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Volume 50, 1999

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Fish cleaning behaviour in Noumea, New Caledonia

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Abstract. Fish cleaning behaviour was quantified at Noumea, New Caledonia, for comparison with other studies, using a combination of cleaner fish diet analyses, client (host) parasite analyses, and observations of the cleaning rates of cleaners and client fish. Most (91%) of the items in the diet of the cleaner wrasse *Labroides dimidiatus* were parasitic gnathiid isopod larvae (165 ± 22 gnathiids per gut, mean ± s.e.) which made up most of the biomass (12.8 g). Gnathiids were common on the client fish *Hemigymnus melapterus* and *Scolopsis bilineatus* with 88% and 55% respectively infested with gnathiids. *L. dimidiatus* spent 26% of its time inspecting large numbers of fish (59.5 ± 5.1 fish per 15 min observation). *H. melapterus* was regularly cleaned by *L. dimidiatus* (2.5 ± 0.5 times for 17.5 ± 2.5 s per 30 min observation period). The cleaning rates of cleaners and clients are comparable to those found at Lizard and Heron Islands, Great Barrier Reef, Australia (1000 km apart), whereas the biomass of gnathiids was lower than at Lizard I. but higher than at Heron I., suggesting that the role of gnathiids in cleaning behaviour is widespread but variable.

Introduction

Fish cleaning behaviour, in which cleaner fish feed on parasites and other materials from the body surfaces and gills of client fish, is common in freshwater and marine temperate systems (Feder 1966) but its ecological significance is widely debated (Losey 1987; Poulin and Grutter 1996). The disagreement among studies may be due to spatial variation in cleaning behaviour (i.e. ecological differences) and/or to differences among cleaner fish species. In the only quantitative study on how cleaning and the role of parasites varied spatially, Losey (1974) found that there were many more cleaner fish and ectoparasites in Puerto Rico than in Hawaii and Enewetak Atoll (tropical Pacific) and suggested that cleaning may be more important for clients in Puerto Rico.

The existence of differences in cleaning behaviour between cleaner species is not surprising. Knowledge of whether cleaning varies spatially within the range of a single cleaner fish species, however, can provide insight into the adaptability of the behaviour and how cleaning behaviour responds to ecological influences. Five species in the genus *Labroides* (Labridae) are the most common cleaner fishes in tropical waters (Randall 1958; Randall *et al.* 1990). Of these, *Labroides dimidiatus* is the most widespread, ranging from Africa to the tropical Pacific (Randall 1958; Randall *et al.* 1990). This species is therefore ideal for making inter-geographic comparisons of cleaning behaviour. Its cleaning rates have been examined in several localities including Japan (Okuno 1969; Kuwamura 1984), Aldabra, Indian Ocean (Potts 1973), and Heron Island, Great Barrier Reef (GBR) (Robertson 1974). Although the diet of *L. dimidiatus* from several localities has been described by Randall (1958), that study and the former studies have involved different methods, so comparison among localities is difficult.

In a study using the same methods at each of two islands (1000 km apart) on the Great Barrier Reef, the biomass of gnathiids in the diet of *L. dimidiatus* was 4 times higher at Lizard Island than at Heron Island (Grutter 1997*a*). Furthermore, Bansemer (1998) showed that *L. dimidiatus* at Heron Island 'cheats' in cleaning interactions, as it mainly eats scales and often appears to attack clients. These differences in diets may reflect the differences in numbers of parasites available, since client fish have more gnathiids at Lizard Island than at Heron Island (Grutter and Poulin 1998). Grutter (1997*a*) suggested that variation in the diet may result in variation in the interactions between cleaners and clients, with clients at Heron Island probably benefitting less from cleaning than clients at Lizard Island. Information on the role of gnathiids and the cleaning behaviour of *L. dimidiatus* from other areas is needed to determine whether the importance of gnathiids in their diet is general or unique to Lizard Island and the extent to which cleaning behaviour varies spatially within a species.

The present study at Noumea, New Caledonia, examined the diet and the cleaning rates of *L. dimidiatus*. In addition, the abundance of parasites (gnathiid isopod larvae) on two common client species [*Hemigymnus melapterus* (Labridae) and *Scolopsis bilineatus* (Nemipteridae)] and the rate at which *H. melapterus* was cleaned by *L. dimidiatus* was measured. The methods used were similar to those used on the GBR (Grutter 1994, 1995*a*, 1995*b*, 1996, 1997*a*, 1997*b*; Grutter and Poulin 1998) allowing a comparison of cleaning behaviour at the different localities.

