

Evidence of predation on the vertebra of a hadrosaurid dinosaur from the Upper Cretaceous (Campanian) of Coahuila, Mexico

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Abstract: In sediments of the Aguja Formation (Late Cretaceous: Campanian) at La Salada in northern part of the state of Coahuila, Mexico, numerous fossils of vertebrates have been discovered including Hadrosauridae. One hadrosaur vertebra provides evidence of predation probably by a giant alligator *Deinosuchus riograndensis*.

Key Words: Coahuila; Mexico; Late Cretaceous; Campanian; Alligatoridae; *Deinosuchus*; Hadrosauridae; predation.

Citation : RIVERA-SYLVA H.E., FREY E. & GUZMÁN-GUTIÉRREZ J.R. (2009).- Evidence of predation on the vertebra of a hadrosaurid dinosaur from the Upper Cretaceous (Campanian) of Coahuila, Mexico.- [Carnets de Géologie / Notebooks on Geology](#), Brest, Letter 2009/02 (CG2009_L02)

Resumen: *Evidencia de depredación en una vértebra de un dinosaurio hadrosáurido del Cretácico Superior (Campaniano) de Coahuila, México.*- En los sedimentos relacionados a la Formación Aguja (Cretácico Tardío: Campaniano) cerca de La Salada en el norte del Estado de Coahuila, México, se han descubierto diversos fósiles de vertebrados incluyendo Hadrosauridae. Una vértebra de hadrosáurido muestra evidencia de depredación posiblemente por *Deinosuchus riograndensis*.

Palabras Claves: Coahuila; México; Cretácico Tardío; Campaniano; Alligatoridae; *Deinosuchus*; Hadrosauridae; depredación.

Résumé : *Preuve de prédation sur une vertèbre de dinosaure hadrosaure du Crétacé supérieur (Campanien) de l'État de Coahuila, Mexique.*- Dans des sédiments appartenant à la Formation Aguja (Crétacé supérieur : Campanien) près de La Salada dans le nord de l'état de Coahuila, Mexique, plusieurs fossiles de vertébrés parmi lesquels des Hadrosauridae ont été découverts. Une vertèbre d'hadrosaure suggère une prédation, probablement par un crocodylien géant *Deinosuchus riograndensis*.

Mots-Clefs : Coahuila ; Mexique ; Crétacé supérieur ; Campanien ; Alligatoridae ; *Deinosuchus* ; Hadrosauridae ; prédation.

Introduction

During the Late Cretaceous, the plains of northern Coahuila were covered by a deltaic river system draining southward into the palaeogulf of Mexico. Further south, the Late Campanian fluvial sediments of the Cerro del Pueblo Formation in the the Parras Basin at Las Aguilas and Rincon Colorado have yielded a rich fossil assemblage (HERNÁNDEZ, 1992; HERNÁNDEZ & KIRKLAND, 1993; HERNÁNDEZ *et alii*, 1996; AGUILLÓN-MARTÍNEZ *et alii*, 1998; HERNÁNDEZ &

DELGADO-DE JESÚS, 2000; BRINKMAN *et alii*, 2002; EBERTH *et alii*, 2003; RIVERA-SYLVA & ESPINOSA-CHÁVEZ, 2006; SERRANO-BRAÑAS *et alii*, 2006; GATES *et alii*, 2007). Until now, little has been known about the slightly younger northern outcrops of the river system. During the past three years HRS has undertaken several expeditions to the area of the Ejido La Salada, Coahuila State, where a team of the INEGI (Instituto Nacional de Estadística, Geografía e Informática) had previously discovered a variety of dinosaur remains including

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Manuscript online since August 1, 2009

titanosaurs, hadrosaurs and other fossils such as Trionychidae that suggest a vertebrate assemblage similar to that from southern Coahuila. At the same site we found gar pike scales too. The foraminifers associated with the vertebrate fossils are of the genus *Heterohelix*, indicating a Late Cretaceous Campanian-Maastrichtian age. In the sediments of this interval, several isolated osteoderms and vertebrae of the gigantic alligatorid crocodylian *Deinosuchus* were collected (RIVERA-SYLVA *et alii*, 2008). They are the first evidence found of this animal in Coahuila.

Deinosuchus material from the Late Cretaceous San Carlos Formation south of Ojinaga, Chihuahua, northern México, has been mentioned occasionally (BROWN *et alii*, 2004; WESTGATE *et alii*, 2006), but never identified to the species level. In Coahuila RIVERA-SYLVA *et alii* (2008), recently discovered new material of *Deinosuchus* is to be described later (RIVERA-SYLVA *et alii*, in prep.). These discoveries expand the range of this crocodile into northern Coahuila.

The hadrosaur remains from the La Salada locality include material ranging from juvenile individuals about two meters in length up to adults probably about eleven meters long. The presence of hadrosaurs at different stages of growth may indicate the presence of family groups, and possible nesting sites in this area as in other localities around the world (WELSH & SANKEY, 2008).

