Heckert, A.B., and Lucas, S.G., eds., 2002, Upper Triassic Stratigraphy and Paleontology. New Mexico Museum of Natural History and Science Bulletin No. 21.

THE OLDEST NORTH AMERICAN PROSAUROPOD, FROM THE UPPER TRIASSIC TECOVAS FORMATION OF THE CHINLE GROUP (ADAMANIAN: LATEST CARNIAN), WEST TEXAS

SUSAN K. HARRIS, ANDREW B. HECKERT, SPENCER G. LUCAS and ADRIAN P. HUNT

New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, 87104-1375

Abstract—An isolated tooth from the Tecovas Formation of the Chinle Group, Crosby County, West Texas, represents the oldest definitive record of a prosauropod dinosaur from North America. Its age is Adamanian (latest Carnian, approximately 225 Ma) based on vertebrate biostratigraphy, palynostratigraphy and other data. It is clearly distinguished from isolated ornithischian teeth by a combination of prosauropod dental synapomorphies. The addition of this tooth to other recent discoveries of late Carnian prosauropod material from Brazil and Madagascar, as well as the Moroccan *Azendohsaurus*, indicates a Pangea-wide distribution for prosauropods near their oldest occurrences.
Keywords: Carnian, prosauropod, Tecovas Formation, tooth

INTRODUCTION

The Prosauropoda are poorly represented in the Upper Triassic of North America. Among the oldest known prosauropod body fossil specimens from the continent is a single dorsal centrum from the Revueltian (early-middle Norian) Bull Canyon Formation of New Mexico (Hunt et al., 1998) and part of the holotype of the putative ornithischian *Technosaurus smalli* Chatterjee, 1984 (Sereno, 1991). All other Triassic prosauropod records in North America are restricted to tracks. These include tracks assigned to the ichnotaxon *Agrestipus hottoni* from the Rhaetian Balls Bluff Siltstone (Newark Supergroup) of Virginia (Weishampel and Young, 1996), many other occurrences of *Tetrasauropus* and *Pseudotetrasauropus* from the Newark Supergroup (Olsen, 1988), and numerous tracks in the uppermost Chinle Group in Oklahoma, New Mexico, and Utah, also assigned to *Tetrasauropus* and *Pseudotetrasauropus* (Lockley and Hunt, 1995; Lockley et al., 2000). Hunt (1988) claimed the oldest prosauropod dinosaur from the Upper Triassic of North America was based on teeth from the Bull Canyon Formation of the Chinle Group in New Mexico. However, Hunt (1989) later reassigned these teeth to the ornithischian dinosaur *Revueltosaurus*.

Recently, we recovered a single prosauropod tooth from a microvertebrate locality in the lower part of the Tecovas Formation of the Chinle Group near Kalgary in Crosby County, Texas. This tooth represents the only body fossil evidence for pre-Norian prosauropods in North America. Here, we establish the Adamanian (latest Carnian) age of this tooth, describe and compare it to that of other basal prosauropods, and discuss briefly early prosauropod distribution and evolution. In this paper, NMMNH refers to the New Mexico Museum of Natural History and Science, Albuquerque.

STRATIGRAPHY AND AGE

The prosauropod tooth described here, NMMNH P-26400, was collected near Kalgary, Crosby County, Texas at NMMNH locality 1430, UTM 3701500 N, 298850 E, zone 14, NAD 27 (Lucas and Luo, 1993) (Fig. 1). We screenwashed more than three metric tons of sediment from the lower part of the Tecovas Formation of the Chinle Group at this locality and recovered only one prosauropod tooth. However, an extensive assemblage of microvertebrates collected from this locality includes many isolated ornithischian teeth, as well as the holotype of *Adelobasileus cromptoni*, the oldest known mammal (Lucas and Luo, 1993).

