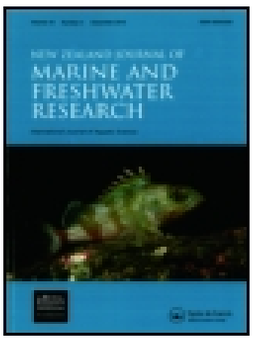

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Incidence of a pea crab and a trematode in cultivated and natural green-lipped mussels

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ABSTRACT

The incidence of infection of green-lipped mussels *Perna canaliculus* with the pea crab *Pinnotheres novaezelandiae* and the trematode *Cercaria haswelli* was recorded from seven sites around New Zealand from Ahipara to Marlborough Sounds. Infection rates in 4314 raft-grown and 2642 natural shore-grown mussels were low, ranging from 0.2% to 3.6% for the seven populations. The condition of the mussels was not significantly affected by the infections. In both natural and cultivated mussel populations, mortality caused by these associate organisms will probably be minimal.

INTRODUCTION

The presence of parasites and other organisms in mussels has been noted often, but their influence on the condition of mussels and their possible significance in mussel culture is uncertain. Large numbers of mussels were examined in this study; more detailed information than previously available was sought on the incidence of infection of the green-lipped mussel *Perna canaliculus* Gmelin with the pea crab *Pinnotheres novaezelandiae* Filhol and the parasitic trematode *Cercaria haswelli* Dollfus. Their effects on the condition of the mussels were noted.

Published information on both these associate organisms is essentially taxonomic (Angel 1960, Bennett 1964, Haswell 1903, Scott 1961), and data on biology and interrelations with the host remains unpublished (Jones unpublished 1975, Linzey unpublished 1971, Milne unpublished 1966, Scriven unpublished 1967).

During 1973–1976 the biology of the green-lipped mussel was studied at various sites around New Zealand to determine the potential of the sheltered inshore waters around the coasts of both islands for suspended cultivation of *Perna*. Growth rate and annual cycle of condition in the mussels were recorded at each site. During the course of investigations many mussels were opened and examined to determine the condition index. At the same time the number of mussels containing *Pinnotheres novaezelandiae* and *Cercaria haswelli* were recorded.

OBSERVATIONS

A total of 4625 mussels collected from 7 sites at roughly monthly intervals between December 1973 and March 1975, were examined. The seven sites comprised six experimental mussel rafts, one in Wellington Harbour (174° 49'E, 41° 17'S), two in Whangaroa Harbour (173° 45'E, 35° 02'S), two at Great Barrier Island (175° 20'E, 36° 10'S), and one in the Marlborough Sounds (174° 57'E, 41° 08'S), and one natural intertidal mussel bank at Ahipara (173° 08'E, 35° 11'S). The mussels were all of similar length (55–75 mm). Monthly samples usually consisted of 50 mussels, occasionally 40 or 45. Of 94 monthly samples examined, 29 (31%) contained pea crabs, 35 (37%) contained the trematode, and 46 (49%) were without either. Infection rates in these samples were within the range 0–12% for the pea crabs and 0–10% for the trematode, but the average infection rate for each was only 1–2% (Table 1). The incidence of the two associate organisms in the mussels at each of the seven sites (Table 2) shows markedly higher numbers of pea crabs in the Mahanga Bay and Crail Bay samples and similarly high trematode infection of the Ahipara mussels. Ten of the 15 Ahipara samples contained trematodes. No definite pattern of seasonal variation in either trematode or pea crab numbers was evident (Table 3).

Three further samples of natural bed mussels from Ahipara collected 6 October 1975, 30 November 1975 and 26 June 1976, and one sample taken from the Mahanga Bay raft on 30 October 1975, were

TABLE 1—Degree of infection with *Pinnotheres novaezelandiae* and *Cercaria haswelli* in samples of green-lipped mussels *Perna canaliculus* from seven sites around New Zealand, December 1973–March 1975

(%) Infection	No. of Samples with *Pinnotheres*	*Cercaria*
< 2	65	59
2– 3	8	16
4– 5	10	12
6– 7	6	4
8– 9	2	2
10–11	2	1
>12	1	-
Total	94	94

