A ceratopsian horncore from the Olmos Formation (early Maastrichtian) near Múzquiz, Mexico

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ABSTRACT

An isolated supraorbital horncore collected from the Olmos Formation near Múzquiz is among the longest ever found, and records the presence in this area of a very large ceratopsid. The specimen probably pertains to a chasmosaurine, but differs significantly from the horncores in Coahuilaceratops known from the nearby Cerro del Pueblo Formation, and cannot be attributed with confidence to any other known ceratopsid.

Key words: ceratopsian, Cretaceous, Olmos Formation, Mexico.

RESUMEN

Un cuerno supraorbital aislado, colectado en la Formación Olmos cerca de Múzquiz, es uno de los más largos que se ha encontrado, y registra la presencia de un ceratópsido de gran talla en esta área. El espécimen probablemente pertenece a un chasmosaurino, pero difiere significativamente de los cuernos de Coahuilaceratops, reportado de la Formación Cerro del Pueblo, por lo que no puede ser atribuido con certeza a cualquier otro ceratópsido conocido.

Palabras clave: ceratópsido, Cretácico, Formación Olmos, México.

INTRODUCTION

In 1984 the Historic Museum of Múzquiz was established, and residents of the region at that time were asked to donate objects of historical interest to the museum. In addition to cultural and archeological materials, many fossils were donated; however, most of these had been recovered years ago and without proper documentation. Beginning in 2005, a group of local amateur paleontologists (Museo de Múzquiz, A. C.) began collecting additional specimens, documenting and preserving these in the museum. In 2008, the museum collections were enrolled in the Public Registry of Archeological Zones and Monuments (INAH).

Among the objects donated to the museum in 1984 was the suprorbital horncore of a ceratopsian dinosaur (MUZ 309; Figure 1). The label associated with the specimen indicates only "Olmos Formation, Superior Cretaceous, Múzquiz County locality." Catalogued with the specimen were a number of additional fragmentary dinosaur bones, including the distal end of a ceratopsian humerus (MUZ 310) and other indeterminate fragments. Although there are twelve dinosaur-bearing localities known in the Múzquiz area, the exact collection site for the horncore has not been precisely established.

Dinosaur bones had been previously reported from the Olmos Formation. In 1968, a fragmentary skeleton of

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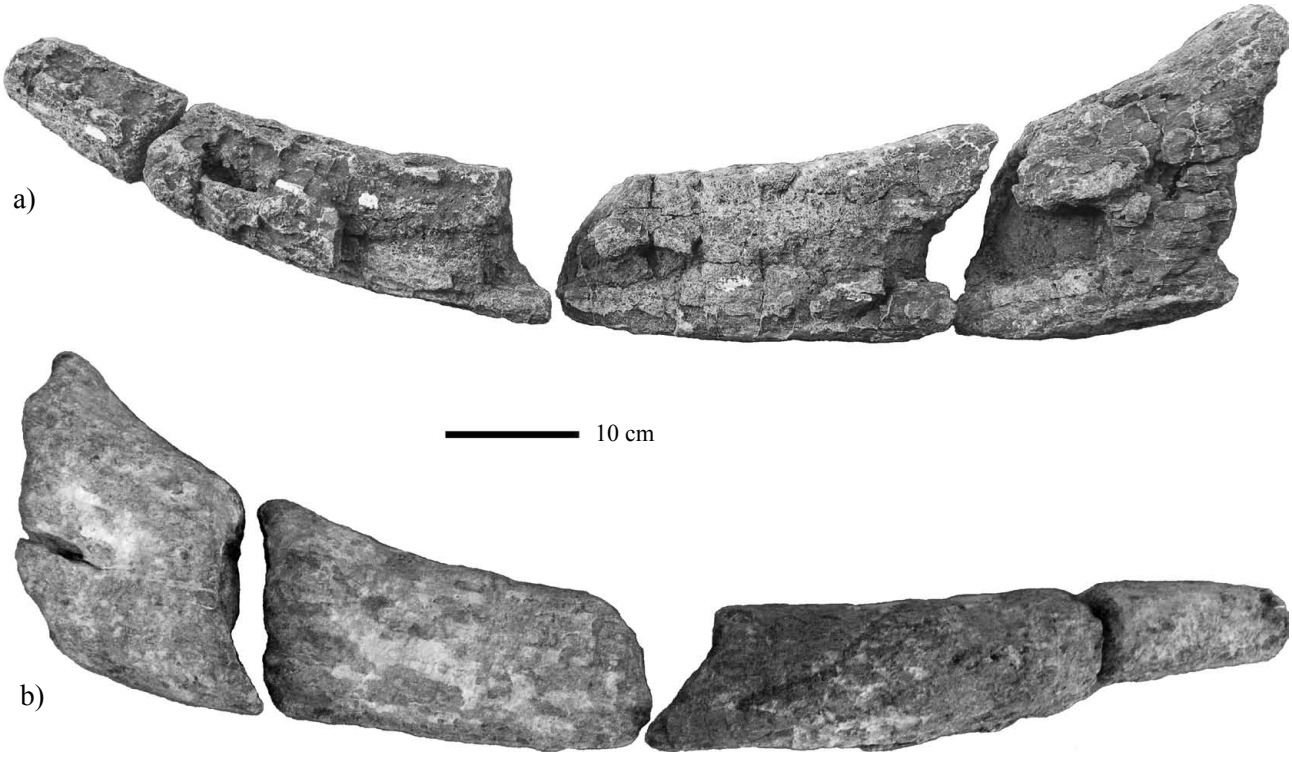

