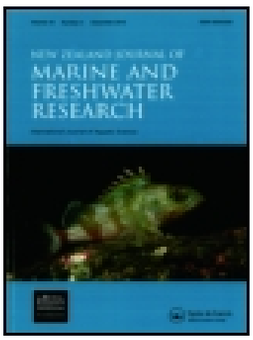

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NATURAL HISTORY OF THE PEA CRAB IN WELLINGTON HARBOUR, NEW ZEALAND

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ABSTRACT

The pea crab *Pinnotheres novaezelandiae* Filhol (Brachyura: Pinnotheridae) infests the mussel *Perna canaliculus* (Gmelin) in Wellington Harbour. The crab passes through the same post-planktonic stages as other pea crabs. The number of eggs hatching increases over summer, although females can be found incubating eggs at any time of the year. Shellfish below the level of low water neap tide are more heavily infested than those above this level. Damage to the host is restricted to erosion of the demibranchs and nodule formation on the mantle.

INTRODUCTION

Very little is known of the life history of the common New Zealand pea crab *Pinnotheres novaezelandiae* Filhol. Bennett (1964) described zoeae larvae hatched from *P. novaezelandiae*, and Wear (1965) recorded the seasonal abundance of zoeae in Wellington Harbour plankton. Scott (1961) reported that the crab was polymorphic in its post-planktonic development, in a similar pattern to that established for *P. pisum* (Pennant) by Atkins (1926, 1958). These developmental stages have been described by Jones (1977).

The data on which this paper is based were collected as part of a more general study of the parasites and symbionts of the green-lipped mussel *Perna canaliculus* (Gmelin) in Wellington Harbour, and thus there was no systematic plan of study.

MATERIALS AND METHODS

Each month from March 1973 to March 1974 (except May 1973) a sample of between 20 and 50 *Perna canaliculus* was collected from Wellington Harbour. Samples were dredged from a charted depth of 4 m off Ward Island using an Aggasiz trawl, or were collected from the same depth by skin diving.

Each mussel was measured to the nearest millimetre using calipers, then opened by severing the large posterior adductor muscle. After removing any visible crabs, the mussel was examined under a stereomicroscope. This ensured the recovery of all crab stages present in the mussel. The carapace length of each crab was measured to the nearest

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0.1 mm using vernier calipers, or under a stereo-microscope fitted with a calibrated ocular micrometer. The post megalopal developmental stage of each crab was determined using the table prepared by Christensen & McDermott (1958) for *Pinnotheres ostreum* Say. Mature females were classified using the following scale:

Stage 1: No eggs under the abdomen;
Stage 2a: Abdomen distended with bright orange eggs, which do not have eyespots;
Stage 2b: Eyed ova (eggs brown orange, with eyespots).

To examine the effect of depth on infestation rates, four samples were collected on the same day in October 1973. Two samples were collected off Ward Island at 2 m and 5 m (chart depth) respectively, and two were collected off Seatoun beach, Wellington Harbour, at 2 m (chart depth) and 0.2 m above the level of low water neap tide respectively.

RESULTS AND DISCUSSION

POST-PLANKTONIC DEVELOPMENT

The planktonic and megalopal stages in pinnotherids are followed by a series of crab instars, one of the first of which is the invasive stage. Upon entering a host, this crab moults into the first of a series of pre-hard stages, each with a soft membranous exoskeleton, the male and female being identical except for the number and structure of the pleopods (Christensen & McDermott 1958, Pearce 1966). Two pre-hard stage *Pinnotheres novaezelandiae* found in March 1973 were the youngest stages found in the present study. The pre-hard stage is followed by the Stage I form with a hard chitin exoskeleton.

Male stage I *P. novaezelandiae* range in carpace length from 3.2 mm to 11.8 mm and are sexually mature. They may continue to moult and grow, but do not change morphologically beyond the Stage I form. Soft-shell Stage I crabs such as those described by Atkins (1958) for *P. pisum* have not been found for *P. novaezelandiae*.

Female Stage I crabs moult into a soft membranous Stage II, then through Stages III–V; at Stage V the female becomes sexually mature. Subsequent moults result in a size increase, but no morphological change (Jones 1977). The range in size for Stage V females is 9.3–20.2 mm carpace length.

LIFE CYCLE

Although female *P. novaezelandiae* incubate eggs throughout the year, the percentage of females with eyed ova shows a seasonal pattern (Fig. 1). The percentage increases from July to October and again in January and February but drops to zero in late March. Zoeae in the plankton increase over this period: Wear (1965) recorded *Pinnotheres* zoeae in Wellington Harbour plankton from August to March, and most commonly in November.

