

## HADROSAURIAN FOOTPRINTS FROM THE LATE CRETACEOUS CERRO DEL PUEBLO FORMATION OF COAHUILA, MEXICO

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### INTRODUCTION

The current Mesozoic vertebrate footprint record in Mexico includes several tracksites ranging in age from the Middle Jurassic to the Late Cretaceous. From these localities, the State of Coahuila, northern Mexico, possess few more than the 70%, most of these localities are known to occur within the sedimentary sequence of the Late Cretaceous (Campanian) Cerro del Pueblo Formation (Difunta Group; Eberth *et al.*, 2004).

A conspicuous situation is that most of these tracksites preserve the footprints made by theropod dinosaurs; the scarcity of ornithopod footprints is notable and in contrast with the abundant hadrosaurian remains found in outcrops of the geological formation above mentioned.

To date, only three of the known tracksites preserve footprints belonging to hadrosaurs; these are the Las Aguilas tracksite, a nearby site known as the "hadrosaurio borracho" ("drunk hadrosaur") and La Parrita tracksite. These tracksites were discovered during the 2003 and 2004 field seasons of the Parras Basin Dinosaur Project, a research project that includes members of the Royal Tyrrell Museum of Palaeontology (Alberta, Canada), the University of Utah (U.S.A.) and the Secretary of Education and Culture, Coahuila, México (Rodríguez-de la Rosa *et al.*, 2003, 2004).

### RESULTS

The hadrosaur footprints are, in most of the cases, tridactyl and mesaxonic, with wide toes and plantar areas; also, bear a bilobate heel outline. The size of the footprints found at the Cerro del Pueblo Formation suggest individuals ranging in size from 1.80 m in length, for the case of the trackway of a juvenile found at the Las Aguilas Tracksite, to individuals of 9 m in length. An isolated track found at La Parrita tracksite suggest a much larger individual of nearly 12 m in length (Rodríguez-de la Rosa *et al.*, 2004).

## Las Aguilas Tracksite

The Las Aguilas Tracksite (Fig. 1A-D) is located close to the small town of Porvenir de Jalpa, Municipio de General Cepeda (Rodríguez-de la Rosa *et al.*, 2004). This tracksite has an area of ca. 5,000 m<sup>2</sup>. The tracksite preserves tracks and trackways belonging to Theropoda (Ornithomimidae and Tyrannosauridae) together with those of hadrosaurian dinosaurs (Fig. 1A). In spite of its close association, the evidence suggests that the theropods were at the place before a group of at least 20 hadrosaurs crossed the mudflat. The site preserves evidence of both gaits, bipedal and quadrupedal (Fig. 1B). Some footprints preserve conspicuous mud-rims, as well as drag marks of digit III (Fig. 1C).

Bipedal trackways suggest individuals of nearly 9 m in length; the tracks are 49.3 cm in mean length, 36.3 cm in mean width. Trackways show a mean step of 1.33 m, a stride of 1.80 m, and a pace angulation of 176°.

A quadrupedal trackway suggests an individual 7 m in length (Fig. 1B); the tracks are 38.6 cm in mean length, 30.5 cm in mean width. This trackway shows a step of 1 m, a stride of 2.25 m, and a pace angulation of 162°. Hand impressions are subtriangular in shape; these impressions show a step of 1.17 m, a stride of 2.10 m, and a pace angulation of 126°.

One meter above the main track layer, it was possible to find a second track level that preserves isolated natural sandstone casts of large hadrosaurian footprints (Fig. 1D).

### “Hadrosaurio borracho”

This tracksite preserves a conspicuous hadrosaurian trackway as the most prominent feature in the outcrop (Fig. 1E, F; Rodríguez-de la Rosa *et al.*, 2004, 2005, 2006). The trackway shows conspicuous features such as the preservation of long drag marks of digit III before each foot stroke, also preserve well defined mud rims, caused by the foot extrusion of the sediment. In the case of hand impressions, these are located in a very lateral position, in regard to the pes impressions, it suggests a wider area of movement for the hadrosaurian forelimb (Fig. 1F; Rodríguez-de la Rosa *et al.*, 2005). Features of this trackway suggest highly hydrated surface conditions at the moment it was made.

