



Habitat-related differences in the abundance of parasites from a coral reef fish: an indication of the movement patterns of *Hemigymnus melapterus*

A. S. GRUTTER

Department of Parasitology, The University of Queensland, Brisbane, Queensland 4072, Australia

(Received 19 December 1997, Accepted 3 March 1998)

The prevalence and number of an undescribed *Benedenia* sp. on *Hemigymnus melapterus* were significantly greater on fish from the reef flat than from the slope at Heron Island, Great Barrier Reef. In contrast, the abundance of gnathiid isopods on the fish did not differ significantly between habitats. As monogeneans do not leave their hosts, the differences in parasite abundance between the habitats suggest that *H. melapterus* does not move between the reef flat and reef slope, habitats separated by only a few hundreds of metres. *Benedenia* may thus be a useful biological tag for following the small-scale movement patterns of coral reef fish.

© 1998 The Fisheries Society of the British Isles

Key words: fish home ranges; spatial variation; habitat effects; monogeneans; gnathiidae; biological indicators.

INTRODUCTION

The processes that influence the structure of parasite communities have been studied extensively, but their relative importance is still debated (Esch *et al.*, 1990). Recently, much emphasis has been placed on the scale at which ecological problems are examined (O'Neill, 1989). Microscale processes and their interaction with space must not be overlooked as structuring forces in ecological systems (O'Neill, 1989; Powell, 1989). However, factors that affect the abundance and distribution of parasites of fish have focused largely on large-scale effects such as latitudinal (Rohde, 1993) and geographical variation (Byrnes & Rohde, 1992). Spatial variation in marine parasites among localities or sites has been studied mostly on parasites of invertebrates (Baxter *et al.*, 1989; Tang-Chong-Ti, 1995); those involving parasites of fish have been mainly on temperate species (Roubal *et al.*, 1996).

On coral reefs, the importance of spatial relations of species cannot be overemphasized (Glynn, 1976). Few studies have examined variation of parasites of coral reef fish among locations (Grutter, 1994; Rohde *et al.*, 1994). Smaller spatial-scale studies of variation in tropical parasites among sites within a location are even rarer for both invertebrate (Abdul-Salam & Al-Khedery, 1992) and fish hosts (Grutter, 1994). Many marine parasites have a benthic component in their life history (Rohde, 1993), so differences in benthic habitats may result in variations in parasite load. Coral reefs show distinct patterns of

