

Bird tracks from Liaoning Province, China: New insights into avian evolution during the Jurassic-Cretaceous transition

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Abstract

Tracks of shorebird-like species from a small outcrop in the upper part of the Tuchengzi Formation at Kangjiatun, in the Beipiao area, Liaoning Province, may be the oldest bird tracks known from China. Formerly considered Late Jurassic in age, new fission track dates give an age of 145.9 Ma for ash beds associated with dinosaur track-bearing beds from the middle part of the Tuchengzi Formation outcrops at a nearby locality. Thus, the age appears to be close to the Jurassic-Cretaceous (Tithonian-Berriasian) boundary. The precise age of the bird track-bearing beds has not been determined, but is unlikely to be younger than about 139 Ma, based on dates for the upper part of the Tuchengzi Formation. Thus, the bird tracks, like the Tuchengzi ichnofauna in general, predate the famous Yixian Formation, which has produced a different avifauna.

The most distinctive tracks are here named *Pullornipes aureus* ichnosp. nov. and are tentatively assigned to the ichnofamily Koreanornipodidae. Other tracks from the same site appear to represent different ichnotaxa and therefore indicate the potential to find diverse avian ichnofaunas at this time. This record supports the evidence that East Asian avian ichnofaunas are the most diverse known during the Early Cretaceous. © 2005 Elsevier Ltd. All rights reserved.

Keywords: Bird tracks; Tuchengzi Formation; Liaoning Province; Early Cretaceous; Fission track dates

1. Introduction

Recently the Yixian Formation in the Beipiao area has become famous for yielding the fossils of feathered dinosaurs such as *Sinosauropteryx*, *Caudipteryx*, and *Protarchaeopteryx*, in association with a rich lacustrine fauna and flora including fish, amphibians, non-dinosaurian reptiles, birds, mammals, and many invertebrate and plant species. To date no vertebrate tracks have been reported from the Yixian Formation. However, an important track site was reported by Yabe et al. (1940)

from the underlying Tuchengzi Formation near the village of Yangshan (Matsukawa et al., 2006).

Recent studies have revealed the presence of three bird trackways at a locality near the village of Kangjiatun, about 15 km northeast of Beipiao, and also about 15 km south-southwest of the main Yixian feathered dinosaur locality (Fig. 1). According to the local geological maps, the locality represents an outcrop of the Tuchengzi Formation, which lies beneath the Yixian Formation (Hao et al., 1986). Other track sites reported from the Tuchengzi Formation in this region reveal abundant small theropod and bird tracks from the middle part of the formation (Wang et al., 1990; Zheng et al., 2001; Matsukawa et al., 2006).

Older reports claimed that the Yixian Formation contained a middle “Jehol” fauna that may be as old as Tithonian in age

