

Invertebrate trace fossils from Triassic continental successions of San Juan Province, Argentina

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Abstract. This paper is the first report on invertebrate trace fossil assemblages from Marayes-El Carrizal and Ischigualasto-Villa Unión Basins (Triassic), San Juan Province, northwestern Argentina. The four analyzed lithostratigraphic units consist of three different fluvial systems (Carrizal, Ischigualasto, and Los Colorados Formations) and a lacustrine delta (Los Rastros Formation). The ichnofossil content of the Late Triassic Carrizal Formation (fluvial channels and shallow floodplain lakes) includes *Taenidium barretti* (Bradshaw), and *Skolithos* isp. The Los Rastros Formation (Middle Triassic) yielded a subaqueous ichnoassemblage that consist of *Helminthopsis* cf. *H. abeli* Ksiazkiewicz, *Skolithos* cf. *S. verticalis* (Hall), and *Palaeophycus* isp. Floodplain facies of the Ischigualasto Formation (Late Triassic) contain *Taenidium*, *Skolithos* and laterally spreading root systems. Most trace fossils of the Los Colorados Formation (Late Triassic) come from sandy sheetflood facies -with two interbedded paleosols- and consist of *Palaeophycus tubularis* Hall, cf. *Skolithos* isp. *Taenidium barretti*, and *Cochlichmus* isp. All alluvial successions contain *Taenidium* and *Skolithos*, and lack evidence for a fully terrestrial ichnofauna in spite of the presence of abundant paleosols.

Key words. Argentina. San Juan. Triassic. Continental. Invertebrate ichnofossils. *Taenidium*. *Skolithos*.

Introduction

Invertebrate trace fossils from Triassic continental sequences of Argentina are poorly known. Vertebrate ichnofossils (mainly footprints) have received more attention since the first description of large quadrupedal footprints from the Los Rastros Formation earlier in the previous century. Many recent studies mention the occurrence of "bioturbation" and/or "root traces" in different basins but no detailed account was given (see review by Melchor *et al.*, in press). One exception is a preliminary report (Melchor, 1998) on invertebrate and vertebrate ichnocoenoses from the Ischichuca Formation (Middle to Late Triassic of Ischigualasto-Villa Unión Basin) at its type locality (Quebrada Ischichuca Chica, La Rioja Province).

This paper reports on the results of a detailed survey of invertebrate trace fossils at selected localities from Marayes-El Carrizal Basin (Carrizal Formation) and Ischigualasto-Villa Unión Basin (Los Rastros,

Ischigualasto, and Los Colorados Formations at Ischigualasto Provincial Park) of San Juan Province (figure 1).

Carrizal Formation (Late Triassic)

A low diversity ichnofossil assemblage was found in the middle section of the Carrizal Formation (Late Triassic), at Marayes river, near Marayes town. Fine-grained carbonaceous sandstone, gravelly sandstone alternating with dark mudstones and thin coal seams are the most common sedimentary facies of this formation (Bossi, 1976). The local paleoenvironment is interpreted as an intermediate to high sinuosity river system with significant development of lacustrine and swamp facies. Recorded ichnofossils include *Taenidium barretti* (Bradshaw), *Skolithos* isp. and cf. *Palaeophycus* isp., which occur at different stratigraphic horizons, usually associated with channel fill facies. Specimens of *Taenidium barretti* are unlined, straight to slightly curved, subhorizontal, sharp walled, 0.2-0.6 cm wide meniscate burrows preserved as *endichnia* and convex *epichnia* (maximum length is 8 cm) (figure 2.A). Arcuate, well-defined menisci are composed of sediment similar to the host although successive packets are slightly different in grain size. Burrows often intersect; two specimens can be traced laterally into a highly inclined burrow. *Taenidium barretti* appears

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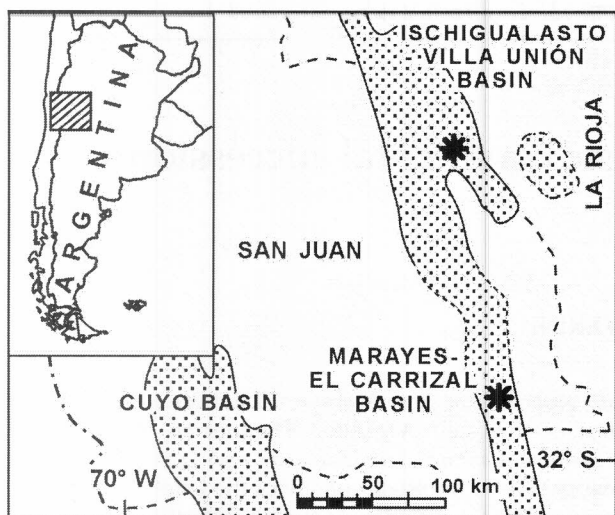