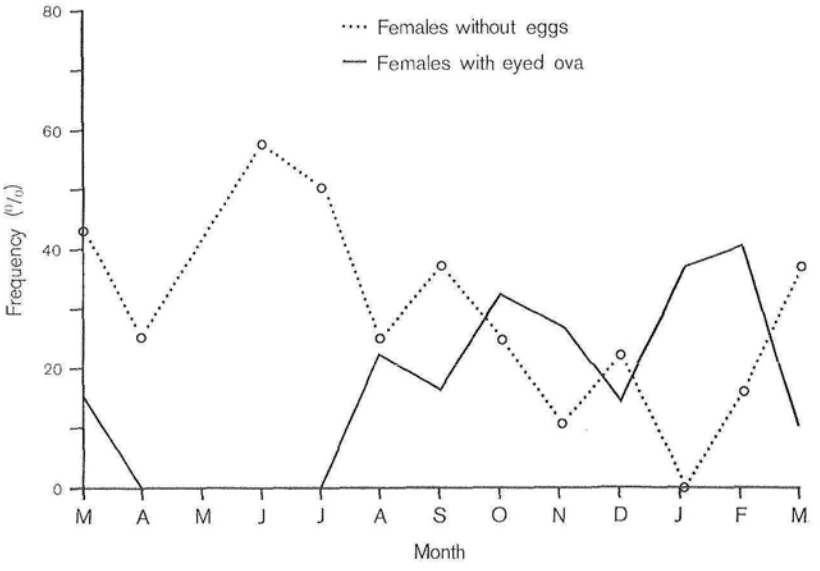
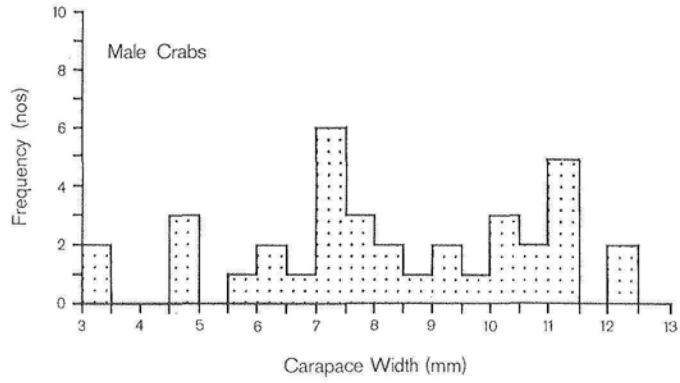


FIG. 1—Frequency of *Pinnotheres novaezelandiae* females not carrying eggs and of females carrying eyed ova, Wellington Harbour, 1973–74.

This pattern suggests a seasonal breeding cycle with a long incubation period, but two crabs caught in October 1974 hatched their eggs and then laid a new brood in 23 d and 37 d respectively. The crabs died before the new eggs developed eye pigment, but a crab caught in November 1974 in Stage 2a hatched her eggs in 19 d, while a second crab also bearing eggs when caught, died in 20 d just as the eye pigment was beginning to form on the eggs. Thus in summer water temperatures, *P. novaezelandiae* may be able to hatch a second brood of eggs within 2 months of the initial brood, and may breed throughout the year, the time of maturation of the broods speeding up in the warm summer months. This hypothesis is supported by a carapace length-frequency histograms of males and females, which show no obvious year classes (Fig. 2).

The numbers of pea crabs collected at the pre-hard stage through to Stage V are shown in Table 1. The scarcity of immature stages suggests that the crabs moult rapidly under natural conditions and reach sexual maturity within 1 y, as Atkins (1926) suggested for *P. pisum*. This hypothesis is supported by the recovery of a Stage V female crab from a mussel 90 mm long which would have been about 10 months old (Flaws 1971); it is impossible for a Stage V female to enter or escape through the narrow gape of so small a mussel, therefore this crab must have matured within this host.

