

# Possible oviraptorosaur (Theropoda, Dinosauria) specimens from the Early Cretaceous Otway Group of Dinosaur Cove, Australia

P. J. CURRIE, P. VICKERS-RICH AND T. H. RICH

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The Early Cretaceous Otway and Strzelecki Groups exposed on the southern coast of Victoria, Australia, have produced a fauna of dinosaurs that lived within the Antarctic Circle. As many as five or six species of hypsilophodontids numerically dominate the collections from there, but the rarer and more fragmentary theropod remains suggest a surprising diversity of carnivorous dinosaurs. A possible surangular and an isolated vertebra have characters considered diagnostic for Late Cretaceous oviraptorosaurs of the Northern Hemisphere. Other fossils suggest the presence of ornithomimosaur, dromaeosaurids and neoceratopsians, and with the possible oviraptorosaur remains, challenge the widespread assumption that these animals originated on the northern continents.

*P. J. Currie, Royal Tyrrell Museum of Palaeontology, Box 7500, Drumheller, Alberta T0J 0Y0, Canada; P. Vickers-Rich, Departments of Earth Sciences and Ecology & Evolutionary Biology, Monash University, Clayton, Victoria 3168, Australia; T. H. Rich, Museum of Victoria, 328 Swanston Street, Melbourne, Victoria 3000, Australia; received 31 December 1994.*

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AT THE BEGINNING of the 20th Century, a single theropod phalanx together with a lungfish tooth was discovered in the Early Cretaceous Strzelecki Group near Inverloch, Victoria, Australia, by William Hamilton Ferguson (Woodward 1906). Subsequently, one specimen of a turtle, *Chelycarapookus arcuatus* Warren (1969) was probably found in the Early Cretaceous Merino Group in the western part of the State, and the Koonwarra biota was recovered from the Strzelecki Group not far from Inverloch (Waldman 1971; Dettmann 1986; Drinnan & Chambers 1986; Jell & Duncan 1986).

A systematic search was initiated in 1978 for fossil tetrapods near Ferguson's locality, and has ultimately resulted in the discovery of four sites of note in the Otway Group and six in the Strzelecki Group (Rich & Rich 1989; Vickers-Rich & Rich 1993).

The dinosaur assemblage from Victoria is unusual in being dominated both in the number of specimens and the variety of species by the hypsilophodontids. Although less than two score of theropod specimens have been found in the same rocks, this is the second most diverse group represented there. The phalanx recovered by Ferguson was compared with "...one of the finest known Megalosaurian claws from the English Wealden..." by Woodward (1906). Within 200 m of the site where it was found, T. Flannery recovered an astragalus, which was tentatively identified as that of *Allosaurus* by Molnar *et al.* (1985).

Three theropods are represented in the assemblage from Dinosaur Cove in the Otway Group. Ornithomimosaur femora from there were the basis for recognising a new genus and species in that family, *Timimus hermani* Rich & Vickers-Rich (1994). In addition, a pubis (NMV P186058) and vertebrae from there and one site

in the Strzelecki Group are referable to the ornithomimosaur. There is also a small dromaeosaurid-like tooth (NMV P186343) known from Dinosaur Cove. Here we report on the probable occurrence of another theropod group, the oviraptorosaurs.

A possible surangular (NMV P186386) and an isolated dorsal vertebra (NMV P186302) compare closely to equivalent bones in Late Cretaceous oviraptorosaurs. Both specimens were collected from the Dinosaur Cove East locality (Rich & Rich 1989) at Dinosaur Cove (38° 46' 53±1" S, 143° 24' 14±1" E) from late Aptian to early Albian rocks (Wagstaff & McEwen-Mason 1989).

*Abbreviations.* AMNH, Department of Vertebrate Paleontology, American Museum of Natural History, New York, U. S. A.; GI, Geological Institute, Section of Palaeontology and Stratigraphy, Academy of Sciences of the Mongolian People's Republic, Ulaan Bataar, Mongolia; NMV, Department of Vertebrate Palaeontology, Museum of Victoria, Melbourne, Australia.

## Description

NMV P186386 (Fig. 1) appears to be an incomplete right surangular of a small theropod. It may be some bone other than a surangular, because it does not match perfectly the surangulars of any known species. Nevertheless, it more closely resembles a theropod surangular than it does any other theropod cranial element. There is a superficial resemblance to the palatal process of a dromaeosaurid pterygoid. However, it is not as close a match in that it is pierced by several foramina, the margins are too strongly folded in relation to the main surface of the bone, and the region that would be interpreted as the junction of the palatal, quadrate and basipterygoid plates is too long and flat. Because the bone is incomplete anteriorly and posteriorly, and the curvature has been accentuated by postdepositional distortion, it may not be possible to positively identify it unless better material is found at the

same site. However, the strong resemblance to a theropod surangular, and the presence in the same beds of theropod bones representing animals of the same general size makes it worthwhile to put the specimen on record.