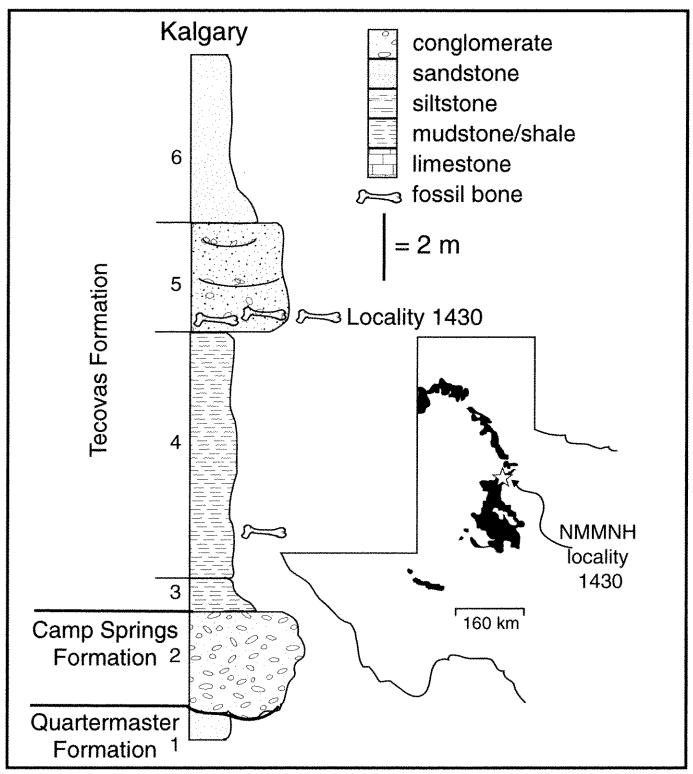

FIGURE 1. Index map and stratigraphic section showing the prosauropod locality.

The fossiliferous deposit is approximately 14 m above the base of the Chinle Group in the Tecovas Formation (Fig. 1). The dominant lithology at NMMNH locality L-1430 is a dark reddish-brown, clay- and siltstone-pebble conglomerate overlain by a very fine-grained, light greenish-gray to pale yellowish-brown micaceous sublitharenite. Clearly, these are channel- to point-bar deposits.

Tetrapod fossils from the Tecovas Formation near Kalgary establish an Adamanian (latest Carnian) age for the upper part of the unit. Specifically, the co-occurrence of the phytosaur *Rutiodon* and the aetosaur *Stagonolepis*, both index taxa of the Adamanian land-vertebrate faunachron, indicate an Adamanian age for the upper part of the Tecovas Formation in West Texas (Lucas and Hunt, 1993; Lucas, 1998).

