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The first record of a neonatal ornithopod dinosaur from Gondwana

Victoria M. Egerton [a,b,*], Fernando E. Novas [c], Peter Dodson [d], Kenneth Lacovara [e]

[a] Department of Biology, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, USA
[b] Faculty of Life Sciences, University of Manchester, Oxford Road, Manchester M13 9PT, UK
[c] CONICET, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Avenida Angel Gallardo 470, Buenos Aires 1405, Argentina
[d] School of Veterinary Medicine and Department of Earth and Environmental Science, University of Pennsylvania, 3800 Spruce Street, Philadelphia, PA 19104, USA
[e] Department of Biodiversity, Earth and Environmental Science, Drexel University, 3141 Chestnut Street, Philadelphia, PA 19104, USA

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ABSTRACT

Discrete post-embryonic teeth and bone fragments have been recovered from the matrix with the holotype skeleton (MPM-10001) of the ornithopod dinosaur, *Talenkauen santacrucensis* Novas et al., 2004 (Upper Cretaceous, Argentina). The minute tooth crowns are 1 mm apicobasally tall and 1.7 mm mesodistally wide. The crowns are symmetrical and have a centrally located primary ridge on the lingual surface. Secondary ridges lead to five marginal denticles on both teeth. The tooth morphology is consistent with dentary teeth in euiguanodontids. There is no evidence of transport, suggesting that the material is autochthonous with respect to the adult body block of *T. santacrucensis* (MPM-10001). Steeply inclined wear facets on the lingual surface and associated microstriae support the conclusion that the minute teeth were from a post-embryonic euiguanodontid dinosaur rather than early stage replacement teeth. The morphology, size, and wear of the teeth and small bone fragments found in the body block of MPM-10001 suggest that this material belongs to a neonatal *T. santacrucensis*. This is the first record of neonatal ornithopod remains from Gondwana.

1. Introduction

The known abundance and diversity of South American ornithopod dinosaurs has increased over the past two decades through discoveries of *Talenkauen* (Novas et al., 2004), *Macrogryphosaurus* (Calvo et al., 2008), *Notohypsilophodon* (Martínez, 1998), *Gasparinisaura* (Coria and Salgado, 1996; Salgado et al., 1997), and *Anabisetia* (Coria and Calvo, 2002). Despite these recent discoveries, the Gondwanan ornithopod record is scant compared to that of the Northern Hemisphere. Moreover, only *Gasparinisaura cincosaltensis* is known from multiple individuals representing different ontogenetic stages, from older juveniles to mature adults (Coria and Salgado, 1996; Salgado et al., 1997; Novas, 2009).

The Cerro Fortaleza Formation is located in Santa Cruz Province, southern Argentina. The formation is exposed along the Río La Leona between lakes Argentino and Viedma and along the southern shore of Lago Viedma (Barrancas Blancas) (Arbe and Hechem, 1984; Arbe, 2002; Novas et al., 2002). The Cerro Fortaleza Formation interdigitates with and overlies the La Anita Formation (Campanian) and is overlain by the La Irene Formation (Maastrichtian). The La Anita Formation has been biostratigraphically dated using ammonite biozones and the La Irene Formation palynological biozones (Arbe and Hechem, 1984; Macellari et al., 1989; Kraemer and Riccardi, 1997; Povilauskas et al., 2008). Thus, the Cerro Fortaleza Formation is Campanian–Maastrichtian in age. This formation ranges in thickness from 350 m on Cerro Fortaleza to 390 m at Barrancas Blancas, approximately 17 km to the northwest (Arbe, 2002; Marenssi et al., 2003). It is characterized by lithified fluvial sands, overbank mud deposits, and paleosols that were deposited in fluvial, fluvial-palustrine, and coastal plain environments on the northeastern margin of the Austral Basin (Arbe and Hechem, 1984; Macellari et al., 1989; Kraemer and Riccardi, 1997; Arbe, 2002; Novas et al., 2002; Marenssi et al., 2003). The Cerro Fortaleza Formation has been referred to as the Pari Aike Formation, the Chorrillo Formation, and the Mata Amarilla Formation (Feruglio, 1938a, b, 1944; Leanza, 1972; Nullo et al., 1981; Kraemer and Riccardi, 1997; Goin et al., 2002; Novas et al., 2002; O'Gorman and Varela, 2010; Varela, 2011).

