



## New material of *Longipteryx* (Aves: Enantiornithes) from the Lower Cretaceous Yixian Formation of China with the first recognized avian tooth crenulations

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### Abstract

We report on a new specimen of *Longipteryx chaoyangensis* from the Lower Cretaceous Yixian Formation in Chaoyang, Liaoning Province, China. The new material preserves previously unknown tooth crenulations. This is the first recognized tooth crenulations within Aves. It not only provides new information regarding the anatomy of the *Longipteryx*, but also sheds new light on the trophic specialization of this genus and even this family. It was discovered from the Yixian Formation, which is older than the *Longipteryx chaoyangensis* bearing-Jiufotang Formation. This new discovery also expands the known stratigraphic range of *Longipteryx*.

**Key words:** Enantiornithes, Lower Cretaceous, Yixian Formation, tooth morphology

### Introduction

During the last two decades, over 60 avian species have been reported from the Lower Cretaceous Jehol Group of northeastern China (Chiappe & Walker 2002; Zhou & Zhang 2006; O'Connor *et al.* 2013; Wang *et al.* 2014). Most of them are preserved nearly completely, and some are even preserved with gastroliths and plumages, which provide direct evidence for understanding their morphology, evolution and lifestyles (Zhou & Zhang 2002; Zhou *et al.* 2004; Hou *et al.* 2004; Chiappe *et al.* 2008, 2014; O'Connor & Chiappe 2011; O'Connor *et al.* 2009, 2010, 2011, 2012, 2013). However, to date no published specimens preserve teeth with structures like serrations or crenulations. In fact, although many Mesozoic birds are toothed, and display a variety of teeth sizes and morphologies (Zhou & Zhang 2001, 2002; Zhou *et al.* 2008; Wang *et al.* 2010), only *Sulcavis georum* O'Connor *et al.*, 2013 has been reported with tooth enamel specialization. Here we report on a new fossil bird (DNHM-D2889) from the Lower Cretaceous Yixian Formation in Chaoyang, western Liaoning, China with the first recognized tooth crenulations. DNHM-D2889 shows close similarities with *Longipteryx chaoyangensis* Zhang *et al.*, 2001, thus providing new information regarding the anatomy and trophic specialization of *Longipteryx*.

**Institutional abbreviations.** IVPP, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; DNHM, Dalian Natural History Museum, Dalian City, Liaoning Province, China.

### Systematic Paleontology

#### Aves Linnaeus, 1758

#### Pygostylia Chiappe, 2002

**TABLE 3.** Comparisons of important bone lengths between DNHM-D2889 and *Longipteryx chaoyangensis* (IVPP-V12325).

Specimen	intermembral index	femur/tibiotarsus	femur/ humerus	clavicle/hypocleideum
DNHM-D2889	1.2	0.8	0.8	1.1
<i>L. chaoyangensis</i>	1.5	1.0	0.6	1.8

To date, the only way to infer the trophic habit of enantiornithines from the Jehol Group is through their cranial or dental morphology (O'Connor *et al.* 2013). Longipterygids constitute a distinct clade within enantiornithines because they have a unique long rostrum, dentition restricted to the premaxilla and rostral-most portion of the dentary, and relatively long forelimbs. They are interpreted as having fed on fish, worms or bivalves (Zhang *et al.* 2001; Hou *et al.* 2004; Morschhauser *et al.* 2009; O'Connor *et al.* 2009; Li *et al.* 2013). DNHM-D2889 preserves crenulations on the caudal margins of its premaxillary teeth and probably on the dentary teeth. This form of tooth ornamentation has neither been observed among birds, nor among non-avian dinosaurs. We consider the crenulations as true structures because they are only present on the caudal margins of these teeth. If they were formed by glue or sediments, they would probably also present on the anterior margins of premaxillary teeth. They are not an artefact of preparation because they are prominently arranged in two lines along the caudal margin, and their surfaces are smooth, which may be interpreted as worn facets. Moreover, very faint crenulations also can be observed in the holotype of *L. chaoyangensis*, on the caudal margins of premaxillary teeth (IVPP-V12325). These tooth crenulations are not the first ornament found on teeth within Aves, since longitudinal grooves on the lingual surface of premaxillary teeth have been observed in *Sulcavis georum* O'Connor *et al.*, 2013 (O'Connor *et al.* 2013). The diversity of dental shapes may reflect differences in food items between taxa (O'Connor *et al.* 2013). The large, recurved, and labiolingually compressed teeth with crenulations and recurved sharp manual and pedal claws suggest that *Longipteryx chaoyangensis* probably occupied more extensive trophic niches than previously thought. They could probably prey on not only fish but also some small terrestrial vertebrates. This feeding habit further expanded their food chain and their living space. This unique dental specialization not only expands the diversity of dental morphologies among Mesozoic birds, but also explained why longipterygids were the most diversified enantiornithines.

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