

Short communication

Discovery of a Cretaceous angiosperm reproductive structure from New Zealand

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Abstract Angiosperm reproductive structure macrofossils have been discovered in Late Cretaceous rocks from northwest Nelson, South Island, New Zealand. We have collected over 100 specimens of the same form, of striking stellate appearance, from a locality of late Campanian or Maastrichtian age. These are the first such fossils of Cretaceous age reported from New Zealand.

Keywords angiosperm reproductive structure; flower macrofossils; Late Cretaceous; northwest Nelson; New Zealand

In recent decades, several notable discoveries of Cretaceous flower macrofossils have been made in the Northern Hemisphere. Of these, the most remarkable are the very elegantly reconstructed *Archaeanthus lindenburgii* (Dilcher & Crane 1984) and an unnamed intact rosalean flower (Basinger & Dilcher 1984), both from the Dakota Formation. The discovery (Friis & Skarby 1981) that the application of sieving techniques to suitable deposits can result in the recovery of tiny charcoaled or mummified flowers which retain much structural detail has resulted in an explosion of finds of Cretaceous floral mesofossils. Examples have been reported from Early Cretaceous deposits from Portugal (Crane et al. 1995; Friis et al. 1999) and the Potomac sequence of the United States (Crane et al. 1995; Friis et al. 1986; Crane & Herendeen 1996). Late Cretaceous mesofloras have been studied from Sweden (Friis & Skarby 1981; Eklund et al. 1997) and elsewhere in Europe (Knobloch & Mai 1991; Eklund & Kvacek 1998), several localities in the

eastern United States (Crane & Herendeen 1996; Herendeen et al. 1999; Sims et al. 1999), and, most recently, Japan (Takahashi et al. 1999) and Kazakhstan (Frumin & Friis 1999). However, although mesofloras have spectacularly demonstrated the diversity of small flowers in the Cretaceous, by their very nature they cannot give a reliable indication of the relative importance of small and large flowers in the floras of that period.

There have been to date very few reports of Cretaceous flower macrofossils from Gondwanan continents, and even studies on southern Cretaceous angiosperm leaf fossils were, until recently, relatively few. In this context, the recognition (Taylor & Hickey 1990) of a flower fossil of Aptian/Albian age from Koonwarra in Victoria, Australia, was unexpected. This unique specimen is indifferently presented and the flowers are tiny. This fossil is sufficiently obscure for it to have been originally referred (albeit with uncertainty) to the Marsileales (Drinnan & Chambers 1986). Until recently, the Koonwarra fossil remained the only report of a Mesozoic flower from the Southern Hemisphere. Flower fossils have now been reported from the Santana Formation of Brazil (Mohr et al. 1999). These flowers are of similar age (late Aptian) to the Koonwarra specimen, also consist of twigs with leaves as well as flowers attached (a rare circumstance), and are also associated with insect fossils. Several different flower types have recently been recovered from mesofloral assemblages from the Antarctic Peninsula (Eklund pers. comm. 2001).

We have investigated plant fossil localities clustered about the Cretaceous/Tertiary boundary in the Pakawau/Puponga district of the far northwestern extremity of the South Island. Although known to the earliest investigators of angiosperm fossils in New Zealand (Hector 1879; Ettingshausen 1887), these macrofloras have, until the present investigation (Kennedy 1993, 1998; Kennedy et al. 2002), been the subject of only one substantial, unpublished study (Mildenhall 1968). The fossil localities lie within the thick sequence of non-marine and marginal marine sediments that make up the Pakawau and Kapuni Groups in the southern part of the oil and gas-producing Taranaki Basin. One collection site has produced numerous examples of a fossil angiosperm reproductive structure, preserved in fluvio-lacustrine siltstone to fine sandstone. This site lies within the non-marine Rakopi Formation (Thrasher 1991) of the Pakawau Group and has been determined as being of latest Cretaceous age (PM2 palynological zone of Raine (1984) which equates to late Campanian or Maastrichtian), based on its associated palynoflora (Raine 1984; M. Warnes pers. comm. 1992) and stratigraphic evidence (Thrasher 1991; Wizevich et al. 1992).

