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THE LATE TRIASSIC AETOSAUR *PARATYPOTHORAX*

SPENCER G. LUCAS[1], ANDREW B. HECKERT[2] AND LARRY F. RINEHART[1]

[1]New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, NM 87104;
[2]Department of Geology, Appalachian State University, ASU Box 32067, Boone, NC 28608-2067

Abstract—*Paratypothorax* is a Late Triassic aetosaur known from Germany, Greenland, North Africa and the American Southwest. The few records in Germany are from the Stubensandstein, whereas the American records have a much longer stratigraphic range. The genus currently is monospecific, with the most complete specimens (which consist only of armor plates and vertebrae) assignable to *P. andressorum*. *Paratypothorax* records are few, not stratigraphically dense and range in age from Adamanian through Revueltian.

INTRODUCTION

Aetosaurs were extensively armored archosaurs with an Upper Triassic fossil record in North America (including Greenland), South America, Europe, India, north Africa and Madagascar (Heckert and Lucas, 2000). Aetosaurs have proven to be of biostratigraphic utility in establishing correlations of Late Triassic vertebrate fossil assemblages across broad areas of Pangea. Here, we review the distribution of the aetosaur *Paratypothorax* to establish its biostratigraphic distribution and biochronological significance. In this paper, DMNH = Dallas Museum of Natural History, Dallas, Texas; FMNH = Field Museum of Natural History, Chicago, Illinois; and PEFO = Petrified Forest National Park, Arizona.

DISTRIBUTION OF *PARATYPOTHORAX*

Presently *Paratypothorax* is known from Upper Triassic rocks of Carnian to Norian age in the American Southwest, Greenland, Germany and north Africa (Fig. 1). A possible occurrence in India has not yet been adequately documented.

American Southwest

In North America, *Paratypothorax* has been reported only from the American Southwest. These are records from the Chinle Group in Arizona, New Mexico and Texas.

Arizona

The most complete North American specimen of *Paratypothorax* is PEFO 3004, originally described by Hunt and Lucas (1992) (Figs. 2-7). This specimen was collected in 1984 by an FMNH party under the direction of John Bolt. The prepared portion of the specimen consists of 17 paramedian scutes, 10 lateral scutes, 4 dorsal vertebrae and 2 caudal vertebrae. All of the lateral scutes are from the right side, as are 12 of the 17 paramedian scutes; 5 paramedians are from the left side. Unprepared elements include at least 5 vertebrae, 4 incomplete paramedian plates and a haemal arch. A single incomplete right dorsal paramedian scute from this specimen remains at the FMNH with the number PR 1610. Measurements (in mm) of this specimen are: length = 90 mm, length anterior bar = 16 (measured at boss), width = 296, width from medial edge to center of boss = 105 mm, and width from boss to lateral edge = 193 mm. The boss does not contact the posterior margin of the scute and is somewhat keeled anteriorly. There is no ventral keel and there is a radial pattern of ridges that are especially elongate laterally. This scute is probably an anterior dorsal paramedian because there is no overlap of the boss posteriorly.

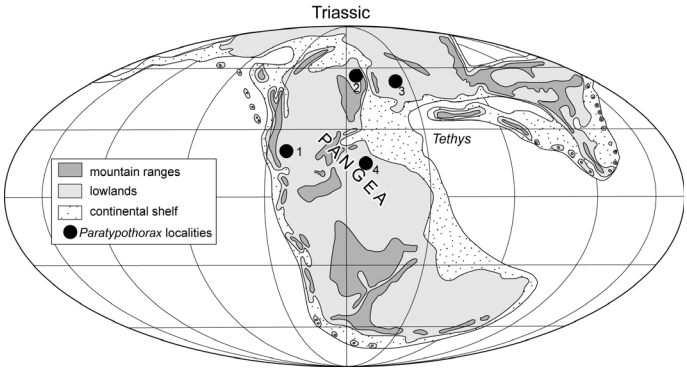

FIGURE 1. Map of Late Triassic Pangea showing distribution of *Paratypothorax* localities. **1**, American Southwest. **2**, Eastern Greenland. **3,** Germany. **4**, Algeria.

