*New Zealand Journal of Geology & Geophysics, 2006, Vol. 49*: 417–427
0028–8306/06/4904–0417

# Additions to the records for decapod Crustacea from Motunau and Glenafric Beaches, North Canterbury, New Zealand

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**Abstract** Concretions collected from Motunau and Glenafric Beaches, North Canterbury, New Zealand, have yielded a new genus and species of crab, *Tongapapaka motunauensis* of the xanthoid family Pseudoziidae and several specimens of the cancrid crab *Metacarcinus novaezelandiae* (Jacquinot in Jacquinot and Lucas), confirming its range from Miocene to Holocene. These beaches have yielded numerous specimens of decapod crustaceans, the lobsters and crabs, over the decades, and the composition of the decapod fauna suggests an offshore setting for the Greta Siltstone and Mt Brown Formation exposed at Motunau and Glenafric Beaches, respectively.

**Keywords** Crustacea; Decapoda; Brachyura; Pseudoziidae; Cancridae; Miocene; New Zealand; paleoecology; paleobiogeography; systematics; *Tongapapaka motunauensis* n. gen. et sp.; new taxonomic names

## INTRODUCTION

Coastal cliffs in North Canterbury, South Island, New Zealand, have yielded a remarkable assemblage of fossil decapod crustaceans, crabs and lobsters, so that the area is now known as one of the best localities for studying them in the country. Notably, Motunau and Glenafric Beaches have been the target of amateur and professional collectors for over 60 yr and a large collection of specimens has been acquired during that time. Many of the specimens collected by amateurs have been deposited in museums, primarily the Canterbury Museum, Christchurch. They have formed the basis for several works on fossil crabs and lobsters, which will be noted below. Continued collecting occasionally results in discovery of new species and better and more complete specimens of known species. The purpose of this work is to describe a new species of crab within the family Pseudoziidae Alcock, 1898, from Motunau Beach, and to provide a comparison of fossil and extant material within the family Cancridae Latreille, 1802, from Motunau and Glenafric Beaches.

Decapods collected from these localities are always preserved within dense concretions cemented by carbonate or ferrugenous minerals. The concretions weather out of two Miocene-age units exposed along the cliffs. At Motunau Beach, the rock unit has been identified as the Greta Siltstone, and at Glenafric Beach, the exposed rocks are referred to the Mt Brown Formation. As will be discussed below, the precise age of the concretions is equivocal as they are not known to contain index fossils. Because the cliffs are extremely steep and unstable, most of the concretions are collected from material on the beach that has been brought down by landsliding and subsequently winnowed out by wave activity. In fact, examination of the cliff faces from beach level rarely reveals exposed concretions. In an attempt to estimate the frequency of occurrence of concretions in the Greta Siltstone, one of us (DM) attempted to count all decapod-bearing concretions within a recent landslide. The slide debris consisted solely of material from the Greta Siltstone. The slide measured 184 m in length along the beach, 22 m in width, and 20 m in height. If one assumes a triangular cross-section for the debris pile, c. 40 500 $m^3$ of material moved downslope. This calculation yields a maximum volume, as no accurate estimate of the reduction of volume at the edges of the slide can be made. Following wave erosion of c. one-third of this mass, 82 decapod-bearing concretions were identified. Based upon these measurements, one can estimate that about one concretion should be exposed for every 165 $m^3$ of sediment weathered from the cliff.

The decapod fauna from the area of Motunau and Glenafric Beaches has yielded eight species, including the new species described herein, although the relative abundance of taxa is very different at the two sites (Table 1). Although the fauna is quite diverse, the relative abundance of the taxa is far from uniform. Two species, *Tumidocarcinus giganteus* Glaessner, 1960, and *Trichopeltarion greggi* Dell, 1969, are estimated to comprise 95% of the specimens collected. The remaining six species account for the remaining 5% of occurrences.

## ABBREVIATIONS

CM, Canterbury Museum, Christchurch, New Zealand; UCMP, University of California, Museum of Paleontology, Berkeley, California; KSU D, Kent State University Decapod Comparative Collection, Department of Geology, Kent, Ohio.

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*G06003; Online publication date 20 November 2006*
*Received 13 February 2006; accepted 19 October 2006*

**Table 1** Systematic list of decapod taxa collected from Motunau and Glenafric Beaches and estimates of relative abundance of each species.

| Taxa | Total estimated abundance |
|---|---|
| Order Decapoda Latreille, 1802 | |
| Infraorder Astacidea Latreille, 1802 | |
| Superfamily Nephropoidea Dana, 1852 | |
| Family Nephropidae Dana 1852 | |
| Genus *Metanephrops* Jenkins, 1972 | |
| *Metanephrops motunauensis* Jenkins 1972 | <1% |
| Motunau Beach | |
| Infraorder Anomura H. Milne Edwards, 1832 | |
| Superfamily Paguroidea Latreille, 1802 | |
| Family Lithodidae Samouelle, 1819 | |
| Genus *Paralomis* White, 1856 | |
| *Paralomis debodeorum* Feldmann, 1998 | <1% |
| Motunau Beach | |
| Infraorder Brachyura Latreille, 1802 | |
| Superfamily Majoidea Samouelle, 1819 *sensu lato* | |
| Family Majidae Samouelle, 1819 *sensu lato* | |
| Genus *Actinotocarcinus* Jenkins, 1974 | |
| *Actinotocarcinus chidgeyorum* Jenkins, 1974 | <1% |
| Glenafric Beach | |
| *Actinotocarcinus maclauchlani* Feldmann, 1993 | <1% |
| Motunau Beach | |
| Genus *Leptomithrax* Miers, 1876 | |
| *Leptomithrax garthi* McLay et al. 1995 | <1% |
| Motunau Beach | |
| Superfamily Cancroidea Latreille, 1802 | |
| Family Atelecyclidae Ortmann, 1893 | |
| Genus *Trichopeltarion* A. Milne Edwards, 1880 | |
| *Trichopeltarion greggi* Dell, 1969 | 40% |
| 98% of total specimens at Motunau Beach | |
| 0% of total specimens at Glenafric Beach | |
| Family Cancridae Latreille, 1802 | |
| Genus *Metacarcinus* A. Milne Edwards, 1862 | |
| *Metacarcinus novaezelandiae* (Jacquinot *in* Jacquinot & Lucas, 1853) | 1% |
| 8 specimens from Motunau Beach | |
| 2 specimens from area of Glenafric Beach | |
| Superfamily Xanthoidea MacLeay, 1838 | |
| Family Tumidocarcinidae Schweitzer, 2005 | |
| Genus *Tumidocarcinus* Glaessner, 1960 | |
| *Tumidocarcinus giganteus* Glaessner, 1960 | 55% |
| 99% of specimens at Glenafric Beach | |
| 0% of specimens at Motunau Beach | |
| Family Pseudoziidae Alcock, 1898 | |
| Genus *Tongapapaka* n. gen. | |
| *Tongapapaka novazealandiae* n. sp. | <1% |
| Motunau Beach | |

