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A test of herbivory-mediated coral–algae interaction on a Brazilian reef during a bleaching event

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ABSTRACT

Many ecosystem services and functions provided by coral reefs have been compromised worldwide because of its conservation status. Despite such evidence, no published studies address herbivory-mediated competitive interactions between corals and algae in Brazilian reefs. The reciprocal effects of the interaction between the endemic massive coral *Siderastrea stellata* and filamentous algae in the presence and absence of herbivory typically found in coastal reefs of Brazil were tested during a bleaching event. To manipulate herbivory, five coral colonies were caged, five left uncaged, and partial cages were placed around five more colonies to test for a cage artifact. In order to assess the competitive interaction, three treatments were applied within each herbivory plot. Coral–algae contact zones either had algae removed, coral tissue removed or both left untouched. During the five month experiment, all 15 colonies bleached because of natural causes and coral tissue did not grow in any of the replicates. Coral mortality was not significantly affected by any experimental factor. On the other hand, algal growth was negatively affected by herbivorous fishes, mainly parrot fishes and damselfishes, but direct contact with *S. stellata* tissue did not have any effect on filamentous algae. Considering that *S. stellata* is one of the most common corals in tide pools and reef tops in Brazil, it is very likely that the bleaching event weakened coral polyps and filamentous algae became the major competitor. In conclusion, the coral *S. stellata* did not offer any resistance to algae overgrowth that was only controlled by herbivory. In case bleaching events alter coral–algae competitive interaction outcomes, herbivory provides a window of opportunity for corals to recover after the disturbance.

1. Introduction

Coral reefs are one of the marine ecosystems most affected by anthropogenic threats worldwide (Halpern et al., 2008). Phase shifts (*sensu* Done, 1992) have been reported since the 1980s (Bellwood et al., 2004; Hughes, 1994; Jackson et al., 2001; McManus and Polsenberg, 2004; Schutte et al., 2010), particularly after mass bleaching events (Diaz-Pulido et al., 2009). Shifts are characterized by passage from a stage of coral dominance to alternative stages of coral depletion and increased cover of algae (Done, 1992) and additional non-reef building organisms (Norström et al., 2009). Algal dominance is mediated by competition for space and light and inhibition through direct or indirect contact (Jompa and McCook, 2003a; McCook et al., 2001; River and Edmunds, 2001; Titlyanov and Titlyanova, 2008).

The relationship between non-endosymbiotic algae and corals is reciprocally negative. Competitive mechanisms include overgrowth, shading, allelopathy, formation of recruitment barriers, and defense against epibiotic colonization termed epithelial sloughing (McCook et al., 2001). In addition, algal canopy modifies hydrodynamics, which increases sediment deposition over corals and reduces nutrient availability (Sebens and Johnson, 1991). Diffusable components produced by algae also support microbial activity, which causes some coral diseases (Smith et al., 2006). Competitive mechanisms depend on the algal functional group; for instance, filamentous algae usually overgrow or affect corals through allelopathy. Corals also have a unique competitive strategy, using cnidocytes on their tentacles to sting algae (River and Edmunds, 2001). Therefore impacts to coral physiological function, like those that occur during bleaching events, can contribute to algal overgrowth (Brown, 1997; Glynn, 1993).

Many studies were designed to detect standards and changes in reef community structure (Goreau, 1992; Hughes, 1994; Liddell and Ohlhorst, 1986; Rogers et al., 1997), not to test for competitive interactions or demonstrate causality. Without experimental evidence, algae

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growing in dead portions of coral colonies cannot be attributed to competition, because non-related factors, such as bleaching or corallivory, may cause coral mortality before algal occupation (McCook, 2001; McCook et al., 2001). Most experiments manipulating competitors or herbivores (Hughes et al., 2007; Jompa and McCook, 2002, 2003a; Lirman, 2001; River and Edmunds, 2001; Titlyanov et al., 2007) were conducted during non-stressful conditions. Comparatively few report algal–coral interactions before and during stressful events, such as coral bleaching.

Herbivorous fishes and echinoids are critical functional groups (CFGs) for maintaining coral reefs (Bellwood et al., 2004; Done et al., 1996) because they control algal growth. Reduced fishery stocks have caused alarm in several regions (Bellwood et al., 2004; Hughes, 1994) because algal growth increased after fish and echinoid populations declined. The function of CFGs also is threatened when they are under-represented in regions that naturally are taxonomically depauperate. Limited functionality implies reduced ecosystem resilience after intensive natural disturbances or anthropic impacts because few CFG species are available to replace losses and maintain key ecological processes (Bellwood et al., 2004).

Brazil is within a well-defined zoogeographical province for reef fishes and corals, which is characterized by small reef area, low species richness and endemism levels ranging from 12 and 20% for fishes and 30% for corals (Floeter and Gasparini, 2000; Leão et al., 2003; Moura and Sazima, 2002; Neves et al., 2006). According to a report published by the Brazilian Ministry of Environment in 2008, most marine fisheries in Brazil are overfished, a common condition faced by countries that economically exploit such resources (MMA, 2006). The low coral coverage of Brazilian reefs (Laborel, 1969) was further reduced because of anthropogenic impacts and global changes (Ferreira et al., 2006; Leão and Kikuchi, 2005). Cruz et al. (2014) recently reported on loss of coral cover and dominance of a zoanthid species for over nine years.

