DOI:10.19615/j.cnki.1000-3118.1999.01.001
第37卷 第1期 脊 椎 动 物 学 报 pp.1～8
1999年 1 月 VERTEBRATA PALASIATICA pls.I～II

辽宁晚侏罗世～早白垩世一长颈双弓类爬行动物[1)]

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摘要 初步记述了采自辽西凌源地区晚侏罗世～早白垩世义县组一新的双弓类水生爬行动物化石材料，并确立其为一新属新种——凌源潜龙(*Hyphalosaurus lingyuanensis* gen. et sp. nov.)。化石产于凌源大王杖子乡范杖子村义县组含火山灰的灰白色湖相页岩中，与狼鳍鱼(*Lycoptera*)共生。

凌源潜龙的正模是一具几乎完整、保存完好的化石骨架，包括近乎完整的头骨、下颌骨和头后骨骼，仅尾椎有少量丢失，标本上主要显露腹面骨骼(中国科学院古脊椎动物与古人类研究所标本编号 V11705)。其与水生爬行类 Choristoderes 共有特征包括平凹型脊椎，3 个荐椎，背肋肿大，肢骨下节远短于上节，腕骨和跗骨弱骨化。凌源潜龙主要鉴别特征为：相对身体比例，头骨较小；颈部大大加长，颈椎 19 个；显著肿大的背肋呈 S 型；超过 20 组腹肋，每组由 3 段组成，而对应每一椎体有 2～3 组腹肋；第 III、IV 蹠骨长度基本相等，第 V蹠骨不为钩状。

凌源潜龙所具有的异乎寻常的长颈与三叠纪海相幻龙类(Nothosaurs)有相似的特征。其所具有的相对小的头骨，尖的吻部，似针状的牙，特殊的长颈及其埋藏特征反映该动物为适应湖泊环境的食鱼性动物。

凌源潜龙是迄今为止中国发现的第一个来自中生代湖相沉积中的长颈水生爬行动物。

关键词 辽宁省凌源，晚侏罗世～早白垩世，双弓类

中图法分类号 Q915.864

1) 中国科学院资源与环境研究重大项目(KZ951-B1-410)和国家自然科学基金项目(49672088)资助。

收稿日期：1998-10-28

A LONG-NECKED DIAPSID REPTILE FROM THE UPPER JURASSIC / LOWER CRETACEOUS OF LIAONING PROVINCE, NORTHEASTERN CHINA

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Abstract A new diapsid reptile is named and described on the basis of a well-preserved skeleton from the Late Jurassic / Early Cretaceous Yixian Formation, Liaoning Province, northeastern China. The specimen represents an unusually long-necked diapsid, which shows specialized adaptations to an aquatic life style in a lacustrine environment. Morphological characters, such as the small skull with a pointed snout, needle-like teeth, and a long neck, strongly indicate a piscivorous diet of the animal. This discovery documents the first known long-necked reptile from the Mesozoic lake deposits of northeastern China.

Key words Lingyuan, Liaoning Province, Late Jurassic / Early Cretaceous, diapsid

1 Introduction

The Late Jurassic and Early Cretaceous deposits in Liaoning Province, northeastern China, have been long known for producing superbly preserved vertebrate fossils. Early discoveries of reptilian fossils, such as *Monjurosuchus* and *Yabeinosaurus*, were mostly from the Chiufotang Formation and its equivalents (Endo, 1940; Endo and Shikama, 1942; Young, 1958). In early literature, the formation was reported to be Late Jurassic age, but is of Early Cretaceous according to a current consensus. Recent discoveries of feathered dinosaur, early bird, lizard, and mammal specimens (Hou *et al.*, 1995; Ji and Ji, 1996, 1997; Hu *et al.*, 1997; Chen *et al.*, 1998; Ji, 1998) from Sihetun and nearby areas are mostly from the underlying Yixian Formation (sensu lato), the age of which (Late Jurassic or Early Cretaceous) is still a matter of debate (Wang *et al.*, 1989; Gu, 1995; Jin, 1996; Chen, 1996; Ren *et al.*, 1997). More recently, Ji *et al.* (1998) named the Chaomidianzi Formation (same as three members of lower part of the Yixian Formation in Sihetun and neighboring areas by Wang *et al.*, 1998), and argued for its Late Jurassic age; however, conflicting results of radiometric dating (Smith *et al.*, 1995; Luo and Li, 1997; Swisher *et al.*, 1998) of rock samples from the same geological sequence still cannot resolve the age problem of the formation.

In the summer of 1998, a well-preserved specimen of a diapsid reptile was collected from the nonmarine Yixian Formation exposed in the Lingyuan area. The specimen represents a new reptile that was highly adapted to an aquatic life style, as evidenced by characters such as the platycoelous vertebrae and pachyostotic ribs. The specimen is unusual in also showing a long neck, evidently convergent on that in Triassic marine nothosaurs. The purposes of this paper are to report this important discovery and to provide a short description of the new taxon; detailed study, including discussion on the phylogenetic relationships of the new diapsid, will be published elsewhere once the specimen is fully prepared.

