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Cryptobenthic fish as clients of french angelfish *Pomacanthus paru* (Pomacanthidae) during cleaning behaviour

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Abstract

The French angelfish *Pomacanthus paru* (Pomacanthidae) is recognised as an important cleaner in tropical reef environments, yet its clients remain relatively undescribed in the literature. Here, we report observations of their cleaning behaviour when interacting with different species of cryptobenthic fish clients. The study was conducted in Bahia state, northeast Brazil. In this region, French angelfish were seen cleaning four different species of cryptobenthic species, respectively, *Coryphopterus glaucofraenum*, *Scorpaena plumieri*, *Labrisomus cricota*, and *Scartella cristata*. These records show the broad spectra of clients that cleaners interact with in coral reef systems, as well as give important insights into the poorly known cryptobenthic fishes habits and ecology.

Keywords: Reef fish, Cleaner fish, Facultative cleaner, Tropical rocky shores, Brazil

Introduction

Cleaning symbiosis has been reported as one of the most important interspecific interactions in reef environments (Côté and Molloy 2003) and it contributes to increased reef fish diversity in such systems (Grutter et al. 2003). Cleaner species can either be obligatory or facultative. Obligatory cleaners feed exclusively on their clients, while facultative cleaners spend only part of their life cycle or time performing cleaning symbiosis (Losey 1972; Côtê 2000). As a consequence, these organisms have a great behavioural plasticity. Facultative cleaners can opportunistically exploit the body of their clients, exploring more resources (considering sporadic cleaners; more details in Coni et al. 2008), or avoiding competing for food with stronger adults (considering species that act as cleaners when juveniles; more details in Côté 2000; Baliga and Mehta 2014). Research has shown that cleaning behaviour is performed by approximately 130 fish (Floeter et al. 2007) and about 24 crustaceans (Arnal et al. 2005) species worldwide, the majority being facultative cleaners.

In Brazilian coastal waters, there is only one species known to act as an obligatory cleaner (the endemic barber goby *Elacatinus figaro* Sazima, Moura & Rosa 1997). On the other hand, in such environments there are a great number of species (and indeed still not extensively studied) performing facultative cleaning behaviours, as the French angelfish *Pomacanthus paru* (Bloch 1787) (Pomacanthidae). This species act as a cleaner only when juveniles, when they show a disruptive colouration marked by yellow bands on a predominantly black body. Adults assume a more discrete colour and become generalists in the consumption of sponges (Ferreira et al. 2004; Andréa et al. 2007). In the Abrolhos bank, the largest and richest coral reef complex in the South Atlantic Ocean (Leão et al. 2003; Moura and Sazima 2000), Sazima et al. (1999) reported that from 62 fish species identified surrounding cleaning stations (situated mainly in seagrass flats), 31 were cleaned by juvenile French angelfish. This fact highlights the significance of *P. paru* as an important cleaner in Brazilian coral reef fish communities. Most of the French angelfish clients cited by Sazima et al. (1999) were conspicuous, big and mobile fishes. Studies involving cryptobenthic reef fish as

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clients, however, are poorly documented. Cryptobenthic reef fish are generally small and have cryptic colourations and/or behaviour and habitats (Willis and Anderson 2003). They are widely distributed in shallow water of tropical marine shore-habitats worldwide (Williams and Tyler 2003). Despite their massive importance, few studies have been published considering cryptic reef fish communities along the Brazilian coast (Gerhardinger et al. 2004; Mendes 2006; Sampaio et al. 2008; Macieira and Joyeux 2011; Dalben and Floeter 2012), providing very scarce information on abundant and common species. As they live hidden in the benthos, understanding their ecology remains a challenge for scientists, especially when considering their interactions with other fish, such as cleaner species.

In this context, this study aims to report observations on the cleaning symbiosis between the cleaner French angelfish *P. paru*, and four species of cryptobenthic reef fish clients in northeast Brazil. The results will improve our knowledge regarding cleaning symbiosis in fish, particularly in the poorly studied Brazilian reef systems. Additionally, our work contributes to the understanding of the ecology of cryptobenthic reef fish and highlights the significance of juvenile *P. paru* as cleaners and a key species in maintaining ecosystem services in Brazilian reef environments.

