



## A new dromaeosaurid (Dinosauria: Theropoda) from the Upper Cretaceous Wulansuhai Formation of Inner Mongolia, China

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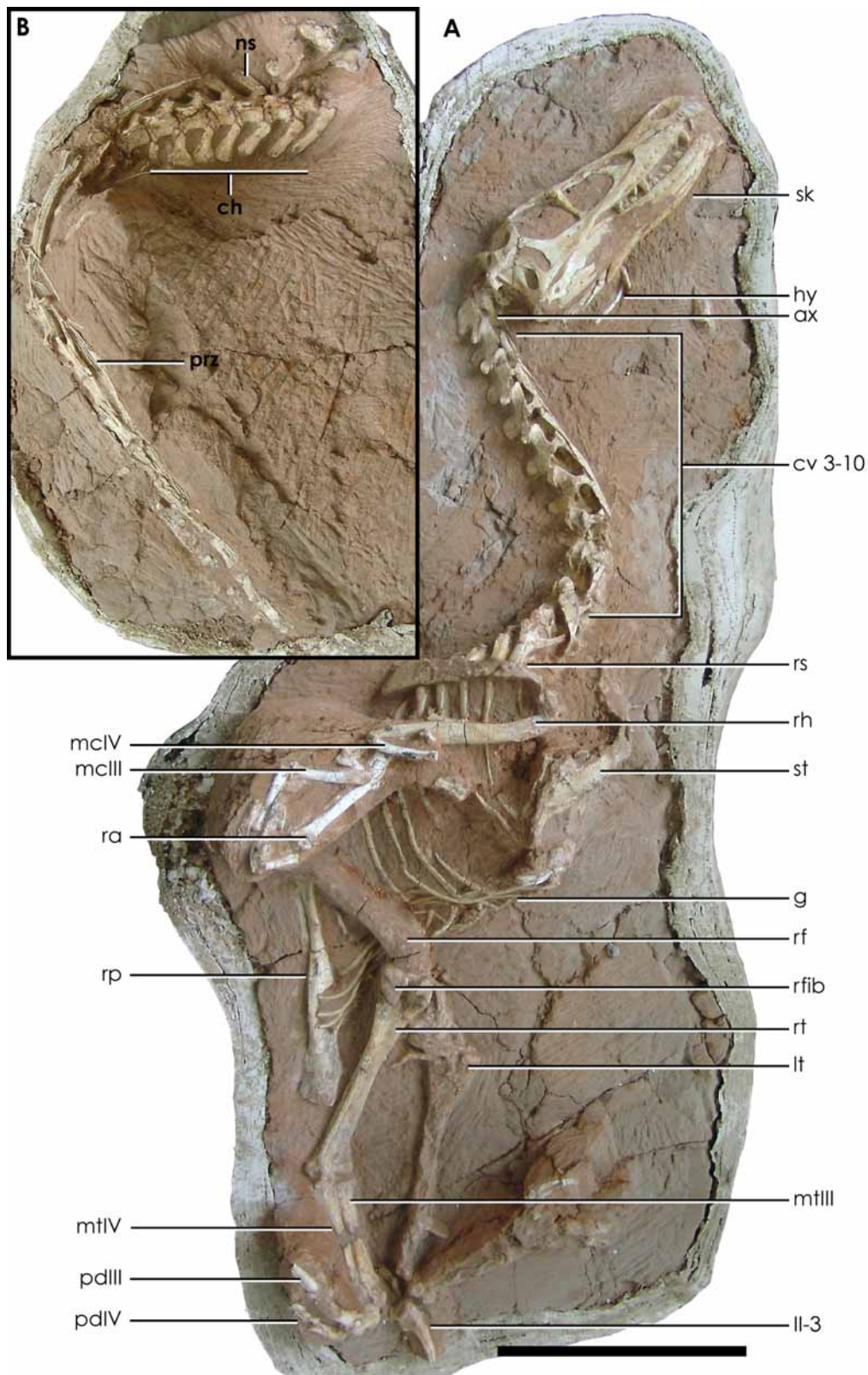
### Abstract

We describe a new dromaeosaurid theropod from the Upper Cretaceous Wulansuhai Formation of Bayan Mandahu, Inner Mongolia. The new taxon, *Linheraptor exquisitus* **gen. et sp. nov.**, is based on an exceptionally well-preserved, nearly complete skeleton. This specimen represents the fifth dromaeosaurid taxon recovered from the Upper Cretaceous Djadokhta Formation and its laterally equivalent strata, which include the Wulansuhai Formation, and adds to the known diversity of Late Cretaceous dromaeosaurids. *Linheraptor exquisitus* closely resembles the recently reported *Tsaagan mangas*. Uniquely among dromaeosaurids, the two taxa share a large, anteriorly located maxillary fenestra and a contact between the jugal and the squamosal that excludes the postorbital from the infratemporal fenestra. These features suggest a sister-taxon relationship between *L. exquisitus* and *T. mangas*, which indicates the presence of a unique dromaeosaurid lineage in the Late Cretaceous of Asia. A number of cranial and dental features seen in *L. exquisitus* and *T. mangas*, and particularly some postcranial features of *L. exquisitus*, suggest that these two taxa are probably intermediate in systematic position between known basal and derived dromaeosaurids. The discovery of *Linheraptor exquisitus* is thus important for understanding the evolution of some salient features seen in the derived dromaeosaurids.