Methods and materials

Labroides dimidiatus specimens ($n = 11$) were collected between 11 and 15 November 1997 from three reefs between the city of Noumea, New

10.1071/MF97078 1323-1650/99/030209

Caledonia (26°16′S,166°27′E) and the outer barrier reef. Fish were captured and fixed immediately, as in Grutter (1997*a*). All collections were made between 0855 and 1300 hours. Gut contents were categorized as in Grutter (1997*a*): gnathiid isopod larvae, Caligidae adults and pre-adults, caligid chalimus stages, other parasitic copepoda species, non-parasitic copepods (benthic and planktonic), scales, other items, mucus, and digested material. Gnathiids, which are parasitic as larvae, can be identified only from adult males and were therefore identified to family only (Holdich and Harrison 1980). The number of items in each of the above categories (except mucus and digested material) were counted in a sorting tray. The amount or 'volume' of different food items in the diet was estimated following Grutter (1997*a*); the proportion of the mean item-cover of the total cover was calculated and the standard error per category was calculated following Armitage and Berry (1987, p. 91). A subsample of gnathiids was measured (not including uropods) by sampling the first 4 to 14 whole gnathiids encountered when counting the items in the diet (total $n = 45$). The biomass of gnathiids was calculated following Grutter (1997*b*).

Hemigymnus melapterus ($n = 8$) and *S. bilineatus* ($n = 7$) were collected following Grutter (1994) 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 to reduce loss of gnathiids due to handling (Grutter 1995*b*). Gnathiids were removed by scraping the gills, fins, and body surfaces with the tip of a wash bottle. Liquids in plastic bags and from the above rinse were then filtered with a plankton filter (62 μm mesh) to recover gnathiids. A subsample of gnathiids was fixed immediately in 4% formaldehyde in seawater and the range in size measured (not including uropods).

The cleaning rate of *L. dimidiatus* was measured following Grutter (1996). Observations ($n = 4$) were made between 0645 and 0750 hours on 16 November 1997 on a fringing reef (depth 2–5 m) on Nouville Peninsula (Noumea). Cleaning time was estimated as the duration of cleaner fish inspection of host fish, which involved visual examination of the gill and or body surfaces of the host fish. The length of an inspection event was determined from the time when a cleaner fish approached a host fish until it departed the host. Each *L. dimidiatus* was observed for 15 min. The host species and the duration of each inspection by *L. dimidiatus* was recorded, and the frequency of inspections calculated from these.

Hemigymnus melapterus individuals were selected haphazardly and observed following Grutter (1995*a*). The behaviours recorded were the frequency of inspection and the duration of inspections by *L. dimidiatus* per observation period (30 min). The latter was defined as the sum of the duration of all inspections per observation period. All observations were made between 0750 and 0900 hours. Observations were made on the same date and locality as the above observations of cleaner fish.

Results

Most (91%) of the items in the diet of *L. dimidiatus* were parasitic gnathiid isopods; the remainder were fish scales, Caligidae adults and pre-adults, non-parasitic copepods, other items (skin fragments, a gill fragment, and sand), caligid chalimus stages, and other parasitic copepods (Fig. 1*a*). Digested material (55%) and gnathiids (34%) had the highest cover or 'volume' in the diet (Fig. 1*b*). The estimated biomass of gnathiids in the diet was 12.8 μg. The standard length (SL) of *L. dimidiatus* was 5.2 ± 0.4 cm (mean ± s.e.), with a range of 3.3–8.3 cm.

