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Feeding association between reef fishes and the fire coral *Millepora* spp. (Cnidaria: Hydrozoa)

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This study aimed to assess the feeding association between coral reef fishes and the hydrozoan Millepora *spp. in two different reef systems (Tamandaré reefs and Fernando de Noronha archipelago) of Pernambuco State (north-eastern Brazil). A total of eight reef fish species, predominantly juveniles, were recorded feeding on colonies of* Millepora *spp. during 35 records. The highest recorded feeding rate was 1.72 ± 0.87 bites.minute^{-1} for* Sparisoma axillare *and the lowest was 0.18 ± 0.40 bites.minute^{-1} for* Stegastes rocasensis. *The colony structure of the genus* Millepora *supports a high diversity of microfaunal and macrofaunal invertebrates, which may result in the frequent foraging behaviour observed here.*

Keywords: hydrocorals, foraging behaviour, macrofauna, north-eastern Brazil

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INTRODUCTION

South Atlantic reefs have a relatively poor, but endemic-rich coral fauna, which is constituted mainly of massive corals (Leão & Dominguez, 2000). These coral forms do not create a large number of microhabitats, since they are structurally less complex than corals from other regions such as the tropical Caribbean and Indo-Pacific (e.g. *Acropora* spp.). One exception are the fire corals *Millepora* spp. (Hydrozoa), which act as important foundation species contributing to the establishment of reef-associated organisms (Garcia *et al.*, 2008, 2009). The powerful nematocysts of *Millepora* spp. are noted for producing an intense burning sensation in humans, exceeding the irritation produced by contact with most scleractinian coral colonies (Lewis, 1989). The two most abundant *Millepora* species along the Brazilian coast and oceanic islands are the branching *M. alcicornis* (Linnaeus, 1758) and *M. braziliensis* Verrill, 1868 (Amaral *et al.*, 2008).

The structural complexity generated by the colony branches of *Millepora* species harbours a great diversity of organisms, including crustaceans, worms, fishes and other organisms living in close association (Patton, 1994; Garcia *et al.*, 2008, 2009; Coker *et al.*, 2009). These animals may stay near to the branching coral or even live among its branches, probably due to the proximity to their food items, which can be the coral or epibionts (see Ciardelli, 1967; Rotjan & Lewis, 2008). Moreover, other organisms may associate with branching corals during breeding or for shelter and protection against predators (Munday *et al.*, 1997; Gibran *et al.*, 2004).

Several fish species feed on calcareous cnidarians in reefs or use these substrata to feed on the associated macrofauna (Cole *et al.*, 2008; Rotjan & Lewis, 2008; Garcia *et al.*, 2009). However, detailed descriptions of such relationship are poorly described for south-west Atlantic reefs, where branching corals are relatively scarce (Leão & Dominguez, 2000). In this context, the present study is the first to describe the foraging behaviour of reef fishes on the colonies of the branching fire corals *Millepora* spp.

MATERIALS AND METHODS

For this study, approximately 40 hours of underwater observations (snorkelling and SCUBA diving) were performed in two different reef systems of Pernambuco State (north-eastern Brazil); Tamandaré reefs (8°44′S and 35°05′W) and Fernando de Noronha archipelago (3°54′S 32°25′W). Both sites feature large and prominent colonies of *Millepora* spp. (Eston *et al.*, 1986; Maida & Ferreira, 1997) and have relatively clean, transparent and warm waters. The prominent coral reef in Tamandaré is located approximately 300 m offshore and has a substrate dominated by macroalgae (including the genera *Sargassum*, *Padina* and *Caulerpa*) and massive corals (e.g. *Montastraea* and *Mussismilia*). On the other hand, Fernando de Noronha contains several habitat types, including oyster reefs, rocky shores, reef flats and parts of shipwrecks which are sparsely distributed in specific areas of the shore (Eston *et al.*, 1986; Souza *et al.*, 2011). In this system the benthos is

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mostly represented by encrusting coralline algae, foliose seaweeds, algal turfs and cnidarians (Eston *et al.*, 1986). During dives, 66 colonies were randomly investigated (46 on Tamandaré reefs and 26 on Fernando de Noronha archipelago) and all predation events towards the hydrocoral polyps and/or skeleton were noted on PVC slates. The studied colonies were located 0.5 to 6 m below the surface.

