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RESEARCH ARTICLE

A New Specimen of the Controversial Chasmosaurine *Torosaurus latus* (Dinosauria: Ceratopsidae) from the Upper Cretaceous Hell Creek Formation of Montana

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Abstract

Torosaurus latus is an uncommon and contentious taxon of chasmosaurine ceratopsid known from several upper Maastrichtian units in western North America. We describe a partial parietal of *To*. *latus* from the Hell Creek Formation of Montana. Although the specimen's ontogenetic maturity means that it cannot inform the ongoing debate over whether *To*. *latus* is the old adult form of the contemporary *Triceratops*, the specimen is one of the best-preserved *To*. *latus* parietals and supplements previous descriptions.

Introduction

Torosaurus latus [1] is a chasmosaurine ceratopsid from the late Maastrichtian of western North America. It is represented by no more than nine specimens: two or possibly three specimens from the Lance Formation of Wyoming (holotype YPM 1830, YPM 1831, and possibly GP 245–4), three from the Hell Creek Formation of Montana (MOR 981, MOR 1122, and MPM VP6841), two from the Hell Creek Formation of South Dakota (ANSP 15192 and SMM P97.6.1), and possibly one from the Frenchman Formation of Saskatchewan (EM P16.1) [2]. Compared to its late Maastrichtian contemporary *Triceratops*, which is known from dozens of skulls [3, 4], *Torosaurus latus* is extremely rare.

Here, we describe a new specimen, ESU 2009–6, of *Torosaurus latus* from the Hell Creek Formation of Montana. The specimen consists of an incomplete parietal and was discovered in 2009 in Garfield County by David Lukens of the Eastern Missouri Society for Paleontology. It was collected from an overbank clay in the middle part of the upper third of the Hell Creek Formation [5]. ESU 2009–6 is currently reposited at Johnston Geology Museum, Emporia State University in Emporia, Kansas, and is on loan for display at the Saint Louis Science Center in Saint Louis, Missouri, USA.

Recently, it has been proposed that *Torosaurus latus* is not a distinct taxon, but rather represents the old adult form of *Triceratops* [4, 6, 7]; however, this hypothesis has been challenged

and the validity of the taxon upheld by other authors [8–10]. The purpose of this paper is not to participate in this continuing debate; however, regardless of whether it is a distinct taxon or the fully mature form of *Triceratops*, *Torosaurus latus* represents a rare morphology, and the description of an additional specimen will be highly beneficial. The specimen will be referred to as *Torosaurus latus* in this paper for ease of communication, with the caveat that *To. latus* remains a problematic entity.

Institutional Abbreviations

ANSP, Academy of Natural Sciences, Philadelphia, PA, USA; EM, Eastend Museum, Eastend, Saskatchewan, Canada; ESU, Emporia State University, Emporia, KS, USA; GP, Glenrock Paleontological Museum, Glenrock, WY, USA; MOR, Museum of the Rockies, Bozeman, MT, USA; MPM, Milwaukee Public Museum, Milwaukee, WI, USA; SMM, Science Museum of Minnesota, St. Paul, MN, USA; YPM, Yale Peabody Museum of Natural History, New Haven, CT, USA.

Description of ESU 2009–6

Measurements of ESU 2009–6 are provided in the supplementary information (S1 Table). ESU 2009–6 comprises most of the left side of the parietal, broken immediately medial to the squamosal contact (Fig 1A). The parietal is gently arched dorsally along its transverse axis. Part of the midline parietal bar is preserved; it is mediolaterally broad and bears a subtle midline ridge. A small portion of the medial rim of the right parietal fenestra is preserved (Fig 1A). In contrast, most of the medial and the entire caudal rims of the left parietal fenestra are preserved; this fenestra appears to have been mediolaterally wide, similar to other specimens referred to *Torosaurus latus* (e.g., MOR 981, MOR 1122) [2].

