Covering behavior in two Caribbean urchin species

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Abstract: Two common Caribbean reef urchin species, *Lytechinus variegatus* and *Tripnuestes ventricosus*, cover their aboral surface with macroalgae, shells and other loose material during the day. Possible factors affecting covering behavior include turbidity, UV radiation, urchin size and predation. We predicted that urchins would cover more in response to UV radiation and increased turbidity, and that larger urchins would exhibit less covering than smaller conspecifics. Additionally, predation avoidance might cause these urchins to choose the cover type that would provide the greatest camouflage. We completed an *in situ* survey of urchin covering during days where turbidity was low and high, and we conducted three experimental studies: a UV experiment, a sediment experiment and a choice experiment. Our results indicate that urchins cover more in turbid than in calm waters, but show no such trend between experiments with and without suspended sediment (sand). Light triggers a strong covering response, but blocking UV wavelengths did not significantly reduce the effect of light. *L. variegatus* and *T. ventricosus* prefer macroalgae as a covering regardless of substrate.

Key Words: *camouflage, covering behavior,* Lytechinus variegatus, *predator defense,* Tripnuestes ventricosus, *turbidity, UV light*

Introduction

Two species of urchins, *Lytechinus variegatus* and *Tripnuestes ventricosus*, exhibit a behavior of using macroalgae, shells and other loose material to cover their aboral surface. Many different urchin genera exhibit similar covering behavior and several studies have focused on cues eliciting this behavior. Previous research has investigated urchin covering in response to turbidity, light, UV radiation, surge and predation. Few studies have tested more than one possible cue or functional significance for a given species. We hypothesize that there are several factors which may affect covering behavior in *L. variegatus* and *T. ventricosus* including UV radiation, turbidity, predation and urchin size.

UV radiation at shallow depths may damage vulnerable surface tissues of urchins and has been shown to do so in a variety of taxa (Jokiel 1980, Dunne and Brown 1996). The urchins *L. anamesus* and *Strongylocentrosus droebachiensis* cover in direct response to UV radiation (Lees and Carter 1972, Adams 2001). If UV light is potentially harmful we predict that both *L. variegatus* and *T. ventricosus* will decrease covering when UV wavelengths are filtered out.

The aboral surface of urchins may be vulnerable to suspended sediment in the water column. Sediment could clog the madreporite and reduce water flow into the water vascular system. The urchin *Paracentrus lividus* in the Mediterranean increases its percent cover with increasing water turbidity (Richner and Milinski 2000). If turbidity negatively affects *L. variegatus* and *T. ventricosus*, we predict that these two urchin species will also respond to turbidity by increasing their cover.

Camouflage from predators may also be an important function of urchin covering (Milligan 1915, Boon 1925, Dayton et al 1970). If so, we predict that the urchins will choose appropriate covering material according to substrate. Additionally, smaller urchins should be more susceptible to predation, and the smaller *L. variegatus* generally covers more than *T. ventricosus* (Keller 1983, Campbell et al. 2001). We therefore predict that smaller individuals of each species will cover more than larger individuals.

Methods

Our experiments were conducted and observations made from 1 - 9 March 2002 at the Discovery Bay Marine Lab, Jamaica. For all experiments, we used two species of urchins that exhibit covering behavior, *Lytechinus variegatus* and *Tripnuestes ventricosus*. Observations were made in the sand flats and turtle grass beds between the marine lab dock and the back-reef, and experimental studies were conducted outside the wet-lab.

Preliminary Survey

We conducted an urchin survey and recorded preliminary observations including percent and type cover as a function of species, size and substrate in which each urchin occurred.

UV Experiment

We arranged 3 experimental treatments to test the effects of different light regimes on the covering response of the 2 urchin species. We used 3 identical plastic tubs, 12 cm deep and 33 cm in diameter, as experimental enclosures. We covered each with one of the following: UV-transmitting plexiglass, UV-blocking plexiglass and opaque plastic. The UV-transmitting plexiglass was OP-4, which permits all light down to 50% of 272 nm. The UV-blocking plexiglass was UF-3, which permits light down to 50% of 413 nm. All tubs were outfitted with a sandy bottom, two small weighted turtle grass clusters and small pieces of a variety of macroalgae and shell and rock fragments for covering materials. Macroalgae consisted of *Avrainvillea longicaulis, Penicillus capitatus* and *Halimeda goreaui*. Fresh seawater flowed into the tanks at all times, and all experiments were conducted in direct sunlight. We placed one urchin in each tank for 1 h and recorded its test diameter and the percent of its surface covered with substrate after 15, 30, 45 and 60 min. Urchin individuals were used only once. We completed 20 total study periods, 10 for *L. variegatus* and 10 for *T. ventricosus*.