The outcrop surface preserves, as well, few theropod footprints. In this case, these footprints show three subparallel digital impressions with no trace of the so-called heel of the track; in such a case, these features relate this tracks with those made under subaqueous conditions (McAllister, 1989; Rodríguez-de la Rosa *et al.*, 2006). Also, on the same surface it is possible to note a shallow footprint of a hadrosaurian dinosaur plus a well preserved bird footprint and few other bird digital impressions.

In this case, the whole ichnological evidence suggests the history of the deposit (Rodríguez-de la Rosa *et al.*, 2006). Under this point of view, the theropod tracks were made under subaqueous conditions, a decreasing of the water level permitted that a hadrosaur crossed the site leaving evidence of pendular movements that normally occur above the sediment-air interface (Gatesy *et al.*, 1999); however, being hyperhydrated, the hadrosaur hindlimbs went down to the level of the metatarso-phalangeal joint and the sediment recorded those pendular movements preserving thus such conspicuous footprints. Posterior to this event, the water level was low enough to permit the record of the bird traces as well as a shallow hadrosaur footprint.

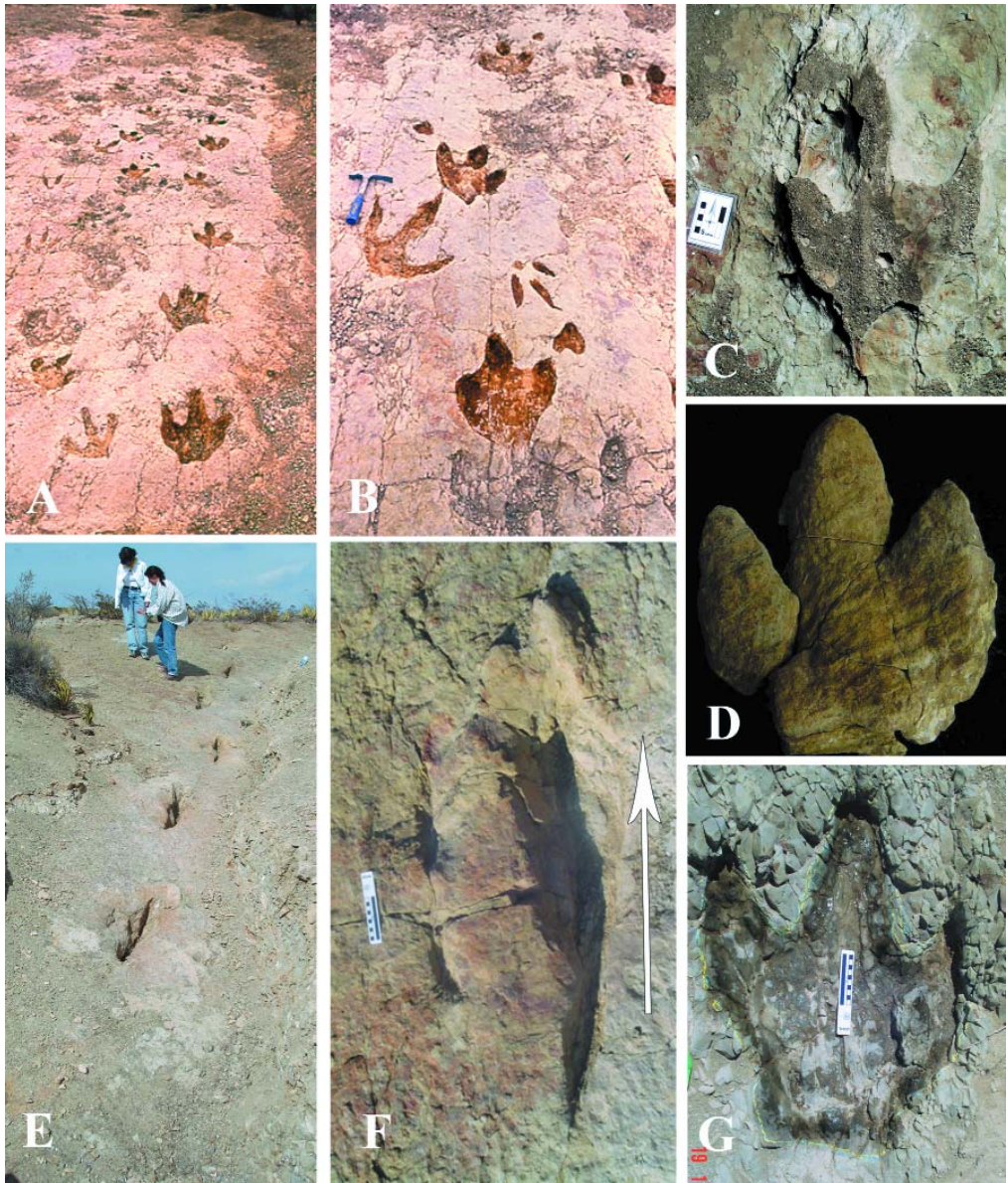


Figure 1. Hadrosaur footprints and trackways from the Late Cretaceous Cerro del Pueblo Formation of southeastern Coahuila, México. A) Panoramic partial view of Las Aguilas tracksite at the right-center of the photograph it is possible to appreciate a bipedal hadrosaur trackway; B) A partial quadrupedal trackway, the large theropod track to the left suggests tyrannosaurid affinities, while the theropod track at the right-center of the photograph is ornithomimid in origin; C) Isolated hadrosaur footprint from Las Aguilas tracksite, note the bilobed heel and the toe drag-marks; D) Hadrosaur natural sandstone cast, note the skin folds; E) "El hadrosaurio borracho" tracksite, note the hadrosaur trackway and elongated morphology of isolated pes impressions, direction of travel is toward the persons; F) Isolated manus/pes set from "el hadrosaurio borracho tracksite", note the elongated morphology of the pes impressions, the conspicuous mudrims on the top of the photograph, and the two manus impressions to the left, white arrow points toward the direction of travel; G) Track of a large hadrosaur from La Parrita tracksite.

