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Recent developments in Australasian sauropterygian palaeontology (Reptilia: Sauropterygia)

Arthur R.I. Cruickshank[1], R. Ewan Fordyce[2] and John A. Long[3]

[1] Earth Sciences Section, Leicester City Museum, New Walk, Leicester LE1 7EA, UK, and Geology Department, Leicester University, Leicester LI1 7RH, UK; email: aric1@leicester.ac.uk

[2] Department of Geology, Otago University, PO Box 56, Dunedin, New Zealand

[3] Western Australian Museum, Francis Street, Perth, WA 6000, Australia

Abstract – A brief review of recent research into Australasian sauropterygians is given. The earliest record is an Anisian pachypleurosaur from South Island, New Zealand. An Early Jurassic record from Queensland, hitherto included in the Plesiosauria is shown to be the last known pachypleurosaur. A diverse record of Pliosauroidea is known from the time of the break-up of East Gondwana, in marginal rift sediments of Western Australia and South Australia, dated to the earliest Cretaceous. The record of the marine incursion into the Eromanga Basin, Queensland, contains Albian-age pliosaurs and elasmosaurs. The New Zealand plesiosaurian record contains mostly members of the 'long-necked' Plesiosauroidea, all from the Haumurian stage of the Campanian-Maastrichtian. One specimen represents a unique record of a cryptoclidid in Australasia, more closely related to the European Callovian *Cryptoclidus* than to the other late cryptoclidids known from South America and the Antarctic Peninsula.

INTRODUCTION

The sauropterygians were an entirely aquatic group of reptiles which trace their ancestry to the Late Permian tangasaurids of Madagascar, and whose intermediate evolutionary stages, the Pachypleurosauridae and the Nothosauriformes, are best displayed in the Middle Triassic of the European Alpine (Tethyan) region (Brown 1981; Carroll 1987). The best-known of the sauropterygians are the Plesiosauria, the earliest of which is *Pistosaurus*, also occurring in the European Tethyan realm, and of Anisian (Middle Triassic) age. A functional progression from laterally undulatory swimming, through a 'rowing' phase, to underwater 'flight', akin to that practised by living sealions, is demonstrated in the sauropterygians, with the plesiosaurians showing full adaptation to underwater flight. The Plesiosauria comprises the plesiomorphic Pliosauroidea (here we follow Brown 1981 in recognizing only a single family, the Pliosauridae: but other classifications recognize the additional families Polycotylidae and Brachauchenidae); and the more derived Plesiosauroidea, obtaining three families: the Plesiosauridae, the Elasmosauridae and the Cryptoclididae. The last two are well represented in the Australasian realm (Figure 1, overleaf).

NEW ZEALAND MATERIAL

Sauropterygians have been known for over a century from the Haumurian Stage of the Campanian-Maastrichtian in South Island, New Zealand (Welles and Gregg 1971; Hiller *et al.* 1997).

More recently, a rich tetrapod fauna, including sauropterygians and other marine reptiles, has been recovered from horizons of much the same age from the Mangahouanga Stream site in the North Island by Dr Joan Wiffen and her associates (Wiffen and Moisley 1986; Molnar and Wiffen 1994; Wiffen 1996; Long 1998). Fordyce (1991) comprehensively reviewed the New Zealand marine vertebrate record, and Long (1998) included an illustrated summary of the known New Zealand Mesozoic marine reptiles.

Another recent discovery in the New Zealand Anisian, as part of the extension of the Tethys, comprises remnants of a pachypleurosaur sauropterygian (Figure 2A). The evidence is in the form of a single very well preserved posterior dorsal or anterior sacral vertebra, and other bone fragments, showing strong affinities with European forms, except that it is much larger than the described species.

The plesiosauroids (Figure 2B,C) are represented by forms in both the Australian Albian and the New Zealand Maastrichtian. The New Zealand