Figure 1. The Múzquiz horncore (MUZ 309) a large left supraorbital horncore from a chasmosaurine ceratopsid in (a) lateral, and (b) medial view.

a ceratopsian dinosaur was reported from "Palaú in the coal zone of the Olmos Formation" (Ojeda-Rivera *et al.*, 1968). The specimen consisted of parts of both hind- and forelimbs, and was tentatively identified as *Chasmosaurus* by Wann Langston, Jr. (Ojeda-Rivera *et al.*, 1968; their fig. 8). However, the present whereabouts of the specimen and its original collection site are unknown. Meyer *et al.* (2005) described footprints of theropod dinosaurs and mentioned the occurrence of hadrosaur and ankylosaur bones in the Olmos Formation. Kirkland *et al.* (2006) described a partial skeleton of the hadrosaur *Kritosaurus* sp., and noted the occurrence here also of tyrannosaurid dinosaur teeth. The Múzquiz horncore is of interest therefore in properly documenting the presence here of ceratopsian dinosaurs. Although this is an isolated fragmentary specimen, it is useful to describe and illustrate it for purposes of comparison with ceratopsians from nearby and correlative deposits.

The fossil flora of the Olmos Formation is much better known than its fossil vertebrate fauna, and includes a wide variety of ferns, conifers, and angiosperms (Weber, 1978; Cervallos-Ferriz and Ricalde-Moreno, 1995; Estrada-Ruiz *et al.*, 2007, 2008, 2010). Some of the fossil wood types found in the Olmos Formation have also been found in the Aguja and Javelina formations in Big Bend National Park, about 250 km northwest of Múzquiz in Texas (Wheeler and Lehman, 2009). Marine invertebrates indicate that the Olmos Formation is Late Campanian to Early Maastrichtian in age (reviewed by Kirkland *et al.*, 2006). The flora suggests correlation of the terrestrial facies of the Olmos Formation with the lower part of the Javelina Formation or uppermost part of the Aguja Formation in Texas, and accords best with an early Maastrichtian age.

DESCRIPTION

The Múzquiz horncore is broken into four segments, but these can be joined to show its entire form (Figure 1). The medial side is well preserved and exhibits the longitudinal vascular impressions typical of ceratopsid horncores. The lateral side was no doubt exposed when the specimen was discovered, and much of the cortical bone has been weathered off of that side. The base of the horncore has a spongiosa-filled central axis, and is lacking the deep cornual sinus found in many other large ceratopsids (*e.g.,* Farke, 2006). Its preserved length, as restored, is 95.2 cm (straight-line distance).

