



Size-selective predation by the cleaner fish *Labroides dimidiatus*

A. S. GRUTTER

Department of Marine Biology, James Cook University of North Queensland,
Townsville, Queensland 4811, Australia

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A comparison of the size–frequency distribution of parasitic gnathiid isopod larvae in the diet of the cleaner fish *Labroides dimidiatus* and on six host fish species (*Chlorurus sordidus*, *Ctenochaetus striatus*, *Hemigymnus melapterus*, *Scolopsis bilineatus*, *Siganus doliatus*, *Thalassoma lunare*) was made on one occasion. The comparison was repeated with *Hemigymnus melapterus* on three occasions and between two islands in Australia. *L. dimidiatus* selected larger gnathiids at all times at Lizard Island but not at Heron Island. Size-selective predation by *L. dimidiatus* suggests any potential effect of cleaner fish on parasites may vary according to the size of parasite. However, this effect appears to vary spatially.

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Key words: cleaning behaviour; gnathiid isopods; ectoparasites; coral reef fish; feeding selectivity; predation.

INTRODUCTION

Cleaner fish feed not only on ectoparasites, host tissues, scales (Youngbluth, 1968), and host mucus (Gorlick, 1980), but also on fish eggs and zooplankton (Losey, 1979) indicating the diet can be wider. Despite an abundance of studies on cleaning behaviour, the significance of cleaning, particularly for the client fish, is little understood (Losey, 1987; Poulin & Grutter, 1996).

The cleaner fish *Labroides dimidiatus* (Cuvier & Valenciennes) on the Great Barrier Reef, Australia, feeds mainly on parasitic gnathiid isopod larvae (Grutter, 1997) which are common on coral reef fish species (Grutter, 1994). Many of the host fish have a wide range of parasites (Grutter, 1994), suggesting that *L. dimidiatus* feeds selectively on gnathiids (Grutter, 1997) perhaps because of their large size (range 0.3–2.7 mm) (Grutter, 1994). Gnathiids also have been found on 21 out of 32 fish species examined at Lizard Island, Australia (Grutter, unpublished data) and on a range of species elsewhere (e.g. Davies & Johnston, 1976; Paperna & Por, 1977). This study compared the size of gnathiids in the diet of the cleaner fish *L. dimidiatus* with the size of gnathiids on six host fish species cleaned regularly by *L. dimidiatus* (Grutter 1996a).

MATERIALS AND METHODS

FISH COLLECTION

Adult *L. dimidiatus* ($n=32$) were collected by divers using a 1.5 × 1-m barrier net and handnet (both 10-mm mesh). Fish were placed in a plastic bag, killed immediately with

Address for correspondence: Department of Parasitology, University of Queensland, Brisbane, Queensland, Australia. Fax: +61 7 3365 1588; email: a.grutter@mailbox.uq.edu.au

a blow to the head, and fixed underwater by injecting the gut cavity with 20% formalin in salt water. The whole fish was fixed 1–2 h later in 10% formalin in salt water. *Chlorurus sordidus* (Bellwood) ($n=11$), *Ctenochaetus striatus* (Quoy & Gaimard) ($n=15$), *Hemigymnus melapterus* (Bloch) ($n=32$), *Scolopsis bilineatus* (Bloch) ($n=9$), *Siganus doliatus* (Cuvier) ($n=23$), *Thalassoma lunare* (Linnaeus) ($n=13$) were collected following Grutter (1996b) by herding one fish at a time into a 15×1.6 -m barrier net, capturing it with a handnet, and placing it in a plastic bag. *Labroides dimidiatus* and host fish were collected at three sites at Lizard Island, Australia ($23^{\circ}27'S$, $151^{\circ}55'E$) in May. *Hemigymnus melapterus* were collected also in August 1992, and January 1993 and at two sites at Heron Island ($145^{\circ}26'E$, $14^{\circ}40'S$) in June 1993. Although *H. melapterus* were collected during the same season for the comparison between locations (May 1992 at Lizard Island and June 1993 at Heron Island), they were collected 1 year apart, therefore the comparison among locations was confounded by year. The sites at both islands were in shallow coral reefs (2–7 m), 1–5 km apart. Sites were pooled as there was little variation among sites within an island in the abundance of gnathiids in the diet of *L. dimidiatus* (Grutter, 1997) and on fish (Grutter, 1994). *Labroides dimidiatus* were collected between 1500–1700 hours and hosts were collected between 0800–1700 hours.

DIET ANALYSES AND RECOVERY OF GNATHIIDS ON FISH

The distinctly shaped heads of gnathiids were identified easily in the diet so gnathiid heads, with or without an attached body, were used to estimate gnathiid abundance in the diet. Gnathiids were recovered from fish following Grutter (1996b) by placing fish in the anaesthetic chloretone (0.4%; BDH Chemicals, Poole, England) for 30–60 min, then rinsing the fish and filtering all liquids. Almost all gnathiids are removed using this method (Grutter, 1996b).