Sediment Experiment

To test for the effects of increased suspended sediment on the urchin covering response, we created a tub with high turbidity. We placed an individual in the tub and sprinkled approximately two teaspoons of sand (collected from the sand flats in the natural environment) over the surface of the water above the urchin immediately, and then every five minutes, to simulate continued turbidity. We ran each experiment for 0.5 h, and recorded percent cover every 5 min, before the addition of sand. The substrate within the tub was similar to that described in the UV experiment. We alternated increased turbidity experiments with control experiments, where we recorded similar observations but did not add sand. We completed 16 sedimentation experiments, 8 for each species.

In Situ Turbidity Survey

We completed 1 h urchin surveys on 4 days, 1 - 2 and 7 - 8 March, with different surge/turbidity levels on a qualitative scale of 0 - 5, with 0 being calm waters and 5 being very turbid. The days were classified as 1, 2, 4 and 5, respectively. Surveys were conducted for 0.5 h in each of two locations, the sand flats and turtle grass beds. For each urchin seen along the haphazardly located transect (approx. 100 m long in each habitat), we recorded species, test diameter (excluding spines) and type and percent cover of substrate on which the urchin was found.

Choice Experiment

In this experiment, we attempted to determine whether the urchins preferentially or randomly selected cover material within their environment. To test this, we set up two tubs with distinct types of substrate: one with a variety of green macroalgae (primarily of the genera *Halimeda, Udotea, Penicillus* and *Thalassia*) and one composed of shells, shell

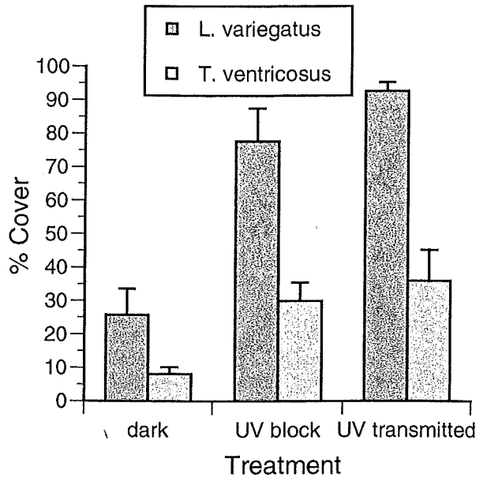

FIG. 1. Mean (± SE) covering response by urchins in three different light treatments (n = 20 for each treatment type).

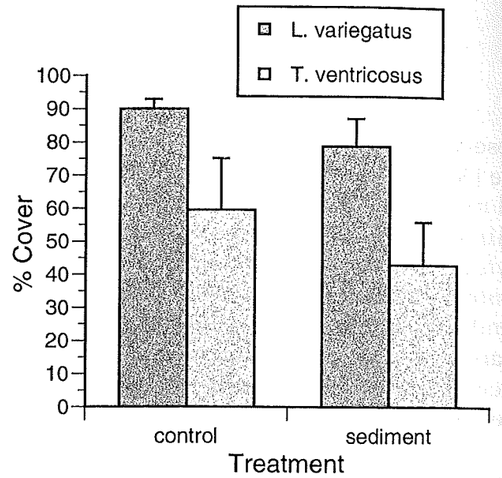

FIG. 2. Mean percent cover (± SE) exhibited by urchins in experimental sedimentation experimentation versus control (no sediment added) treatments.

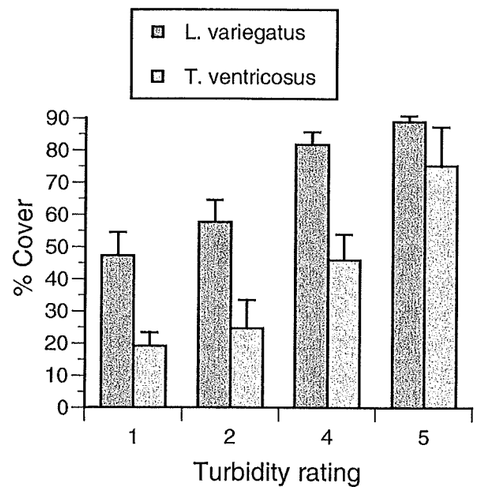

FIG. 3. Percent cover (± SE) exhibited by urchins during four observations at different swell/turbidity levels. Tubidity rating value is based on a qualitative scale of 0 to 5, 0 being calm and 5 being very turbid (n = 144).

fragments and rocks collected from the bay. We placed an individual in one substrate type, allowed it to cover itself for 15 min, then switched the urchin to the tub with the other substrate type. We then left the urchin in the second tub for 45 min and recorded percent cover of each type (macroalgae and shells) every 5 minutes, both prior to and after the substrate type switch. We completed 15 total choice experiments (n = 8 for *T. ventricosus* and n = 7 for *L. variegatus*).

