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The Most Complete Pistosauroid Skeleton from the Triassic of Yunnan, China

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Abstract: A new specimen discovered from the Falang Formation in northeastern Yunnan represents the most complete skeleton of Triassic pistosauroids. The new specimen is referred to *Yunguisaurus* Cheng et al., 2006 on the basis of the skull features, such as the presence of a separated nasal entering the external naris, a large pineal foramen located at the frontal/parietal suture and an interpterygoid vacuity with a narrow anterior extension. The new specimen differs from the type species of *Yunguisaurus liae* Cheng et al., 2006 in some aspects. Most of these differences can be attributed to ontogenetic variations. The new specimen is provisionally considered as *Yunguisaurus cf. liae* although its relatively short snout of the skull and slenderer hyoid may not be explained ontogenetically. Whether or not the new specimen represents a different taxon has to wait for a detailed study of the whole skeleton.

Key words: Pistosauroid, *Yunguisaurus*, complete skeleton, Falang Formation, late Middle Triassic, Yunnan

1 Introduction

Pistosauroids, the crown group of Sauropterygia, are well known for their derived representatives, the plesiosaurs formed a group that achieved considerable diversity and cosmopolitan distribution during the Jurassic and Cretaceous. However, our knowledge on the early members of the group, Triassic pistosauroids, has been limited because of the lack of good materials. Early pistosauroids so far known (such as *Augustasaurus* Sander et al., 1997; *Chinchenia* Young, 1965; *Corosaurus* Case, 1936; *Cymatosaurus* Fritsch, 1894; *Kwangsisaurus* Young, 1959; *Pistosaurus* Meyer, 1839; Edinger, 1935; Rieppel, 1997, 1998, 1999; Storrs, 1991; *Bobosaurus* Dalla Vecchia, 2006; Lü et al., 2006) are represented by incomplete specimens. *Yunguisaurus* (*Y. liae*) Cheng et al., 2006 was recently reported as the most complete Triassic pistosauroid. However, its skull roof is partially damaged and the most part of its tail is missing.

Here we report an almost complete and beautifully preserved skeleton of a pistosauroid. This specimen was collected from the limestone of the Zhuganpo Member of the Falang Formation (the late Middle Triassic) in northeastern Yunnan, China. Because of the rarity of good specimens of Triassic pistosauroids, we are providing a swift description on the basis of the skull and mandible while the postcranial skeleton waits a full description when its preparation is completed. In the following text, the comparison will be made mainly with those pistosauroids which have the skull materials preserved.

2 Systematic Paleontology

Sauropterygia Owen, 1860

Pistosauroidea Baur, 1887–1890

Yunguisaurus cf. *liae* Cheng et al., 2006

Referred Specimen: ZMNH (Zhejiang Museum of Natural History) M8738, an almost complete and articulated skeleton, with the right forelimb slightly damaged and the tip of the tail missing.

Locality and horizon: Western side of the Huangnihe River, Fuyuan County, Yunnan Province; Zhuganpo

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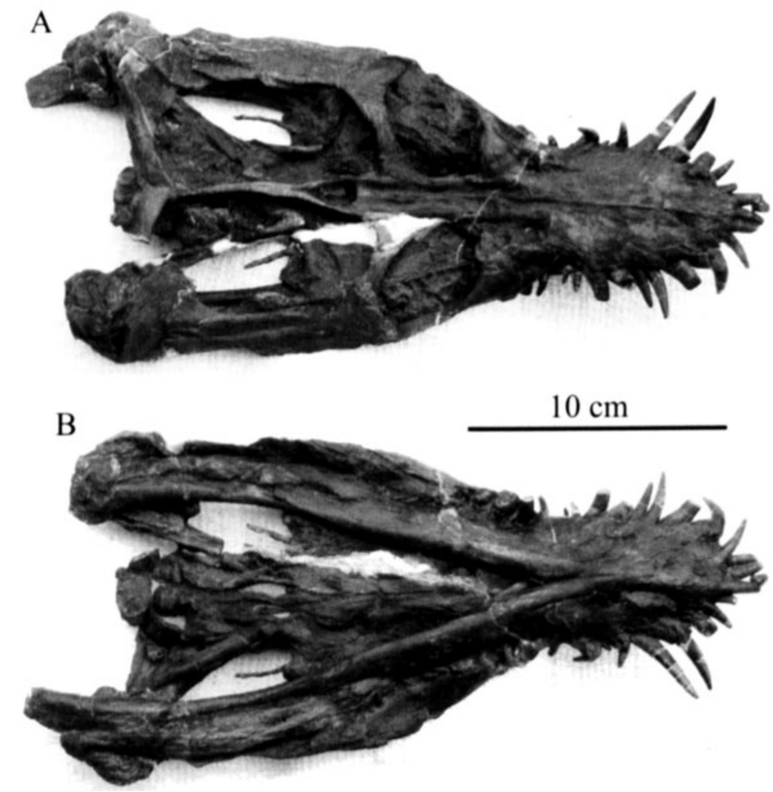