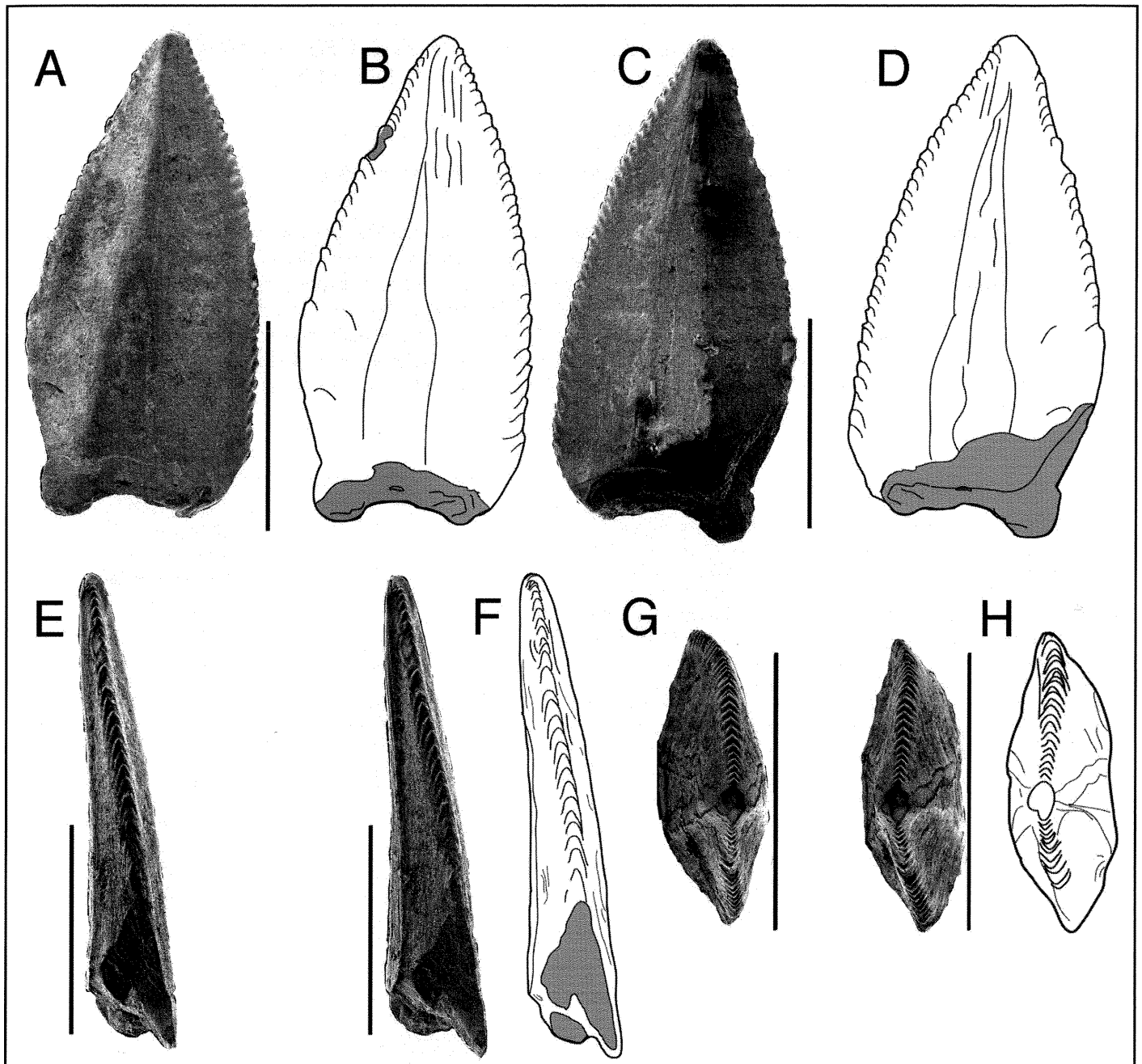

FIGURE 2. NMMNH P-26400, tooth of Prosauropoda indet., photographs and interpretative sketches. **A-B**, Labial view; **C-D**, Lingual view; **E**, Stereopair of posterior view; **F**, Sketch of E; **G**, Stereopair of occlusal view; **H**, Sketch of G. Scale bar = 2 mm.

DESCRIPTION

NMMNH P-26400 is a laterally compressed and spatulate tooth (Fig. 2). It is 6 mm tall, with a basal labio-lingual crown width of 1 mm. Mesiodistally, the labial surface of the crown is slightly more convex than the lingual surface (Fig. 2E-J). In lingual or labial view, the tooth is symmetrical, with the maximum width of the crown (3 mm) apical to the crown-root junction (Fig. 2A-D). The crown base has an antero-posterior length of 3 mm and shows slight constriction. The apex of the crown is straight and slightly tapered.

The conical denticles of NMMNH P-26400 are apically inclined approximately 45° to the crown edges. As many as 33 denticles extend along the entire length of the anterior edge of the crown, but denticulation is not preserved along the lower third of the posterior crown margin. Apically, the size of the denticles decreases gradually. Near the base there are approximately 8 denticles per mm. Higher on the crown this number increases, approaching 10 denticles per mm. On both the lingual and labial surfaces, a median ridge gradually widens from the apex to the base of the crown, where it is four times its apical width. The basal half of the ridge is flat to gently concave, which may represent abrasion of both the lingual and labial ridge surfaces. However, the crown surfaces show no wear facets. The tooth thus displays the following features, which in combination are dental synapomorphies of the Prosauropoda *sensu* Galton (1990) and Hunt and Lucas (1994): (1) spatulate shape; (2) symmetrical crown; (3) numerous, obliquely-angled marginal serrations; (4) poorly

developed "neck"; and (5) straight and narrow shape in mesiodistal views.

