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PARASITES AND SYMBIONTS OF THE CRAB *PORTUNUS PELAGICUS* FROM MORETON BAY, EASTERN AUSTRALIA

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ABSTRACT

Fifteen parasites and symbionts were found in the tissues, in the branchial chambers, and on external surfaces of the sand crab *Portunus pelagicus*. Female crabs possessed more species of parasites and symbionts, and had a more specialized fauna than did male crabs. Females also had a higher prevalence of the peritrich ciliate *Operculariella* sp., a tetraphyllidean cestode, and the barnacles *Octolasmis* spp. Juvenile crabs had fewer parasites than mature crabs, being regularly colonized by only 2 parasites (the lecanicephalid cestode *Polypocephalus moretonensis* and the microphallid trematode *Levinseniella* sp.), and 2 symbionts (the barnacles *Octolasmis* spp. and *Chelonibia patula*). There were positive correlations between intensity of infection and host size (carapace width) for only 1 parasite and 2 symbionts (*P. moretonensis*, the nemertean *Carcinonemertes mitsukurii*, and *Octolasmis* spp., respectively). Not surprisingly, the molt condition of the crab influenced the abundances of the sessile external symbionts. Crabs in the postmolt condition had fewer *Opercullariella* sp., *C. patula*, and *Octolasmis* spp. The abundances of the motile *Carcinonemertes mitsukurii* and the internal parasites and symbionts were not, however, affected by the molt condition of their hosts.

Portunid crabs are common constituents of tropical and subtropical estuarine and nearshore habitats. Indeed, over 80 species of portunid crabs have been reported from eastern Australia alone (Stephenson, 1962, 1972). Most of the parasitological work on Australian crabs has focused on those of commercial importance, i.e., the mud crab *Scylla serrata* (Forsskål) (see Arudpragasam, 1967; Bian and Egusa, 1982; Lio-Po *et al.*, 1982; Jeffries *et al.*, 1985, 1989), and the sand crab *Portunus pelagicus* (L.) (see Phang, 1975; Phillips and Cannon, 1978; Bishop and Cannon, 1979; Weng, 1987). Both crabs support substantial fisheries along the eastern seaboard of Australia, and other Asian and South Pacific countries.

Few parasites and symbionts of *Portunus pelagicus* have been reported. Two parasites of the sand crab have, however, been previously described from Moreton Bay, Australia: the lecanicephalid cestode *Polypocephalus moretonensis* Bulter and the rhizocephalan barnacle *Sacculina granifera* Boschma. The symbiotic barnacles *Octolasmis* spp. (=*Dichelaspis* spp.) and *Chelonibia patula* Ranzani have also been recorded from sand crabs from Moreton Bay (Phillips and Cannon, 1978). Two parasites and three other symbionts of *P. pelagicus* have also been described or reported from Asia: the bopyrid isopod *Allokepon sinensis* (Danforth) (from Thailand and the Philippines, Markham, 1985, 1989), the rhizocephalan *Thompsonia* sp. (from Singapore, Phang, 1975), the nemertean *Carcinonemertes mitsukurii* Takakura (from Singapore, Humes, 1942), the nicothoid copepod *Choniosphaera indica* Gnanamathu (ex *P. sanguinolentus* from Madras, India, Gnanamathu, 1954), and the barnacles *Octolasmis spp.* (from Singapore, Jeffries *et al.*, 1982).

I report the parasite and symbiont fauna of *Portunus pelagicus* from Moreton Bay, Australia. The prevalences and intensities of parasites and symbionts are examined; and faunal associations with crab maturity and size, and molt condition are presented.

MATERIALS AND METHODS

The study site was a moderately fished area of Moreton Bay, Australia (between the mouth of the Brisbane River and Cabbage Tree Creek). Crabs were collected at night with the University of Queensland R V *Sea Wanderer*, using twin Yankee Doodle otter trawls (38-mm mesh, 7.5-m headline, 8.7-m footline, and drop-chain) with an average duration of 10–15 min/trawl in 5–7 m of water. Most crabs were transported live to the laboratory where they were kept in aquaria until dissected; dead crabs were refrigerated at 4°C or frozen prior to dissection. Collections were made in February, March, April, May, September, and November 1989. I necropsied a total of 205 crabs.