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TABLE 2—Incidence of *Pinnotheres novaezelandiae* and *Cercaria haswelli* in green-lipped mussels *Perna canaliculus* from seven sites around New Zealand, December 1973–March 1975

Sampling site	Samples (No.)	Mussels (No.)	*Pinnotheres* No.	*Pinnotheres* Infection (%)	*Cercaria* No.	*Cercaria* Infection (%)
Waihi Bay, Whangaroa Harbour	14	685	13	1.9	7	1.0
Pekapeka Bay, Whangaroa Harbour	12	585	1	0.2	4	0.7
Nagle Cove, Great Barrier I.	14	690	6	0.9	8	1.2
Port Fitzroy, Great Barrier I.	14	680	3	0.4	3	0.4
Mahanga Bay, Wellington Harbour	13	645	22	3.4	13	2.0
Crail Bay, Marlborough Sounds	12	590	21	3.6	4	0.7
Raft Grown Totals	**79**	**3875**	**66**	**1.7**	**39**	**1.0**
Ahipara	15	750	4	0.5	26	3.5
All Sample Totals	**94**	**4625**	**70**	**1.5**	**65**	**1.4**

also examined for pea crabs and trematodes. The Ahipara samples consisted of 723, 552, and 617 mussels respectively, 11–90 mm long. The Mahanga Bay sample comprised 439 mussels, 31–130 mm long; these mussels had grown entirely under suspended cultivation after being collected as spat on Ninety Mile Beach, just north of Ahipara (Hickman 1976). The degree of infection of these samples in relation to mussel size is shown in Table 4. There was a noticeable absence of both associate organisms in the smaller, raft grown mussels, whereas pea crabs were found even in the smallest mussels examined from Ahipara; the trematode parasite was found only in the larger mussels. Probably the absence of both organisms in the largest size group from both Ahipara and Mahanga Bay is related to the small numbers in each sample.

TABLE 3—Seasonal variation in numbers of *Pinnotheres novaezelandiae* and *Cercaria haswelli* in 94 samples of green-lipped mussels *Perna canaliculus* from seven sites, December 1973–March 1975

Month	*Pinnotheres*	*Cercaria*
Jan	9	4
Feb	12	8
Mar	4	4
Apr	9	9
May	14	5
Jun	5	6
Jul	1	3
Aug	6	6
Sep	0	8
Oct	6	4
Nov	4	3
Dec	0	5
Total	70	65

In only one of the 6956 mussels examined were 2 pea crabs (1 male, 1 female) recorded in the same mussel; this was a large mussel (in the 111–120 mm size group) from the Mahanga Bay raft. The mussels were examined by naked eye, and therefore only adult pea crabs, which were removed before condition index estimation, and obvious trematode infection, as shown by the presence of pinkish red sporocyst stages in the mantle or gonad tissue, were noted.

The condition index of the mussels in the monthly samples was determined using the method of Baird (1958) in which the analyses are made on groups of five mussels. With the generally low levels of infection of each "parasite" the possibility of more than one specimen occurring in any one group of five mussels was low. In 21 of the 925 groups examined more than one associate organism per group of 5 mussels was recorded. Under this method of group rather than individual determinations only a pronounced effect the parasite has on the condition of the mussel would be evident. No significant effect on condition was apparent in groups with a single associate organism; the condition of the infected group was always within the range of condition for that particular sample, 55% being above the mean condition for the sample and 45% below it. The effect of multiple infection is similarly obscure, as shown by the relationship between condition in infected mussels and uninfected mussels in Table 5. In multiple infections the condition was usually lower than the mean value for the whole sample, but in a few it was markedly higher.

Indices of condition for individual mussels were obtained by comparing the freeze dried weight of mussel meat with the weight of the whole mussel less the weight of the shell. Results from individual mussels in the October 1975 sample from Mahanga Bay are as variable as from the grouped data, infected mussels showing condition indices both above and below the mean values, but generally within the range found in uninfected mussels (Table 6).

DISCUSSION

Although in small samples of *Perna canaliculus* infection rates as high as 12% for *Pinnotheres* and 10% for *Cercaria* were recorded, the average levels for both in large samples of mussels were no more than 1–4%.

