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FURTHER FOSSIL WHALE BARNACLES FROM NEW ZEALAND

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ABSTRACT

Five compartments of *Coronula diadema* (Linnaeus) are recorded from Nukumaru (Pleistocene) rocks in South Wairarapa and North Canterbury. A complete compartment of *Coronula aotea* Fleming, from Mangaotero River, Dannevirke (Mangapanian, Pliocene) shows that the species is more closely related to the living *C. reginae* Darwin than to *C. diadema*.

INTRODUCTION

Dr J. Marwick recognised, and forwarded to the New Zealand Geological Survey, the first fossil whale barnacle from New Zealand—an incomplete compartment collected by BP, Shell and Todd Petroleum Development Limited, and later described by Fleming (1958) as *Coronula aotea*—so it is fitting to dedicate this note on further whale barnacles to Dr Marwick, in his 81st year.

Since Fleming recorded the single compartment from Waipipian (Pliocene) rocks in Waihua Valley, Wairoa, northern Hawke's Bay, whale barnacles have proved to be rare fossils in New Zealand. The six specimens recorded here are the only ones I know of that have been collected since Fleming's record.

A detailed description of the shell morphology of *Coronula* was given by Darwin (1854a, pp. 397–414), and again later, more succinctly (Darwin 1854b, pp. 37–8). Accurate figures of the three living species: *C. diadema* (L.), *C. balaenaris* (Ranzani, 1817) (= *C. complanata* Mörch, 1852, = *C. balaenaris* "Gmelin" of Darwin, 1854a), and *C. reginae* Darwin, were given by Pilsbry (1916, pls. 63–5). According to Darwin (1854a, p. 416; 1854b, p. 39), *C. balaenaris* differs from the other species in having the alae attached directly to the inner surfaces of the thickened and convoluted radii of adjacent compartments, rather than to special supporting plates separated from the radii by cavities (and is thus placed in the subgenus *Cetopirus* Ranzani, 1817). The degree to which fossil species have the cavity beneath the radius filled is a major taxonomic character. Generic and higher taxa of Cirripedia were reviewed recently by Newman *et al.* (1969, p. R289).

Fleming (1958, p. 243) remarked of the holotype: "The compartment most closely resembles (and is described as) a left lateral or carinolateral . . . , but could perhaps be a rostral lacking the right radius and adjacent radial fold of the paries". Three of the further specimens recorded here are lateral or carinolateral compartments, one is not determinable, and two are complete shells. Lateral and carinolateral compartments are presumably most common because there are four of them in each shell to each one of the other two types (rostrum and carina).

SYSTEMATICS

Subclass CIRRIPEDIA

Order THORACICA

Family BALANIDAE

Genus *Coronula* Lamarck, 1803

TYPE SPECIES (by subsequent designation, Pilsbry, 1916): *Lepas diadema* Linnaeus, 1767, Pleistocene to Recent, world-wide, attached to humpback whales (*Megaptera*).

***Coronula aotea* Fleming, 1958. Fig. 9, 10.**

1958 *Coronula aotea* Fleming, *N.Z. J. Geol. Geophys.* 2: 243, fig. 1-5, 7, 9, 10.

The additional specimen of *C. aotea* is a moderate-sized, remarkably broad, right lateral or carinolateral compartment, almost complete but broken transversely during collecting and thus lacking small areas of the paries. The paries, radius, sutural edge of the radius, and in particular, the ala, are much thicker and stronger than in any Recent species, and as described by Fleming, the space between the radius and the special plate supporting the ala of the adjacent compartment is almost completely filled with solid shell material, as in *C. barbara* Darwin (Darwin, 1854b, p. 38). As noted for *C. barbara* by Darwin (1854b, p. 39), the upper and lower edges of the ala are very little different in length, and the sheath is very short compared with the basal open area of ribs, showing that *C. aotea* is a low, broad barnacle related to *C. reginae* Darwin and *C. balaenaris* (Ranzani), rather than to the tall, cylindrical, strongly radially ribbed *C. diadema* (Linnaeus). In the present specimen the anterior and posterior ribs of the folded small, between the sheath and the paries, have branched to provide additional small chambers. The more posterior of the two central ribs has also branched at a slightly lower level than the other two branches, so that there are six ribs and seven chambers at the ventral margin. Correspondingly, there are seven broad, low ribs on the outside of the paries, due to intercalations between and divisions of the original three folds in the shell wall. The dorsal margin of the ala is unusual, having a prominent, thick, bevelled edge, but as the holotype tapers to a normal thin edge, it seems to be an individual aberrant feature. The sculpture of the exterior parietal ribs is of very low transverse folds beaded by weak radial lirae, exactly as in the holotype. The internal edges of the suture lines between the folds in the shell wall are finely nodulated, with low irregular folds fading out transversely away from the nodules, similar to the nodules in *C. barbara* Darwin but much more weakly developed.