2 Systematic paleontology

Subclass Diapsida Osborn, 1903

Family Incertae sedis

Genus *Hyphalosaurus* gen. nov.

Etymology *hyphalos* (Gr.), submerged, under water; *sauros* (Gr.), lizard.

Type species *Hyphalosaurus lingyuanensis* sp. nov.

Diagnosis As for the type and only known species.

Range Late Jurassic / Early Cretaceous, northeastern China.

***Hyphalosaurus lingyuanensis* sp. nov.**

(pls. I～II)

Etymology Lingyuan (place name).

Holotype IVPP V11705, nearly complete skull, mandible, and well-preserved postcranial skeleton.

Type locality and horizon Fanzhangzi, Dawangzhangzi, Lingyuan, Liaoning Province, northeastern China; Late Jurassic / Early Cretaceous Yixian Formation.

Known distribution Known only from the type locality and horizon.

Diagnosis An aquatic diapsid sharing with choristoderes the following character states: vertebral centrum platycoelous; three sacral vertebrae; dorsal ribs pachyostotic; epipodial segment of limbs much shorter than propodial; and carpal and tarsal ossification greatly reduced.

Differing from other diapsids including choristoderes in having a combination of the following character states: skull proportionally small in relation to body size; neck greatly elongated, having 19 cervical vertebrae; pachyostotic dorsal ribs strongly sigmoid; more than 20 rows of gastralia present, each row consisting of three segments and each body segment corresponding with two to three rows; third and fourth metatarsals subequal in length, and fifth metatarsal not hooked.

3 Description

The specimen IVPP V11705 consists of a nearly complete skull with articulated mandible, and a well-preserved postcranial skeleton with only a small part of the tail missing. The entire skeleton is exposed in ventral view, and is preserved in association with at least six *Lycoptera* fish on the block: one near the snout, one at the left abdominal region, one at the pelvis, and three close to the tail.

Skull and mandible: The dermal roofing elements of the skull are still imbedded in the matrix and need to be prepared for examination. The skull is proportionally small in respect to body size, having a short but pointed snout. This configuration of the skull, in keeping with the needle-like teeth and greatly elongated neck (see below), strongly indicates a piscivorous (fish-eating) diet of the animal in life. Small palatal teeth are identifiable, but their association with the specific palatal elements is unclear, as the sutures between the elements cannot be delimited without preparation of the specimen.

Most of the marginal teeth are not exposed, but the exposed tips of the maxillary teeth show that the teeth are slender, simple, and needle-like. Both sides show a single row of teeth, and there is no indication of a second row (contra *Monjurosuchus splendens*, see Endo, 1940; von Huene, 1942). The teeth are homodont, having no enlarged or caniniform teeth developed anteriorly. Loss of enlarged anterior teeth is a derived condition in early reptiles and the condition is achieved at the eosuchian level (Evans, 1988; Laurin, 1991; de Braga and Rieppel, 1997).

The mandible is well preserved and is in articulation with the skull. The exposed ventral border shows that the lower jaw is slender, in accordance with the lightly built skull. The snout is short but pointed, and the mandibular symphysis is terminal, showing no posterior elongation (contra choristoderes). The retroarticular process is weakly developed but clearly-defined, differing from choristoderes, which have no definite retroarticular process (Gao and Fox, 1998).

Vertebral column and ribs: The vertebral column consists of 19 cervicals, 16～17 dorsals, three sacrals, and more than 55 caudals. As in other aquatic reptiles such as choristoderes, the vertebrae of this new diapsid have platycoelous centra, with essentially articular surfaces both anteriorly and posteriorly. All the cervicals but the atlas-axis complex are weakly elongated and are slightly shorter than the dorsal vertebrae. The cervicals are strongly keeled ventrally, in keeping with development of a lateral fossa on both sides of the centrum.

At least 13 pairs of dorsal ribs are identifiable, and several more pairs close to the pelvis are probably too short to be exposed in ventral view. The dorsal ribs are

holocephalous (or single-headed), as evidenced by one anterior rib that has been disarticulated from its associated vertebra. Convergent with other aquatic reptiles such as the fresh-water choristoderes and marine nothosaurs, the dorsal ribs of this new diapsid are pachyostotic, as they are thickened distally. Functionally, this thickening appears to increase the specific gravity of the body, enabling the animal to remain submerged with a minimum of effort (Carroll, 1988). The pachyostotic ribs in this new reptile are sigmoid, and are imbricated distally with a ventroposterior extension as preserved.

A series of gastralia (or so-called abdominal ribs) is developed on the ventral aspect of the trunk region (Pl. II). As in choristoderes, the gastralia are slender and spindle-like, covering a large part of the abdominal region. The gastralia start anteriorly below the seventh dorsal vertebra and terminate posteriorly below the last vertebra of the dorsal series. There are more than 20 rows of gastralia, and two to three rows are present corresponding to each vertebral segment. Each horizontal row consists of three segments: one is in the middle, and this articulates to the posteromedial part of the two lateral segments symmetrically located on either side of the abdominal region.

