Comparison of spicule densities in sponges from exposed and sheltered reef sites

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Abstract: Sponges (Porifera) often rival corals and other invertebrates in both abundance and diversity on tropical coral reefs. Because sponges play an important role in reef dynamics, determinants of their health may be critical to overall reef health. Competition for space and limited food resources, as well as high disturbance levels (hurricanes) are among the factors shaping sponge distribution. Wulff (1995) reported high levels of storm damage sustained by non-cryptic sponges with a high spicule density. Sponge skeletons are composed of rigid (siliceous) spicules and/or flexible (protein) fibers. We hypothesized that lower level disturbances such as those due to seasonal storms similarly damage sponges. To test this hypothesis, we compared spicule density in sponges at 8 m and 15 m between an exposed and a sheltered reef site at Discovery Bay, Jamaica. We predicted that spicule density would be greater in sponges from the sheltered site and at greater depth. Sponges from the sheltered, back-reef site had significantly higher spicule density than those from the exposed, fore-reef site. Within the sheltered site, sponges at 15 m had higher spicule density than those at 8 m. We also examined spicule densities within morphological categories and found a similar distribution of spicule densities in each. Our findings indicate that differences in disturbance levels between the fore-reef and back-reef at Discovery Bay may affect sponge populations at these sites. Frequent, lower-level disturbances may limit sponge distribution on coral reefs.

Key Words: Columbus Park, Discovery Bay, disturbance, hurricane damage, LTS (Caricomp), spongin

Introduction

Sponges (Porifera) frequently rival corals and other invertebrates in both abundance and diversity on tropical coral reefs. Their presence is vital to reef health, maintaining nutrient balance, counteracting bioerosion, promoting reef recovery after disturbance and providing structural support (Wulff 1995). A variety of factors determine the distribution, abundance and growth rates of reef sponges. These include competition for space and limited food resources, predation pressure, sedimentation and damage from disturbance.

Wulff (1995) found that after Hurricane Joan in 1988, sponges with similar, non-cryptic growth forms sustained different levels of damage depending on their skeletal structure; sponges with a higher proportion of spicules (siliceous) to spongin (protein) in skeletal fibers were more heavily damaged than those composed primarily of spongin. Sponges with high spicule density are less flexible than those with spongin skeletons, and are more likely to break under rough conditions. In 1988, Hurricane Gilbert caused extensive damage to the reef at Discovery Bay, Jamaica. Sponge populations were severely depleted to depths of at least 30 m but grew back within 3 to 5 years (Scoffin and Hendry 1984, Wilkinson and Cheshire 1988). We hypothesized that differences in spicule density among sponge species will control their distribution among high and low disturbance areas in Discovery Bay, Jamaica.

We predicted that non-cryptic sponges growing on the exposed fore-reef would have a lower average spicule density than those growing on the relatively sheltered back-reef. We also predicted that sponges growing at a shallow depth (8 m) would have lower average spicule density than those growing in deeper water (15 m).

Methods

On 3 – 7 March 2002 we collected non-cryptic sponges from an exposed site on the fore-reef (LTS) and a sheltered site on the back-reef (Columbus Park) in Discovery Bay, Jamaica. Using SCUBA, we sampled sponges at 8 m and 15 m at each site. At each of these depths, we haphazardly located 4 points and used a corer and dive knife to collect a small piece (0.5 – 2 cm) of every sponge within 2 m of those points. Each sponge was placed into one of four categories: rope, bulbous, tube and encrusting.

In the lab, we placed each sponge piece on a dry paper towel to drain for 15 sec, then weighed the tissue. To estimate sponge spicule density, we dissolved each piece of sponge (wet weight range: 0.1 - 1.5 g) with bleach until all of the living tissue was removed. We then used a dissecting microscope to categorize the relative spicule and spongin density of each sponge as: 0) no spicules (only spongin), 1) some spicules (mostly spongin), 2) approximately equal amounts of spicules and spongin, 3) mostly spicules (some spongin), 4) only spicules.

We used contingency tests to compare the frequency of sponges with different spicule density ratings between locations with depths combined, between depths with locations combined, between depths at each location and between locations at each depth. To compare spicule densities within morphological categories across locations and depths, we averaged the spicule density of sponges in each category and compared the means using ANOVA and Tukey-Kramer pairwise comparisons.

Results

Pooling across depths, sponges collected at the sheltered site, Columbus Park, had higher spicule densities than sponges at the exposed site, LTS ($G = 30.70$, $df = 4$, $P < 0.001$; Fig. 1). This relationship was consistent across each depth (8 m: $G = 12.97$, $df = 4$, $P = 0.01$; 15 m: $G = 24.97$, $df = 4$, $P < 0.001$).

Sponges had significantly higher spicule densities at 15 m than at 8 m at the protected site ($G = 11.96$, $df = 4$, $P = 0.02$; Fig. 2).

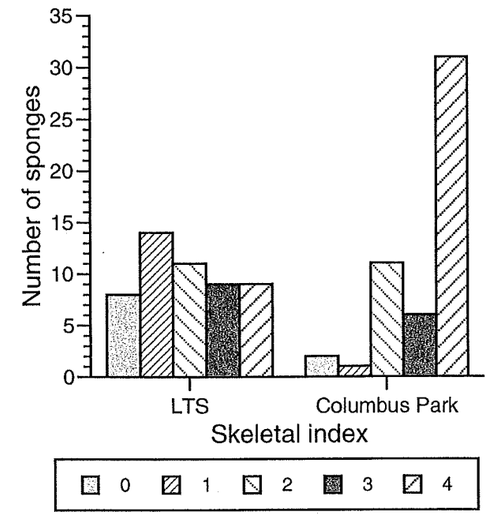

FIG. 1. Number of sponges within each skeletal index found at each site (depths pooled).