DIMENSIONS: largest dorsal margin-ventral margin dimension, 29.1 mm; width, 27.4 mm; width of dorsal edge of radius and ala, 23.2 mm; greatest height of sheath, 9.3 mm; estimated height of whole barnacle, 24 mm.

LOCALITY: GS 10746, shelly sandstone below *Chlamys delicatula* bed on west side of Mangaotero River, one-quarter mile upstream from bridge on Mangahei Road, Dannevirke District; collected A. G. Beu and J. I. Sutherland, June 1970.

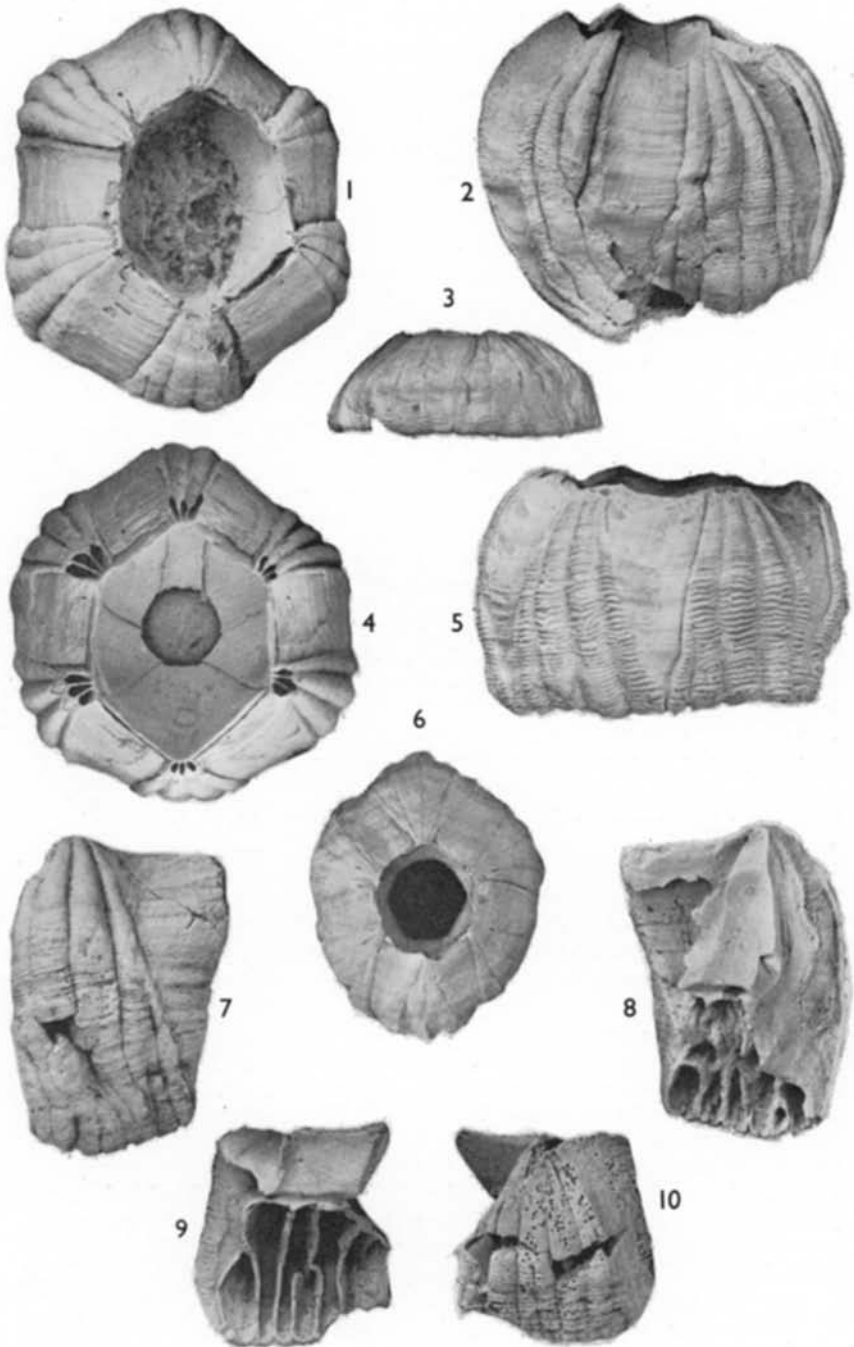
AGE: Mangapanian (late Pliocene).

