New Zealand Journal of Zoology, 1983, Vol. 10: 151–162
0301–4223/83/1002–0151$2.50/0

Description of a new species of *Pinnotheres*, and redescription of *P. novaezelandiae* (Brachyura: Pinnotheridae)

RODERIC D. M. PAGE
Department of Zoology
University of Auckland
Private Bag, Auckland, New Zealand

Abstract *Pinnotheres novaezelandiae* Filhol, a common associate of the green-lipped mussel, *Perna canaliculus* (Gmelin), is redescribed and a lectotype is designated. *Pinnotheres schauinslandi* Lenz is considered to be a junior synonym of *P. novaezelandiae*. A new species, *Pinnotheres atrinicola*, is described from the horse mussel, *Atrina zelandica* (Gray). The 2 species are morphologically very similar; differences are most evident in the hard-stage male. In male hard-stage *P. novaezelandiae* the first pleopod is stout, blade-like, slightly curved, and densely setose, whereas in *P. atrinicola* it is slender, strongly curved, and sparsely setose. In mature female *P. novaezelandiae* the legs of both sides are similar in length, whereas *P. atrinicola* females have noticeably asymmetric legs. The first-stage zoea larvae of the 2 species are very similar, differing slightly in size and chromatophore pattern. Both species are endemic, and are the only known representatives of the family Pinnotheridae in New Zealand.

Keywords Brachyura; Pinnotheridae; *Pinnotheres novaezelandiae*; redescription; lectotype designation; *Pinnotheres atrinicola*; new taxa; distribution; pea crab hosts.

INTRODUCTION

Pea crabs are familiar associates of bivalve molluscs. Scott (1961) reviewed the literature on the group in New Zealand, concluding that only the polymorphic *Pinnotheres novaezelandiae* Filhol occurs. She listed the hosts as *Mytilus edulis aoteanus* Powell, *Perna canaliculus* (Gmelin), *Xenostrobus pulex* (Lamarck) (as *Modiolus neozelanicus* Iredale), *Atrina zelandica* (Gray), *Spisula aequilateralis* (Deshayes), and *Resania lanceolata* Gray. Bennett (1964) concluded that *Pinnotheres schauinslandi* Lenz occurs; and indeed, larvae of 2 species of *Pinnotheres* have been reported from Wellington Harbour plankton (Wear 1965, Jones 1977). Morphological differences between zoea larvae hatched from *Pinnotheres novaezelandiae* obtained from *Perna canaliculus* and *Pinnotheres* from *Atrina zelandica* led Jones (1975, 1978) to suggest that the pea crab found in *A. zelandica* is a different species. Jenkins (1979), noting that *Pinnotheres novaezelandiae* is common in *Perna canaliculus*, stated that "a similar species, *Pinnotheres* sp. is equally common in *Mytilus*".

This taxonomic confusion is understandable in light of the inadequate original description of *P. novaezelandiae* given by Filhol (1885a, b) and the polymorphic development characteristic of the Pinnotheridae. In genus *Pinnotheres* the planktonic zoea and megalopa larvae are followed by a complex series of crab instars. The first crab instar, the 'invasive stage', is free-swimming and invades the host. Both sexes then pass through a series of 'pre-hard' stages in the host before moulting into the Stage I or 'hard-stage' form with a hard, well calcified exoskeleton. Male hard-stage crabs are sexually mature, but the hard-stage female moults through a further 4 soft stages (Stages II–V), becoming mature only at Stage V. With the exception of the invasive stage, the post-planktonic developmental stages of *P. novaezelandiae* have been described by Jones (1977).

Examination of both adult and larval pea crabs from various hosts and localities around New Zealand confirms Jones's (1975, 1978) suggestion that the pea crab present in *Atrina zelandica* deserves recognition as being distinct from *P. novaezelandiae*. The hard-stages, mature female, and first-stage zoea of both species are described in this paper.

Much work remains to be done on the New Zealand Pinnotheridae, however. Of the material collected from *Spisula aequilateralis* and *Mactra discors* Gray by Bennett (1964, p. 78), only 1 damaged female (AQ 2372) remains in the Canterbury Museum. Further material is needed before the identity of the pea crabs found in these 2 bivalve species, as well as those occurring in *Nemocardium pulchellum* Gray, *Resania lanceolata*, *Tiostrea lutaria* (Hutton), *Pecten novaezelandiae*

Received 14 October 1982

Reeve, *Modiolus* sp., and *Xenostrobus pulex* (Dell 1960, Scott 1961, Bennett 1964, Jones 1978), can be determined. Most of the planktonic and early post-planktonic stages of *Pinnotheres novaezelandiae* and the new species described below are either unknown or undescribed.

MATERIAL AND METHODS

My own material has supplemented specimens in collections held by the University of Auckland Department of Zoology, Auckland Institute and Museum, National Museum of New Zealand, Dr J. B. Jones (Fisheries Research Division, Ministry of Agriculture and Fisheries), Canterbury Museum, and University of Canterbury Department of Zoology. The syntypes of *Pinnotheres novaezelandiae* were obtained on loan from the Museum National d'Histoire Naturelle, Paris. An unsuccessful attempt was made to locate the type material of *Pinnotheres schauinslandi* (see also Schmitt et al. 1973, p. 85).

The maximum carapace width of adult crabs and the dorsal length of the carpus, propodus, and dactylus of the second leg of the mature female crab were measured to the nearest 0.1 mm using dial calipers.

First-stage zoea larvae were hatched from gravid females collected from intertidal populations of *Perna canaliculus* and *Atrina zelandica* in Auckland's Waitemata Harbour during 1981–82. Zoeae were also obtained from Waitemata Harbour plankton during 1981–82. The chromatophores of living zoeae were recorded using the classification system of Wear (1968). The maximum carapace length and width of zoeae were measured using a micrometer eyepiece in a stereo microscope.

Both hatched and planktonic zoeae were dissected and mounted in polyvinyl lactophenol and examined with a bright-field microscope. A small series of zoeae were prepared for scanning electron microscopy by either critical point drying (using liquid carbon dioxide as the transitional fluid) or freeze-drying. The zoeae were then mounted on double-sided adhesive tape on aluminium stubs, coated with 30 nm of gold in a diode sputter coater (Poleron E5000), and examined with a Philips 505 scanning electron microscope.

In the list of material examined, the gravid female crabs are listed separately from non-gravid females—for example, 4♀, 2g♀ indicates a total of 6 females. The setation of the appendages of the zoeae is represented by formulae; a diagonal stroke indicates a joint between segments, and groups of setae on the same segment are separated by hyphens.

DESCRIPTIONS

Family PINNOTHERIDAE
Genus *Pinnotheres* Bosc

Pinnotheres novaezelandiae Filhol
(Fig. 1, 2A–H)

Pinnotheres pisum (Linnaeus, 1767). Heller, 1868: 67. – Miers, 1876: 48. –Filhol, 1885a: 50; 1885b: 394. – Adensamer, 1897: 105–106 (part). –Thomson *in* Ayson, 1900: 22. –Hutton, 1904: 250. –?Chilton, 1911: 255–256. –Thomson, 1913: 238. –Borradaile, 1916: 100–101 (part; not text-fig. 12 *fide* Bennett (1964, p. 76)). –Tesch, 1918: 249, 251, 287. – Thomson & Anderton, 1921: 101. –?Gurney, 1924: 195 (part). –Chilton & Bennett, 1929: 775–776. – Richardson, 1949: 30, 36, fig. 23.

Pinnotheres novaezelandiae Filhol, 1885a: 15–16, 50; 1885b: 395–396, 495, pl. 46 fig. 1–6. –*Lenz, 1901: 467, pl. 32 fig. 11–14. –*Hutton, 1904: 250. – *Tesch, 1918: 249, 251, 287. –*Young, 1929: 152. – Powell, 1937: 371, 382; 1947: 39–40. –*Richardson, 1949: 36. –Scott, 1961: 303–309, fig. 1, 4, and 6 (part). –Dell, 1963: 50, 2 figs. –Bennett, 1964: 76–79, fig. 84, 85, 88, 92, and 93 (part). –*Wear, 1965: 16, 18, fig. 6D. –*Silas & Algarswami, 1967: 1175, 1203, 1207. –*Morgans, 1967: 171. –Dell, 1968a: 26 (part); 1968b: 233, 238. –Morton & Miller, 1968: 292 (part; not fig. 101). –Schmitt et al., 1973: 58–59 (part). –Hayward, 1974: 159, fig. 1 and 2. – Carpenter, 1976: 16. –?Gordon & Ballantine, 1976: 122. –Jones, 1977: 145–158, fig. 1–7; 1978: 667–676. –Fenwick, 1978: 208. –Hickman, 1978: 211–215. – Pregenzer, 1979: 22–30, fig. 4, 9, 12, 20, 20A, 28, and 29. –Jenkins, 1979: 44–45. –Baxter, 1982: 77–83.