## SYSTEMATIC PALEONTOLOGY

### Order DECAPODA Latreille, 1802

### Infraorder BRACHYURA Latreille, 1802

### Section HETEROTREMATA Guinot. 1977

### Superfamily MAJOIDEA Samouelle, 1819 *sensu lato*

### Family **MAJIDAE** Samouelle, 1819 *sensu lato*

### Genus **Actinotocarcinus** Jenkins, 1974

### ***Actinotocarcinus chidgeyorum*** Jenkins, 1974 (corrected)

***Actinotocarcinus chidgeyi*** Jenkins, 1974, p. 872, pl. 117.

DISCUSSION: Jenkins (1974) erected the species *Actinotocarcinus chidgeyi* in honour of two male members of the Chidgey family. However, according to Article 31.1.2 of the International Code of Zoological Nomenclature (1999), the correct ending must be -orum when deriving a species-group name from a personal name of more than one man. Thus, we herein correct the name to reflect the appropriate ending.

### Family **CANCRIDAE** Latreille, 1802

### Subfamily **CANCRINAE** Latreille, 1802

INCLUDED GENERA: *Anatolikos* Schweitzer & Feldmann, 2000; *Anisospinos* Schweitzer & Feldmann, 2000; *Cancer sensu stricto* Linnaeus, 1758; *Glebocarcinus* Nations, 1975; *Metacarcinus* A. Milne Edwards, 1862; *Notocarcinus* Schweitzer & Feldmann, 2000; *Platepistoma* Rathbun, 1906; *Romaleon* Gistl, 1848.

DIAGNOSIS: A diagnosis of the subfamily has recently been published (Schweitzer & Feldmann 2000) and will not be repeated herein.

### Genus ***Metacarcinus*** A. Milne Edwards, 1862

TYPE SPECIES: *Cancer magister* Dana, 1852, by original designation.

INCLUDED SPECIES: *Metacarcinus antonyi* (Rathbun, 1897), as *Cancer* (Pliocene–Holocene); *M. danai* (Nations, 1975), as *Cancer* (middle Miocene); *M. davidi* (Nations, 1968), as *Cancer* (middle Pliocene to middle Miocene); *M. edwardsii* (Bell, 1835), as *Cancer* (Holocene); *M. goederti* Schweitzer & Feldmann, 2000 (Oligocene); *M. gracilis* (Pliocene–Holocene); *M. granti* (Rathbun, 1932), as *Cancer* (late Pliocene); *M. izumoensis* (Sakumoto et al., 1992), as *Cancer* (*Metacarcinus*) (middle Miocene); *M. jenniferae* (Nations, 1975), as *Cancer* (middle Pliocene); *M. magister* (Dana, 1852), as *Cancer* (Pliocene–Holocene); *M. minutoserratus* (Nagao, 1940), as *Cancer* (Pliocene); *M. novaezelandiae* (Jacquinot in Jacquinot & Lucas, 1853), as *Platycarcinus* (Miocene–Recent); *M. plebejus* (Poeppig, 1836), as *Cancer* (Holocene); *M. starri* (Berglund & Goedert, 1996), as *Cancer* (*Metacarcinus*) (early Miocene); ?*Metacarcinus* sp. Schweitzer & Feldmann, 2000 (late Oligocene to early Miocene).

DISCUSSION: The Cancridae and the genus *Cancer* have been the subject of several studies in recent years (Nations 1975; Schweitzer & Feldmann 2000). In the former work, the genus was subdivided into several subgenera, one of which was *Metacarcinus*. Re-examination of the definitional bases for the subgenera, as defined by Nations (1975), led Schweitzer & Feldmann (2000) to elevate the subgenera to generic status, to define three new genera to embrace some fossil species, and to reassign some species to different genera. The New Zealand cancrid was assigned to *Cancer* (*Metacarcinus*) by Nations (1975) with which Schweitzer & Feldmann (2000) concurred, although they elevated the subgenus to generic rank.

***Metacarcinus novaezelandiae*** (Jacquinot in Jacquinot & Lucas, 1853) Fig. 1(1–8), 3(1–7)

1853 *Platycarcinus novae-zelandiae* Jacquinot in Jacquinot & Lucas p. 34, pl. 3, fig. 6.

1865 *Cancer novae-zealandiae* (Jacquinot). A. Milne Edwards p. 189; Miers 1874, 1876; Filhol 1886; Lenz 1901; Chilton 1909, 1911; Thomson 1912; Thomson & Anderton 1921; Stephensen 1927; Chilton & Bennett 1929, p. 744; Young 1929; McNeill & Ward 1930, p. 377, pl. 61, fig. 3–7; Richardson 1949; Benson & Finlay 1950, p. 269.

