

Skin impressions of *Tehuelchesaurus* (Sauropoda) from the Upper Jurassic of Patagonia

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Abstract: Most of the postcranial skeleton of the sauropod dinosaur, *Tehuelchesaurus benitezii*, collected from the Cañadón Calcáreo Formation (Upper Jurassic) in the Chubut River valley, includes several fragments of skin impressions, which correspond to different parts of the body, such as portions of forelimbs, scapular and thorax regions. The most representative skin samples (Type I) consist of non-overlapping tubercular scales of hexagonal shape (3 cm long - 2,4 cm width), alternating with smaller ones (2 cm long - 1,5 cm width) disposed in a rosette pattern. Other scale samples (Type II) are similar to the first ones, but smaller in size, displaying rhomboidal shapes disposed also in a rosette pattern. This discovery means an unique opportunity to improve the knowledge of the external aspect of non-avian dinosaurs.

Key words: Sauropod, Skin, Jurassic, Chubut, Argentina.

Articulated sauropods skeletons from continents that were once part of Gondwana are not common. Accordingly, the discovery of a partial skeleton of *Tehuelchesaurus benitezii* Rich *et al.* (1999) in the western Chubut Province, Argentina, is of particular interest. This specimen belongs without doubt, to a single individual, and much of it was found in articulation. Unfortunately, it was found without the skull, but includes dorsal, sacral and caudal vertebrae, parts of both fore and hind limbs, parts of scapular girdles and pelvic, few rib fragments, and skin impressions from different parts of the body. The aim of this paper is to present a detailed description of the skin impressions of the *Tehuelchesaurus benitezii*.

History of discovery

The first discovery of dinosaur skin impressions corresponds to a 20 cm diameter patch directly overlapping on a forelimb of the sauropod *Pelorosaurus* (Mantell, 1852), from the Jurassic of England. This skin impression consisted of non-overlapping scales tubercles, arranged in rosette-pattern. The largest sample of skin impressions associated to sauropods bones was discovered by Barnum Brown (1935) at the Howe Quarry (Wyoming, USA). Unfortunately, most of the impressions were lost during the excavation to recover the bones. Recently, numerous skin impressions and many dermal spines have been referred to diplodocid sauropods, that presumably were aligned from the neck going down to the tail (Czerkas, 1992, 1994). There are numer-

ous discoveries of the Titanosauria in which bone plates are associated with the skeleton found. The most particular one was the *Saltasaurus loricatus* (Bonaparte & Powell, 1980) which has bony scutes surrounded by small ossicles, suggesting that some sauropods were armored. More recently in NW Patagonia several impressions of embryonic skin were found within numerous titanosaur sauropod eggs (Chiappe *et al.*, 1998). Discoveries of sedimental skin impressions of Jurassic sauropods are very scarce throughout the world. This is the first notice about the skin of these megaherbivorous in South America.

Abbreviations. MPEF-PV: Museo Paleontológico «Egidio Feruglio», Chubut, Argentina; PVL: Fundación Miguel Lillo, Tucumán, Argentina; MCF-PVPH: Museo Carmen de Funes, Paleontología de Vertebrados, Plaza Huincul, provincia del Neuquén, Argentina.

MATERIALS AND METHODS

The materials described here correspond to a variety of skin fragments associated to the holotype specimen of *Tehuelchesaurus benitezii* (MPEF-PV 1125) collected during the summer of 1994–1995.

Original location. The holotype of *Tehuelchesaurus benitezii* Rich *et al.* (1999), was collected at 43° 10' 3" S - 69° 15' 00" W (World Geodesic System, 1984) on Estancia Fernández, Chubut, Patagonia, Argentina (Fig. 1).