Pinnotheres schauinslandi Lenz, 1901: 468–469, pl. 32 fig. 15–18. –Chilton, 1911: 295–296. –Tesch, 1918: 250–251, 287. –Chilton & Bennett, 1929: 775–776. – Scott, 1961: 303, 307. –Bennett, 1964: 79–80, fig. 87 and 89–91 (part; not fig. 86). –Silas & Algarswami, 1967: 1209, 1221. –Schmitt et al., 1973: 85 (part).

?*Pinnotheres* sp. Dell, 1960: 5.

Pinnotheres sp. Jenkins, 1979: 44–45, fig. 46.

Not *Pinnotheres novaezelandiae* Filhol. –*Chilton, 1911: 295–296. –Takeda & Miyake, 1969: 180–181. (= *Pinnotheres atrinicola* n.sp.)

Not *Pinnotheres novaezelandiae* Filhol. –Rathbun, 1923: 98, text-fig. 2, pl. 16 fig. 2. –*Guiler, 1952: 40. (= *Pinnotheres hickmani* (Guiler))

Diagnosis. Chelae of hard-stage without a continuous dorsal row of setae on propodus. Terminal segment of hard-stage abdomen trapeziform. Male 1st pleopod stout, blade-like, its distal end slightly curved, densely setose. Legs of mature female not markedly asymmetrical. Second leg with dactylus always shorter than carpus, carpus and propodus subequal in length. First 3 legs without long setae on carpus, propodus, and dactylus.

First-stage zoea without dorsal and lateral carapace spines; rostrum minute. Lateral carapacial chromatophore with a single centre; black subin-

*A variant or misspelling of the original synonym occurs in these references

testinal chromatophore in telson proximal to yellow lateral intestinal chromatophore.

Description. HARD-STAGE (Fig. 1A–G). Carapace (Fig. 1A) hard, smooth except for minutely pitted frontal and branchial regions, oval to circular, strongly arched longitudinally, convex dorsally; width range 3.4–11.3 mm; lateral margins nearly vertical; front protruding, deflexed downwards, convex or straight in dorsal view, sometimes with a medial notch. Eyes visible in dorsal view.

Third maxilliped endopod (Fig. 1B) with ischium and merus fused; aboral surface convex, with small setae scattered over surface; lateral margin with a dense row of stout setae; medial margin and medial oral surface with long, plumose setae; medial aboral surface with a row of stout setae; lateral margin of carpus and propodus with a dense row of curved setae; dactylus arising near propodus/carpus articulation; distal end of dactylus bearing long setae.

Chelipeds stout; merus with a row of setae on dorsal and ventral margins; carpus with a row of setae on ventral margin and a dense tuft of setae dorsally on inner face; chelae (Fig. 1C,D) stout; propodus inflated; inner ventral margin (Fig. 1D) with a row of distally directed setae extending from articulation with carpus to tip of fixed finger; propodus with tufts of setae dorsally and ventrally near articulation with carpus, a short row of setae on outer face below articulation with moving finger (Fig. 1C), and a short row of setae on inner dorsal face at articulation with moving finger (Fig. 1D), extending on to proximal half of moving finger; fingers stout, crossing when closed, each with a proximal tooth; teeth biting together when fingers closed; a single row of stout, dagger-like setae between tooth and tip on both fingers, flanked on either side by longer setae; a short row of dagger-like setae on inner face of fixed finger immediately proximal to tip (Fig. 1D).

Legs flattened, the 4th shortest, the 2nd and 3rd subequal in length. Merus of each leg bearing a row of long setae on dorsal margin; a dense fringe of setae on ventral margin of each merus, carpus, and propodus; carpus of each leg with a tuft of short setae dorsally at articulation with propodus; 2nd and 3rd legs each with 2 rows of long, pinnate setae, one on ventral margin and one on posterior face near dorsal margin of last 3 segments; merus and dorsal and ventral margins of carpus and propodus of last leg with similar setae (these long setae reduced or absent in large males).

Abdomen 7-segmented. Male abdomen (Fig. 1E) tapering from segment 3, the broadest, to segment 7; margins of 3rd segment markedly convex; terminal segment trapeziform; segments fringed with short setae. Female abdomen (Fig. 1F) broader and less tapering than in male; 2nd segment relatively broader; terminal segment more rounded.

Male 1st pleopod (Fig. 1G) densely setose, stout, blade-like, tapering gradually, its distal end slightly curved laterally; medial row of setae terminating on sternal side of pleopod just below tip.

Colour pattern complex, clearly defined, strongly pigmented. Anterior half of carapace orange-brown, with white spots and cream areas forming a distinctive pattern (Fig. 1A); posterior half more variable in pattern, with white spots and markings on a mauve and yellow background. Legs brown with darker areas; chelae yellowish-brown with brown markings. Thoracic sternites creamy yellow with brown patches along junctions between individual sternites. Abdomen with paired brown patches dorsally. Both the colours and their extent are variable.

MATURE FEMALE (Fig. 1H–J). Carapace (Fig. 1H) soft, smooth, longitudinally arched, dorsally convex, oval in dorsal view, laterally angular; width range 7.8–20.0 mm; front rounded. Eyes not usually visible in dorsal view.

Third maxilliped (Fig. 1I) as for hard-stage, but lateral setae on fused merus/ischium and on carpus shorter and sparser.

Cheliped merus with a short row of setae dorsally and another ventrally, the latter row reduced or absent in large females; carpus with a row of setae dorsally on inner face; chelae stout, variable in shape, the propodus glabrous except for a row of setae on ventral face; setation of biting surfaces of fingers as for hard-stage; inner tip of moving finger with a few setae.

Legs subcylindrical, the 4th shortest, the 2nd and 3rd subequal. Second leg (Fig. 1J) with carpus and propodus subequal (length ratio of carpus to propodus 1:1.09 ± 0.07 SD; n = 28), dactylus always shorter than carpus. Legs on each side symmetrical (ratio of sum of lengths of last 3 segments of 2nd leg, shortest to longest, 1:1.02 ± 0.02 SD; n = 27). Merus of each leg with a row of long setae along dorsal margin. First 3 legs with scattered setae on ventral margin of propodus and dactylus. All 4 legs with dactylus bearing a row of fine, tooth-like setae on ventral margin.

Abdomen 7-segmented, as wide as carapace or wider, its edges usually extending to coxae of legs; segments fringed with setae.

Colour pattern (where present) as for hard-stage, but less heavily pigmented, and pattern less well defined; otherwise creamy white all over. Mature ovaries clearly visible through carapace as a purple mass.

FIRST-STAGE ZOEA (Fig. 2A–H). Carapace (Fig. 2A) globulose, without dorsal or lateral spines but with a pair of setae dorsally; mean length 0.50 mm (range

0.45–0.55 mm), mean width 0.37 mm (range 0.35–0.38 mm). Rostrum minute, variable in size.

Antennule (Fig. 2A,B) a small, hemispherical bud with 2 aesthetascs and 1 seta.

Antenna (Fig. 2A) minute, bearing 1 seta.

Mandible: incisor process (Fig. 2C) stout, with a major tooth and 2 smaller accessory teeth.

Maxillule (Fig. 2D): endopod of 2 segments, with 4 (0/4) setae; basal endite with 5 setae; coxal endite with 4 setae.

Maxilla (Fig. 2E): endopod with 3 setae; bilobed basal endite with 4 and 5 setae; coxal endite with 5 or 6 setae, the 6th (where present) minute; scaphognathite with 4 plumose setae and a plumose proximal extension.

Maxilliped 1 (Fig. 2F): basis with 10 (1–1–2–3–3) setae; endopod of 5 segments, with 2/2/1/2/5 (4–1) setae; exopod with 4 natatory setae.

Maxilliped 2 (Fig. 2G): basis with 4 setae; endopod of 2 segments bearing 0/5 setae; exopod as for maxilliped 1.

Maxilliped and pereiopods 1–4 present as unsegmented buds.