Pinnotheres novaezelandiae is distributed throughout the whole of New Zealand (Bennett 1964) but levels of infection have been recorded only by Stead (1971), who noted that "several *Perna* examined contained a pea crab" during a mussel survey in the Marlborough Sounds, and by Jones (unpublished 1975) who found a 39% infection rate (43% in male mussels, 35% in female mussels) in 462 mussels from Wellington Harbour. Wide variation in infection rates for pinnotherids in mussels occurs in other parts

TABLE 4—Infection rates of natural (Ahipara) and cultivated (Mahanga May) mussels with *Pinnotheres novaezelandiae* and *Cercaria haswelli* in relation to size of green-lipped mussel *Perna canaliculus* (Ahipara samples October, November 1975, June 1976; Mahanga Bay sample October 1975; – = no sample; N/A = not applicable)

	Mussel Length (mm)												Av. infection rate (%)
	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	
AHIPARA													
Number of mussels (n = 1892)	221	285	420	297	312	237	92	28	–	–	–	–	N/A
Infection %, *Pinnotheres*	3.2	1.1	1.0	1.0	1.6	0.0	3.3	0.0	–	–	–	–	1.3
Infection %, *Cercaria*	0.0	0.0	0.0	1.3	0.3	3.4	2.2	0.0	–	–	–	–	0.8
MAHANGA BAY													
Number of mussels (n = 439)	–	–	50	50	50	50	50	50	50	50	35	4	N/A
Infection %, *Pinnotheres*	–	–	0	0	0	0	0	2	6	16	6	0	3.2
Infection %, *Cercaria*	–	–	0	0	0	0	0	0	0	2	3	0	0.5

of the world, for example 98% (Pearce 1964) and 1–85% (Kruczynski 1974) for *P. maculatus* Say in the U.S.A., 5–46% (Seed 1969) for *P. pisum* L. in Great Britain. Intertidal height largely determines the abundance of pea crabs in mussels (Houghton 1963, Seed 1969), longer submergence of the host allowing greater opportunity for invasion by crabs (Beach 1969, Kruczynski 1974). The higher infection rates for Mahanga and Crail Bay samples (Table 2) suggest that the permanently submerged mussels on these rafts have been invaded by pea crabs, known to be present in these two areas (Wear 1965, Stead 1971), to produce infection rates higher than would be expected; all experimental rafts were originally stocked with small mussels (< 50 mm long) from Ahipara. The paucity of natural mussels in the vicinity of the other four rafts, with consequent low numbers of pea crabs, may be the reason for the lack of any significant increase in infection rates in the raft populations of mussels at these sites.

Mussels infected with *Cercaria haswelli* have been reported from both North and South Islands, infection rates varying in different environments; 1–16% in shore mussels at Scarborough, near Christchurch (Linzey unpublished 1971), 15–20% in dredged mussels from Pelorus Sound (Stead 1971), 4–70% in Wellington Harbour sublittoral mussels (Jones unpublished 1975). A higher incidence of parasites in larger mussels (Table 4), together with lower infection rates in raft-grown mussels than in shore-grown mussels of similar size (Table 2), suggests that the degree of infection is related not only to the period of exposure to infection (larger mussels have been exposed longer and are therefore more heavily infected) but also to the demersal nature of the infective miracidium stage, which probably develops in the faeces of the yellow-eyed mullet, *Aldrichetta forsteri* (Jones unpublished 1975).

The interrelations between each of these associate organisms and the mussel host have been the subject of discussion by many of the authors cited. *Cercaria haswelli* is clearly parasitic, but although *Pinnotheres novaezelandiae* has generally been referred to as a symbiont or associate, it too is probably metabolically dependent on the mussel and might therefore also be considered a parasite (Silas & Alagarswami 1967). The effects of mussel parasites have frequently been gauged by their influence on the condition of the mussel (Cole & Savage 1951, Hrs-Brenko 1964, Dethlefsen 1975). From the present results it is not possible to be certain whether the "parasites" have a deleterious effect on the condition of the mussels. Jones (unpublished 1975) showed that *Pinnotheres* adversely affected the condition factor of *Perna* at certain times of the year. He did not record the effect of *C. haswelli* on the condition of mussels, but found that a closely related trematode *Bucephalus longicornutus* (Manter) caused an increase in condition in oysters. *Cercaria tenuans* Cole can decrease the quality of mussel meat by heavy infestations (Cole 1935, Canzonier 1972). There is divergence of opinion on the effects of other mussel parasites, such as the copepod *Mytilicola intestinalis* Steuer, on the host (see review by Dethlefsen 1975).