Tel.: 61 7 3365 5773; fax: 61 7 3365 5799; email: a.grutter@mailbox.uq.edu.au

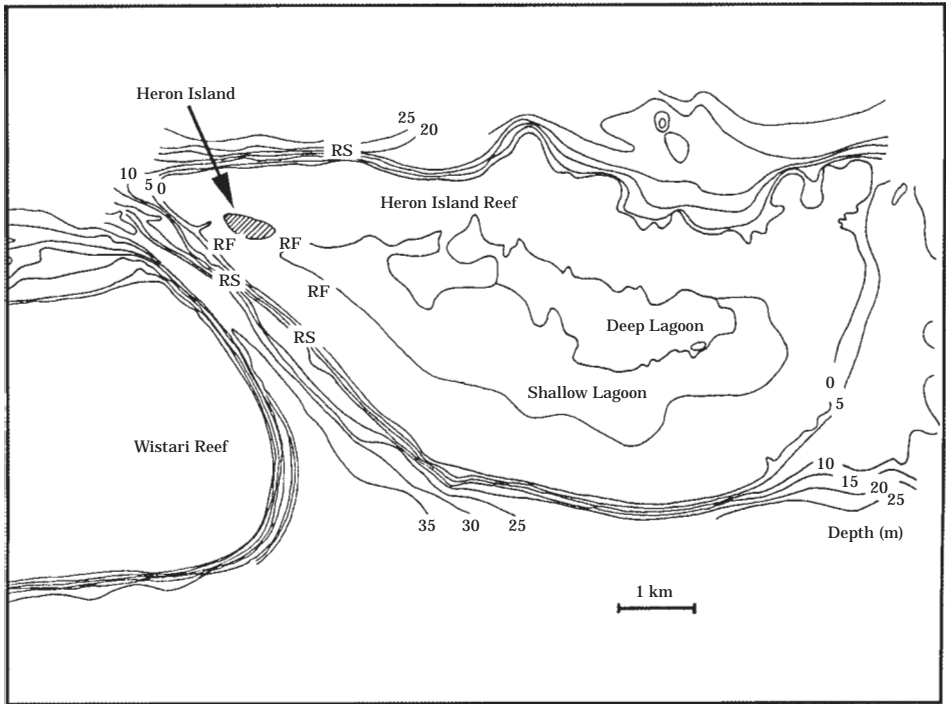


FIG. 1. Map of Heron Island showing sites of collection of fish. RF, Reef flat; RS, reef slope.

zonation with several different habitats occurring within a few metres of each other (Glynn, 1976). The habitat use of these zones varies among coral reef fish species (Green, 1996) with most habitat segregation of fish occurring at spatial scales of 10–100 m (Sale, 1991). Studies of habitat-related abundance of parasites on coral reef fish are very few (Yeo & Spieler, 1980).

This study compared the abundance of parasites of coral reef fish between two habitats, the shallow reef flat and the deeper reef slope, at Heron Island, Great Barrier Reef. The parasites compared were a monogenean *Benedenia* sp. and juvenile gnathiid isopods, both on the blackeye thicklip wrasse *Hemigymnus melapterus* (Bloch, 1791).

MATERIALS AND METHODS

COLLECTION OF FISH

Hemigymnus melapterus was collected between 22 and 30 March 1997 from two different habitats, the reef slope and reef flat (see diagram in Green, 1996) at Heron Island (23°27'S, 151°55'E). Each habitat was replicated at three different sites (Fig. 1). The reef slope at Heron Island drops from the reef crest to a depth of 10–15 m. The reef slope is made of coral matrix with high coral cover on the crest declining rapidly with depth. There are occasional spurs and grooves and small caves. The bottom of the reef slope is generally sandy. Fish were collected mainly on the slope at a depth of 3–12 m. The 1000-m wide reef flat lies behind the reef crest (Fig. 1) and consists of 1–5-m² live and dead coral patches separated by shallow open sandy areas (1–2 m deep at high tide). The reef crest is exposed occasionally at low tide. The southern side of the island is exposed to the prevailing south-easterly winds.

A SCUBA diver herded fish one at a time into a 15×1.6 -m barrier net (Grutter, 1994), captured them rapidly with a hand net and transferred them immediately into a plastic bag to reduce loss of parasites due to handling (Grutter, 1995).

Abundance of two types of ectoparasites, juvenile gnathiid isopods and an undescribed species of monogenean *Benedenia* sp. were estimated from 54 fishes, seven to 15 fish per site for gnathiids and seven to 12 fish per site for monogeneans. The same fish were used to estimate the two different parasites except at one site (north-eastern reef flat) where different fish were used.

PARASITE REMOVAL

Gnathiid juveniles were removed by anaesthetizing fish in MS-222 (0.1 g l^{-1}) for 3–5 min and scraping gills, buccal cavity, body, and fins gently with the tip of a wash bottle. The anaesthetic and other liquids were filtered with a $62\text{-}\mu\text{m}$ mesh to recover parasites. This method removed 97% of gnathiids (Grutter & Poulin, 1998). Gnathiids can be identified to species only from adult males which are benthic (Cohen & Poore, 1994), so juveniles were identified to family. However, it is likely that they belonged to *Gnathia*, *Caegognathia*, or *Elaphognathia*, as these genera have been identified in the Great Barrier Reef (Cohen & Poore, 1994; G. Poore, pers. comm.).

To remove monogeneans, fish were soaked in fresh water for 3–5 min, their bodies rubbed gently with textured plastic gloves, and the fresh water filtered at $62 \mu\text{m}$ to recover parasites. Three fish examined under a microscope ($16\times$) had no monogeneans remaining after this procedure. All parasites were fixed in 10% formalin in sea water and counted under a microscope ($20\times$). *Benedenia* sp. were identified by M. Deveney by using Yamaguti (1963) and following the amendments of Whittington & Kearns (1993).