The structures are pentamerous, with a septate central disc, bearing a star-like perianth with lanceolate arms (Fig. 1A,B). These fossils are described conservatively as “angiosperm reproductive structures”. This is technically correct because it is possible that they represent a fruiting

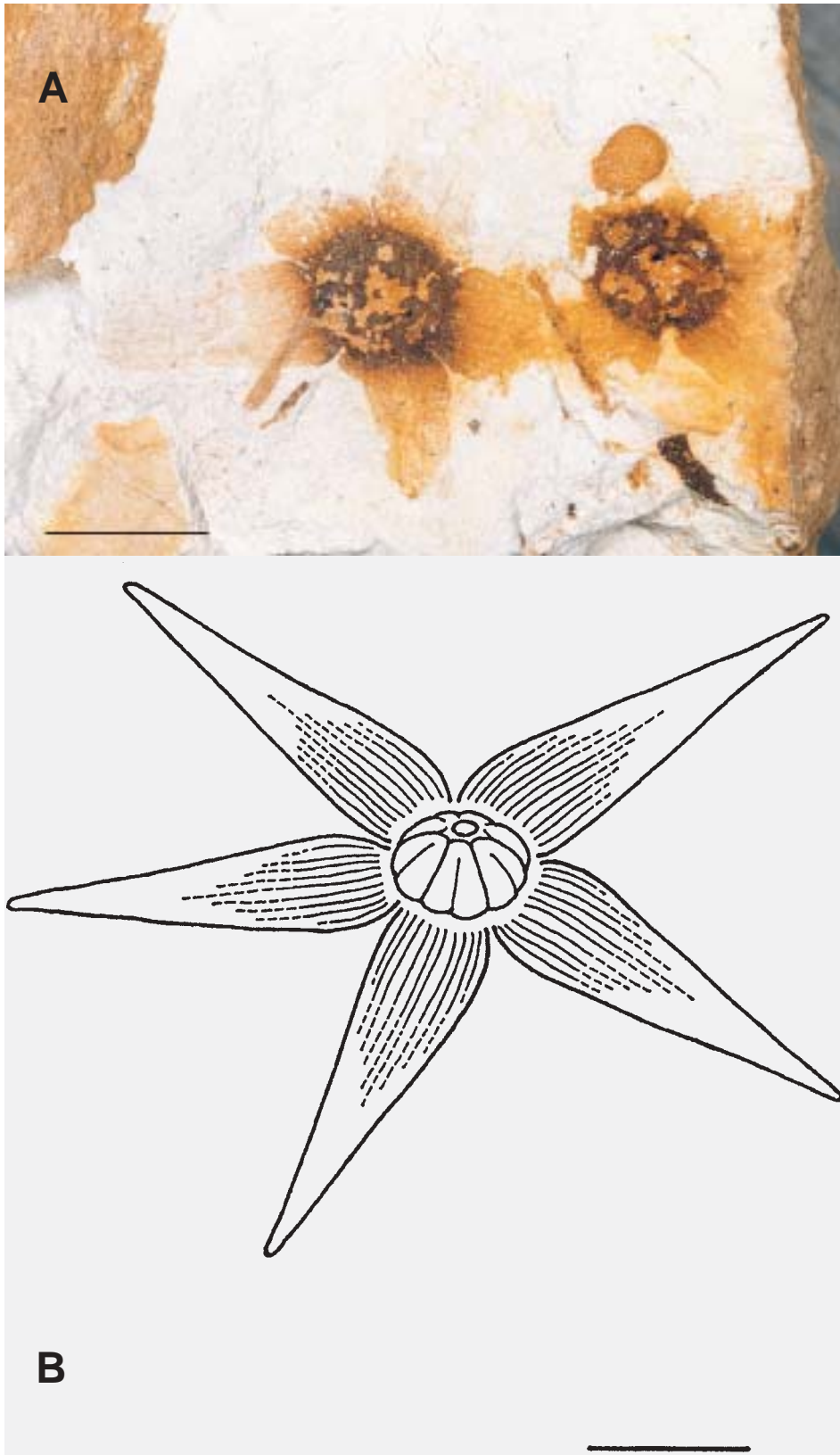


Fig. 1 Pentamerous flower from the latest Cretaceous Rakopi Formation, northwest Nelson, New Zealand. **A**, Two overlapping flowers. **B**, Suggested reconstruction of the flower with developing fruit. Scale = 1 cm. The specimens are held at GNS, Lower Hutt and have New Zealand Fossil Record File no. M25/f105. (Photo: Simon Pollard)