Of those specimens that have been described in the scientific literature, PEFO 3004 is second only to the holotype in terms of its completeness. Hunt and Lucas (1992) described and illustrated parts of this specimen, which is from the Jim Camp Wash Bed just above the Rainbow Forest Bed of the Sonsela Member, Petrified Forest Formation, Chinle Group near the Crystal Forest in Petrified Forest National Park (Hunt and Lucas, 1992, fig. 1; Heckert and Lucas, 2002). In the appendix we provide detailed measurements of the dorsal paramedian scutes of this specimen.

The dorsal paramedians are extremely wide relative to their length (Table 1). The lateral scutes all have spikes and range in width from 51 to 131 mm. The dorsal vertebrae are amphicoelous, have laterally expanded tips on the dorsal ends of their neural spines to act as platforms for the scutes, and have transverse processes that are ventrally tilted flanges of bone. Their anterior central diameters range from 33.4 to 48.1 mm, centrum lengths are 41.5 to 52.6 mm and posterior centrum diameters are 37.4 to 40.2 mm. The caudal vertebrae are amphicoelous, have long centra and small, posteriorly positioned transverse processes. Their anterior centrum diameters range from 27.2 to 29.9 mm, centrum lengths are 46.1 to 49.1 mm and posterior centrum diameters are 26.5 to 28.7 mm. The detached haemal arches of these caudal vertebrae are flat flanges of bone that are paddle shaped in lateral view and curved posteriorly.

PEFO 3004 exhibits diagnostic features of *Paratypothorax andressorum* including: extremely wide dorsal paramedian plates with ornamentation of long rays that parallel the posterior margin of the scute; short, anteriorly-directed rays; large lateral eminence on the posterior dorsal, sacral and anterior caudal paramedians; and lateral presacral scutes with horns (Long and Ballew, 1985; Heckert and Lucas, 2000). Despite this, Long and Murry (1995, p. 110) only identified this specimen as *Paratypothorax* sp., claiming that it differed significantly from the German genoholotype in having more delicate and pyramidal scute eminences. However, we are unable to verify this difference, so we follow Hunt and Lucas (1992) and Heckert and Lucas (2000) in assigning PEFO 3004 to *P. andressorum*.

Long and Murry (1995) claimed that other records of *Paratypothorax* in Arizona are from the Blue Mesa and Painted Desert members of the Petrified Forest Formation, and from the Owl Rock

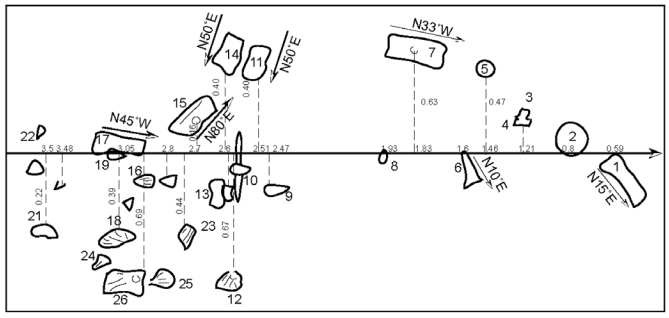

FIGURE 2. Quarry map of the excavation of PEFO 3004, *Paratypothorax andressorum*. Modified from field notes by W.F. Simpson and S. Gatesy on file at PEFO. Distances are recorded in meters along a baseline running N40°W.

Formation. However, subsequent work has only verified records in the Sonsela Member, in part because a refined lithostratigraphy of the PEFO (Heckert and Lucas, 2002; Woody, 2006) transferred many *Paratypothorax* occurrences from the Blue Mesa Member to the Sonsela Member (Parker and Irmis, 2005; Heckert et al., 2005). Parker and Irmis (2005) also re-assigned to *Paratypothorax* several isolated osteoderms that Long and Ballew (1985) identified as *Desmatosuchus* (see also Parker, 2005, 2006).