STATISTICAL ANALYSES

A nested analysis of covariance (ANCOVA) using fish standard length and time of collection as covariables, was used to test for differences in the abundance of gnathiids between habitats and sites (S.A.S. Institute Inc., 1991). The former covariable was selected because gnathiid abundance is correlated with host size (Grutter, 1996) and the latter because gnathiid abundance decreases from dawn to sunset (Grutter, unpubl.). Non-significant interaction terms ($P > 0.20$) were dropped and the analysis repeated. The type III mean square for site (habitat) was used as the error term to test for differences between habitats. Data were $\log_{10}(x+1)$ transformed to satisfy the assumptions of the analysis. In the monogenean data, zeros were linked to one habitat which violated the assumptions of the ANCOVA. Therefore χ^2 goodness-of-fit analyses were used to test for differences between habitats in the total number (summed across all fish) and in the presence or absence of monogeneans. For the former, expected values were based on sampling effort (total number per habitat divided by fish number).

RESULTS

There were significant differences in the standardized total number of *Benedenia* sp. between habitats ($\chi^2 = 55.5$, d.f. = 1, $P < 0.001$) with more monogeneans on fish from the reef flat (Fig. 2, Table I). Overall, 84% of fish from the reef flat were infected with *Benedenia* sp., compared to 41% of fish from the reef slope ($\chi^2 = 10.3$, d.f. = 1, $P < 0.001$). The size–frequency distribution of *Benedenia* sp. did not differ between habitats (Fig. 3). The number of *Benedenia* sp. was correlated positively with the size of host on the reef flat ($r = 0.444$, $n = 25$, $P = 0.026$) (Fig. 2). There was no significant difference in the size of hosts for *Benedenia* sp. between habitats ($t = 1.56$, d.f. = 52, $P = 0.124$) (Table I).

After accounting for the significant effect of fish standard length, there were no significant differences in the $\log_{10}(x+1)$ transformed number of gnathiids per fish between sites within a habitat nor between habitats (Table II) (Fig. 4). The

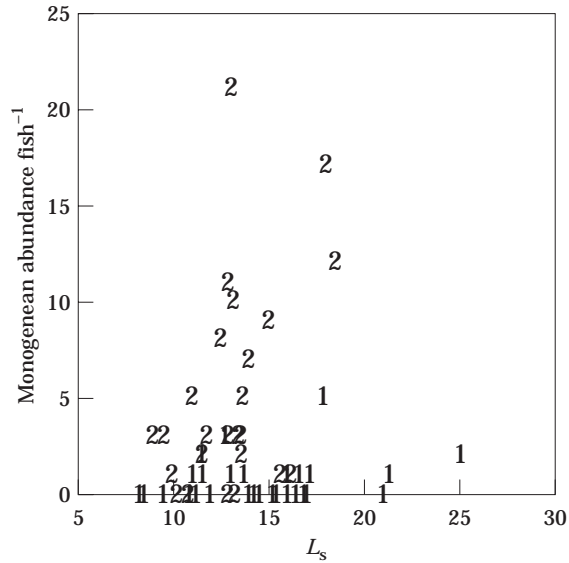


FIG. 2. The relationship between the abundance of *Benedenia* sp. and the size of host *Hemigymnus melapterus* in 1, reef slope; 2, reef flat.

TABLE I. The mean abundance, standard error (S.E.), and range of parasites per fish and fish standard length (L_s) per habitat

Source	Habitat	Mean parasites	S.E.	Range	Mean L_s	S.E.	Range
<i>Benedenia</i> sp.	RS	0.69	0.21	0-5	14.45	0.72	8.2-25
<i>Benedenia</i> sp.	RF	5.20	1.10	0-21	13.06	0.48	9-18.5
Gnathiids	RS	4.50	1.45	0-42	14.58	0.69	8.2-25
Gnathiids	RF	1.54	0.34	0-7	13.23	0.56	9-18.5

RS, Reef slope; RF, reef flat.

proportion of fish infected with gnathiids (67%) from the reef flat did not differ significantly from that of fish from the reef slope (77%) ($\chi^2=0.66$, d.f.=1, $P=0.415$). The size frequency distribution of gnathiids did not differ between habitats (Fig. 5). There was no significant difference in the size of hosts for gnathiids between habitats ($t=1.48$, d.f.=52, $P=0.146$) (Table I).