Assuming that NMV P186386 is a surangular, in overall size and shape it is close to the right surangular of AMNH 5356, the holotype of *Dromaeosaurus albertensis* (Currie 1995). This suggests the jaw of the complete animal was about 20 cm long. Most of the bone (Fig. 1) was a curved but more or less vertical plate that presumably formed the lateral wall of the adductor fossa. The height of the bone decreases posteriorly, until it is an almost horizontal, flat plate of bone (Fig. 1c), the ventrolateral surface of which would have contacted the angular. The apparent suture with the angular pinches out anteriorly. There is no demarcation between the angular contact and the rim of the external mandibular fenestra, so it is not possible to determine the exact size of the fenestra, although it appears to have been large. The thin, convex margin of the supposed surangular is more similar to that of *Dromaeosaurus* (Currie 1995) than it is to *Caenagnathus* (Currie *et al.* 1993).

Although NMV P186386 resembles a dromaeosaur surangular in general form, especially the contact with the angular, there are a number of peculiarities. The coronoid process has a pronounced medial inflection (Fig. 1a) that is characteristic only of oviraptorosaurs (Sternberg 1940; Barsbold *et al.* 1990; Currie *et al.* 1993). Anterolateral to the inflection, there is a longitudinal depression (Fig. 1a, b) along the lateral surface of the upper margin of the possible surangular, possibly marking the insertion of the *M. pseudotemporalis superficialis* as in oviraptorosaurs. There is no evidence of either anterior or posterior surangular foramina, both of which seem to have been incorporated into the enlarged external mandibular fenestra of oviraptorosaurs. The medial margin of the inflected coronoid process is pierced anteriorly by a foramen, however, suggesting that the exit for the external mandibular artery and cutaneous