Here we report on a hadrosaur vertebra with a bite mark from the lower section of the Aguja Formation (Late Cretaceous, Late Campanian), which crops out near the community of La Salada, Township of Ocampo, northwestern Coahuila, Mexico (Fig. 1). The specimen was discovered by HRS during the field season of 2007. The shape and depth of the bite mark are indicative of *Deinosuchus*. There are only two other records of such bite marks. They are from the Aguja Formation in Texas (SCHWIMMER, 2002). The record presented here is the first evidence in Mexico of predation on a dinosaur.

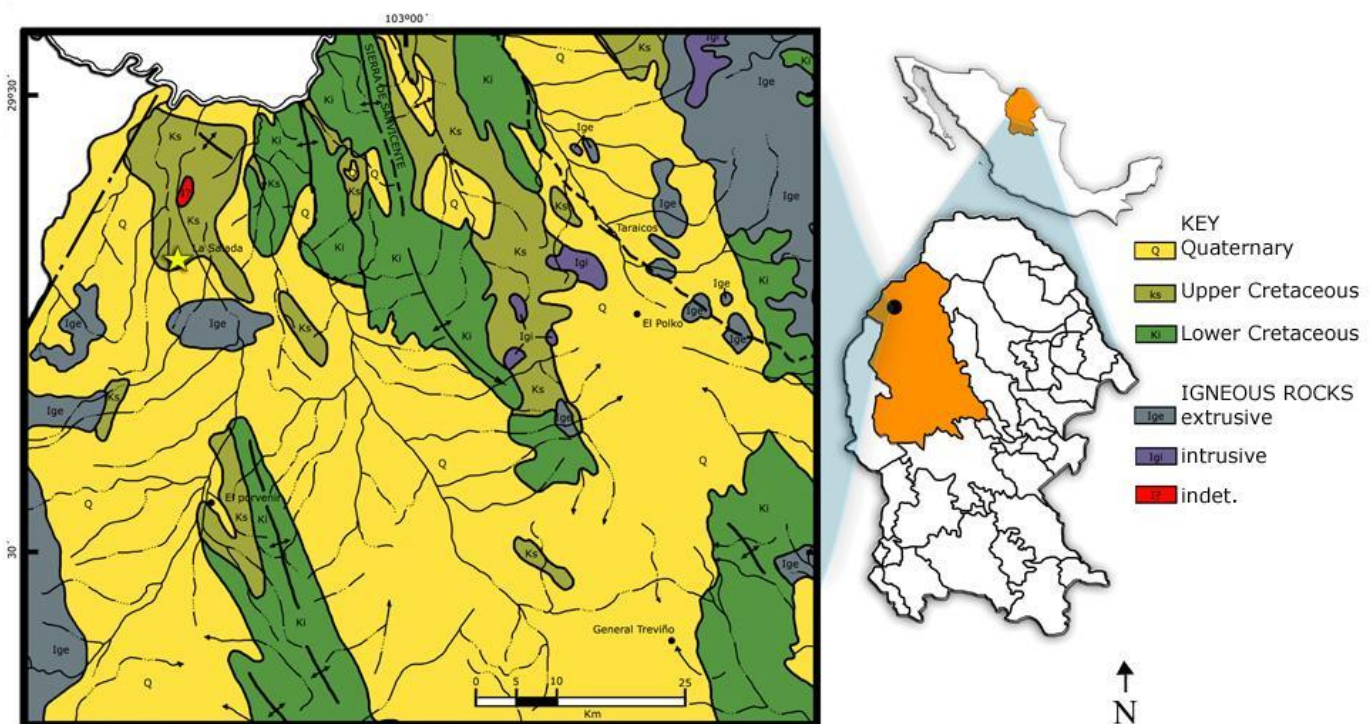


Figure 1: Location map showing the site near La Salada, indicated with a star (after LÓPEZ-RAMOS, 1967).

Geological setting and palaeoenvironment

The area in which the vertebrate fossils occur is characterized tectonically by elongate anticlines and broad synclines. Both structures are affected by normal and lateral faults. There is a discordant contact between the marine sequence of limestone and mudstones and the continental member, owing to the existence of a lateral fault between them. The marine sequence has lamellibranchs and abundant

foraminifers that are the equivalent of the marine member of the Aguja Formation. Above this member is a transitional sequence of sandstones, mudstones and limonites, which is correlative with the continental sequence in which the dinosaur remains occur. Biostratigraphic correlation using marine invertebrates suggests a Late Campanian age for the lower part of the Aguja Formation (CUSHMAN, 1946; PESSAGNO, 1967). According to the stratigraphical data the new locality in northern Coahuila lies within the range of the *Kritosaurus-Parasaurolophus* assemblage (LEHMAN,

2001) and thus correlates with the Judithian Climax (Late Campanian), 80 to 75 million years ago. The sediments were deposited in a deltaic system in a narrow prodelta with marshes, oxbows, and near shore marine deposits (HOPKINS, 1965; WEIDE *et alii*, 1972; LEHMAN, 1982). The diverse vertebrate record is a result of the interdigitation of land, fresh and salt water environments in very close proximity.