RESULTS

A total of eight reef fish species (predominantly juveniles) were recorded feeding on colonies of *Millepora* spp. during 35 records (Table 1; Figure 1). In Tamandaré, the highest bite rate was recorded for the grey parrotfish *Sparisoma axillare* (Steindachner, 1878) (1.72 ± 0.87 bites.min^{-1}), followed respectively by the yellowtail damselfish *Microspathodon chrysurus* (Cuvier, 1830) (1.61 ± 0.21 bites.min^{-1}), Brazilian dusky damselfish *Stegastes fuscus* (Cuvier, 1830) (1.35 ± 0.93 bites.min^{-1}), the redlip blenny *Ophioblennius trinitatis* (Miranda Ribeiro, 1919) (0.97 ± 0.35 bites.min^{-1}), cocoa damselfish *Stegastes variabilis* (Castelnau, 1855) (0.81 ± 0.24 bites.min^{-1}), Zelinda's parrotfish *Scarus zelindae* (Moura, Figueiredo & Sazima, 2001) (0.58 ± 0.35 bites.min^{-1}) and banded butterflyfish *Chaetodon striatus* (0.43 ± 0.11 bites.min^{-1}). In Fernando de Noronha, adults of Rocas gregory *Stegastes rocasensis* were also recorded feeding on the polyps of the fire coral at a low rate. However, *S. rocasensis* juveniles were constantly found in close association with *Millepora* spp. colonies using the corals as a refuge.

DISCUSSION

In the present study, the fish predation events on *Millepora* spp. were performed mostly by fish that are predominantly considered herbivorous (e.g. damselfishes and parrotfishes) (Ferreira *et al.*, 2004). Since most of the predation recorded here was performed by juvenile individuals of these groups, this could be indicative that these fishes may often search for other food items during their juvenile stage (Ferreira *et al.*, 1998). Moreover, all predation events seemed to focus on the polyps or mucus, with no apparent injuries to the skeleton of the hydrocorals.

In Brazilian waters, Bonaldo *et al.* (2006) and Francini-Filho *et al.* (2008) recorded corallivorous behaviour for reef fishes. The former study was also performed in Fernando de Noronha and recorded that two parrotfish species (*Sparisoma amplum* and *S. frondosum*) occasionally took bites of *Millepora* spp., but the authors argued that this behaviour may have related to territorial behaviour of the adults, which does not apply to our study, since our records refer primarily to juveniles, that may use the hydrocorals for shelter and feeding. Francini-Filho *et al.* (2008) analysed the foraging behaviour of parrotfish on massive corals (e.g. *Mussismilia braziliensis*, *Montastrea cavernosa* and *Siderastrea* spp.) on Abrolhos Bank (eastern Brazil) and found high feeding rates of *Scarus trispinosus* (17.8 ± 1.8 bites.min^{-1}) and juvenile *Sparisoma amplum* (7.0 ± 0.7 bites.min^{-1}).

Parrotfishes are the main group that feed on corals in the western Atlantic, both on Caribbean (Bruckner & Bruckner, 1998; Reyes-Nivia *et al.*, 2004; Rotjan & Lewis, 2006) and Brazilian reefs (Bonaldo *et al.*, 2006; Francini-Filho *et al.*, 2008). In these systems, parrotfish densities are relatively high (Bonaldo *et al.*, 2006; Francini-Filho *et al.*, 2008) and since the coral consumption by parrotfish can be detrimental for corals (Francini-Filho *et al.*, 2008), it should be expected that these species may play an important role in the ecology of *Millepora* spp. in Brazil. However, the impact of these fish on tropical reefs has been controversial, because many species cause only minor damage to the corals (mucus-feeders), although a few excavators feed by removing live coral tissue with major portions of the underlying skeleton (Rotjan & Lewis, 2008, Bonaldo *et al.*, 2011).

The family Chaetodontidae is well known for using corals as a main food resource, both in studies from stomach contents analysis (Sano, 1989) and in observations of feeding behaviour (Gregson *et al.*, 2008). Moreover, it was established that juvenile buterflyfishes can cause a decline in coral tissue (Pratchett & Cole, 2010). Nevertheless, Bonaldo *et al.* (2005) and Bellwood *et al.* (2010) noted low foraging rates for *Chaetodon striatus*, which may be associated with peak activity of the species throughout the day or even rejection of corals from the genus *Millepora* in the diet of this species.

Four species from the family Pomacentridae were observed in feeding association with fire coral in this study. Moreover, in Tamandaré reefs (Pernambuco State) the genus *Stegastes* occurs in high frequency on colonies of *Millepora* spp., using them as a shelter or even as part of the territory (Leal *et al.*, unpublished data). Pomacentridids are reef fishes that most often live associated with the structure of staghorn coral colonies (Precht *et al.*, 2010; Johnson *et al.*, 2011), and there is a wide variation in food frequency between species. The presence of these individuals is so significant that they

Table 1. List of reef fishes and families, trophic guilds*, and life phase (A, adult; J, juvenile). N, number of observed individuals feeding on the *Millepora* spp. coral colonies.