1960 *Cancer novaezealandiae* (Jacquinot). Glaessner p. 20, pl. 3, fig. 5, 6; Nations 1975, p. 45, fig. 7, 11, 37-5, 37-6; Neef 1981; Feldmann & Keyes 1992, p. 10.

1963 *Cancer novaezelandiae* (Jacquinot). Dell p. 42; Dell 1968, p. 25; 1969, p. 369; Vermeij 1977; Marsden & Fenwick 1978; Probert et al. 1979; Marsden 1981; Knox 1983; Wear & Fielder 1985; McLay 1988, p. 190; Creswell & Marsden 1990; Cresswell & McLay 1990; Chatterton & Williams 1994.

2000 *Metacarcinus novaezealandiae* (Jacquinot). Schweitzer & Feldmann p. 235.

DIAGNOSIS: Carapace with medial frontal spine below level of adjacent frontal spines; lateral margin with 10 subtle lobes, each with 2–5 tiny spines; posterolateral margin coarsely granulose; carapace surface uniformly and very finely granulose as a reflection of epi/endo/high tubercle development (Waugh 2002) in the endocuticle.

DESCRIPTION: Carapace ovoid, wider than long, greatest width posterior to midlength; weakly vaulted transversely and longitudinally.

Front not projected significantly beyond orbits, with 5 short spines including inner orbital spines; medial spine situated below adjacent spine pair and slightly above inner suborbital spines. Orbits distinctly concave with 2 distinct, closed orbital fissures; innermost fissure at about midpoint of orbit and outermost half-way between inner fissure and blunt outer orbital spine. Anterolateral margin crispate, with about 10 blunt spines separated by shallow, closed fissures; fissures become less distinct posteriorly. Spines bear variable number of small, secondary projections which may bear 2 or 3 spinelets. Posterolateral margin defined by fine, densely spaced granules. Posterior margin weakly convex to straight.

Carapace surface with weakly defined regions. Protogastric regions longitudinally ovate, typically elevated above general carapace surface. Mesogastric and metagastric regions less strongly inflated. Cardiac region prominently inflated, broadest of axial regions, bearing 2 tubercles in anterior half. Intestinal region subtle, broadest posteriorly. Lateral regions indistinct. Entire carapace surface finely granular.

Buccal frame rectangular, slightly longer than wide. Third maxillipeds elongate, rectangular, completely covering space within buccal frame. Sternum narrow, completely covered by broad mature female abdomen and proximally exposed laterally in males. Female abdomen broadening posteriorly to 4th somite, remaining equally broad to 6th somite and terminating in a large, triangular telson. Male abdomen broadest at 2nd somite, covering entire space between bases of pereiopods 4 and 5; male abdominal somites 3–5 fused, tapering posteriorly; abdominal somite 6 longer than wide, tapering distally; telson short, triangular.

Chelipeds isochelous, propodus length less than twice height, maximum height attained at point of articulation of dactylus; fingers short, stout. Upper surface of manus weakly arched, bearing 2 rows of coarse tubercles separated by finer granules. Outer surface convex, bearing 5 rows of tubercles or granules; uppermost row is coarsest, extending from upper point of articulation of carpus and propodus to outer point of articulation of propodus and dactylus. Second row parallels first, with coarse tubercles proximally, becoming obscure distally; 3rd row parallels first two, with finer tubercles; 4th and 5th rows very distinct, with fine, closely spaced granules; rows 4 and 5 parallel to one another along manus and converging along fixed finger to join at tip. Lower surface of propodus weakly concave, smooth; inner surface weakly curved to conform to curve of anterior and anterolateral margin. Dactylus coarsely granular on upper surface and upper part of outer surface, becoming smooth on lower part of outer surface. Occlusal surfaces and tips of both fingers darkly pigmented; generally with about 4, large, domed denticles.

MEASUREMENTS: Measurements, in millimetres, and ratios taken on the available specimens are given in Table 2.

LOCATION AND STRATIGRAPHIC POSITION: Eight specimens, CMzfc34, 128, 237, c243, 262, all from grid ref. N34/156954 (Fossil Record File no. N34/f0113; CM2006.1.2, from grid ref. N34/141957 (Fossil Record File no. N34/f0112); CM2006.1.3 and 2006.1.4, from grid ref. N34/161951 (Fossil Record File no. N34/f0114), all deposited in the Canterbury Museum, Christchurch, New Zealand, were collected from concretions on Motunau Beach, North Canterbury, New Zealand, and presumed to have been derived from the Greta Siltstone. The age of the Greta Siltstone has been considered to be anything from early Miocene to Pleistocene (Lewis 1976; Fordyce 1982; Browne & Field 1985). The age of the formation at Motunau Beach was discussed by Feldmann & Keyes (1992, p. 32), who concluded that a concensus age of middle–late Miocene (Waiauan–Tongaporutuan) was most likely. That determination was supported by the presence of *Tumidocarcinus giganteus* Glaessner, 1960, which has been collected from a wide range of localities ranging in age from Lillburnian to Tongaporutuan (Glaessner 1960). However, the middle–late Miocene age for these concretions is highly likely but not firmly constrained. One specimen, CMzfc46, was collected from a concretion on Glenafric Beach at grid ref. N34/015899 (Fossil Record File no. N34/f0111), and another, 2006.1.1, was collected just south from Glenafric Beach at grid ref. N34/959859 (Fossil Record File no. N34/f0115), North Canterbury, New Zealand, interpreted to

**Table 2** Measurements, in millimetres, ratios, and gender determination of specimens of *Metacarcinus novaezelandiae*. Data from the extant specimen UCMP 14118 was taken from Nations (1975) and measurements on the extant specimen KSU D 306 were taken from a specimen in the spirit collection in the Department of Geology, Kent State University. L = maximum carapace length; W1 = maximum carapace width; W2 = frontal width; W3 = fronto-orbital width; W4 = posterior width; L to MW = length to position of maximum width; PA = angle of posterolateral margin to posterior margin.

