

EMBRYOS OF EARLY CRETACEOUS CHORISTODERA (REPTILIA) FROM THE JEHOLO BIOTA IN WESTERN LIAONING, CHINA

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Abstract: The Choristodera is a poorly known clade, but very a distinctive group of aquatic reptiles, which has been found from the Late Triassic to the Late Oligocene in Asia, North America and Europe. Although thousands of choristoderian specimens have been collected from the Early Cretaceous non-marine beds in Liaoning, China, no direct evidences have been found to determine whether they were oviparous like sea turtles or viviparous like *Keichousaurus hui* of Pachypleurosauria (marine reptiles). Here we report a well-preserved specimen of *Hyphalosaurus baitaigouensis* with leathery embryonic eggs from the Jiufotang Formation in western Liaoning, China. It provides the first direct evidence to indicate that choristoderian reptiles are most likely viviparous like Late Triassic *Keichousaurus hui* from Guizhou, Southern China.

Key words: Embryos, Choristodera, Jehol biota, Liaoning, China

INTRODUCTION

In China only three kinds of lacustrine choristoderian reptiles have been reported in the Jehol biota of Early Cretaceous. The first one is a kind of small semiaquatic reptiles *Monjurosuchus*, type species is *M. splendens* Endo 1940, which was classified as a primitive member of Thecodontia (Endo, 1940). Unfortunately, the holotype of *Monjurosuchus splendens* was reportedly lost during the World War II. This taxon was referred as Choristodera on the basis of the neotype specimen (Gao *et al.*, 2000). The second is a kind of large-sized, long-rostrum crocodile-like reptiles *Ikechosaurus*, of which three species have been reported from the Jehol biota in western Liaoning and Inner Mongolia (Sigogneau-Russell, 1981; Brinkman and Dong, 1993; Lü *et al.*, 1999). The third is a kind of small-headed, long-necked and tailed reptiles *Hyphalosaurus*, which was named and assigned to Choristodera in 1999 by Gao *et al.* (1999). However, the validity of the name of this taxon is still controversial up to now (Li *et al.*, 1999; Smith and Harris, 2001).

In western Liaoning, there are two fossil localities and horizons for *Hyphalosaurus*. One fossil site lies in the north of the Dawangzhangzi village of Lingyuan City. In this locality, only a few specimens of *Hyphalosaurus lingyuanensis*, the type species of the genus *Hyphalosaurus*, have been collected from the lower part of the Yixian Formation, which is characterized by having a small skull, needle-like teeth, 19 cervicals, 16~17 dorsals, 3 sacrals and more than 55 caudals (Gao *et al.*, 1999). The other fossil site is located near the Baitaigou village in the northwest of the Yizhou town of Yixian County. In this locality, thousands of specimens of the other species, *Hyphalosaurus baitaigouensis*, which is distinguished from *H. lingyuanensis* mainly by having 26 cervicals (Ji *et al.*, 2004), have been unearthed from the upper part of the Jiufotang Formation. Both adult and juvenile individuals are usually well preserved and sometimes associated with each other (Fig. 1). Here we report a desirable specimen of *Hyphalosaurus baitaigouensis* associated with eggs and embryos.

DESCRIPTION

[CAGS-IG (Institute of Geology, Chinese Academy of Geological Sciences) -03-7-02], is collected



Fig. 1. A well-preserved specimen (CAGS-IG-03-7-08), showing an adult and a juvenile individuals of *Hyphalosaurus baitai-gouensis* died together.

from a set of light gray to white thin-bedded tuffs and tuffaceous shales and mudstones with fine horizontal beddings in the upper portion of the Jiufotang Formation near Baitaigou village in the northwest of Yizhou town of Yixian County. The associated fossils are *Sinamia zdanskyi*, *Jinanichthys longicephalus*, *Longdeichthys luojiaxiaensis* (fishes), *Microraptor zhaoianus*, *M. gui* (theropods), *Shenzhouraptor sinensis*, *Jixiangornis orientalis*, *Yixianornis grabaui*, *Yanornis martini* (birds), *Haopterus gracilis* (pterosaurs) and some invertebrates and plants.