Figure 1. Location map showing Triassic basins of central north-west Argentina (shaded areas) and visited localities (asterisks). Modified from López Gamundí *et al.* (1994).

frequently in fine-grained micaceous sandstone beds with parallel or ripple cross-lamination usually associated with *Skolithos* isp. The material assigned to *Skolithos* includes chiefly vertical, unlined, straight to curved burrows with massive fill (coarser than host rock) and elliptical to circular cross-section. Burrow diameters are slightly larger than those of co-occurring *Taenidium* (0.3-1.4 cm), maximum recorded length 4 cm. Highly bioturbated beds were also recognized in the same section.

Los Rastros Formation (Middle Triassic)

This is a lacustrine unit that records repeated progradation of deltaic sandstone bodies into an open lake (*e.g.*, Milana and Alcober, 1994). Martínez (1994) pointed out the presence of bioturbation in beds of this formation at La Chilca river locality. The few ichnofossils identified during this study occur both on the heterolithic interval and on top of wave rippled sandstone beds of intermediate thickness (< 1 m). Three morphologies were distinguished: (1) *Helminthopsis* cf. *H. abeli* Książkiewicz. Burrows about 0.5 cm in diameter, irregularly winding and meandering with massive fill, preserved as convex *epichnia* on top of wave rippled siltstone and sandstone beds. (2) *Skolithos* cf. *S. verticalis* (Hall). Subvertical to inclined, 0.4-0.6 cm wide, 3-4 cm long, cylindrical burrows with massive sandstone fill in thin-bedded siltstone and mudstone beds showing parallel, wavy, and flaser bedding. (3) *Palaeophycus* isp. Subhorizontal, slightly curved, 1 cm in diameter, subcylindrical, thinly-lined burrows preserved as *endichnia* with massive fill similar to the host sandstone. *Helminthopsis* and subhorizontal burrows appear in mouth bar facies, and *Skolithos* is rare in heterolithic delta front facies.

Ischigualasto Formation (Late Triassic)

This formation is of fluvial origin with thick successions of floodplain fine-grained sediments punctuated by numerous paleosols and channel sandstones. At the surveyed localities ("Cancha de Bochas" and "Valle Pintado") there is a dominance of tuffaceous siltstones and fine-grained sandstones with interbedded paleosols, thick channel sandstone bodies, and thin (less than 0.5 m thick) crevasse-splay deposits (Martínez, 1994). Previous workers (Martínez, 1994; Milana and Alcober, 1994) recognized the presence of "root traces", burrows and/or bioturbation at many horizons, as well as probable borings in fossil bone.

Paleosols commonly exhibit vertic features (*e.g.* mukkara structure and deep homogeneous profiles) and slender, shallow penetrating root traces (however, they are not abundant at any horizon). A drab-colored massive paleosol with tabular root systems, abundant rhynchosaur remains and coprolites (V. Contreras, personal communication) were also recognized.

A *Taenidium-Skolithos* association was distinguished in crevasse-splay/massive floodplain deposits. Thin (<0.5 m thick) ripple cross-laminated, brownish gray, fine-grained sandstone beds intercalated in massive siltstones and sandstones contain subhorizontal to highly inclined meniscate burrows. They are 0.5-1 cm wide, up to 7 cm long, subhorizontal to inclined, unlined burrows, with arcuate menisci similar to host rock (marked by minor grain size contrast), here assigned to *Taenidium barretti*. Scarce subvertical *Skolithos* burrows with massive fill seems to be restricted to interbedded green to red siltstones and sandstones lacking pedogenic features (figures 2.B-C). However, a couple of featureless burrows were recorded from a paleosol.

Los Colorados Formation (Late Triassic)

This is a red bed sequence interpreted as the product of an ephemeral fluvial system. Sandy sheetflood deposits with interbedded highly bioturbated heterolithic intervals prevail in the lower part of the unit (Milana and Alcober, 1994). Our study was conducted at the base of the impressive cliffs called "Barrancas Coloradas" near Salado river, focusing on a 30 m thick section located about 100 m above the transition with the underlying Ischigualasto Formation. At the study area, red laminated siltstones and mudstones interbedded with thin (<0.10 m) fine-grained sandstone beds and centimeter thick gypsum laminae are capped by a ~10 m thick multi-storey (?) channel belt (~500 m wide) filled with massive and parallel bedded meter-scale fine-grained