The tall, narrowly spatulate crown of NMMNH P-26400 is more similar to the crown shape of the Middle Norian *Sellosaurus* from the Middle Stubensandstein than to the proportionally broader spatulate crowns of *Plateosaurus*, from the Upper Stubensandstein and the overlying Knollenmergel of Germany (Galton, 1985). NMMNH P-26400 also resembles *Sellosaurus* in the slender, conical shape of the denticles, in contrast to the fuller, wider denticles of *Plateosaurus*. Specifically, NMMNH P-26400 is most comparable to teeth from the posterior portions of the dentition of *Sellosaurus*, which are characterized by symmetrical (absence of recurvature), spatulate crowns and subequal denticulation on the mesial and distal crown edges (Galton, 1985). Its size is also comparable to that of *Sellosaurus* teeth illustrated by Galton (1985) and much smaller than teeth assigned to *Plateosaurus*.

EARLY PROSAUROPOD TEETH AND EVOLUTION

Gauffre (1993a) assigned a Carnian age to *Azendohsaurus laaroussii* from the Argana Formation of Morocco, thereby making it not only one of the earliest dinosaurs, but the oldest known prosauropod. Lucas (1998) further resolved the age of these strata as Otischalkian (early late Carnian) based on the presence of the aetosaur *Longosuchus*.

More recently, other early prosauropod material was recovered from upper Carnian strata in Madagascar and Brazil. Flynn et al. (1999) reported two new prosauropods from the base of the Isalo II Beds in Madagascar that display contrasting dental morphologies. One form is based on several maxillae and dentaries that share characters with *Azendohsaurus*. These include a neck between the crown and root of the teeth and anteroposterior expansion of the crowns beginning at their bases. The dental morphology of the second Malagasy prosauropod is characterized by the dental apomorphies of the Prosauropoda. However, like NMMNH P-26400 and teeth of *Sellosaurus*, the crowns are elongate with slender denticles.

Flynn et al. (1999) assigned a probable early Carnian age to the base of the Isalo II, based largely on the inferred stage of evolution of the rhynchosaur *"Isalorhynchus" genovefae* (Whatley et al., 1999). However, we concur with Langer and Schultz (2000) and Langer et al. (2000) and consider *Isalorhynchus* to represent a *Hyperodapedon*-grade rhynchosaur. *Hyperodapedon* is otherwise known from late Carnian units in Argentina, Brazil, Scotland and India (Langer and Schultz, 2000).

Other Late Triassic prosauropods from South Africa include *Euskelosaurus browni* Huxley, 1866, *Blikanasaurus cromptoni* Galton and Heerden, 1985, and *Melanorosaurus readi* Haughton, 1924, all from the lower Elliot Formation. These taxa, as well as an undescribed prosauropod from the same unit in Lesotho (Gauffre, 1993b) are of probable Revueltian (early-mid Norian) age. Previous reports placing the lower Elliot Formation in the Carnian (Gauffre, 1993b; Galton and van Heerden, 1998) were based on the mistaken assumption that traversodontid cynodonts, which co-occur with the South African prosauropods, are unknown from strata younger than Carnian (Gauffre, 1993b). However, traversodontids are known from strata as young as Rhaetian (Hahn et al., 1988), and the only other Triassic prosauropod-dominated assemblages are Norian to Rhaetian in age. Thus, while the Elliot Formation lacks taxa age-diagnostic below the level of Late Triassic, it is most parsimonious to consider the fauna as analogous to the Revueltian faunas from the Stubensandstein of Germany, as Cooper (1982) proposed.

