PARASITE COMMUNITIES AND DIET OF *CORIS BATUENSIS* (PISCES: LABRIDAE) FROM LIZARD ISLAND, GREAT BARRIER REEF

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Parasite infracommunities of the wrasse *Coris batuensis* (Bleeker, 1857) were analysed, and the relationship between endoparasites, diet, and host body weight inferred. Thirty-two fish were collected from Lizard Island, Australia. Percentage frequency of occurrence of prey categories in the gut was determined and abundance, prevalence and species richness of parasites were calculated. Fish mainly ate snails, bivalves and crustaceans and this did not vary with body weight. Thirty-one fish were parasitised with at least one of 21 taxa of parasites (4 ectoparasite and 17 endoparasite species), with an average of 4 species and 47 individuals per host. Tetraphyllidean cestode larvae were the most common and abundant group. Parasite life cycles are not known in detail, but small crustaceans, such as copepods and amphipods, are likely to be intermediate hosts for the cestodes, nematodes and digeneans found in *C. batuensis*. Molluscs, although frequent in the diet, may not be transmitting any parasite species. Numbers of prey and parasite species richness were not correlated. Composition, abundance and species richness of the parasite fauna were similar in hosts with different body weight, corresponding with *C. batuensis* having a similar diet throughout life. ❑ *Coris batuensis, wrasse, parasites, diet, coral reef, Australia.*

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Parasite communities can be affected by many variables from the environment (physical or chemical conditions) and from the host (ecological characteristics) (Rohde, 1993). Thus, the study of parasite communities of fishes has been used as a tool to discriminate host populations (e.g. George-Nascimento, 2000), infer trophic web interactions (e.g. Marcogliese, 2003) and identify contaminated habitats (e.g. Khan & Thulin, 1991; Schludermann et al., 2003). Moreover, the body size and diet of the hosts are considered one of the major ecological variables that relate to the variation of parasite communities (e.g. Sasal et al., 1999; Muñoz et al., 2002). In general it is concluded that, relative to a small body, a large body will offer more resources to parasites and will have been available for longer for parasite species to be acquired (Muñoz et al., 2002). Most endoparasites need intermediate hosts in their life cycles, so that variations in parasite communities are also likely to be associated with diet variation (e.g. Valtonen & Julkunen, 1995). Variation in diet composition can also be associated with ecological characteristics of hosts such as foraging behavior and seasonal changes. These factors may all affect parasite composition so that their exploration can provide a better understanding of the parasite community structure (Valtonen & Julkunen, 1995; Knudsen et al., 2004).

This study considers the body size and the diet of a fish species, the batu cori *Coris batuensis* (Bleeker, 1857), and explores their relationship to the number of parasites and their composition. This fish belongs to the Labridae, which is the second most species rich family of fishes in the Great Barrier Reef (GBR) (Randall et al*.,* 1997). Surprisingly, little is known about parasite communities of such fishes. Lester & Sewell (1989) listed the parasites known for six species of labrids on the GBR. Later, Grutter (1994) and Grutter & Poulin (1998) studied the ectoparasite assemblages of some wrasse species but few studies have considered whole parasite communities (Muñoz & Cribb, 2005). Additional taxonomic and ecological studies described and recorded endoparasite species of these fishes (e.g. Cribb & Bray, 1999; Chambers et al*.,* 2000; Pichelin & Cribb, 2001; Muñoz et al., 2006).