Fig. 1. Black-white digital photos of the skull and mandible of ZMNH M8738 (*Yunguisaurus* cf. *liae*) in dorsal (A) and ventral (B) views.

Member, Falang Formation, late Middle Triassic (Ladinian).

Description and comparison: ZMNH M8738 is preserved in ventral view and no morphological features of the dorsal side of the postcranial skeleton are observable. The preserved skeletal length is about 4.10 m (from the tip of the snout of the skull to the end of the preserved tail). The missing tail tip may include the last 10 caudal vertebrae, which may reach 10 cm in length. In this case, the total length of the new pistosauroid is about 4.2 m. The skull and mandible are roughly prepared on both sides (Figs. 1 and 2). The skull is about 22 cm long along the dorsal midline (from the anterior tip to the occipital edge of the skull roof) or over 21 cm long from the anterior tip to the occipital condyle. The maximum length of the mandible is over 27 cm. As a whole, the skull is more than 1.7 times longer than that of the holotype of the type species of *Yunguisaurus liae* (Cheng et al., 2006), slightly longer than that of *Cymatosaurus fridericianus* (see figs. 1 and 2 in Rieppel, 1997), twice longer than that of *Cymatosaurus latifrons* (see fig. 75 in Rieppel, 2000) and that of *Corosaurus alcovensis* (see fig. 3 in Storrs, 1991 or figs. 2 and 3 in Rieppel, 1998) but just about 2/3 of that of *Augustasaurus* (see figs. 2 and 3 in Rieppel et al., 2002) and definitely shorter than that of *Pistosaurus* (see fig. 11 in Sues, 1987; fig. 78 in Rieppel, 2000).

In dorsal view, the outline of the skull is similar to that of *Yunguisaurus*. The snout is relatively short, much shorter than that of *Cymatosaurus* and *Augustasaurus* but similar to (slightly shorter than) that of *Yunguisaurus*. The snout of *Corosaurus* is short too but triangular in profile. The snout is incomplete in *Pistosaurus* but the preserved portion suggests that it is relatively longer and slenderer than in ZMNH M8738. There is a notch at the premaxillary/maxillary suture. Such a construction is present in *Cymatosaurus* (see figs. 1 and 2 in Rieppel, 1997 or fig. 74 in Rieppel, 2000) but very weak if any in *Yunguisaurus* (Cheng et al., 2006). The external naris is very small, much smaller than that of any of the above mentioned taxa. The orbit is oval and obliquely oriented, more similar to that of *Yunguisaurus* than any other taxa. The large supratemporal fenestra is more or less rectangular in outline, especially with a square-shaped anteromedial margin, again most similar to that of *Yunguisaurus* among the aforementioned taxa. As in *Yunguisaurus*, the large, elongate pineal foramen is exactly the same in position at the parietal-frontal suture, which is located far back from the suture in the other taxa. The occipital edge of the skull roof is curved anteriorly at a degree much greater when compared with the situation in *Cymatosaurus* and *Corosaurus*. In *Augustasaurus*, the occipital edge is nearly straight transversely (see figs. 1–3 in Rieppel et al., 2002). This cannot be compared with that of *Yunguisaurus* because of the incompleteness. As in other pistosauroids (except for *Corosaurus*), the intertemporal region narrows into a sagittal ridge. It is clear that a separate nasal bone is present. It is elongated triangular in outline and forms the posterior margin of the external naris, as in *Yunguisaurus* (see fig. 1 in Cheng et al., 2006). In the other known pistosauroids in which the relevant part is complete, the nasal is often not recognizable or fused with the neighboring bones.