TABLE 5—Relationship between Condition Index (C.I. = (Wet meat vol./Shell cavity vol.) × 100) of green-lipped mussels *Perna canaliculus* infected with *Pinnotheres novaezelandiae* and *Cercaria haswelli* and the mean and range of C.I. in uninfected mussels of the same monthly sample (samples collected from seven sites, December 1973–March 1975; a = higher, b = lower, than range of C.I. in uninfected mussels)

Infection (per group of 5 mussels)	C.I. of Infected Group	Mean and Range of C.I. in uninfected groups	
2 *Cercaria haswelli*	60.0	62.3	59.3–65.8
	43.9	46.7	43.1–53.1
	43.2	45.2	42.9–49.2
	32.6	32.4	30.3–35.9
	50.0a	46.2	42.9–48.5
2 *Pinnotheres novaezelandiae*	73.0	69.9	67.1–73.3
	54.5	56.0	50.0–58.0
	55.6	57.2	52.4–61.8
	51.1	53.0	49.3–57.4
	47.5	46.4	43.8–49.4
	65.1	64.0	59.4–69.7
	54.2	54.5	52.9–56.8
1 *C. haswelli* + 1 *P. novaezelandiae*	44.8	46.7	43.1–53.1
	43.3b	49.6	47.5–54.5
	47.6	48.3	44.8–50.6
	36.0b	40.1	38.3–43.2
	34.9	36.3	34.0–42.7
	57.4a	52.9	49.3–55.5
	68.0b	69.9	68.3–73.3
2 *P. novaezelandiae* + 1 *C. haswelli*	67.1b	69.9	68.3–73.3
2 *C. haswelli* + 1 *P. novaezelandiae*	54.6b	57.8	55.8–61.1

TABLE 6—Relationship between Condition Index (C.I. = (dry meat wt./total wt.—shell wt.) × 100) of individual green-lipped mussels *Perna canaliculus* infected with *Pinnotheres novaezelandiae* and *Cercaria haswelli* and the mean and range of C.I. in uninfected mussels (in 10 mm length groups) for sample of 439 mussels from Mahanga Bay raft, 30 October 1975

Mussel length Group (mm)	Infection	C.I. of Infected Mussel	Uninfected Mussels Mean & Range of C.I. in Uninfected Mussels	
81–90	1 *Pinnotheres*	8.2	10.9	7.6–14.2
91–100	1 *Pinnotheres*	6.2	9.5	5.7–12.4
91–100	1 *Pinnotheres*	9.9	9.5	5.7–12.4
91–100	1 *Pinnotheres*	7.6	9.5	5.7–12.4
101–110	1 *Cercaria*	14.9	9.7	6.7–12.4
101–110	1 *Pinnotheres*	10.4	9.7	6.7–12.4
101–110	1 *Pinnotheres*	10.3	9.7	6.7–12.4
101–110	1 *Pinnotheres*	8.2	9.7	6.7–12.4
101–110	1 *Pinnotheres*	11.3	9.7	6.7–12.4
101–110	1 *Pinnotheres*	9.2	9.7	6.7–12.4
101–110	1 *Pinnotheres*	11.3	9.7	6.7–12.4
101–110	1 *Pinnotheres*	9.9	9.7	6.7–12.4
101–110	1 *Pinnotheres*	8.9	9.7	6.7–12.4
111–120	2 *Pinnotheres*	9.1	8.4	4.0–10.7
111–120	1 *Cercaria*	5.7	8.4	4.0–10.7

Those authors who have considered the significance of the parasites of mussels in relation to mussel culture (Canzonier 1972, Dethlefsen 1975, Jones unpublished 1975) conclude that at low levels of infection losses in both natural and cultivated mussel populations will be minimal.

The present results support this view. Nevertheless, associate organisms, particularly parasites, in both cultivated and natural populations of mussels should be monitored, so that management procedures (e.g., stocking densities and transfer of stocks between areas) can be adjusted to minimise outbreaks of infection.

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