SIZE OF GNATHIIDS

As most gnathiids were partially digested, except for the head which remained intact, the length (not including uropods) of 315 gnathiids in the diet was estimated from their head widths using simple linear regression [body length (mm), not including uropods = $-0.232 + 6245$ (head width μm) ($r=0.843$)]. The latter was obtained using randomly selected individuals of at least two unidentified gnathiid species and individuals with developed and non-developed abdomen. To estimate their length, the widths of eight to 10 randomly selected gnathiid heads (with or without an attached body) were measured per gut sample. For comparison, the lengths (not including uropods) of 1355 gnathiids collected from hosts were measured under a stereo microscope at $35 \times$. All gnathiids were grouped in four size classes (<1.10 mm, 1.10–1.39 mm, 1.40–1.69 mm, >1.70 mm) for statistical analyses.

STATISTICAL ANALYSES

The size of gnathiids in the diet was compared to that on each fish collected in May using separate χ^2 -analyses for each species (except for *H. melapterus*, see below). Differences in the size of gnathiids in the diet and on *H. melapterus* among times at Lizard Island were tested with a three-way log-linear (multiway frequency) analysis with time, source of gnathiid (in diet or on body), and size class of gnathiid as predictors (Tabachnick & Fidell, 1989). The size of gnathiids in the diet of *L. dimidiatus* and on the body of *H. melapterus* at Heron Island was tested for differences between source with χ^2 -analysis.

RESULTS

All χ^2 -analyses testing for differences in the size–frequency distribution of gnathiids in the diet compared to that on fish collected in May (*Chlorurus sordidus*, *Ctenochaetus striatus*, *Scolopsis bilineatus*, *Siganus doliatus*, *Thalassoma lunare*) were significant ($\chi^2=15.8$ –98, d.f.=3, $P<0.001$). Gnathiids on all fish

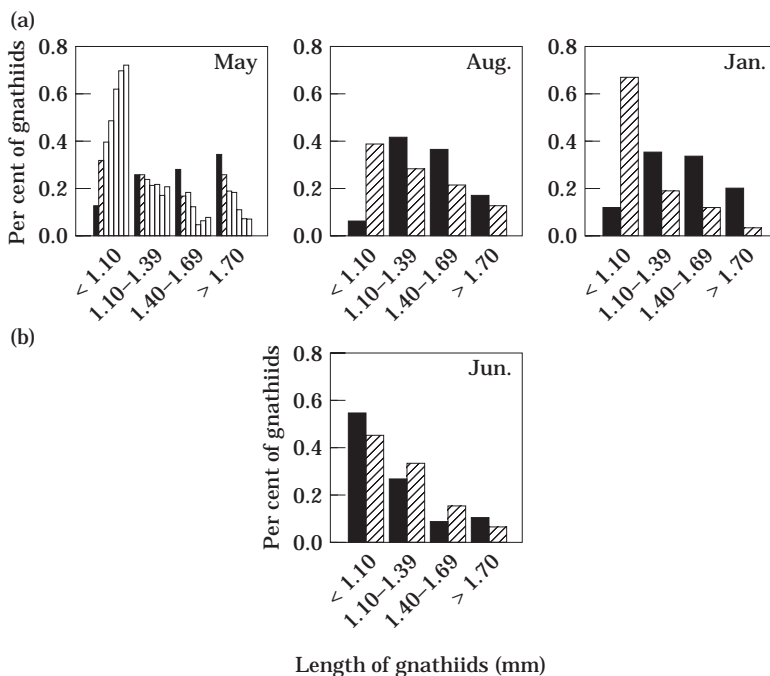


FIG. 1. The length–frequency distributions of gnathiid isopod larvae found in the diet of *Labroides dimidiatus* and on the body of the fish collected in (a) May 1992, August 1992 and January 1993 at Lizard Island and (b) June 1993 at Heron Island. ■, In diet; ▨, on *H. melapterus*; □, on other species (in the order they appear on the plot: *Thalassoma lunare*, *Chlorurus sordidus*, *Ctenochaetus striatus*, *Signanus doliatus*, and *Scolopsis bilineatus*).