In ventral view, the skull braincase and mandible resemble those of *Yunguisaurus*. The basioccipital bears a midline ridge anterior to the occipital condyle, which meets the ventral keel of the basisphenoid-parasphenoid complex anteriorly. The mandible has a moderately long symphysis with a relatively round tip; the width/length ratio of the symphysis is about 0.62, similar to that of *Yunguisaurus*. In *Augustasaurus*, the basioccipital does not have a midline ridge and the mandibular symphysis is relatively longer (about twice longer than breadth) and has a pointed tip (see figs. 2B and 3B in Rieppel et al., 2002); while in other taxa, the symphysis is damaged. Much of the posterior portion of the palate is exposed except for the sides covered by the occluding mandible. It is clear that

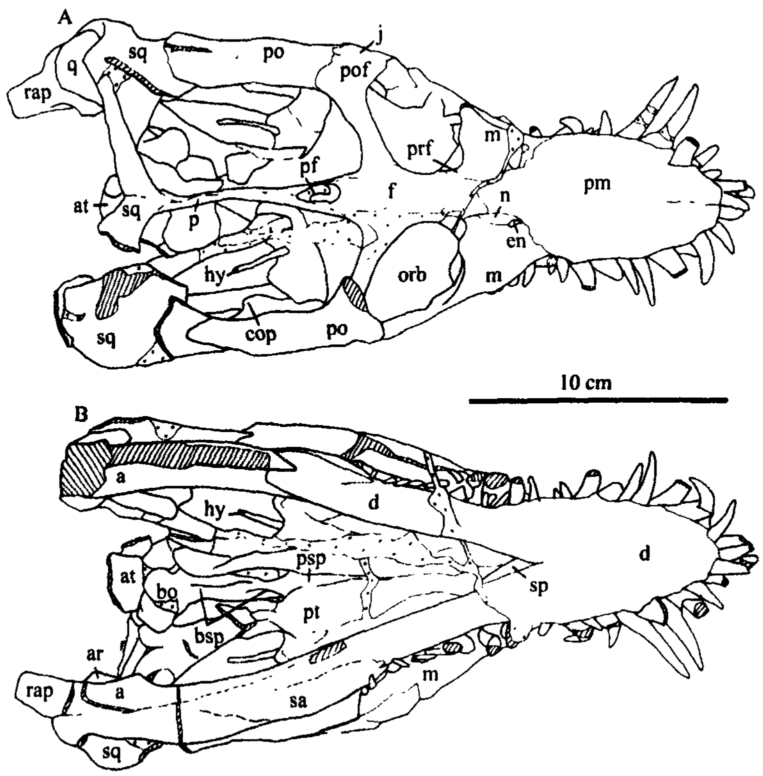

Fig. 2. Outlines of the skull and mandible of ZMNH M8738 (*Yunguisaurus* cf. *liae*) in dorsal (A) and ventral (B) views.

Abbreviations: a – angular; ar – articular; at – atlas; bo – basioccipital; bsp – basisphenoid-parasphenoid complex; cop – coronoid process of mandible; d – dentary; en – external naris; f – frontal; hy – hyoid; j – jugal; m – maxilla; n – nasal; orb – orbit; p – parietal; pf – pineal foramen; po – postorbital; pof – postfrontal; prf – prefrontal; psp – parasphenoid process; pt – pterygoid; q – quadrate; rap – retroarticular process of mandible; sa – surangular; sp – splenial; sq – squamosal.