A distinct dinosaurian fauna has been described from the "Pari Aike Formation," which we interpret as the Cerro Fortaleza Formation: *Talenkauen santacrucensis* (Novas et al., 2004), *Puertasaurus reuili* (Novas et al., 2005), *Orkoraptor burkei* (Novas et al., 2008), *Austrocheirus isasii* (Ezcurra et al., 2010), and a new genus and species of titanosaur is currently under study by Lacovara et al. Microvertebrate remains including, elasmobranch teeth (*Archaeolamna kopingensis*), semionotiform/lepisoteid scales, dipnoan teeth, testudine fragments, and theropod teeth have also been identified (Schroeter et al., pers. comm., Lacovara et al., in prep). Poorly preserved leaf impressions from indeterminate conifers and cycads have also been discovered, but not yet described

* Corresponding author at: Faculty of Life Sciences, University of Manchester, Oxford Road, Manchester M13 9PT, UK. Tel.: +44 7926338377.
E-mail addresses: vegerton@gmail.com (V.M. Egerton), fernovas@yahoo.com.ar (F.E. Novas), dodsonp@vet.upenn.edu (P. Dodson), lacovara@drexel.edu (K. Lacovara).

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(Novas et al., 2002, 2008). Furthermore, fossilized angiosperm and gymnosperm wood is found throughout the formation (Egerton et al., 2010).

The holotype (MPM-10001) of *T. santacrucensis* Novas et al., 2004 was discovered on the southern coast of Lago Viedma (Lat. 49° 51′ 16.2″ S, Long. 72° 06′ 26.3″ W) on Cerro Los Hornos. This specimen was encased in a well-cemented, medium-grained sandstone interpreted as having been deposited in a fluvial channel. *T. santacrucensis*, a medium-sized ornithopod, was the first formally described dinosaur from the Cerro Fortaleza Formation (Fig. 1). This taxon is described from a partially articulated skeleton (Novas et al., 2004). *Talenkauen* has many iguanodontian synapomorphies, such as: rhomboid-shaped maxillary teeth with a prominent primary ridge on the labial surface of the crown; V-shaped predentary with processes for dentary articulation; presacral count of 9 cervical and 16 dorsal vertebrae; sigmoidal-shaped ilium that is shorter than the femur; and a mediolaterally, dorsoventrally deep pubis with prepubic process (Norman, 2004; Novas et al., 2004; Novas, 2009). Novas (2009) regarded *Talenkauen* as an an euiguanodontian closely related to *Macrogryphosaurus* and *Anabisetia*.

Institutional abbreviation. MPM = Museo Padre Molina, Río Gallegos, Santa Cruz Province, Argentina.

2. Material

Two minute teeth and bone fragments were recovered during preparation of the body block of MPM-10001. They were found close to the rib cage. The two teeth were imaged using a scanning electron microscope (Phillips XL30) at the Museo Argentino de Ciencias Naturales Bernardino Rivadavia. Because the teeth were found associated with the body block of *T. santacrucensis*, the Museo Padre Molina chose to assign them the same museum number as the holotype of this species, although they belong to another individual. For the purpose of this paper, we will be informally referring to the main body block as MPM-10001A and the minute teeth as MPM-10001B.

3. Description

The small isolated teeth (MPM-10001B) are symmetrical and labial lingually compressed (Fig. 2). The minute tooth crowns are approximately 1 mm apicobasally high and 1.7 mm mesodistally wide. A centrally located primary ridge occurs on the lingual surface with five secondary ridges accompanying the primary ridge. The secondary ridges run parallel to sub-parallel, relative to the primary ridge, and each leads to a marginal denticle (Fig. 2B, C). The labial surface of the crown is enameled and has a steeply inclined wear facet (Fig. 2A). Microstriae occur on the surface of the crown (Fig. 2D, E). A cingulum delineates the base of the crown. The roots are not preserved.