Material and methods

Observations were performed during snorkelling and scuba dive sessions carried out at three different locations in the State of Bahia, northeast Brazil: the Barra rocky shores (see Nunes et al. 2013), the Pedra Cardinal reef, a coral reef located near Salvador in the Todos os Santos Bay (use Cruz et al. 2009 for details) and at tidepools in Villas do Atlântico (north coast of Salvador city) between August 2010 and February 2013. Cleaning symbiosis involving juveniles of *Pomacanthus paru* and cryptobenthic reef fish as clients were observed following the 'focal animal' methodology (according to Lehner 1979). All occurrences were recorded and photographs were taken using digital cameras. Number of cleaning events, client species, average fish sizes (for both cleaners and clients) and the depth in each station were also recorded.

Results

During the observations, four different species were recorded being cleaned by *P. paru* (Fig. 1): the bridled goby *Coryphopterus glaucofraenum* Gill, 1863 (Gobiidae), the spotted scorpionfish *Scorpaena plumieri* Bloch, 1789 (Scorpaenidae), the molly miller blenny *Scartella cristata* Linnaeus, 1758 (Blenniidae) and the mock blenny *Labrisomus cricota* Sazima, Gasparini & Moura, 2002 (Labrisomidae). Table 1 summarises the four cleaning interactions recorded between juveniles of *Pomacanthus paru* and cryptobenthic reef fish clients. In the cleaning interaction between *P. paru* and *C. glaucofraenum,* the bridled goby started moving its pectoral fins in an apparent sign of a willingness to be cleaned. Immediately after, the French angelfish swam to the lateral region of the client and started pecking it (Fig. 1). *P. paru* and *S. plumieri* interacted for 2 min in a coral reef located in the inner Todos os Santos Bay, with *P. paru* feeding on only one region of the client's body. The cleaning of *P. paru* on *L. cricota* occurred in the rocky shores of Farol da Barra (coast of Salvador), for one min during which the cleaner foraged both on the dorsal fin and on the flank of the client, with the client remaining static during the cleaning period in an apparent sign of cooperation. Finally, the interaction between a *P. paru* and one adult *S. cristata* was also observed at a hard bottom habitat in the Barra rocky shores. As observed before, the client stayed in a stereotyped position, keeping a motionless headstand pose, while the cleaner foraged over both of its dorsal fin and flanks during the cleaning event (Table 1; Fig. 1).

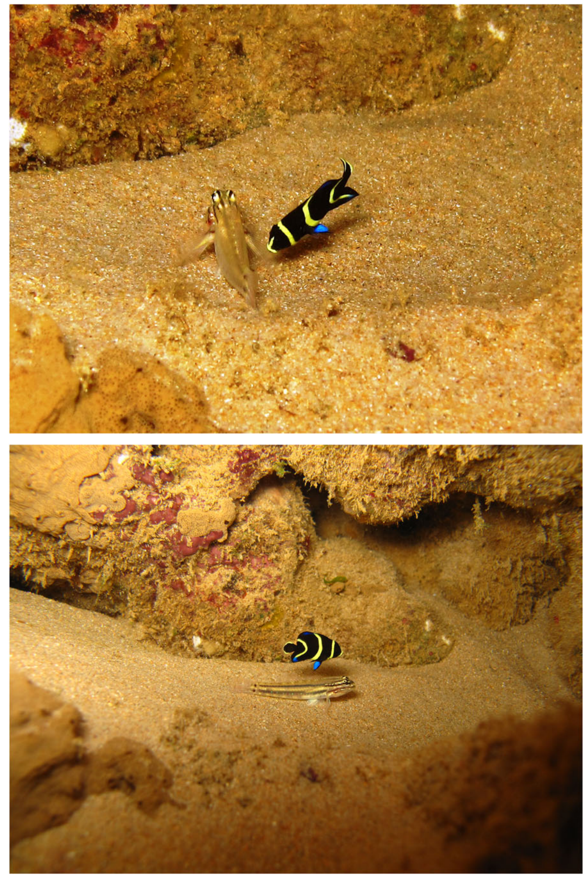

Fig. 1 *Pomacnthus paru* (~4 cm in total length - TL) inspecting the lateral region of *C. glaucofraenum* (~7 cm TL)

Table 1 Cleaning interactions observed between juveniles of *P. paru* (cleaners; approximately 4 cm in length) and four species of cryptobenthic reef fish (clients). Also shown are the length of clients, their life stages and characteristics of reef station (local, kind of habitat, main substrata of cleaning stations and average depth) and duration of each interaction