| Catalogue number | L | W1 | L/W1 | W2 | W2/W1 | W3 | W3/W1 | W4 | L to MW | PA | Gender |
|---|---|---|---|---|---|---|---|---|---|---|---|
| UCMP 14118 | 32.2 | 48.8 | 0.66 | 7.1 | 0.15 | 13.6 | 0.28 | 13.8 | 18.1 | 25° | ? |
| KSU D 306 | 63.8 | 99.1 | 0.64 | 11.1 | 0.11 | 23.3 | 0.24 | 20.4 | 34.5 | 26° | female |
| CMzfc 237 | 70.3 | 109 | 0.64 | 12.3 | 0.11 | 24.0 | 0.22 | c. 31 | c. 36 | 30° | ? |
| CMzfc 128 | 70.7 | 111.1 | 0.64 | 14.4 | 0.13 | 25.2 | 0.23 | 34.2 | 33.5 | 26° | ? |
| CMzfc 34 | 54.8 | 86.0 | 0.64 | 10.8 | 0.13 | 16.1 | 0.19 | 23.3 | c. 31 | 22° | male |
| CMzfc 243 | 60.8 | 106.3 | 0.57 | – |  | – | – | – |  | 26° | ? |
| CM2006.1.1 | 74.5 | 109.3 | 0.68 | 9.0 | 0.08 | 30.2 | 0.28 | 26.7 | 43.7 | 33° | ? |
| CM2006.1.2 | 72.3 | 113.4 | 0.64 | – |  | – | – | – | 39.3 | 33° | ? |
| CM2006.1.3 | 53.8 | 88.2 | 0.61 | 10.2 | 0.12 | 20.6 | 0.23 | 20.4 | 36.6 | 21° | male |

have been derived from the Mt Brown Formation of middle Miocene (Waiauan) age (Feldmann & Keyes 1992). Browne & Field (1985) noted that the Mt Brown Formation at various localities ranges from early Miocene (Otaian) to late Miocene (Tongaporutuan).

DISCUSSION: Although the biology of living *Metacarcinus novaezelandiae* has been extensively studied (e.g., McLay 1988; Creswell 1988; Creswell & Marsden 1990; Cresswell & McLay 1990; Chatterton & Williams 1994), references to fossil occurrences are largely anecdotal. Glaessner (1960) discussed the occurrences of the species that were then known from early Pliocene–Pleistocene rocks. They consisted largely of fragmentary remains, and none was reported from the coastal cliffs of Canterbury. Feldmann & Keyes (1992) provided an updated and expanded list of occurrences of the species in which the occurrences at Motunau and Glenafric Beaches were noted, but no systematic discussion was included. Thus, this represents the first detailed documentation of the assignment of fossil specimens to *M. novaezelandiae*.

The description of the species, presented here, characterises the morphology of extant and fossil specimens and reflects the similarity in form of both extant and fossil representatives. The frontal region on the known fossil specimens is incomplete on all but one specimen, CM2006.1.4, so that the details were based upon examination of modern specimens; however, the fragmentary remains seen on fossils conform to the description. Similarly, the description of the third maxillipeds and their relationship to the buccal frame was taken from extant material, though one of the fossil specimens, CMzfc34, has a moderately well-exposed, morphologically comparable buccal frame with the third maxillipeds in place. Finally, the female abdomen was described from an extant specimen, KSU D306; none was exposed on the available fossils. The male abdomen was described from two fossil specimens, CMzfc34 and CM2006.1.3.

Examination of the fossil material provides one cautionary note. The appearance of the anterolateral margin, a key feature in the identification of cancrid crabs in general, is quite variable among fossil specimens. This difference can be attributed to two factors, one intrinsic and one extrinsic. Inspection of very well preserved extant and fossil specimens reveals some variation in the nature of the anterolateral margin, particularly with regard to the degree of development of the primary fissures in the posterior-most part of the margin and also with regard to the development of secondary spines and spinelets. These variations seem to be attributable to individual variation. Other variations are related to the nature of preservation of the fossils. The anterolateral margin can appear precisely as it does in extant forms or it can appear much smoother and more uniform than in modern specimens due to subtle abrasion of the carapace edge.

The size of the fossils studied herein range from carapace widths of 86.0–113.5 mm, which are consistent with sizes reported elsewhere. Bennett (1964) reported a male specimen with a carapace width of 144 mm, and McLay (1988) noted male specimens up to 150 mm and females of as much as 112 mm. The measurements given by McLay show that males grow larger than females; however, within the fossil assemblage studied, the smallest two specimens were males. Because of the very small sample size, this size difference cannot be considered significant.

One of the significant results of the detailed comparison of fossil and extant specimens is that the duration of the species may be as much as 12 m.y. That duration is based upon the inferred age of the concretions in the Greta Siltstone and the Mt Brown Formation. During this time span, the species has remained endemic to New Zealand, with only a presumed introduced record of the species in Australia and Tasmania (Nations 1975; Davie 2002; Poore 2004). Other species within the genus are known from the North Pacific, the Southeast Pacific, and the North Atlantic oceans at the present time and from Oligocene–Pliocene occurrences in the fossil record of the Pacific (Nations 1979; Schweitzer & Feldmann 2000).

### Family **PSEUDOZIIDAE** Alcock, 1898

INCLUDED GENERA: *Archaeozius* Schweitzer, 2003 (Eocene); *Euryozius* Miers, 1886 (Miocene–Holocene); *Flindersoplax* Davie, 1989 (Holocene); *Haemocinus* Ng, 2003 (Holocene); *Planopilumnus* Balss, 1933 (Holocene); *Platychelonion* Crosnier & Guinot, 1969 (Recent); *Priabonocarcinus* Müller & Collins, 1991 (Eocene); *Pseudozius* Dana, 1851 (Holocene); *Santeexanthus* Blow & Manning, 1996 (Eocene); *Tongapapaka* new genus (Miocene).