Langer et al. (1999) described a new prosauropod, *Saturnalia tupiniquim*, based on a partial skeleton from the upper Carnian interval of the Santa Maria Formation of southern Brazil. Although the holotype contains no cranial material, a natural cast of a mandibular ramus with teeth is included in the paratype material. Illustrated teeth of the anterior ramus are tall and narrowly spatulate with at least one showing significant recurvature, while the posterior teeth are short and spatulate with the maximum width of the crowns equal to their height. Although the anterior teeth of *Sellosaurus* are also taller than those of the posterior maxilla or dentary, the difference between the two crown shapes is much greater in *Saturnalia*. The tall crown of NMMNH P-26400 is similar to anterior teeth of *Saturnalia*. However, the illustration does not allow a comparison of denticulation.

At least two dental morphologies exist in the basal prosauropods. One morphotype is characterized by the typical prosauropod morphology seen in NMMNH P-26400 and, with minor differences, in many later prosauropods. A second morphotype is characterized by convergent features also seen in ornithischians (prominent neck between crown and root; low triangular crowns; and anteroposterior expansion of crowns beginning at their bases). These features are present in some teeth of *Azendohsaurus* (Gauffre, 1993a) and in one of the newly discovered Malagasy prosauropods (Flynn et al., 1999). Dental morphology may also vary within the tooth row of one individual in early prosauropods as illustrated by Langer et al. (1999) in the heterodont partial dentary of *Saturnalia* and in the dentaries and maxillae of *Azendohsaurus* (Gauffre, 1993). Thus, the dentition of basal prosauropods shows significantly more variation than that of later prosauropods.

Azendohsaurus, from the Otischalkian (early late Carnian) Argana Formation of Morocco, retains its status as the oldest known member of the Prosauropoda. The presence of slightly younger Adamanian (latest Carnian) prosauropod material from three continents indicates a Pangean-wide distribution of the Prosauropoda near their first occurrence. The radiation of basal prosauropods may be characterized by a high degree of dental morphologic innovation.

ACKNOWLEDGMENTS

The NMMNH funded SEM examination of this specimen. F. Humble allowed us to collect microvertebrates from his land. P. Galton read an earlier verison of this manuscript.

REFERENCES

Attridge, J., Crompton, A. W., and Jenkins, F. A. Jr., 1985, The southern African Liassic prosauropod *Massospondylus* discovered in North America: Journal of Vertebrate Paleontology, v. 5, no. 2, p. 128-132.

Cooper, M. R., 1982, A mid-Permian to earliest Jurassic tetrapod biostratigraphy and its significance: Arnoldia Zimbabwe, v. 9, p. 77-104.

Flynn, J. J., Parrish, J. M., Rakotosamimanana, B., Simpson, W. F., Whatley, R. L., and Wyss, A. R., 1999, A Triassic fauna from Madagascar, including early dinosaurs: Science, v. 286, p. 763-765.

Galton, P. M., 1985, Cranial anatomy of the prosauropod dinosaur *Sellosaurus gracilis* from the Middle Stubensandstein (Upper Triassic) of Nordwürttemberg, West Germany: Stuttgarter Beiträge zur Naturkunde B, v. 118, p. 1-39.

Galton, P. M., 1990, Basal-Sauropodomorpha-Prosauropods, *in* Weishampel, D. B., Dodson, P., and Osmólska, H., eds., The Dinosauria: Berkeley, University of California Press, p. 320-344.

Galton, P. M., and Heerden, J. v., 1985, Partial hindlimb of *Blikanasaurus*

cromptoni n. gen. and n. sp., representing a new family of prosauropod dinosaurs from the Upper Triassic of South Africa: Geobios, v. 18, no. 4, p. 509-516.

Galton, P. M., and Heerden, J. v., 1998, Anatomy of the prosauropod dinosaur *Blikanosaurus cromptoni* (Upper Triassic, South Africa), with notes on the other tetrapods from the Lower Elliot Formation: Paläontologische Zeitschrift, v. 72, p. 163-177.

Gauffre, F., 1993a, The prosauropod dinosaur *Azendohsaurus laaroussii* from the Upper Triassic of Morocco: Palaeontology, v. 36, p. 897-908.

Gauffre, F.-X., 1993b, Biochronostratigraphy of the lower Elliot Formation (southern Africa) and preliminary results on the Maphutseng dinosaur (Saurischia: Prosauropoda) from the same formation of Lesotho.: New Mexico Museum of Natural History and Science Bulletin, v. 3, p. 147-149.