Abdomen (Fig. 2H) of 5 segments plus telson. Segments 2 and 3 with small dorsolateral protuberances, those of segment 2 joined by a slightly raised dorsal ridge. Segments 2–5 each with a pair of short setae dorsally, near posterior margin of segment. Segments 4 and 5 widening posteriorly to a trilobed, spatulate telson. Median lobe of telson projecting beyond lateral lobes, which are posterolaterally serrate and terminate in a stout, minutely serrate spine with a further small spine laterally; between median lobe and each lateral lobe are 3 setose processes.

Chromatophore pattern (Fig. 2A,H; Table 1): lateral carapacial chromatophore well developed, with a single centre; abdominal segments 2–5 (Fig. 2H) with paired yellow and black chromatophores, the latter coalesced in segments 2–4; black subintestinal chromatophore of telson proximal to yellow lateral intestinal chromatophore.

Material examined. AUTHOR'S PERSONAL COLLECTION. Waitemata Harbour, from *Perna canaliculus*: Westmere reef, 15 Oct 1981, 15 Dec 1981, 10 Feb 1982, 26 Apr 1982, 26 May 1982, numerous specimens; Stanley Point, 11 Feb 1981, 1g♀; Narrow Neck, 11 Apr 1982, 4♀, 2g♀, 2♂. Harris Bay, Banks Peninsula, from *Mytilus edulis aoteanus* and *P. canaliculus*, 28 Jan 1982, 6♀, 1g♀, 3♂. Camp Bay, Lyttelton Harbour, from *M. e. aoteanus* and *P. canaliculus*, 30 Jan 1982, 2♀, 5g♀, 2♂.

AUCKLAND INSTITUTE AND MUSEUM. Kerikeri Inlet, Bay of Islands, from *M. edulis*, 30 Jan 1973, A. B. Stephenson, 21♀, 21g♀, 9♂ (AIM. 3924, 3925). Kaipara Harbour, from *M. edulis*, 17 Jan 1978, T. J. Bayliss, 1♀, 1g♀ (AIM. 3931). The Noises islands, from *P. canaliculus*, 23 Jan 1967, 25 Feb 1967, 25 Mar 1967, A. B. Stephenson, 2♀, 18g♀, 4♂ (AIM. 3916–20). SE Ponui I., 5 Jun 1967, A. B. Stephenson, 2♂ (AIM. 3922). Motuihi Channel, between Emu Pt and Home Bay, 8–10 fm, from *P. canaliculus*, 28 Mar 1930, A. W. B. Powell, 1g♀ (AIM. 3915). B.a.2, suction dredge off Devonport Wharf, Oct 1927, Mrs Movat, 1g♀ (det. E. W. Bennett; AIM. 3914). ?Manukau Harbour, 1g♀ (det. E. W. Bennett; AIM. 3926). Matakana I., Tauranga, 4 ft, assoc. with *Mytilus*, 30 Jan 1972, A. B. Stephenson, 1♂ (AIM. 3923).

NATIONAL MUSEUM OF NEW ZEALAND. Bay of Islands, dredged, Dec 1956, J. C. Yaldwyn, 1♀ (det. M. Scott, 1959; Cr. 949). Coromandel, from *Chione stutchburyi*, 31 Dec 1964, D. P. Orwin, 2g♀ (Cr. 2530). Long Bay, Auckland, from *P. canaliculus*, Feb 1950, R. K. Dell, 6♀, 11g♀, 8♂ (Cr. 942). Waiheke I., G. Chamberlain, 5♀, 18 g♀, 4♂ (det. M. Scott, 1959; Cr. 944, 953). Off Ponui I., Hauraki Gulf (36°51'S, 175°15'E), 10–15 fm, 29 Aug 1956, J. C. Yaldwyn, 1g♀ (det. M. Scott, 1959; Cr. 945). Levin, from mantle cavity of toheroa: Waitarere Beach, 8 Nov 1951, 1g♀ (det. M. Scott, 1959; Cr. 948); Hokio Beach, 5 Aug 1956, F. D. W., 1♀ (det. M. Scott, 1959; Cr. 946). Otaki Beach, from toheroa, *Paphies* (*Mesodesma*) *ventricosa*, 16 Sep 1978, G. H. Brandeis, 1g♀ (Cr. 2527). Wellington Harbour: N end of Somes I. from 48 *Perna canaliculus*, 27 Jul 1964, P. H. J. Castle, 2♀, 7g♀, 1♂ (Cr. 1496); Somes I., from *P. canaliculus*, 8 Apr 1957, J. Moreland, 17♀, 6 g♀, 2♂ (Z. Cr. 676); off Days Bay, 4 fm, among algae, 19 Jan 1953, R. K. Dell and J. M. Moreland, 1♂ (Cr. 2525). Days Bay, from *P. canaliculus*, 4 Apr 1954, R. A. Falla, 1♀ (Cr. 954); wharf at light [sic], 16 Feb 1957, R. K. Dell, 6♀, 1♂ (Cr. 958); wharf piles, 12 Apr 1957, P. M. Ralph, 1♀, 1g♀ (det. M. Scott, 1959; Cr. 950); Kau Pt, from 30 mussels, 20 Aug 1962, P. Castle, 2♀, 12g♀, 2♂ (Cr. 2517); Kau Pt, from 43 *P. canaliculus*, 10 Feb 1962, J. Moreland, 4♀, 8g♀ (Cr. 1197); Kau Pt, from *P. canaliculus*, 19 May 1962, J. Moreland, 1♂ (Cr. 1198); Karakara [sic] Bay, from *P. canaliculus*, 16 Feb 1948, R. K. Dell, 4g♀ (det. M. Scott, 1959; Cr. 943). Totaranui, Nelson, free-living in *Corallina*, May 1963, R. K. Dell, 1♂ (Cr. 1313). Long I., Queen Charlotte Sound, from *M. edulis*, 29 Sep 1963, M. A. Crozier, 1♀ (Cr. 2526). Tory Channel, Marlborough, 1957, M. Kirk, 1g♀ (Cr. 957). Ketu Bay, Pelorus, mantle cavity of mussels, 1 Jan 1956, 1♀, 1g♀, 1♂ (det. M. Scott, 1959; Cr. 947).

J. B. JONES PERSONAL COLLECTION. Specimens from Ahipara, Wellington area (Ward I., Seatoun beach, Eastbourne), and Marlborough Sounds (East Entry, Pelorus Sound, Kenepuru Sound) collected from *P. canaliculus* and *M. edulis*. Kaipara Harbour, from raft 1 m deep, Pacific oyster, 1♀. From *Crassostrea*, 1♂. Waitangi, from 16 *Chione*, 1 Aug 1973, 2g♀, 1♂.

CANTERBURY MUSEUM. Ponui passage, Aug 1915, W. J. Barr, 4♂ (*Pinnotheres schauinslandi* det. E. W. Bennett, 18 Nov 1930; AQ 2388), 1♀, 7g♀, 1♂ (det. E. W. Bennett, 18 Nov 1930; AQ 2250). Kaikoura, Jan 1936, H. R. Millar, 3♀, 1g♀ (AQ 2279). New Brighton, in polyzoan *Flustrella binderi* (drift from Sumner), 2 Jul 1927, E. W. Bennett, 1♂ (*P. schauinslandi* det. E. W. Bennett, 18 Nov 1930; AQ 2384). New Brighton, Hutton, 5♀ (det. E. W. Bennett, 18 Nov 1930; AQ 2389). Sumner, C. Wood, 9♀ (AQ 2270). Robin Hood Bay, 30 Aug 1913, R. Bigg-Wither, 3♂ (*P. schauinslandi* det. E. W. Bennett, 18 Nov 1930; AQ 2380). Riverton, 1♂ (*P. schauinslandi* det. E. W. Bennett, 18 Nov 1930; AQ 2371, ex Chilton Collection), 1♀ (det. E. W. Bennett, 18 Nov 1930; AQ 2367, ex Chilton

Fig. 1 *Pinnotheres novaezelandiae*: A, hard-stage ♂, dorsal view; B, left 3rd maxilliped, hard-stage ♂; C,D, left chela, hard-stage ♂, outer and inner faces; E, abdomen, hard-stage ♂, ventral view; F, abdomen, hard-stage ♀, ventral view; G, left 1st pleopod, ♂, sternal view; H, mature ♀, dorsal view; I, left 3rd maxilliped, mature ♀; J, right 2nd leg, mature ♀, anterior view (scale lines represent 1 mm except for A and H, 5 mm).

