Cretaceous Research 50 (2014) 52–58

Contents lists available at ScienceDirect

Cretaceous Research

journal homepage: www.elsevier.com/locate/CretRes

New evidence for the possible occurrence of *Tyrannosaurus* in West Texas, and discussion of Maastrichtian tyrannosaurid dinosaurs from Big Bend National Park

Steven L. Wick*

Division of Science and Resource Management, Big Bend National Park, TX 79834, USA

ARTICLE INFO

Article history:
Received 30 July 2013
Accepted in revised form 15 March 2014
Available online

Keywords:
Tyrannosaurus
Cretaceous
Maastrichtian
Texas
Javelina

ABSTRACT

Speculation regarding *Tyrannosaurus* in West Texas has been largely based upon a sub-adult tyrannosaurid maxilla from the Javelina Formation (Late Cretaceous–Maastrichtian) of Big Bend National Park. However, a very large anterior caudal vertebra, recently collected from the Javelina Formation, exhibits a morphology that can confidently be assigned to Tyrannosauridae and, because of its size, likely pertains to an adult *Tyrannosaurus*. The stratigraphic position of the specimen is closely bracketed by titanosaurid remains and further supports coexistence of these taxa. The stratigraphic position of the specimen possibly records one of the earliest occurrences of *Tyrannosaurus*. If so, *Tyrannosaurus* likely existed during roughly equivalent temporal intervals in disparate paleobiomes in both northern and southern late Maastrichtian faunal realms of North America.

Published by Elsevier Ltd.

1. Introduction

Maastrichtian tyrannosaurid dinosaurs from Big Bend National Park (BBNP) are known from a meagre, but significant, collection of remains. Apart from isolated fragmentary teeth, the clade is largely represented by an isolated left maxilla with incomplete dentition. This is the only Maastrichtian tyrannosaurid specimen from BBNP thus far described (Lawson, 1972, 1976). Recently, a partial right lower leg and pes was also collected from BBNP and is currently on display at the Perot Museum of Science and Nature in Dallas, Texas. It has yet to be described.

Because tyrannosaurid remains from the southernmost biome of late Maastrichtian North America are so rare, the discovery of a large, relatively complete tyrannosaurid caudal vertebra in the Javelina Formation of BBNP provides a useful opportunity for new discussion regarding the possible occurrence of *Tyrannosaurus* in West Texas.

Institutional abbreviations: **AMNH**, American Museum of Natural History, New York; **BBNP**, Big Bend National Park, Texas; **BHI**, Black Hills Institute, Hill City; **BIBE**, Perot Museum of Science and Nature, Dallas; **FMNH**, Field Museum of Natural History, Chicago; **MOR**, Museum of the Rockies, Bozeman; **MPC**, *Mongolian Paleontological Center*, Ulaan Bataar; **NMC**, National Museum of Canada, Ontario; **RMM**, Red Mountain Museum, Birmingham; **RSM**, Royal Saskatchewan Museum, Regina; **TMM**, Jackson School of Geosciences, University of Texas, Austin; **UMNH**, Utah Museum of Natural History, Salt Lake City.

2. Brief history of referral

Lawson (1972) first reported an isolated, tyrannosaurid left maxilla (TMM 41436-1) from the upper Javelina Formation of BBNP (Fig. 1). Described as "two-thirds" the size of *T. rex* (p. 121), Lawson informally diagnosed this specimen as representing a new species of *Tyrannosaurus* (*T. "vannus"*) based upon the rather small size of the maxilla and its relatively large, second antorbital fenestra. He also noted that the general proportions of the maxilla "are most like those of *T. rex* among the tyrannosaurs of North America" (Lawson, 1972, p. 123).

In 1976, Lawson published a description of TMM 41436-1. However, here, he formally referred the maxilla to *T. rex* citing morphological similarities between this specimen and *T. rex* as well as ontogenetic data which suggested that the specimen was from a "young adult" individual (p. 161). A re-examination of TMM 41436-1 (cast) during this study revealed that it retains a low rostroventral ridge around the antorbital fossa. It is also significantly smaller than FMNH PR2081 so is herein regarded as likely representing a sub-adult *Tyrannosaurus* as defined by Carr (1999) and Carr and Williamson (2004).

* Tel.: +1 (432) 477 1150.
E-mail address: steven_wick@nps.gov.

http://dx.doi.org/10.1016/j.cretres.2014.03.010
0195-6671/Published by Elsevier Ltd.

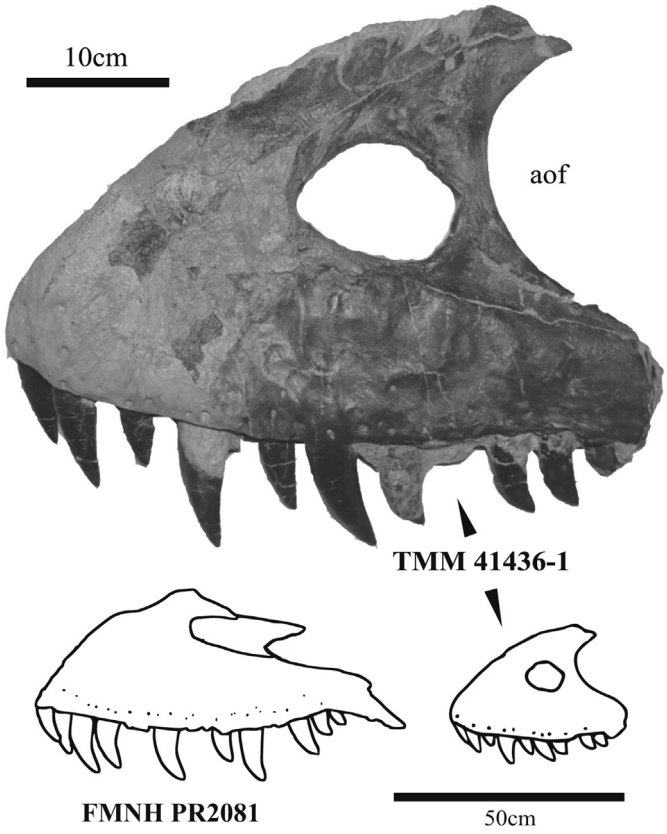

Fig. 1. Photo of TMM 41436-1 (cast with restored teeth), and general comparative proportions with mature *Tyrannosaurus rex* maxilla specimen FMNH PR2081 (redrawn from Brochu, 2003); aof = antorbital fenestrae.