Crabs were examined externally for obvious signs of disease. Their size [carapace width (CW, excluding epi-

Table 1. Prevalences and mean intensities (±SE) of common parasites and symbionts of *Portunus pelagicus* from Moreton Bay, Australia ($N = 205$ crabs; February–November 1989). ID no. refers to the Queensland Museum accession number.

Parasite	Location in/on host	Prevalence (%)	Mean intensity	ID no.
Protozoa				
Operculariella sp.	gills	18.5	NR	GL13005
Acineta sp.	gills	6.3	NR	GL13006
Thelohania sp.	foregut	0.9	NR	
Nematopsis sp.	foregut	4.9	NR	
Ameson sp.	muscles, blood, ovaries	2.9	NR	GL12718
Hematodinium sp.	blood	0.9	NR	GL13049
Helminths				
Planoceroid turbellarian[L]	gills	5.4*	*	GL13004
Levinseniella sp.[L]	blood, muscles, nerves, gonad	9.8	25.0 ± 10.4	GL13001
Polypocephalus moretonensis[L]	nerves	91.7	34.9 ± 4.2	GL13003
Tetraphyllid cestode[L]	foregut	13.7	2.5 ± 0.7	GL13002
Carcinonemertes mitsukurii	gills, eggs	23.9*	*	GL13007
Crustaceans				
Choniosphaera indica[E]	eggs	7.3*	*	W16915
Sacculina granifera	internal organs	12.2	1.0 ± 0.0	
Octolasmis spp.	gills	70.2	46.7 ± 8.1	W16917
Chelonibia patula	carapace	21.5	11.9 ± 2.6	

* Only found on female crabs. For prevalences on female crabs see Tables 2 and 3.
NR, not recorded.
[L] larval parasite.
[E] Host and geographic range extension.

branchial spines), and merus length (the longest merus of either cheliped)], sex, and condition (maturity, shell disease, sacculina externa) were noted. Live crabs were cooled to 4°C until they became torpid. Blood was drawn with a pipette by puncturing the axilla of the fifth walking leg; the contents were then smeared on a clean glass slide. Fresh wet smears and Giemsa- or Wright's-stained dry smears were examined ($N = 93$). The carapace of each crab was lifted off the body for dissection. The branchiae, the sterna of the branchial portion of the thorax, foregut, midgut, hindgut, and portions of the hepatopancreas and gonads were removed and examined with a stereomicroscope for metazoans. Preparations of muscle, gill lamellae, gill cleaners, foregut, ventral nerve ganglia, and blood were examined with a compound microscope for protozoans and metazoans.

The egg clutches of ovigerous crabs were also examined for parasites. The egg-bearing pleopods were cut from the abdomen and stored in 10% Formalin-sea water. The pleopods were agitated for 3 min in water to remove parasites, which were then counted with the aid of a stereomicroscope; the egg-bearing setae were cut free of the pleopod and examined for parasites as above.

The number and location of the various parasites and symbionts, and the gross pathology of any disease condition were recorded. The term infect is used for parasites and infest for symbionts. Standard histological techniques were applied where appropriate (Johnson, 1980; Pritchard and Kruse, 1982). Representative specimens of various parasites and symbionts have been deposited in the Queensland Museum (Table 1).

The molt stage of each crab was determined following Kuris (1975) and Johnson (1980, p. 388). The gill cleaner (epipod of the first maxilliped), gill lamellae, and the relative hardness of the carapace of the crab were examined to determine the molt stage (i.e., A–E of Drach, 1939). For statistical analyses, the molt stages were grouped according to molt condition (i.e., postmolt, intermolt, and premolt).