DISCUSSION

Habitat differences in *Benedenia* sp. infections on *H. melapterus* at Heron Island showed small-scale spatial variation with differences over only hundreds of metres. Similar habitat differences in parasites have been found at Heron Island with the acanthocephalan *Pomphorhynchus heronensis* from the spanish flag *Lutjanus carponotatus* (Richardson, 1842) (Cribb & Anderson, unpubl.). Recently, studies in Moorea, French Polynesia have found small-scale spatial

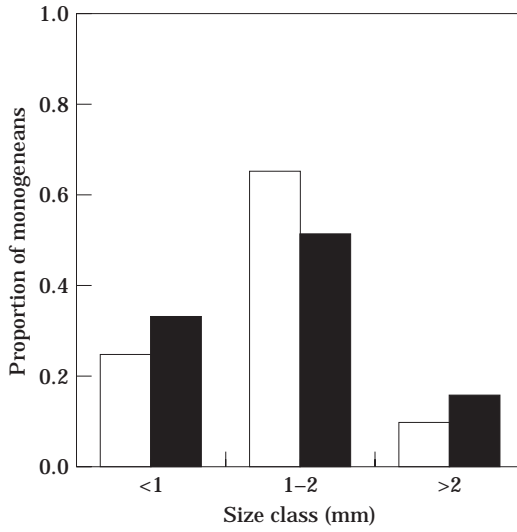


FIG. 3. Size-frequency distribution of *Benedenia* sp. on *Hemigymnus melapterus* in (□), reef slope; (■), reef flat. $\chi^2=1.41$, d.f.=2, $P=0.49$.

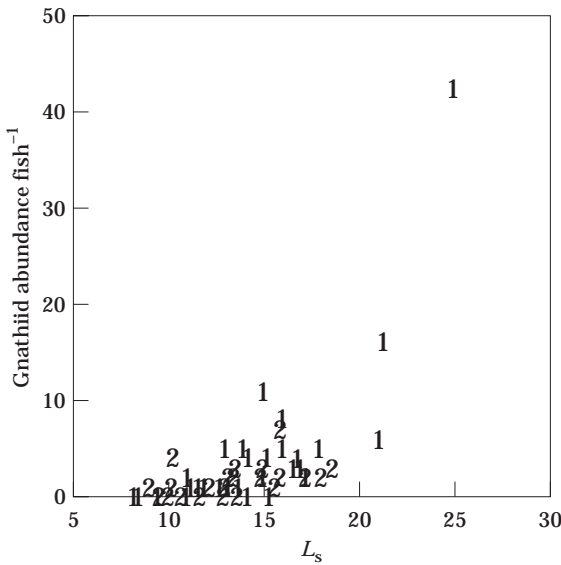


FIG. 4. Abundance of parasitic gnathiid isopods on *Hemigymnus melapterus* in 1, reef slope; 2, reef flat.

variation in digeneans and other endoparasites of fish between habitats (barrier reef and fringing reef) 100–200 m apart (C. Lo and M. Rigby, respectively, pers. comm.). Yeo & Spieler (1980) found differences in the occurrence of parasites of a pomacentrid fish between a coral reef and a narrow inlet 2 km apart. The findings show that sampling programmes for parasites must account for small-scale spatial variation.

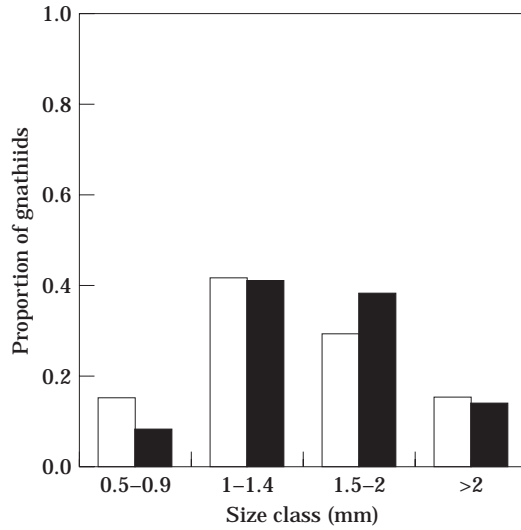


FIG. 5. Size frequency distribution of parasitic gnathiid isopods on *Hemigymnus melapterus* in (□), reef slope; (■), reef flat. $\chi^2=1.76$, d.f.=3, $P=0.62$.