species were smaller than in the diet of cleaner fish [Fig. 1(a)]. This shows that *L. dimidiatus* feeds selectively on larger gnathiids. All tests of significance (partial likelihood ratio χ^2) for the first-order effects and the two-way associations in the log–linear analysis testing for differences among the size of gnathiids in the diet of *L. dimidiatus* and on the body of *H. melapterus* at Lizard Island were significant (time: $\chi^2=155.41$, d.f.=2, $P<0.001$; source of gnathiid: $\chi^2=81.39$, d.f.=1, $P<0.001$; time \times source of gnathiid: $\chi^2=15.68$, d.f.=2, $P<0.001$; size class: $\chi^2=23.26$, d.f.=3, $P<0.001$; time \times size class: $\chi^2=60.26$, d.f.=6, $P<0.001$; source of gnathiid \times size class: $\chi^2=91.71$, d.f.=3, $P<0.001$). There was no three-way interaction. The significant interaction term between source of gnathiid and size class (source of gnathiid \times size class) indicates that there are more large gnathiids in the diet than on the body of *H. melapterus* at all times [Fig. 1(a)] showing that size-selective predation by *L. dimidiatus* at Lizard Island occurred at all times sampled. Only 4% of the expected component frequencies were under five which indicates the model had a good fit (Tabachnick & Fidell, 1989). There was an increase in the number of small gnathiids from May to January both in the diet and on *H. melapterus* (time \times size class) [Fig. 1(a)]. The remaining interaction term (time \times source of gnathiid) reflects differences in the sample size.

In contrast, the size–frequency distribution of gnathiids in the diet and on *H. melapterus* at Heron Island were not different ($\chi^2=2.52$, d.f.=3, $P=0.472$) and

consisted mainly of many small gnathiids [Fig. 1(b)]. A comparison of the size–frequency distribution of gnathiids at Heron Island [Fig. 1(b)] with the size of gnathiids at Lizard Island at a similar time of year (May) [Fig. 1(a)] reveals that the patterns in the diet and on the fish differ among locations. First, there were more large gnathiids, both in the diet and on the host, at Lizard Island in May 1992 than at Heron Island in June 1993; and second, the size selectivity of gnathiids by *L. dimidiatus* at Lizard Island did not appear to occur at Heron Island.

Gnathiids were identified to species using adult males, therefore, larvae could only be identified to family. However, it is likely that they belong to *Elaphognathia*, *Gnathia* or *Caecognathia* as only these genera have been found in the Great Barrier Reef (Cohen & Poore, 1994).

DISCUSSION

Labroides dimidiatus selected larger gnathiids at Lizard Island. The size–frequency distribution of gnathiids in the diet had more large individuals compared to gnathiids on the six host species tested. The comparisons made at different times at this location showed similar patterns. Size selectivity by cleaner fish has been found also in several temperate labrid cleaner fish species which preyed selectively on the larger stages of sea lice *Lepeophtheirus salmonis* (Krøyer), found on farmed Atlantic salmon *Salmo salar* L. (Treasurer, 1994; Tully *et al.*, 1996; M. J. Costello, pers. comm., University of Dublin, Ireland). Size-selective predation by *L. dimidiatus* did not occur at Heron Island. The majority of gnathiids on *H. melapterus* at Heron Island were small, so these gnathiids were the only available food for *L. dimidiatus*.

Gnathiids are one of the larger (0.3–2.7 mm) common parasites of coral reef fish (Grutter, 1994). The observed size-selective predation explains why *L. dimidiatus* feeds selectively on gnathiids (Grutter, 1997). In other studies, caligid copepods, which are relatively large (most are 1–6 mm) ectoparasites (Kabata, 1979; Grutter, 1994), are one of the most numerous parasites in the diet of *Labroides* spp. (Youngbluth, 1968; Chikasue, unpublished MSc Thesis, Department of Biology, University of Ehime, Ehime 790, Japan). Caligid copepods are found also in the diet of *L. dimidiatus* at Lizard Island and Heron Island, however their abundance is relatively low (Grutter, 1997). This may be due to the low numbers of caligid individuals on host fish at these locations (Grutter, 1994).

The selective feeding habits of *L. dimidiatus* at Lizard Island may have significant ecological consequences. Not only do *L. dimidiatus* select the larger individuals, they also feed selectively on gnathiids (Grutter, 1997). Thus, *L. dimidiatus*, which appear to have an effect on the abundance of gnathiids (Grutter, 1996c), probably will have more of an effect on the larger gnathiids. This has important implications for host fish as the most deleterious effects of gnathiids, resulting in the mortality of captive fish, have involved relatively large gnathiids (adults 4–5 mm) (Paperna & Por, 1977). The gnathiid larvae in this study were relatively small and their effects on hosts are unknown.

The lack of size-selective feeding at Heron Island may reflect lower food availability. The diet of *Labroides dimidiatus* at Heron Island contains more

benthic copepods and mucus and fewer parasites than the diet of fish collected at Lizard Island, suggesting ectoparasites are less available at Heron Island (Grutter 1997). The difference in size-selective feeding between islands indicates flexibility in cleaner fish feeding selectivity. Most importantly, it suggests that any potential effect of cleaner fish on parasites, and thus the relationship between cleaner and client fish, may vary spatially also.

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