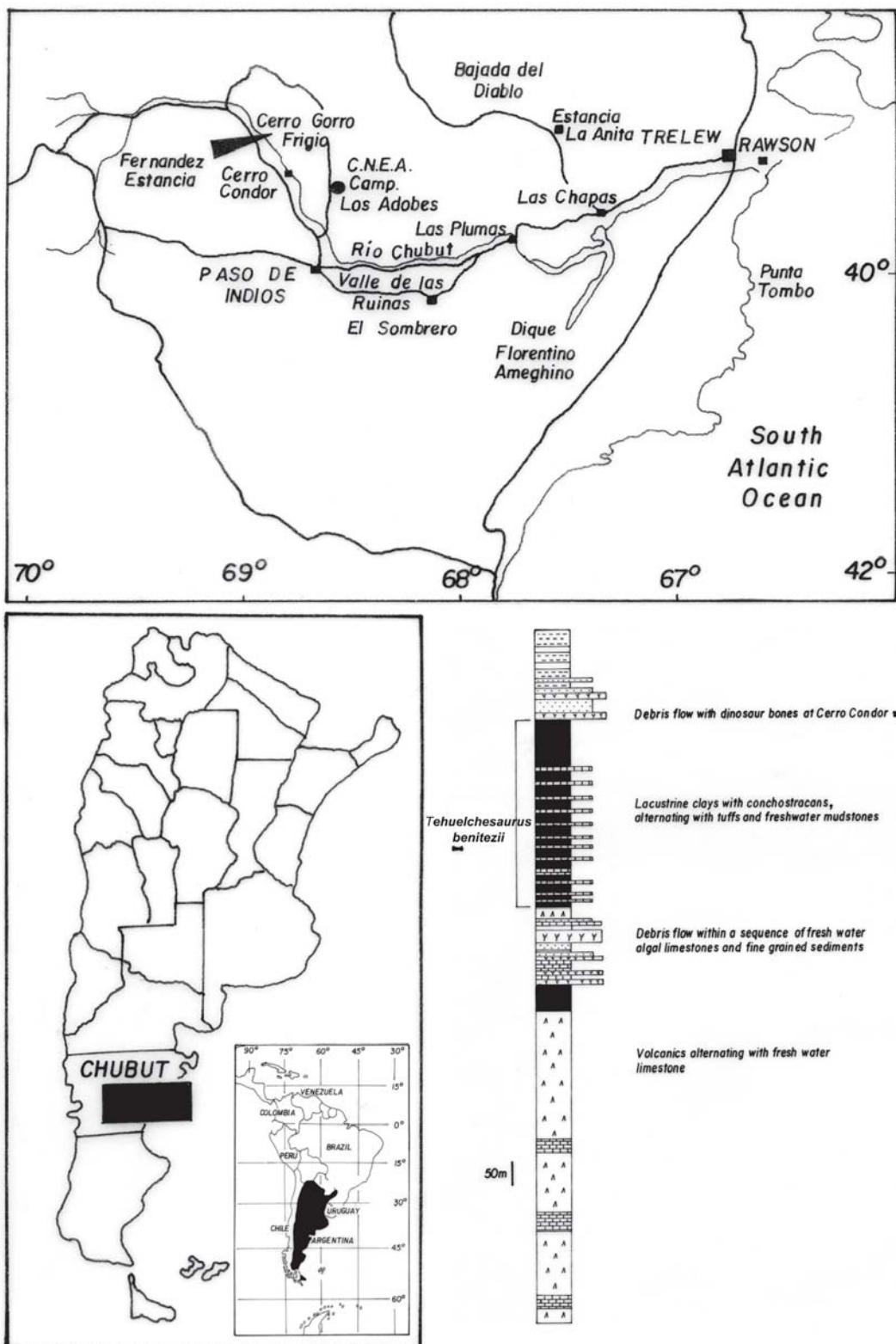


Fig. 1. Geographic location and stratigraphic section through the Cañadón Calcáreo Formation, showing the location of *Tehuelchesaurus benitezii* at Estancia Fernandez, Chubut, Argentina. To Rich *et al.* (1999).



Fig. 2. Skin impressions of *Tehuelchesaurus benitezii*. Skin patch Type I, showing a large tuberculated scales MEF-PV 1125/1. Scale bar: 1 cm.



Fig. 3. Detail of rosette structure of skin patch (Type I) MEF-PV 1125/1. Scale bar: 1 cm.

Stratigraphy. Traditionally, all the Middle–Upper Jurassic sediments of the Cañadón Asfalto basins have been grouped together in the Cañadón Asfalto Formation, although two different sequences have been recognized (Figari & Courtade, 1993; Page *et al.*, 1999). Whereas the lower sequence (Cañadón Asfalto *sensu stricto*) is mainly composed of lacustrine shales, limestone and marls, with rare intercalations of conglomerates and sandstones, the upper one starts with lacustrine shales, but is later dominated by fluvial and overbank deposits. Furthermore, both sequences also differ significantly in their tectonic structure and age. Thus, it might be justified to distinguish an Upper Jurassic (Kimmeridgian–Tithonian) Cañadón Calcáreo Formation from the Middle Jurassic (Callovian) Cañadón Asfalto Formation, as proposed by Proserpio (1987). Although *Tehuelchesaurus* (Rich *et al.*, 1999), was originally attributed to the Cañadón Asfalto Formation (Middle – Upper Jurassic), at present, its stratigraphical occurrence has been proposed for the overlying Cañadón Calcáreo Formation (Rauhut, 2003).