TMM 41436-1 was subsequently included in a study regarding variation in *Tyrannosaurus rex* by Carpenter (1990). Here, he observed that the individual represented by TMM 41436-1 "possessed a face considerably shorter than *T. rex*" (p. 143) and concluded that it fell outside the range of individual variation for that taxon; therefore, he suggested that TMM 41436-1 may belong to a new genus.

Citing the morphology noted earlier by Lawson, Carr and Williamson (2000, 2004) rejected Carpenter's earlier suggestion regarding TMM 41436-1's taxonomic distinctiveness and referred the BBNP maxilla "unequivocally" to *T. rex* (Carr and Williamson, 2000, p. 126). Although they agreed with Carpenter regarding the truncated rostral margin of TMM 41436-1, they suggested a similar morphology present among some specimens of *T. rex*, *Daspletosaurus*, and *Albertosaurus*, represents typical variation within Tyrannosauridae (Carr and Williamson, 2000).

An additional reference to TMM 41436-1 was offered by Brochu (2003) in his description of the *Tyrannosaurus rex* specimen FMNH PR2081. Although he did not formally refer TMM 41436-1 to *T. rex*, he suggested that its morphology is consistent with that taxon or "a close relative" (p. 3).

Sampson and Loewen (2005) considered the Javelina Formation tyrannosaurid to be among a number of fragmentary southern tyrannosaur specimens "not confidently ascribed to genus and species" (p. 470) although they affirmed *T. rex* as the only tyrannosaurid species present in North America during late Maastrichtian time.

Although the Perot Museum tyrannosaurid leg and pes has yet to be described, preliminary measurements of the *insitu* tibia of BIBE 45850, taken by the author during its excavation (83.7 cm long without astragalus), revealed that it is just over 73% the size of the tibia of FMNH PR2081 (Brochu, 2003); so is likely from a sub-adult individual if from that taxon. However, it is also possible that it belongs to a tyrannosaurid species smaller than *Tyrannosaurus*; something also true regarding the BBNP maxilla (TMM 41436-1).

3. Specimen and location

TMM 46028-1 is a very large anterior tyrannosaurid caudal (ca) vertebra consisting of complete centrum and partial neural arch with zygapophyses and intact right transverse process (Fig. 2). The specimen was discovered *insitu* within fluvial sandstone of the Javelina Formation at the 'Willow' locality in southwest BBNP. Exact locality data available at the Vertebrate Paleontology Laboratory at the Jackson School of Geosciences, University of Texas at Austin.

4. Geologic setting and stratigraphy

The Javelina Formation is largely restricted to BBNP (Fig. 3). It contains continental strata deposited on an inland floodplain several hundred kilometers from the paleoshoreline of the Western Interior Seaway. Sedimentologic and tectonic evidence supports deposition of these fluvio-lacustrine sediments within an upland, intermontane basin (Lehman, 1985, 1991). The unit contains Maastrichtian (=late Edmontonian through Lancian land mammal age) strata with its upper half being of Lancian age (Lehman et al., 2006). At the 'Willow' locality in southwest BBNP, the Javelina Formation consists of interfingering fluvally-derived sandstones, conglomerates, and floodplain mudstones with incipient paleosols; comparable in facies composition to other exposures of the Javelina Formation in western portions of the park.

The exposed section of the Javelina Formation at 'Willow' is 65 m thick (Fig. 3). This contrasts with the stratigraphic sections at Dawson Creek (120 m thick; 13 km north), and at Peña Mountain (133 m thick; 5 km northeast) (Lehman et al., in prep.); however, the lower half of the formation at 'Willow' is truncated by faulting. Although the top of the stratigraphic section at 'Willow' is largely obscured by alluvium, a nearby, upsection exposure of dark gray and maroon paleosol couplets reveals that the exposed section of the Javelina Formation at 'Willow' is very close to the contact with the overlying Black Peaks Formation. These distinctive couplets are very rare or absent elsewhere in the sandstone-dominated Javelina Formation but are common in the overlying, mudstone-dominated Black Peaks Formation. The nearby exposure of the Javelina Formation at Peña Mountain is 133 m thick. Therefore, I approximate the 65 m thick section exposed at 'Willow' to be comprised of the upper half of the Javelina Formation; hence, the stratigraphic position of TMM 46028-1 generally correlates with the middle of the Javelina Formation as represented elsewhere in western areas of BBNP.

4.1. Methods

Measurements of TMM 46028-1 were taken by the author on the actual specimen. Caudal centra length measurements for RSM P2523.8, BHI 3033, and MPC 100/61 were based on measurements from the original specimens. Anterior joint surface measurements of RSM P2523.8 were compiled from laser scans of the original specimens. Measurements of MOR 555 were compiled using digital photographs with scale. Measurements of FMNH PR2081 were compiled from 1st-generation molds of the original specimens. Measurements of NMC 8506 were reported by Russell (1970). Centrum width = maximum horizontal distance across the widest point of the anterior joint surface; centrum height = maximum