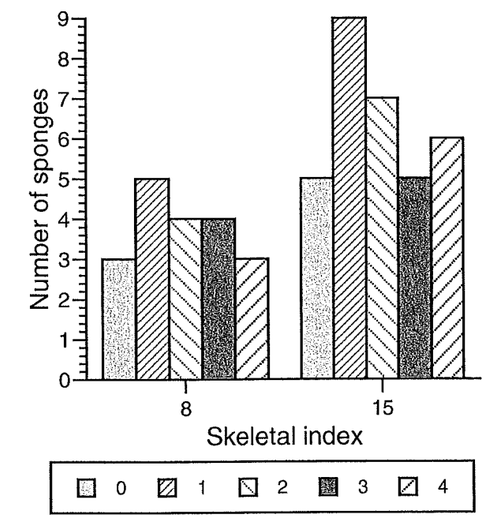

FIG. 2. Number of sponges found within each skeletal in-dex at LTS (sheltered site) at each depth.

No difference was found in spicule densities between depths at the exposed site or between depths overall ($P > 0.28$).

Three sponge types (rope, bulbous and encrusting), combined over depths and locations, had the same frequency distributions of spicule densities ($G = 7.51$, $df = 8$, $P = 0.48$). Because of a small sample size ($n = 14$), we

TABLE 1. Mean spicule densities (± SE) calculated from a scale of 0 – 4; 0 = no spicules (all spongin), 4 = all spicules (no spongin).

	LTS		Columbus Park	
	8 m	15 m	8 m	15 m
Rope	0.5 ± 0.5	2 ± 0.71	3.14 ± 0.34	3.43 ± 0.37
Colonial	2.18 ± 0.35	2.06 ± 0.31	3.38 ± 0.26	3.45 ± 0.28
Tube	1.5 ± 0.87	1.33 ± 0.71	1.33 ± 0.67	0
Encrusting	3 ± 1	2.2 ± 0.58	3.8 ± 0.2	3.44 ± 0.38

were unable to include tube sponges in this comparison.

Within morphotype categories, mean spicule density varied between depths and sites for rope sponges ($F_{3,20} = 4.63$, $P = 0.02$) and bulbous sponges ($F_{3,45} = 5.48$, $P = 0.003$; Table 1). Rope sponge spicule density was higher at Columbus Park than LTS at both 8 m and 15 m (Tukey-Kramer $P < 0.05$). Bulbous sponges from 15 m at Columbus Park had higher spicule density than sponges from either depth at LTS. Sponges from 8 m at Columbus Park had higher spicule density than those from 15 m at LTS (Tukey-Kramer, $P < 0.05$). Spicule density in tube sponges and encrusting sponges did not vary across site and depth ($P > 0.14$).

Discussion

Sponge spicule density was greater in samples from the sheltered site, supporting the hypothesis that higher disturbance levels may decrease survival of sponges with high spicule density. Since sponge populations are known to re-establish within 5 years after a large-scale disturbance such as a hurricane, our findings indicate that lower-level disturbances such as seasonal storms may put constant pressure on coral reef sponge populations. Other differences between the two sites such as variation in substrate type, sedimentation and sponge dispersal ability may contribute to differences in spicule density, although possible mechanisms are unknown.

We found greater spicule density in sponges at 15 m than 8 m only at the sheltered sampling site. This indicates that disturbance may vary more with depth at this site than at the exposed site. The fore-reef (exposed site) slopes gently downward from the reef crest, extending into open ocean for over a mile before dropping off. Storms increase turbulence in the water column in this exposed area and our findings indicate that the resultant disturbance level does not vary greatly between 8 and 15 m. The fore-reef and reef crest reduce disturbance in the back-reef by forcing waves to break before they enter the bay. During storms, shallow water may be easily disturbed by surface waves, but waves large enough to disturb deeper water will rarely develop.

Since all sponge morphotypes were present across sites and depths, and since sponges within each morphotype category spanned a range of spicule densities, we are confident that our findings do not simply reflect a difference in the types of sponges present at different sites and depths. This is supported by our finding that rope sponges and bulbous sponges had higher spicule density at the sheltered site at both depths.

Analyses of the variations we found were limited by the number of samples we were able to collect. Additional sampling of sponges from deeper than 15 m would provide data for spicule density of sponges growing in a lower disturbance habitat and could further test the trends that we found.

Extensive research has examined the effects of hurricane-level disturbances on coral reefs, but the long-term importance of these

infrequent events is unclear. Our results indicate that smaller, frequent disturbances play an important role in shaping reef communities. Their effects could help explain long-term patterns of distribution and abundance in these environments.

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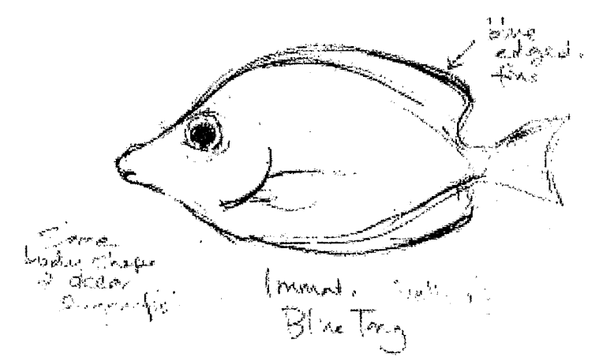
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