Pectoral girdle and forelimb: The elements of the pectoral girdle are fully articulated, with little distortion; however, the interclavicle is not preserved, precluding any interpretation about its morphology. All the elements are well ossified, and the glenoid is clearly defined. The supraglenoid buttress and the supraglenoid foramen, both are normally present in primitive reptiles and in early diapsids as well, cannot be determined because of preservation. An acromion process is absent in the scapula (see de Braga and Rieppel, 1997 for comments). The coracoid plate is a single broad and roughly rounded element, lacking a significant posterior extension (contra nothosaurs). The coracoid foramen penetrates the coracoid anteroventral to the glenoid fossa. A cleithrum is absent, as a derived condition in diapsids (Evans, 1981).

The forelimbs are well preserved on both sides. The humerus is evidently longer than the epipodial segment (radius and ulna). Proximally, the humerus lacks an internal tuberosity seen in most archosaurs (Romer, 1956), and distally, it lacks an indication of either ectepicondylar or entepicondylar foramen. The epipodial segment of the forelimb and the forefoot are still imbedded in the matrix.

Pelvic girdle and hindlimb: The pelvis and the hindlimbs are as well preserved as the pectoral girdle and the forelimbs. As in other aquatic reptiles (e.g., nothosaurs and choristoderes), the iliac blade of the pelvis is much reduced, lacking a strong anterior extension. The puboischiadic plate is well ossified, but it apparently lacks a definite thyroid fenestration. Such a fenestra is absent in primitive diapsids, but is well developed in nothosaurs (Carroll and Currie, 1991; de Braga and Rieppel, 1997).

The hindlimbs are nearly completely preserved on both sides of the specimen. Like the forelimb, the epipodial segment of the hindlimb is significantly shorter than the propodial (femur). The tibia is slightly longer than the fibula, and is obviously more robustly built than the latter. The hindfoot is largely covered in the matrix, but it can be observed that the third and the fourth metatarsals are subequal in length. The fifth metatarsal is shorter than others, but is not hooked at all, nor is a plantar tubercle developed. In this respect, the new diapsid differs from the more derived condition in either of the saurian groups (lepidosauromorphs and archosauromorphs).

4 Comparison and discussion

As described above, the new diapsid reptile from the Late Jurassic/Early Cretaceous Yixian Formation is unusual in having a greatly elongated neck. Consisting of some 19 cervical vertebrae, the neck clearly distinguishes this new reptile from *Monjurosuchus* (Endo, 1940; von Huene, 1942) and other known aquatic diapsids. A long neck is well known for nothosaurs (sauropterygians), the record of which is confined to Triassic marine deposits. The similarity of the new diapsid to nothosaurs in this respect is homoplastic, as supported by the following evidence (even though the temporal bars are not exposed): the interpterygoid vacuity remains open; a strong posterior extension of the coracoids is lacking; the thyroid fenestra of the pelvis is absent; and the tail is greatly elongated in relation to the body length. Therefore, the new taxon from Lingyuan documents the first known fresh-water reptile that is convergent to marine nothosaurs in this feature.

The taphonomic features (the mode of preservation and nature of the matrix) of the specimen clearly indicate a lacustrine environment, in which the animal lived. The skeleton is well preserved without post-mortem disarticulation, and the flattened body lies parallel to the bedding plane of the volcanoclastic shales in which it is preserved. This type of preservation reflects simultaneous deposition of volcanoclastic material and death, with rapid burial of the animal body in a calm aquatic environment (preventing scavenging or the action of other destructive agents). The flattening of the skeleton is the consequence of the cementation and compaction of the sediments, and is commonly seen in other vertebrate specimens from the Late Jurassic/Early Cretaceous deposits in western Liaoning Province.

In keeping with the sedimentological evidence, the specimen shows other morphological features that reflect an aquatic life style: platycoelous vertebrae; pachyostotic dorsal ribs; poor ossification of the distal ends of the limb bones; reduced ossification of the carpals and tarsals; and short epipodials (see Carroll and Currie, 1991 for discussion of these features). The proportionally small skull, pointed

snout, needle-like marginal teeth, and greatly elongated neck strongly indicate the piscivorous habits of this animal in life.

Acknowledgments This research was supported by the Chinese Academy of Sciences (grant #KZ951-B1-410) and National Science Foundation of China (grant #49672088). Gao's work was supported by the American Museum of Natural History and his travel to China was supported by the National Geographic Society (grant #6311-98). Dr. Fox R C carefully read the manuscript and made suggestions to improve the paper. We thank Hou Lianhai, Jin Fan, Wang Yuanqing, and Xu Xing for helpful discussion on taxonomic and stratigraphic problems related to the new reptile specimen from Lingyuan.

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Explanations of plates

Hyphalosaurus lingyuanensis gen. et sp. nov.

Plate I Holotype specimen in ventral view, IVPP V11705. Scale bar equals 4cm

Plate II 1. Close-up of the pectoral girdle and forelimb of the holotype. Scale bar equals 4cm

2. Close-up of the pelvic girdle and hindlimb of the holotype. Scale bar equals 4cm