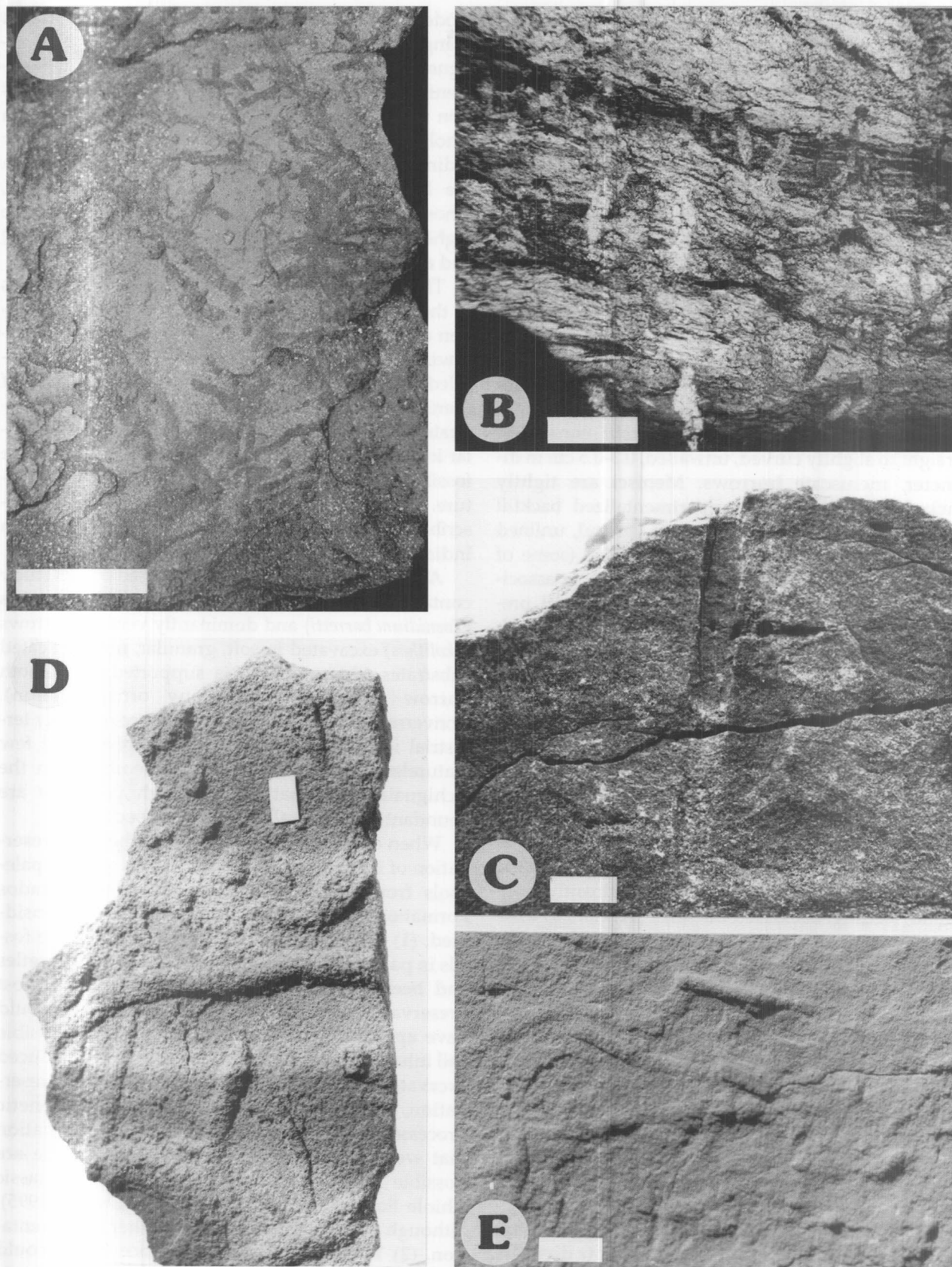


Figure 2. Representative ichnotaxa from the analyzed triassic successions. A, *Taenidium barretti* (Bradshaw) from the Carrizal Formation. B, *Skolithos* isp. in cross-laminated siltstone facies. C, *Skolithos* isp. from crevasse-splay sandstones. B and C are from the Ischigualasto Formation. D, *Palaeophycus tubularis* Hall and probable *Skolithos* isp. E, small *Taenidium barretti* (Bradshaw) in flood-plain sandstone facies. D and E from the Los Colorados Formation. Scale bar = 1 cm.

sandstone bodies. There are two paleosols (one of them with vertic features) in the mentioned fine heterolithic interval; which is interpreted as deposited in a floodplain setting with temporary ponds. Contreras and Bracco (1998) described poorly preserved tetrapod footprints from one sandstone block of the channel facies at this locality.