Coris batuensis is a small wrasse that reaches no more than 17cm in length (Randall et al*.,* 1997). It is abundant at Lizard Island and principally inhabits the reef base and sandy patches (Green, 1996). There are no published studies about the diet
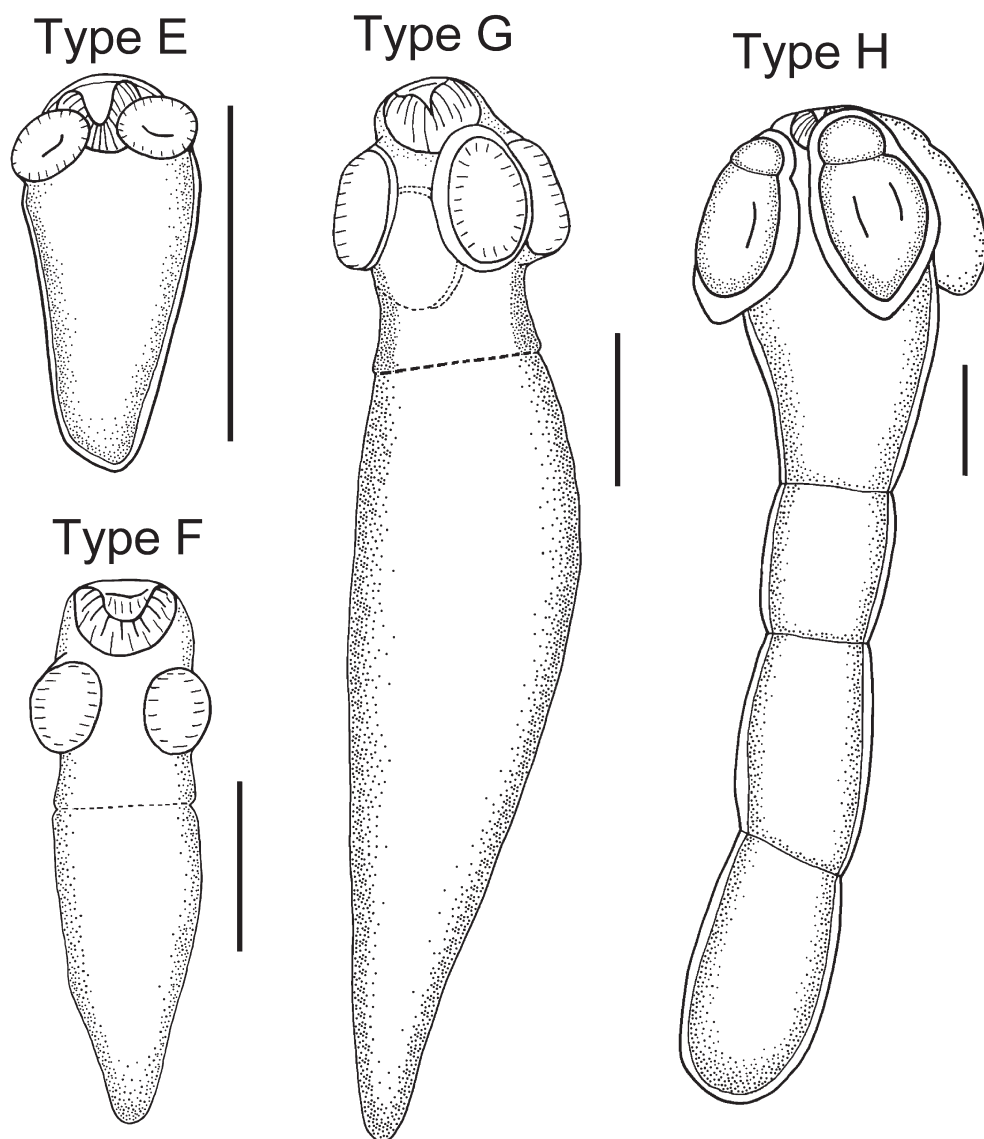
FIG. 1. Larval stages of four tetraphyllideans from *Coris batuensis*, scale-bars: 0.1 mm

or the parasite communities of *C. batuensis*. Other *Coris* species are said to prey on crustaceans and gastropods (Sano et al*.,* 1984).

Our study aimed to identify all the metazoan parasite species (external and internal) found in *Coris batuensis*. We determined the identity and frequency of prey categories to consider what organisms may be intermediate hosts for the endoparasites found in this fish. We then combined analysis of the diet and endoparasite infracommunities of *C. batuensis* to investigate possible changes in relation to fish body weight.

MATERIALS AND METHODS

Between January 2003 and May 2004, 32 individuals of *Coris batuensis* were collected from the Lizard Island (14° 40'S, 145° 28'E), GBR, Australia. The fish were mainly caught by net while diving and sometimes by speargun while snorkelling.