The maturity of male crabs was determined by the relative development of the testes (not present, no development, partially developed, and completely developed), and the carapace width and merus length. In general, immature male crabs had a carapace width less than 100 mm, and a merus length less than 41 mm. The maturity of female crabs was determined by the carapace width (<90 mm), merus length (<41 mm), and the absence of infestation by *Carcinonemertes mitsukurii* (worms were mainly found on ovigerous and postovigerous females—cf. *C. carcinophila,* after Humes, 1942).

Data for the various statistical analyses (ANOVA, Sidak's inequality, Bartlett's test for equal variances, linear regression) were log-transformed to reduce differences in the variances between groups. A value of $P < 0.05$ was accepted as significant. Prevalence and intensity are defined in Margolis *et al.* (1982).

Results

The parasite and symbiont fauna of *Portunus pelagicus* from Moreton Bay was diverse (Table 1). A total of six protozoan, five helminth, and four crustacean species was found in crabs in 1989. Fewer than 3% of the crabs were uninfected; approximately 65% were infected by at least 3 species, while less than 4% were infected by 6 or more

Table 2. Prevalences (%) of protozoan parasites and symbionts by sexual condition of *Portunus pelagicus* from Moreton Bay, Australia (N = 205 crabs; February–November 1989). *Thelohania* sp. and *Hematodinium* sp. were not included because they were rare in the crab population.

Sexual condition of crabs	N	*Opercu-lariella*	*Nema-topsis*	*Acin-eta*	*Ame-son*
Mature females	92	18.5	2.2	9.8	2.2
Ovigerous females	27	44.4[a]	11.1	7.4	3.7
Juvenile females	25	4.0	4.0	0.0	4.0
Mature males	45	15.6	8.9	0.0	4.4
Juvenile males	16	6.2	0.0	0.0	0.0

[a] Prevalence was significantly different from other sexual conditions (Chi-square$_{(3)}$ = 8.04; $P < 0.05$).

species. Eight species, however, occurred in over 9% of the mature female crabs. Protozoans were less prevalent than helminths and crustaceans. Seven species were found in the internal organs, five in the branchial chamber, and three externally on the carapace or in the egg masses of their host (Table 1). The influences of seasonality, salinity, and temperature on the abundances of these organisms were not investigated.

Female crabs possessed significantly more species than male crabs (mature hosts, mean number of species = 3.4 ± 1.4 versus 2.5 ± 1.2, respectively, $t = 4.088$, $d.f. = 162$, $P < 0.001$). Furthermore, female crabs possessed four specialized symbionts that were not found on male crabs (Tables 2, 3, and 4). These were: the suctorian ciliate *Acineta* sp. (Table 2), an unidentified planoceroid turbellarian, the egg-predatory nemertean *Carcinonemertes mitsukurii* (Table 3), and the egg-predatory nicothoid copepod *Choniosphaera indica* (Table 4). The 4 symbionts were found in the branchial chambers or in the egg clutches of their hosts. In addition, the peritrich ciliate *Opercullariella* sp., the tetraphyllidean cestode, and the barnacles *Octolasmis* spp. showed significant preferences for female crabs in their prevalence of infection (Tables 2, 3, and 4).

In general, juvenile hosts had fewer parasites (prevalence and mean intensity) than mature hosts (Tables 2, 3, and 4). Only 2 parasites (*Polypocephalus moretonensis, Levinseniella* sp.) and 2 symbionts (*Octolasmis* spp., and *Chelonibia patula*) regularly colonized small, juvenile crabs. Furthermore, four other parasites and symbionts did not occur on juvenile crabs (Tables 2 and 3). In addition, significant positive correlations were found between host size (log CW) and the intensity of infection (log) for one parasite and two symbiont species (intensity = uninfected crabs excluded from analysis: *P. moretonensis*, $R = 0.262$, $N = 178$, $P < 0.01$; *C. mitsukurii*, $R = 0.495$, $N = 65$ female crabs, $P < 0.01$; and *Octolasmis spp.*, $R = 0.341$, $N = 144$, $P < 0.01$).