Although the rim of the orbit is not preserved, several features allow for identification of the medial, lateral, anterior, and posterior surfaces. In most or all ceratopsids, the posterior base of the horncore smoothly continues the curvature of the rear flange of the postorbital where it approaches the squamosal suture. In contrast, the anterior base of the horncore typically ends in a sharp angle with a rugose surface where it is sutured to the palpebral, producing an antorbital 'buttress' (*e.g.*, Lehman, 1989). This permits identification of the anterior and posterior surfaces of the Múzquiz specimen (Figure 1).

The lateral side of the horncore in most ceratopsids is flattened above the dorsal rim of the orbit, whereas the medial side flares away from the horncore to form the roof of the frontal sinus (or 'postfrontal fontanelle' of authors, *e.g.*, Lehman, 1989). This permits identification of the inner and outer sides of the horncore in MUZ 309 (Figure 1). If the inner and outer, forward and rear sides of the Múzquiz specimen are correctly identified as described above, then this is a left supraorbital horncore and it is posteriorly curved, rather than anteriorly curved as is more typical for large ceratopsids.

DISCUSSION

The Múzquiz horncore is very long, a condition typical for supraorbital horncores of chasmosaurine ceratopsids but also known in basal centrosaurines such as *Albertaceratops* (Ryan, 2007). This horncore is, however, longer than in any ceratopsian other than the largest known specimen of *Pentaceratops* (Oklahoma Museum of Natural History, OMNH 10165; Lehman, 1998). The horn appears to lack a cornual sinus, a condition among chasmosaurines only found in *Chasmosaurus* (other recently named taxa such as *'Agujaceratops', 'Mojoceratops'*, *'Utahceratops'*, and *'Vagaceratops'* are similar in this respect, and perhaps congeneric with *Chasmosaurus*; *e.g.,* Paul, 2010). A rudimentary cornual sinus is found in *Anchiceratops* and in *Pentaceratops* (Farke, 2006). Because the base of the Múzquiz horncore is broken, it would have been somewhat longer than preserved, and so it is possible that a sinus could have been present in the unpreserved part. However, the degree of expansion shown in the preserved base suggests that very little is missing, and we consider it unlikely that a cornual sinus was present. If the orientation suggested above is correct, the horn is posteriorly curved, a condition known only in *Chasmosaurus* (and closely related taxa listed above).

The Múzquiz horncore is also quite slender for its length (Figure 2; basal anteroposterior width = 20.8 cm, transverse width = 12.2 cm). The ratio of the basal anteroposterior width to the length of the horncore (0.22) is lower than in any chasmosaurine for which measurements are available, other than the largest known specimen of *Chasmosaurus mariscalensis* (TMM 43098-1). Large chasmosaurines, such as *Triceratops* and *Torosaurus* typically have horncores that are relatively much wider at the base. The base of the horncore is extended posteriorly in large chasmosaurines (*Triceratops*, *Torosaurus*, and *Pentaceratops*) such that the basal transverse to anteroposterior width ratio is low (< 0.5). The Múzquiz horncore retains a relatively high basal width ratio (0.59; Figure 3).

The size and form of the Múzquiz horncore, as well as the proximity of its collection site, suggest that it might pertain to *Coahuilaceratops* found in the Cerro del Pueblo Formation near Saltillo (Loewen *et al.*, 2010). However, only fragments of the supraorbital horncores were recovered with the type specimen (CPC 276), and the authors restored the horncores to a length of only about 60 cm (Loewen *et al.*, 2010; their fig. 7.4), substantially smaller than in the Múzquiz specimen. Moreover, one of the horncores in the type specimen has a cornual sinus, and a basal width ratio (0.77) much greater than in the Múzquiz specimen. The authors in describing *Coahuilaceratops* were also uncertain as to whether the horncores were curved anteriorly or posteriorly. The authors restored the horncores with anterior curvature (Loewen *et al.*, 2010; their fig. 7.4).

