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Short communication

Small scale scrapes suggest avian display behavior by diminutive Cretaceous theropods

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ABSTRACT

A set of about 25 diminutive sub-parallel scrapes in the Cretaceous Haman Formation of South Korea fit the morphology of the small theropod track *Minisauripus* which is also known from this formation. The scrapes are interpreted as evidence of display behavior, and suggest that the trace maker was an adult engaged in avian-like courtship behavior. Although avian theropods are also known from this formation, the scrapes are inconsistent with their foot morphology. Although large theropod scrapes have been interpreted as evidence of display behavior they are only known from North America. Thus, the scrapes described here are the first reported from Asia, and the first interpreted as evidence of display behavior in such a diminutive species.

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1. Introduction

A recent report of large scale scrapes made by Cretaceous non-avian theropods in Colorado (Lockley et al., 2016) has raised interesting questions about "nest scrape display" behavior and its potential to be preserved as traces in the fossil record. As shown by these authors several sites in the track-rich, Dakota Sandstone of Colorado (Lockley et al., 2014) reveal multiple, paired scrapes made by the hind feet of large non-avain theropods. In one case more than 50 large scrapes, some up to 2 m in diameter occur in a small area of 750 m^2, suggesting a display arena site. These large paired or bilobed scrapes represent a new type of trace fossil named *Ostendichnus bilobatus* (Lockley et al., 2016).

These authors show that the Cretaceous trace fossil evidence is consistent with the nest scrape display behavior of a number of modern ground-nesting bird species (Cairns, 1982; Harris, 1984; Bomford, 1986; Bergstrom, 1988; Whitfield and Brade, 1991; Powesland et al., 1992), and with the lekking behavior of a number of modern species (Armstrong, 1942; Merton et al., 1984; Payne, 1984; Thery, 1992; Jiguet et al., 2000). The Cretaceous evidence suggest that nest scrape display behavior can be traced back for at least 100 million years, raising the obvious question of whether other examples of this kind of scrape behavior might be preserved elsewhere.

The purpose of this paper is to report a single isolated set of scrapes found on a surface in the Cretaceous Haman Formation of Korea (Fig. 1) which is well-known for its abundance and diversity of avian theropod, non-avian theropod and other dinosaur traces. The tracksite, now unfortunately lost, is only about 3 km south of the famous Gajin-ri tracksite, described by Kim, J-Y. et al. (2012a). The set of scrapes, described here, was made by a very small trackmaker with very fine claws.

2. Description of material

The complex of scratches described here is known only from photographs and personal observation by one of us (KSK). Attempts to re-locate and recover the specimen after it was first observed and photographed at close range proved unsuccessful due to the specimen having been moved to an unknown location, presumably by persons unaware of the specimen's significance. However, the

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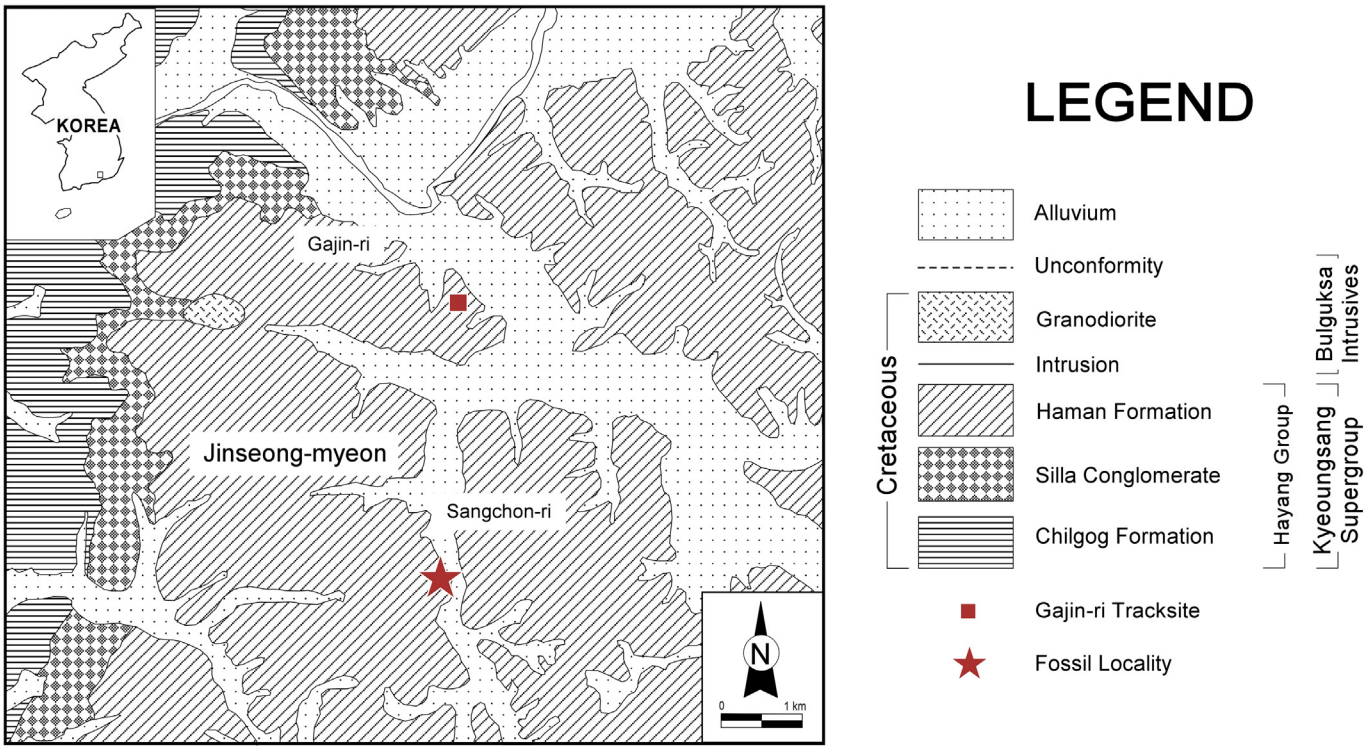