New Mexico

In east-central New Mexico, *Paratypothorax* has been reported from the Tres Lagunas Member of the Santa Rosa Formation, the Garita Creek Formation and the Bull Canyon Formation (Hunt and Lucas, 1992, 1995; Long and Murry, 1995). Heckert (1997) documented a record of *Paratypothorax* in the lower part of the Bluewater Creek Formation in west-central New Mexico. The Bluewater Creek Formation occurrence is the stratigraphically lowest occurrence of the genus in North America.

TABLE 1. Measurements (in mm) of paramedian scutes of *Paratypothorax andressorum*, PEFO 3004. Asterisks (*) indicate approximate measurements of damaged or incomplete scutes. The scute numbers are those in the excavation map in Figure 2.

Number	2	5	6	8	10	13	19	20	21	24	25	27	28	29	32	100	?
Width	-	-	350	340	370*	195	315	-	133	228	141	99	119	168	360*	344*	111
Length	74	84	79	71	68*	63	70*	60*	74	69	70	67	63	68	79	79*	62

Texas

Paratypothorax has been reported from the Tecovas Formation and the Bull Canyon Formation (= "Cooper Canyon Formation") in west Texas (Small, 1989a, b; Long and Murry, 1995). A lateral scute from the Tecovas Formation in Crosby County referred to cf. *Paratypothorax* sp. by Lucas et al. (1995; see also Long and Murry, 1995) pertains to the new taxon *Tecovasuchus* described by Martz and Small (2006), as does the paramedian scute described by Lucas et al. (1995). The DMNH specimen from the Bull Canyon Formation described briefly by Long and Murry (1992) is the only known articulated specimen of *Paratypothorax* and will be very important in understanding the position of isolated elements.

GREENLAND

Jenkins et al. (1994) documented a paramedian scute of *Paratypothorax andressorum* from the Ørsted Dal Member of the Fleming Fjord Formation in eastern Greenland.