In the laboratory the total length and the weight of each fish was measured. Fish were then examined for ectoparasites on the body surface and gills, and for endoparasites in the body cavity, gall bladder and gut. At the same time, the food contents from the gut were recorded. Parasites and gut contents were fixed in 5% formaldehyde for later examination.

Food contents were determined to family, where possible, according to Wilson (1993) and Abbott & Dance (1998) for molluscs and Jones & Morgan (2002) for crustaceans. The frequency of occurrence for each prey category was calculated as the number of fish that had a specific prey category, divided by the total number of fish with gut contents and expressed as a percentage.

Most parasites (platyhelminths) were stained in Mayer's haematoxylin and mounted in Canada balsam. Copepods and nematodes were cleared with chlorolactophenol for observations under light microscopy. Copepods were identified following Cressey & Cressey (1989) and monogeneans following Hayward (1996). Larval stages of tetraphyllidean cestodes were identified only as morphotypes according to Chambers et al. (2000); trypanorhynch cestodes were identified according to Campbell & Beveridge (1994, 1996). Digeneans were identified following Bray & Cribb (1989) and Bray et al. (1993); nematodes were identified following Olsen (1952) and Ogden (1969). Species richness, abundance and prevalence of parasites were calculated according to Bush et al. (1997).

Fish were collected during several seasons. To ensure seasonality was not affecting the results, we applied Kruskal-Wallis tests (see Zar, 1996) to compare abundances and species richness of parasites in hosts collected in different seasons.

Parametric linear correlations (e.g. Pearson correlations) were used to relate number of dietary categories and parasitological descriptors of parasites to the host body weight (Zar, 1996). This was applied only for endoparasites which are generally transmitted in food. Because crustaceans are probably the intermediate hosts for most of the endoparasites, the number of crustacean categories was correlated with host body weight. In order to remove the effect of host body weight in these correlations, residuals of linear regressions between descriptors (species richness and abundance of parasites vs host body weight) and diet categories (total items and crustacean items vs host body weight) were utilised to relate parasitological descriptors and diet. A significance level of 0.05 was used for statistical analyses.

RESULTS

Twenty-three of 32 individuals of *Coris batuensis* had food in the gut. The diet was comprised of small prey items, no more than 10 mm in length. Molluscs, crustaceans and annelids occurred at frequencies of 100, 74 and 13% respectively. Snails of the family Dialidae, which are small and abundant in lagoons of coral reefs (Wilson, 1993), were the most common food categories (Table 1). Snails, bivalves and crustaceans were all found in small and large fish, and were present at 5–10 prey categories per fish. The number of prey categories did not increase with the fish body weight (Pearson correlation: n= 23, r= 0.18, P= 0.40). The number of crustacean categories did not increase with host body weight (n= 23, r= 0.05, P= 0.82).

Thirty-one fish were parasitised with at least one of 17 parasite species: 4 were ectoparasites and 13 were endoparasites (Table 2). Two ectoparasite species were gathered from the body surface and another 2 species were from the gill filaments. Thirteen species were collected from the gut and 4 species were from the body cavity including the gall bladder (Table 2). Because the samples were collected at different seasons, the sampling effect on species richness and abundance of parasites was evaluated comparing the averages of these descriptors between sampling time (summer, autumn and late winter). There were no significant differences in the total abundances and species richness of parasites among the three seasons (Kruskall-Wallis results using adjusted probabilities for small sample size: n= 32, $H_{(2)}$= 0.86, P= 0.65 for species richness; $H_{(2)}$= 0.77, P= 0.68 for abundance). There were also no differences in parasite composition; the most abundant and frequent parasites (Table 2) were present in all three seasons considered. Thus, sampling time was not an important variable in the parasite infracommunities of *C. batuensis*. Consequently, the following analyses are based on the combined fish sample.

