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# The smallest ceratopsid skull—Judith River Formation of Alberta

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A partial skull found at Dinosaur Provincial Park, Alberta, in Upper Cretaceous (Campanian) sediments is the smallest specimen of a ceratopsid ever found, belonging to an animal about 1.1 m long. It represents an animal probably less than 2 years old, one fifth of its adult size. The shape of the squamosal and the thinness of the parietal suggest a tentative referral to *Monoclonius*. Strong positive allometric growth of the parietal fenestra is inferred.

Une crâne partiel trouvé au Parc provincial des Dinosaures, Alberta, dans les sédiments du Crétacé supérieur (Campanien) est le plus petit spécimen de cératopside jamais trouvé, appartenant à un animal d'environ 1,1 m de long. Il représente un animal âgé probablement de moins de 2 ans et d'un cinquième de sa taille adulte. La forme du squamosal et la minceur du pariétal suggèrent une assignation à *Monoclonius*. On en déduit une croissance allométrique fortement positive de la fenêtre pariétale.

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## Introduction

Upper Cretaceous (Campanian) sediments of the Judith River (Oldman) Formation exposed along the Red Deer River at Dinosaur Provincial Park in southern Alberta have yielded the most abundant, diverse fauna of articulated dinosaur remains on Earth (Russell 1967; Dodson 1971, 1983; Béland and Russell 1978). As is typical of dinosaur faunas elsewhere (e.g., Richmond 1965), juvenile dinosaurs are uncommon at Dinosaur Park. Juvenile and subadult lambeosaurines, ranging in overall length from approximately 4 to 7 m (one third to two thirds of adult size), have been described (Dodson 1975), and a very small hadrosaurine skull, indicating an animal of 2 m length or less, was described by Sternberg (1955).

Until the present, associated remains of juvenile ceratopsids have been lacking (Sternberg 1949). We describe the first skull of a juvenile ceratopsid from Dinosaur Provincial Park (quarry 181, lsd. 5, sec. 5, tp. 21, rge. 11, W 4th mer.)—incidentally, the smallest known specimen of a ceratopsid. The specimen, Tyrrell Museum of Palaeontology TMP 82.16.11, consists of a nearly complete parietal, both squamosals and laterosphenoids, a complete right splenial, and fragments of what appear to be jugal, postorbital, palatine, and pterygoid. It was collected by T. Tokaryk, who discovered it while excavating a partial hadrosaur skeleton. Dodson (1984) gave a brief preliminary notice of the specimen.

## Description

*Parietal*

As preserved, the parietal measures 210 mm in length along the midline, with a maximum length of 220 mm (Fig. 1). Probably less than 10 mm is missing at the rostral end. The left side is comparatively well preserved, whereas the right side is distorted and slightly telescoped. The maximum width from the midline to the edge on the undistorted side is 125 mm; thus, the width of the parietal may be estimated at 250 mm. The sagittal ridge is prominent, measuring 25 mm in height at the rostral end and diminishing only near the caudal end, where it measures 13 mm. The ridge is rounded transversely (a specimen of *Brachyceratops* in the United States National Museum of Natural History, USNM 7950, a parietal about 50% longer than this one, has a very sharp sagittal ridge) and undulates somewhat; there is a peak 30 mm from the front; there is a second one 65 mm behind the first. Two specimens of *Brachyceratops* show five more or less distinct undulations along the sagittal ridge—USNM 7950 (Gilmore 1917) and USNM 14765 (Gilmore 1939), a large specimen measuring 575 mm along the sagittal ridge.

The caudal margin of the parietal is thin, ranging from 5.5 to 7.9 mm in thickness, the maximum (apart from the sagittal thickening) being at the caudolateral corner. Six gentle "epoccipitals" are preserved along the left caudal border; the right side seems to confirm this count. The lateral margin borders the squamosal. The caudal three sevenths of the border forms a simple butt suture with the squamosal, with a nearly uniform thickness of 7–8 mm. The parietal thins rostrally, where it is overlapped by the squamosal and forms the medial wall of the upper temporal fenestra. An indistinct line runs rostromedially from the point of overlap of the squamosal to the rostral apex of the parietal. On the left side, the thickness of this portion of the parietal varies between 4 and 5 mm.