Molt condition had a significant effect on the prevalence and intensity of the three sessile symbionts found in the branchial chambers or on the carapaces of the crabs (Table 5). Crabs in the intermolt and premolt condition had significantly more of these symbionts than did crabs that had recently molted (postmolt). *Octolasmis* spp. were the only symbionts to show significant differences in intensity between the intermolt and premolt conditions. The parasite *Sacculina granifera* was not statistically associated with any molt condition presumably due to the low sample size (N = 25

Table 3. Prevalences (%) and mean intensities (±SE) of the helminth parasites and symbionts by sexual condition of *Portunus pelagicus* from Moreton Bay, Australia (N = 205 crabs). For sample sizes, see Table 2. Values with different letters are significantly different between prevalences (a, b) or intensity (y, z) (Chi-square or ANOVA, Sidak's inequality, $P < 0.05$).

Sexual condition of crabs	Turbellarian	*Levinseniella*	*Polypocephalus*	Tetraphyllidean	*Carcinonemertes*
Mature females	10.9	9.8	90.2	14.1 a	53.3
	2.3 ± 1.0	30.2 ± 11.6	45.3 ± 8.1	1.5 ± 0.2	21.6 ± 5.2 y
Ovigerous females	3.7	11.1	100.0	37.0 a	65.4
	4.0 ± 0.0	7.7 ± 6.2	32.8 ± 10.6	3.7 ± 1.7	11.8 ± 4.6 z
Juvenile females	0.0	8.0	84.0	4.0 b	0.0
	—	1.5 ± 0.5	29.1 ± 8.9	1.0 ± 0.0	—
Mature males	0.0	11.1	93.3	8.9 b	0.0
	—	40.2 ± 36.8	25.6 ± 4.7	3.0 ± 2.0	—
Juvenile males	0.0	6.2	93.7	0.0	0.0
	—	1.0 ± 0.0	15.8 ± 3.7	—	—

Table 4. Prevalences (%) and mean intensities (±SE) of crustacean parasites and symbionts by sexual condition of *Portunus pelagicus* from Moreton Bay, Australia (N = 205 crabs). For sample sizes, see Table 2. Values with different letters are significantly different between prevalences (a, b) or intensities (x, y, z) (Chi-square or ANOVA, Sidak's inequality, $P < 0.05$).

Sexual condition of crabs	*Choniosphaera*	*Sacculina*	*Octolasmis*	*Chelonibia*
Mature females	*	14.1	81.5 a	18.5
	—	1.0 ± 0.0	57.4 ± 13.7 x	10.3 ± 3.0
Ovigerous females	57.7	3.7	85.2 a	25.9
	89.9 ± 31.6	1.0 ± 0.0	44.6 ± 19.0 x	12.3 ± 9.3
Juvenile females	0.0	8.0	40.0 b	16.0
	—	1.0 ± 0.0	27.0 ± 9.1 y	5.7 ± 1.9
Mature males	0.0	17.8	60.0 b	24.4
	—	1.0 ± 0.0	38.5 ± 12.5 y	13.6 ± 6.2
Juvenile males	0.0	6.2	56.2 b	31.2
	—	1.0 ± 0.0	8.2 ± 2.0 z	17.4 ± 10.1

* Not examined for copepodites.

infected crabs with internae and externae). Populations of motile and internal parasites and symbionts were not affected by the molt condition of their host.

Other symbionts were also found on *P. pelagicus*. The external surfaces and branchial chambers of heavily fouled crabs possessed polychaetes, oysters, cnidarians (hydrozoans, scleractinians), entoprocts, phoronids, and nematodes. These organisms were found in low abundances (prevalences 1–2%, intensities 1–3) and were found only on very large females or on sacculinized crabs with old externae.