Males were found somewhat irregularly over the period sampled (Table 1), but collections from other areas show that the male crabs may



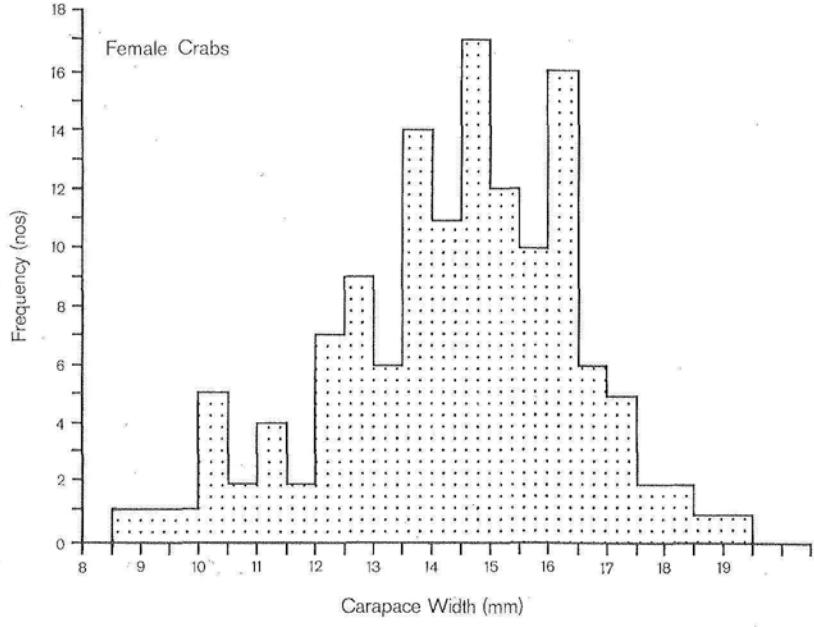


FIG. 2—Carapace length-frequency histogram for all male and female *Pinnotheres novaezelandiae* caught in Wellington Harbour, 1973–74.

TABLE 1—Pea crabs *Pinnotheres novaezelandiae* collected from mussels *Perna canaliculus* in Wellington Harbour, March 1973–March 1974 (no sample in May 1973; n = no. of *Perna* examined; – = none found)

MONTH	n	PRE-HARD STAGES	STAGE I Male	STAGE I Female	STAGE II	STAGE III	STAGE IV	STAGE V	% STAGE V IN BERRY
March 1973	32	2	5	1	–	–	1	7	57.14
April	23	–	2	–	–	1	–	4	75.0
June	22	–	–	–	–	2	–	7	42.9
July	35	–	5	–	1	–	1	12	50.0
August	43	–	2	–	2	–	1	12	75.0
September	50	–	6	1	–	–	2	18	61.1
October	42	–	–	1	–	–	1	8	75.0
November	50	–	9	1	–	2	3	18	88.9
December	49	–	4	–	1	1	1	9	77.8
January 1974	41	–	–	–	–	–	–	8	100.0
February	49	–	1	–	–	1	–	17	82.35
March	50	–	2	–	–	–	–	15	73.33
	486								

be found in mussels throughout the year. On three occasions crushed male crabs were recovered from the aquaria, presumably after attempting to enter or leave mussels. Stauber (1945) tested the ability of male *P. ostreum* to enter oysters and found that although 70% were successful in gaining entry, 13% were crushed in the process. Mating behaviour of *P. novaezelandiae* may therefore be similar to *P. pisum* and *P. ostreum*. In these species the male is thought to seek out the female within her host, whereas in other species (*P. maculatus* and *Fabia subquadrata*) the males and females form free-swimming copulatory swarms (Pearce 1964, 1966). The relatively high incidence of male and female *P. novaezelandiae* found in the same host (8 pairs in 173 mussels containing crabs, compared with 3 in 2088 for *F. subquadrata*) is support for the individual mating of *P. novaezelandiae*.

MULTIPLE INFESTATIONS

Of the 486 mussels examined, 178 contained only one crab, and 10 contained two crabs. Of these 10, one mussel had a pre-hard male and a Stage I male, one held two females, and the other eight each contained a male and a female crab (Table 2).

Stage V female *P. novaezelandiae* are hostile towards one another, and in laboratory aquaria the stronger female will harass and eventually kill the weaker female, so it is not surprising that females rarely occur together. Such hostility has not been observed between males, or between males and females. The presence of Stage I males with female crabs of Stages I, II, III and V suggests that males may copulate with females of any stage of development beyond the pre-hard stage.