Species	Family	Trophic guilds	Life phase	N	Bites/minute (±SE)
Sparisoma axillare	Scaridae	ROVH	J	1	1.72 ± 0.87
Microspathodon chrysurus	Pomacentridae	TERH	J	7	1.61 ± 0.21
Stegastes fuscus	Pomacentridae	TERH	J	13	1.35 ± 0.93
Ophioblennius trinitatis	Blenniidae	MIF	A	4	0.97 ± 0.35
Stegastes variabilis	Pomacentridae	TERH	J	1	0.81 ± 0.24
Scarus zelindae	Scaridae	ROVH	J	4	0.58 ± 0.35
Chaetodon striatus	Chaetodontidae	SIF	J	5	0.43 ± 0.11
Stegastes rocasensis	Pomacentridae	TERH	A	2	0.18 ± 0.40

*, trophic guilds based on Ferreira *et al.* (2004): ROVH, roving herbivores; TERH, territorial herbivores; MIF, mobile invertebrate feeders; SIF, sessile invertebrate feeders.

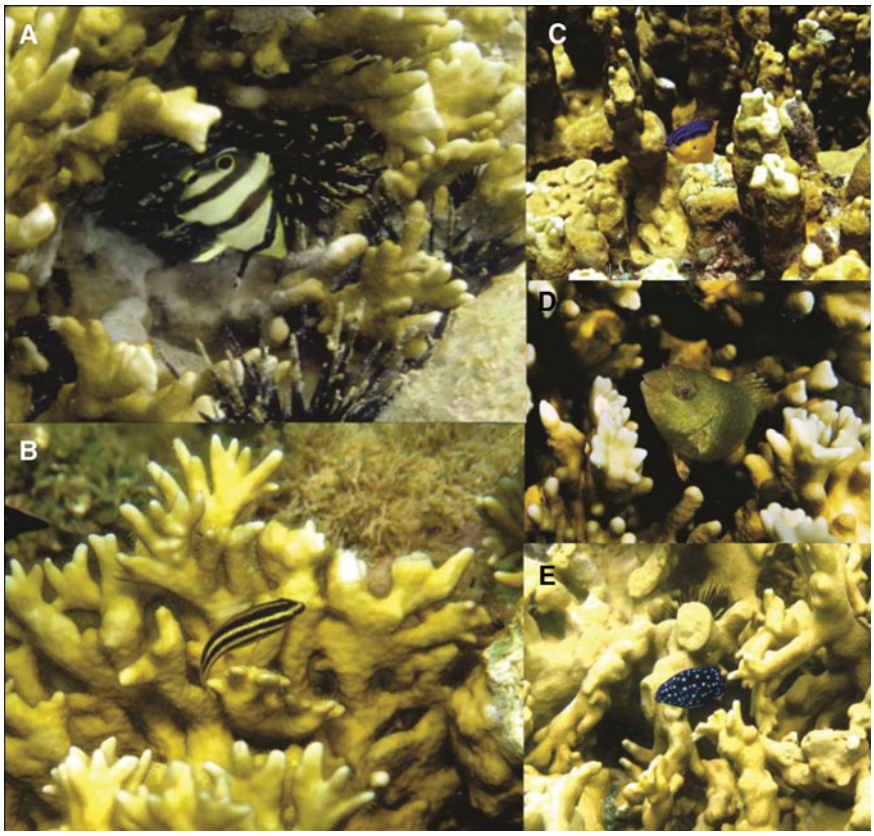

Fig. 1. *Chaetodon striatus* (A) and *Scarus zelindae* (B) feeding on the fire coral polyps in Tamandaré reef; *Stegastes rocasensis* (C), *Sparisoma axillare* (D) and *Microspathodon chrysurus* (E) were also recorded feeding on the *Millepora* spp. colonies.

can even modify the structures of the fish communities associated with hard corals (Johnson *et al.*, 2011).

A high diversity of fauna associates with the complex structure of *Millepora* spp., including micro- and macrofaunal invertebrates (e.g. protozoans, molluscs, crustaceans and annelids) (Lewis, 1989; Amaral *et al.*, 2008; Garcia *et al.*, 2008) and the number of associated individuals has been reported to be directly related to the volume of the colony (Garcia *et al.*, 2009). These invertebrates are often eaten by reef fish feeding on other substrata such as algae and seagrass beds (McCormick, 1995; Pereira *et al.*, 2010), thus the occurrence of associated fauna and provided refuge may support the frequent foraging behaviour observed in the present study. The observed feeding events mostly occurred on the body and extremities of the *Millepora* spp. colonies, areas with a greater availability of crustaceans and echinoderms (Garcia *et al.*, 2008).

This study indicated that fish may associate with *Millepora* spp. not only for shelter, but that juvenile fishes may feed on the soft tissues of the hydrozoan, its mucus or small epibionts. The relationships between reef fishes and hydrocorals of the genus *Millepora* have not been evaluated properly on south-west Atlantic reefs and so further studies of the diets and the feeding behaviours of the associated ichthyofauna should be undertaken.

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