Client species	Client total length (cm)	Client life stage	Reef station	Reef habitat	Substrate type	Depth (m)	Duration (min)
C. glaucofraenun	6	adult	Villas do Atlântico	rocky pools	interface of reef and sand bottom	0.5 – 1.0	1
S. plumieri	25	adult	Pedra Cardinal reef	coral reef	corals	8.0	2
L. cricota	5	juvenile	Farol da Barra	rocky shore	rocky surface	1.5	1
S. cristata	6	adult	Farol da Barra	rocky shore	rocky surface	1.5	1.2

Discussion

This study provides new information regarding the ecology of juvenile French angelfish in Brazilian reef systems. French angelfish in this area were reported having cryptobenthic reef fishes as clients, including the smallest client ever recorded being cleaned by a *P. paru*. Juveniles of this species are known to also use a wide range of other reef fish species as clients. However, to the best of our knowledge Gobiidae and Bleniidae species were not recorded as clients of *P. paru* (Sazima et al. 1999). Up to date, there was only one cryptobenthic fish reported as being a client of the French angelfish, the hairy blenny *Labrisomus nuchipinnis* (Quoy & Gaimard, 1824) (Labrisomidae). They were observed interacting by Sazima et al. (1999) when studying the cleaning role of *P. paru* in the Abrolhos reef. Recently, Bernal et al. (2015) observed a high incidence of ectoparasites in reef fish in the Caribbean, but no records for cryptobenthic fish (Gobiidae and Scorpaenidae) were found in the literature. In Australia, Grutter (1998) showed that the incidence of monogenean parasites in fish differs between habitats, possibly due to differences in transmission rates, such as the tidepools and rocky reefs considered in this study. The low mobility of cryptobenthic fish, associated with the tidepools and rocky reefs characteristics (i.e., reduced area, isolation during low tide, and low complexity) could in fact contribute to the incidence of some parasites. The cleaning symbioses, however, are still unknown in these environments, especially considering these small, abundant and important reef fishes.

The four species recorded here represents therefore novel information that highlights the importance of the French angelfish in possibly maintaining the fitness (since they clean several species) of reef fish communities in Brazilian reef ecosystems. This is particularly relevant for ectoparasites with direct transmission, where the predator's reduction or absence can lead to a higher population of infected fish that would contaminate the healthy ones. Bernal et al. (2015) reported that many surgeonfish with high incidence of parasites in Curacao (Caribbean) had their mobile abilities damaged, even mentioning that in some cases, these individuals would move so slowly that it seemed like the researchers could capture them manually.

The low number of existing records involving cleaning of cryptobenthic fish could be related to four possible explanations: (1) their small size, cryptic colouration and habitats could hamper the observation of possible cleaning interactions when these were happening (despite the common disruptive colouration of the cleaners); (2) the interaction might happen in hidden or camouflaged places, where cryptobenthic species live, eventually visited by facultative cleaners that do not always have fixed territories as cleaning stations; (3) the low mobility of these species makes the access to a cleaner even harder, and so they might consider using other strategies to remove ectoparasites or other unwanted body parts; (4) considering the third explanation, we ask whether: cryptic invertebrates (generally shrimps or crabs) could be main cleaners of cryptobenthic reef fish. In fact, Sampaio et al. (2008) and Medeiros et al. (2011) reported the opportunistic observed cleaning behaviour of grapsidae crabs, which were cleaning two cryptobenthic reef fish [*L. nuchipinnis* and the green moray *Gymnothorax funebris* Ranzani, 1839 (Muraenidae].

In conclusion, further studies should be conducted in order to assess the role of the cleaning symbiosis in the fitness of cryptobenthic reef fish. More observations would be valuable in describing which cryptobenthic reef fish species use cleaners, and how those species that do not use cleaners solve the problem of removing parasites.

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Authors' contributions
CLSS Conception of manuscript, writing and revision; ML write and revision; LPC write and revision; DVM got subaquatic image and has made a manuscript revision; JPQ write and revision; RJM write and revision; JAR wrote and made revisions of all replies made by reviewers; JACCN write and revision. All authors read and approved the final manuscript.

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The authors declare that they have no competing interests.

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