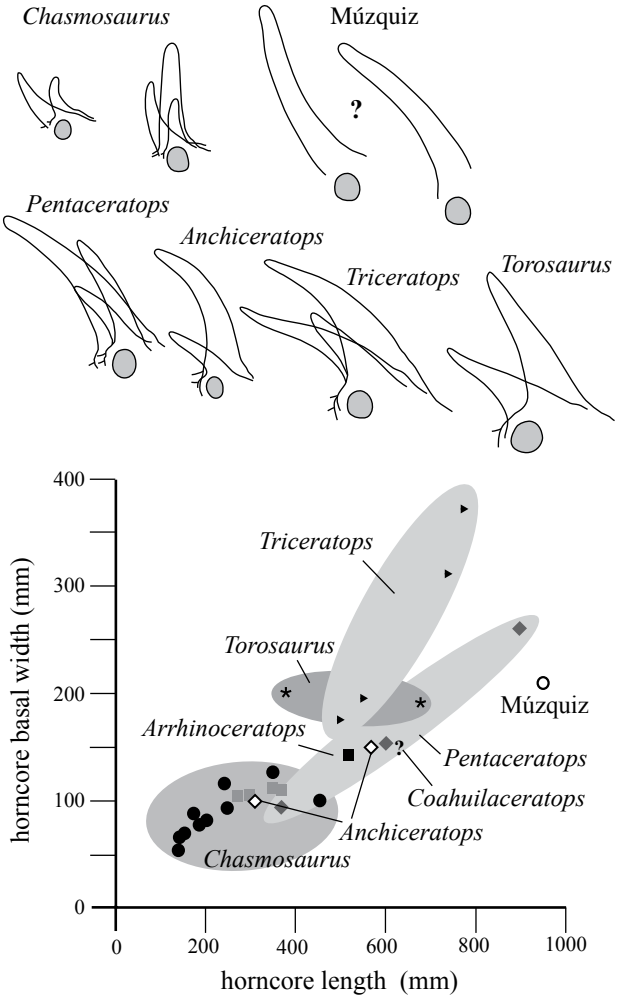

Figure 2. Bivariate plot showing the relationship between basal anteroposterior width and length of supraorbital horncores in chasmosaurine ceratopsids for which measurements are available. Data for *Chasmosaurus* are from Lehman (1989; *C. mariscalensis*, filled circles) and Godfrey and Holmes (1995; *C. russelli*, gray squares); *Anchiceratops* from Brown (1914, open diamonds); *Arrhinoceratops* from Parks (1925, black square); *Pentaceratops* from Lehman (1998; gray diamonds); *Triceratops* from Hatcher *et al.* (1907; dark triangles); *Torosaurus* from Colbert and Bump (1947; stars); compared with the Múzquiz horncore (MUZ 309; open circle). The horncore length for *Coahuilaceratops* is estimated based on the restoration given by Loewen *et al.* (2010; question mark). Drawings show variation among chasmosaurine supraorbital horncores (modified from Lehman, 1990), comparison with the Múzquiz horncore and alternate interpretations showing anteriorly- or posteriorly-curved orientation (to scale).

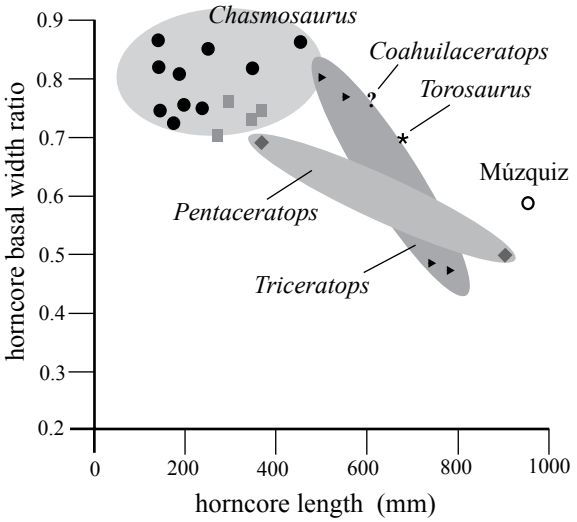

Figure 3. Bivariate plot showing the relationship between basal width ratio (transverse/anteroposterior width) and length of supraorbital horncores in chasmosaurine ceratopsids for which measurements are available. Data for *Chasmosaurus* are from Lehman (1989; *C. mariscalensis*, filled circles) and Godfrey and Holmes (1995; *C. russelli*, gray squares); *Pentaceratops* from Lehman (1998; gray diamonds); *Triceratops* from Hatcher *et al.* (1907; dark triangles); *Torosaurus* from Colbert and Bump (1947; stars); compared with the Múzquiz horncore (MUZ 309; open circle). The horncore length for *Coahuilaceratops* is estimated based on the restoration given by Loewen *et al.* (2010; question mark).