TIME RANGE: Waipiian and Mangapanian (Pliocene).

RELATIONSHIPS: The discovery of this complete compartment shows that, as noted by Fleming (1958, p. 243), the holotype of *C. aotea* is highly incomplete, lacking one complete radial fold on the posterior, and the ala if it is a lateral compartment rather than a rostrum. The form is now seen to be low and broad, with a short central living chamber, and with the sides of the central chamber sloping in a little towards the aperture as described by Darwin (1854b, p. 40) for *C. barbara* and *C. balaenaris*, and not sloping markedly outwards as in *C. diadema*. The filled space beneath the radius is a feature in common with *C. barbara* Darwin but not known in any other species. However, the specimens of *C. barbara* figured by Darwin (1854b, pl. 2, fig. 8) have extremely coarse, rugose external sculpture, whereas *C. aotea* has a sculpture of low transverse ridges. The sculptured sutural edge of the radius occupies about a third to a half of the anterior radial surface, as in *C. diadema* and *C. reginae* but unlike the broad sutural zone of *C. balaenaris*. The nature of the branching of the ribs between the paries and the sheath cannot be determined from a single compartment, but from the resemblance of the sutural radial edge to that of *C. reginae* it can be predicted that it is irregular, and not symmetrically dendritic as in *C. balaenaris* (Pilsbry, 1916, pl. 63). In most features, and in particular in the low form and fine beaded external sculpture, *C. aotea* very closely resembles *C. reginae* Darwin, but it differs from *C. reginae* in having the space beneath the radius filled with shell material, and in having weak nodules along the internal edges of the line of suture of the radial folds. These nodules are very much weaker than in *C. barbara* Darwin, but are known only in these two species; perhaps their weakness is complementary to the weakness of the external sculpture compared with that of *C. barbara*. Not enough is known of the variation in sculpture of *C. barbara* and *C. aotea* to be certain that the recorded sculptural differences are constant, and the two names may prove to be synonyms, although they seem best left separate at present.

Coronula barbara was considered by Darwin to be related to *C. diadema*, but in view of the short sheath, described by Darwin (1854b, p. 39) and shown clearly in his view of the interior of the rostrum (Darwin, 1854b, pl. 2, fig. 8b), and the low, broad form of the whole barnacle that must be inferred from it, it seems more likely that *C. barbara* is related to *C. reginae*. *Coronula aotea* seems also to be related to *C. reginae* by its low

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- FIG. 1, 2—*Coronula diadema* (Linnaeus), Pukenui Limestone in cutting on White Rock Road above Birch Hill, South Wairarapa; Nukumaruan (Lower Pleistocene). Fig. 1, apertural view, carina to the bottom; Fig. 2, side view, carina to the right.
- FIG. 3, 6—*Coronula reginae* Darwin, Recent shell from humpback whale cast up on Foxton Beach. Fig. 3, side view, carina to the right; Fig. 6, apertural view, carina to the bottom.
- FIG. 4, 5—*Coronula diadema* (Linnaeus), regularly-shaped Recent shell from humpback whale, Tory Channel whaling station. Fig. 4, apertural view, carina to the bottom; Fig. 5, side view, carina to the right.
- FIG. 7, 8—*Coronula diadema* (Linnaeus), right lateral or carinolateral plate lacking the ala; cliff east of Lake Ferry Hotel, Palliser Bay, Nukumaruan (Lower Pleistocene).
- FIG. 9, 10—*Coronula aotea* Fleming, right lateral or carino-lateral plate; GS 10746, Mangaotero River, Dannevirke, Mangapanian (late Pliocene).
- (All figures actual size)