The mean infracommunity species richness was 3.9 species and the mean abundance was 46.7 parasites per host. The most common parasites were cestode larvae. Eight morphotypes of tetraphyllideans were distinguished (Table 2). In this study each type was considered as a species because they were clearly distinguishable one another and there was no significant

TABLE 1. Prey categories and frequency of occurrences (OF) in gut contents of 23 individuals of *Coris batuensis*.

PHYLUM Class, Superorder or Order	Suborder or Family	OF (absolute)	OF (%)
ANNELIDA	Polychaeta	3	14.3
MOLLUSCA			
Gastropoda	Bullidae	1	4.4
	Cheritidae	4	17.4
	Dialidae	22	95.7
	Eulinoidae	1	4.4
	Naticidae	3	13.0
	Eggs (from snails?)	1	4.4
Bivalvia	Cardiidae	5	21.7
	Mytiloidea	4	17.4
	Veneridae and Tellinidae	8	34.8
	Bivalve (unidentified)	5	21.7
Polyplacophora		5	21.7
ARTHROPODA			
Amphipoda		6	26.1
Copepoda	Calanoida	2	8.7
	Harpacticoida	1	4.4
Isopoda		6	26.1
Ostracoda		4	17.4
Peracarida	(unidentified)	1	4.4
Tanaidacea		5	21.7
Decapoda	Brachyura	6	26.1
Pycnogonida		1	4.4
Insecta	Chironomidae (larvae)	2	13.0
CNIDARIA	(Corals)	1	4.4

variation in the morphology within each group. Tetraphyllidean types A, B, C and D correlated to types 1, 4, 6 and 10 respectively from the study by Chambers et al. (2000). The other types E–H have not been described previously so their morphologies are shown in Fig. 1. Voucher specimens of these 4 tetraphyllidean morphotypes were deposited in the Queensland Museum: G225273 (Tetraphyllidea type E), G225274 (Tetraphyllidea type F), G225275 (Tetraphyllidea type G), G225276 (Tetraphyllidea type H). Tetraphyllidea Type B was the most prevalent parasite, whereas Tetraphyllidea Type E was the most abundant (Table 2).

The body weight of *C. batuensis* varied between 3.4 and 43.6g, corresponding to lengths of 5.8 and 14cm. There was a correspondence between body weight and maturity of the fish because small fishes were always juveniles whereas all large fish were adults. Species richness and abundance of parasites were significantly correlated (n=32, $r= 0.59$, $P< 0.003$). Neither the species richness nor the species richness of parasite community (Pearson correlation: n= 32, $r= -0.32$; $P= 0.08$) nor the abundance (Pearson correlation: n= 32, $r= -0.05$; $P= 0.79$) was related to host body weight. Three cestode species had high prevalences, tetraphyllideans types B and G, and *Pterobothrium australiense* (Table 2). The abundance of tetraphyllidean type B and *P. australiense* was not correlated with host body weight (Pearson correlations, n= 32: $P= 0.11$, $P= 0.21$, respectively for each species). However, Tetraphyllidea type G was negatively correlated with host body weight (n=32, $r= -0.47$, $P= 0.006$).

Species richness and abundance of endoparasites were not significantly correlated to the total number of diet categories (n=23, $P> 0.55$ for richness and abundance) and crustacean categories (n= 23, $P> 0.46$ for richness and abundance). There were no significant correlations when the residuals of the linear regressions after parasitological descriptors and number of diet categories were

TABLE 2. Species, maturity stages (MS; a: adults, l: larvae), number of parasites (NP), prevalence (P%), abundance (ABU) and standard deviation (s.d.), and site of parasites from *Coris batuensis* (n= 32) collected at Lizard Island.

