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A new rhamphorhynchid pterosaur (Pterosauria) from Jurassic deposits of Liaoning Province, China

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Abstract

Compared to pterosaurs from the Early Cretaceous from China, Late Jurassic pterosaurs are relatively rare. A new rhamphorhynchid pterosaur, *Orientognathus chaoyngensis* **gen. et sp. nov.**, is erected based on an incomplete skeleton from the Upper Jurassic Tuchengzi Formation of Chaoyang, Liaoning Province, China. It is identified by the following characters: the toothless tip of the lower jaw is slightly pointed; the length ratio of wing metacarpal to humerus is 0.38, the ulna is shorter than each wing phalanx and the tibia is nearly equal to femur in length. A phylogenetic analysis recovers *Orientognathus chaoyngensis* as a rhamphorhynchid pterosaur. *Orientognathus chaoyngensis* is perhaps the youngest Jurassic pterosaur from western Liaoning Province of China.

Key words: Upper Jurassic, Tuchengzi Formation, Pterosauria, Rhamphorhynchidae

Introduction

Pterosaurs from the Early Cretaceous Jehol Biota of western Liaoning and its surrounding areas are numerous, but those from the pre-Early Cretaceous deposits of China are rarer, although recently they have been increasing both in number and variety. The most important discovery among these Jurassic forms is *Darwinopterus*, a transitional form with a cranium and cervical series that is of typical pterodactyloid morphology, whereas the remainder of the postcranial skeleton is almost identical to that of typical long-tailed non-pterodactyloid pterosaurs (Lü *et al.* 2010a; 2011a). This taxon is pivotal for understanding the evolution of pterodactyloid pterosaurs, and their characteristic anatomy, from more basal forms. Another spectacular discovery is a female *Darwinopterus* preserved with an egg, which has implications for understanding sexual dimorphism and reproductive biology in pterosaurs (Lü *et al.* 2011b). Other Middle Jurassic pterosaurs from China include the non-pterodactyloid *Changchengopterus* (Lü 2009); the rhamphorhynchids *Pterorhynchus* (Czerkas and Ji 2002), which is regarded as close to wukongopterid pterosaurs (Andres *et al.* 2014), and *Qinglongopterus* (Lü *et al.* 2012); the scaphognathines *Fenghuangopterus* (Lü *et al.* 2010b), *Jianchangnathus* (Cheng *et al.* 2012; = *Scaphognathus*, Bennett 2014), *Jianchangopterus* (Lü and Bo 2011c); and the anurognathid *Dendrorhynchoides mutodungensis* (Lü and Hone 2012).

Here we report a new pre-Cretaceous pterosaur, a rhamphorhynchid designated as the new genus and species *Orientognathus chaoyngensis*, from the possible Late Jurassic deposits of Chaoyang, Liaoning Province, of north-eastern China (Fig. 1). A phylogenetic analysis recovers *Orientognathus chaoyngensis* as a rhamphorhynchid pterosaur. The discovery of *Orientognathus chaoyngensis* provides important new information on the evolutionary history of the Rhamphorhynchinae and on pterosaur evolution in the Jurassic more generally.

Orientognathus differs from *Qinglongopterus* in having a smaller ratio of the length of the metacarpal IV to the humerus (0.38 vs. 0.51; Lü *et al.* 2012). The shape of the deltopectoral crest in *Orientognathus* is also different from that of *Qinglongopterus*, where it is more developed compared with the humeral shaft.

Orientognathus differs from *Pterorhynchus* (Czerkas and Ji 2002) in that the anterior teeth are stouter and longer in *Orientognathus* than in *Pterorhynchus*. The length ratio of metacarpal IV to humerus is also smaller in *Orientognathus* (0.38 vs. 0.55).

Orientognathus differs from the scaphognathine pterosaur *Fenghuangopterus* (Lü *et al.* 2010b) in that the teeth are straight in *Orientognathus* whilst they are curved in *Fenghuangopterus*. The length ratio of metacarpal IV to humerus is smaller in *Orientognathus*, which also has a shorter length ratio of the metacarpals to humerus (0.38 vs. 0.56). The rostral end of the lower jaw is toothless and pointed in *Orientognathus*, but expanded in *Fenghuangopterus*.

It is difficult to compare *Orientognathus* with *Jianchangnathus* (Cheng *et al.* 2012), because of the lack of overlapping complete elements. The teeth of *Jianchangnathus* are relatively smaller and stouter than these of *Orientognathus*.

Orientognathus differs from *Jianchangopterus* (Lü and Bo 2011c) in that the tibia is much longer than the femur in *Jianchangopterus*, whilst the length of tibia is nearly equal to the femur in *Orientognathus*. The length ratio of the pteroid to the humerus is smaller in *Orientognathus* (approximately 0.21) than in *Jianchangopterus* (approximately 0.42), and the length ratio of metacarpal IV to the humerus is approximately 0.38 in *Orientognathus* but much larger in *Jianchangopterus* (approximately 0.82).

Orientognathus differs from the transitional form *Darwinopterus* in that the length ratio of the pteroid to the humerus is smaller in *Orientognathus* (0.21 vs. 0.59). Furthermore, the pteroid is short with an expanded distal end in *Orientognathus*, but it is slender with a pointed distal end in *Darwinopterus* (Lü *et al.* 2009; Wang *et al.* 2010). The length ratio of the metacarpal IV to the humerus is approximately 0.66 in *Darwinopterus*, which is much larger than in *Orientognathus* (approximately 0.38).

Orientognathus most likely comes from the Late Jurassic Tuchengzi Formation, which is younger than the Tiaojishan Formation (Bureau of Geology and Mineral Resources of Liaoning Province 1989). It therefore most likely represents the youngest Jurassic pterosaur found in China thus far.

Conclusions

Orientognathus is the largest rhamphorhynchinae pterosaur discovered in the Upper Jurassic deposits of northeastern China thus far. The discovery of *Orientognathus* may help fill the temporal gap between the better-sampled Middle Jurassic and Early Cretaceous pterosaur faunas of China, and indicates that more Upper Jurassic pterosaurs may remain to be found.

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APPENDIX 1. Character codings for *Orientognathus chaoyangensis* **gen. et sp. nov.** for the phylogenetic analysis of Lü *et al.* (2012). The complete matrix includes 82 characters and 24 taxa (with *Orientognathus chaoyangensis* **gen. et sp. nov.** added).

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