

# THE PACHYCEPHALOSAURID DINOSAUR *STEGOCERAS VALIDUM* FROM THE UPPER CRETACEOUS FRUITLAND FORMATION, SAN JUAN BASIN, NEW MEXICO

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**Abstract**—A frontoparietal of the well-known pachycephalosaurid dinosaur *Stegoceras validum* is documented and described from the upper Fruitland Formation (Fossil Forest Member), San Juan Basin, New Mexico. This is the first bona-fide record of this taxon outside of Alberta, Canada. Its presence in the upper Fruitland Formation extends the temporal range of *S. validum* from the late Judithian to early Kirtlandian. The broad geographic distribution of *S. validum* (Alberta-New Mexico) contradicts the idea of dinosaur endemism or provincialism in the Western Interior during the Late Cretaceous.

## INTRODUCTION

Pachycephalosaurid dinosaur fossils are relatively rare in the Upper Cretaceous strata of the San Juan Basin, New Mexico, but recently a number of specimens have been reported by Sullivan (2000a, 2003b) and Williamson and Carr (2002a, 2005). Most of the specimens are from the De-na-zin Member of the Kirtland Formation and are referable to the taxon *Prenocephale goodwini* (Sullivan, 2003, 2005, 2006). Here, we describe and identify a juvenile frontoparietal from the Fruitland Formation (Fossil Forest Member) of the San Juan Basin, New Mexico, first reported by Williamson and Carr (2002a), but tentatively identified by them as a “new genus and new species” of Pachycephalosauridae. We demonstrate, below, that the specimen belongs to the taxon *Stegoceras validum* (*sensu stricto*) as redefined by Sullivan (2003, 2005, 2006). In this paper, NMMNH = New Mexico Museum of Natural History and Science (Albuquerque).

## SYSTEMATIC PALEONTOLOGY

Dinosauria Owen 1842

Ornithischia Seeley, 1887

Pachycephalosauria Maryańska and Osmólska, 1974

Pachycephalosauridae Sternberg, 1945

*Stegoceras* Lambe, 1902

*Stegoceras validum* (Lambe, 1902): emend. Sues and Galton, 1987, p. 5.

**Referred specimen**—NMMNH P- 33893, nearly complete frontoparietal (Fig. 1).

**Locality**—NMMNH locality 4716, San Juan Basin, New Mexico.

**Formation/Age**—Upper Fruitland Formation (Fossil Forest Member), late Campanian (early Kirtlandian).

**Description**—The frontoparietal measures 75 mm in length along the midline. Dorsally, the posterior portion of the frontal region is the thickest, forming an incipient dome that is approximately 20 mm high and is positioned slightly anterior to the frontoparietal suture on the ventral side. The dorsal surface is pitted and has a distinctive, node-like textural surface. The parietal portion of the frontoparietal is depressed posteriorly, and the median section of the parietal extends posteriorly 15 mm beyond the anterior-most margin of the supratemporal fossae. This parietal projection laterally adjoins, on both sides, the left and right supratemporal fossae, and thus participates in the formation of the parietosquamosal shelf.

The anteromedial margin of the right supratemporal fossa is well-defined, whereas the left is less so, suggesting that the left supratemporal fenestra may be less well-developed, as it does not appear to be damaged. The sutural surface on the posterior part of the right squamosal, coupled with the prominent median extension of the parietal and well-