Fig. 1. The scrape site locality in Haman Formation, marked with a star, is only about 3 km south of the well-known Gajin-ri tracksite.

available photographs show a number of very distinctive features. These include a complex of sub-parallel scratch marks about 11 cm long and 7 cm wide with at least 25 separate very fine scratch marks. All these traces have a similar orientation, sub-parallel to the long axis of the complex (Figs. 2 and 3) and none are more than 1–2 mm wide. Two other scratches aligned with the long axis of the complex occur about 3 cm away. The complex has a roughly bilobed shape, with the longest scratches on the outside. In contrast, the center of the complex contains shorter overlapping scratches and an indented area that may represent a track, comparable in size to

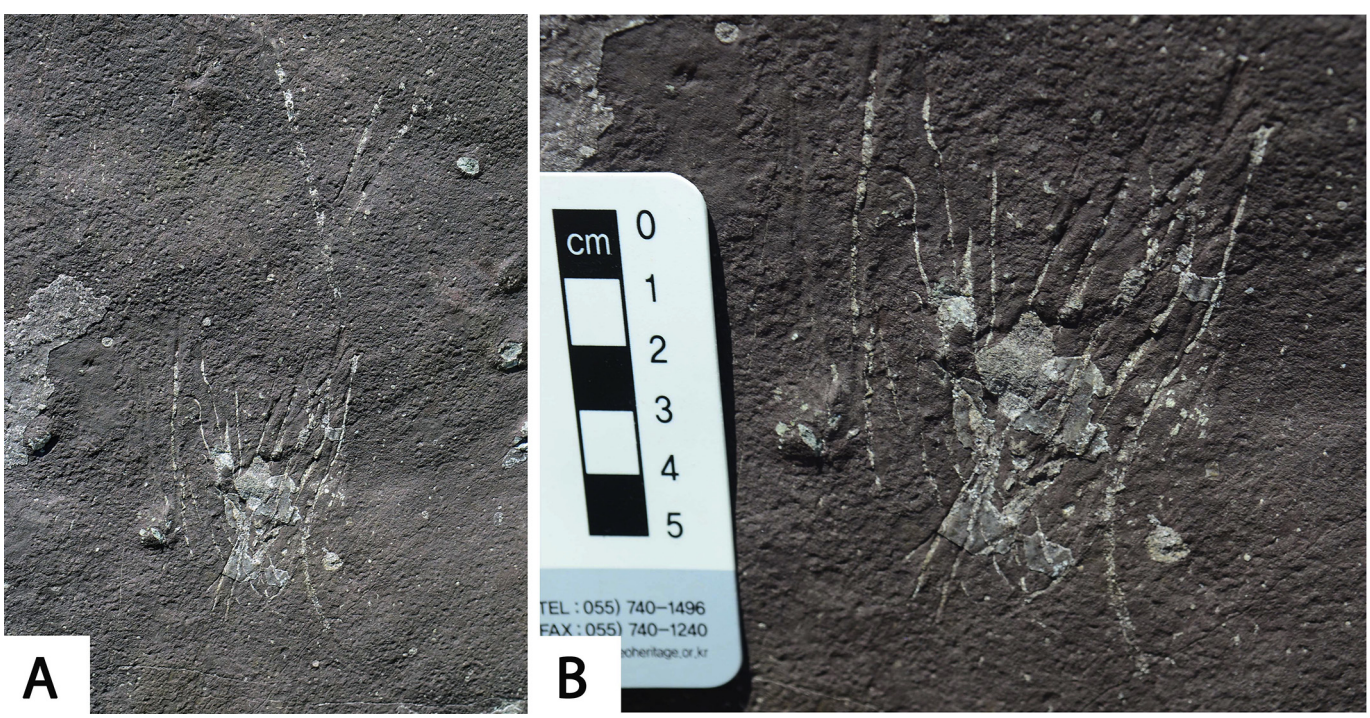

Fig. 2. A: Photograph of scratch marks, with detail (B) of main complex. Note mineralized veneer on part of surface and in some scratches. Compare with Fig. 3.

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