The skull and postcranial skeleton of CAGS-IG-03-7-02 are preserved in dorsal view, and more than 11 eggs with embryos are scattered around the skeleton (Fig.2). The skull is small, about 6.5cm in length, and only some bones such as the prefrontal, frontal, maxilla, jugal and postfrontal can be recognized because of crushing (Fig.3). In addition, about 20 conical teeth are visible in the maxilla. There are 41 pre-sacral vertebrae preserved in CAGS-IG-03-7-02, comprising 17 dorsal vertebrae and 24 postaxial cervical vertebrae. Counting the atlas and axis unpreserved, CAGS-IG-03-7-02 should have at least 26 cervical vertebrae. The sacrum is composed of 3 vertebrae. Although 31 caudal vertebrae are identi-

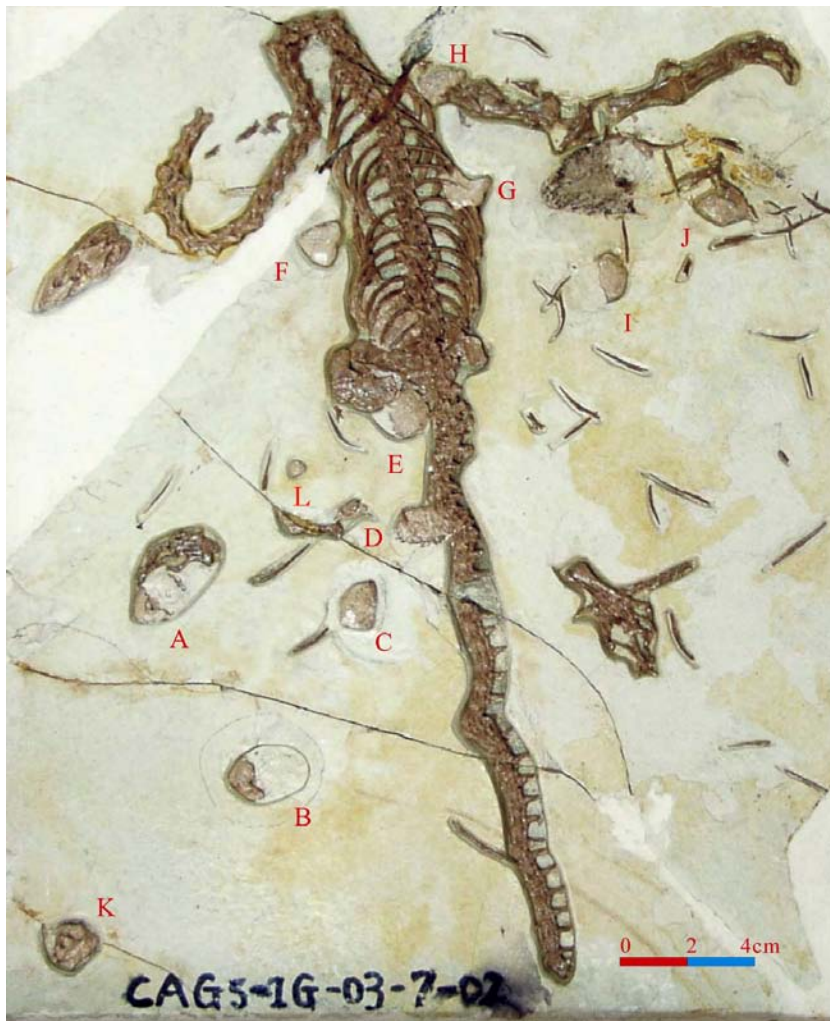


Fig. 2. The specimen CAGS-IG-03-7-02 of *Hyphalosaurus baitaigouensis*, showing leathery eggs (A to L) scattered around the skeleton.