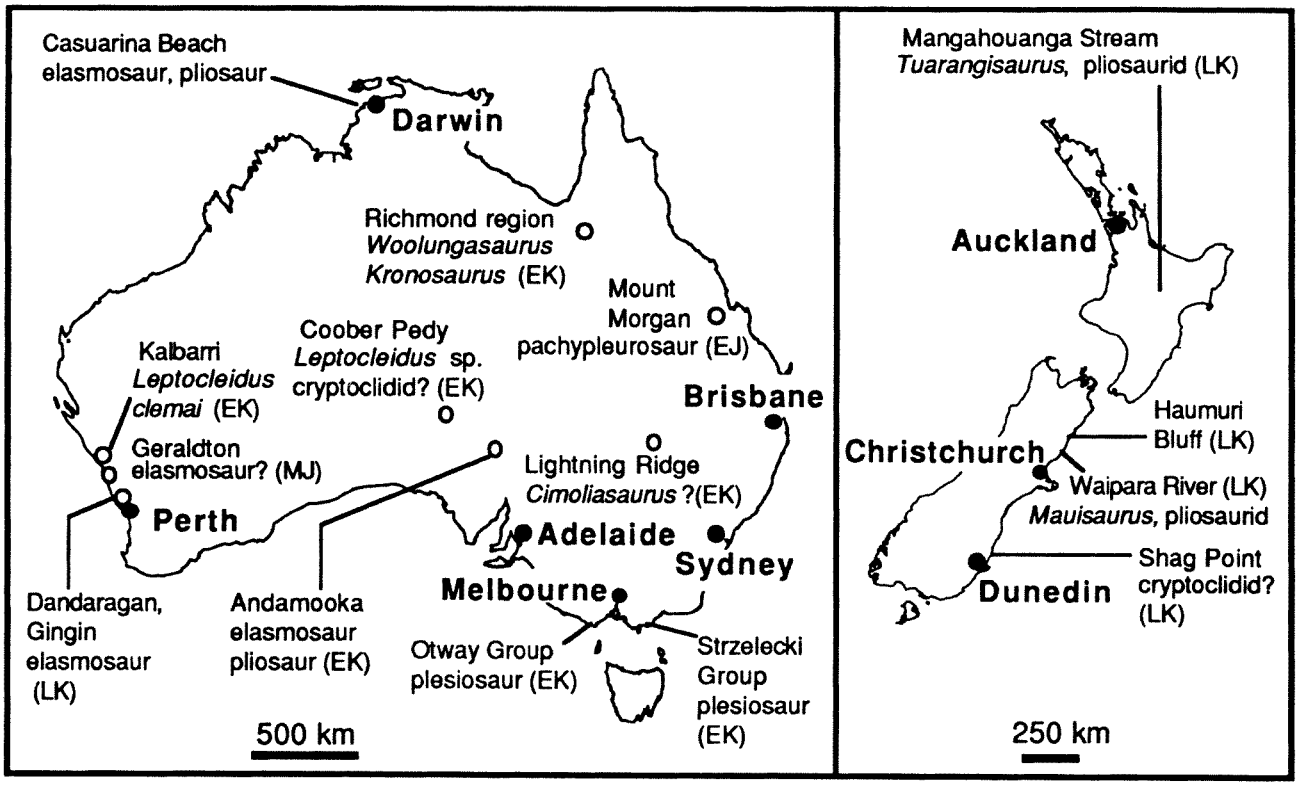

Figure 1 Maps showing major occurrences of sauropterygian fossils in Australia and New Zealand. EJ = Early Jurassic; MJ = Middle Jurassic; EK = Early Cretaceous; LK = Late Cretaceous.

elasmosaurs are historically important, having been reported from the earliest days of geological exploration of that country (Long 1998). Two genera predominate in these faunas; *Mauisaurus*, the historically important taxon, and *Tuarangisaurus*, collected by Joan Wiffen and colleagues (Wiffen and Moisley 1986). The former is not well defined, being based on a quantity of dissociated limb and other postcranial material, whereas the latter is known from a single skull and some uncertainly-associated neck vertebrae. Unfortunately there is no overlap of this material. However, re-examination of fossil holdings in the Canterbury Museum and further collection of new specimens may solve this problem (Hiller *et al.* 1997).

Whereas elasmosaurids (Figure 2C) are the apparently common plesiosaurian group found in New Zealand, a recently recognized cryptoclidid from Shag Point, North Otago, presents a novel set of adaptations (Cruickshank and Fordyce 1996, 1998). The specimen is from very near the top of the Maastrichtian sequence, and at 6.5 m overall length is among the largest of known cryptoclidids. The skull is proportionally larger than normal for a plesiosauroid and has relatively large orbits and temporal openings. Cladistic analysis shows it to be closer to *Cryptoclidus* (Figure 2B) than to the other two austral genera reported to date – *Aristonectes* and *Turneria* (Cabrera 1941; Chatterjee and Small 1989). It appears that there were at least two radiations of large southern cryptoclidids in the Late Cretaceous Palaeopacific, which, alongside the numerical importance of the elasmosaurs, indicates an ocean of more than minimal productivity at that time.

Pliosauroids are also present in the Late Cretaceous of New Zealand, based on generically indeterminate postcranial material from Waipara River and Haumuri Bluff districts described by Welles and Gregg (1971), and from the Mangahouanga Stream site (Wiffen and Moisley 1986).

