**Tetrapod footprint ichnofauna of the Upper Triassic Redonda Formation, Chinle Group, Quay County, New Mexico**

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TETRAPOD FOOTPRINT ICHNOFAUNA OF THE UPPER TRIASSIC REDONDA FORMATION, CHINLE GROUP, QUAY COUNTY, NEW MEXICO

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Abstract.—The tetrapod footprint ichnofauna from the Upper Triassic Redonda Formation in Quay County, east-central New Mexico, consists of four ichnogenera—Rhynchosauroides (rhynchocephalian), Brachychirotherium (aetosaur), Grallator (theropod) and Pseudotetrasauropus (prosauropod). A unique feature of the Redonda tetrapod ichnofauna is the absence of the sauropod track Tetrasauropus and the dominance of the prosauropod track Pseudotetrasauropus, which may indicate a local, mutual ecological separation of prosauropods and sauropods. This dominance of prosauropod tracks in the Redonda Formation is not mirrored by its body fossil record, which lacks sauropods and is dominated by semiaquatic taxa. The Redonda tetrapod ichnofauna resembles other Chinle Group tetrapod ichnofauna of the Apachean Rock Point sequence and well represents a global Late Triassic ichnofauna characterized by Rhynchosauroides, Brachychirotherium, Grallator, Pseudotetrasauropus and Tetrasauropus.

INTRODUCTION

In 1934, Robert Abercrombie discovered tetrapod footprints in Upper Triassic strata at Mesa Redonda, Quay County, New Mexico (Fig. 1). Gregory (1972) first mentioned this discovery, which was in strata now termed Redonda Formation of the Chinle Group. Gregory (1972) also noted similar track occurrences in the Redonda Formation at Apache Canyon, Quay County (Fig. 1). Collecting during the 1980s and 1990s revealed both localities in Quay County to be rich sources of tetrapod footprints (Hunt et al., 1989, 1993, 2000; Lockley and Hunt, 1995; Cotton et al., 1996, 1997, 1998; Lockley et al., 2000). Here, we review the tetrapod ichnofauna of the Redonda Formation and discuss its significance. MDM = Mesalands Dinosaur Museum, Tucumcari; NMMNH = New Mexico Museum of Natural History, Albuquerque; UM = University of Michigan, Ann Arbor.

GEOLOGICAL CONTEXT

Redonda tetrapod tracks come from two collecting areas, Mesa Redonda and Apache Canyon in Quay County (Fig. 1). At Mesa Redonda, tracks are found around the entire perimeter of the mesa, though most collections come from limestones and siltstones stratigraphically high in the Redonda Formation in sec. 27, T9N, R31E (Fig. 1). The Apache Canyon localities are also stratigraphically high in the Redonda Formation, occurring in the sandstone interval Gregory (1972) referred to as the “Redonda ledge” (Fig. 1). The localities are widely distributed along the Llano Estacado edge, and include sites in sec. 9, T8N, R33E (NMMNH localities 445, 446) and in sec. 28, T9N, R33E (NMMNH locality 1471). Redonda Formation deposition took place in and around a large lake (Hester, 1988), and the tetrapod tracks occur in lake-margin facies (Hester, 1988).

TETRAPOD ICHNOTAXA

Redonda tetrapod footprints represent only four ichnogenera (Fig. 2). Here, we briefly review these ichnogenera and the Redonda specimens.
Most *Rhynchosauroides* tracks from the Redonda Formation are relatively small (pes up to 2 cm long) tracks of a quadruped in which the pentadactyl manus is much smaller than the pentadactyl pes. Both manus and pes are longer than wide, and have long, thin digits that taper to clawed tips. The digits are straight or slightly curved, and length increases from digit I to digit IV, with digit V being as small or smaller than digit I. The animal usually walked in a digitigrade posture as heel (palm) impressions are rare. A large number of ichnospecies of *Rhynchosauroides* have been proposed (Baird, 1964; Haubold, 1971, p. 46), but we make no attempt to assign the Redonda specimens to an ichnospecies. *Rhynchosauroides* tracks are well represented in the Redonda Formation, especially at Apache Canyon, and most are extramorphological variants that preserve four or fewer digits (Fig. 2A). Others, however, are much larger (pes length ~5 cm) that have distinct heel impressions (Fig. 3A-B). Probably, the Redonda *Rhynchosauroides* specimens encompass two distinct ichnospecies. *Rhynchosauroides* tracks are generally lizard-like and best match the foot structure of Triassic rynchocephalians (Baird, 1964), which are also well known from body fossils (especially sphenodont teeth) in the Chinle Group.