form, its relatively narrow sculptured area of the radial edge, and its weak sculpture; but closely resembles *C. barbara* in its infilled cavity beneath the radius.

In summary, it appears that both *C. barbara* Darwin and *C. aotea* Fleming are low, broad barnacles of the group of *C. reginae* Darwin, having the cavity beneath the radius primitively filled. They are probably on the line leading to the present *C. reginae* group, but *C. barbara* shows in its coarse sculpture a feature not seen in any living species of *Coronula*, and was not directly on the main line.

A specimen of *C. reginae* Darwin is figured here (Fig. 3, 6) for comparison with *C. aotea*.

Coronula diadema (Linnaeus, 1767). Fig. 1, 2, 5, 7, 8.

1767 *Lepas diadema* Linnaeus, Systema Naturae, ed. 12, 1, p. 1108.

MATERIAL: Fossil specimens of *Coronula diadema* (Linnaeus) have been examined from the following four New Zealand localities: V465, N165/1179, beneath second band of Pukenui Limestone, roadside cutting east of junction of Makara River and Mangaopari Stream, White Rock Road, South Wairarapa, single apical portion of a broken right lateral or carinolateral compartment in collection of Geology Department, Victoria University of Wellington, coll. D. Rodley; cream coquina near top of band "A", near base of Pukenui Limestone in large new road cutting overlooking Birch Hill Station, one and one-half miles south-east of Hautotara Bridge, White Rock Road, complete shell (Fig. 1, 2), coll. Mrs N. Howett; N165/1180, thin gravelly shell bed in brown sand, first bluff east of Lake Ferry Hotel, Palliser Bay coast, South Wairarapa, almost complete right lateral or carinolateral (lacking ala) (Fig. 7, 8), coll. Mr Mark James; GS 10214, S62/991, grid ref. S62/463458, three-quarters of a mile below bridge over Leamington Stream (Gower River), North Canterbury, small fragment of three parietal ribs in N.Z.G.S., coll. A. C. Beck, D. Beck, E. T. Annear, G. C. Caughley.

In addition, a complete shell of *Coronula diadema*, collected from the Limestone at Castlepoint, eastern Wairarapa coast, by Mr S. Keston and figured in his unpublished M.Sc. thesis on Castlepoint (in the library, Victoria University of Wellington), can be recorded here but could not be found for inclusion in this study.

AGE: all five fossil specimens of *Coronula diadema* are Nukumaruan (early Pleistocene) in age.

The complete specimen from White Rock Road (Fig. 1, 2), lent by Mrs N. Howett, is a medium-sized whale barnacle with all (other than opercular) plates associated, and with protrusion of the ribbed parietal areas, shape, and sculpture agreeing closely with those of the more irregular specimens of *Coronula diadema* (Linnaeus) examined by the writer in the Dominion Museum, from Tory Channel whaling station, Cook Strait. The base of the shell is markedly constricted, presumably because it had only a small attachment area among other crowded barnacles. As in about half the Recent specimens examined, some (two in this specimen) of the parietal folded areas have some folds anastomosing, again presumably reflecting crowded growth. The specimen from Lake Ferry (Fig. 7, 8), lent by Mr Mark James, is unusual in having almost the whole posterior face sculptured with ramifying sutural ridges, which are normally restricted to the outer third of the face in *C. diadema*. The specimen has suffered major injury to the outer parietal surface, causing the folds of the paries to subdivide irregularly so that the internal ribs and chambers are highly irregular. The broad sutural area is

thus considered to be an individual feature. Both near-complete lateral compartments have deeply open spaces between their radii and their special alar plates. The other two specimens listed agree with *C. diadema* in all observable features. Recent specimens of *C. diadema* (Fig. 4, 5) and *C. reginae* (Fig. 3, 6) are figured here for comparison with the fossils.