Parietal fenestrae are present. They are small and asymmetrical in size and position. Further preparation has revealed that the left fenestra is larger than reported in Dodson (1984). It now measures 37 mm in length and 17 mm in maximum width (but 12 mm for most of its length), and its caudal edge is 61 mm rostral to the caudal border of the parietal. The left fenestra is parasagittal in orientation, the rostral end is 38 mm from the midline, and the caudal end is 33 mm from the midline. The bone surrounding the opening has a thickness of 2–3 mm. Because of telescoping, the right opening is an oblique slit measuring 26 mm in length and 5 mm in greatest width. The caudal border is 54 mm from the caudal edge of the parietal and 35 mm from the midline. The rostral border is 25 mm from the midline.

*Squamosal*

Both right and left squamosals are preserved, and each is nearly complete, although the left is in better condition than the right (Fig. 2). As is typical of ceratopsid squamosals, the caudal portion is more robust and is better preserved than the somewhat more delicate rostral portion. The caudal portion abuts the parietal and forms the lateral portion of the frill. The rostral portion forms the lateral border of the upper temporal fenestra. It also forms the dorsal border of the lateral temporal fenestra, and by means of a slender quadrate process, part of its caudal border. Rostrally it thins to overlap the jugal and the postorbital.

The left squamosal measures 165 mm in length (Fig. 2). The caudal border thickens to 11 mm and bears four distinct "epoccipitals." Four or five scallops is the most common number for short-frilled ceratopsids, but as few as three (*Styracosaurus parksi* Brown and Schlaikjer 1937) and as many as six (*Centrosaurus flexus* Brown 1914) are known. The parietal contact is straight for a distance of 92 mm, and the butt suture has a thickness of 8 mm for a distance of 30 mm. Rostral to this, it thins to 3.5–4 mm as it overlaps the parietal. The rostral portion of the squamosal is also straight for a distance of 73 mm. However, the medial border diverges sharply ("steps down") from the parietal contact by about 20 mm. On the medial surface of the squamosal are several bony ridges oriented dorsoventrally that converge at the point of the step-down, i.e., at the caudal edge of the upper temporal fenestra. The internal ridges are very characteristic of ceratopsids (Hatcher *et al.* 1907) and show the position of attachment of the exoccipital and the quadrate to the squamosal. The left squamosal shows the ridges well enough that the separate exoccipital and quadrate scars can be identified. The rostral portion of the squamosal is thin, ranging between 3 and 4 mm in thickness, and sutural relationships with the jugal and postorbital are not clear, although little bone seems to be missing. Fragments of the postorbital and ?pterygoid are attached to the rostral medial surface of the left squamosal (Fig. 2*b*).

The right squamosal (Figs. 2*c*, 2*d*) is similar to the left one in overall length (168 mm) and length of the caudal portion (94 mm) and shows the strong step-down from the parietal border to the fenestral border. A weak (exoccipital?) ridge just caudal to the quadrate process runs part way dorsally then dies out. A second internal ridge begins at the same place and angles rostrodorsally. Fragments of the right jugal and possibly exoccipital are closely appressed to the medial surface of the right squamosal (Fig. 2*d*). In Fig. 3, the appearance of the parietosquamosal frill is reconstructed.

*Splenial*

The right splenial was found attached to the underside of the parietal (Fig. 1*b*). The medial surface is exposed, showing the