Discussion

This study documents differences in parasitism between male and female crabs. Few studies have elucidated such differences between sexes in a host species. Parasite diversity and abundance were both greater on mature females than on mature males. Several factors may help to explain the differences in parasitism between the sexes. (1) Female crabs may have a slower growth rate (i.e., longer molt interval, Campbell and Fielder, 1986), hence they have more time to acquire fouling organisms, i.e., *Operculariella* sp. and *Octolasmis* spp. (2) There may be possible differences in the feeding and migratory habits between the sexes (Williams, 1982; Sumpton *et al.*, 1989; Shields and Wood, in preparation) that may result in different parasite loads, e.g., the tetraphyllidean cestode. (3) The egg clutch of female crabs represents a unique microhabitat with a rather specialized fauna, e.g., *Carcinonemertes mitsukurii* and *Choniosphaera indica*. (4) Two symbionts have, however, an unexplainable predilection for female crabs: the suctorian, *Acineta* sp. and the planoceroid turbellarian. I speculate that the suctorian may require hormonal cues from the female crab for colonization and growth, and that the turbellarian may be a predator of the gill-dwelling symbionts.

Host size/age is a common factor in the diversity and abundance of parasites (Threlfall, 1968; Chappell, 1969; Noble and Noble, 1982). A unique feature of crustacean host-parasite systems, however, is that the hosts molt during growth. Hence, the suc-

Table 5. Prevalences (%) and mean intensities (±SE) of the parasites and symbionts of mature *Portunus pelagicus* in relation to the molt condition of the host. Only symbionts with significant associations are shown. Values with different letters are significantly different between prevalences (a, b) or intensities (x, y, z) (Chi-square or ANOVA, Sidak's inequality, $P < 0.05$).

Condition	N	*Operculariella*	*Octolasmis*	*Chelonibia*
Postmolt	31	4.9 a	51.2 a	7.3 a
		—	22.1 ± 7.0 y	5.0 ± 2.4 y
Intermolt	102	21.0 b	79.8 b	24.4 b
		—	40.2 ± 8.2 y	11.1 ± 3.9 z
Premolt	28	23.8 b	60.9 a	28.5 b
		—	89.3 ± 17.4 z	15.4 ± 4.6 z

cessional patterns of parasites on crabs can be analyzed not only with respect to host size but also by molt condition. An analysis of the successional patterns of parasites and symbionts from *Portunus pelagicus* showed that few external symbionts (two) and internal parasites (two) were acquired by juvenile crabs and that the internal parasites were larvae, i.e., the crabs were acting as intermediate hosts.

The patterns of succession among parasites have not been well described for any crab host. Molting obviously removed the sessile external symbionts on infested crabs. Those hosts that do not molt (crabs possessing the externa of *Sacculina granifera*) and those that molt infrequently (large mature females) had higher prevalences of external symbionts (*Operculariella* sp., *Octolasmis* spp.) than uninfested male crabs. The internal parasites and the motile external symbionts were not, however, lost at molting. Indeed, the foregut-dwelling tetraphyllidean cestode showed no significant decrease in abundance between postmolt and premolt crabs, even though the foregut is shed at ecdysis. In addition, the motile symbiont *C. mitsukurii* was observed on the external surfaces of crabs in late premolt and early postmolt stages. Wickham and coworkers (1984) found that *Carcinonemertes errans* moved to the epimeral suture of molting crabs, thence to the newly molted crabs. Most of the parasites and symbionts appear well adapted to the molt cycle of their hosts, and may either colonize hosts shortly after ecdysis (*Octolasmis* spp., Jeffries *et al.*, 1989) or remain on/in the body of the hosts as they molt.

The rhizocephalan *Sacculina granifera* has been well studied in Moreton Bay. Thomson (1951) reported the prevalence of externa as 4–29% in fished crabs. Phillips and Cannon (1978) found an overall prevalence of 11–13% in female and male crabs. They also noted that the barnacles *Octolasmis* spp. and *Chelonibia patula* had a higher prevalence on sacculinized crabs. Weng (1987) noted differences in the prevalence of infection in crabs from the Gulf of Carpentaria and Moreton Bay (1.2% versus 6.6% overall, respectively). He also noted that the sex ratio of infected male and infected female crabs did not differ. The present study reports a prevalence similar to that of Phillips and Cannon (1978) and supports the similar sex ratios of Weng (1987).

