Mighty *Diadema*: Here it comes to save the day! The effects of *Diadema antillarum* recovery on coral populations

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Abstract: The urchin *Diadema antillarum* has been shown to have important effects on coral community survival and growth, both by limiting macroalgal growth, and by coral predation and damage. After *D. antillarum* suffered a mass mortality in 1983, allowing macroalgae to dominate the reef, a population recovery began in 1996. We investigated the effects of this recovery on young coral between 4 – 7 m deep at Discovery Bay, Jamaica. We sampled coral in an area with high *D. antillarum* density and a neighboring area dominated by macro-algae. There was significantly more coral in the "urchin zone" than in the "algal zone," and the community composition was significantly different between the two. Although *D. antillarum* seems to be beneficial to corals at its present density, we expect that it may begin to negatively affect coral growth and survival at these depths as its density continues to approach levels comparable to those prior to 1983.

Key Words: algal zone, coral growth, SCUBA, spat, urchin zone

Introduction

Experimental studies in Discovery Bay have shown that grazing by *Diadema antillarum* influences the structure of the benthic community (Sammarco 1982a, 1982b). A decrease in competition for substrate due to algal grazing by *D. antillarum* can contribute to coral growth and survival (Sammarco 1982a, Hughes 1989). However, while grazing, *D. antillarum* may rasp coral surfaces and directly prey upon coral, decreasing newly settled corals (Sammarco 1982a). Certain densities of *D. antillarum* may therefore create optimal conditions for settlement and survival of coral spats and colony growth (Sammarco 1980). Furthermore these studies have demonstrated that both the negative effects of *D. antillarum* on coral and the susceptibility of coral to algal smothering are genera-specific (Sammarco 1982a, Hughes 1989).

This study looks at the effects of *D. antillarum* on the community structure of coral. After a mass mortality of *D. antillarum* in 1983, its density remained very low until recovery began in 1996 (Aronson and Precht 2000). Assuming a maximum growth rate for coral of 10 mm per year (Huston 1985), and because *D. antillarum* presumably had little effect until 1996, we restricted our sampling to corals with a maximum dimension of 40 mm, thereby focusing on the effect of *D. antillarum*'s recovery on recruitment and juvenile corals. From initial observations, *D. antillarum* grazing activities on the fore reef of Discovery Bay appeared to be mostly limited to patches (the "urchin zones"). We hypothesized that the resurgence of *D. antillarum* has affected the growth and survival of corals in these zones. We predicted that the size distribution and abundance of corals would differ between the urchin zone and the area outside of the urchin zone (the "algal zone"). Additionally, we hypothesized that the re-establishment of urchins would affect coral community composition because of genera-specific variation in coral susceptibility to *D. antillarum* grazing and algal competition. We predicted that diversity and evenness would differ between the urchin and algal zones.

Methods

We sampled small coral colonies (maximum dimension < 40 mm) in the "urchin zone" and in a nearby area outside of the urchin zone, between 4 and 7 m deep, south of the M1 buoy in Discovery Bay, Jamaica, on 5 – 9 March 2001. The urchin zone is easily distinguishable from the surrounding habitats by its pale substrate, high density of *D. antillarum*, and the lack of macroalgal cover. The algal zone we sampled, next to the urchin zone, is characterized by distinctly lower *D. antillarum* density and greater algal cover. Although we attempted to sample at similar depths in each habitat, the algal zone transects were generally 1 –2 m deeper than urchin zone transects. Nine 5 m by 0.5 m transects were haphazardly chosen at least 6 m from the urchin zone boundary into each of the zones. We estimated coral area, from measurements of length and width, and counted the number of *D. antillarum*, within 2 m of each transect.

To separate those corals that most likely settled during times of higher *D. antillarum* densities from those that probably settled before or at the onset of the *D. antillarum* recovery, we divided the corals into two size classes, greater than and less than 200 mm^2. The size and coral abundance data were normalized by log transformation, and analyzed using ANOVA. We grouped all but the four most common genera and compared the community composition of each habitat using a Chi-Square test.