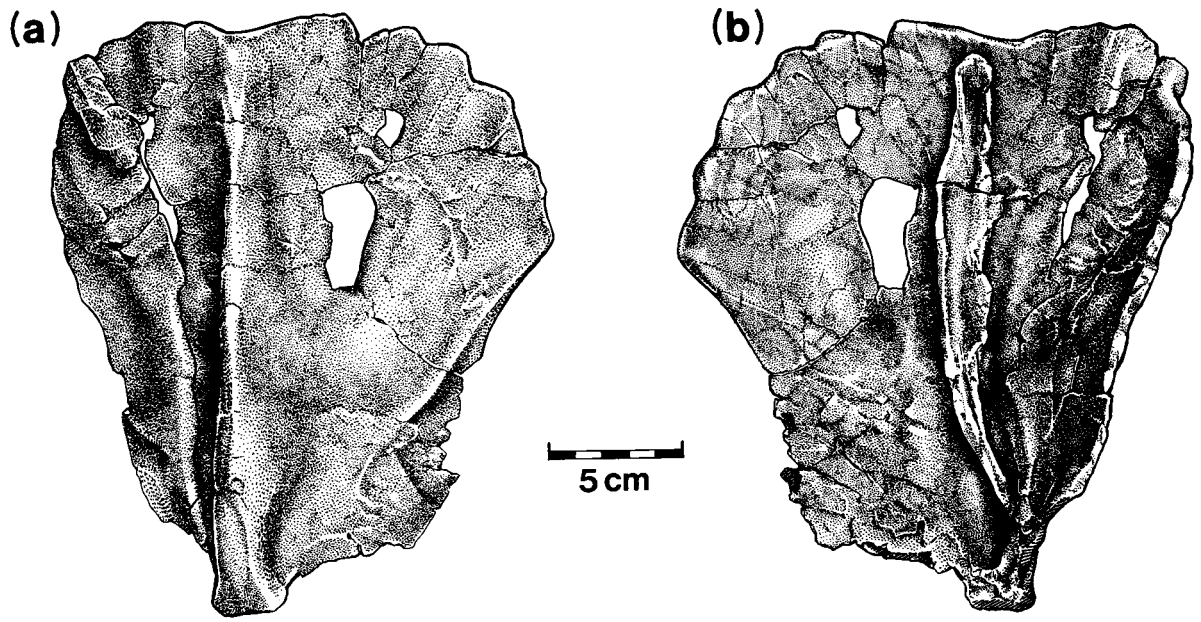


FIG. 1. Parietal bone of TMP 82.16.11 in (*a*) dorsal and (*b*) ventral views. Right splenial visible in (*b*).

