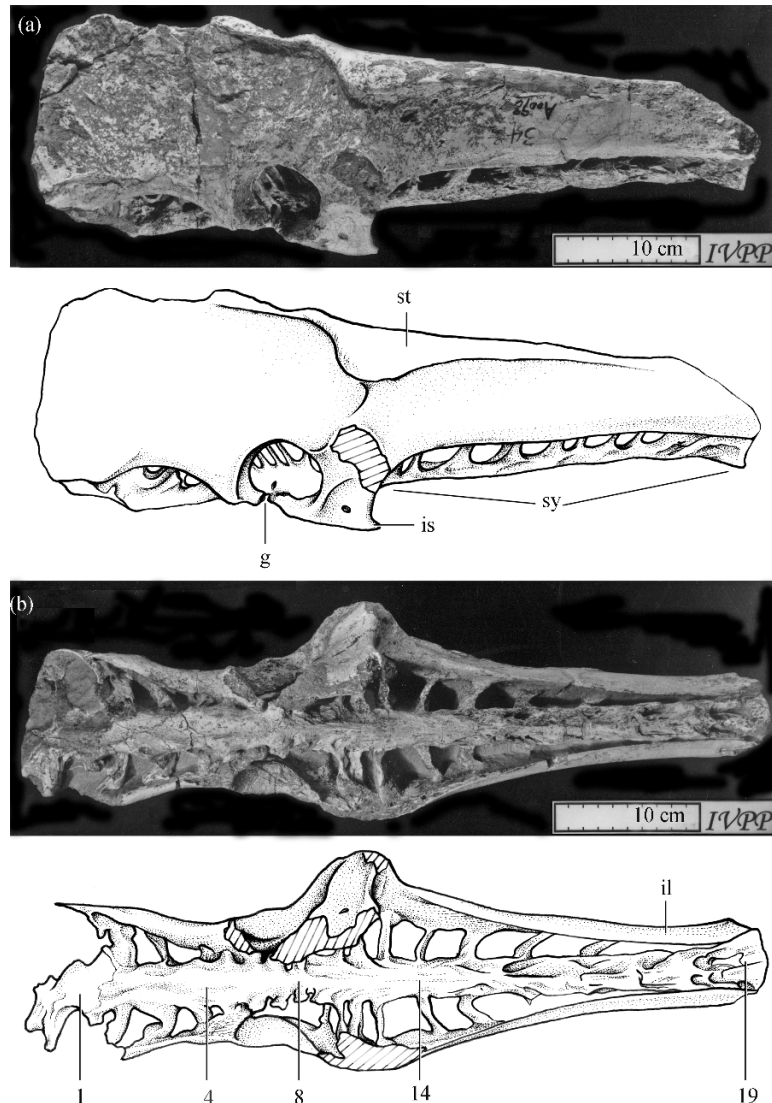


Fig. 1. Holotype of *Struthio linxiaensis* sp. nov. (H.M.V. 1381). (a) Pelvis in left lateral view; (b) Pelvis in ventral view. g, transverse groove; il, ilium; is, ischium; st, processus supratrochantericus; sy, synsacrum; 1, 4, 8, 14, 19, representing 1st, 4th, 8th, 14th and 19th sacral vertebrae, respectively.

pands laterally in this region. The sacrals in the acetabular region are relatively short with short transverse processes, and as a result, the ilium is medially constricted and narrow. The transverse processes of the sacrals become much elongated after the acetabulum, and reach the maximum width near the area between the two antitrochanters where the ilium is also the broadest; the transverse processes then become gradually shorter distally while the ilium becomes narrower. The paratype specimen is slightly larger than the holotype, and is generally similar to the holotype in major features. Both specimens are slightly larger than *Struthio camelus*.

Living palaeognathous birds (Palaeognathe) comprise 5 orders: Struthioniformes, Rheiformes, Casuariiformes, Apterygiformes, and Tinamiformes, and are generally believed to form a monophyletic group^[3]. The sternal keel

is reduced if not lost altogether in these birds, with scapula and coracoid forming an obtuse angle. Struthioniformes are distributed in Middle East and northern Africa, Casuariiformes in Australia, Apterygiformes in New Zealand, Rheiformes in South America, and Tinamiformes in South America^[4].

