

Cleaning interactions of fishes at São Tomé Island, West Africa

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Abstract: This study reports six new types of cleaning interactions among tropical reef fish species at São Tomé Island, and confirms previously reported interactions for this area. *Spicara melanurus* was recorded as a cleaner for the first time, and *Abudefduf saxatilis* was confirmed in this role, following reports from the Southwest Atlantic. Individuals belonging to the family Labridae were the most commonly-observed cleaners, involved in over 85% of recorded interactions. Juveniles of *Bodianus speciosus* played a key role as cleaners, interacting with at least seven client species. In addition, some of the client fishes, including *Paranthias furcifer* and *Acanthurus monroviae*, interacted with at least four cleaner fish species. All cleaner fish species reported in this study were facultative; obligate cleaners appear to be absent from this region.

Résumé : Interactions de nettoyage de poissons de l'île Sao Tomé, Afrique de l'Ouest. Cette étude présente six nouveaux types d'interactions de nettoyage entre plusieurs espèces de poissons de récif tropicales de l'île de São Tomé, et confirme quelques observations précédemment rapportées pour cette région. *Spicara melanurus* a été observé comme nettoyeur pour la première fois et *Abudefduf saxatilis* a été confirmé dans ce rôle, d'après des études menées dans le Sud-ouest de l'Atlantique. Des individus appartenant à la famille Labridae ont été les plus observés en tant que nettoyeurs, impliquée dans plus de 85% des interactions enregistrées. Les juvéniles de *Bodianus speciosus* ont un rôle primordial en tant que nettoyeurs, ils ont été observés en interaction avec au moins sept espèces. En outre, certains poissons clients, comme *Paranthias furcifer* et *Acanthurus monroviae*, ont interagi avec au moins quatre espèces de nettoyeurs. Toutes les espèces de poissons nettoyeurs décrites dans cette étude étaient facultatives; les poissons nettoyeurs obligatoires semblent être absents de cette région.

Keywords: Mutualism • Cleaning behavior • Fish • Tropical Eastern Atlantic • Gulf of Guinea • Facultative cleaner

Introduction

Cleaning symbioses are widespread among marine animals, and are among the most intriguing of all interspecific interactions (Coté, 2000). In cleaner fish symbiotic interactions, there are two classes of partners: the cleaner fish and their clients, each of which supplies a service or good required by the other (ectoparasite removal and a meal, respectively) (Soares et al., 2008). Among cleaner fish, Coté (2000) states that the majority are facultative, relying only in small part on cleaning as a source of food, where cleaning is performed mainly by juveniles, but in some cases, adults may also partake in cleaning activity. On the other hand, obligate cleaners, which depend on cleaning to gain virtually all of their food, are the minority.

In any case, the reduction of ectoparasite load on fish by cleaners can be crucial to client fish survival because the parasites may cause disease (Cusack & Cone, 1986) reduce growth (Kabata, 1970; Pulkkinen & Valtonen, 1999) affect survival either directly through their pathological effects (Rohde, 1984) or indirectly through increased predation on weakened hosts (Lafferty & Morris, 1996) and decrease mating and reproductive success (Møller et al., 1999) in client fishes.

Cleaner fish interactions are well-studied in many places in the Indo-Pacific (e.g. Grutter & Poulin, 1998; Coté, 2000), Caribbean (e.g. Arnal et al., 2000; Coté, 2000), Mediterranean (e.g. Van Tassell et al., 1994; Zander & Sötje, 2002) and south-western Atlantic (e.g. Francini-Filho et al., 2000; Sazima & Sazima, 2001), but relatively understudied in the Tropical Eastern Atlantic, particularly the Gulf of Guinea.

Since the work of the Portuguese scientist Osório, late in the 19th century, very few papers have addressed coastal ichthyofaunal diversity in the São Tomé and Príncipe (STP) Islands (e.g. Afonso et al., 1999; Wirtz et al., 2007), which comprise an archipelago in the Gulf of Guinea, West Africa. In addition, only sparse notes on cleaning associations (e.g. Wirtz, 1997; Debelius, 1997) were reported for this area, until a dedicated study on the diversity of reef fish clients and cleaners of STP was published (Quimbayo et al., 2012).