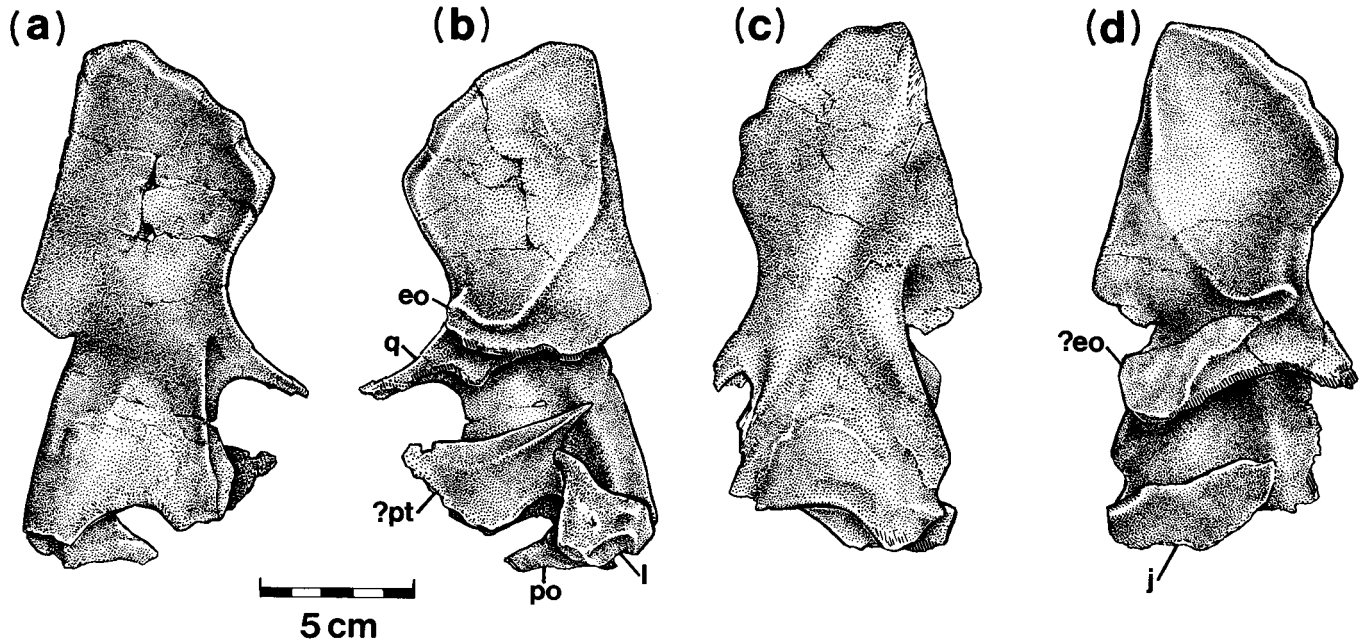


FIG. 2. Left (*a*, *b*) and right (*c*, *d*) squamosals of TMP 82.16.11 in lateral (*a*, *c*) and medial (*b*, *d*) views. Abbreviations: eo, exoccipital suture; ?eo, exoccipital fragment; j, right jugal fragment; l, left laterosphenoid; po, postorbital fragment; ?pt, possible pterygoid fragment; q, quadrate suture.

concave surface that enclosed the mandibular fossa. The splenial is long (160 mm) and slender as in other ceratopsids, with a maximum height rostral to the internal mandibular foramen of 23 mm. As the bone appears to be complete, it is apparent that the lower jaw (excluding the predentary) would have been less than 200 mm long.

*Laterosphenoid*

Both laterosphenoids are well preserved. Each consists of a robust rectangular body (Fig. 4), pierced by a prominent trigeminal foramen, and a more delicate rostrodorsally inclined postorbital process. The foramen for the first branch of the trigeminal nerve is completely enclosed by the left laterosphenoid, but on the right side, the prootic (not preserved) formed part of the border of the foramen. Distinct thickened facets indicate articulations with the basisphenoid ventrally, prootic caudally, and the supraoccipital dorsally. It measures 42 mm in length and 32–36 mm in height. The maximum thickness is 16 mm at the base of the postorbital process, which is 3.6 mm thick.

## Discussion

The taxonomy of ceratopsids is based almost exclusively on adult specimens, which typically have distinctive patterns of horns and frills. The present specimen has no horns, and the

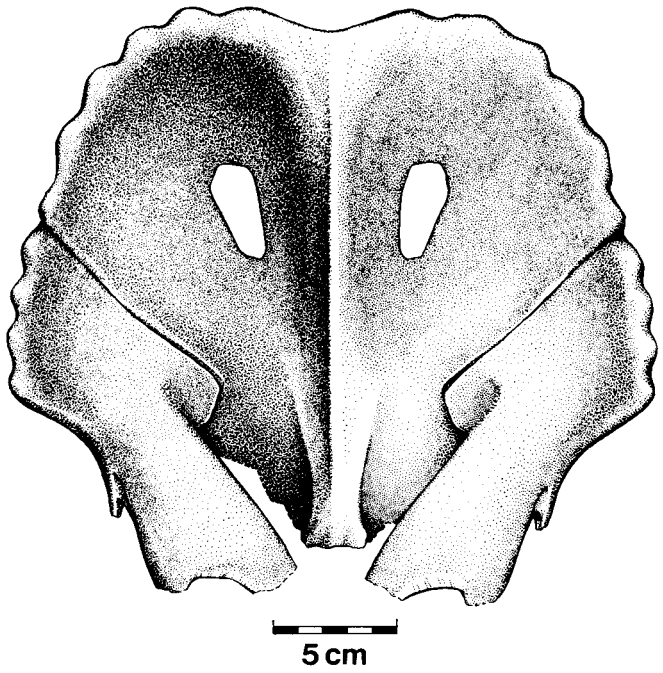


FIG. 3. cf. *Monoclonius sp.* Reconstruction of parietosquamosal frill of a juvenile, based on TMP 82.16.11.

