Zootaxa 3911 (1): 043–062
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.3911.1.2
http://zoobank.org/urn:lsid:zoobank.org:pub:AE247236-09A1-45E9-8E70-1C7ADD709B0D

A new species of *Euprox* (Cervidae, Artiodactyla) from the upper Miocene of the Linxia Basin, Gansu Province, China, with interpretation of its paleoenvironment

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Abstract

The Linxia Basin, Gansu Province, China, is known for its abundant and well preserved fossils. Here a new species, *Euprox grandis* **sp. nov.**, is established based on a skull and antlers collected from the upper Miocene Liushu Formation of the Linxia Basin. The new species is distinguishable from other *Euprox* species by its large body size, notably long pedicle and weak burr. The main beam and the brow tine are slightly curved both medially and backwards, and the apex of the main beam turns, curving slightly laterally. The upper cheek teeth are brachydont, with a clear central fold on the premolars and internal postprotocrista and metaconule fold on M1-M2. The cingulum is almost absent, only occasionally weakly developed at the anterior and lingual surface of the teeth. Cladistic analysis was carried out using the TNT software, and two most parsimonious trees were retained. As the strict consensus tree shows *E. grandis* appears to be an advanced muntiacine form, which may have a close relationship with the genus *Muntiacus*. The presence of *E. grandis* in the Linxia Basin adds new evidence to support a warm and humid environment during the late Miocene in the basin.

Key words: Linxia Basin, upper Miocene Liushu Formation, Cervidae, Muntiacinae, *Euprox*

Introduction

The Linxia Basin, Gansu Province, China, known for its abundant and well preserved fossils, is located in the transitional zone between the Tibetan and Loess plateaus, and filled with 700–2000 m of Cenozoic deposits. The currently accepted lithostratigraphical subdivisions of the Linxia Cenozoic deposits (Deng *et al*. 2004a, 2004b, 2013; Deng 2005), in ascending order, are as follows. Oligocene: Tala and Jiaozigou formations; Miocene: Shangzhuang, Dongxiang, Hujialiang, and Liushu formations; Pliocene: Hewangjia and Jishi formations; early Pleistocene: Wucheng Formation.

Here, a new species of two-pronged antlered deer is described based on the specimens collected from the upper Miocene deposits of the Linxia Basin. The Miocene two-pronged antlered cervids with true burr and strongly inclined pedicle in side view, such as *Euprox* Stehlin 1928, *Muntiacus* Rafinesque 1815, *Paracervulus* Teilhard de Chardin & Trassaert 1937, *Eostyloceros* Zdansky 1925 and *Amphiprox* Haupt 1935, were proposed to be the predominant representatives of the subfamily Muntiacinae (Azanza, 1993; Azanza & Montoya 1995; Azanza *et al*. 2013; Wang & Zhang 2011). The new specimens from the Linxia Basin resemble the genus *Euprox* by the relatively large body size, long pedicle and short antler base, thus were placed in *Euprox*, and a new species, *Euprox grandis* **sp. nov.** was erected based on the notably large body size and long pedicle and relatively weak burr.

Previously, only *Euprox* cf. *furcatus* from Shanxi Province, *E.* sp. from Tunggur and the Qsaidam Basin, *E. robustus* from Yuanmou and *E. altus* from Nei Mongol were reported in China, and were usually rare or fragmentary, without associated skull and antlers (Zdansky 1925; Bohlin 1937; Colbert 1936, 1940; Dong *et al*.

Accepted by L. Hautier: 25 Nov. 2014; published: 16 Jan. 2015

The climate of northern China has been interpreted as being influenced partly by the intensification of monsoon circulation that resulted from the uplift of the Tibetan Plateau. Located in the transitional zone between the Tibetan and Loess plateaus, the Linxia Basin is undoubtedly deeply influenced. A surprisingly humid climate during the late Miocene in northern China was suggested, while Europe was experiencing arid conditions, based on the hypsodonty of Neogene herbivores; and the "*Hipparion* Red Clay" of northern China was suggested to be apparently deposited under these humid conditions (Fortelius *et al*. 2002). The composition of the late Miocene mammalian faunas of northern China has been interpreted as indicating regional differentiation between a close and humid environment in the east and an open and arid one in the west, which was closely related to the intensification of the summer monsoon (Zhang 2006).The Linxia Basin strata dating to the middle-late late Miocene are thought to have been deposited in an open but humid environment, based on a cenogram analysis of their fossil mammal fauna (Deng 2009). Stable carbon isotope analysis of the tooth enamel of Chinese late Neogene mammals shows that, during the late Miocene before 7 Ma, northern China was covered in steppe dominated by C3 grasses instead of savanna dominated by C4 plants; then between 7 Ma and the early Pliocene, the Chinese Loess Plateau was characterized by a pattern of northward-increasing C4 vegetation, but there were still nearly pure C3-plant ecosystems in the southern Chinese Loess Plateau and the Linxia Basin which lies on the western margin of the Chinese Loess Plateau (Hou *et al*. 2006; Passey *et al*. 2009). The discovery of *Sinohippus*, *Tapirus* and *Chleuastochoerus* in the late Miocene of Linxia Basin also implies a relatively open and humid environment (Hou *et al*. 2007, 2014; Deng *et al*. 2008).

Conclusions

The new species, *Euprox grandis*, from the Linxia Basin bears large body size, notably long pedicle and a relatively weak true burr; the relatively brachydont upper check teeth of the new species bear clear internal postprotocrista and metaconule fold, and lack strong cingula. Phylogenetic analysis suggests the new species may represent an advanced form of *Euprox*. The Linxia Basin discoveries of the largest known *Euprox* that bears the longest pedicle and has relatively brachydont cheek teeth add new evidence to support a relatively warm and humid environment during the late Miocene in the Linxia Basin.

Acknowledgements

I thank Profs. Zhanxiang Qiu and Wei Dong for useful discussion and suggestions for improving an earlier version of this paper, Nikos Solounias for providing illustrations and Lawrence Flynn for English improvement. I am grateful to Shiqi Wang, Qinqin Shi and Boyang Sun for the field work. This work was supported by the National Natural Science Foundation of China (41202002, 41430102, 41372001), the Chinese Academy of Sciences (XDB03020104), the State Key Laboratory of Palaeobiology and Stratigraphy (Nanjing Institute of Geology and Palaeontology, CAS) (No.123105), the Ministry of Science and Technology of China (2012CB821906), and the Key Deployment Project of Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences.

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