Parasite group	Species	MS	NP	P(%)	ABU	s.d.	Site
ECTOPARASITES							
MONOGENEA	*Polylabris* sp.	a	7	9.4	0.22	0.71	Gills
ISOPODA	*Gnathia* sp.	l	39	40.6	1.22	2.51	Body surface, gills
COPEPODA	*Orbitacolax williamsi* Cressey & Cressey, 1989	a	2	6.3	0.06	0.25	Body surface
	Chondracanthidae gen. sp.	l	1	3.1	0.03	0.18	Gills
ENDOPARASITES							
TREMATODA	*Helicometra fasciata* (Rudolphi, 1819)	a	9	18.8	0.28	0.63	Intestine
	Diplobulbus minuta Pritchard, 1966	a	3	6.3	0.09	0.39	Intestine
	Macvicaria sp.	a	16	15.6	0.50	1.44	Intestine
	Lecithaster stellatus Looss, 1906	a	1	3.1	0.03	0.18	Intestine
	Lecithaster sp.	a	2	6.3	0.06	0.25	Intestine
CESTODA	Tetraphyllidea Type A	l	23	31.3	0.72	1.71	Intestine, rectum
	Tetraphyllidea Type B	l	98	75.0	3.06	2.95	Intestine, rectum, gall bladder
	Tetraphyllidea Type C	l	18	28.1	0.56	1.24	Rectum
	Tetraphyllidea Type D	l	1	3.1	0.03	0.18	Intestine
	Tetraphyllidea Type E	l	3	6.3	0.09	0.39	Rectum
	Tetraphyllidea Type F	l	2	3.1	0.06	0.35	Rectum
	Tetraphyllidea Type G	l	1,212	53.3	37.88	65.07	Intestine
	Tetraphyllidea Type H	l	1	3.1	0.03	0.35	Gall bladder
	Pterobothrium australiense Campbell & Beveridge, 1996	l	31	37.5	0.97	1.53	Body cavity
	Pseudonybelinia sp.	l	5	6.3	0.16	0.63	Pericardial cavity
NEMATODA	*Spirocamallanus* sp.	a	13	25.0	0.41	0.91	Intestine
	Heliconema sp.	l	7	3.1	0.22	1.24	Body cavity
TOTAL			1,494		46.69	65.89	

first correlated with the host body weight (n= 23, *P*> 0.52 for all linear regressions).

DISCUSSION

Even though *Coris batuensis* is a small fish species, it exhibited a high species richness and abundance of parasites. However, some parasite species were very infrequent and in low number (only one specimen of Chondracanthidae, Tetraphyllidea D and H, and *L. stellatus*, Table 2),

so that they may not be common parasites of *Coris batuensis*. Species richness and abundance of parasites do not vary with the host body weight, apparently because small and large fish live in the same habitat (Green, 1996) and eat similar prey (this study).

The absence of a relationship between average parasite species, richness and abundance and host body weight suggests that there is no accumulation of parasites in the host over time.

Probably most or all the parasite species have short life spans and are turned over continually. The parasites that are encysted, principally in muscles and body cavity, cannot be released from the host and therefore may accumulate in the host body. The lifespan of encysted parasites may be longer than those of gut parasites, although their abundance was generally lower (Table 2). Several published studies have found high abundance of parasite as a function of large host body size (e.g. Grutter & Poulin, 1998; Lo et al., 1998; Muñoz & Cribb, 2005), although this is not always the rule (e.g. Muñoz et al., 2006). A large host body can provide more resources for parasites; however, the arrival and population growth of parasites may not depend on resources but may depend on the number of parasites able to reach the host body (Olsen, 1974). This can be seen specifically in Tetraphyllidea type G which significantly decreased in abundance with the host body weight. This indicates that body size of the host as representative of resources, space and food, is not the main determinant of the parasite recruitment in the fish. Consequently, other characteristics, such as physical-chemical conditions and immune response, may act as determinant factors of parasite recruitment. Juvenile fish may differ from adults in internal environmental conditions, so that settlement of some parasite species may be better in juveniles and other in adult hosts (Rohde, 1993). Other explanations are that juvenile fish may be more susceptible to infection by Tetraphyllidea type G and that an immune response occurs after a certain degree of infection (Wakelin, 1984).

Most endoparasites found here were larvae that reach the fish via its diet. However, no relationship was found between endoparasites and diet. The route of transmission can be affected by multiple factors: prey infected with parasites, rate of infected prey eaten by the fish and number of parasites that may finally be recruited in the host body. Moreover, the life cycle of most marine parasites remains unknown. We suspect that molluscs, although important in the diet of *Coris batuensis*, may not (directly) transmit any of the parasite species. However, small crustaceans (mainly zooplankton and decapods) are probably involved in the life cycle of most of the endoparasite species reported here.