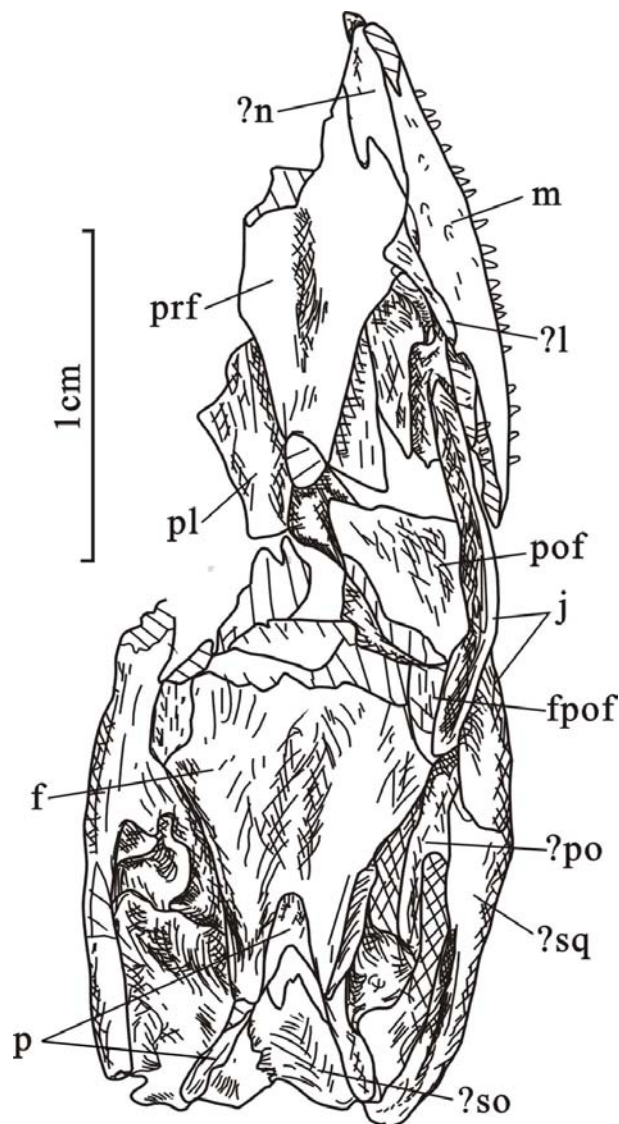


Fig. 3. Line drawing of the skull of *Hyphalosaurus baitaigouensis*.

Abbreviations: f-frontal, fpof-facet for postfrontal, j-jugal, l-lacrimal, m-maxilla, n-nasal, p-parietal, pl-palatine, po-postorbital, pof-postfrontal, prf-prefrontal, so-supraoccipital and sq-squamosal.

able, the total number of caudal vertebrae is unclear because of lacking the distal portion of the tail.

Cervicle ribs are not visible, but dorsal ribs are well developed and pachyostotic distally. Most preserved dorsal ribs are uncapitate. Gastralia consist of at least two segments of each side. The proximal ends of the well-developed sacral ribs are not fused with the sacral vertebrae. The distal ends of the first two sacral ribs are strongly extensive and rostrocaudally plate-shaped, while the distal end of the third one bends anteriorly with nearly unchangeable width. The transverse processes of the proximal caudal vertebrae are well developed and gradually become short backward, then almost disappear from the 10th caudal vertebra.

The scapula and coracoid are plate-shaped, and the latter possesses a clear coracoid foramen. The hu-

merus is expanding at both ends; moreover, the distal end is much wider than the proximal end. The ectocondylar foramen is slit in shape. The ulna is as long as the radius, and both much shorter than the humerus. The tibia equals to the fibula in length, which are also obviously shorter than the femur. Most manual and pedal bones are preserved and show the similar structures as in the terrestrial diapsids.

It is worth to pay attention to some “nodule”-like structures, which are scattered around the skeleton of *Hyphalosaurius baitaigouensis* in the specimen CAGS-IG-03-7-02. They vary in size and shape to some extent, of which some are oval or sub-circular, and others are sub-triangular or irregular (Figs. 3, 4). The biggest one (A) is oval (2.5 X 1.7 cm), while the smallest one (L) is sub-triangular (0.4 X 0.5 cm). After preparation, some embryos are found within them (Fig. 4). Although these embryos cannot be anatomically compared with the mature skeleton directly, the general morphology of the embryonic skull shows close similarity to the skull of *Hyphalosaurius baitaigouensis* (Fig. 5). Although the eggs are hardly linked with any individual of *Hyphalosaurius baitaigouensis*, it is reasonable that these eggs are considered to be