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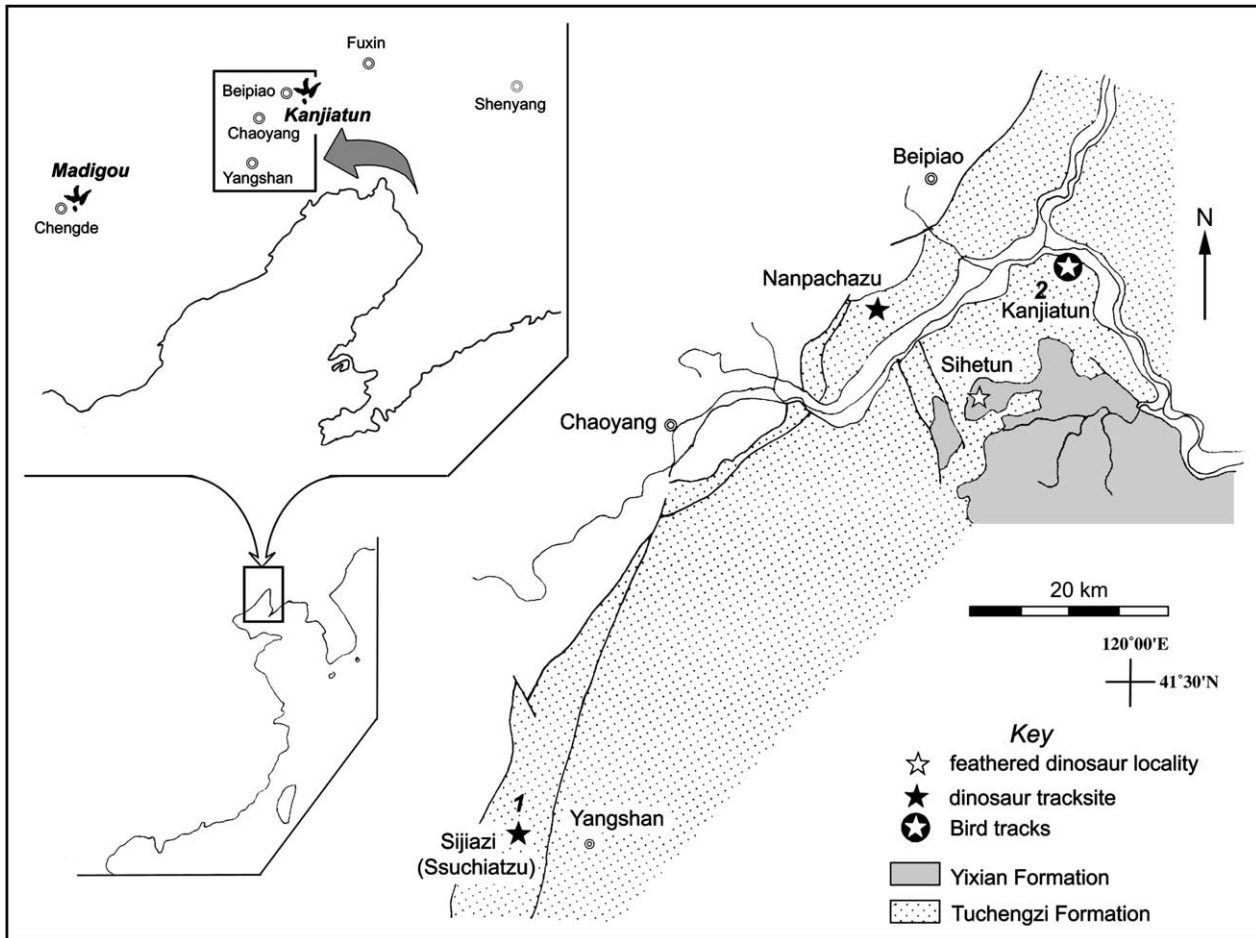


Fig. 1. Location map with detail of Beipiao-Chaoyang-Yangshan area showing the location of the Kangjiatun bird track site in relation to dinosaur track sites in the Tuchengzi Formation at Nanpachazu and Yangshan. The main feathered dinosaur locality at Sihetun is also shown, and the outcrops of the Yixian and Tuchengzi formations. The Madigou locality in Hebei Province is about 250 km east of Chaoyang. Compare with Figs. 2 and 3.

(Chen, 1999). Thus, the age of the underlying Tuchengzi Formation was generally inferred as older, i.e., late Middle–Late Jurassic (Pu and Wu, 1985; Wang et al., 1990; Zheng et al., 2001). However, more recent interpretations of the age of the Yixian formation suggest younger dates (124–123 Ma), suggesting a late Neocomian (Hauterivian–Barremian) age. Thus, the question arises as to whether the Tuchengzi Formation is also younger. Fission track dates obtained from the Tuchengzi Formation during the course of this study suggest an age of about 145.9 million years (Lockley et al., 2001b).

Since unequivocal bird tracks are not known from any pre-Cretaceous deposits, the bird tracks, which we assign to one or more shorebird-like taxa, probably suggest an earliest Cretaceous age, possibly Berriasian, based on the available dating. Only two other bird track sites, from Spain (Fuentes Vidarte, 1996) and British Columbia (McCrea et al., 2001), have been assigned such an early Berriasian age.

2. Description of the Kangjiatun site and trackways

The Kangjiatun track site, known locally as the “Golden Chicken” site, consists of a small bedding surface of greenish, fine-grained, ripple-marked sandstone exposed in an area

about 10 m long and 4 m wide (Figs. 2, 3). Latitude and longitude coordinates are: $41^{\circ} 44' 682''$ N, $120^{\circ} 56' 429''$ E. The bedding surface, which dips to the east at about 28 degrees, exposes three bird trackways (A–C). The longest (A) extends



Fig. 2. Photograph of the Kangjiatun bird track site looking south. North–south ripple crest trend runs parallel to strike. Compare with Fig. 3.

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