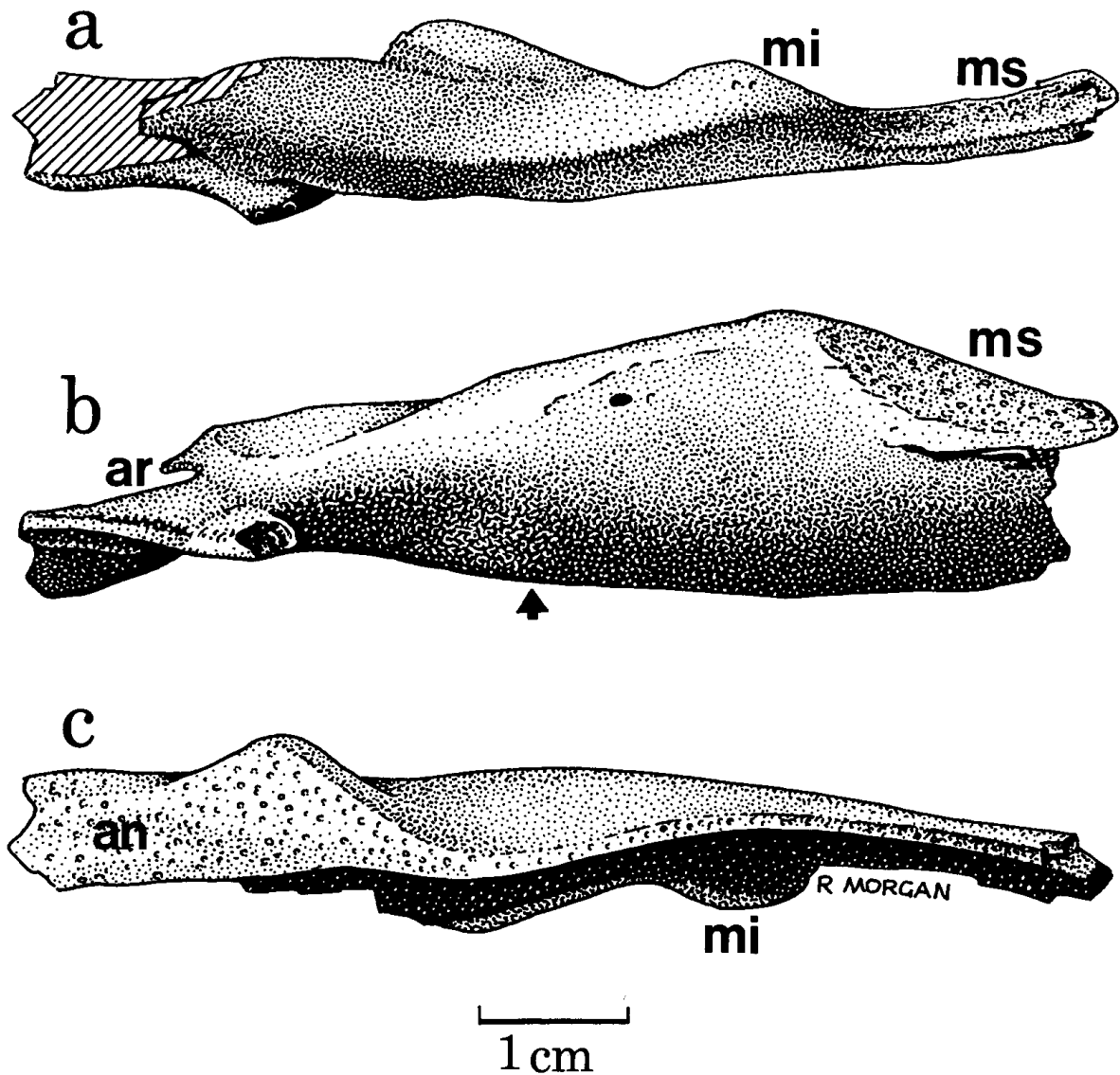


Fig. 1. NMV P186386, incomplete possible right surangular of a possible oviraptorosaur in dorsal (a), lateral (b) and ventral (c) aspects. Margin of external mandibular fenestra would have been to the right of the arrow. Abbreviations: an, sutural surface for angular; ar, sutural contact with articular; mi, medial inflection of coronoid process; ms, muscle scar of *M. pseudotemporalis superficialis*.

branch of the inferior alveolar nerve (Oelrich 1956) may simply have changed its position. There is a depression in the lateral surface of the possible surangular anteroventral to the contact with the articular. Although NMV P186386 more closely resembles a caenagnathid because of these peculiarities, it was not fused to the articular and coronoid as it is in all known oviraptorosaurs (Currie *et al.* 1993).

An isolated dorsal vertebra (NMV P186302,

Figs 2, 3) of a small theropod is relatively primitive in most aspects. The centrum is 23 mm long with shallow platycoelous ends, and is as wide as it is high (30 mm). The ends flare out conspicuously (Fig. 2c) from a mid-length constriction (21 mm). There is a single pleurocoel (diameter 3.8 mm) high on each side of the centrum (Fig. 2a), which enters a large internal vacuity (pneumatic camera) separated by a medial septum from its equivalent on the other side (Fig.