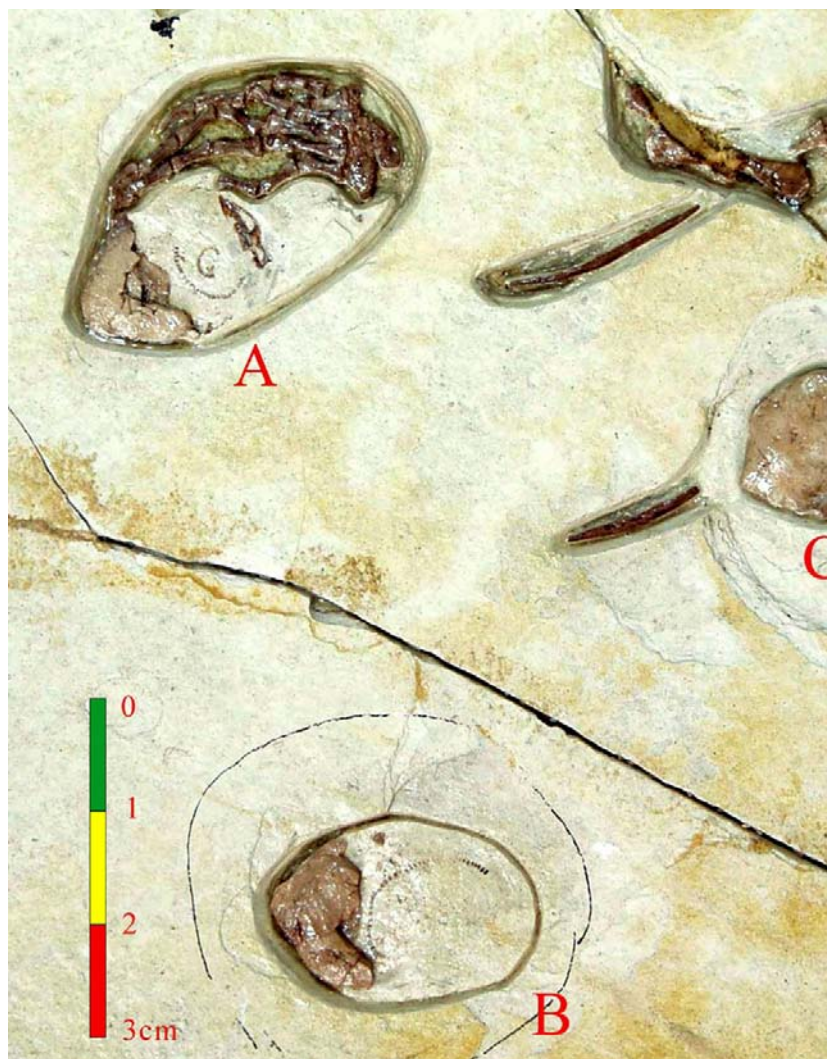


Fig. 4. Showing the embryos within the eggs A and B of *Hyphalosaurius baitaigouensis*.

laid by *Hyphalosaurius baitaigouensis* on the basis of their preserved condition and general morphology.

In addition, according to our observation, the egg shells are very thin and membranous. Up to now, we have not found any evidence of hard shells or any structure that can be supposed the existence of hard shells. It undoubtedly shows that the eggs are soft-shelled (Fig.4). It gives the reason why the shapes of the eggs are quite variable.

CONCLUDING REMARKS

The characters such as the long neck, plate-shaped scapula and coracoid, pachyostotic ribs and 3 sacral s show that this animal is an aquatic reptile. It is obviously similar to *Hyphalosaurius lingyuanensis* from Dawangzhangzi, another fossil site in Lingyuan, western Liaoning (Gao, 1999). The specimen CAGS-IG-03-7-02 can be clearly included within the genus *Hyphalosaurius* but it also differs from *H. lingyuanensis* in much more cervical vertebrae in number (26 versus 19), therefore it is identified as *H. baitaigouensis*.