TABLE 2—Ten double infestations of pea crabs *Pinnotheres novaezelandiae* from among 476 mussels *Perna canaliculus* from Wellington Harbour, March 1973–March 1974 (+ = present in mussel; – = absent)

	MALE STAGE	FEMALE STAGE						
NUMBER OF MUSSELS	PRE-HARD	I	I	II	III	IV	V	MONTH OF OCCURRENCE
2	–	+	–	+	–	–	–	Aug & Dec
2	–	+	–	–	+	–	–	Nov & Dec
4	–	+	–	–	–	–	+	Jun (3) & Nov (1)
1	+	+	–	–	–	–	–	Mar
1	–	–	–	–	–	+	+	Nov

CRAB GROWTH AND DEVELOPMENT CORRELATED WITH MUSSEL LENGTH

The pea crabs were found in mussels ranging in size from 50 mm to 290 mm. Mussels were grouped into 10 mm size groups and plotted against the crab data (Fig. 3). There was a significant trend ($P = 0.05$) for large female *P. novaezelandiae* to inhabit the larger mussels (Fig. 3a), but this relationship did not apply to male crabs (Fig. 3b). This indicates that the female crabs survive longer than 1 y and increase in size with their host. A similar size relationship between female pea crabs and their hosts has been found in all other species studied. The absence of a correlation between the size of the male *P. novaezelandiae* and the length of the mussel is to be expected if male crabs are entering and leaving mussels in search of females. Houghton (1963), however, attributed the absence of a correlation between the size of male *P. pisum* and host length to the male crabs dying after copulation, although whether the life expectancy of the male is affected by copulation has never been determined.

EFFECT OF DEPTH

Shellfish collected at or above the low tide level (LWNT) were rarely infested with crabs, but a high infestation was observed in samples of mussels collected in deeper waters (Table 3). Similar findings have been reported for Northern Hemisphere pinnotherids by Houghton (1963), Seed (1969), and Kruczynski (1972, 1974).

EFFECT OF CRAB ON HOST

Dean (1892) first noted that pinnotherids could cause damage to their hosts. This damage has often been cited in papers as a reason for classing *Pinnotheres* as a parasite.

The erosion of the gill demibranchs in the anterior part of the mussel, just posterior to the labial palps, is a common feature of *Perna canaliculus* inhabited by *P. novaezelandiae*. This damage is caused by crabs picking foodstrings off the gills with the chelipeds and legs (Orton 1921, Stauber 1945).

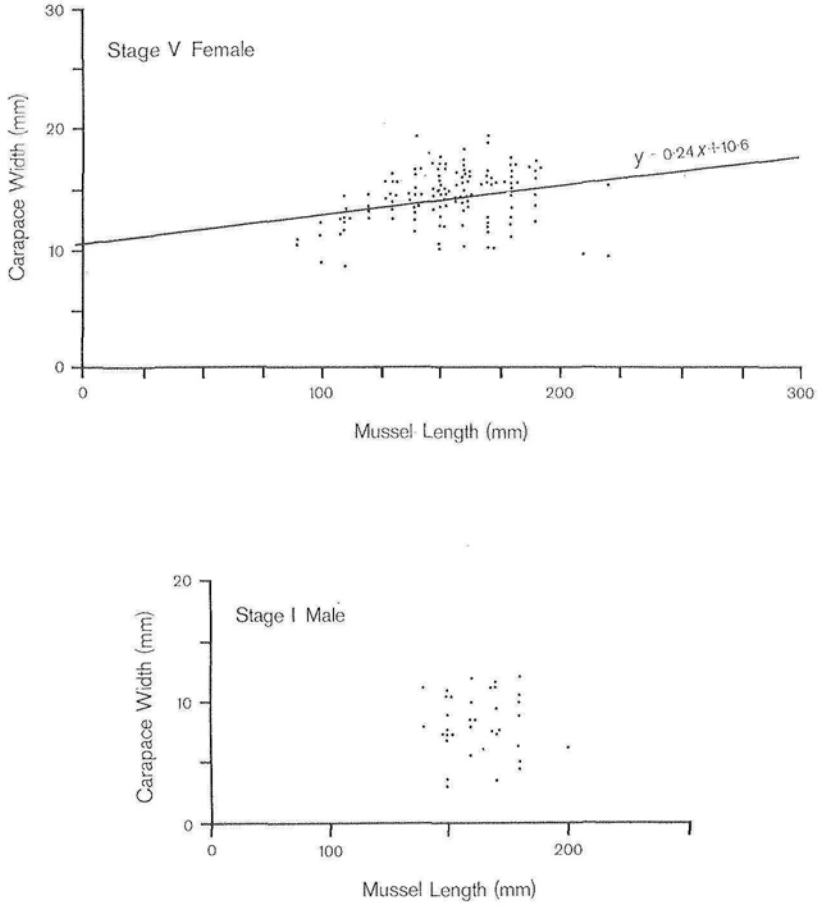


FIG. 3—Carapace width of pea crabs *Pinnotheres novaezelandiae* plotted against length of host mussel *Perna canaliculus*. The least squares equation and line for the female data are drawn on the graph.