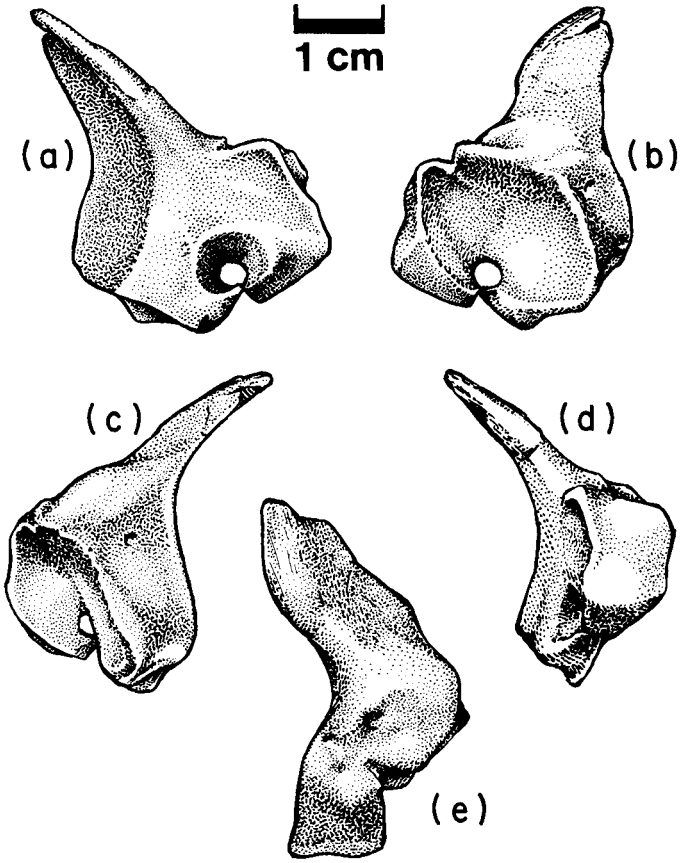


FIG. 4. Right laterosphenoid of TMP 82.16.11 in (*a*) lateral, (*b*) medial, (*c*) caudal, (*d*) rostral, and (*e*) dorsal views.

nearly solid frill does not readily suggest any particular species. Solid-frilled ceratopsids are almost unknown from the Campanian (*Avaceratops* (Dodson 1986) being the only reported example). Determining the identity of this juvenile specimen is thus a challenging exercise. *Centrosaurus* and *Chasmosaurus* are among the most common dinosaurs found in the park, being twice as common as *Styracosaurus* and four times as common as *Monoclonius* (Dodson 1983). *Chasmosaurus* may be ruled out because its squamosal has a very distinctive shape, with a flexed profile of its dorsal border. In fact, the stepped profile of the dorsal border of the squamosal is very distinctive of the *Centrosaurus–Monoclonius–Styracosaurus* type. The adult *Centrosaurus* is characterized by a thickened caudal border of the parietal, with a pair of horns projecting backwards and one or two horns pointing forwards overhanging large parietal openings (Dodson, in preparation). *Styracosaurus* has a distinctive, elaborate set of parietal spikes. The thin caudal border of the parietal of TMP 82.16.11 suggests none of the features that are so distinctive of *Centrosaurus* or *Styracosaurus*. It is therefore referred, albeit tentatively, to *Monoclonius*, the parietal of which is thin along the caudal edge and lacks parietal horns of any kind (Sternberg 1938, 1940).

Until now, there has been almost no information on ontogenetic changes in ceratopsid skulls. By default, information from *Protoceratops* (Brown and Schlaikjer 1940; Dodson 1976) must apply. In *Protoceratops*, the length of the parietal and the length and width of the parietal were isometric in ontogeny, i.e., they show no change in relative size during growth. Adults of all known Judithian ceratopsids show large parietal fenestrae. Therefore, strong positive allometry of parietal fenestrae is inferred. Evidently, the sagittal ridge on the parietal decreases in prominence ontogenetically, for in adult *Centrosaurus, Monoclonius*, and *Styracosaurus* it forms a low median bar rather than a sagittal ridge. It is possible that strong positive allometry of the parietal during growth could result in the production of a thickened caudal bar and parietal horns. However, this must remain a matter of conjecture until additional specimens are found.

If isometry of the length of the parietal as in *Protoceratops* be assumed, it is possible to estimate the length of the individual based on Gilmore's (1917) reconstruction of *Brachyceratops*. *Brachyceratops* was 1.6 m long and had a parietal that measured 315 mm; TMP 82.16.11 has a parietal that measures 210 mm in length and accordingly scales as an animal 1.1. m long, approximately one fifth the size of an adult *Centrosaurus* or *Monoclonius*. Such a juvenile would have been no more than three times its hatching length, and it was certainly less than 2 years old.

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