TABLE II. Analysis of covariance testing for differences in the abundance of gnathiids between habitats

Source	d.f.	Type III SS	MS	<i>F</i>	<i>P</i>
Habitat	1	0.170	0.170	2.99	0.091
Site (habitat)	4	0.231	0.058	1.01	0.411
L_S	1	2.797	2.797	49.15	<0.001
Time	1	0.138	0.138	2.43	0.126
Time \times habitat	1	0.188	0.188	3.29	0.076
Test using site (habitat) as the error term:					
Habitat	1	0.170	0.170	2.95	0.161

The differences in *Benedenia* sp. infections between the reef flat and reef slope suggest that *H. melapterus* does not move between the two habitats. This corroborates Lewis's (1997) finding that *H. melapterus* on isolated 100–220 m² coral patches surrounded by at least 20 m of open sand show little post-larval migration. Also, Grutter (unpubl.) observed that over a 30-min period 10–15 cm *H. melapterus* at Lizard Island remained in an area of 50–200 m². That there was no difference in the size of monogeneans between habitats suggests that the difference in abundance was not due to factors that affect the growth of the parasite.

Parasites, including monogeneans, have been used successfully as biological indicators to differentiate fish stocks (Lester, 1990; Williams *et al.*, 1992). The spatial scale of these studies was relatively large (usually separations of 100–1000s km). In contrast, the present study shows that parasites may also be useful

as biological tags to differentiate between groups of fish over just several hundreds of metres. This information can provide insight into the size of the home range of a fish species. The characteristics of *Benedenia* fit most of the guidelines on parasites as indicators of host populations (Williams *et al.*, 1992), namely: they show significant differences in infections between study areas; they have only one host in their life cycle (Llewellyn, 1972); they live for at least 55 days (M. Deveney, pers. comm.); they are detected and identified easily; and they require a minimum of dissection.

In the laboratory, heavily infected *H. melapterus* (>100 monogeneans per fish) die 2–3 weeks after becoming infected (pers. obs.). Thus fish on the reef flat, where *Benedenia* sp. infections were higher, were likely to have a lower body condition than those on the slope. Yet, at Heron Island *H. melapterus* were more abundant on the reef flat than on the slope (pers. obs.). *Hemigymnus melapterus* are selective feeders (M. Gottlieb, pers. comm.) which may influence their patterns of distribution on the reef. Habitat differences in the abundance of the parasite *Argulus canadensis* have been found in sticklebacks *Gasterosteus aculeatus* L.: fish in shallow vegetated microhabitats, where parasites were more abundant, were parasitised more heavily than fish in open microhabitats (Poulin & FitzGerald, 1989). Yet even in the presence of parasites sticklebacks still visited the high-risk vegetation. The authors suggested this was due to foraging preferences or predator avoidance. Whether a similar situation occurs in *H. melapterus* is unknown.

In invertebrates, habitat variability and host behaviour influence parasite transmission (Llewellyn, 1972; Souza & Grosholz, 1991). These may also affect parasite transmission in Monogenea. *Benedenia* produce benthic eggs which hatch into infective oncomiracidia which then seek a host fish; the fate of eggs and oncomiracidia are affected greatly by environmental conditions (Llewellyn, 1972). Higher monogenean abundance and prevalence of infections on the reef flat compared to the slope may have been due to increased transmission rates in this habitat. The reef flat is shallower than the slope and at low tide may be exposed, forcing fish to seek shelter in the coral matrix. Reduced water volumes and increased contact with the benthos on the reef flat may increase the risk of infection by monogenean larvae. In addition, the presence of strong currents on the reef slope may decrease the rate of infection by monogeneans in this habitat.