Parasitic castration by *S. granifera* was incomplete. A single ovigerous crab was found bearing a small, undeveloped sacculina externa. Indeed, infected female crabs infrequently possessed ripe ovaries, an indication that the ovary was not completely affected by the rhizocephalan. Infected male crabs were, however, completely castrated; in most cases their testes were completely destroyed or lacked development. Complete and incomplete castration has been previously reported for many crab-rhizocephalan systems (Reinhard, 1956).

Several rare protozoans were found in *P. pelagicus*. Spores of the microsporidian *Thelohania* sp. and the gregarine *Nematopsis* sp. were found in the foregut of crabs. The tissues of the crabs with these spores in the foregut did not, however, contain the protozoans. These rare infections may represent an accidental consequence of the feeding habits of the crabs, i.e., the parasites are typically found in bivalves (Sprague, 1970) and bivalves represent a large component of the diet of the sand crab (Williams, 1982). However, the microsporidian *Ameson* sp. caused severe muscle necrosis of infected crabs (Shields, unpublished data). Similarly, infections of *Ameson michaelis* in *Callinectes sapidus* (see Weidner, 1970; Overstreet, 1978) cause muscle necrosis and may lead to the death of the host. The dinoflagellate *Hematodinium* sp. was infrequently found in the hemolymph cells of infected crabs. The blood of infected crabs was cloudy and did not clot readily. Crabs presumably die from the infection (Couch, 1983; Overstreet, 1978; Meyers *et al.*, 1987; Shields, personal observation).

Three other very rare parasites were recently found in *P. pelagicus* from Moreton Bay (Shields, unpublished data). The sporozoan parasite *Aggregata* sp. has tentatively been identified from the connective tissues, the ciliate *Paranophrys* sp. (QM GL13051) occurred in the hemolymph, and an unidentified trypanorhynch plerocercus infected the musculature. These parasites were not found in the present study and occurred only very rarely in 1990.

Other parasites have been reported from *P. pelagicus*. Phang (1975) reported on the occurrence of *Thompsonia* sp. in Singapore.

While *Thompsonia* sp. was not found in the present study, it has been found in Australia on a species of *Thalamita* from the Great Barrier Reef (Potts, 1915; Shields, personal observation). Markham (1985, 1989) reported and redescribed the bopyrid isopod *Allokepon sinensis* from Thailand and the Philippines. The isopod presumably castrates the host, as do other members of the Bopyridae.

Most of the parasitological work on portunid crabs has focused on the American blue crab *Callinectes sapidus,* because of its economic importance, and on the green shore crab *Carcinus maenas,* because of its wide range and accessibility. In their reviews of the subject, Couch (1983) and Overstreet (1978, 1983) reported 15 parasites and symbionts (seven protozoans and eight metazoans) from *C. sapidus. Portunus pelagicus* had a similar fauna to *C. sapidus*; there were three protozoans and seven metazoans that were of the same or similar genera or taxa: *Acineta* sp., *Hematodinium* sp., *Ameson michaelis, Carcinonemertes carcinophila, Levinseniella capitanea,* tetraphyllid scolex, *Octolasmis muelleri, Chelonibia patula,* and the rhizocephalan *Loxothylacus texanus.* Several taxa of fouling organisms also occur on the two species of crabs (Overstreet, 1983). Two relatively common protozoan parasites of *Callinectes sapidus* were not, however, found in *Portunus pelagicus.* Species of *Paramoeba* and *Lagenophrys* were not found or did not occur in the Australian crab. The striking faunal similarities between the two crabs likely reflect similarities in their physiology and ecology.

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