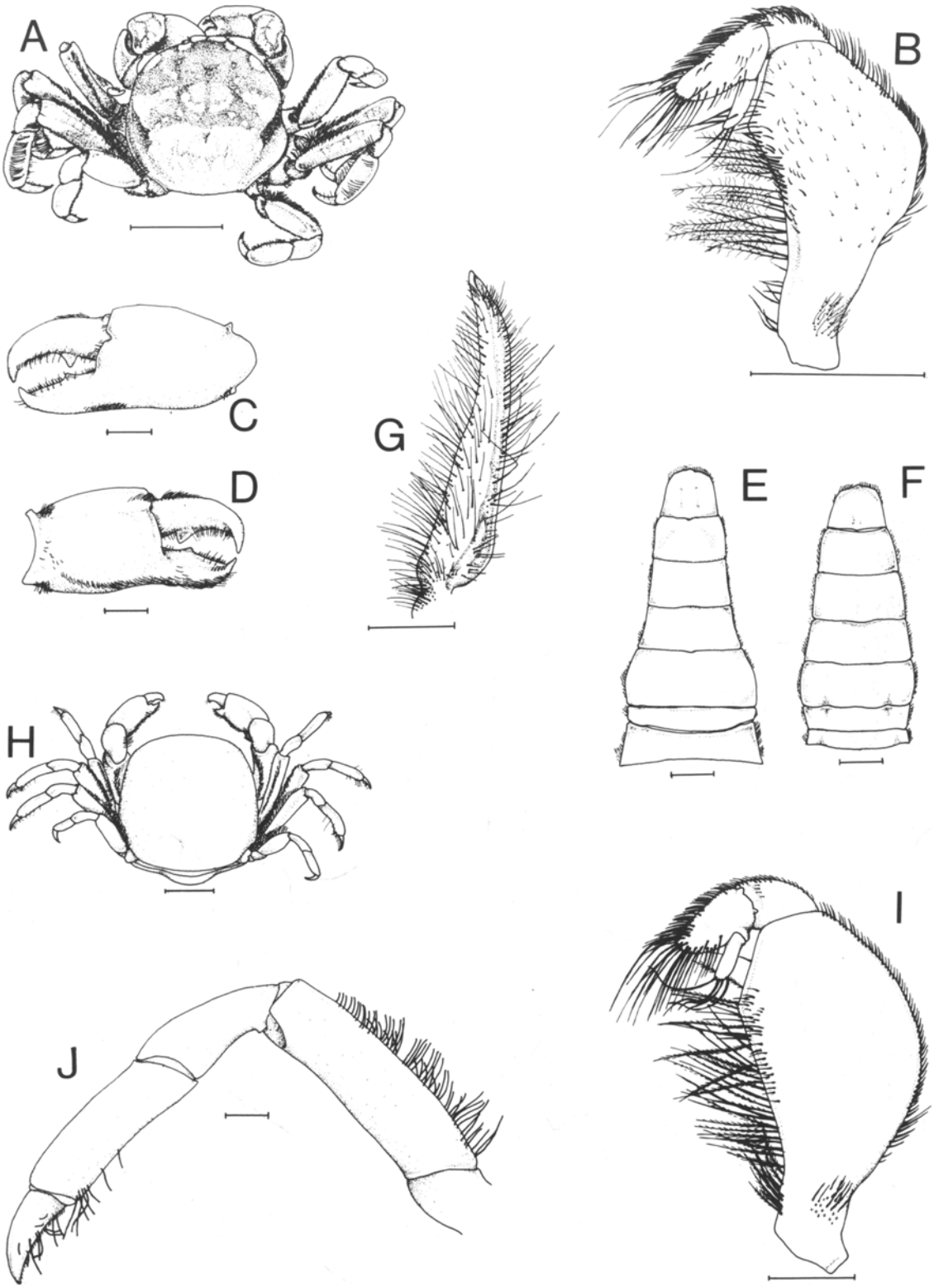

A
B
C
D
G
E
F
H
I
J

Table 1 Chromatophore patterns of first-stage zoea larvae of *Pinnotheres novaezelandiae* and *P. atrinicola* (—, chromatophore absent).

	novaezelandiae	*atrinicola*
PRIMARY SYSTEM		
NEURAL GROUP		
1. Supracerebral	—	—
2. Antennular	—	—
3. Antennal	dichromatic, black/yellow	black
4. Labral	—	—
5. Mandibular	black	black
6. Maxillary	black	black
7. Maxillipedal	black	black
8. Lateral intestinal	yellow	yellow
9. Subintestinal	black, paired in segment 5 and telson	black, paired in all segments
VISCERAL GROUP		
10. Median gastric	black	black
11. Precardiac	black	black
12. Subcardiac	dichromatic, black/yellow	dichromatic, black/yellow
13. Postcardiac	—	—
SECONDARY SYSTEM		
14. Posterior carapacial	—	—
15. Posteroventral	dichromatic, black/yellow	dichromatic, black/yellow
16. Lateral carapacial	dichromatic, black/yellow	dichromatic, black/yellow
17. Dorsal carapace spine	—	—
18. Maxillipedal	—	—
19. Optic	—	—
20. Median ocular centre	black	black

Collection). Stewart I., in *Mytilus*, Apr 1916, W. Traill, 1♂ (*P. schauinslandi* det. E. W. Bennett, 18 Nov 1930; AQ 2304), 17♀, 2♂ (det. E. W. Bennett, 18 Nov 1930; AQ 2525). Chatham Island, Hutton, 5♀ (det. E. W. Bennett, 18 Nov 1930; AQ 2392).
UNIVERSITY OF CANTERBURY. Camp Bay, Lyttelton Harbour, from *Perna canaliculus*, 1981, A. S. Baxter, 4♀, 5♂.

Distribution. North and South islands, Stewart Island, and the Chatham Islands. Intertidal to 30 m. Endemic. The record of this species from Bass Strait, Tasmania (Rathbun 1923, Guiler 1952) has been referred by Pregenzer (1979) to *Pinnotheres hickmani* (Guiler).

Hosts. Known hosts are *Perna canaliculus*, *Mytilus edulis aoteanus*, *Aulacomya ater maoriana* (Iredale), *Crassostrea gigas* (Thurnberg), *Paphies ventricosa* (Gray), and *Chione stutchburyi* (Gray). Reported incidence in *P. canaliculus* ranges from zero to 70.27% (Jones 1978, Hickman 1978, Baxter 1981). Stead (1971, p. 9) noted that several of the *P. canaliculus* examined during a survey of Pelorus Sound mussels contained a pea crab, and that pea crabs were also found occasionally in *M. e. aoteanus*. Baxter (1981) found 1.96–2.30% of *A. a. maoriana* from the Avon–Heathcote Estuary and Lyttelton Harbour to contain *Pinnotheres novaezelandiae*. In the *C. stutchburyi* populations studied by Larcombe (1971) the incidence of pea crabs, probably this species, was less than 1%.