The lack of an effect of habitat on the abundance of gnathiids, in contrast to that of *Benedenia* sp. may reflect differences in the life history and host–parasite interactions of these two parasite groups. Unlike monogeneans, gnathiids remain on hosts only while feeding for 2–4 h to several days (Paperna & Por, 1977) and so have a high turnover rate (Grutter, 1996). The abundance of gnathiids also decreases from dawn to sunset (Grutter, unpubl.). Because gnathiids cannot be identified as juveniles (Cohen & Poore, 1994) they were pooled in this study. However, juveniles reared to adult males showed there were at least two species of gnathiids on *H. melapterus* (Grutter, unpubl.). The variability introduced by these factors may have masked any potential spatial differences. The results contrasted with those for Californian fish in midwater traps which were attacked less frequently by nocturnal predatory benthic isopods than were fish in bottom traps (Stepien & Brusca, 1985).

The lack of an effect of habitat on the size frequency distribution of monogeneans indicates that the numerical differences between habitats were not due to factors that affected the growth of the parasite. That there were no differences in the size frequency distribution of gnathiids between habitats suggests that the growth and development of gnathiids in these habitats were similar. However, this should be interpreted cautiously as it was not possible to identify the juveniles of gnathiids to species.

The author thanks L. Walters, G. Grutter, and the Heron Research staff for their assistance in the field; J. Hendrikz for help with the statistical analyses; E. Faliex for discussion on biological indicators; L. Chisholm, M. Deveney, I. Ernst, and I. Whittington for advice on monogeneans and R. J. G. Lester for helpful comments on an earlier version of the manuscript. The study was funded by an Australian Research Council Postdoctoral Research Fellowship.

References

- Abdul-Salam, J. & Al-Khedery, B. (1992). The occurrence of larval digeneans in some snails in Kuwait bay. *Hydrobiologia* **248**, 161–165.
- Baxter, J. M., Hodgson, A. N. & Sturrock, M. G. (1989). Variations in infestation rates of *Lepidochitona cinereus* (Polyplacophora) by *Minchinia chitosis* (Sporozoa) in twelve populations in Scotland and Northern Ireland. *Marine Biology* **102**, 107–117.
- Byrnes, T. & Rohde, K. (1992). Geographical distribution and host specificity of ectoparasites of Australian bream, *Acanthopagrus* spp. (Sparidae). *Folia Parasitologica (Prague)* **39**, 249–264.
- Cohen, B. F. & Poore, G. C. B. (1994). A phylogeny of the Gnathiidae (Crustacea: Isopoda) with descriptions of new genera and species from south-eastern Australia. *Memoirs of the Museum of Victoria* **54**, 271–397.
- Esch, G. W., Bush, O. A. & Aho, J. M. (eds) (1990). *Parasite Communities: Patterns and Processes*. London: Chapman & Hall.
- Glynn, P. W. (1976). Some physical and biological determinants of coral community structure in the eastern Pacific. *Ecological monographs* **46**, 431–456.
- Green, A. L. (1996). Spatial, temporal and ontogenetic patterns of habitat use by coral reef fishes (Family Labridae). *Marine Ecology Progress Series* **133**, 1–11.
- Grutter, A. S. (1994). Spatial and temporal variations of the ectoparasites of seven coral reef fish from Lizard Island and Heron Island, Australia. *Marine Ecology Progress Series* **115**, 21–30.
- Grutter, A. S. (1995). A comparison of methods for sampling ectoparasites of coral reef fishes. *Journal of Marine and Freshwater Research* **46**, 897–903.
- Grutter, A. S. (1996). Parasite removal rates by the cleaner wrasse *Labroides dimidiatus*. *Marine Ecology Progress Series* **130**, 61–70.
- Grutter, A. S. & Poulin, R. (1998). Intraspecific and interspecific relationships between host size and the abundance of parasitic larval gnathiid isopods on coral reef fish. *Marine Ecology Progress Series*, in press.
- Lester, R. J. G. (1990). Reappraisal of the use of parasites for fish stock identification. *Australian Journal of Marine and Freshwater Research* **41**, 855–864.
- Lewis, A. R. (1997). Recruitment and post-recruitment immigration affect the local population size of coral reef fishes. *Coral Reefs* **16**, 139–149.
- Llewellyn, J. (1972). Behaviour of monogeneans. In *Behavioural Aspects of Parasite Transmission* (Canning, E. U. & Wright, C. A., eds), pp. 19–30. London: Academic Press.
- O'Neill, R. V. (1989). Perspectives in hierarchy and scale. In *Perspectives in Ecological Theory* (Roughgarden, J., May, R. M. & Levin, S. A., eds), pp. 140–156. Princeton, NJ: Princeton University Press.