Gnathiids were common on the clients *H. melapterus* and *S. bilineatus*, with 88% and 57% of the fish being infested respectively. *Hemigymnus melapterus*, measuring 11.0 ± 0.7 cm (range 9.0–14.6) SL had 10.9 ± 5.7 (range 0–39) gnathiids per fish; *S. bilineatus*, measuring 14.1 ± 0.4 cm (range

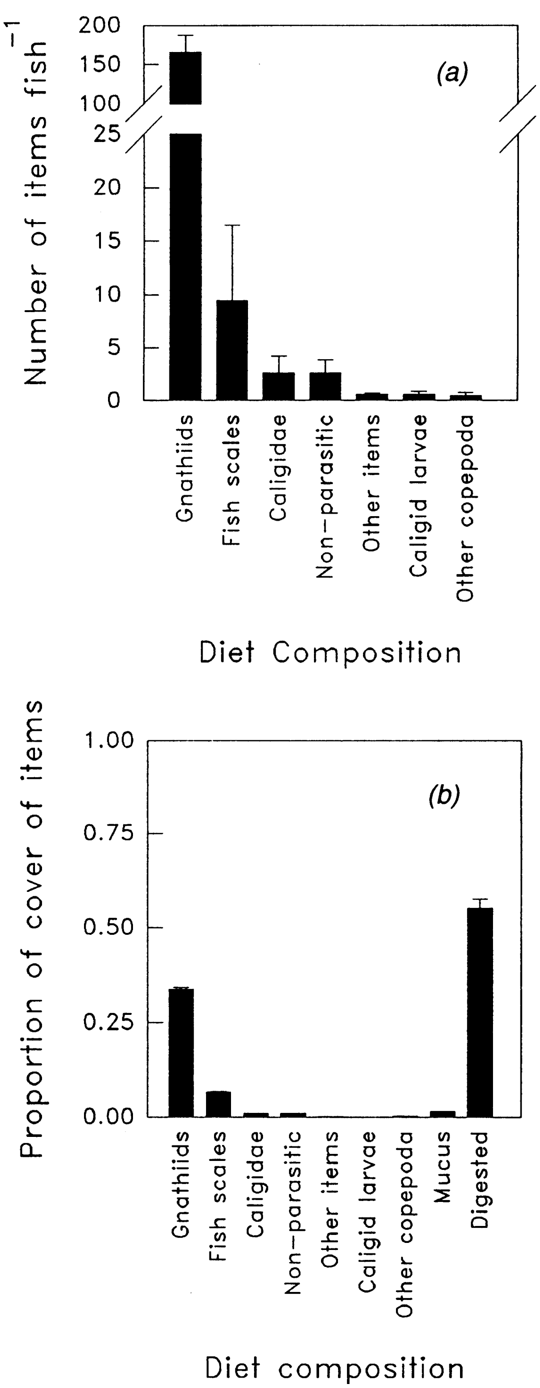

Fig. 1. Diet of the cleaner wrasse *Labroides dimidiatus*: *(a)* number of items per fish; *(b)* proportion of cover or 'volume' of items per fish.

12.0–15.5) SL had 3.9 ± 2.5 (range 0–21) gnathiids per fish. The size ranges of gnathiids were 0.83–0.98 mm on *H. melapterus* and 0.55–0.64 mm on *S. bilineatus*.

On average, *L. dimidiatus* spent 4.0 ± 0.9 min inspecting 59.5 ± 5.1 fish per 15 min observation. The number of species cleaned during this time was 15.0 ± 1.2, with a cumulative 33 species cleaned during four observation periods. *Hemigymnus melapterus* measuring 10–15 cm SL were cleaned 2.5 ± 0.5 times for a total of 17.5 ± 2.5 s per 30 min observation period.

Discussion

Parasitic gnathiid isopods are important in the cleaning interactions of fish on the reefs sampled in New Caledonia. Hence, the importance of gnathiids in the diet of *L. dimidiatus* is not unique to Lizard Island, GBR (Grutter 1997*a*). Gnathiids made up most of the diet of the cleaner wrasse *L. dimidiatus* and were commonly found on the two client species examined, *H. melapterus* and *S.bilineatus*. The diet composition of *L. dimidiatus* in New Caledonia is similar to that of *L. dimidiatus* on the Great Barrier Reef (Grutter 1997*a*). Gnathiids and, to a much lesser extent, scales were the dominant items in all three localities. All the remaining categories of diet items that were found on the GBR (Grutter 1997*a*) were found in the diet of *L. dimidiatus* in New Caledonia. The average gnathiid abundance per gut of cleaner fish in New Caledonia (165 ± 22) was similar to that at Lizard Island (range 114 ± 13 to 253 ± 46, sampled in May, August, October 1992, and January 1993) but higher than that at Heron Island [72 ± 14, sampled in June 1993 (Grutter 1997*a*) and 25.4 ± 5.8 sampled in March–May 1998 (Bansemer 1998)]. The estimated biomass of gnathiids in the diet of *L. dimidiatus*, however, was one-half to one-quarter that at Lizard Island but double that at Heron Island (Grutter 1997*a*). These differences in biomass are in part due to the smaller size of gnathiids in New Caledonia and Heron Island (Grutter 1997*b*). The diet of *L. dimidiatus* on the GBR and in New Caledonia is in stark contrast to *L. dimidiatus* in the Gilbert Islands where it eats no gnathiids, the Marshall Islands where it eats 'a few small isopods' (Randall 1955) and the Phoenix and Society Islands where it eats 0–5 gnathiids per gut (Randall 1958); it should be noted, however, that these studies used different sampling methods.