In the present paper, we describe previously-unreported cleaner fish associations, and confirm reported ones for this region.

Material and Methods

Field work was carried out at São Tomé Island (0°20'11"N-6°43'38"E), in the Gulf of Guinea (Fig. 1), during November 2015, while the authors were documenting reef ichthyofaunal diversity and using underwater photography to illustrate the first reef fish guide of STP.

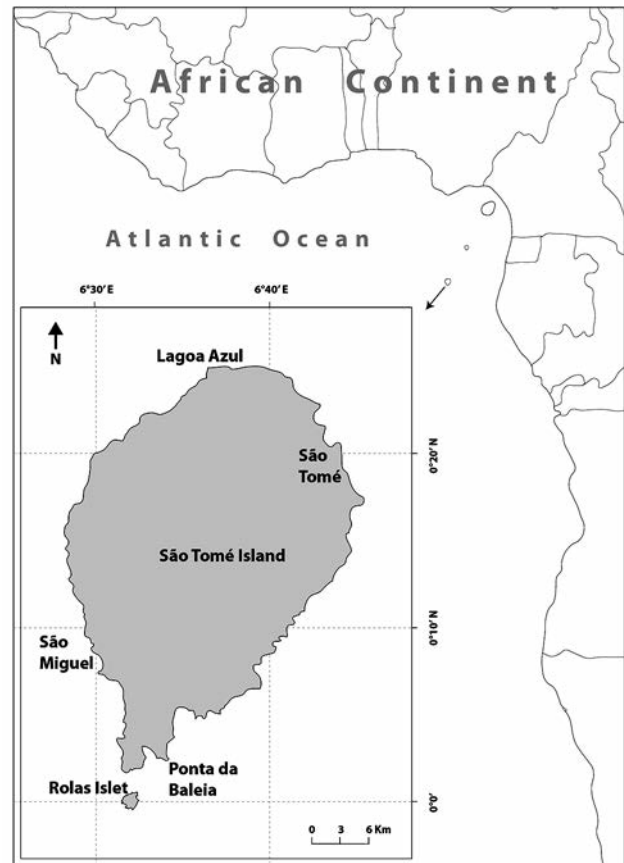


Figure 1. Geographic location of São Tomé Island.

Observations were made through SCUBA diving using air, with up to three dives per day, mostly during day times (total of 21 dives), between 09:00 and 17:00 h, plus two night dives (N = 23 dives total). NVR and AAB performed all 23 dives, and JF performed 18. Observations ranged between 1 and 46.6 m depth, totaling 61.6 hours (53.1 hours on Rolas Islet and 8.5 hours on São Tomé Island), with an average dive duration of 57' ($\pm 4.4'$ Standard Error), and a mean depth of 25.0 m (± 2.25 m S.E.). All cleaning interactions were documented using underwater photography, and relevant notes were recorded on waterproof slates. Surveys covered most representative habitats for the area, including sandy bottoms, rubble, rhodolith beds, boulders, caves and rocky reefs.

Benthic cover varied considerably among sites and depths, but hard substrate was generally covered by a combination of macroalgae, crustose coralline algae, sponges, soft corals (gorgonians from mid to deeper areas) and hard corals.

Results

Of the eight cleaner fish species observed, half belonged to

the family Labridae; these four cleaner fish species interacted with 86% of the clients observed (Table 1). The Blackbar hogfish, *Bodianus speciosus* (Bowdich, 1825) interacted with seven client species, followed by Dodongo *Coris atlantica* Günther, 1862, Newton's wrasse *Thalassoma newtoni* (Osório, 1891) and the Spotfin hogfish, *Bodianus pulchellus* (Poey, 1860) with three client fish species each. On the other hand, the Monrovia doctorfish, *Acanthurus monroviae* Steindachner, 1876 and the Creole-fish, *Paranthias furcifer* (Valenciennes, 1828) were the most represented client fish species, interacting with four associated cleaner fish species each: the Night sergeant *Abudefduf taurus* (Müller & Troschel, 1848), *B. speciosus*, *C. atlantica* and *T. newtoni* for the Monrovia doctorfish and the three banded Butterflyfish, *Chaetodon robustus* Günther, 1860, *B. pulchellus*, *B. speciosus* and *C. atlantica* for the Creole-fish.