In addition to the gill damage, the mussels often develop fibrous lumps or nodules on the mantle lip where the carapace of the crab rubs (Fig. 4). These nodules can be up to 1 cm in diameter, and have occasionally been found in mussels which have no pea crab. Presumably the crab has died, the gills have been repaired (Stauber 1945), but the nodule remains. Longitudinal sections cut through the nodules show that the thickening consists of a mass of irregularly orientated muscle fibres. Dix (1973) recorded nodules with the same structure from *Pinctada maxima* Jameson, the pearl oyster, infested with *Pinnotheres villosulus* Guerin.

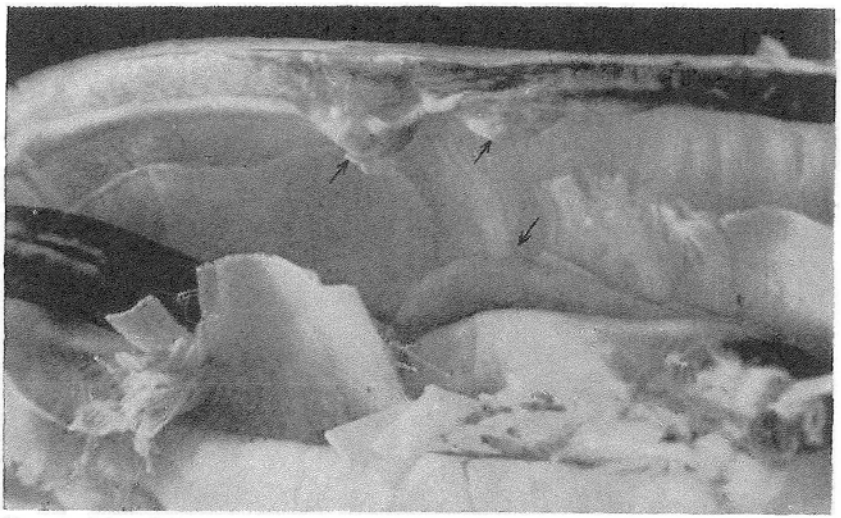


FIG. 4—Mussel *Perna canaliculus* with left valve removed and gills partially cut away, revealing *Pinnotheres novaezelandiae* damage to gills on right side (behind and to right of arrows), and showing nodules on the mantle of the right valve and base of gills (arrows), where the carapace of the pea crab apparently rubs.

CONCLUSIONS

These observations on the natural history of *Pinnotheres novaezelandiae* illustrate the need for a comprehensive study of both the biology and taxonomy of the New Zealand Pinnotheridae.

The number of zoeal megalopal stages for *P. novaezelandiae* is unknown, and the invasive stage has not been found. The habitat of the male is also unknown, though Bennett (1964) recorded a hard-shell female *P. schauinslandi* (*P. novaezelandiae*?, see Jones 1977) sheltering among seaweed, and it may be that the males will be found in a similar habitat.

TABLE 3—Distribution of pea crabs *Pinnotheres novaezelandiae* in mussels *Perna canaliculus* at different depths, Wellington Harbour (all samples collected on 15 October 1973) (* = above level of low water neaps)

DEPTH (m)	NUMBER OF MUSSELS	MEAN SIZE OF MUSSELS (mm)	NUMBER OF CRABS	INFECTION (%)
Area 1 (off Ward Island)				
2	37	165.74	6	16.21
5	37	161.82	26	70.27
Area 2 (off Seatoun Beach)				
2	35	105.03	5	14.28
−0.2*	76	75.23	2	0.026

The number of species of pea crab in New Zealand is unknown, but is at least two (Wear 1965, Jones 1977). The pea crabs found in *Atrina zelandica* (Gray) are probably a different species from *P. novaezelandiae*, as revealed by morphological differences in the first stage zoea (author's unpublished data). Pea crabs have also been recorded from *Mytilus edulis aoteanus* (Powell), *Modiolus* sp., *Spisula aequilateralis* (Deshayes), *Resania lanceolata* Gray, *Ostrea lutaria* Hutton, and *Pecten novaezelandiae* Reeve (Scott 1961, Bennett 1964, and author's notes). What species of crab these molluscs are infested with has not been determined.

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