DISCUSSION: Davie (2002) and Poore (2004) considered the Pseudoziinae to be a subfamily of the Goneplacidae MacLeay, 1838. The Pseudoziidae was elevated to family level by Ng & Liao (2002), a position maintained by Schweitzer (2003) and Karasawa & Schweitzer (2006). We follow the latter position herein, maintaining the Pseudoziidae as a distinct family.

A single new specimen was collected from South Bay, Motunau Beach, north of Christchurch, South Island, New Zealand. This unique specimen possesses an ovate, longer than wide carapace shape, anterolateral margins with lobes developed into short spines at the distal ends, and moderately defined carapace regions, suggesting that it is referable to a xanthoid or goneplacoid family. The vaulted carapace, ovate shape, narrow orbits, and narrow fronto-orbital width exclude it from all families within the Goneplacoidea MacLeay, 1838, despite the fact that the new specimen is superficially similar to many goneplacoid genera. The new specimen bears some superficial resemblance to species of *Carcinoplax* H. Milne Edwards, 1852; however, species of that genus tend to have two well-developed, if small, anterolateral spines and a straight front with no medial notch (Poore 2004). The new specimen has a frontal notch and three, poorly defined anterolateral spines. Species of *Georgeoplax* Türkay, 1983, variously considered to be a goneplacid (Davie 2002) or a pilumnid (Karasawa & Kato 2003), have extremely short anterolateral margins and broad, poorly defined orbits, neither of which characterise the new specimen (Poore 2004).

The only xanthoid family that can accommodate the new specimen is the Pseudoziidae. The Pseudoziidae can embrace taxa with a straight front with a central notch; a beaded ridge parallel to the frontal margin; a frontal width c. 30% maximum carapace width; an inner orbital spine set posteriorly from the frontal margin, interpreted to form a concavity into which the third antennal segment can rest (Davie 2002); entire, weakly rimmed orbits; a fronto-orbital width about one-half the maximum carapace width; a straight section extending laterally from the outer orbital angle which then merges into the anterolateral margin; an anterolateral margin with lobes or weak spines; a posterolateral margin at about a 40–45° angle to the posterior margin; a posterior margin c. 30% maximum carapace width; a posterolateral reentrant; and weakly defined carapace margins. All of these are features present in the new specimen.

The only major differences between the new specimen and the other members of the Pseudoziidae are that it is less wide compared to its length, with a length to width ratio of

**Fig. 1** **1,2** *Metacarcinus novaezelandiae*, Recent, Wellington Sand Flats, New Zealand, KSU D 306, dorsal (1) and ventral (2) views of female. **3,4,6** *Metacarcinus novaezelandiae*, Motunau Beach, North Canterbury, CM2006.1.3, deposited in the Canterbury Museum, dorsal (3) and ventral (4) views of male, and oblique view (6) showing the form of the chelipeds. **5,7,8** *Metacarcinus novaezelandiae*, Motunau Beach, North Canterbury, CMzfc34, deposited in the Canterbury Museum, dorsal (5) and ventral (7) views of male, and enlargement of third maxillipeds and anterior part of sternum (8). Scale bars = 1 cm.

about 0.84 as compared to 0.65–0.75 in other taxa; and the position of maximum width is positioned closer to the anterior edge of the carapace in the new specimen, at about one-third the distance posteriorly, instead of about one-half the distance posteriorly. The new specimen is also more vaulted than other taxa within the Pseudoziidae. As has been noted previously, however, the dorsal carapace morphology of the Pseudoziidae is quite variable (Schweitzer 2003), and indeed *Haemocinus*, recently referred to the family, has well-defined carapace regions (Ng 2003), unlike any other genera within the family. Because the new specimen shares many features with taxa within the Pseudoziidae, we place it within that family. In particular, the inner orbital spine set posteriorly from the frontal margin, forming a concavity into which the third antennal segment can rest, seems to be diagnostic and quite recognisable in fossils, including the new specimen. Because the new specimen lacks the sternum and abdomen which can help verify family placement of xanthoid taxa, the assignment is subject to review upon discovery of additional material.

Fossil occurrences of the Pseudoziidae display a modified Tethyan distribution, known from the Eocene of North Carolina and Washington, USA, and Hungary, and the Miocene of Japan (Schweitzer 2003). The family could have dispersed eastward into the Indo-Pacific via the Tethys Seaway and westward into the Atlantic and eastern Pacific via the Tethys Seaway and the open Central American Seaway (Bice et al. 2000). Thus, the New Zealand occurrence of a member of the family may be explained by dispersal through the Tethys to the Indo-Pacific region. It seems that the family dispersed in this way to its current known occurrences today in the Indo-Pacific and Australian waters (Davie 2002; Poore 2004), probably a relict of the Tethyan distribution. The Pseudoziidae does not appear to be found today in New Zealand waters (McLay 1988) although it is well-known from Australia.

### Genus ***Tongapapaka*** n. gen.

DIAGNOSIS: As for species.

DESCRIPTION: As for species.

ETYMOLOGY: The genus name is derived from the Maori words *pāpaka*, meaning crab, and *tonga*, meaning south (http://translator.kedri.info/), in reference to the holotype of the type and only species being found on the South Island in New Zealand. The gender is feminine.

OCCURRENCE: The new genus is known only from the occurrence reported below.

DISCUSSION: As discussed above, the specimen described here cannot be accommodated by any of the previously described genera and species within the Pseudoziidae. The extant New Zealand brachyuran fauna includes one species of *Carcinoplax*, which is superficially similar to the new genus, but it differs from *Tongapapaka* as mentioned above in lacking a frontal notch and possessing well-defined anterolateral spines. *Heterozius rotundifrons* A. Milne Edwards, 1867, known from southern New Zealand (McLay 1988), has a triangular front, markedly projected anterolateral margins, and poorly developed orbits, all of which differentiate it from *Tongapapaka*.