Living Struthioniformes comprise only one family (Struthionidae) with one genus and species, *Struthio camelus*. The new ostrich material most resembles *S. camelus* in the size and morphology of the pelvis. For instance, the ischium does not appear to be in contact with the ilium distally. The new ostrich can be easily distinguished from other palaeognathous birds. In Casuariiformes, the ischium is fused with the ilium distally, but the pubis is separated from them. In Rheiformes, the pubis, ischium and ilium are all fused together distally. In Ap-

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terygiformes and Tinamiformes, the pelvic structure is even more different. The preacetabular wing of the ilium is extremely elongated in Apterygiformes, and none of the pubis, ischium or ilium is fused with each other distally.

The new ostrich material from the Linxia Basin is also similar to *S. camelus* in some other detailed features, such as postacetabular wing of ilium relatively straight, and narrow compared to the preacetabular wing; preacetabular wing dorsally domed; antitrochanter and processus supratrochantericus close in position, and presence of 5 sacrales before the acetabulum. On the basis of these similarities, it is referred to the genus *Struthio*. The new material also shows some remarkable differences from *S. camelus*: preacetabular wing of ilium with a bigger and deeper concavity, postacetabular wing relatively high, highest point of the ilium far anterior to the acetabulum while in *S. camelus* the highest point lies approximately above the acetabulum. In addition, the Linxia ostrich also retained several primitive traits, such as a deep transverse groove on the ventral margin of the acetabulum separating the pubis and ischium, and postacetabular wing of ilium not as narrow as in *S. camelus*. Therefore, we propose to erect a new species of ostrich, *S. linxiaensis* sp. nov., in this paper based on these new materials.

During the geological history, cursorial birds began to appear from the Late Cretaceous, such as *Patagopteryx deferrariisi* from South America, which is still a small bird with a reduced forelimb, and three unfused pelvic bones^[5]. Cursorial birds have also been represented in various stages since the Paleocene. Among them, most notable examples include the carnivorous *Diatryma* from the Eocene in west Europe and North America, *Phorusrhacus* from the Oligocene of South America. Among those large-sized cursorial birds that had coexisted with human beings but have become extinct today, *Dinornis* from New Zealand and *Aepyornis* from Madagascar are probably most famous.

Palaeotis weigelti from the Eocene of France lacks a sternal keel, and is believed to be the earliest representative of Struthioniformes, but cannot be referred to the family Struthionidae. The earliest known fossil record of an ostrich with characteristics of living ostrich, *S. coppensi*, is from the early Miocene of Africa, and is represented only by a few hindlimb bones^[6]. Another important late Miocene ostrich, *S. orlovi*, has been discovered from Moldavia^[7], but represented only by the distal end of a right tibiotarsus. Therefore, they are not comparable to the Linxia ostrich. Four ostrich species have been known from the Pliocene, and they are all distributed in Eurasia: *S. asiaticus* (India, Ukraine, Moldova), *S. chersonensis* (Greece, Ukraine, Kazakhstan), *S. wimani* (China, Mongolia) and *S. bradydactylus* (Ukraine)^[7,8]. These materials are all based on fragmentary eggshells and limb bones. Ostrich egg fossils have been common in the Neogene strata in China and Mongolia^[9–11]. The evidence derived

from limbs and eggs suggests that ostrich had existed in northern China until the late Pleistocene about 10000 years ago^[12].

Among the known ostrich fossils, *S. linxiaensis* has probably preserved the best pelvic structure. As the earliest known ostrich (*Struthio*) is from Africa, it has been proposed that ostrich had probably originated from Africa, and spread to Eurasia in the middle and late Miocene^[6]. The discovery of an ostrich from the Linxia Basin indicates that by the late Miocene ostrich had already been widely distributed in Africa and Eurasia. Further, the finding of the ostrich in the Linxia Basin may also have some implications for reconstructing the paleoclimates of the region, and provide new information for the discussion of the early evolutionary radiation of ostrich.

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