AUSTRALIAN MATERIAL

A review of the Mount Morgan 'plesiosaur' (Bartholomai 1966; Molnar 1991) has been undertaken by one of us (A.R.I.C.). This difficult material consists of negative moulds in a ferruginous sandstone, and comprises remains of several individuals. The age is constrained as Early Jurassic (Playford and Cornelius 1967). A close examination of the material indicates that it has pachypleurosaur affinities, and is not plesiosaurian. The redescription will indicate that in the Australasian Tethys there was an early representative of the Sauropterygia and (if the above identification is correct), the latest known pachypleurosaur.

Although the plesiosaurs are taken to be a typical component of marine faunas, several Jurassic and

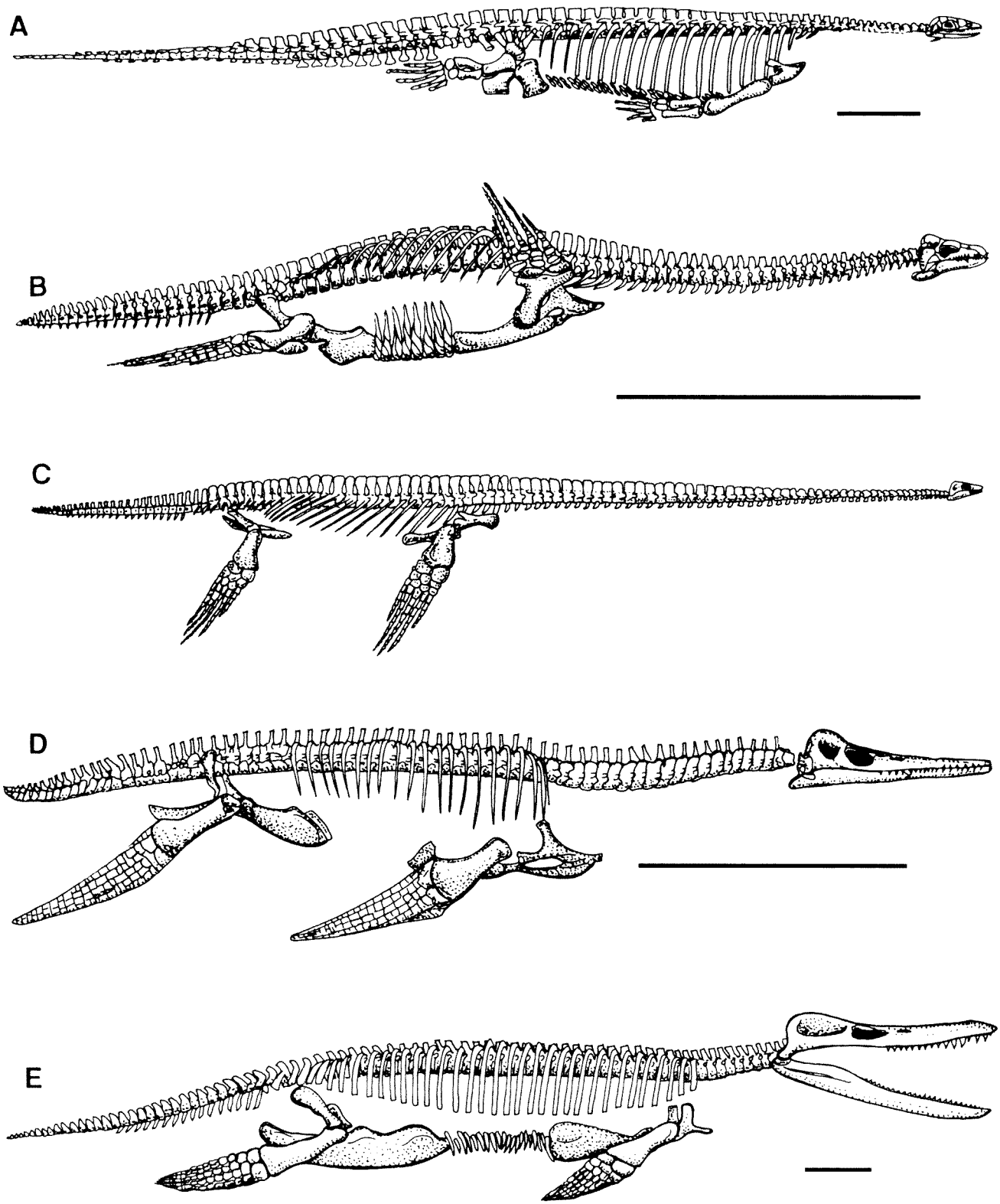

Figure 2 Representative skeletons of Mesozoic sauropterygian groups discussed in the text. The scale bar for A = 10 cm; for B–E = 1 m. A, a pachypleurosaur *Pachypleurosaurus*, Family Pachypleurosauridae. B, a short-necked plesiosaur *Cryptoclidus*, Family Cryptoclididae. C, a long-necked plesiosaur *Hydrotherosaurus*, Family Elasmosauridae. D, a long-necked pliosaur *Dolichorhynchops*, Family Pliosauridae. E, a short-necked pliosaur *Kronosaurus*, Family Pliosauridae. A–C, E are after Carroll (1987), D is after Williston (1902).