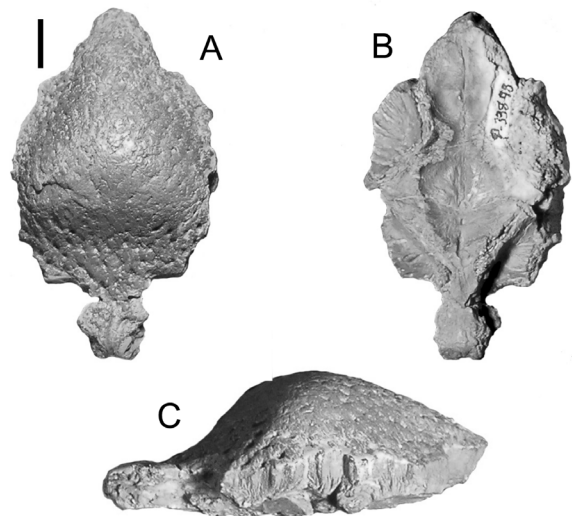


FIGURE 1. *Stegoceras validum* (NMMNH P-33983), nearly complete frontoparietal from the upper Fruitland Formation (Fossil Forest Member), San Juan Basin, New Mexico. A, dorsal view; B, ventral view; and C, right lateral view. Bar scale = 10 mm.

developed supratemporal fossae, further indicate the presence of a well-developed parietosquamosal shelf. Both squamosals are missing. The sutural surfaces for the anterior supraorbital, posterior supraorbital, and postorbital, are nearly complete on the right, with damage between the posterior supraorbital and postorbital resulting in a gap between the two. Only the left postorbital sutural surface is preserved, and both left supraorbital surfaces are damaged. Anteriorly, both the left and right prefrontal sutural surfaces are present with the medial nasal surfaces. The sutural surfaces vary in height, between 5-10 mm, along the periphery of the frontoparietal.

Ventrally, the frontoparietal suture is distinct, and it rises dorsally into the damaged lateral surfaces mentioned above. Laterally, the roof of the right orbit is preserved, while that of the left is obstructed with matrix. Anteriorly, the impression of the dorsal surface of the olfactory bulbs is evident; so, too, is that of the cerebrum and cerebellar regions posteriorly. The cerebellar region is confined to the parietal portion of the frontoparietal. The dorsal surfaces of the supratemporal fossae are preserved on both sides of the parietal, and both diverge anteriorly from the sagittal plane. The dorsal surface of the median parietal projection is relatively flat and smooth.

**Identification**—A number of small frontoparietals, isolated parietals and frontals of pachycephalosaurs have been noted previously, displaying various degrees of doming and fusion (Goodwin et al., 1998;

Sullivan, 2003). On NMMNH P-33893, the flattened region of the parietal, coupled with the well-developed posterior medial extension of the parietal, indicate the presence of the well-developed squamosal shelf that is seen in a number of specimens of *Stegoceras validum*, including the holotype (Sullivan, 2003). This same morphology is seen in specimens referred to *Ornatolithus browni*, a taxon formally synonymized with *S. validum*. Goodwin et al. (1998) were the first to suggest that this morphology represented an early growth stage of *Stegoceras*, and this was accepted by Sullivan (2003). Indeed, no other incipiently domed, or fully-domed pachycephalosaurid from the Campanian has a well-developed parietosquamosal shelf. Therefore, NMMNH P-33893 is referred *Stegoceras validum*.

## DISCUSSION

Two pachycephalosaurid taxa are now known from the Kirtlandian land-vertebrate “age” as defined by Sullivan and Lucas (2006): *Stegoceras validum*, from the upper Fruitland Formation (Fossil Forest Member), is part of the Hunter Wash local fauna; and *Prenocephale goodwini*, from the Kirtland Formation (De-na-zin Member), is a member of the Willow Wash local fauna (Sullivan and Lucas, 2006). The Alberta records of *S. validum* are from the Oldman and Dinosaur Park formations (late Judithian

(Sullivan, 2003, 2006). Its occurrence in the upper part of the Fruitland Formation (Fossil Forest Member) represents only a slight temporal range extension from the late Judithian into the early Kirtlandian age (Sullivan and Lucas, 2006).