Hahn, G., Lepage, J. C., and Wouters, G., 1988, Traversodonten-Zähne (Cynodontia) aus der Ober-Trias von Gaume (Sud-Belgien): Bulletin du Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre, v. 58, p. 177-186.

Haughton, S. H., 1924, The fauna and stratigraphy of the Stormberg Series: Annals of the South African Museum, v. 12, no. 8, p. 323-497.

Hunt, A. P., 1988, The oldest prosauropod dinosaur in North America, from the upper shale member of the Chinle Formation (Late Triassic) in east-central New Mexico: New Mexico Geology, v. 10, p. 65.

Hunt, A. P., 1989, A new ?ornithischian dinosaur from the Bull Canyon Formation (Upper Triassic) of east-central New Mexico, *in* Lucas, S. G., and Hunt, A. P., eds., Dawn of the age of dinosaurs in the American Southwest: Albuquerque, New Mexico Museum of Natural History, p. 355-358.

Hunt, A. P., and Lucas, S. G., 1994, Ornithischian dinosaurs from the Upper Triassic of the United States, *in* Fraser, N. C., and Sues, H.-D., eds., In the shadow of the dinosaurs: Early Mesozoic tetrapods: Cambridge, Cambridge University Press, p. 227-241.

Hunt, A. P., Lucas, S. G., Heckert, A. B., Sullivan, R. M., and Lockley, M. G., 1998, Late Triassic dinosaurs from the western United States: Geobios, v. 31, no. 4, p. 511-531.

Huxley, T. H., 1866, On the remains of large dinosaurian reptiles from the Stormberg Mountains, South Africa: Geological Magazine, v. 3, p. 363.

Langer, M. C., Abdala, F., Richter, M., and Benton, M. J., 1999, A sauropodomorph dinosaur from the Upper Triassic (Carnian) of southern Brazil: Comptes Rendus Academie des Sciences, Paris, Sciences de la Terre et des Planetes, v. 329, p. 511-517.

Langer, M., Boniface, M., Cuny, G., and Barbieri, L., 2000, The phylogenetic position of *Isalorhynchus genovefae*, a Late Triassic rhynchosaur from Madagascar: Annales de Paléontologie, v. 86, no. 2, p. 101-127.

Langer, M. C., and Schultz, C. L., 2000, A new species of the Late Triassic rhynchosaur *Hyperodapedon* from the Santa Maria Formation of south Brazil: Palaeontology, v. 43, no. 4, p. 633-652.

Lockley, M. G., and Hunt, A. P., 1995, Dinosaur tracks and other fossil footprints of the western United States: New York, Columbia University Press, 338 p.

Lockley, M. G., Lucas, S. G., and Hunt, A. P., 2000, Dinosaur tracksites in New Mexico: A review: New Mexico Museum of Natural History and Science Bulletin, v. 17, p. 9-16.

Lucas, S. G., 1998, Global Triassic tetrapod biostratigraphy and biochronology: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 143, p. 347-384.

Lucas, S. G., and Luo, Z., 1993, *Adelobasileus* from the Upper Triassic of West Texas: the oldest mammal: Journal of Vertebrate Paleontology, v. 13, p. 309-334.

Olsen, P. E., 1988, Paleontology and paleoecology of the Newark Supergroup (early Mesozoic, eastern North America), *in* Manspeizer, ed., Triassic-Jurassic rifting: Continental breakup and the origin of the Atlantic Ocean and passive margins, Part A: Amsterdam, Elsevier, p. 185-230.

Sereno, P. C., 1991, *Lesothosaurus*, "fabrosaurids," and the early evolution of Ornithischia: Journal of Vertebrate Paleontology, v. 11, p. 168-197.

Whatley, R. L., Flynn, J. J., Simpson, W., and Wyss, A. R., 1999, *Isalorhynchus* revisited: Two rhynchosaur skeletons from southwestern Madagascar: Journal of Vertebrate Paleontology , v. 19, no. 3A, p. 84A.