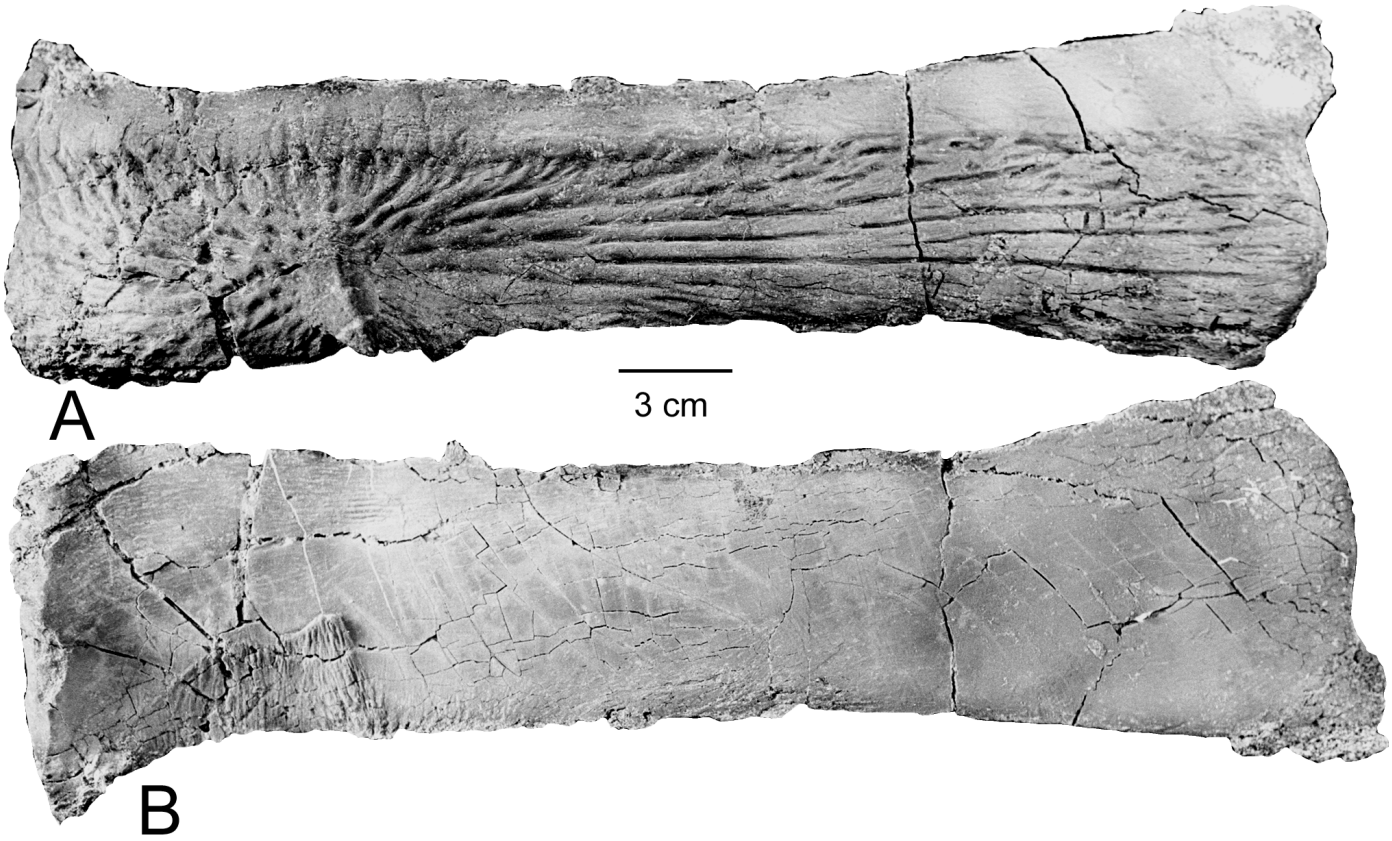

FIGURE 3. *Paratypothorax andressorum*, PEFO 3004, right dorsal paramedian scute from the middle portion of the carapace in **A**, dorsal and **B**, ventral views. This is scute no. 8 on Figure 2.