the interpterygoid vacuity is single, with a narrow anterior extension (Figs. 1B and 2B). This differs from that of *Augustasaurus* (see figs. 2B and 3B in Rieppel et al., 2002) and *Pistosaurus* (see fig. 11 in Sues, 1987) but resembles that of *Yunguisaurus* (see fig. 1B and D in Cheng et al., 2006). As in the latter, the parasphenoid process is exposed and extends anteriorly within the interpterygoid vacuity. In *Cymatosaurus*, the vacuity is closed and it is unknown in *Corosaurus*. The transverse flange of the pterygoid is strong, comparable in both size and morphology to that of *Yunguisaurus*, *Augustasaurus* and *Pistosaurus*. Posterior to the flanges is a pair of the rod-like bones, which are identified as the pair of the ossified hyoids, which are much slenderer than those of *Yunguisaurus* (see fig. 1 in Cheng et al., 2006). The mandibular symphysis is partially fused, indicating that ZMNH M8738 is quite old. The strong coronoid process projects through supratemporal fenestra. This process is not often described in other known pistosauroids. As in *Augustasaurus*, the retroarticular process is relatively stout and similar in length but relatively shorter than that of *Yunguisaurus*. Among the known pistosauroids, the dentition is more similar to that of *Yunguisaurus*. The teeth on both upper and lower jaws vary in size. The premaxillary teeth, the anterior two maxillary teeth and the anterior dentary teeth are much larger than the other teeth, sharply pointed and curved while the other teeth are short, small although curved too.

3 Discussion

Except for *Yunguisaurus*, previously known Triassic pistosauroids from China are not well-represented. However, most of them are distinguishable from ZMNH M8738. *Chinchenia* (see Rieppel, 1999) from the Anisian Guanling Formation is based on a fragment of the left ramus of the mandible and some limb bones; its mandibular symphysis is much shorter than that of the new specimen. *Kwangsisaurus* (see Rieppel, 1999) from the upper Lower or lower Middle Triassic of the Guangxi Zhuang Autonomous Region is represented by a partial postcranial skeleton; its radius and ulna are relatively longer than those of ZMNH M8738. The left forelimb of the new specimen is exposed, which is very similar to that of *Yunguisaurus* (see fig. 2 in Cheng et al., 2006). It shows that the humerus is slender but the radius and ulna are relatively short and broad, and the ulna is hour-glass-like in outline. *Dingxiaosaurus luyinensis* Liu et al., 2002 was established on the basis of an incomplete specimen (represented by a pair of the hind limbs missing most of the femur and some fragmentary vertebrae and ribs) from the Yangliujing Formation in Guizhou. It was originally described as a potential ichthyosaur, and later considered by Cheng et al. (2006) as a *nomen dubium* because of the lack of diagnostic features.

As compared above, ZMNH M8738 is very similar to *Yunguisaurus* in a number of aspects. The most striking similarities they share are the followings: presence of a separated nasal entering external naris, a large pineal foramen located at the frontal/parietal suture, interpterygoid vacuity with a narrow anterior extension, and hour-glass-shaped ulna. These are the most important diagnostic features for *Yunguisaurus* (Cheng et al., 2006). Furthermore, the new specimen and *Yunguisaurus* share a narrow but relatively short snout, a pronounced coronoid process in the mandible, a moderately elongated mandibular symphysis, an oval obit that is obliquely oriented and a large supratemporal fenestra with a square-shaped anteromedial margin. The presence of such a number of similarities indicates that ZMNH M8738 is referable to the genus *Yunguisaurus*. There are some differences between the new specimen and the holotype of

Y. liae, however. The former is about 1.7 times larger than the latter. Among those differences, such as the fused or separated frontals, the pronounced or weak premaxillary/maxillary notch, the small- or large-sized external naris, etc., may reflect ontogenetic variation. Other differences are, however, not simply attributed to the ontogeny. For example, the relatively short snout and much slenderer hyoids in ZMNH M8738 are hard to explain as ontogenetic variations. It is common that the snout becomes longer in large (old) than in small (young) individuals in diapsid reptiles (see crocodylians in Iordansky, 1973 or Cong et al., 1984), and it is reasonable that the hyoid becomes relatively thicker or massive in large individuals than small individuals. Unfortunately, we do not have any evidence available directly from a pistosauroid. Therefore, whether or not ZMNH M8738 represents a new taxon has to wait for the detailed study of the whole specimen. At the present, it is provisionally referred as *Yunguisaurus* cf. *liae*.

3 Conclusion

The new specimen differs from the holotype of *Yunguisaurus liae* in some aspects. Most of these differences can be attributed to ontogenetic variations. Therefore, the new specimen is provisionally referred as *Yunguisaurus* cf. *liae* although its relatively short snout of the skull and slenderer hyoid may not be explained ontogenetically. The true taxonomic status has to wait for the study of the whole specimen.

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