The caudal parietal bar is rostrocaudally broad and gently convex along its caudolateral margin, indicating that the complete parietal would have had a rounded shape (Fig 2), similar to other specimens referred to *Torosaurus latus* (e.g., ANSP 15192, MOR 981, MOR 1122, YPM 1831) [2, 11]. Six epiparietals are present on the caudolateral margin of the parietal, suggesting that the total epiparietal count was 12, as in MOR 1122 [2]. The epiparietals are low, rounded, and slightly rugose (Fig 1B–1D).

Discussion

Systematics

Torosaurus latus is a derived member of the ceratopsid subclade Chasmosaurinae according to recent phylogenetic analyses that have treated it as a taxon distinct from *Triceratops* [2, 12–15]. Those analyses that have included the other species of *Torosaurus*, *To. utahensis* from the North Horn Formation of Utah [16, 17], have recovered different positions relative to *To. latus*. Sampson et al. [12], Mallon et al. [13], and Brown and Henderson [15] recovered a monophyletic *Torosaurus* including *To. latus* and *To. utahensis*, while Longrich [14] found *To. utahensis* (as "*Triceratops utahensis*") to form a clade with *Triceratops horridus* and *Tr. prorsus*. The taxonomy and phylogeny of these Maastrichtian chasmosaurines will continue to be refined as additional specimens and new closely related taxa (e.g., *Eotriceratops xerinsularis* [18], *Ojoceratops fowleri* [19], *Regaliceratops peterhewsi* [15]) are discovered.

Ontogenetic Status

Although histological sampling was not feasible, there are other indications of ontogenetic stage preserved on ESU 2009–6. The dorsal and ventral surfaces of the parietal exhibit rugose,