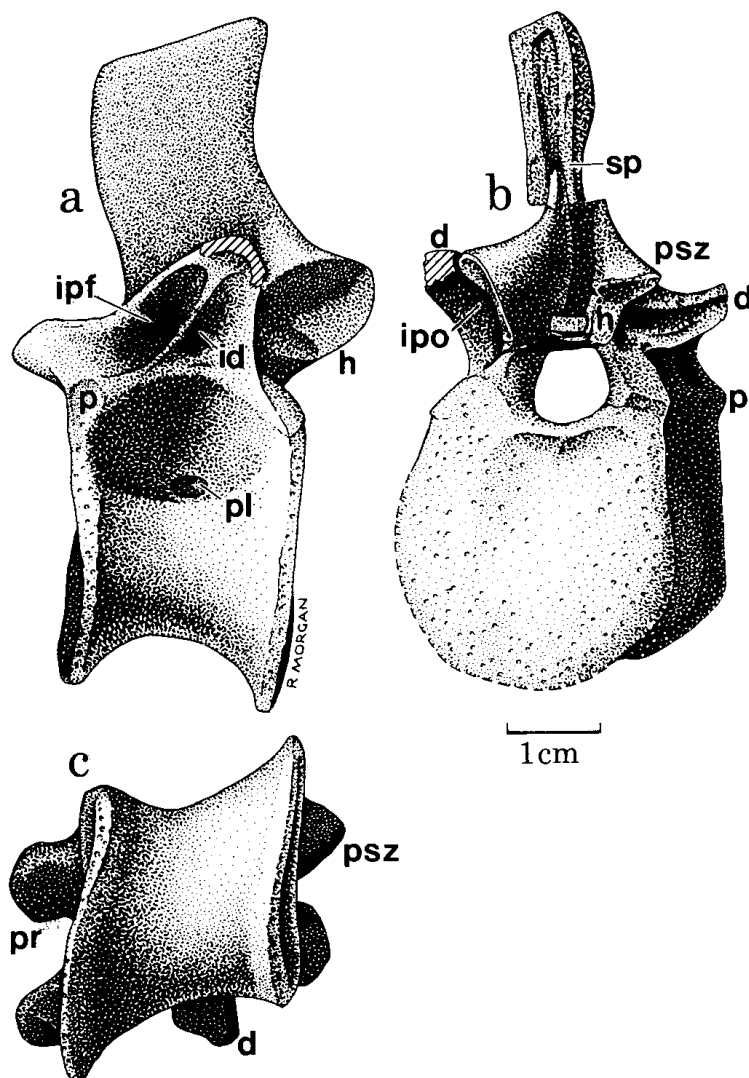


Fig. 2. NMV P186302, isolated dorsal vertebra of a small theropod, possibly an oviraptorosaur, in left lateral (a), posterior (b) and ventral (c) views. Abbreviations: d, diapophysis; h, articular facet of hyosphene; id, infradiapophysial fossa; ipf, infraprezygapophysial fossa; ipo, infrapostzygapophysial fossa; p, parapophysis; pl, pleurocoel; pr, prezygapophysis; psz, postzygapophysis; sp, suprapostzygapophysial lamina.

3b, c). The presence of simple internal cavities divided by a median septum is considered to be primitive for theropods (Britt 1993). It is not surprising that this is a widespread character that is found in both dromaeosaurids and oviraptorosaurs. The neurocentral suture has not been obscured by co-ossification, but was still tightly bound. The neural spine is relatively low, and rises to a height of 37 mm above the top of the neural canal. It expands distally to an antero-

posterior length of 19 mm, and width of 8 mm.

The parapophyses and diapophyses are incomplete. Their positions relative to the neural canal show that NMV P186302 was an anterior dorsal vertebra, probably around the fifth. The zygapophysial facets are oriented more ventrally than laterally. The articular facet of the postzygapophysis curves medioventrally into a poorly-defined, laterally-facing hyosphene articular facet (Fig. 2b) similar to that of

*Deinonychus antirrhopus* (Ostrom 1969, fig. 33B). Like most primitive theropods, the neural arch has a complicated system of laminae and pneumatic fossae and foramina. Well-defined laminae (Fig. 2a, b) join the prezygapophysis to the diapophysis, the diapophysis to the posteroventral corner of the neural arch, the prezygapophysis to the anterolateral margin of the neural spine, the postzygapophysis to the posterolateral margin of the neural spine, and both zygapophyses to their mates on the opposite side. There is a strong ridge between the prezygapophysis and the parapophysis, and a low, weak lamina between the parapophysis and the posteroventral corner of the neural arch. The intricate system of laminae and ridges outline the infraprezygapophysial, infradiapophysial and infrapostzygapophysial pneumatic fossae (Britt 1993). Foramina in the inner walls of each fossa open into the base of the neural arch (Fig. 3a, b), and into the transverse processes and neural spine, but do not extend into the zygapophyses. The spongy bone towards the distal ends of the neural spine and transverse processes may be

pneumatic too because it bears a superficial resemblance to the complex pneumatic interior of tyrannosaurid centra. The supraprezygapophysial laminae border a shallow, vertical trough (the intraspinous ligament scar; Britt 1993) on the anterior surface of the neural spine, as do the suprapostzygapophysial laminae (Fig. 2b) on the posterior side. These troughs are deep ventrally between the zygapophyses.

## Discussion

If NMV P186386 is correctly identified as a right surangular, it shows characteristics that are intermediate between dromaeosaurids and oviraptorosaurs. Like caenagnathid oviraptorosaurs, there is a distinct medial inflection of the coronoid process, a distinct longitudinal muscle attachment anterolateral to the inflected process, loss of the anterior and posterior surangular foramina, a large external mandibular fenestra and a deep lateral depression anteroventral to the contact with the articular.