Results

The mean number (± 1 SE) of *D. antillarum* per transect was 2.98 (± 0.43) in the urchin zone, and 0.043 (± 0.004) in the algal zone, and *D. antillarum* density in the urchin zone was higher than that reported in previous years (Fig. 1). There were significantly more corals per transect in the urchin zone than in the algal zone (ANOVA, $F = 34.19$, df = 1, 17, $P < 0.001$; Fig. 2). The coral community composition at the two habitats differed significantly ($\chi^2 = 12.53$, df = 4, 432, $P = 0.014$; Fig. 3), mostly attributable to a relatively higher abundance of *Stephanocoenia* and *Porites*, and a relatively lower abundance of *Agaricia*, in the algal zone. The most common species of *Agaricia* was *A. agaricites*, *S. siderea* was the most common *Siderastrea* species, and *S. michilini* was the only *Stephanocoenia* species found. The most common *Porites* species in the algal zone was *P. porites*, and *P. astreoides* was the most common in the urchin zone.

The mean size of corals in the urchin zone was significantly smaller than that of

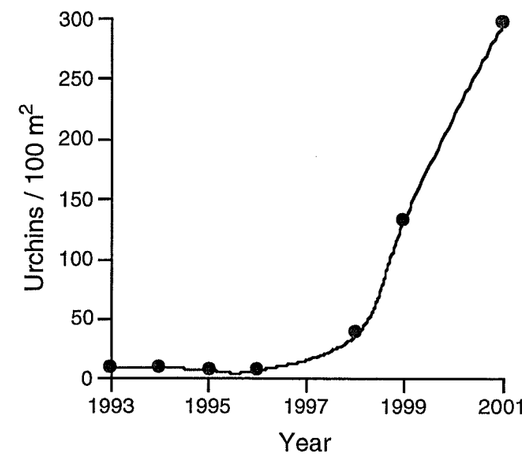

Fig 1. Density of urchins on the shallow fore reef at Discovery Bay, Jamaica. Values from 1993-1999 are approximated from data by Aronson and Precht (2000).

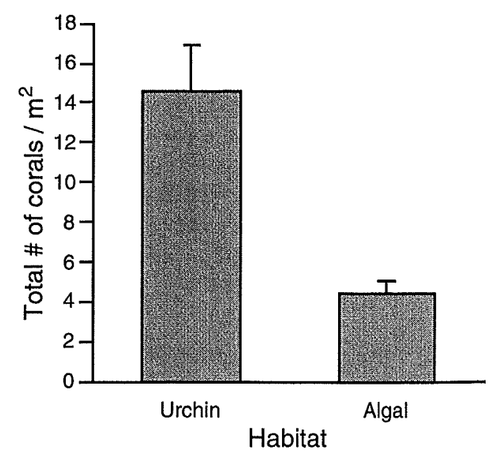

Fig. 2. Density of small corals, as mean number of corals (± 1 SE) with a less than 40 mm maximum linear dimension per m^2 at Discovery Bay, Jamaica. Transects were 5 m by 0.5 m (n = 9 in the urchin, n = 10 in the algal habitat).

coral in the algal zone (ANOVA, F= 8.11, df = 1, 224, P = 0.0048). The ratio of corals < 200 mm² to corals 200 - 1600 mm² was greater in the urchin zone (Fig. 4). There was no significant difference in size between the three most common genera – *Agaricia, Siderastrea,* and *Porites* (ANOVA, F = 0.39, df = 2, 296, P = 0.68).

Although the Shannon-Wiener diversity index was not significantly different between the two habitats (ANOVA, F = 0.73, df = 1, 17, P = 0.41), the evenness index of the coral community in the algal zone (0.90 ± 0.02, mean ± 1 SE) was significantly higher than that in the urchin zone (0.75 ± 0.04; ANOVA F = 14.57, df = 1, 17, P = 0.0014).