stage of development. Nevertheless, it is plain enough that the better preserved examples would colloquially be called “flower” fossils. These structures are preserved as impressions and were clearly subject to differential decay, with the central disc being most resistant. In many examples

nothing but the disc remains, and if better preserved examples were not known, they would be unrecognisable. However, 60 specimens show at least some clear traces of perianth. So far, no examples of petals or stamens have been obtained; these would of course be the most delicate parts of the flower.

In addition to the reproductive structures, we made a large collection of leaf fossils from this locality. Most of the leaf flora consists of dicotyledonous angiosperms with minor components of conifers, ferns, and a probable monocotyledonous angiosperm. Fifty-eight dicotyledonous leaf forms have so far been distinguished at this collection site (Kennedy 1993), making identification of the leaf form that was associated in life with the reproductive structure particularly difficult.

In the absence of evidence of petals, we cannot determine whether the perianth is a calyx or a whorl of tepals, that is, primitively uniseriate. No example of the perianth is complete, but it is clear that the perianth arms were of considerable length. The longest arm preserved is 14 mm long, and 4 mm broad at the point of breakage, still slightly more than half its basal width. Extrapolative reconstruction indicates that the arms could have been 30 mm long if they were lanceolate and, even if the apex was obtuse, not less than 20 mm. The base of each perianth arm is clearly free from its neighbours. The limb expands to its maximum width close to its origin, thereafter gradually tapering to the apex. Each arm has 9 or 10 parallel veins. The central disc is 7 mm in diameter. Well-preserved examples show not only a central cone, interpreted as the base of the stigmatic column, but also pentamerous septation of the gynoecium, aligned with the perianth arms. Whether the carpels were 5 or 10 in number is not certain, but some specimens show indications that the receptacle disc may have borne 10 segments. The specimen illustrated here (Fig. 1A) is chosen because it best displays the general appearance of the fossil and the longest perianth arms preserved. In contrast, the venation of the perianth arms is not well shown. The reconstruction (Fig. 1B) is a synthesis based on a number of individual specimens. Detached bean-shaped seeds or fruits, which are of dimensions that would allow them to belong to this flower, are also present on some of the collected blocks.

All the known characteristics of this fossil are consistent with an attribution to the Malvales as circumscribed by Cronquist (1981), largely similar in content to the family Malvaceae, as re-defined and widened by Judd & Manchester (1998) (Judd et al. 1999). It is nevertheless distinct from any extant Malvacean species or from any taxon in the present-day New Zealand flora. In size and form, this fossil superficially resembles the persistent conspicuous calyx and flattened broad segmented fruit of the living genus *Malva*, but we do not infer a close relationship on this basis. Pollen of the Bombaceae, a relatively advanced member of the group, is known from the Maastrichtian (Cronquist 1981), which strongly suggests an earlier origin for the order. The carbonaceous film on one of the specimens was macerated for palynological analysis to see if the sample yielded a concentration of any particular pollen type. Unfortunately, the sample contained few pollen grains, and nothing that assisted with taxonomic affiliation. Either the appropriate pollen grains were not present at the time of deposition or were not preserved.

The fossils reported here are the first flower macrofossils to be recorded from the Mesozoic of New Zealand. Previously, we had thought that the odds against such discoveries being made in such a tectonically active landmass, with relatively limited outcrop exposure, might well be impossibly long; but there is now reason to hope that further discoveries may reward persistent search. A detailed, fully illustrated, formal description of this fossil is

in an advanced state of preparation and will be published in the paleobotanical literature.

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