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Commentary

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Are Some Photosymbiotic Bioeroding Sponges More Bleaching-Tolerant than Hard Corals?

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Abstract

Some bioeroding sponges of the *Cliona viridis* species complex are aggressive space competitors on coral reefs, which can often kill hard corals. Like hard corals, *C. viridis* complex spp. are symbiotic with the dinoflagellates *Symbiodinium* spp., which provide vital energy for the hosts' survival. In this study, *C. viridis* complex spp. and hard corals were observed on a Caribbean reef over a year. Many hard corals were found bleached (tissue whitening due to the loss of *Symbiodinium* spp.) at elevated temperatures. However, *C. viridis* complex spp. appeared to be unaffected and remained dark brown at all times, indicating abundant *Symbiodinium* within the sponges. Our observations suggest a higher tolerance of some *C. viridis* complex spp. to bleaching compared to hard corals. This finding also implies a competitive advantage of these bioeroding sponges over hard corals during increasingly frequent and severe mass bleaching events under climate change, potentially leading to net reef erosion.

Keywords

Cliona; Bioerosion; Caribbean; Reefs; *Symbiodinium*; Zooxanthellae; Temperature; Acidification

Hard corals live in symbiosis with dinoflagellates of the genus *Symbiodinium*, microbial partners which provide vital energy for the hosts' survival and calcification performance [1]. Failure of this symbiosis can be lethal to the hosts and is commonly referred to as bleaching, a phenomenon of tissue whitening due to the damage or loss of *Symbiodinium* spp. [2,3]. Mass bleaching events and subsequent large-scale mortality of hard corals have been observed in various habitats under climate change, and rising temperature has been identified as one of the main threats [4,5]. Another significant but often ignored putative threat to future coral reefs is accelerating bioerosion, i.e. enhanced erosion of reef carbonate frameworks by biological activities [6]. Among many bioeroding organisms, sponges of the *Cliona viridis* species complex represent aggressive excavators and space competitors on coral reefs that can often kill hard corals [7].Like hard corals, *C. viridis* complex spp. are also symbiotic with *Symbiodinium* spp., but some of these sponges may be more tolerant to bleaching. This may partly be due to the sponges' ability to relocate symbionts within their three-dimensional tissue structures, and partly to the traits of their symbionts [8-11]. This tolerance to bleaching can be a critical factor to determine the competitive strength of *C. viridis* complex spp. against hard corals under climate change.

Here we report observations on *C. viridis* complex spp. and hard corals around Little Cayman in the central Caribbean during the third global coral bleaching event [5,12]. Judging from their surface colour, up to 30% of hard coral colonies were partially or completely bleached in November 2015 (30–31°C, average daily seawater temperature; e.g. Figure 1). The extent of coral bleaching was much reduced by May/June 2016 (27–28°C), but partial bleaching was again evident on up to 15% of hard coral colonies, principally below 15 m depth, in November/December 2016 (28-29°C) following warmer seawater temperatures in July/August 2016 (30–32°C). In contrast, observed *C. viridis* complex spp. remained dark brown at all times, which was indicative of abundant *Symbiodinium* within the sponges (e.g. Figure 1). These field observations are in line with the hypothesis that some *C. viridis* complex spp. are more bleaching-tolerant than hard corals during thermal events [8-9,13]. In this regard, natural bleaching of *C. viridis* complex spp. appears to be rare and to date has only been observed on *Cliona varians* in the Florida Keys [14]. However, personal communication of authors confirmed that bleached *C. varians* had 'mostly recovered' three months later. In an earlier field experiment, *C. varians* had also bleached when transplanted from 20 m to 1 m depth (possibly due to light stress), but the sponge regained high densities of *Symbiodinium* within three months [15, *C. varians* as *Anthosigmella varians*]. The ability of *C. viridis* complex spp. to effectively prevent or recover from bleaching suggests a great resilience of their association with *Symbiodinium*. However, this relationship can fail as well under extreme conditions [16-18, for *Cliona orientalis*].