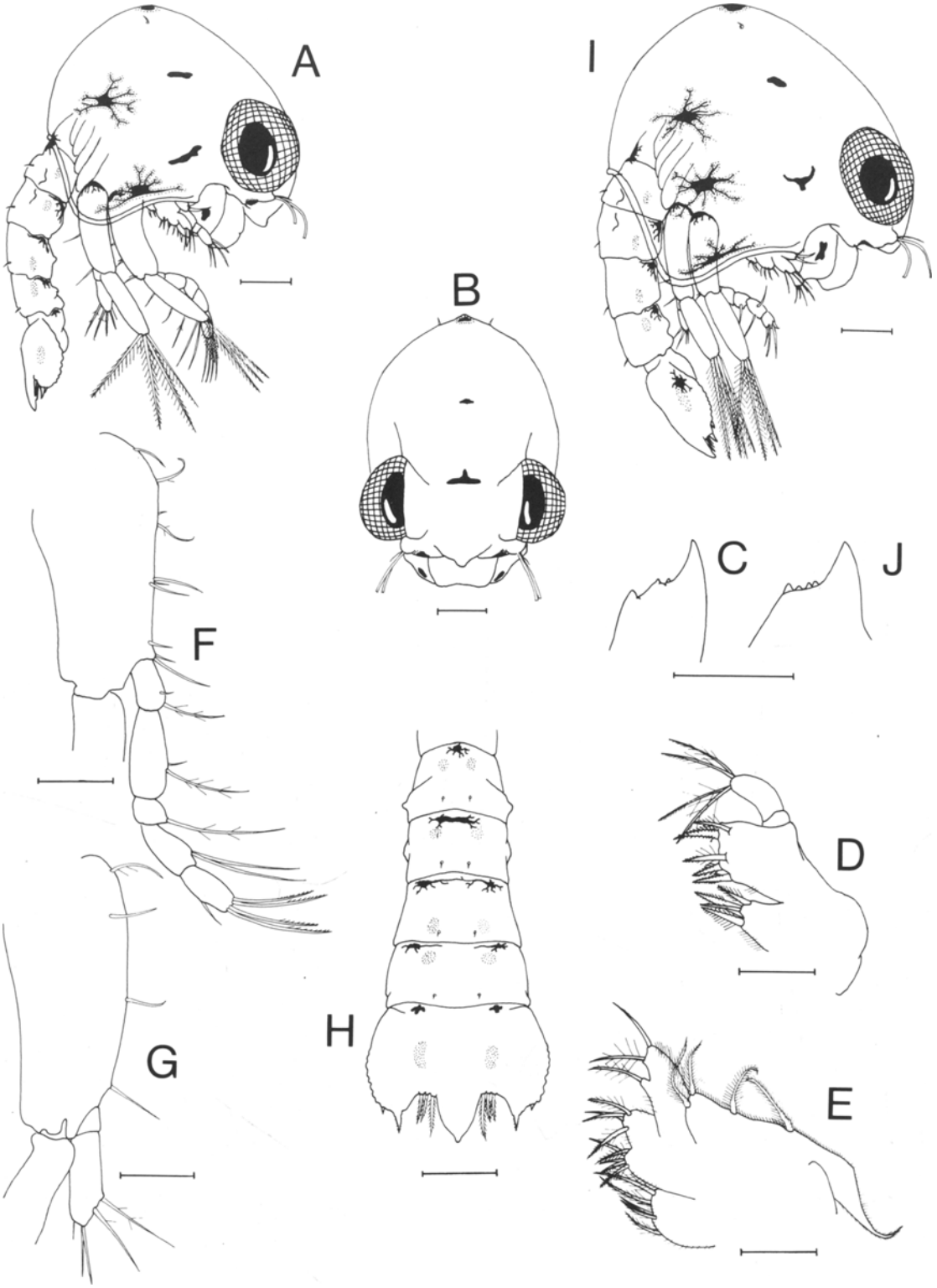
Hard-stage males and females have been taken free-living in *Corallina*, in subtidal algae, and on wharf piles.

Remarks. Filhol (1885a, b) described this species from specimens collected from *Mytilus edulis* at Golden Bay ("Baie du Massacre"). The syntypes (Museum National d'Histoire Naturelle, B. 8323) are 2 hard-stage females—described by Filhol as male—in excellent condition, and 11 mature females (2 gravid), most of which are badly damaged. The largest mature female (carapace width 14.9 mm, without abdomen, left chela detached) is referable to the new species of *Pinnotheres* described below, not to *P. novaezelandiae* as understood by recent authors. This suggests that Filhol's material came from more than one locality and host. Of the remaining syntypes, 3 are readily determinable as *P. novaezelandiae* and 7 are badly damaged, making identification difficult. I have chosen here to select the larger hard-stage female (carapace width 9.1 mm) as the lectotype of *P. novaezelandiae* and to designate the remaining syntypes, with the exception of the largest mature female mentioned above, paralectotypes.

Lenz (1901) examined one of Filhol's specimens, together with material from *Mytilus* from French Pass, and noted several inaccuracies in Filhol's figures (see also Scott 1961). In addition Lenz described a new species, *Pinnotheres schauinslandi*, based on 2 specimens of unstated sex collected with *P. novaezelandiae* from the same host at the same locality.

Chilton (1911) suggested that Lenz had in fact described the male (i.e., hard-stage) of *P. novaezelandiae* as a new species, a view that Scott (1961) supported. Only Bennett (1964) has recognised *P. schauinslandi* as a valid species. Examination of Canterbury Museum material determined by Bennett in 1930 shows that he assigned all hard-stage *Pinnotheres* to *P. schauinslandi* and all soft-stages to *P. novaezelandiae*. Apparently Bennett

Fig. 2 First-stage zoea larvae of (A–H) *Pinnotheres novaezelandiae* and (I,J) *P. atrinicola*: A,I, lateral view; B, anterior view; C,J, mandible; D, maxillule; E, maxilla; F, maxilliped 1; G, maxilliped 2; H, abdomen (solid black – black pigment; stippling – yellow pigment; scale lines represent 0.05 mm except for A, B, H, and I, 0.1 mm).


A
B
I
C
J
F
D
H
G
E

was unaware of the complex polymorphic development of the Pinnotheridae, and regarded hardand soft-stage pea crabs as different species rather than developmental morphs. There are small differences between hard-stage *P. novaezelandiae* and Lenz's description of *P. schauinslandi* (see Bennett 1964, p. 79; Jones 1977), and until Lenz's material (if extant) is examined the status of *P. schauinslandi* will remain open to doubt. However, given the original description, the host, and the circumstances of collection I agree with Chilton (1911) and Scott (1961), and include *P. schauinslandi* in the synonymy of *P. novaezelandiae*.

In a postscript, Scott (1961) stated that the pea crab recorded by Dell (1960) as *Pinnotheres* sp. from *Nemocardium pulchellum* Gray in Petre Bay, Chatham Islands, was a hard-stage female, not a male as Dell stated, and that it differed from *P. novaezelandiae* in possessing a row of setae on the dorsal margin of the dactylus of the chelae. In fact, most females of *P. novaezelandiae* also possess these setae. I could not find Dell's specimen in either the Canterbury Museum or the National Museum, where the 1954 Chatham Islands Expedition material was deposited, so the identity of this specimen remains uncertain.

The persistent, erroneous records of the European *Pinnotheres pisum* (L.) have been discussed by Scott (1961) and Bennett (1964), and Pregenzer (1979) has compared the adults of *P. pisum* and *P. novaezelandiae* in some detail. The differences in the first-stage zoeae of the 2 species are briefly discussed by all 3 authors. *P. novaezelandiae* has also been confused with the Australian *P. hickmani* (Guiler); Pregenzer (1979) has distinguished these 2 species.

Since Jones's (1978) study of the natural history of *P. novaezelandiae* the incidence of this species in natural and cultivated populations of *P. canaliculus* has been discussed by Hickman (1978), and Baxter (1981, 1982) has studied aspects of its ecology and physiology.

Pinnotheres atrinicola n.sp. (Fig. 2I,J, 3)

Pinnotheres novaezelandiae Filhol. –*Chilton, 1911: 295–296. –Scott, 1961: 307 (part). –Bennett, 1964: 76–79 (part; not figs). –Takeda & Miyake, 1969: 180–181.
Pinnotheres schauinslandi Lenz. –Bennett, 1964: 79–80 (part; not fig. 87 and 89–91).
Pinnotheres. Waite, 1909: 52.
Pinnotheres "undescribed species". Gordon, 1936: 165.
Pinnotheres sp. ("probably *P. schauinslandi*"). Wear, 1965: 16, 18.

*The original synonym is misspelt in this reference

Diagnosis. Hard-stage: chelae with a continuous dorsal row of setae on propodus; terminal segment of abdomen quadrate; male 1st pleopod slender, strongly curved in distal third, less setose than in *P. novaezelandiae*. Mature female: legs noticeably asymmetric; 2nd leg with dactylus subequal to carpus or longer, propodus longer than carpus. First 3 legs with long setae on carpus, propodus, and dactylus. First-stage zoea larger than in *P. novaezelandiae*, and with a different chromatophore pattern.

Description. Similar to *P. novaezelandiae*, against which characters are compared.

HARD-STAGE (Fig. 3A–G). Carapace (Fig. 3A) less dorsally inflated, less shouldered, 4.1–8.0 mm wide; front more protruding and convex.

Third maxilliped (Fig. 3B) slightly narrower.

Chelae (Fig. 3C,D) stouter, less inflated in male than female; row of setae on inner dorsal face of propodus extending from articulation with carpus to articulation with moving finger.

Legs with all setae usually more strongly developed and less reduced in large males.

Male abdomen (Fig. 3E) with segments 1–3 broader, terminal segment quadrate. Female abdomen (Fig. 3F) broad, convex ventrally, tapering strongly to quadrate terminal segment.