Systematic palaeontology

Dinosauria OWEN, 1842
 Ornithischia SEELEY, 1888
 Ornithopoda MARSH, 1881
 Hadrosauoidea COPE, 1869
 Hadrosauridae COPE, 1869
 Gen. et sp. indet.

Comments:

The collection number CPC-308 includes seven caudal vertebrae, the distal fragment of a humerus and the distal fragment of a metatarsus, all from one subadult hadrosaur. One of these caudal vertebrae (CPC-309), 85 mm long, shows a bite mark with a diameter of 7.89 mm and a depth of 5.68 mm on its left side (Fig. 2). The inner surface of the impact pit shows crushing with semilunar breakage along the outer margin of the bite mark, which is indicative of an impact bite (NJAU & BLUMENSCHINE, 2006). Furthermore, the margin of the bite mark is bisected, which is typical of crocodylian bite marks (FRANZEN & FREY, 1993; DAVIDSON & SOLOMON, 1990; NJAU & BLUMENSCHINE, 2006). Due to the rounded bowl-shaped impact it is highly likely that the bite was applied by a *Deinosuchus*.



Figure 2: Hadrosaurid caudal vertebra from the Campanian of La Salada, Coahuila (CPC-309), in left lateral view showing a bite mark. Scale = 10 cm.

Discussion

Near the hadrosaur specimen with the bite mark in a caudal vertebra were found some teeth and postcrania assigned to the alligatorid eusuchian *Deinosuchus*. The specimens are attributed to the genus *Deinosuchus* sp. based not only on their morphology and a morphometric analysis of the thickness of the tooth enamel and thickness of the osteoderms, but also on the significant ornamentation of deep irregular grooves and radially orientated pits on the dorsal osteoderm (RIVERA-SYLVA *et alii*, in prep.). Therefore there is direct evidence that *Deinosuchus* inhabited the river system along which numerous hadrosaurs must have lived. Apparently at least the subadult hadrosaurians occasionally fell prey to the giant

alligatorines, for hadrosaur carcasses were scavenged by them. Bite marks attributed to *Deinosuchus* have been reported also from a theropod limb bone from the Marshalltown Formation of New Jersey, and on hadrosaur tail vertebrae from the Aguja Formation in Texas (SCHWIMMER, 2002). The shape and impact characteristics of these bite marks resemble closely those described here. The fact that the bite was on the tail, however, is more suggestive of an attack (Fig. 3). According to observations on extant *Crocodylus niloticus*, the prey often turns to escape as the crocodile launches itself from its ambush or its attacked from behind while swimming. Severe bites in the rear quarters are the consequence (COTT & POOLEY, 1971).



Figure 3: Reconstruction of a *Deinosuchus riograndensis* attacking a *Kritosaurus* sp. (illustration by Jorge A. ORTIZ-MENDEIETA, 2008).

Crocodylians also feed regularly on carcasses. Small carcasses are lifted into the air and are shaken apart vigorously there. Most large carcasses, are dismembered by several crocodiles using torsion (COTT & POOLEY, 1971). In any case from any prey only disarticulated bits and pieces will be left. The fact that the tail vertebrae were associated with limb fragments indicates that the carcass torn apart had been entire. A fatal *Deinosuchus* attack would likely have resulted in a massively dismembered carcass with multiple marks of chewing (FRANZEN & FREY, 1993) provided that the prey had not been ingested completely. Even if the

carcass was left to rot, the killing and handling would have produced bite marks. There is also no trace of a mass killing, as it frequently happens in the Okavango Delta, where the *Crocodylus niloticus* population feasts on wildebeests until they are so full that they abandon prey only partly eaten (GUGGISBERG, 1972). Therefore the most likely scenario is that the juvenile hadrosaur escaped a *Deinosuchus* attack after a bite on the tail. Because the bite penetrated the vertebra, it must have been very powerful and probably caused a lethal flesh wound, particularly so the hadrosaur pulled its tail out of the closed jaws of the crocodylian. Due to blood loss or wound

infection the hadrosaur died shortly after the bite, before callus tissue could grow. In the Recent, such escape wounds often cause death a few days after a crocodile attack (CALDICOTT *et alii*, 2005).

Acknowledgments

We would like to thank the following individuals for their contribution to this project: Ileana DE LA PEÑA, Jose LÓPEZ, Elizabeth JARDÓN, Marie Celine BUCHY (from MUDE) and Javier Francisco LÓPEZ from the Municipality of Ocampo. In the same manner we wish to thank Francisco PALOMINO and Mr. Edgar GUZMÁN (both now retired from INEGI). Also we would like to thank Jorge A. ORTÍZ-MENDIETA (MNHN DDF) for skillfully drawing the original illustrations for this paper. We want to thank Drs. Kenneth CARPENTER (Denver Museum of Natural Science) and Eric BUFFETAUT (CNRS, France) for their reviews and suggestions that improved this manuscript. The Museo del Desierto is also thanked for supporting this investigation.

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