During our observations, we documented a previously-unreported interaction between juveniles of *C. atlantica*, a common and abundant wrasse in STP, and the West-african parrotfish *Sparisoma choati* (Rocha et al., 2012). The *C.*

atlantica juveniles were observed near the bottom cleaning an adult *S. choati*, which remained motionless on its side, lying on the sand (Fig. 2A).

Interactions between cleaner fish *T. newtoni*, and client fish comprising the Brown chromis *Chromis multilineata* (Guichenot, 1853) (Fig. 2B) and Blackspot picarel, *Spicara melanurus* (Valenciennes, 1830) (Fig. 2C) were also recorded for the first time, although this cleaner fish species had already been reported cleaning *A. monroviae* by Quimbayo et al. (2012).

The two cleaning stations of *T. newtoni* observed were 2m apart from each other on top of a reef at 7m depth. Each small group of *S. melanurus* and *C. multilineata* attending their stations hovered around the reef and returned to the station every 60 seconds approximately, for a duration of about 15 minutes.

The Blackbar hogfish *B. speciosus* was observed to behave as a cleaner fish interacting with seven different client species (more than 50% of the reported client species), including *P. furcifer* (Fig. 2D) which had previously been reported as a common client (Quimbayo et

Table 1. Fishes observed as cleaners and clients at São Tomé and Príncipe Islands. Families are listed according to Nelson (2016), and species are ordered alphabetically.

Cleaner	Client	Reference
SPARIDAE		
<i>Spicara melanurus</i> *	<i>Tylosurus</i> sp.	Present paper (Fig. 2F)
CHAETODONTIDAE		
<i>Chaetodon robustus</i>	<i>Mulloidichthys martinicus</i>	Quimbayo et al., 2012
	<i>Paranthias furcifer</i>	Quimbayo et al., 2012
POMACENTRIDAE		
<i>Abudefduf saxatilis</i>	<i>Tylosurus</i> sp.	Present paper
<i>Abudefduf taurus</i>	<i>Acanthurus monroviae</i>	Wirtz et al., 2007; Quimbayo et al., 2012
LABRIDAE		
<i>Bodianus pulchellus</i>	<i>Clepticus africanus</i>	Afonso et al., 1999; Quimbayo et al., 2012
	<i>Myripristis jacobus</i>	Quimbayo et al., 2012
	<i>Paranthias furcifer</i>	Quimbayo et al., 2012
<i>Bodianus speciosus</i>	<i>Acanthostracion notacanthus</i>	Quimbayo et al., 2012
	<i>Acanthurus monroviae</i>	Afonso et al., 1999
	<i>Apsilus fuscus</i>	Afonso et al., 1999
	<i>Chaetodon robustus</i>	Afonso et al., 1999
	<i>Lutjanus goereensis</i>	Debelius, 1997
	<i>Paranthias furcifer</i>	Quimbayo et al., 2012; Present paper (Fig. 2D)
	<i>Scarus hoefleri</i>	Present paper (Fig. 2E)
<i>Coris atlantica</i>	<i>Acanthurus monroviae</i>	Quimbayo et al., 2012
	<i>Paranthias furcifer</i>	Quimbayo et al., 2012
	<i>Sparisoma choati</i>	Present paper (Fig. 2A)
<i>Thalassoma newtoni</i>	<i>Acanthurus monroviae</i>	Quimbayo et al., 2012
	<i>Chromis multilineata</i>	Present paper (Fig. 2B)
	<i>Spicara melanurus</i>	Present paper (Fig. 2C)

*new record of facultative cleaner.