## La Parrita tracksite

This tracksite remains still unstudied; however it preserves few isolated tracks belonging to hadrosaurs and a possible titanosaurian trackway. One of the best preserved hadrosaur footprints is 70.5 cm in length and 51 cm in width suggesting a very large individual, 2.82 m in hip-height and few more than 12 m in length (Fig. 1G).

## CONCLUSIONS

The vertebrate fossils found in the outcrops of the Cerro del Pueblo Formation (Late Campanian) of southeastern Coahuila, Northern Mexico, include fish remains, reptiles (e.g., turtles, crocodylians, lizards, pterosaur remains, etc.), mammals and, obviously, dinosaurs (Brinkman *et al.*, 2002, Eberth *et al.*, 2003, Rodríguez-de la Rosa *et al.*, 2004). This record also includes ichnofossils such as coprolites and footprints; among the later those of turtles, crocodiles, pterosaurs and dinosaurs are known (Rodríguez-de la Rosa, 2003; Rodríguez-de la Rosa *et al.*, 1998, Rodríguez-de la Rosa *et al.*, 2004).

However, most of the dinosaur footprints belong to theropods; a situation that is notable when comparing the great amount of ornithopod osteological remains, and the scarcity of theropod skeletal evidence (Brinkman *et al.*, 2002, Eberth *et al.*, 2004).

This apparent preservational gap became solved when in 2003 the Las Aguilas Tracksite became discovered, as well as the two smaller sites (Rodríguez-de la Rosa *et al.*, 2004).

The Las Aguilas Tracksite, with ca. 5,000 m<sup>2</sup>, represents the largest area preserving dinosaurs footprints in Mexico (Rodríguez-de la Rosa *et al.*, 2004). Current work is underway to complete the full study and protect the site. Although the area preserves such an association of footprints, of bipedal/quadrupedal ornithopods and theropods, the preserved evidence suggests that the theropod footprints represent a previous event, in regard to the hadrosaur footprints.

The evidence found at the "hadrosaurio borracho" locality allowed the paleoecological interpretation of the site. Under this point of view, it was possible to note the initial presence of swimming theropod dinosaurs, posteriorly a hadrosaur crossed the area leaving a conspicuous trackway, a decreasing in humidity conditions allowed the preservation of a shallow hadrosaur track as well as few bird traces.

The La Parrita tracksite permits to illustrate the great potential for new paleoichnological discoveries through the Late Cretaceous rocks in northern Mexico.

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