Despite such evidence, no published studies address herbivory-mediated competitive interactions between corals and algae in Brazilian reefs. The objective of the present study was to test the reciprocal effects of interactions between the endemic massive coral *Siderastrea stellata* and filamentous algae, in the presence and absence of herbivory typically found in coastal reefs of Brazil during a bleaching event. Although algae were the dominant organism followed by corals, the selected mechanisms involved on phase shifts still could be tested and the results applied to other regions having greater coral cover.

2. Material and method

2.1. Study area

The Caramuanas Reef Bank is located in the Southern coast of Itaparica Island, State of Bahia, Brazil (Fig. 1). This reef complex is within the state-designated Todos os Santos Bay Area of Environmental Protection (APA BTS) (Bahia state decree 7.595/99 dated June 5th, 1999), and the municipally-designated Pinaúnas Reef Area of Environmental Protection (APA) (Vera Cruz municipal law 467/97 dated October 20th, 1997). However, the management plan is still being developed. The closest beach, Aratuba, is 4 km distant, which makes it difficult for tourists and divers to access this reef but they are visited more frequently by fishermen. The experiment was implemented at a site 3 m deep (13° 8.011′ S and 38° 44.188′ W).

2.2. Study species

The massive coral *S. stellata* is endemic to Brazil. It is one of the most common corals in tide pools and reef tops and is considered resistant to variation in temperature, salinity and turbidity (Leão et al., 2003; Santos et al., 2004). Skeletal growth of this species in the region varies between 2 and 3 mm (Reis and Leão, 2000). Neves (2004) revised the diagnostic features of the genus *Siderastrea*, and proposed a sympatric occurrence of *S. radians* and *S. stellata* in the Brazilian Northeastern coast. These two taxa were considered as synonymies during a certain time period, mainly because it is impossible to distinguish the difference between them in the field, but recent study of skeletal morphology and molecular aspects demonstrated a divergence between them (Neves, 2004; Neves et al., 2008).

Cruz et al. (2009) recorded 8% average coverage for *Siderastrea* spp. and 14% for filamentous algae in the Caramuanas Reef Bank. Direct contacts were confirmed between these organisms through the presence of filamentous algae in recently dead portions of *Siderastrea* colonies, which formed frontiers of contact with live coral. Recently dead is defined by the Atlantic and Gulf Rapid Reef Assessment (AGRRA) as any non-living parts of the coral in which the corallite structures are still intact and covered over by a thin layer of filamentous algae where coral tissue regeneration can still occur (Kramer and Lang, 2003). Filamentous algae growing on coral skeletons is the dominant substrate

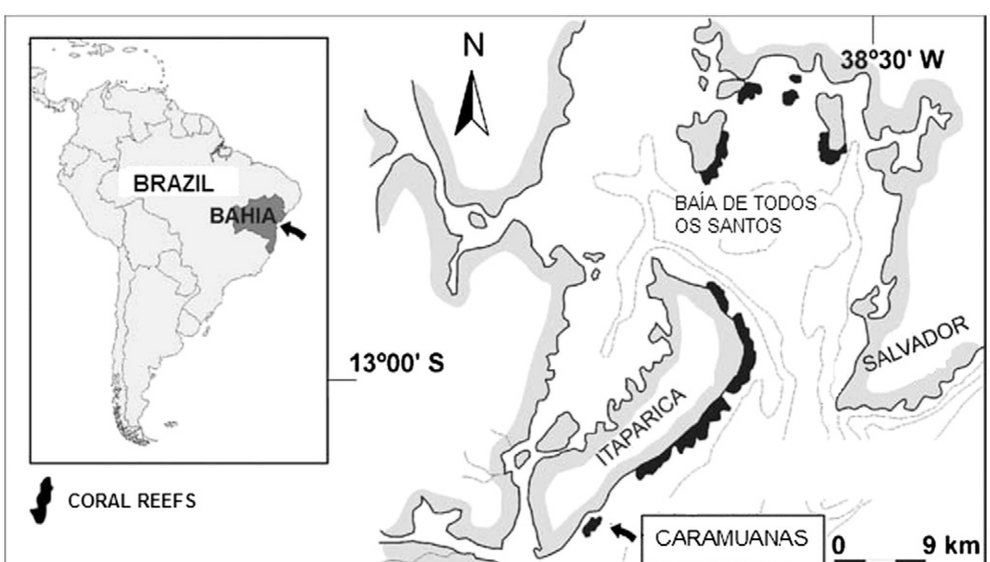

Fig. 1. Study area — Caramuanas Reef Bank (13° 8.011′ S and 38° 44.188′ W), Bahia. Adapted from Ramos et al. (2010).