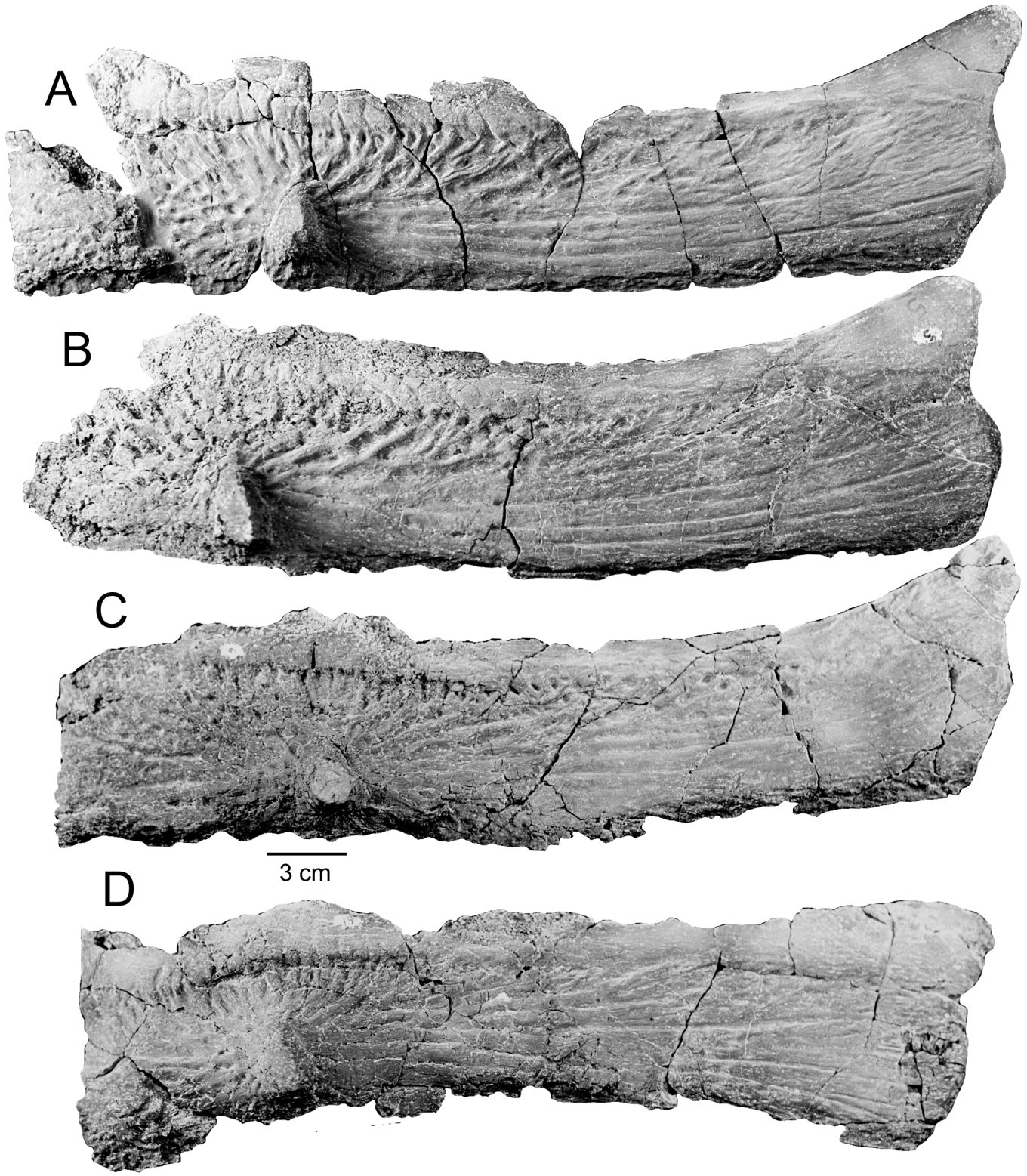

FIGURE 4. *Paratypothorax andressorum*, PEFO 3004, right dorsal paramedian scutes in dorsal views. **A**, Scute no. 10 on Figure 2. **B**, Scute no. 5 on Figure 2. **C**, Scute no. 6 on Figure 2. **D**, Scute no. 19 on Figure 2.

GERMANY

The holotype of *Paratypothorax andressorum* and other specimens of the species (all armor plates) are known from the Stubensandstein of Baden-Württemburg. Originally described as phytosaur armor (e.g., Meyer, 1861; see synonymies in Heckert and Lucas, 2000), Gregory (1953a, b) first recognized these plates as aetosaur, and they have been described and/or illustrated most recently by Long and Ballew (1985), Long and Murry (1995) and Heckert and Lucas (2000). The holotype consists of more osteoderms than the PEFO specimen illustrated here (15 right and 22 left dorsal paramedians as well as 11 lateral scutes), but lacks any other skeletal elements. Lucas (2000) documented pathological osteoderms of *Paratypothorax* from Germany as well.