The rocks containing bones and skin impressions of *Tehuelchesaurus benitezii* (Fig. 1) are

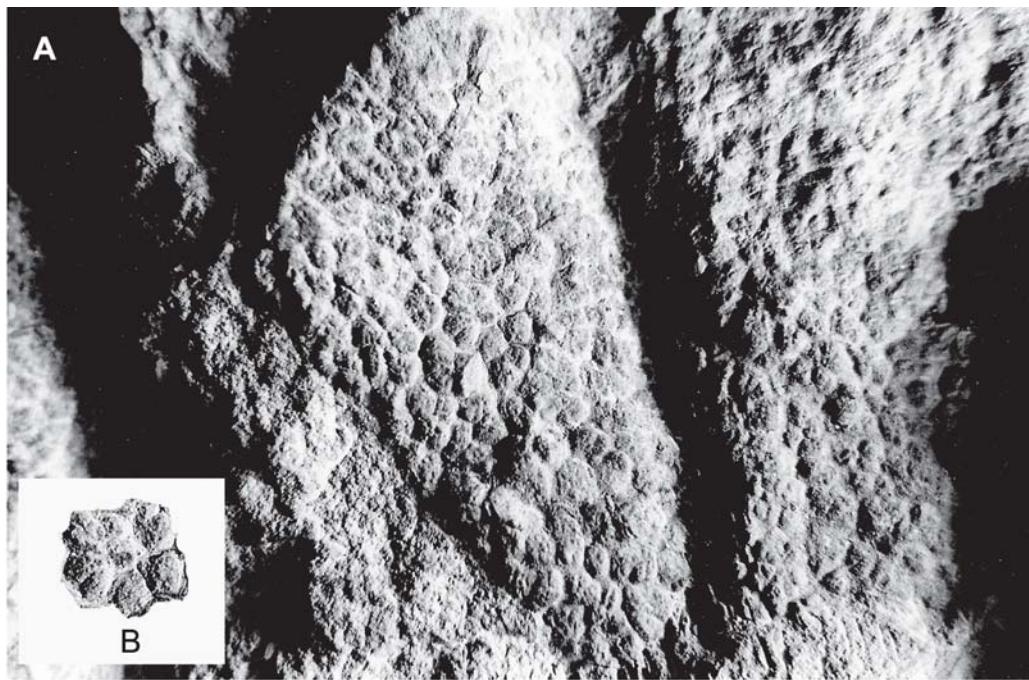


Fig. 4. Skin impressions of *Tehuelchesaurus benitezii*. A. Skin patch (Type II) MEF-PV 1125/3. B. Small tuberculated scales. Scale bar: 1 cm.

fine, light green tuffs. Conchostracean and plant impressions are present in the bone-bearing unit. The well-preserved plant remains suggest a nearly autochthonous taphocoenosis (Rich *et al.*, 1999).

DESCRIPTION OF THE EPIDERMAL IMPRESSIONS

In the epidermal impressions of *Tehuelchesaurus benitezii* no evidence of the existence of bony plates, thus indicating that these sauropods were no armoured. The term tubercle must be interpreted as non-overlapping scales adopting the terminology proposed by Gavrilov (1958).

In all parts of the body where the epidermal impressions are preserved, the skin consists of tuberculate non-overlapping scales radiating in a rosette pattern. The size of individual tubercles is determined by the size of the scales. A basic ground plan consists of the smaller scales were found on the underside of the animal. Larger tubercles scales were found on the animal's outer surface.

The available fragments of skin impressions of *Tehuelchesaurus* correspond to different parts of the body. One of the fragments (natural cast of the integument and its counterpart) from the

thoracic region is associated with a rib fragment MPEF-PV 1125/3 (Fig. 4) and another fragments were found in association to the left humerus MEF-PV 1125/4. The largest specimen collected MPEF-PV 1125/1 (see Fig. 2) measures 25 cm by 40 cm and was associated to the left scapular blade, which suffered a *post mortem* displacement. Two other fragments were found in association with dorsal vertebrae MEF-PV 1125/5/6. An isolated patch of integument, not associated to any specific part of the body, is preserved as a positive print and its negative counterpart MPEF-PV 1125/2. The morphology of the integument shows polygonal tubercled scales. Although dermal spines have been reported for diplodocids sauropods (Czerkas 1992, 1994, 1997), our specimen shows no evidence of these structures.