The gnathiids in the diet of *L. dimidiatus* (1.01 ± 0.05 mm) and on the client *H. melapterus* from New Caledonia (0.83–0.98 mm) were small, similar to those sampled at Heron Island where most gnathiids in the diet of *L. dimidiatus* and on *H. melapterus* were also <1.10 mm (Grutter 1997*b*). This is in contrast to gnathiids ingested by *L. dimidiatus* at Lizard Island, which were larger (most >1.10 mm) than on the client *H. melapterus* (most <1.10 mm), showing that cleaners at Lizard Island selectively feed on larger gnathiids (Grutter 1997*b*). By rearing gnathiids to adult males it has been shown that there are at least two gnathiid species on *H. melapterus* from Lizard Island, two other species on *H. melapterus* at Heron Island and a fifth species on *H. melapterus* in New Caledonia (Grutter and Poore, unpublished). The difference in size between gnathiids consumed by cleaner fish in New Caledonia and Lizard Island is therefore possibly due to their being different species.

The cleaning rates of *L. dimidiatus* in New Caledonia were similar to those from Lizard Island (Grutter 1996), Aldabra Atoll (East Africa) (Potts 1973), Japan (Okuno 1969; Kuwamura 1984), Heron Island (34.6 ± 4.7 inspections for a total of 2.6 min per 15 min observation) (Grutter, unpublished), and Ningaloo Reef (Western Australia) (54 ± 7 inspections for a total of 4 ± 1.2 min per 15 min observation) (Grutter, unpublished). In addition, the rate at which individual *H. melapterus* were cleaned by *L. dimidiatus* in New Caledonia was in the same range as that at Lizard Island (3.6 ± 0.6 inspections for a total of 30 ± 6 s per 30 min observation (Grutter 1995*a*) but less than that at Ningaloo Reef (10 ± 1 inspections for a total of 47 ± 20 s per 30 min observation) (Grutter, unpublished). The abundance of gnathiids in the diet and the cleaning rates of *L. dimidiatus* in New Caledonia are comparable to those found at Lizard and Heron Islands where gnathiids are important in cleaning interactions (Grutter 1996, 1997*a*); however, the biomass of gnathiids on client fish in New Caledonia was intermediate between those at Lizard and Heron Islands. This suggests that the role of gnathiids in the cleaning behaviour of *L. dimidiatus* is widespread but variable.

Acknowledgments

I thank R. Galzin and S. Morand for organizing the field trip and providing logistical support. For the field trips I received valuable help from the Noumea Aquarium, The Pacific French University, the ORSTOM Research Program 'Ecotrope', the French National Program on Coral Reefs, the International Cooperative Scientific Program between France and Australia (PICS CNRS 385) and the South Province of New Caledonia. Claude Chauvet provided local knowledge of the reefs. Many thanks to C. M. Lo, A. Lo-Yat, P. Sasal, M. C. Rigby, T. H. Cribb, S. Pichelin, L. Euzet, T. Lison de Loma, L. Lison de Loma and M. L. Harmelin-Vivien for their assistance in the field and laboratory and to T. H. Cribb and J. Greenwood for constructive comments on an earlier version of the manuscript. Travel to New Caledonia was funded by an ARC Postdoctoral Fellowship.

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Manuscript received 2 July 1998; revised 22 October; accepted 21 December 1998