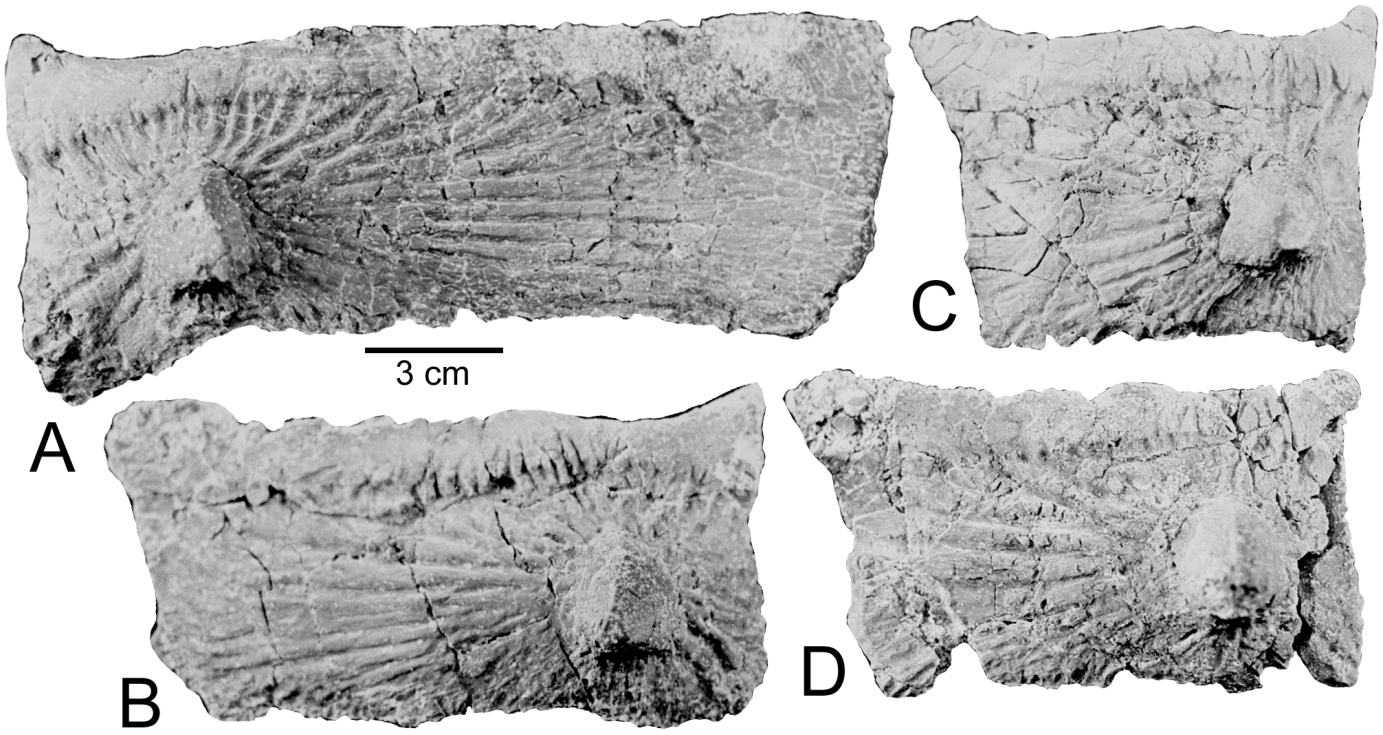

FIGURE 5. *Paratypothorax andressorum*, PEFO 3004, left (**A**) and right (**B-D**) dorsal paramedian scutes in dorsal views. **A**, Scute no. 13 on Figure 2. **B**, Scute no. 25 on Figure 2. **C**, Scute no. 27 on Figure 2. **D**, Scute no. 26 on Figure 2.