The occurrence of *Stegoceras validum* in Alberta and New Mexico indicates that it had a broad geographic distribution in late Campanian time. This runs counter to models that suggest north-south provinciality of dinosaurs (Lehman, 1997, 2001), or that propose more extensive dinosaur endemism during the Late Cretaceous (e. g., Sampson, et al., 2004). *S. validum* is part of a broadly distributed dinosaur fauna in the Western Interior during the Judithian-Kirtlandian transition. The paleogeographic distribution of *Stegoceras validum* during late Campanian time (at the Judithian-Kirtlandian transition) further supports the model of temporal segregation (Sullivan and Lucas, 2006) and undermines the idea of dinosaur endemism and provincialism (the concept of “northern” and “southern” vertebrate faunas) of Late Cretaceous dinosaurs in the Western Interior.

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## REFERENCES

- Goodwin, M.B., Buchholtz, E.A., and Johnson, R.E., 1998, Cranial anatomy and diagnosis of *Stygomoloch spinifer* (Ornithischia: Pachycephalosauria) with comments on cranial display structures in agonistic behavior: *Journal of Vertebrate Paleontology*, v. 18, p. 363-375.
- Lehman, T.M., 1997, Late Campanian dinosaur biogeography in the Western Interior of North America; in Wolberg, D.L., Stump, E. and Rosenberg, G.D., eds., *Dinofest International. Proceedings of a symposium sponsored by Arizona State University: Philadelphia, Academy of Natural Sciences*, p. 223-240.
- Lehman, T.M., 2001, Late Cretaceous dinosaur provinciality; in Tanke, D. and Carpenter, K., eds., *Mesozoic vertebrate life: Bloomington and Indianapolis*, Indiana University Press, p. 310-328.
- Sampson, S.D., Loewen, M., Roberts, E.T., Smith, J.A., Zanno, L.E., and Gates, T., 2004, Provincialism in Late Cretaceous terrestrial faunas: New evidence from the Campanian Kaiparowits Formation of Utah (abs): *Journal of Vertebrate Paleontology*, v. 24, p. 108A.
- Sullivan, R.M., 2000, *Prenocephale edmontonensis* (Brown and Schlaikjer) new comb. and *P. brevis* (Lambe) new comb. (Dinosauria: Ornithischia: Pachycephalosauria) from the Upper Cretaceous of North America: *New Mexico Museum of Natural History and Science, Bulletin 17*, p. 177-190.
- Sullivan, R.M., 2003, Revision of the dinosaur *Stegoceras* Lambe (Ornithischia, Pachycephalosauridae): *Journal of Vertebrate Paleontology*, v. 23, p. 167-193.
- Sullivan, R.M., 2005, Pachycephalosaurs from Dinosaur Provincial Park, Alberta: taxonomy, biostratigraphy, and paleobiogeographic implications; in Braman, D. R., Therrien, F., Koppelhus, E.B., and Taylor, W., eds., *Dinosaur Park Symposium—Short Papers, Abstracts, and Program: Drumheller, Special Publication of the Royal Tyrrell Museum*, p. 121-126.
- Sullivan, R. M., 2006, A taxonomic review of the Pachycephalosauridae (Dinosauria; Ornithischia): *New Mexico Museum of Natural History and Science Bulletin*, this volume.
- Sullivan, R.M. and Lucas, S.G., 2006, The Kirtlandian land-vertebrate “age”—faunal composition, temporal position and biostratigraphic correlation in the nonmarine Upper Cretaceous of western North America: *New Mexico Museum of Natural History and Science Bulletin*, this volume.
- Williamson, T.E. and Carr, T.D., 2002a, A juvenile pachycephalosaur (Dinosauria: Pachycephalosauridae) from the Fruitland Formation, New Mexico: *New Mexico Geology*, v. 24, p. 67-68.
- Williamson, T.E. and Carr, T.D., 2002b, A new genus of derived pachycephalosaurian from western North America: *Journal of Vertebrate Paleontology*, v. 22, p. 779-801.
- Williamson, T.E. and Carr, T.D., 2005, New pachycephalosaur specimens from the Late Cretaceous of New Mexico: *New Mexico Geology*, v. 27, p. 45.