Other xanthoid taxa from the fossil record of New Zealand cannot accommodate the new specimen. Two species of *Carcinoplax* are now recognised from the fossil record of New Zealand. *Carcinoplax proavita* (Glaessner, 1960) was originally referred to *Galene* de Haan, 1833, and was later referred to *Carcinoplax* (Karasawa & Kato, 2003). That species has a broader carapace with respect to the length and has epibranchial and branchial ridges, all of which the specimen herein referred to *Tongapapaka* lacks. *Carcinoplax proavita* also has shorter anterolateral margins than does the sole specimen of the sole species of *Tongapapaka*. The late Eocene *Carcinoplax temikoensis* Feldmann & Maxwell, 1990, has a much more angular carapace and much broader orbits than does *Tongapapaka*. Species referred to *Tumidocarcinus* Glaessner, 1960, from the Eocene–Miocene of New Zealand, are much more inflated and have a markedly four-lobed front, much different than the carapace of the specimen forming the basis of *Tongapapaka*. The early Miocene *Goneplax arenicola* (Glaessner, 1960), originally referred to *Ommatocarcinus* and later placed in *Goneplax* by Karasawa & Kato (2003), has much longer orbits than *Tongapapaka* and only two anterolateral spines. Species of *Ommatocarcinus* White, 1852, which are known from the fossil record of neighboring Australia, are characterised by extremely long orbits and a very narrow, T-shaped front, very different from those seen in *Tongapapaka*. Thus, the new genus is warranted.

### ***Tongapapaka motunauensis*** n. sp. Fig. 2(1–3)

DIAGNOSIS: Carapace subcircular, wider than long, length c. 85% maximum width; frontal margin with central notch, straight and beaded on either side of notch; small spine on inner orbital angle; anterolateral margin with 3 spines, first 2 sharp and triangular; last a blunt knob.

DESCRIPTION: Carapace ovate, wider than long, length c. 85% maximum width, widest at position of 2nd anterolateral spine, about one-third the distance posteriorly; carapace moderately vaulted transversely, somewhat more strongly vaulted longitudinally, especially anteriorly; regions generally poorly developed, expressed as low swellings of carapace. Frontal margin with central notch, straight and beaded on either side of notch, front projecting beyond orbit, with beaded ridge parallel to frontal margin, portion anterior to beaded ridge deflexed strongly, small spine on inner orbital angle, frontal width c. 30% maximum carapace width. Orbits semicircular, entire, weakly rimmed, directed forward, bounded externally by straight sections merging into anterolateral margins; fronto-orbital width about one-half maximum carapace width.

Anterolateral margin short, measured from distal end of outer orbital segment to last anterolateral spine about one-half maximum carapace length and c. 85% posterolateral margin length measured from last anterolateral spine to anterior end of posterolateral reentrant; with 3 spines, first 2 largest, triangular, sharp, directed forward, last one a blunt projection. Posterolateral margin entire, sinuous, with a beaded rim anteriorly. Posterolateral reentrant well developed, with a beaded rim. Posterior margin rimmed, weakly concave centrally, c. 36% maximum carapace width.

Protogastric regions weakly inflated, hepatic regions flattened. Urogastric region well-defined laterally by deep groove, lateral margins concave. Cardiac region broad, intestinal region with moderately defined lateral margins.

Bases of 5th pereiopods preserved.

Cuticle with at least 2 layers, outer layer with small tubercles; inner layer with large, white tubercles with appearance of beaded styrofoam.

MEASUREMENTS: Measurements (in mm) taken on the dorsal carapace of the holotype and sole specimen: maximum carapace length = 54.3; maximum carapace width = 63.6; fronto-orbital width = 31.7; frontal width = 19.1; posterior width = 22.6; length to position of maximum width = 19.0; length of anterolateral margin = 24.8; length of posterolateral margin = 29.3.

ETYMOLOGY: The trivial name is derived from Motunau Beach, where the holotype and sole specimen was collected by one of us (DM).