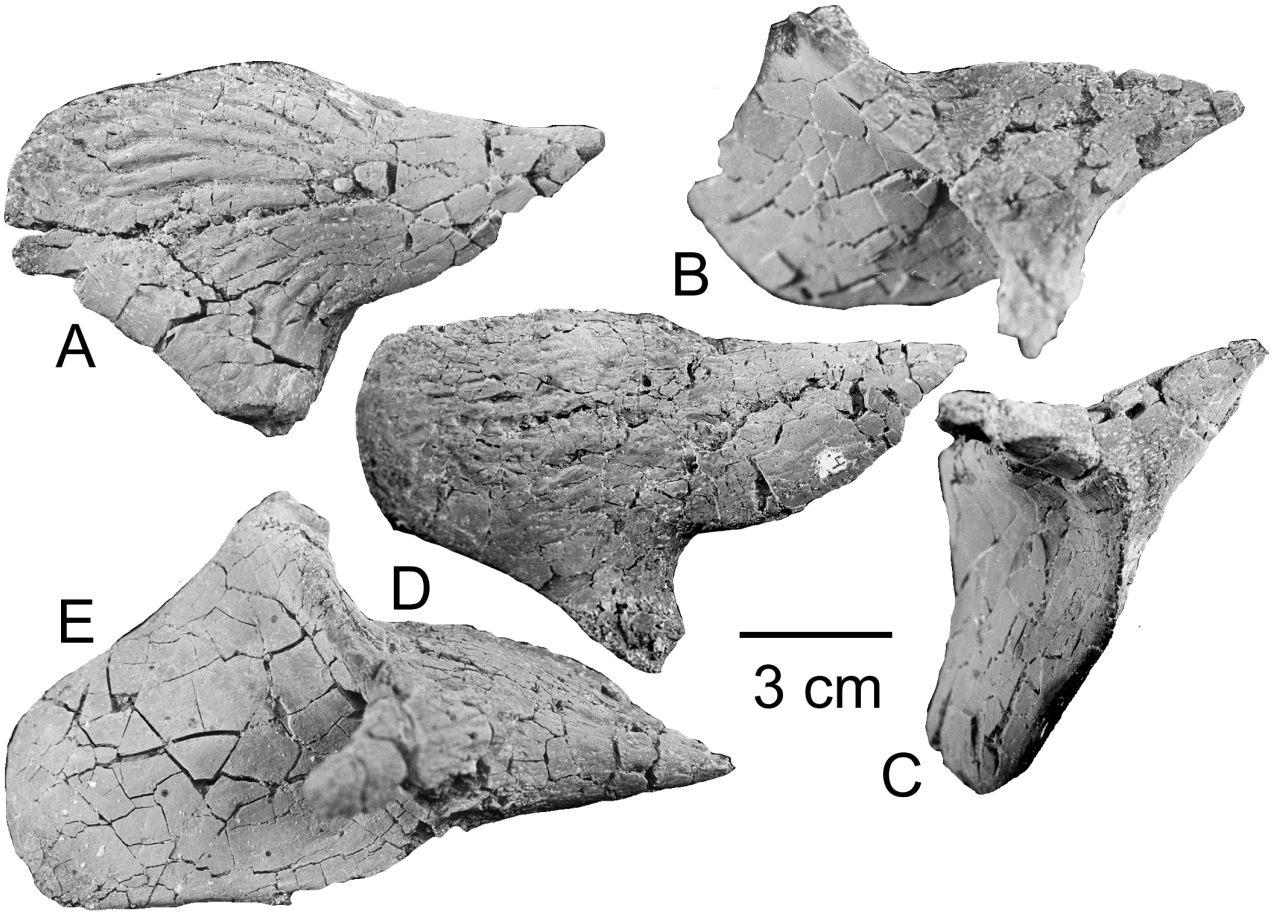

FIGURE 6. *Paratypothorax andressorum*, PEFO 3004, right lateral scutes in various views. **A-C**, Scute no. 7 on Figure 2 in **A**, ventral, **B**, dorsal, and **C**, posterior views. **D-E,** Scute no. 4 on Figure 2 in **D**, ventral, and **E**, dorsal views.