Early Cretaceous specimens have been recovered from 'non-marine' horizons (Cruickshank 1997). In the Early Cretaceous (Barremian/Valanginian) of Western Australia a new species, *Leptocleidus clemai*, has recently been described from sediments containing fossilized wood and a dinosaur vertebra (Long and Cruickshank 1996; Cruickshank and Long 1997). The genus *Leptocleidus* is known from a close-inshore deposit in South Africa, and from a non-marine 'Wealden' locality in England (Andrews 1911, 1922). Another closely related specimen is the famous 'Eric', an almost complete opalized skeleton from the Maree Formation, a near-shore marine deposit at Coober Pedy in South Australia, which has been the subject of a thesis recently submitted by Schroeder (1998). Other fragmentary plesiosaurian material from 'freshwater' deposits has been recorded from Andamooka in South Australia, as part of the sedimentary history of the marine incursion when Antarctica and Australia broke apart.

Leptocleidids are relatively small plesiosaurs which possibly fed on fish and cephalopods in the surf-zone, or estuaries, and seem to be related to the 5 m long Early Jurassic genus *Rhomaleosaurus*. They are also of interest in seeming to form an intermediate stage towards the other, relatively small-sized, plesiosaur group, the polycotylids, a common component of the Late Cretaceous Great American Seaway (Figure 2D). 'Eric' is the youngest of known *Leptocleidus* species (Albian) and seems to be the closest to the polycotylids of all the known species. A very early polycotylid is under study in Brisbane by Drs Thulborn and Wade — the 'Richmond pliosaur', known from a complete articulated skeleton almost 5 m in length (figured in Long 1998: 146–147).

Historically important pliosaurid material has also been known from the Queensland Albian for many years, including *Kronosaurus* (Figure 2E), one of the largest sauropterygians ever described (Longman 1924). *Kronosaurus queenslandicus* is a giant form reaching nearly 14 m, as shown by the reconstructed skeleton on display at the Harvard University Museum of Comparative Zoology (Romer and Lewis 1959), although much of this reconstruction comprises plaster reconstructions of missing pieces. *Kronosaurus* is now known from almost a dozen specimens and is the subject of a doctoral dissertation by Colin McHenry of the University of Queensland.

Several elasmosaurs have been reported from Australia, but only one has been named. This is the genus *Woolungasaurus* from the Albian of Queensland (Persson 1982). The type is of additional interest as it shows clear evidence of how it met its demise: there are tooth marks on the side of the skull and the skull has been crushed flat (Thulborn and Turner 1993). A very large dorsal vertebra, plus smaller elongate vertebrae belonging to elasmosaurs are also known from the early Late Cretaceous Molecap Greensand, at Dandaragan, Western Australia, and have recently been described by Long and Cruickshank (1998). Other South Australian elasmosaurs include the 'Andamooka sea monster' (Rich and Rich 1985) and more unassigned opalized specimens, as well as several occurrences reported and figured by Long (1998) from isolated finds over many years.

CONCLUSIONS

The Australasian realm seems to have been an important area for the evolution of leptocleidid pliosaurs in the shallow seas which resulted from the first rifting of the breakup of East Gondwana; it was also possibly the place where the early radiation of polycotylids took place. It has at least one Triassic pachypleurosaur, and probably the very last of them, in a freshwater refuge in what is now Queensland. The Central Australian seaway was host to one of the largest pliosaurs ever to inhabit Mesozoic seas, as well as to its own large elasmosaur.

New Zealand has a wealth of Late Cretaceous plesiosauroids, indicating a rich marine fauna. Finally, at the end of the Cretaceous, the entire spectrum of marine tetrapods, with the exception of the Chelonia, became extinct. The first of the whales did not appear until the early Eocene, after a gap of 10 million years. The Cretaceous/Tertiary sequence is almost unbroken in many parts of New Zealand and it would be of great interest to analyse the faunas of the Paleocene to see whether there were any top tetrapod predators after the plesiosaurs and mosasaurs, and before the advent of the whales.

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