DISCUSSION

Fleming (1958) summarised the knowledge of and possible correlation value of fossil whale barnacles, and there is little to add to his summary. However, the time ranges of the two species recorded here call for comment. The time ranges are:

Coronula aotea Fleming, Waipapian-Mangapanian (Upper Pliocene);
Coronula diadema (Linnaeus) Nukumaruan (early Pleistocene) to present.

This suggests that whale barnacles may be useful local stratigraphic index fossils, the change from *C. aotea* to *C. diadema* corresponding to the Mangapanian-Nukumaruan (approximately the Pliocene-Pleistocene) boundary.

As *C. aotea* appears to be related to the living *C. reginae* Darwin rather than to *C. diadema*, the change from *C. aotea* to *C. diadema* was possibly caused by changing migration patterns of whales, or perhaps by extinction of the species of whale to which *C. aotea* was attached, rather than by evolutionary changes in the barnacles. The change in migration routes may reflect a change in sea temperature at the onset of the Pleistocene.

Ages assigned to *Coronula aotea* Fleming (Waipapian and Mangapanian Stages of New Zealand; late Pliocene) and *Coronula barbara* Darwin are of interest in view of the apparent similarity in evolutionary grade of the two barnacles. Localities for *C. barbara* recorded by Darwin (1854, p. 38) are: ". . . Red Crag (Bawdsey and Sutton); . . .". The English Coralline Crag is currently assigned a Pliocene age, whereas all the overlying "crag" beds are now assigned to the Pleistocene (Shotton and West, 1969, p. 156). Apart from the "Suffolk bone-bed", a thin deposit between most of the "crag" beds and the country rock, the oldest formation of the Pleistocene "crag" is the Older Red Crag, of Waltonian (basal Pleistocene) age (Shotton and West, 1969, p. 156). Sutton is the main locality in East Anglia from which Chatwin (1961, pp. 43, 47, 48) figured sections through the Red Crag and its contact with the Coralline Crag, so Darwin's locality "Sutton" may be taken to refer to the Older Red Crag, of basal Pleistocene age.

The Bawdsey Crag was listed by West (1963, p. 155) as one of the formations included in the redundant Butleyan Stage of former subdivisions of the British Quaternary. West (1963, p. 156) assigned "*Scrobicularia* and Newbournian-Butleyan Red Crag" to the Ludhamian Stage, subsequently (Shotton and West, 1969, p. 156) assigned a position immediately above the Waltonian.

Thus *Coronula barbara* is recorded from Sutton (Older Red Crag, Waltonian) and Bawdsey (Bawdsey Crag, Ludhamian), two localities of early Lower Pleistocene age. The Waltonian is the initial cold-fauna phase of the

British Quaternary, to be correlated with the *Chlamys delicatula* Ecozone at the base of the New Zealand Quaternary, while the Ludhamian is the first British Quaternary temperate phase, to be correlated with the Nukumaruan Stage (*sensu stricto*) of New Zealand. There can be little doubt that despite their similarities of evolutionary grade, *Coronula barbara* is significantly younger than *C. aotea*. Possibly *C. barbara* represents a branch line that evolved from barnacles resembling *C. aotea*, and it apparently lived on, in the North Atlantic, after *C. diadema* had become the dominant whale barnacle of the Southern Hemisphere.

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Mr Mark James of Wainuiomata, Mrs N. Howett of Auckland and Prof. Paul Vella of Victoria University of Wellington kindly loaned specimens recorded here. Mr J. Brodie and Mr E. W. Dawson, New Zealand Oceanographic Institute, Dr J. Yaldwyn, Dominion Museum, and Mr S. Keston helped search for the Castlepoint shell, and Dr Yaldwyn showed me barnacles in his care. Drs M. Te Punga and R. P. Suggate provided references on the British Quaternary, and Dr C. A. Fleming and Mr G. H. Scott, New Zealand Geological Survey, reviewed the manuscript. Mr D. L. Homer, New Zealand Geological Survey, took the photographs.

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