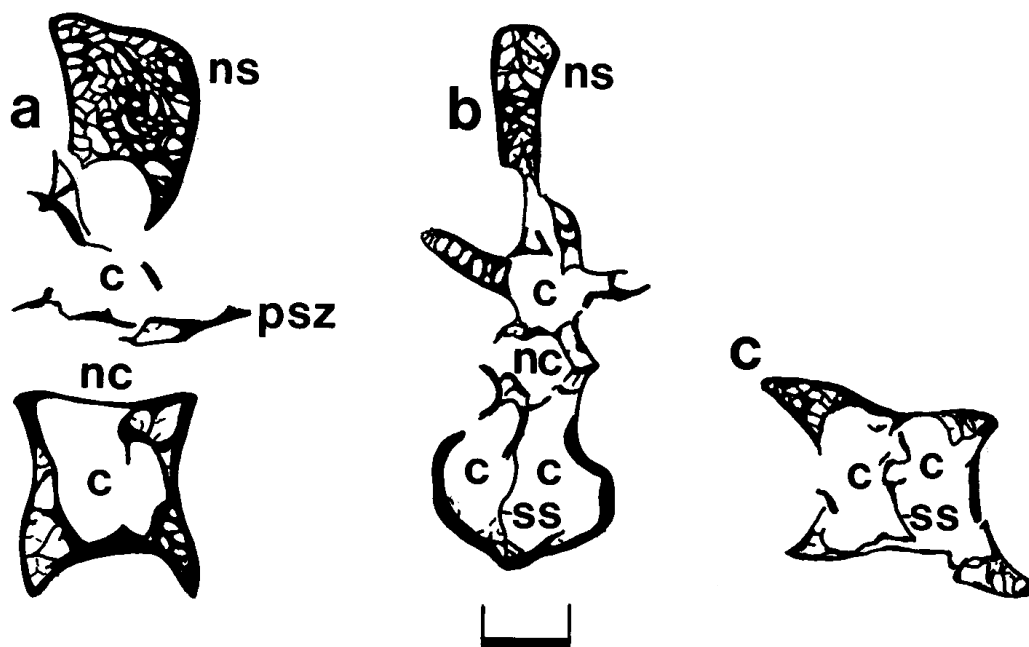


Fig. 3. NMV P186302, drawing from CT scans showing pneumatic spaces within dorsal vertebra: a, parasagittal section to the left of the midline; b, cross-section through bases of diapophyses; c, horizontal section through mid-height of centrum. Abbreviations: c, pneumatic camera; nc, neural canal; ns, neural spine; psz, postzygapophysis; ss, sagittal septum. Scale = 10 mm.

Unlike known oviraptorosaurs, the possible Australian surangular is not fused to the articular, nor is there any evidence that it was fused to the coronoid. The presence of an oviraptorosaur in the Early Cretaceous of Australia is not unreasonable. The earliest caenagnathids are from Turonian beds of Uzbekistan (Currie *et al.* 1993), but they are already highly specialised oviraptorosaurs that had obviously split off from other theropod lineages long before. Currie & Russell (1988) speculated that *Microvenator celer* of the Early Cretaceous of Montana may be an early oviraptorosaur.

The anterior dorsal vertebra has many plesiomorphic characters, making it difficult to place. In most theropods, however, pleurocoels are generally only found in the cervical vertebrae and the first one or two dorsals, and pleurocoels entering the side of the centrum are paired. The two exceptions to this amongst small theropods are the dromaeosaurids and oviraptorosaurs (Gilmore 1924; Currie *et al.* 1993), both of which have single pleurocoels on each side of every dorsal centrum. The neural spines of known dromaeosaurids (Ostrom 1969; Currie & Varricchio, in preparation) are relatively taller than that of NMV P186302, whereas those of oviraptorosaurs (such as GI 100/42) are shorter with a relatively greater dorsal expansion. The low, poorly developed lamina between the parapophysis and posteroventral corner of the neural arch of NMV P186302 is something that has not been seen on any dromaeosaur dorsal, but is present in *Oviraptor philoceratops* (GI 100/42).

Specimens collected from the south coast of Victoria suggest that at least four distinct types of theropods lived in Australia during Aptian-Albian times. Although relatively diverse there, theropod fossils continue to be extremely rare. The presence of a diverse fauna of small theropods, including possibly oviraptorosaurs, is not unexpected. The rarity of maniraptoran theropods in Lower Cretaceous rocks is related to preservational biases, and many families common in Upper Cretaceous sediments can trace their ancestry as far back as Late Jurassic times

(Milner & Evans 1991; Howse & Milner 1993; Chure 1994; Zinke & Rauhut 1994). In fact, a possible oviraptorosaur has recently been reported from the Early Cretaceous of Brazil (Frey & Martill 1995).

Recently, ornithomimosaur and neoceratopsians have been reported from Australia (Rich & Vickers-Rich 1994). Being Aptian, the neoceratopsian record if true, is much earlier than the group is known elsewhere. The ornithomimosaur *Timimus hermani* and the possible oviraptorosaur reported here are among the earlier records for their respective groups. Although these Australian occurrences do not establish that these groups originated on the Gondwana continents, they at least suggest increased geographic and temporal ranges.

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