There are two other factors that mitigate against finding an association between parasite and diet. First, there were limitations in the determination of frequency of diet categories; molluscs have hard shells that are not digested, so that their collection and identification is relatively easy in comparison to small crustaceans. Thus, although there were a large number of mollusc categories in the diet of *C. batuensis*, crustaceans may be more common in frequency and in species than the survey showed. Second, parasites exhibit longer permanence time in the digestive tract than diet, so that parasites do not necessarily reflect the present diet of the host (Muñoz et al., 2002).

However, the lack of association between parasites and diet suggests that apparently juvenile and adult fish have similar diet (no correlation between parasitological descriptors, host body weight, and host diet). Also, juveniles and adults live in the same habitats (Green, 1996). Zooplankton also constitutes the main diet for larval fish (Marcogliese, 1995), so it is possible that zooplankton is a regular diet category throughout the life of *C. batuensis*. All these analyses and inferences suggest that the lack of association between diet and parasites is real, and not because the confounding factors such as difficulties in the determination of prey diet and the difference in the lifespan of diet and host. In short, we conclude that *C. batuensis* has much the same diet throughout most of its life and, because of that, a similarly unchanging parasite composition.

As mentioned above, zooplankton probably transmits most of the parasites found in *C. batuensis*. In fact, zooplankton is an important component in the life cycle of many parasites because a large number of species have a planktonic life (Marcogliese, 1995). This section is focused on indirect inference of the invertebrate hosts of the endoparasites of *C. batuensis*. These inferences consider the diet of the fish and the generalised life cycles of congeneric species of parasites.

Trematodes (five species) were from two families, Opecoelidae and Lecithasteridae. Opecoelids overwhelmingly use arthropods (crustaceans and insects) as second intermediate hosts; the use of vertebrates and molluscs is exceptional. Of the three opecoelid genera reported here, life cycles are known only for species of *Helicometra*. *Helicometra gibsoni* infects alphaeid shrimps as second intermediate hosts (Meenakshi et al., 1993). Both lecithasterids reported here belong to *Lecithaster*. Køie (1989) showed that *Lecithaster gibbosus* uses copepods as second intermediate hosts. We therefore conclude that probably all of the trematode infections are acquired by ingestion of infected crustaceans.

Only one complete life cycle is known for a trypanorhynch; *Lacistorhynchus dollfusi* has copepods as first intermediate hosts (Sakanari & Moser, 1989). These are eaten by small fish in which plerocercoids develop. We conclude that the *Coris batuensis* would become infected with *Pterobothrium* and *Pseudonybelinia* by eating small crustaceans.

Few complete life cycles are known for tetraphyllideans, but, where known, procercoids appear to infect small crustaceans much as described above for trypanorhynchs (Antamaran & Krishawamy, 1958; Jarecka & Burt, 1984).

The *Spirocamallanus* sp. and *Heliconema* sp. probably enter this fish through crustaceans such as copepods and shrimps (Anderson, 2000). *Heliconema* nematodes were encysted in the host body cavity indicating that *C. batuensis* may be a paratenic host. This group of nematodes (Physalopteridae) does not use a fish as second intermediate hosts.

Eleven species of endoparasites were only represented by larval stages (Table 2), which reach their sexual maturity in other fishes. In general, tetraphyllideans and trypanorhynchs mature in sharks and rays (see Sakanari & Moser, 1989; Campbell & Beveridge, 1994, Chambers et al*.,* 2000), and nematodes of the genus *Heliconema* mature mainly in anguilliform fishes, but also in some other teleosts and elasmobranchs (Anderson, 2000). Therefore, these groups of fishes are likely predators of *C. batuensis*. In this respect, *C. batuensis* may be a significant component in the trophic and parasite webs in the Great Barrier Reef region. This fish species is not just prey for other fishes, but also constitutes an important pathway in the life cycle of several endoparasite species.

ACKNOWLEDGEMENTS

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