Types of skin patterns. *Type I.* The largest available skin impression MEF-PV 1125/1, associated to a scapular blade, reveals that the skin was arranged in rosette patterns formed with almost smooth, hexagonal in outline, large tubercle scales (2,5 cm by 3 cm) alternating with smaller tubercles (2 cm by 1,5 cm), (Fig 2). A rosette pattern of scales is present in MEF-PV 1125/1-6 1125/1-6 (Fig. 3). The hexagonal central scale is surrounded by six scales. Five of them has

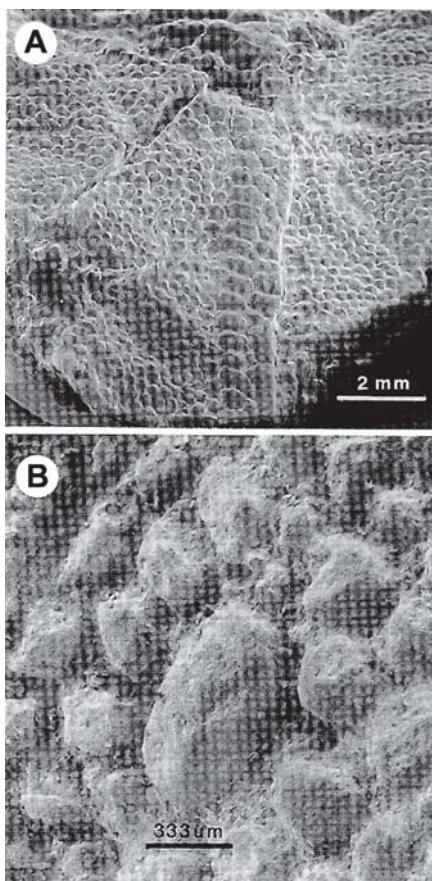


Fig. 5. Natural cast of the integument of the sauropod embryos from Auca Mahuevo. A. Large patch (PVH-126). B. Detail of rosette structure of PVPH-130. (Adopted from Chiappe *et al.*, 1998).

nearly the same diameter of the central one, and the other displays the central scale's diameter.

Type II. Very small tubercles, varying from 1 to 3 mm in diameter and 2 to 4 mm long, being romboidal in outline, not imbricated, showing a rosette-like pattern (Fig.4). One fragment of minute tubercles corresponds to the thoracic region MEF-PV 1125/3, and two fragments to the arm MEF-PV 1125/4.

Comparisons. The natural cast of *Tehuelchesaurus* were confronted to those of other sauropods, including the forelimb of the *Pelorosaurus* (Mantell, 1852), from the neck, and the belly region at diplodocid sauropods (Czerkas, 1992, 1994); as well with the skin of embryos of Titanosauria (Chiappe *et al.*, 1998) MCF-PVPH-126. In the case of materials housed abroad, the bibliographical information has been the main data source.

In general, the skin of *Tehuelchesaurus* is similar to other non-avian dinosaurs, showing non-overlapping scales, polygonal in outline (hexagonal), arranged in a rosette pattern (Giménez, 2000) and no armored. Nevertheless, the *Tehuelchesaurus* skin is more similar to *Pelorosaurus* and diplodocid sauropods than to the embryos of Auca Mahuevo, in which each rosette is formed by a hexagonal central scale surrounded by other six. Besides in the three taxons the external surface of each of the scales (Type I) presents delicate smooth bumps, which were interpreted as delicate eculturations which are the result of the contact between dermis and epidermis (Hooley 1917; Czerkas, 1992, 1994, 1996). The tegimentary impressions of *Tehuelchesaurus* are different from those of the embryos from the Auca Mahuevo MCF-PVPH-126, the circular, central scale is surrounded by 10 smaller scales that have roughly one-half the central scale's diameter (Fig. 5 a, b). The scales are not polygonal, but rather circular and disposed adopting the shape of a daisy similar distribution of the osteoderms associated to the Titanosauria skeleton (Chiappe *et al.*, 1998), including *Saltasaurus loricatus* (see Bonaparte & Powell, 1980).

The tegimentary uniform morphology presented in the bigger skin fragments belonging to the embryos (Fig. 5a) constitutes another difference with the *Tehuelchesaurus* and *Pelorosaurus* in which type I and type II scales are recognized. Another difference is the presence of rectangular scales presented in three rows which belong to the dorsal region.

Some modern reptiles, such as chameleons and gekonids, have a tubercular integument morphology. *Heloderma suspectum*, the Gila Monster, presents tubercles over the head that are larger compared to the body size of the animal.

CONCLUSIONS

The interpretation of the tegimentary samples of *Tehuelchesaurus*, *Pelorosaurus*, diplodocids and embryos titanosaurs allows us to support a reptilian nature of the skin displaying tubercles scales, non-overlapping and a rosette pattern which differs in size according to the distinct parts of the body. The larger scales are from the dorsal region of the body and the smaller ones were found on the underside region.

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