Although the supraorbital horncores in *Coahuilaceratops* are smaller, have a greater basal width ratio, and possess a cornual sinus, these differences could be within the realm of individual ontogenetic variation observed in other chasmosaurines (*e.g.,* Lehman, 1989, 1998). If the anteriorly curved orientation shown in the restoration of CPC 276 is mistaken, or if the posteriorly curved orientation suggested here for MUZ 309 is incorrect, then the Múzquiz specimen could pertain to *Coahuilaceratops*; albeit probably from a much larger individual. However, the type skull of *Coahuilaceratops* is also from a very large mature animal, and magnetostratigraphy of the Cerro del Pueblo Formation suggests that these strata are probably older than the Olmos Formation (*e.g.,* Eberth *et al.*, 2004). Therefore, it seems doubtful that the Múzquiz specimen belongs to *Coahuilaceratops*, and it may instead represent a distinct taxon.

CONCLUSIONS

The Múzquiz horncore is very long and slender, and probably pertains to a chasmosaurine ceratopsid. Its great length, low basal width ratio, apparent posterior curvature, and lack of a cornual sinus, suggest that it cannot be attributed to *Coahuilaceratops magnacuerna* known from the nearby Cerro del Pueblo Formation in Saltillo. It is also clear that the Múzquiz specimen pertains to a species unlike either *Chasmosaurus mariscalensis* (Lehman, 1989) or *Torosaurus* cf. *utahensis* (Hunt and Lehman, 2008) the only two ceratopsians thus far known from the nearby Aguja and Javelina formations in Texas. In all likelihood the horncore belongs to an unknown taxon. This could reflect either marked provinciality or environmental segregation of horned dinosaurs at that time (*e.g.,* Lehman, 1997) or possibly that the Olmos Formation was deposited during a time not represented by the Cerro del Pueblo Formation or the Aguja - Javelina succession in Texas.

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REFERENCES

Brown, B., 1914, *Anchiceratops*, a new genus of horned dinosaurs from the Edmonton Cretaceous of Alberta, with discussion of the origin of the ceratopsian crest and the brain casts of *Anchiceratops* and *Trachodon*: American Museum of Natural History Bulletin, 33, 539-548.

Cervallos-Ferriz, S.R.S., Ricalde-Moreno, O.S., 1995, Palmera fósiles del north de México: Anales del Instituto Biología, Universidad Nacional Autónoma de México, Serie Botánica, 66, 37-106.

Colbert, E.H., Bump, J.D., 1947, A skull of *Torosaurus* from South Dakota and a revision of the genus: Philadelphia Academy of Natural Sciences Proceedings 99, 93-106.

Eberth, D.A., Delgado-de Jesús, C.R., Lerbekmo, J.F., Brinkman, D.B., Rodríguez-de la Rosa, R.A., and Sampson, S.D., 2004, Cerro del Pueblo Fm (Difunta Group, Upper Cretaceous) Parras Basin, southern Coahuila, Mexico: reference sections, age, and correlation: Revista Mexicana de Ciencias Geológicas, 21(3), 335-352.

Estrada-Ruiz, E., Martínez-Cabrera, H.I., Cevallos-Ferriz, S.R.S., 2007, Fossil woods from the Late Campanian - Early Maastrichtian Olmos Formation, Coahuila, Mexico: Review of Palaeobotany and Palynology, 145, 123-133.

Estrada-Ruiz, E., Upchurch, G.R., Cevallos-Ferriz, S.R.S., 2008, Flora and climate of the Olmos Formation (Upper Campanian - Lower Maastrichtian), Coahuila, Mexico: a preliminary report: Gulf Coast Association of Geological Societies Transactions, 58, 273-283.

Estrada-Ruiz, E., Martínez-Cabrera, H.I., Cevallos-Ferriz, S.R.S., 2010, Upper Cretaceous woods from the Olmos Formation (Late Campanian - Early Maastrichtian) Coahuila, Mexico: American Journal of Botany, 97, 1179-1194.

Farke, A.A., 2006, Morphology and ontogeny of the cornual sinuses in chasmosaurine dinosaurs (Ornithischia: Ceratopsidae): Journal of Paleontology, 80, 780-785.