**Brachychirotherium**

*Brachychirotherium* tracks from the Redonda Formation are relatively large tracks (pes ~18 cm long) of a quadruped with a pentadactyl pes much larger than the pentadactyl manus. The digits are thick, with rounded tips, and the “heel” of the pes is broad and rounded. Actually, this “heel” impression is that of a metatarsal pad, so that there are four digits anterior to it, and occasionally digit V is impressed posteriorly. A large number of ichnospecies of *Brachychirotherium* have been named (Haubold, 1971, p. 56-57), but we make no attempt to assign an ichnospecific name to the Redonda specimens. These specimens (Fig. 3C-E) well preserve the thick digits I-IV of the pes, and some specimens (Fig. 3D-E) show a poorly differentiated manus impression immediately anterior to the pes. *Brachychirotherium* tracks are those of a crurotarsan archosaur, and those from the Chinle Group are most reasonably assigned to an aetosaur (Lockley and Hunt, 1995). Aetosaurs are among the most common body fossils of tetrapods from the Chinle Group.

**Grallator**

*Grallator* is the name we apply to tridactyl tracks of small theropod dinosaurs found in the Redonda Formation (Fig. 4D-E). These relatively small tracks (pes length ~8-12 cm) have a very long middle toe and long, thin digits with clawed tips, and distinct, well-differentiated digital pads in most examples. Lockley
et al. (2000) and Hunt et al. (2000) recently reviewed Grallator records from the Redonda Formation, noting that some specimens earlier assigned to this ichnogenus by Hunt and Lucas (1989), Hunt et al. (1989) and Lucas (1993) are actually tridactyl extramorphological variants of Pseudotetrasauropus (Fig. 2D, Fig. 4C) Thus, contrary to earlier statements (e.g., Hunt et al., 1989), tracks of Grallator are not the most common tracks in the Redonda Formation; instead, tracks of Pseudotetrasauropus are most abundant.

**PSEUDOTETRASAUROPOUS**

Relatively large tracks (pes length ~ 12-16 cm) of a biped from the Redonda Formation are assigned by us to Pseudotetrasauropus (Fig. 4A-C). These tracks are tetradactyl, with widely diverging, long slender digits that usually taper to sharp, pointed claws. On one Redonda specimen there is an unusual extramorphological variant — a bifurcation of a digit tip (Fig. 4A), which may simply represent the penetration and extraction phases of the claw (cf. Peabody, 1959). Cotton et al. (1997, 1998) mapped an area at Apache Canyon of ~ 10 m² that shows evidence of preferred orientation of seven Pseudotetrasauropus trackways, probable evidence of gregarious behavior.

*Pseudotetrasauropus* is the most common track known from the Redonda Formation (Lockley et al., 2000). It resembles somewhat larger prosauropod tracks termed Otozoum (Gand et al., 2000), and well matches the foot structure of a prosauropod dinosaur (Lockley and Hunt, 1995).

**DISCUSSION**

The significance of the Redonda Formation tetrapod ichnofauna is threefold:

1. A unique feature of the Redonda tetrapod ichnofauna is the absence of the sauropod track Tetrasauropus, which is the dominant track at Peacock Canyon in the Upper Triassic Sloan Canyon Formation of northeastern New Mexico and in the Upper Triassic Sheep Pen Sandstone at Furnish Canyon in southeastern Colorado (Lockley et al., this guidebook). This may indicate some sort of mutual ecological separation between prosauropods and sauropods in the Redonda depositional basin, though the two ichnogenera do co-occur elsewhere.

2. The dominance of prosauropod tracks in the Redonda Formation is not mirrored by its body fossil record, which lacks prosauropods and is dominated by semiaquatic phytosaurs and metoposaurus.

3. The Redonda tetrapod ichnofauna resembles other Chinle Group tetrapod ichnofaunas of the Apachean Rock Point sequence. These ichnofaunas are characterized by Rhynchosauroides, Brachychirotherium, Grallator and Pseudotetrasauropus or Tetrasauropus (e.g., Lockley and Hunt, 1995). Indeed, the Redonda tetrapod ichnofauna well represents a global Late Triassic ichnofauna characterized by Rhynchosauroides, Brachychirotherium, Grallator, Pseudotetrasauropus and Tetrasauropus. Such ichnofaunas are known from the lower Stormberg Group of southern Africa (Ellenberger, 1970; Olsen and Galton, 1984; Raath et al., 1990; Raath, 1996), the upper Keuper and equivalent strata in western Europe (e.g., Haubold, 1971, 1984; Lockley and Meyer, 2000; Gand et al., 2000) and the Upper Triassic portion of the Newark Supergroup in eastern North America (e.g., Silvestri and Szajna, 1993; Olsen et al., 1998) as well as the Chinle Group in the American Southwest.

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**REFERENCES**