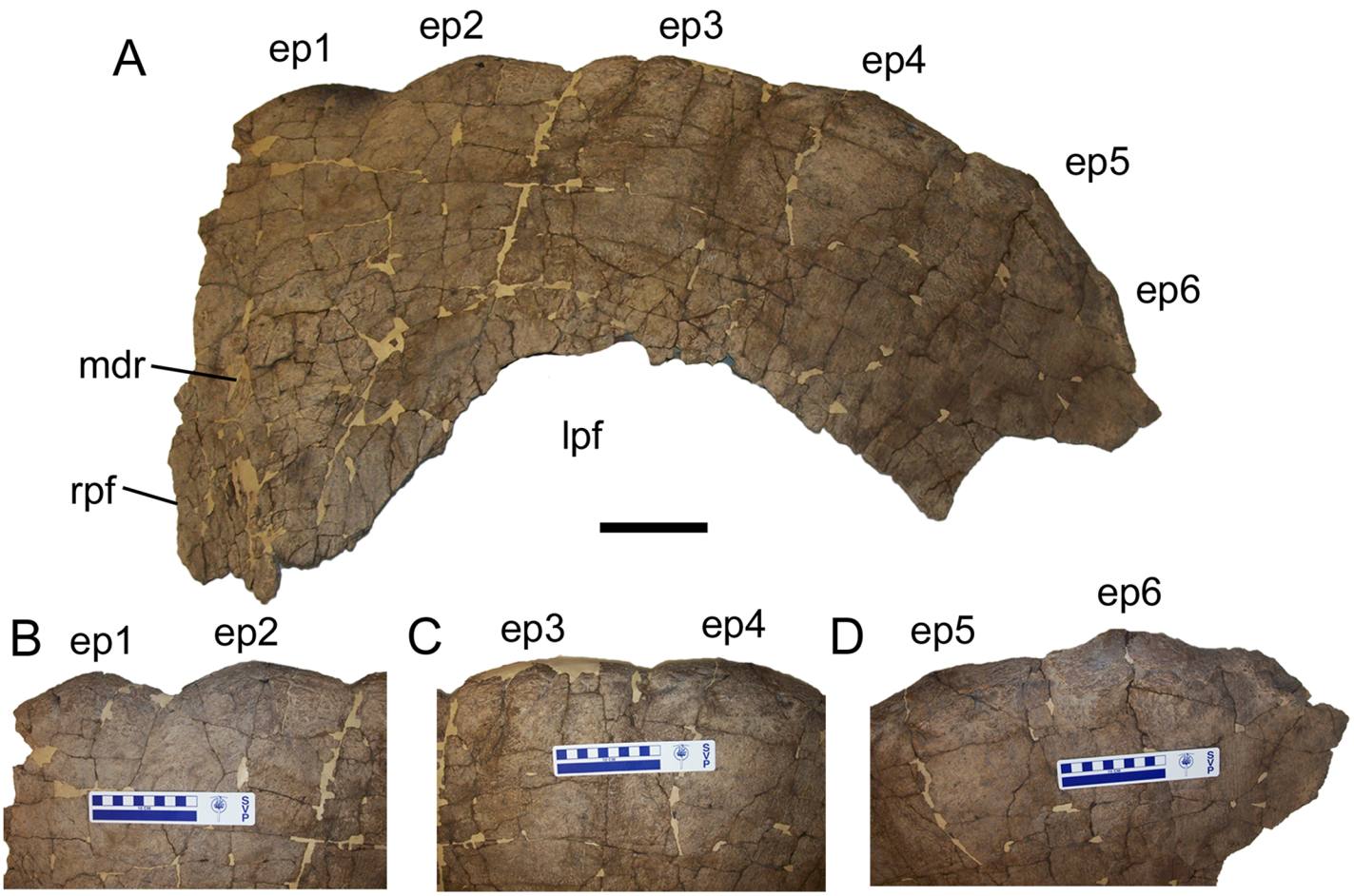

Fig 1. Parietal of *Torosaurus latus*. (A) ESU 2009–6 in dorsal view. (B–D) Epiparietals in dorsal view, including (B) ep1 and ep2, (C) ep3 and ep4, and (D) ep5 and ep6. *Abbreviations*: *ep1*, epiparietal locus 1; *ep2*, epiparietal locus 2; *ep3*, epiparietal locus 3; *ep4*, epiparietal locus 4; *ep5*, epiparietal locus 5; *ep6*, epiparietal locus 6; *lpf*, left parietal fenestra; *mdr*, midline ridge; *rpf*, rim of right parietal fenestra. Scale bars equal 10 cm.

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well-vascularized bone texture consistent with a skeletally mature individual [6, 8, 20–24]. Furthermore, the epiparietals are fully fused to the caudolateral margin of the parietal, and the epiparietals themselves are rostrocaudally compressed and contact each other at their bases, features that also indicate maturity [25]. Because of the advanced ontogenetic stage of ESU 2009–6, it cannot significantly contribute to either argument in the ongoing debate over whether *Torosaurus latus* is the old adult form of *Triceratops*. However, it does add another useful data point to the ever-growing chasmosaurine sample from the Hell Creek Formation, which recently was used to explicate a sequence of evolutionary changes in the *Triceratops* lineage from the base to the top of the formation [4]. ESU 2009–6 also provides only the third complete left or right side of the parietal of *Torosaurus latus*, in addition to MOR 981 and MOR 1122 [2].