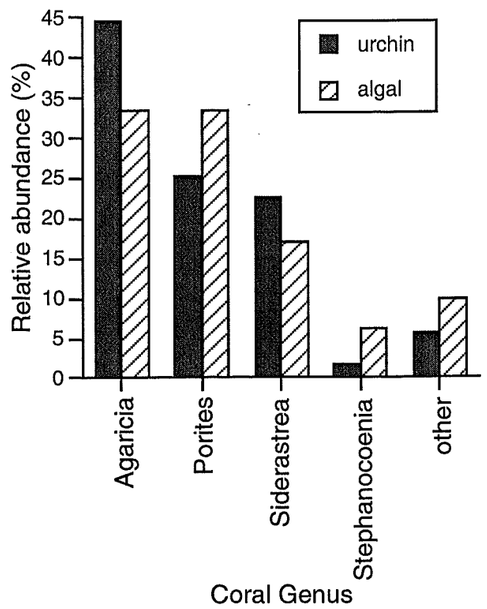

Fig. 3. Relative abundance of coral genera in two habitats at Discovery Bay (n = 329 in the urchin, n = 111 in algal habitat).

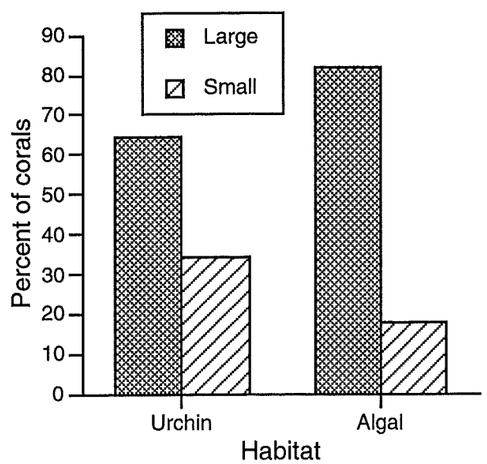

Fig. 4. Percentages of small (< 200 mm²) and large (200 - 1600 mm²) corals in algal (n = 111) and urchin (n = 329) habitats in Discovery Bay, Jamaica.

Discussion

The higher abundance of juvenile corals in the urchin zone compared to the algal zone indicates that the re-establishment of *D. antillarum* has affected the survival of corals in this zone. Since 1996, *D. antillarum* has placed increasing pressure on algal growth in the urchin zone, thereby decreasing competition between corals and algae for substrate, and possibly allowing for increased survival of juvenile corals. This effect was most pronounced in corals < 200 mm², evidenced by the relatively high abundance of this size class in the urchin zone. This finding suggests that new recruits are more susceptible to algal encroachment, and have experienced a greater increase in survival with the resurgence of *D. antillarum* than older juvenile corals. Although it is possible that coral settlement, and not only survival, decreases with macroalgal cover, Sammarco (1980) showed that algae do not inhibit coral settlement in the absence of a grazer.

As expected from previously documented genera-specific variation in the susceptibility of corals to *D. antillarum* grazing and algal competition we found differences in community composition of corals in the two habitats. We found a greater proportion of *Agaricia* in the urchin zone, which may be explained by several factors. In addition to exhibiting "copious" larval recruitment (Hughes 1989), *Agaricia* has been shown to be more susceptible to algal encroachment (Hughes 1989) and less susceptible to urchin grazing (Sammarco 1980). The high relative abundance of *Agaricia* in the urchin zone may explain the lower level of evenness there.

Although previous research has shown *Porites* to be vulnerable to *D. antillarum* grazing (Sammarco 1982a), we found over twice as many *Porites* individuals in the urchin zone than in the algal zone. Thus *D. antillarum* density now may be approaching a density at which it inhibits algal encroachment, but does not produce grazing pressure high enough to decrease survivorship of juvenile corals.

This recent change in juvenile coral community composition could have future effects on the overall community composition and abundance of corals across size classes in the urchin zone. As *D. antillarum* density approaches pre-die-off levels (16 m⁻², Copeland 1980), the interactions between *D. antillarum*, macroalgae, and coral will continue to change. Thus the tradeoff between decreasing algal overgrowth and the effects of urchin grazing and predation may shift. A long term study following specific juvenile individuals, surveying the < 200 mm² size class, and sampling *D. antillarum* density could illuminate the overall effect increasing *D. antillarum* densities are having on the shallow forereef.

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