Male 1st pleopod (Fig. 3G) less setose, slender, strongly curved laterally in distal third.

Colour pattern typically with a large, orange marking along midline of posterior half of carapace.

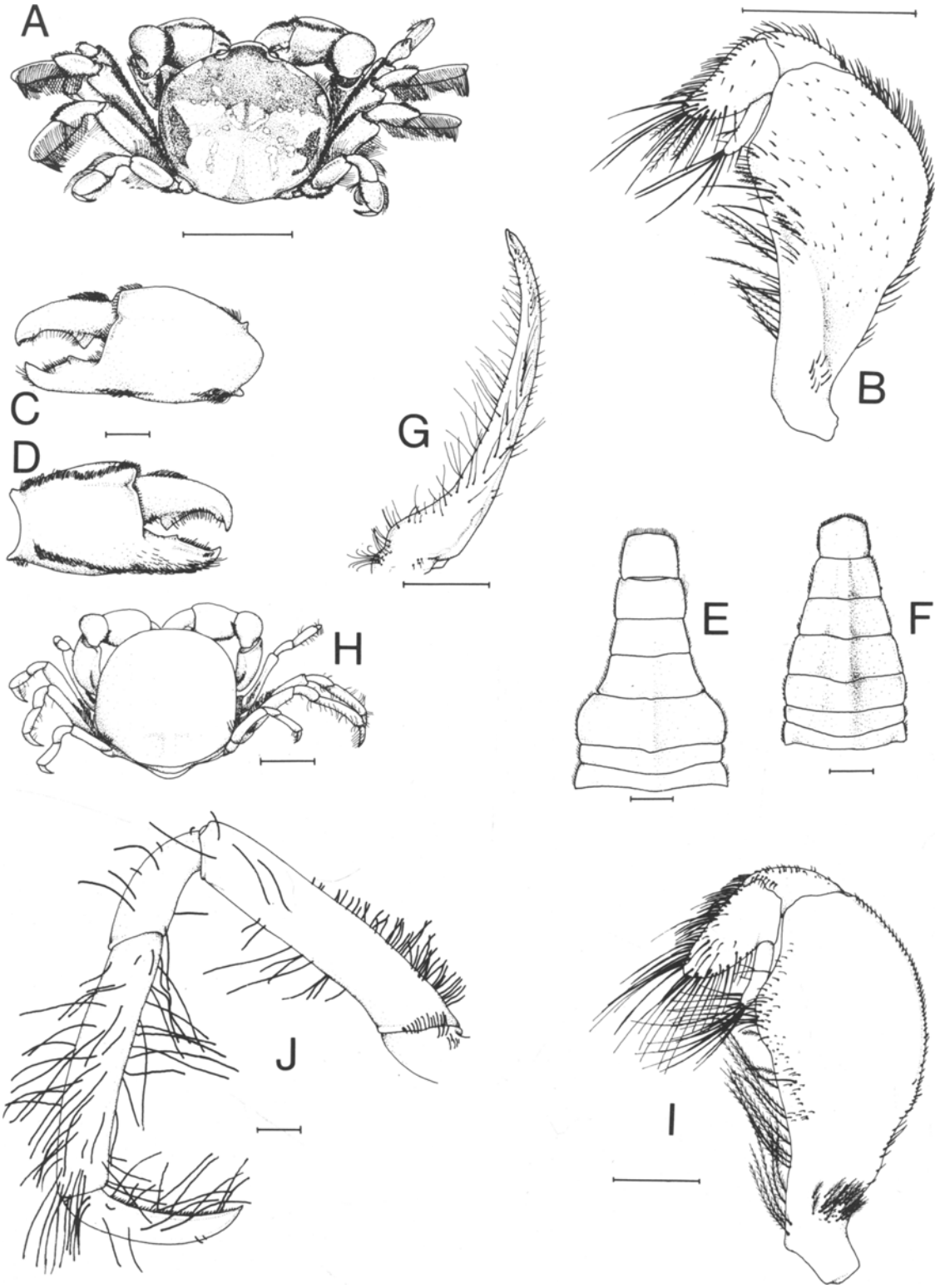
MATURE FEMALE (Fig. 3H–J). Carapace (Fig. 3H) more laterally inflated and more rounded, less arched longitudinally, less convex dorsally, 10.0–19.9 mm wide.

Third maxilliped (Fig. 3I) slightly narrower than in hard-stage.

Cheliped merus with dorsal setae reduced or absent, ventral row absent; chelae stout, inflated.

Legs slender, subcylindrical, the 2nd longest, the 3rd subequal in length to it, the 4th shortest. Second leg (Fig. 3J) with propodus longer than carpus (ratio 1:1.48 ± 0.12 SD; n = 24), dactylus subequal to carpus or longer. Legs noticeably asymmetric (ratio of sum of lengths of last 3 segments of 2nd leg,

Fig. 3 *Pinnotheres atrinicola*: A, hard-stage ♂, dorsal view; B, left 3rd maxilliped, hard-stage ♂; C,D, left chela, hard-stage ♂, outer and inner faces; E, abdomen, hard-stage ♂, ventral view; F, abdomen, hard-stage ♀, ventral view; G, left 1st pleopod, ♂, sternal view; H, mature ♀, dorsal view; I, left 3rd maxilliped, mature ♀; J, right 2nd leg, mature ♀, anterior view (scale lines as in Fig. 1).


A
B
C
D
E
F
G
H
I
J

shortest to longest, 1:1.7 ± 0.07 SD; n = 22); legs on 'shorter' side less robust and setose than those on 'longer' side. Merus with dorsal row of setae extending only halfway along margin. First 3 legs with scattered setae on lower half of merus and carpus, long setae on carpus, propodus, and dactylus. Last leg with scattered setae on dactylus and distal ventral margin of propodus.

Abdomen as in *P. novaezelandiae*.

Usually unpigmented.

FIRST-STAGE ZOEA (Fig. 2I) larger – mean carapace length 0.56 mm (range 0.53–0.63 mm), mean width 0.39 mm (range 0.37–0.43 mm). Rostrum usually shorter.

Mandible with incisor process variable, usually bearing 1 major tooth and 4 smaller accessory teeth (Fig. 2J).

Chromatophore pattern (Fig. 2I; Table 1): lateral carapacial chromatophore with 2, sometimes 3 centres; abdomen with paired black and yellow chromatophores; black subintestinal chromatophores of telson immediately ventral to yellow lateral intestinal chromatophores.

Type data. Holotype ♂ (hard-stage): NEW ZEALAND, Whangarei Harbour between High Island and mainland, 0–1 m, from *Atrina zelandica*, 13 May 1982, B. Dobson, G. Miles, C. Turbott, and C. Worthington (National Museum of New Zealand, Cr. 3021). **Paratypes** (National Museum of New Zealand). Bay of Plenty, B. L. Godfriaux, 3♀, 7♂ (sample no. 39A; Cr. 2529). B.S. 488, 40°09.5′S, 174°36′E, *c.* 18 miles S of Waitotara R. mouth, in 82 m, 2 Mar 1976, r.v. *Acheron*, 1♀ (Cr. 2521). Evans Bay powerhouse intake, 13 Oct 1954, R. K. Dell, 1♀ (*Pinnotheres novaezelandiae* det. M. Scott, 1959; Cr. 952). Lyall Bay, Wellington, from *A. zelandica*, Sep 1949, R. K. Dell, 1♀ (*P. novaezelandiae* det. M. Scott, 1959; Cr. 955). B.S. 528, 40°36.5′S, 173°00.5′E, off shelf flats inside Farewell Spit (Tasman Bank), in 24–26 m, 9 Mar 1976, r.v. *Acheron*, 2♀ (Cr. 2519, 2520). B.S. 527, 40°37′S, 172°48′E, *c.* 5 miles off Pakawau Beach, Golden Bay, in 24 m, 9 Mar 1976, r.v. *Acheron*, 1g♀ (*P. novaezelandiae* det. G. R. F. Hicks, in *A. zelandica*; Cr. 2524). 40°33′S, 173°27′E, in 73 m, from *Modiolus areolatus*, 10 Apr 1964, r.v. *Constantia*, 1♀ (pres. N.Z. Marine Department; Cr. 2528). B.S. 431, Orchard Bay, Marlborough Sounds, from head to entrance, 16 fm, 30 Aug 1975, r.v. *Acheron*, 1♀ (Cr. 2522). B.S. 515 (41°00.5′S, 174°00′E), W side of Forsyth Bay, Marlborough Sounds, in 9–18 m, 5 Mar 1976, r.v. *Acheron*, 1♀, 3g♀ (Cr. 2518). Off Cape Campbell, 40 fm, 5 Dec 1956, F. Abernethy, 1♀ (*P. novaezelandiae* det. M. Scott, 1959; Cr. 956). Off Cape Campbell, 40 fm, from *A. zelandica*, Mar 1957, F. Abernethy, 1♀ (*P. novaezelandiae* det. M. Scott, 1959; Z. Cr. 687). Off Otago Harbour, from *A. zelandica*, 9 Mar 1952, vessel *Taiaroa*, J. C. Yaldwyn, 1g♀ (Cr. 941).