4. Discussion and conclusion

The centrally located primary ridge, bilateral symmetry and five marginal denticles on the lingual surface indicate that these are dentary teeth from a basal ornithopod. Labiolingual compression of the crown and secondary ridges ending in marginal denticles are common in euornithopod teeth (Norman et al., 2004; Galton, 2009). The *Talenkauen* holotype contains maxillary, and dentary teeth; the premaxilla contains alveoli; however, no premaxillary teeth have been discovered. The shape of the teeth and the features exclude it from being a premaxillary tooth. The dentary teeth of the mature *Talenkauen* individual (MPM-10001A) are triangular and have central primary coronal ridges on the lingual surfaces (Fig. 3 A, B). Comparatively, maxillary teeth are asymmetrical with prominent primary ridges occurring distally and more secondary ridges that occur mesially (Fig. 3C). The dentary teeth of the mature *Talenkauen* have five to six uniform secondary apical ridges that occur on either side of the primary ridge and run parallel to sub-parallel to the latter, a condition that is similar in the juvenile MPM-10001B teeth (Fig. 3A, B). Basally, the lateral margins form broad ridges that merge with the primary ridge to form a moderate cingulum. Similarly, in both the mature and juvenile MPM-10001 specimens, the lingual surfaces of the dentary teeth also possess ridges; however, in the mature MPM-10001A individual, the dentary teeth have 9–12 ridges. The dentary teeth of the mature MPM-10001A individual become mesodistally compressed and labiolingually expanded basally. Wear facets are steeply inclined on the labial surface in both the mature and juvenile MPM-10001 specimens.

Other South American ornithopods (*G. cincosaltensis* and *Anabiestia saldiviai*) share the same dental morphology as observed in other euornithopods (Coria and Salgado, 1996; Coria and Calvo, 2002; Norman et al., 2004). *Gasparinisaura* dentary teeth have smooth labial surfaces; the features of the lingual surfaces are unknown. The number of marginal denticles in *Gasparinisaura* is the same as those in small MPM-10001B specimen (Coria and Salgado, 1996). However, marginal denticle number can vary within individuals and cannot be reliably used as a diagnostic character (Norman et al., 2004). *Anabiestia* has lingual ridges on the dentary teeth but does not appear to have a primary ridge (Coria and Calvo, 2002).

A recent taphonomic study on human teeth has shown that transportation in medium and coarse-grained sediments leads to extensive pitting and polishing of the enamel, respectively (King et al., 1999). Despite being encased in a medium-grained sandstone, the juvenile MPM-10001B teeth do not display pitting, polishing, or any damage other than a small chip on one of the teeth (Fig. 2E). This suggests that these teeth were not transported over significant distance.

Well-defined, steeply inclined wear facets and microstriae occur on the labial surfaces of the teeth (Fig. 2A). Wear facets on the teeth of embryonic ornithopods (*Maiasaura peeblesorum* and *Hypracrosaurus stebingeri*) initially led some authors to misidentify embryos as hatchlings (Horner and Makela, 1979; Horner and Currie, 1994; Horner, 1999). Thus, wear facets alone do not necessarily indicate that the small MPM-10001B teeth were from a hatchling. However, the combination of wear facets and microstriae reliably indicate whether or not an individual is a hatchling. Typical microwear occurs as roughly unidirectional scratching or pitting on the enamel surfaces of a tooth from mastication or food processing, while random scratching and pitting is often due to post-mortem processes (Walker et al., 1978; Godon, 1988; Teaford, 1988). The microstriae on the enamel of the juvenile MPM-10001B teeth are generally uniform, apicobasally. Therefore, the striations on MPM-10001B are due to the processing of food, indicating the individual was a hatchling.

Embryonic and hatchling ornithopod dinosaurs are rare and have only been described from North America: *Dryosaurus* sp. *H. stebingeri*, *M. peeblesorum*, *Orodromeus makelai* (Horner and Weishampel, 1988; Carpenter, 1994; Horner and Currie, 1994; Horner, 1999), and Europe: *Telmatosaurus transsylvanicus* (Grigorescu et al., 2010). Of those above, only *M. peeblesorum* and *O. makelai* embryos and neonates have been found associated with adult skeletons (Horner and Currie, 1994).

The size, wear patterns, and tooth morphology of the minute teeth found in the body block of a mature individual of *T. santacrucensis* (MPM-10001) reasonably indicates that this material pertains to a recent hatchling of *Talenkauen*. This comprises the first record of a neonatal ornithopod dinosaur from Gondwana, and only the fourth record

Fig. 1. MPM-10001, Reconstruction of *Talenkauen santacrucensis* (Novas et al., 2004).