Godfrey, S.J., Holmes, R., 1995, Cranial morphology and systematics of *Chasmosaurus* (Dinosauria: Ceratopsidae) from the Upper Cretaceous of western Canada: Journal of Vertebrate Paleontology 15, 726-742.

Hatcher, J.B., Marsh, O.C., Lull, R.S., 1907, The Ceratopsia: U. S. Geological Survey Monograph 49, 300 pp.

Hunt, R.K., Lehman, T.M., 2008, Attributes of the ceratopsian dinosaur *Torosaurus*, and new material from the Javelina Formation

(Maastrichtian) of Texas: Journal of Paleontology 82, 1127-1138.

Kirkland, J.I., Hernández-Rivera, R., Gates, T., Paul, G.S., Nesbitt, S., Serrano-Brañas, C.I., Garcia-de la Garza, J.P., 2006, Large hadrosaurine dinosaurs from the latest Campanian of Coahuila, Mexico, *in* Lucas S. G., Sullivan, R. M. (eds.), Late Cretaceous vertebrates from the Western Interior: New Mexico Museum of Natural History and Science Bulletin, 35, 299-315.

Lehman, T.M., 1989, *Chasmosaurus mariscalensis*, sp. nov., a new ceratopsian dinosaur from Texas: Journal of Vertebrate Paleontology, 9(2), 137-162.

Lehman, T.M., 1990, The ceratopsian subfamily Chasmosaurinae: sexual dimorphism and systematics, *in* Carpenter, K., Currie, P. (eds.), Dinosaur Systematics: Perspectives and Approaches: New York, Cambridge University Press, 211-229.

Lehman, T.M., 1997, Campanian dinosaur biogeography in the western interior of North America, *in* Wolberg, D., Stump, E. (eds.), Dinofest International, proceedings of a symposium sponsored by Arizona State University: Philadelphia Academy of Natural Sciences, Special Publication, 223-240.

Lehman, T.M., 1998, A gigantic skull and skeleton of the horned dinosaur *Pentaceratops sternbergi* from New Mexico: Journal of Paleontology, 72, 892-904.

Loewen, M.A., Sampson, S.D., Lund, E.K., Farke, A.J., Aguillón-Martínez, M.C., de Leon, C.A., Rodríguez-de la Rosa, R.A., Getty, M.A., Eberth, D.A., 2010, Horned dinosaurs (Ornithischia: Ceratopsidae) from the Upper Cretaceous (Campanian) Cerro del Pueblo Formation, Coahuila, Mexico, *in* Ryan, M. J., Chinnery-Allgeier, B. J., Eberth, D. A. (eds.), New Perspectives on Horned Dinosaurs: Bloomington, Indiana University Press, 99-116.

Meyer, C.A., Frey, E.D., Thuring, B., Etter, W., Stinnesbeck, W., 2005., Dinosaur tracks from the Late Cretaceous Sabinas Basin (Mexico): Darmstadter Beitrage zur Naturgeschichte, Heft 14, 41-45.

Ojeda-Rivera, J., Delgado-Hernández, J., Villamar, S., 1968, Coal geology of the Sabinas Basin, Coahuila: Geological Society of America, Fieldtrip Guidebook Series No. 1, 72 pp.

Parks, W.A., 1925, *Arrhinoceratops brachyops*, a new genus and species of Ceratopsia from the Edmonton Formation of Alberta: University of Toronto Studies, Geological Series, 19, 5-15.

Paul, G.S., 2010, The Princeton Field Guide to Dinosaurs: Princeton University Press, New Jersey, 320 pp.

Ryan, M.J., 2007, A new basal centrosaurine ceratopsid from the Oldman Formation, southeastern Alberta: Journal of Paleontology, 81, 376-396.

Weber, R., 1978, Some aspects of the Upper Cretaceous angiosperm flora of Coahuila, Mexico: Courier Forschunginstitut Senckenberg, 30, 38-46.

Wheeler, E.A., Lehman, T.M., 2009, New Late Cretaceous and Paleocene dicot woods of Big Bend National Park, Texas and review of Cretaceous wood characteristics: International Association of Wood Anatomy Journal, 30, 293-318.

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