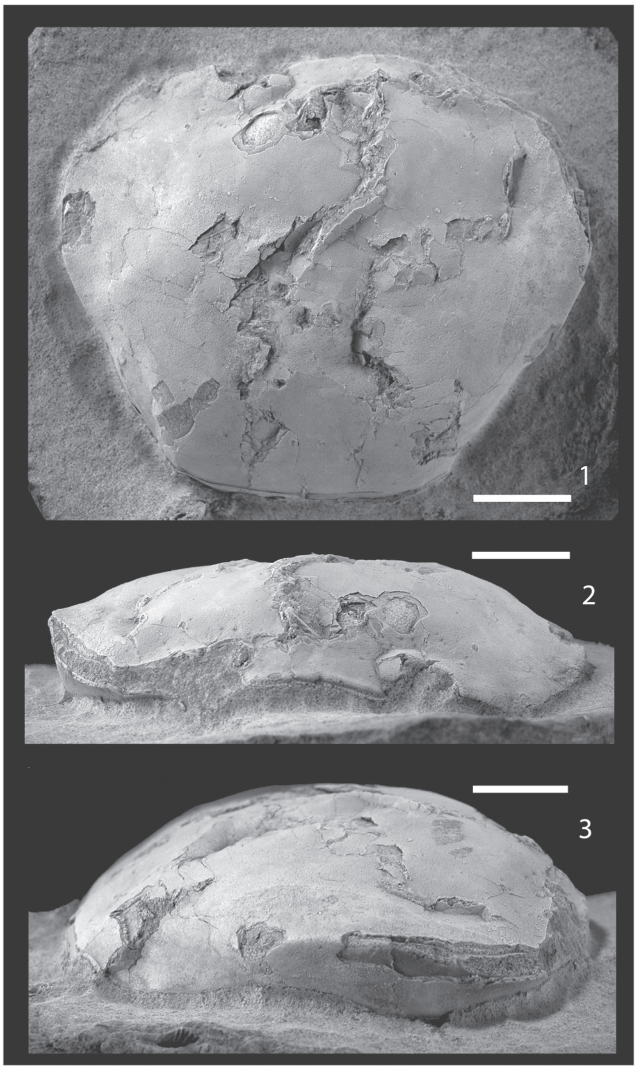

**Fig. 2** **1–3** *Tongapapaka motunauensis* n. gen., n. sp., Motunau Beach, North Canterbury, Holotype, CM2006.1.5, deposited in the Canterbury Museum, dorsal (1), frontal (2), and right lateral (3) views. Scale bars = 1 cm.

HOLOTYPE: The holotype and sole specimen, CM2006.1.5 from grid ref. N34/141957 (Fossil Record File no. N34/f0112), is deposited in the Canterbury Museum, Christchurch, New Zealand.

TYPE LOCALITY: The holotype and sole specimen was collected from South Bay, Motunau Beach, north of Christchurch, South Island, New Zealand.

DISCUSSION: The new species is represented by only one specimen which is slightly crushed and sheared. Damage to the cuticle of the dorsal carapace, and corresponding damage to the cuticle left in the counterpart of the dorsal carapace, suggests that there may have been epibionts on the dorsal carapace surface. Breakage of the carapace cuticle has exposed some of the cuticle layers, but because there is only a single specimen, destructive sampling techniques to permit more quantitative description of the cuticle was not possible.

## TAPHONOMY

As discussed above, specimens of decapod crustaceans from Motunau and Glenafric Beaches are invariably enclosed within dense, siliceous concretions. Although some of the specimens are abraded on the surface of the concretions by erosion following exposure, the majority of specimens are preserved either as entire, articulated individuals or as complete carapaces or claws. The material does not show signs of a significant amount of abrasion and breakage prior to burial. As a result, careful preparation tends to yield excellent specimens. Typically, concretions contain a single specimen; however, some do contain more than one specimen, although none was studied in this work. It also is not common to find other macrofossils preserved along with decapods. One exception to this is CMzfc46, a concretion in which the specimen of *Metacarcinus novaezelandiae* bears epibionts, discussed below, and is surrounded by tiny nuculid bivalves.

The details of preservation of decapod material within the concretions can be quite variable, however. This is well illustrated by examining the figures herein. Specimens of *Metacarcinus* exhibit all manner of degradation (Fig. 3(1–7)). The most completely preserved specimens contain well-preserved cuticle. However, separation of the part and counterpart of those concretions containing the best preserved specimens typically results in separation of the exocuticle from the endocuticle in the manner described by Waugh et al. (2004). Upon examination of the available specimens it appears that the surface of the cuticle is characterised by development of low nodes, as defined by Waugh (2002, fig. 14), and that the nodes reflect epi/endo/high tubercle architecture (Waugh 2002, fig. 16; Waugh & Feldmann 2003, fig. 1.1) in which pillar-like protuberances of the endocuticle, which are the innermost calcified layers of the cuticle, deform the exocuticle and epicuticle into the low node.

Whether or not separation of cuticle has occurred, the outline and convexity of the specimens is retained and the definition of carapace regions by grooves remains intact. Other specimens are preserved with extremely corroded cuticular material and, in one case, the carapace has been shattered and flattened. Because that specimen is complete, the fragments are in place, and the crab is completely encased within a concretion, we interpret the crushing to have been a result of post-depositional compression of the sediment, perhaps by loading of overlying sediments and dewatering. Although only one specimen of *Metacarcinus novaezelandiae* exhibits this type of crushing, nearly all specimens of *Trichopeltarion greggi* are preserved in this fashion. Thus far, it has not been possible to determine whether the crushed forms are confined to discrete parts of the beach and, therefore, were derived from specific sites within the original enclosing sediments.

Only one of the specimens in the present study exhibits epibionts. That specimen, CMzfc46, has at least five balanid barnacles attached on the right and left margins of the branchial region. Placement on the branchial regions is common because it is one of the areas that cannot be groomed by the crab (Waugh et al. 2004). Presence of epibionts often seems to be most common on fully mature individuals in which molting is infrequent (Waugh et al. 2004).

The fossil decapod fauna of the beaches of North Canterbury is unusual because it embraces lobsters, anomurans (in this case, a king crab, which is not a true crab), and brachyurans (true crabs) (Table 1). Many decapod faunas contain only true crabs; or only true crabs and anomurans. It is far less common that all three groups are found within the same unit. The taxa preserved within the beaches of North Canterbury indicate an offshore depositional environment for both of the respective formations from which the decapods have been recovered. Both extant *Metanephrops* and extant king