The strata yielding *Hyphalosaurius baitaigouensis* composed of light gray and grayish white thin-bedded lacustrine tuffaceous shales with horizontal bedding, containing rich freshwater fossils. According to the sedimentary and paleontological evidences, this fossil site is considered to be a low-energy shallow-water lake paleoenvironment. But we wonder if this fossil site is the burial place or

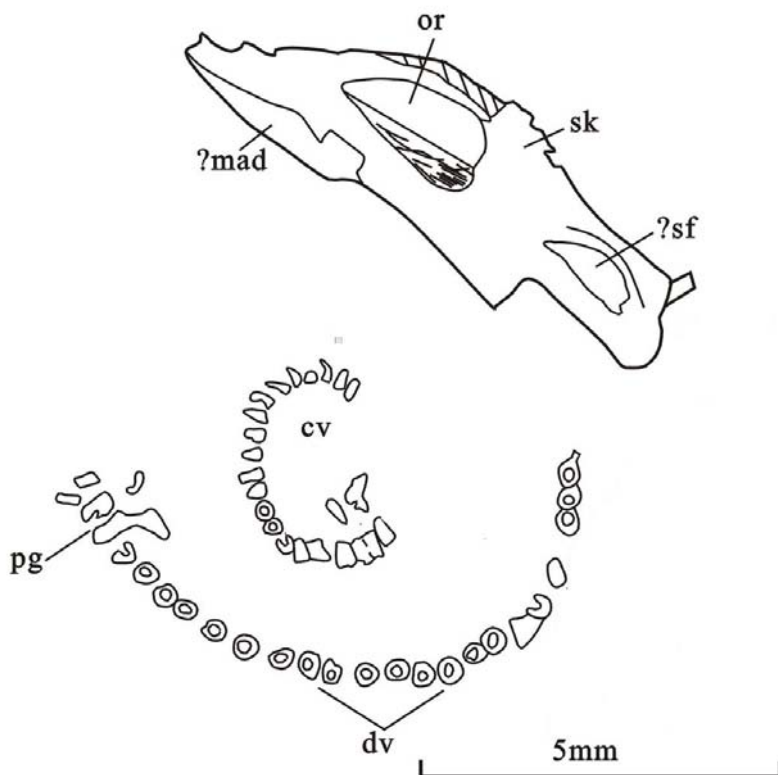


Fig. 5. Line drawing of the embryo of the egg A of *Hyphalosaurius baitaigouensis*.

Abbreviation: cv-caudal vertebrae, dv-dorsal vertebrae, mad-mandible, or-orbital, pg-pelvic girdle, sf-supratemporal fenestra and sk-skull.

the original living site. On the other hand, although these leathery eggs are very small and variable in size (the smallest one even less than 0.5 cm in size), they are actually developed with embryos. It just shows that they are in the stage of developing in mother's body. Despite we are difficult to determine whether the choristoderian reptiles such as *Hyphalosaurius baitaigouensis* are viviparous or oviparous, it is most likely that they gave birth in the water to living young like Triassic marine reptile *Kuichousaurus hui* (Cheng *et al.*, 2004). We presume that the death of this individual of *Hyphalosaurius baitaigouensis* is probably caused by a sudden event, such as a volcanic eruption, an earthquake, or a flood, and its skeleton and eggs were buried together in the bottom of the lake. The other possibility is that *Hyphalosaurius baitaigouensis* was scared and aborted by a prey and a sudden event. Then the eggs were expelled from mother's body and buried in the bottom of the lake. We think that this *in situ* preservation cannot be caused by long distance transportation from land. Otherwise, the soft-shelled eggs would not be so well-preserved together.

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중국 서부 요녕성의 Jehol Biota에서 산출된 전기 백악기 Choristodera (파충류)의 태아화석

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요 약: Choristodera는 잘 알려지지 않은 그룹이지만 매우 독특한 해양 파충류로 후기 트라이아스기에서부터 후기 올리고세까지 아시아, 북미, 유럽에 걸쳐 산출된다. 비록 수천 개의 choristodera 표본이 중국 전기 백악기 Jehol biota에서 수집되었지만 바다거북처럼 난태생이었는지 Pachypleurosauria (해양 파충류) *Keichousaurus hui*처럼 태생이었는지 아직 확실하게 밝혀지지 않았다. 우리는 이 논문에서 중국 서부 요녕성의 Jiufotang층에서 산출된 가죽질의 알껍데기가 함께 잘 보존된 *Hyphalosaurius baitaigouensis* (파충류, Choristodera)를 보고한다. 이것은 *Hyphalosaurius baitaigouensis* 같은 choristoderian 파충류가 남중국 Guizhou에서 산출된 후기 트라이아스기 *Keichousaurus hui*처럼 태생이었을 것임을 지시하는 직접적인 첫 번째 증거다.

주요어: 태아화석, Choristodera, Jehol biota, 요녕성, 중국

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