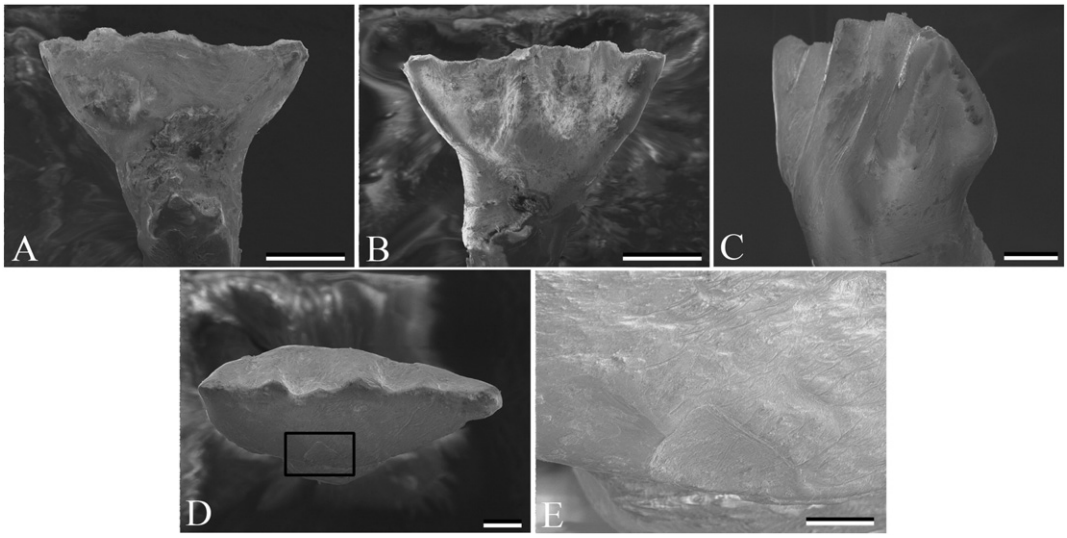

Fig. 2. MPM-10001B, Neonatal dentary teeth. A. Labial view of tooth 1; scale bar = 500 μm. B. Lingual view of tooth 1; scale bar = 500 μm. C. Mesiolingual view of tooth 2; scale bar = 200 μm. D. Occlusal view of tooth 2; scale bar = 200 μm. E. Microwear on labial surface of crown of tooth.2; Scale bar = 100 μm.

of a neonatal ornithopod associated with a mature skeleton. The physical association of hatchling and mature individuals invites the question of parental care in this species; however, more compelling evidence is required to adjudicate this issue.

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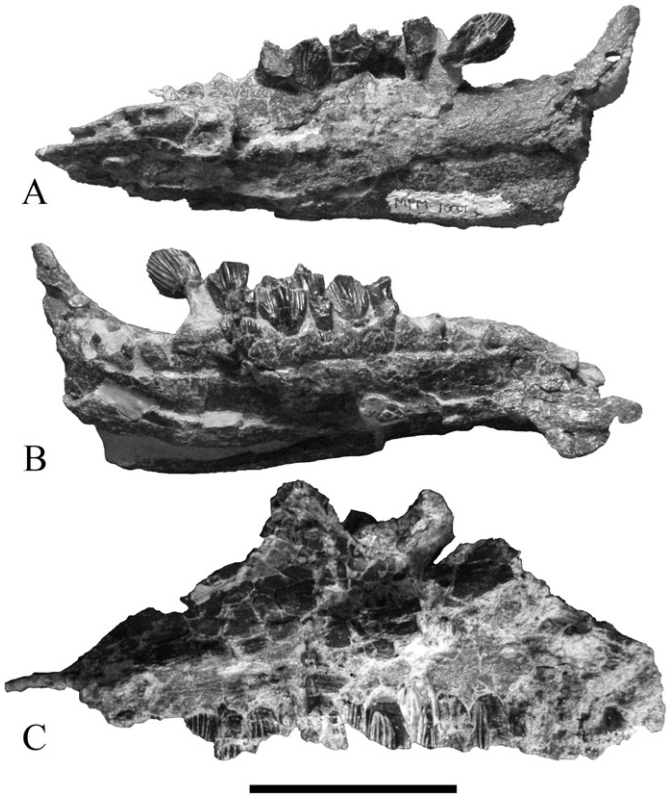

Fig. 3. MPM-10001A, Left dentary and teeth from the adult *Talenkauen* in labial (A) and lingual (B) views and maxilla (C) in labial view; scale bar = 5 cm. Note that the caudal-most tooth is rotated 180° so it is in lingual view in 3A and labial view in 3B.

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