- Paperna, I. & Por, F. D. (1977). Preliminary data on the Gnathiidae (Isopoda) of the Northern Red Sea, the Bitter Lakes, and the Mediterranean and the biology of *Gnathia piscivora* n. sp. *Rapports de la Commission Internationale pour la Mer Méditerranée* **24**, 195–197.
- Poulin, R. & FitzGerald, G. R. (1989). Risk of parasitism and microhabitat selection in juvenile sticklebacks. *Canadian Journal of Zoology* **67**, 14–18.
- Powell, T. M. (1989). Physical and biological scales of variability in lakes, estuaries, and the coastal ocean. In *Perspectives in Ecological Theory* (Roughgarden, J., May, R. M. & Levin, S. A., eds), pp. 157–176. Princeton University Press.
- Rohde, K. (1993). *Ecology of Marine Parasites: An Introduction to Marine Parasitology*. 2nd edn. Wallingford: CAB International.
- Rohde, K., Hayward, C., Heap, M. & Gosper, D. (1994). A tropical assemblage of ectoparasites: gill and head parasites of *Lethrinus miniatus* (Teleostei, Lethrinidae). *International Journal for Parasitology* **24**, 1031–1053.
- Roubal, F. R., Quartararo, N. & West, A. (1996). Spatial and temporal variation in populations and communities of ectoparasites on young snapper, *Pagrus auratus* (Bloch & Schneider) (Sparidae), from the wild and captivity at Port Hacking, Sydney, Australia. *Marine and Freshwater Research* **47**, 585–593.
- Sale, P. F. (1991). Habitat structure and recruitment in coral reef fishes. In *Habitat Structure: The Physical Arrangement of Objects in Space* (Bell, S. S., McCoy, E. D. & Mushinsky, H. R., eds), pp. 197–210. London: Chapman & Hall.
- S.A.S. Institute Inc. (1991). *S.A.S.[®] System for Linear Models*, 3rd edn. Cary NC, U.S.A.: S.A.S. Institute Inc.
- Souza, W. P. & Grosholz, E. D. (1991). The influence of habitat structure on the transmission of parasites. In *Habitat Structure: The Physical Arrangement of Objects in Space* (Bell, S. S., McCoy, E. D. & Mushinsky, H. R., eds), pp. 300–324. London: Chapman and Hall.
- Stepien, C. A. & Brusca, R. C. (1985). Nocturnal attacks on nearshore fishes in southern California by crustacean zooplankton. *Marine Ecology Progress Series* **25**, 91–105.
- Tang-Chong-Ti (1995). Spatial variation in the larval trematode infections of populations of *Nodilittorina trochoides* and *Nodilittorina radiata* (Gastropoda: Littorinidae) from Hong Kong. *Asian Marine Biology* **12**, 19–26.
- Whittington, I. D. & Kearns, G. C. (1993). A new species of skin-parasitic benedeniine monogenean with preference for the pelvic fins of its host, *Lutjanus carponotatus* (Perciformes: Lutjanidae) from the Great Barrier Reef. *Journal of Natural History* **27**, 1–14.
- Williams, H. H., MacKenzie, K. & McCarthy, A. M. (1992). Parasites as biological indicators of the population biology, migrations, diet, and phylogenetics of fish. *Reviews in Fish Biology and Fisheries* **2**, 144–176.
- Yamaguti, S. (1963). *Systema Helminthum, Vol. IV. Monogenea and Aspidocotylea*. New York: Interscience Publishers.
- Yeo, S. T. & Spieler, R. (1980). Habitat effects on the occurrence of parasites inhabiting the sergeant major, *Abudefduf saxatilis* (Linnaeus), with a list of parasites of Caribbean damselfishes. *Bulletin of Marine Science* **30**, 313–324.