Factors affecting the distribution of cryptic sponges

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Abstract: Sessile marine organisms such as sponges face challenges from mobile predators as well as environmental stresses. Previous studies of shallow-water sponges living on tropical coral reefs have shown that sponge distribution may be limited by their inability to tolerate ultra-violet radiation or to deter fish predators. We examined cryptic sponges in the back-reef of Discovery Bay, Jamaica to test whether the limitation of sponges to under-rubble habitat is primarily due to predation, UV radiation or a combination of the two. We tested the hypothesis that both of these factors are important by using a factorial experimental design. Though we found several interesting trends, we were unable to support our hypothesis that UV-radiation and predation limit this cryptic sponge community. Future research could build on our results by lengthening the sampling period and by examining alternative limiting factors such as turbidity and wave action.

Key Words: community distribution, physiological limitation, Porifera

Introduction

Sessile marine organisms such as sponges face challenges from mobile predators as well as environmental stresses. Previous studies of sponges living on tropical coral reefs have shown that their distribution may be limited by their ability to tolerate ultra-violet radiation (Jokiel 1980), or to deter fish predators (Dunlap and Pawlik 1996). Many sponges, particularly those growing below depths of 15 m, have been shown to contain noxious chemicals (Pawlik 1998). Sponges growing in shallow water are often found on the underside of rubble, and generally do not produce noxious chemicals (Bakus 1981). UV radiation is also greater at shallower depths. Therefore, it is unclear whether the tendency for these cryptic sponges to be restricted to under-rubble habitat is due to predation risk or an inability to repair UV damage.

We examined cryptic sponges in the back-reef of Discovery Bay, Jamaica. We hypothesized that cryptic sponge distribution in the reef is limited by both predation and UV radiation. We tested this hypothesis using a factorial experimental design examining mortality of cryptic sponges in response to predation or UV radiation exclusion. In a follow-up study, we specifically tested the effects of *Diadema antillarum* predation on sponges.

Methods

Enclosure experiment

To determine the effects of predation and UV light on under-rubble sponge communities we set up 4 experimental treatments and 1 open comparison treatment of overturned rubble on the west end of the back-reef at Discovery Bay. All treatments were located at ~2 m depth, ~25 m from the reef crest on sandy substrate with scattered patch reef and low levels of algal cover. Experimental treatments included: 1) UV light exclusion and fish exclusion, 2) UV light exposure and fish exclusion, 3) UV light exclusion without protection from fish, and 4) UV light exposure without protection from fish. There were 3 replicates of each experimental treatment. Treatments were carried out in 30.5 x 30.5 x 16 cm wire enclosures with UV or non-UV transparent Plexiglass tops. Treatments 1 and 3 had open sides in order to allow fish predation. In addition, five rocks with sponge communities were overturned and left unenclosed in an open comparison treatment (treatment 5). Rocks were chosen haphazardly from the surrounding area, and were no larger than the dimensions of the enclosures. Each rock harbored between 1 and 8 individual sponges of varying morphotypes. Sponges were morphotyped according to color, and there were 9 morphotypes in all.

We recorded changes in sponge color, physical structure and area from 4 – 9 March 2002. Sponges were recorded as discolored if any of their tissue changed color during the experiment, damaged if any tissue was missing or if there were obvious bite marks, and missing if they could not be found. Observations were made after 24, 48 and 120 hours for treatments 1 – 4 and after 24, 48 and 96 hours for treatment 5. We compared discoloration, damage and absence rates of enclosed treatments using nested ANOVA tests to isolate the effects of predator and UV exposure after 24, 48 and 120 hours. The open treatment was compared to the UV transmitting, predator inclusive treatment using a paired t-test, comparing observations made after 96 hours in open treatments and 120 hours in the UV transmitting, predator inclusive treatment.

Diadema antillarum predation experiment

In a follow-up experiment, we tested for *D. antillarum* predation on sponges in 12 wire-cage enclosures, 5 with 3 *D. antillarum* each and 7 without *D. antillarum*. Cages were located at ~2 m depth and included 2 – 3 overturned rocks with under-rubble sponge communities. Rocks were chosen haphazardly from the surrounding area, and were of similar dimensions to those in the enclosure experiment. Each rock harbored between 1 and 13 individual sponges of 11 distinct color morphotypes. Cages were set out at 15:00 on 7 March and were checked for predation in the morning and afternoon of 8 March, and on the morning of 9 March. Sponges were recorded as missing, present with damage or present without damage. We compared discoloration, damage and tissue loss noted on the last observation period (after 36 h) using paired t-tests.