**Key words:** Dromaeosauridae, Theropoda, Upper Cretaceous, Nei Mongol, China

### Introduction

Dromaeosaurids are a derived group of maniraptoran theropod dinosaurs currently known from the Cretaceous of both Laurasia and Gondwana (Norell & Makovicky 2004; Novas *et al.* 2009), although current phylogenetic hypotheses and the presence of troodontids (the sistergroup to dromaeosaurids) in older sediments predict their presence in the Jurassic (Sereno 1999; Xu *et al.* 2001; Hu *et al.* 2009). As one of the theropod groups most closely related to the Aves, dromaeosaurids are important for understanding avian origins and have been the focus of several recent studies (Norell & Makovicky 1997, 1999; Xu 2002; Senter *et al.* 2004; Makovicky *et al.* 2005; Turner *et al.* 2007b). The Upper Cretaceous Djadokhta Formation and its laterally equivalent beds in Mongolia and China have previously produced four dromaeosaurid taxa: *Velociraptor mongoliensis* Osborn, 1924; *Velociraptor osmolskae* Godefroit, Currie, Li, Shang & Dong, 2008; *Tsaagan mangas* Norell, Clark, Turner, Makovicky, Barsbold & Rowe, 2006; and *Mahakala omnogovae* Turner, Pol, Clarke, Erickson & Norell, 2007b. Here we report a fifth taxon from these beds based on a well-preserved specimen. It represents one of the few nearly complete and articulated dromaeosaurid skeletons from the Upper Cretaceous worldwide. The specimen was found in the Wulansuhai Formation of Bayan



**FIGURE 1.** Photographs of the holotype of *Linheraptor exquisitus* (IVPP V 16923). The specimen was collected in two separate plaster-jackets: the main jacket (A) contains the majority of the skeleton; the second jacket (B) contains the partial tail. Abbreviations: II-3, pedal ungual, digit II; ax, axis; ch, chevrons; cv, cervical vertebra; g, gastralia; hy, hyoid; lt, left tibia; mc, metacarpal; mt, metatarsal; ns, neural spine; pd, pedal digit; prz, elongated prezygapophyses; ra, radius; rf, right femur; rfib, right fibula; rh, right humerus; rp, right pubis; rs, right scapula; rt, right tibia; sk, skull; st, sternum. Scale bar equals 20 cm.

Among known dromaeosaurids, *Linheraptor* is probably more closely related to *Tsaagan* than to other dromaeosaurid taxa because the two taxa share a few unique features unknown in other dromaeosaurids: large, anteriorly located maxillary fenestra; lacrimal lacking lateral flange over descending process and with relatively broad medial lamina; sharp angle between anterior and ascending processes of quadratojugal; and contact between jugal and squamosal that excludes postorbital from infratemporal fenestra. The two taxa also share a relatively long anterior projection of the maxillary body beyond the antorbital fossa (a feature also seen in *Velociraptor*) and tooth crowns lacking serrations along the anterior carina (similar to basal dromaeosaurids). Although *Linheraptor* is similar to *Velociraptor* in many features, most of these features are probably plesiomorphic. Furthermore, *Velociraptor* is probably more closely related to derived dromaeosaurids than to *Linheraptor* because *Velociraptor* and derived dromaeosaurids share a number of features. These include tooth crowns with posterior serrations that are considerably larger than anterior ones and proportionally shorter tibia and metatarsus relative to femur. These features are unlike the typical coelurosaurian condition and indicative of the uniqueness of the group (Currie 1997).

The importance of *Linheraptor*, in the context of dromaeosaurid diversity, is enhanced by the preservation in this taxon of many phylogenetically informative postcranial features that cannot be assessed in the highly incomplete *Tsaagan*. These features help to establish that *Linheraptor* and *Tsaagan*, which can be identified as close relatives on the basis of cranial features, constitute a unique dromaeosaurid lineage in the Late Cretaceous of Asia. The new character information provided by *Linheraptor* is likely to confirm that *Tsaagan* and *Linheraptor* are both intermediate in systematic position between the basal and derived dromaeosaurids, a phylogenetic hypothesis already proposed for *Tsaagan* (Norell *et al.* 2006). This phylogenetic position is supported by the presence of a lateral expansion near the midpoint of the pubic shaft, a feature probably homologous to the lateral projection seen in basal Early Cretaceous dromaeosaurids from Liaoning (Xu 2002). Additional evidence comes from the proportions of the forelimb and hindlimb. The significantly shortened manual phalanx IV-2 is proportionally intermediate between the Liaoning dromaeosaurids and other dromaeosaurids (Xu 2002). The moderately elongate lower segments of the hindlimb are intermediate between highly cursorial basal dromaeosaurids and derived dromaeosaurids with distal hindlimb elements that are relatively short compared to other non-avian coelurosaurian theropods (Currie 1997). A detailed description of *Linheraptor* and a numerical analysis of its systematic position will be given elsewhere.

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