Overall, our field observations suggest a more robust symbiosis with *Symbiodinium* in some *C. viridis* complex spp. compared to that in hard corals, a conclusion which is however dependent on the combination of species/clades between *Symbiodinium* and the hosts. This also implies at least a temporary competitive advantage of some *C. viridis* complex spp. over hard corals during mass bleaching events, which will likely become more frequent and severe under future climate change [3-5,19]. Further development may lead to selective survival of the more resilient *C. viridis* complex spp., as previously observed at various sites in the Caribbean and on the Great Barrier Reef after major coral bleaching events [20-21]. The success of *C. viridis* complex spp. can be due to enhanced sponge physiology under moderately changed future conditions, along with improved settlement in environments with bleached/dead corals compared to those with unbleached/living corals [6-7,22-25]. Both of these pathways will accelerate reef bioerosion, which may eventually outweigh calcification and shift some coral reefs into net erosional states.

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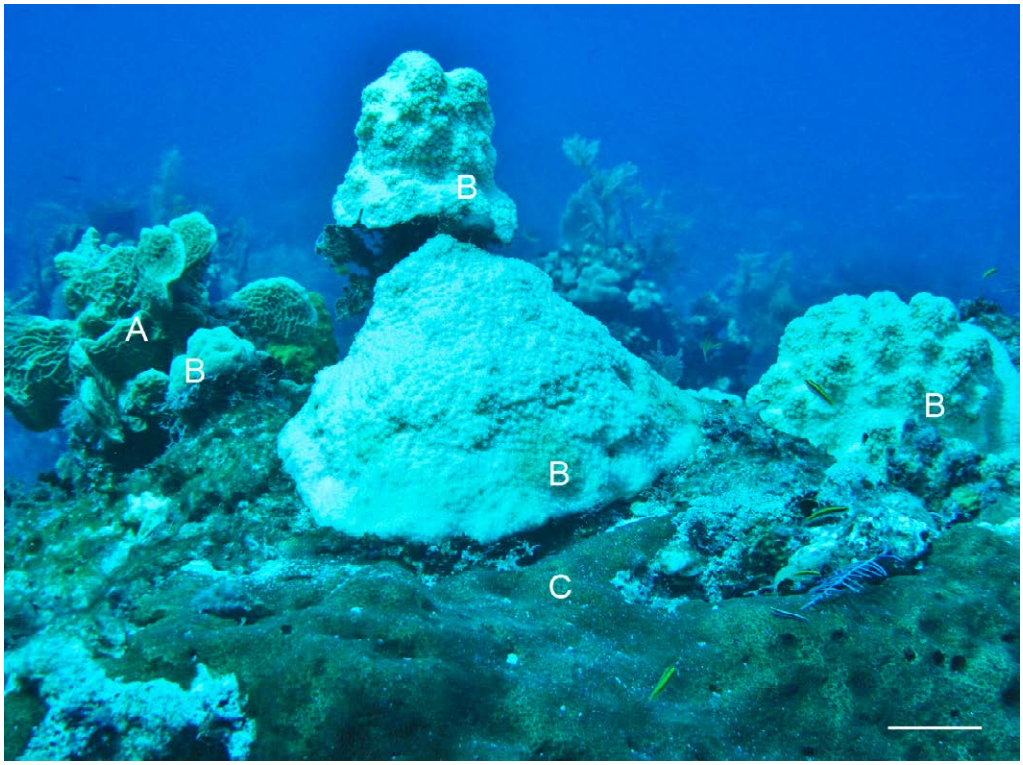

Figure 1: A coral reef community containing partially bleached corals, **(A)** *Agaricia agaricites* and **(B)** *Orbicella faveolata*, and **(C)** an adjacent unbleached bioeroding sponge of the *Cliona viridis* species complex at 15 m depth on the Little Cayman Wall in Crawl Bay, northwest of Little Cayman on the 8th of November 2015. The scale bar indicates approximately 10 cm.

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