Results

Enclosure experiment

Overall we observed extensive discoloration of some sponges, but relatively little

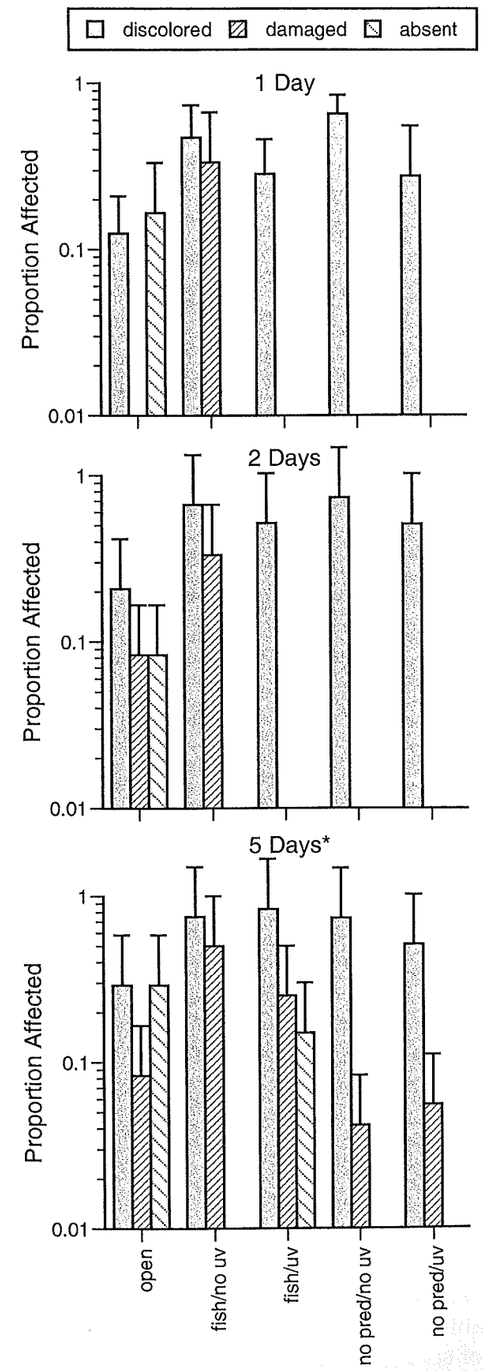

FIG. 1. Proportions of sponges discolored, damaged or absent in five predator/uv exposure treatments (±SE) after 1, 2 and 5 days (*open treatments 1, 2 and 4 days).

physical damage or tissue loss in our enclosure experiment. The average proportion of sponges discolored during the experiment was (mean ± SE) 56.9 ± 8.0%, with a range of 29.2 - 83.3%. The proportion missing at the end of the experiment was 12.2 ± 6.1%, with a range of 0 - 29.2%, and the proportion that sustained physical damage was 16.9 ± 7.2%, with a range of 4.2 - 50%.

Fishes and urchins were observed in open enclosures, including dusky damselfish (*Stegastes fuscus*), juvenile princess parrotfish (*Scarus taeniopterus*), juvenile striped parrotfish (*Scarus croicensisi*), redband parrotfish (*Sparisoma aurofrenatum*) and the sea urchins *Lytechinus veriegatus* and *Tripneustes ventricosus*. In addition, we also observed goldspot and bridled gobies (*Coryphopterus glaucofraenum* and *Gnatholepis thompsoni*) in both open and predator exclusion treatments.

We found no difference in sponge discoloration between any of the experimental treatments after 24, 48 or 120 hours (Table 1). However, significantly fewer sponges in open treatments were discolored than in the UV transmitting, predator inclusive treatment over the course of the study ($F_{1,34}$ = 6.34, P = 0.02). This difference was not significant until the final day of the experiment ($F_{1,7}$ = 8.76, P = 0.021).

No sponges were missing when observations were first taken at 24 hours, and there was no difference in the proportion missing among treatments after 48 hours (Table 3). The proportion of sponges absent from predator-inclusion treatments was marginally higher than in the predator-exclusion treatment after 120 hours ($F_{3,20}$ = 3.86, P = 0.09). The proportion of sponges missing from the UV-transmitting treatment was marginally higher than in the UV-blocking treatment ($F_{3,20}$ = 3.86, P = 0.09). Interaction between UV-transmitting and predation treatments was marginally significant ($F_{3,20}$ = 3.86, P = 0.056). The proportion of sponges missing from the open treatment and the UV transmitting, predator inclusive treatment did not differ ($F_{1,34}$ = 1.81, P = 0.28).

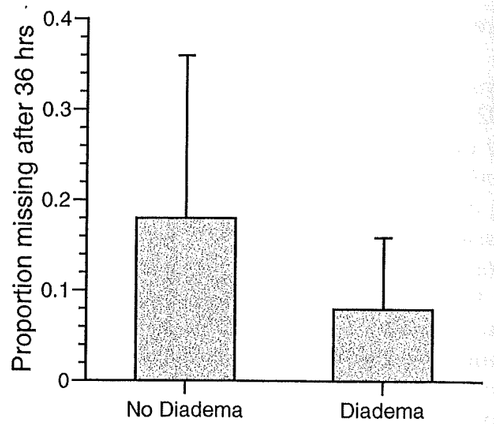

FIG. 2. The relative propotion of sponges missing after 36 hours in enclosures with and without *Diadema antillarum* (±SE).