Invertebrate ichnofossils are preserved in parallel laminated, fine-grained, micaceous sandstone and siltstone beds of the overbank interval. The most common ichnotaxa are *Palaeophycus tubularis* Hall and cf. *Skolithos* isp., although *Taenidium barretti* and *Cochlichnus* isp. also occur. Specimens of *Palaeophycus tubularis* are straight, smooth, thinly lined, horizontal burrows with massive fill (0.2 cm-1.0 cm in diameter; up to 20 cm long) and elliptical cross section (figure 2.D). Bifurcations are absent or rare, occasional cross-cuttings can occur. *Taenidium barretti* consist of straight to slightly curved, unwalled, 0.3-0.5 cm in diameter, meniscate burrows. Menisci are tightly packed forming a non-compartmentalized backfill (figure 2.E). Tentatively, we assign vertical, unlined burrows with structureless fill to *Skolithos* (some of them are aligned, see figure 2.D), which occur associated with *Taenidium*. A single sinusoidal trail preserved as concave epichnia (furrow) along with *Palaeophycus* and *Taenidium* is identified as *Cochlichnus* isp. The degree of bioturbation could be moderate although it is usually low.

Concluding remarks

Invertebrate trace fossils are not abundant in the analyzed Triassic successions, which include a lacustrine delta and different types of fluvial systems. The invertebrate ichnofauna in channel-fill facies of the Carrizal Formation comprises predominantly horizontal, feeding, backfilled burrows (*Taenidium*) associated with vertical semi-permanent domiciles (*Skolithos*). There is no indication of emergence in the analyzed interval although a subaqueous origin for these traces is unlikely. The presence of a low-diversity association including *Taenidium*, *Skolithos* and highly bioturbated beds has been recognized as characteristic of fluvial channel facies (see review in Buatois and Mángano, 1996). *Taenidium* and *Skolithos* associated with other ichnotaxa were also recognized in other continental settings, including shallow-lacustrine wave-influenced deposits (e.g., Poiré and Larriestra, 1993).

The lacustrine delta assemblage of the Los Rastros Formation reflects a fully subaqueous, low diversity, mostly surface grazing ichnofauna attributed to deposit feeder, non-specialized organisms that exploited the substrate temporarily available in relatively shallow water. These features agree with existing

models for this kind of environments (cf. Buatois and Mángano, 1996). On the other hand, *Skolithos* is assigned to a deeper water (as suggested by the sedimentary facies), resident, and presumably suspension feeder ichnofauna. Melchor (1998) described an ethologically comparable ichnofauna from similar sedimentary facies of the same basin (though from the Ischichuca Formation at La Rioja Province), whose main differences with this assemblage are higher ichnodiversity (seven recorded ichnogenera) and absence of vertical dwelling burrows.

The ichnocoenosis from crevasse-splay deposits of the Ischigualasto Formation reflects the colonization of a wet/moist substrate by deposit-feeder, burrowing organisms that constructed meniscate back-filled structures and the (subsequent?) excavation of dominantly vertical domiciles in a slightly drier substrate. The Los Colorados Formation contains a similar ichnoassemblage. Many examples of similar trace fossil assemblages have been reported in the literature. In particular, Sarkar and Chaudhuri (1992) described a comparable association of the same age in India.

All the alluvial successions analyzed in this study contain unlined, meniscate backfilled burrows (*Taenidium barretti*) and dominantly vertical burrows (*Skolithos*) excavated in soft, granular, not desiccated substrates (this assertion is supported by smooth burrow surfaces, lacking any ornamentation). Conversely, there is almost no evidence of a fully terrestrial ichnofauna (except for the presence of few featureless *Skolithos* burrows in paleosols from the Ischigualasto Formation), although paleosols are abundant and generally well developed.

When evaluating the reasons for the low preservation of ichnofossils in the numerous stacked paleosols from the Ischigualasto and Los Colorados Formations at least two factors should be considered. (1) The most common producers of trace fossils in paleosols, such as ants, termites, dung-beetles and bees, whose constructed nests are the most preservable ones (Genise and Bown, 1994) would have appeared later in the Mesozoic Era. Possible soil inhabitants of the Triassic would have produced excavated structures having low potential of preservation, especially in the absence of diagenetic processes such as ferricretization and silcretization that would enhance their preservation. There are possible records of insect nests from the Triassic Chinle Formation (i.e., Hasiotis and Dubiel, 1995), although these findings require further documentation. (2) Taphonomic overprint: trace fossils could result blurred or destroyed by intense pedogenic homogenization in the soil profile; particularly in vertisols, which are common in the studied successions.

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