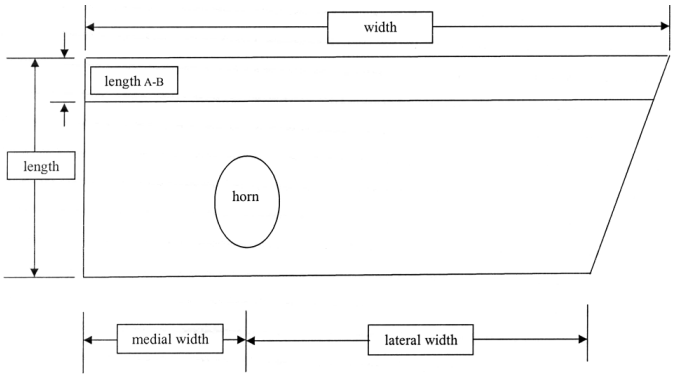

FIGURE 7. Measurement protocol of paramedian scute of *Paratypothorax* for measurements reported in the Appendix.

NORTH AFRICA

Jalil et al. (1995) and Jalil (1999) reported osteoderms of *Paratypothorax* from the Zarzaitine series of Algeria. Heckert and Lucas (2000) listed these as specimens of *P. andressorum*, but they are probably best assigned to *Paratypothorax* sp. Jalil et al. (1995, fig. 2b, d) illustrated a lateral scute of PEFO 3004 described here as comparative material.

INDIA

A "*Paratypothorax*-like" aetosaur has been listed from the lower vertebrate fossil assemblage of the Dharmaram Formation in India (e.g., Kutty and Sengupta, 1989). However, this report lacks documentation, so we do not consider it an established record of *Paratypothorax*.

BIOCHRONOLOGY

In the American Southwest, records of *Paratypothorax* range from Adamanian to early Revueltian in age. All of these specimens from the Chinle Group are assignable to *P. andressorum* or are so incomplete that they can only be identified as *Paratypothorax* sp. Records of *P. andressorum* in Greenland and Germany are of Revueltian age.

Paratypothorax records are relatively few and widely dispersed when compared to the much more extensive fossil records of some of the other aetosaur genera. Thus, it is difficult to advocate precise and robust biostratigraphic correlations based on *Paratypothorax*. Particularly important as well is the possibility that more than one species of *Paratypothorax* existed, as much of the known material is so incomplete that species-level assignment is tentative at best. Thus, at present, *Paratypothorax* is indicative of Adamanian-Revueltian time and little more.

ACKNOWLEDGMENTS

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APPENDIX: DETAILED MEASUREMENTS OF PARAMEDIAN SCUTES OF PEFO 3004 (FIG. 7)

Specimen number PEFO-3004 *Paratypothorax andrressorum*
PARAMEDIAN SCuTE MEASUREMENTS (mm)

#'s =/> 100 assigned to scutes with no PEFO#
"ap" indicates that scute is damaged or incomplete and is measured "as preserved"
"x" indicates material is missing

PEFO#	side	width	med width	lat width	length	A-B length	Notes:
2	R	260	53	107	75ap	18ap	lat end damaged, med end OK
5	R	320ap	74ap	239	85ap	18ap	medial edge missing
6	R	350	102	225	67ap	x	~good preservation
8	R	337	87	223	93	31	good preservaton
10	R	356ap	95	245	83ap	18ap	poor preservation, lat end missing
13	R	185	43	121	83	18	~good preservation
17	R	270ap	60	x	88	29	poor preservation, lat end missing, med end OK
19	R	312	74	205	90	20	edges broken
20	R	184ap	48ap	110	72ap	x	bad preservation
21	L	130	25	85	77	22	~good preservation
24	R	228	33	162	86ap	26	edges damaged
25	L	140	29	88	74	24	~good preservation
26	R	109	20	80ap	72ap	17ap	~good preservation
27	L	99	18	61	75	16	good preservaton
28	L	121	29	69	69	16ap	~good preservation
29	L	166	28	110	75	23	edges broken
31	R	82	19	53	65ap	17ap	med end broken
32	L	183ap	x	x	76ap	x	partial scute, lat edge only
100	R	351	99	222	86ap	26ap	med end bad, lat end good
101 (7?)	R	250ap	105	145ap	85ap	x	bad preservation, lateral end missing