Figure 2. Cleaning interactions at São Tomé. **A.** *C. atlantica* cleaning *S. choati*. **B.** *T. newtoni* cleaning *C. multilineata*. **C.** *T. newtoni* cleaning *S. melanurus*. **D.** *B. speciosus* cleaning *P. furcifer*. **E.** *B. speciosus* cleaning *S. hoefleri*. **F.** *S. melanurus* cleaning *Tylosurus* sp. (Photos: NVR & AAB).

al. 2012), and the Guinean parrotfish *Scarus hoefleri* (Steindachner, 1881), also a previously unreported interaction that we observed at 20 m depth (Fig. 2E).

Individuals of *B. speciosus* also have been reported previously as cleaning six other client fish species in the Cape Verde Islands that occur also at São Tomé: the African hind, *Cephalopholis taeniops* (Valenciennes, 1828), *B. speciosus* (i.e. conspecific cleaning), the west African

goatfish *Pseudupeneus prayensis* (Cuvier, 1829), the Yellow goatfish, *Mulloidichthys martinicus* (Cuvier, 1829), *C. multilineata* and the Longspined porcupinefish *Diodon holocanthus* Linnaeus, 1758, besides others that do not occur in this region (see Quimbayo et al., 2012).

Only one multi-species interaction was observed in this study, in a shallow water lagoon at Rolas Islet. The interaction involved both juveniles of the Sergeant-major

A. saxatilis (Linnaeus, 1758) and *S. melanurus* both simultaneously cleaning adult individuals of the Needlefish *Tylosurus* sp. Our observations of this cleaning behavior constitute the first report for both of these cleaner fish species with members of this client fish genus.

All of the cleaning interactions reported here were observed at Rolas Islet, except for the observation of *B. speciosus* cleaning *S. hoefleri*, which was made at Lagoa Azul, São Tomé Island (Fig.1).

Discussion

Our study highlights the important ecological role that wrasses (Labridae) play in this region, because half the known cleaner fishes in the region belong to this family, and they interact with most of the client fishes reported. All of the interactions reported here involved only facultative cleaners, confirming the study of Quimbayo et al. (2012), which documented that no specialized (obligate) cleaners have been reported for the region to date. The apparent absence of obligate cleaners is probably explained by their lineages (i.e. *Elacatinus* spp. and *Labroides* spp.) being restricted to more species-rich coral reef regions (Quimbayo et al., 2012). One other possibility is that the cleaning services provided by a larger number of facultative species is enough to ensure a balanced parasite load on the ecosystem (yet, to be evaluated), thus preventing/postponing the evolutionary process of development of obligate cleaners, either from other areas or endemic ones.

As expected for facultative cleaners, only juvenile phases were observed here engaging in cleaning behavior (Coté, 2000; Narvaez et al., 2015).

The observed *C. atlantica* and *T. newtoni* showed similar behavior to their temperate relatives: the Mediterranean rainbow wrasse, *Coris julis* (Linnaeus, 1758) and the Ornate wrasse, *Thalassoma pavo* (Linnaeus, 1758), respectively, which are also facultative cleaners of a wide range of client fish species (Van Tassel et al., 1994; Bertoncini et al., 2009; Narvaez et al., 2015; Vasco-Rodrigues & Cabrera, 2015).

This study presents six previously-unreported cleaning interactions, and the first record of cleaning activity for *A. saxatilis* in the eastern Atlantic – although it was previously reported as cleaner in the western Atlantic (Sazima, 1986; Whiteman et al., 2002). Yet, *S. melanurus* is reported as a cleaner species for the first time (Fig. 2F).

The apparent absence of obligated cleaner species in the region underscores the importance of facultative cleaners, once they seem to be the only cleaning mechanism for ectoparasite control on reef fishes, thus playing a key ecosystem role and potentially providing some measure of reef health. Moreover, overexploitation of these cleaner species and juveniles in particular, may produce cascading detrimental

effects on the reefs' balance and health. Despite the contribution presented herein, additional work is necessary to better understand the role played by cleaning mutualistic relations in such an understudied region.

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