Damage sustained by sponges did not differ significantly between enclosed treatments. However, damage rates to sponges in predator-inclusion treatments were marginally significantly lower than in predator-exclusion treatments after 120 hours ($F_{1,10}$ = 3.20, P = 0.10). This relationship was not significant before 120 hours (Table 2). Damage sustained by sponges did not differ between the open treatment and the UV transmitting, predator inclusive treatment ($F_{1,34}$ = 0.12, P = 0.73).

Diadema antillarum *predation experiment*

Fish and sea urchins were observed within cages, including 2 indigo hamlets (*Hypoplectrus indigo*), 1 ocean surgeonfish (*Acanthurus bahianus*), *Lytechinus veriegatus* and *Tripneustes ventracosus*.

There was only one sponge missing during the first 24 hours of the *D. antillarum* predation experiment. At 36 hours, we saw no difference between *D. antillarum* inclusion and exclusion treatments ($F_{2,9}$ = 0.505, P = 0.62; Fig. 2).

We were unable to run statistical analyses on individual morphotypes due to extremely low damage rates. The most common morphotypes in this experiment were green and purple sponges. The proportion of green and purple sponges missing at completion of the experiment was 5.5% and 7.4% respectively.

TABLE 1. P-values from ANOVA tests of the proportion of sponges discolored between various experimental treatments. WHOLE values are from nested ANOVA tests of results from both UV and predator treatments.

Time (h)	Pred/No Pred	UV/No UV	WHOLE
24	0.72	0.26	0.64
48	0.86	0.33	0.76
120	0.35	0.69	0.60

TABLE 2. P-values from ANOVA tests of the proportion of sponges damaged in various experimental treatments. WHOLE values are from nested ANOVA tests of results from both UV and predator treatments.

Time (h)	Pred/No Pred	UV/No UV	WHOLE
24	0.35	0.35	0.44
48	0.35	0.35	0.44
120	0.10	0.56	0.36

TABLE 3. P-values from ANOVA tests of the proportion of sponges not found (missing) in various experimental treatments. WHOLE values are from nested ANOVA tests of results from both UV and predator treatments.

Time (h)	Pred/No Pred	UV/No UV	WHOLE
24	-	-	-
48	0.13	0.13	0.13
120	0.08	0.08	0.08

Discussion

Contrary to our predictions, we found no significant relationship between sponge discoloration and exposure to UV radiation in our experimental treatments. However, we did find a significantly lower proportion of discoloration among sponges in open treatments than in UV transmitting, predator inclusive enclosures. This result might be due to some unforeseen effect of the enclosures; for example both UV-transmitting and UV-blocking Plexiglass plates may reduce transmittance of some longer wavelength UV light, perhaps inhibiting UV-stimulated molecular repair mechanisms. It has been shown that the repair mechanisms for damage caused by UV-B radiation (280 - 320 nm) are stimulated by UV-A radiation (320 - 400 nm; Dunne and Brown 1996). It is possible that repair mechanisms stimulated by UV-A did not receive enough of the radiation for activation, i.e. there may be some threshold of UV-A radiation necessary for induction of cellular repair mechanisms. Thus, if the UV-transmitting Plexiglass deflects enough UV-A, sponges in this treatment may not have been able to repair damage caused by UV-B radiation.

Though discoloration rates were high in enclosure treatments (29.2 - 83.3%), the discoloration rate in the open treatment was significantly lower than the enclosure treatments. This suggests that UV tolerance does not limit cryptic sponges to under-rubble habitats. This result contradicts results of a previous study in Hawaii that found high sensitivity of cryptic sponges to UV radiation (Jokiel 1980). The discrepancy between these studies suggests

that further study is necessary to understand the effects of UV radiation on cryptic sponge distribution.

Sponges in predator treatments tended to suffer more physical damage than sponges in predator exclusion enclosures, though this pattern was only marginally significant. It is possible that with a longer sampling period, this relationship would become stronger over time. Another explanation might be that while larger sponge-eating fish were able to graze on sponges in the open treatment, our enclosures were too small to allow them to effectively reach the sponges inside. Furthermore, we observed several *D. antillarum* in the vicinity of our experimental setup, leading us to suspect that they were preying on the sponges of the open treatment, since they are too large to fit in the enclosures. However, our findings from the *D. antillarum* predation experiment do not support this theory. As there is no past evidence for grazing on sponges by *D. antillarum*, it is unlikely that this urchin caused the damage seen in open treatment sponges.

We did not observe the rapid and extensive sponge predation recorded by Dunlap and Pawlik (1996). The high macroalgal cover found in nearby parts of the reef at Discovery Bay may explain this unusual result. Parrotfish species previously reported to eat cryptic sponges by Dunlap and Pawlik may prefer these algal food resources.

Interestingly, we recorded sponge disappearances only in treatments exposed to both predation and UV-radiation. This finding might imply that exposure to UV radiation is reducing the effectiveness of sponge predation defense. Thus, the distribution of cryptic sponges in shallow waters of Discovery Bay may be limited by both UV-radiation and predation. Alternatively, other studies have suggested that sponge community distribution above substrate is affected by turbidity and wave action (Gischler and Ginsburg 1996). Future research could observe sponge damage and mortality over longer time periods and examine turbidity and wave action as alternative explanations for the cryptic growth of shallow water sponges.

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