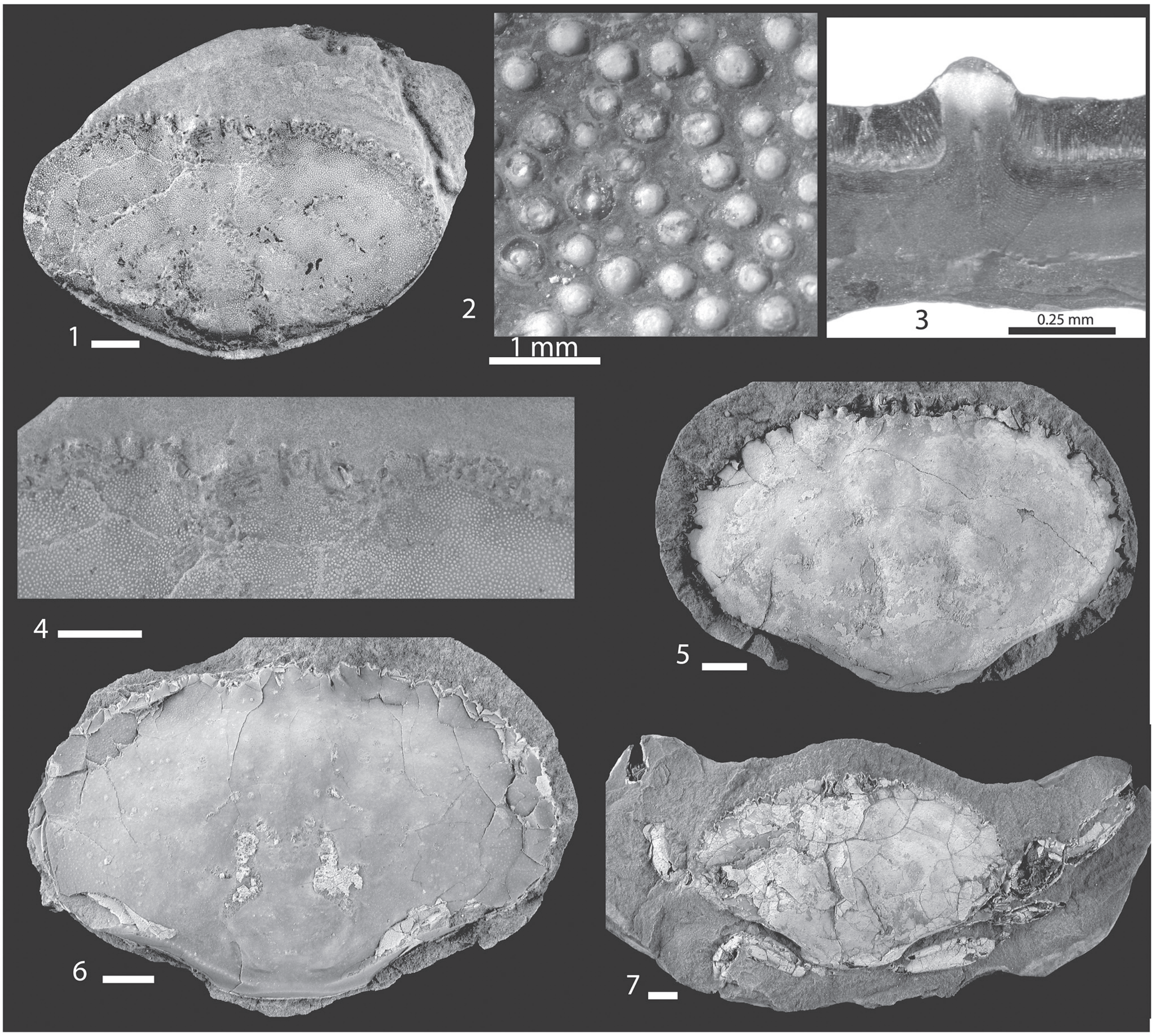

**Fig. 3(1–7)** *Metacarcinus novaezelandiae*, exhibiting various forms of preservation. **1–4** CM2006.1.4, dorsal (1) view, enlargement of dorsal surface (2) showing beaded appearance resulting from exposure of tubercles arising in endocuticle, cross-section of a single tubercle (3) showing cuticular laminations, and enlargement of frontal region (4) showing scale of beaded structures. **5**, CM2006.1.1, dorsal view of carapace retaining endocuticle. Exocuticle is retained on counterpart. **6**, CMzfc128, mold of the interior of dorsal carapace with small patches of cuticle. Remainder of cuticle is preserved on the counterpart. **7**, CM2006.1.2, dorsal view of carapace and appendages on which the cuticle has been retained but the entire specimen is severely fractured. All specimens are from Motunau Beach, North Canterbury, and are deposited in the Canterbury Museum. Scale bars = 1 cm, except where indicated.

crabs of the family Lithodidae are known from offshore, deeper water habitats. For example, all but two species of extant *Metanephrops* are known from depths >200 m (Jenkins 1972), and most species of *Paralomis*, an extant lithodid, reside below 200 m (Macpherson 1988). The spider crab *Leptomithrax* has living congeners in a variety of water depths from shallow to >550 m (McLay et al. 1995), and living spider crabs with long spines, as seen on *Actinotocarcinus*, are commonly found in deep water (Jenkins 1974). Extant species of *Trichopeltarion* inhabit waters of depths of >80 m, ranging up to 1650 m (Schweitzer & Feldmann 1999). Adults of *Metacarcinus* show behavioural habits of moving offshore (McLay 1988), which may be niche partitioning so that they do not compete with juveniles for resources, or a predator avoidance response. Extant members of the Pseudoziidae are reported to inhabit deep-sea environments (*Flindersoplax*, *Planopilumnus*, *Pseudozius*; Poore 2004). Specimens of the pseudoziid *Euryozius* described by Ng & Liao (2002) were collected from depths of 200–300 m. Thus, all of the available sedimentological and paleontological data suggest that these decapods inhabited an offshore, outer-shelf environment, probably at least 200 m in depth.

## ACKNOWLEDGMENTS

A supplement to NSF Grant OPP-9909184 to Feldmann and K. L. Bice supported fieldwork in New Zealand in 2004/05. B. Kelley and P. Stonier, both of the Department of Geology, Kent State University, assisted in collecting specimens during the 2004/05 field season. N. Hiller facilitated the loan of material from the Canterbury Museum in Christchurch, New Zealand. D. Waugh, Department of Geology, Kent State University, commented on the cuticle of *Tongapapaka motunauensis* n. gen.et sp. Constructive reviews were provided by R. E. Fordyce, Department of Geology, University of Otago, Dunedin, New Zealand, and C. L. McLay, School of Biological Sciences, University of Canterbury, Christchurch, New Zealand. Our thanks to these individuals.

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