Other material examined. AUTHOR'S PERSONAL COLLECTION. Whangarei Harbour: same data as holotype, from 86 *A. zelandica*, 48♀, 28g♀, 5♂; MacDonald Bank, from *A. zelandica*, 10 May 1982, 5♀. Ngataringa Bay, Waitemata Harbour, from *A. zelandica*, 12 Dec 1981, 4♀, 2g♀, 14 Dec 1981, 11♀, 4g♀, 2♂, 13 Jan 1982, 9♀, 2g♀, 27 Feb 1982, 1♀, 1g♀.

UNIVERSITY OF AUCKLAND DEPARTMENT OF ZOOLOGY. Okahu Bay, Waitemata Harbour, from *Chione stutchburyi*, 15 Aug 1981, A. Grimm, 1♂.

AUCKLAND INSTITUTE AND MUSEUM. Ruakaka, Marsden Pt, 2 Jan 1969, W. Farley, 1♀ (AIM. 3929).

J. B. JONES PERSONAL COLLECTION. Seatoun beach, from *A. zelandica*, 1♀.

CANTERBURY MUSEUM. Takapuna Beach, from *A. zelandica*, 29 Sep 1914, 2♀ (*P. novaezelandiae* det. E. W. Bennett, 18 Nov 1930; AQ 2369). Cheltenham Beach, from *A. zelandica* (ex Chilton Coll., no. 489), 2♀ (*P. schauinslandi* det. E. W. Bennett, 18 Nov 1930), 1♂ (*P. novaezelandiae* det. E. W. Bennett, 18 Nov 1930; AQ 2383). Auckland (dredged), Capt. Bollons, 2♀ (*P. novaezelandiae* det. E. W. Bennett, 18 Nov 1930; AQ 2396). Off Lyttelton heads, trawled sand–mud, 25–28 fm, 7 Mar 1967, vessel *Golden Light*, Mr Smith, 1♀ (AQ 2066). *Nora Niven* Expdn 1907, Stations 20 and 44, 5♀ (AQ 2242).

Distribution. North and South islands. Intertidal to 200 m. Endemic.

Hosts. The principal host is *Atrina zelandica*. There are single records of hard-stages from *Modiolus areolatus* (Gould) and *Chione stutchburyi*. Waite (1909, p. 52) found that "almost every adult *Pinna* [= *Atrina*] taken had its crustacean commensual, *Pinnotheres*", as did Stead (1971): in a sample of 87 *A. zelandica* taken from Whangarei Harbour on 13 May 1982, 83 (95.4%) contained a specimen of *P. atrinicola*.

Remarks. Differences between *P. novaezelandiae* and *Pinnotheres* from *Atrina zelandica* were first noted by Bennett (1964, p. 76), who observed that mature females of "*P. novaezelandiae*" from *A. zelandica* were usually larger and had relatively longer legs. Wear (1965) reported zoea larvae of 2 species of *Pinnotheres* in Wellington Harbour plankton: one he could not distinguish from *P. novaezelandiae* as described by Bennett (1964, p. 78–79, fig. 92 and 93); the other, he suggested, was probably *P. schauinslandi*, "as this is the only other adult of the genus *Pinnotheres* recorded from New Zealand (Bennett, 1964)". Apart from figuring the telson of *P. novaezelandiae*, Wear did not describe his specimens. Jones (1977) has confirmed that they belong to different species.

Using scanning electron microscopy, Jones (1975) compared first-stage zoeae of *P. novaezelandiae* and *Pinnotheres* from *A. zelandica*, noting small

differences in the morphology of the rostrum, labrum, and mandibles which led him to suggest that the latter was a different species (Jones 1975, 1978).

P. atrinicola is obviously very similar morphologically to *P. novaezelandiae*. The latter is more common in mytilids, especially *Perna canaliculus*, while with 2 exceptions *P. atrinicola* is known only from *A. zelandica*. *Chione stutchburyi* is the only host the 2 species have in common. This relative lack of overlap in hosts raises the possibility that the crabs I have recognised here as distinct species are in reality morphs of a single, polymorphic species in which post-planktonic morphology is determined by the identity of the host occupied. However, the morphology of both species is relatively constant, and both *P. novaezelandiae* and *P. atrinicola* show no patent morphological changes when found in bivalves other than their respective principal hosts, *Perna canaliculus* and *Atrina zelandica*. Further work, such as an electrophoretic study of allele frequencies in pea crabs from these 2 hosts, would help remove any remaining doubt about the status of *P. atrinicola*.

The specific epithet is constructed from *Atrina*, genus of the type host, and *-cola* (L.), a suffix denoting one who inhabits.

ACKNOWLEDGMENTS

For access to collections I thank Dr A. N. Baker, Mr W. R. Webber, and Mrs S. Norrie (National Museum of New Zealand), Mr A. B. Stephenson (Auckland Institute and Museum), Mr R. A. Savill (Canterbury Museum), and Dr M. B. Jones (University of Canterbury). Dr J. Forest (Museum National d'Histoire Naturelle, Paris) kindly made the syntypes of *Pinnotheres novaezelandiae* available on loan. Mrs M. T. Burgham, Messrs G. Boswell, B. Dobson, G. Miles, A. Moore, D. S. Page, C. Turbott, and C. Worthington, and Dr J. Walsby assisted with collecting. Dr J. B. Jones (Fisheries Research Division, Ministry of Agriculture and Fisheries) provided data and specimens, and commented on a draft of this paper. I am grateful to Mr A. S. Baxter (Taranaki Catchment Commission) for specimens and for permission to quote from an unpublished BSc (Hons) project, and to Mrs H. Silyn-Roberts (University of Auckland) for the SEM work on the zoeae. Dr B. A. Foster (University of Auckland) arranged the loan of the Filhol syntypes, commented on the manuscript, and provided much-needed encouragement and advice.

REFERENCES

Adensamer, T. 1897: Revision der Pinnotheriden in der Sammlung des k.k. naturhistorischen Hofmuseums in Wien. *Annalen des k.k. naturhistorischen Hofmuseums in Wien 12* : 105–107.

Baxter, A. S. 1981: Ecology of the New Zealand pea crab, *Pinnotheres novaezelandiae* Filhol, 1886 (Brachyura: Pinnotheridae). Unpubl. BSc (Hons) project, University of Canterbury, New Zealand.

———— 1982: Salinity tolerance and osmoregulation of the New Zealand pea crab, *Pinnotheres novaezelandiae* Filhol, 1886 (Brachyura: Pinnotheridae). *Mauri Ora 10* : 77–83.

Bennett, E. W. 1964: The marine fauna of New Zealand: Crustacea Brachyura. *New Zealand Department of Scientific and Industrial Research bulletin 153*. 123 p.

Borradaile, L. A. 1916: Crustacea, I. Decapoda. *British Antarctic ('Terra Nova') Expedition, 1910, natural history reports, zoology 3(2)* : 75–110.

Carpenter, A. 1976: A guide to the crabs (Crustacea: Decapoda) of the Avon-Heathcote Estuary, Canterbury. *Mauri Ora 4* : 15–18.

Chilton, C. 1906: Report of some Crustacea dredged off the coast of Auckland. *Transactions of the New Zealand Institute 38* : 265–269.

———— 1911: Scientific results of the New Zealand Government trawling expedition, 1907 – Crustacea. *Records of the Canterbury Museum 3* : 285–312.

Chilton, C.; Bennett, E. W. 1929: Contributions for a revision of the Crustacea Brachyura of New Zealand. *Transactions and proceedings of the New Zealand Institute 59* : 731–778.

Dell, R. K. 1960: Crabs (Decapoda, Brachyura) of the Chatham Islands 1954 Expedition. *New Zealand Department of Scientific and Industrial Research bulletin 139* : 1–7.