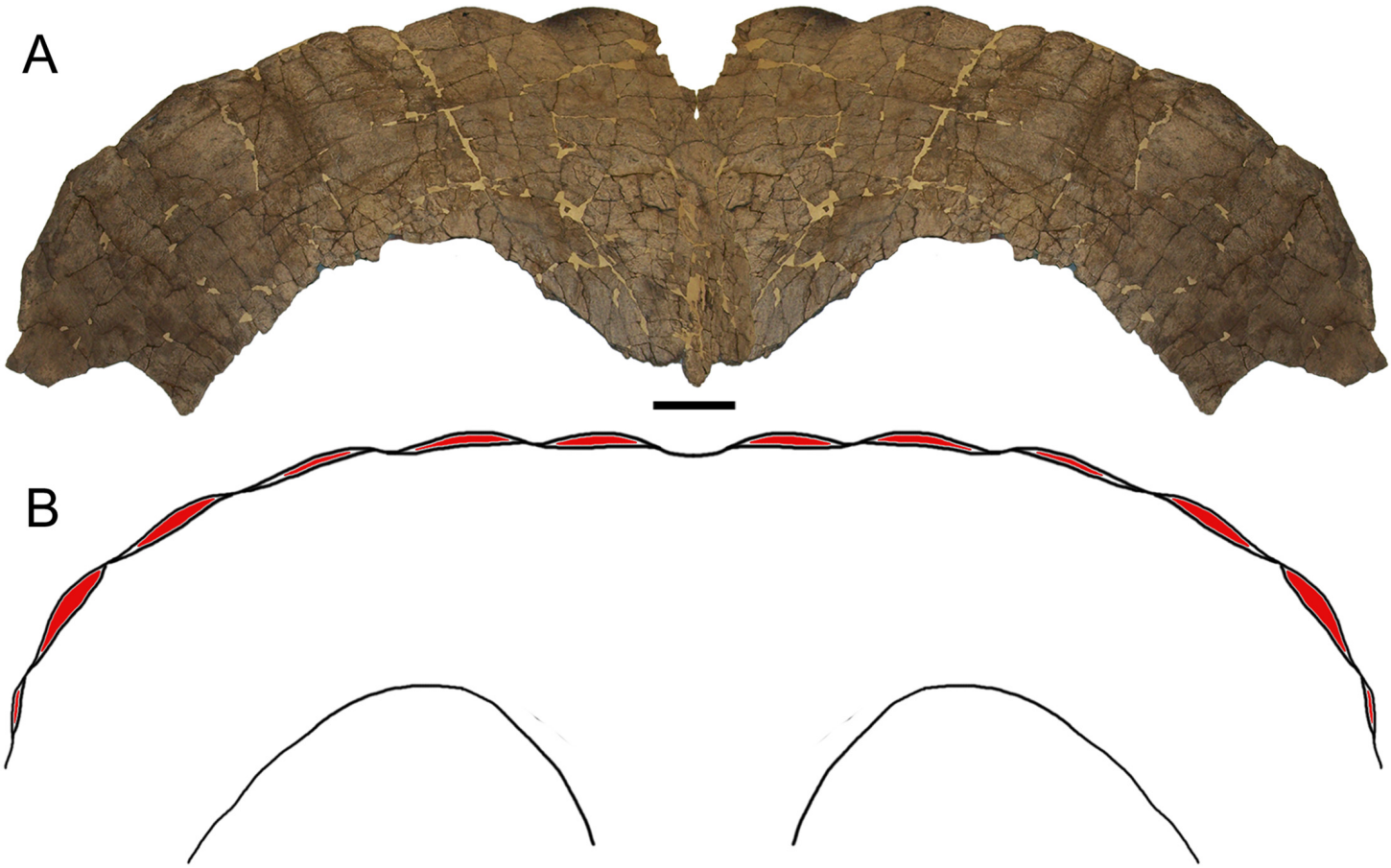

Fig 2. Parietal of *Torosaurus latus*. (A) Image in which ESU 2009–6 has been mirrored horizontally and the two halves aligned along the midline ridge, in dorsal view. (B) Reconstruction of the caudal parietal bar of the individual represented by ESU 2009–6 in dorsal view, with the epiparietals highlighted in red. Scale bar equals 10 cm.

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Supporting Information

S1 Table. Table of Measurements. Select measurements of ESU 2009–6.
(DOC)

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Author Contributions

Conceived and designed the experiments: ATM CEC BT. Performed the experiments: ATM CEC BT. Analyzed the data: ATM CEC BT. Contributed reagents/materials/analysis tools: ATM CEC BT. Wrote the paper: ATM CEC.

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