———— 1963: Nature in New Zealand. Native crabs. Wellington, A. H. and A. W. Reed. 64 p.

———— 1968a: Notes on New Zealand crabs. *Records of the Dominion Museum 6* : 13–28.

———— 1968b: Composition and distribution of the New Zealand brachyuran fauna. *Transactions of the Royal Society of New Zealand, zoology 10(25)* : 225–240.

Fenwick, G. D. 1978: Decapoda of the Snares Islands, New Zealand. *New Zealand journal of marine and freshwater research 12(2)* : 205–209.

Filhol, H. 1885a: Considerations relatives à la Faune des Crustacés de la Nouvelle-Zélande. *Bibliotheque de l'Ecole des Hautes Etudes, section des sciences naturelles 30* : 1–60.

———— 1885b: Catalogue des Crustacés de la Nouvelle-Zélande, des îles Auckland et Campbell. P. 349–510 *in:* Recueil de memoires, rapports et documents relatifs à l'observation du passage de Vénus sur le soleil du 9 Décembre 1874. *Mission de l'Ile Campbell 3(2), no. 1,* and *Atlas, zoologie 3(2).*

Gordon, D. P.; Ballantine, W. J. 1976: Cape Rodney to Okakari Point Marine Reserve. Review of knowledge and bibliography to December 1976. *Tane 22 (supplement).* 146 p.

Gordon, I. 1936: On a few Indo-Pacific species of *Pinnotheres*, with special reference to the asymmetry of the walking legs. *Journal of the Linnean Society of London, zoology 40(269)* : 163–180.

Guiler, E. R. 1952: A list of the Crustacea of Tasmania. *Records of the Queen Victoria Museum, Launceston, Tasmania 3(3)* : 15–44.

Gurney, R. 1924: Crustacea IX, Decapoda larvae. *British Antarctic ('Terra Nova') Expedition, 1910, natural history reports, zoology 8(2)* : 37–202.

Hayward, B. W. 1974: Kawerua crabs. *Tane 20* : 159–161.

Heller, C. 1868: Crustaceen. *Reise der österreichischen fregatte Novara um die Erde in den Jahre 1857, 1858, 1859 unter den befehlen des Commodore B. von Wüllerstorf-Urbair, zoologischer Theil 2(3).* 280 p.

Hickman, R. W. 1978: Incidence of a pea crab and a trematode in cultivated and natural green-lipped mussels. *New Zealand journal of marine and freshwater research 12(2)* : 211–215.

Hornell, J.; Southwell, T. 1909: Description of a new species of *Pinnoteres* [sic] from *Placuna placenta*, with a note on the genus. P. 99–103 *in:* Hornell, J., Report to the Government of Baroda on the marine zoology of Okhamandel in Kattiawar, 1.

Hutton, F. W. 1904: Index faunae Novae Zelandiae. London, Dulau. 372 p.

Jenkins, R. J. 1979: Mussel cultivation in the Marlborough Sounds (New Zealand). Wellington, New Zealand Fishing Industry Board. 75 p.

Jones, J. B. 1975: Studies on animals closely associated with some New Zealand marine shellfish. Unpubl. PhD thesis, Victoria University of Wellington, New Zealand.

——— 1977: Post-planktonic stages of *Pinnotheres novaezelandiae* Filhol, 1886 (Brachyura: Pinnotheridae). *New Zealand journal of marine and freshwater research 11(1)* : 145–158.

——— 1978: Natural history of the pea crab in Wellington Harbour, New Zealand. *New Zealand journal of marine and freshwater research 11(4)* : 667–676.

Larcombe, M. F. 1971: The ecology, population dynamics and energetics of some soft shore molluscs. Unpubl. PhD thesis, University of Auckland, New Zealand.

Lenz, H. 1901: Ergebnisse einer Reise nach dem Pacific (Schauinsland 1896–1897), Crustaceen. *Zoologische Jahrbücher: Abteilung für Systematik, Ökologie und Geographie der Tiere (Jena) 14* : 420–482.

Miers, E. J. 1876: Catalogue of the stalk- and sessile-eyed Crustacea of New Zealand. London, E. W. Jansen. 136 p.

Morgans, J. F. C. 1967: Records of breeding activity of marine invertebrates at Kaikoura. *Transactions of the Royal Society of New Zealand, zoology 9(12)* : 169–174.

Morton, J. E.; Miller, M. C. 1968: The New Zealand seashore. London, Collins. 638 p.

Powell, A. W. B. 1937: Animal communities of the sea-bottom in Auckland and Manukau Harbours. *Transactions and proceedings of the Royal Society of New Zealand 66(4)* : 354–401.

——— 1947: Native animals of New Zealand. Auckland Museum handbook of zoology. Auckland, Unity Press. 96 p.

Pregenzer, C., Jr. 1979: A redescription of *Pinnotheres hickmani* (Guiler) and comparison with *Pinnotheres novaezelandiae* Filhol and *Pinnotheres pisum* (L.) (Decapoda Brachyura). *Crustaceana, supplement 5* : 22–30.

Rathbun, M. J. 1923: Report on the crabs obtained by the F.I.S. 'Endeavour' on the coasts of Queensland, New South Wales, Victoria, South Australia and Tasmania. *Biological results of the fishing experiments carried on by the F.I.S. 'Endeavour' 1909–1914, 5(3)* : 95–156.

Richardson, L. R. 1949: A guide to the brachyrhynchus crabs. *Tuatara 2(1)* : 29–36.

Schmitt, W. L.; McCain, J. C.; Davidson, E. S. 1973: Decapoda I. Brachyura I. Fam. Pinnotheridae. *In:* Gruner, H. E.; Holthuis, L. B. *eds*, Crustaceorum Catalogus 3. The Hague, Dr W. Junk. 160 p.

Scott, M. S. 1961: A review of the New Zealand Pinnotheridae. *Transactions of the Royal Society of New Zealand, zoology 1(22)* : 303–309.

Silas, E. G.; Alagarswami, K. 1967: On an instance of parasitism by the pea crab (*Pinnotheres* sp.) on the backwater clam (*Meretrix casta* (Chemnitz)) from India, with a review of the work on the systematics, ecology, biology, and ethology of pea crabs of the genus *Pinnotheres* Latreille. P. 1161–1227 *in:* Proceedings of the symposium on Crustacea held at Ernakalum, January 12–15, 1965; part III. Marine Biological Association of India.

Stead, D. H. 1971: A preliminary survey of mussel stocks in Pelorus Sound. *New Zealand Marine Department fisheries technical report 61.* 16 p.

Takeda, M.; Miyake, S. 1969: A small collection of crabs from New Zealand. *OHMU; occasional papers of the Zoological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, Japan 2(8)* : 157–193.

Tesch, J. J. 1918: Decapoda Brachyura II. Goneplacidae and Pinnotheridae. *Siboga-Expeditie 39c* : 149–295.

Thomson, G. M. 1900: P. 22 *in:* Ayson, L. F., Report on experimental trawling. *Appendix to the Journals of the House of Representatives of New Zealand 1900, vol. III, H(Miscellaneous)–15A.* Wellington, Government Printer.

——— 1913: The natural history of Otago Harbour and the adjacent sea, together with a record of the researches carried on at the Portobello Marine Fish-hatchery: Part I. *Transactions and proceedings of the New Zealand Institute 45* : 225–251.

Thomson, G. M.; Anderton, T. 1921: History of the Portobello Marine Fish-hatchery and Biological Station. *New Zealand Board of Science and Art bulletin 2.* 131 p.

Waite, E. R. 1909: Scientific results of the New Zealand Government Trawling Expedition 1907. Introduction. *Records of the Canterbury Museum 1(2)* : 45–64.

Wear, R. G. 1965: Zooplankton of Wellington Harbour, New Zealand. *Zoology publications from Victoria University, Wellington 38.* 31 p.

——— 1968: Life-history studies on New Zealand Brachyura. 2. Larvae of *Heterozius rotundifrons* A. Milne Edwards, 1867, *Ozius truncatus* H. Milne Edwards, 1834 and *Heteropanope* (*Pilumnopeus*) *serratifrons* (Kinahan, 1856). *New Zealand journal of marine and freshwater research 2(2)* : 293–332.

Young, M. W. 1929: Marine fauna of the Chatham Islands. *Transactions and proceedings of the New Zealand Institute 60(1)* : 136–166.