Results

UV Experiment

Urchins covered themselves less when placed in the dark treatment than either of the light treatments (*L. variegatus* $F_{2,27} = 22.47$, $P < 0.001$; *T. ventricosus* $F_{2,27} = 5.30$, $P = 0.01$; Fig. 1). In addition, urchins tended to cover more in the UV-transmitting treatment than the UV-blocking treatment, but this difference was not significant ($t = 0.93$, $df = 38$, $P = 0.36$). For *T. ventricosus*, average percent cover exhibited by urchins in the dark treatment was 8.15 ± 2.00%, while UV-blocking and UV-transmitting treatments had average cover percentages of 29.98 ± 5.48% and 35.9 ± 9.33%, respectively. *L. variegatus* in the dark treatments had an average of 25.8 ± 7.84% cover, UV-blocking had 77.8 ± 9.81% and UV-transmitting treatments had 92.68 ± 2.64%. Time did not have an effect on urchin covering ($F_{1,238} = 0.46$, $P = 0.50$), thus percent cover was averaged across time for each individual.

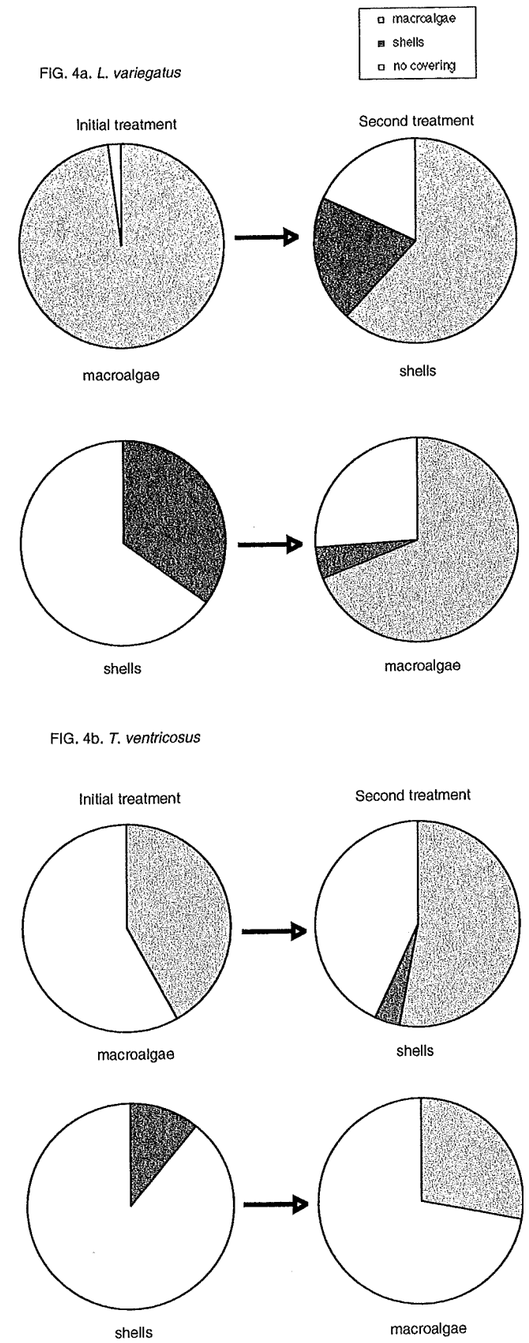

FIG. 4. Percentage of cover type chosen by urchins in initial substrate type and secondly in alternate substrate type (n = 15).

Sediment Experiment

Urchins did not show a difference in covering response between the experimental sedimentation treatment and the control treatment (*L. variegatus*: $t = 1.28$, $df = 6$, $P = 0.25$; *T. ventricosus*: $t = 0.81$, $df = 6$, $P = 0.45$; Fig. 2). Mean coverage for the test and control experiments were 60.90 ± 4.18% and 74.75 ± 4.18%, respectively.

In Situ Turbidity Survey

Percent cover exhibited by the urchins increased with increasing swell/turbidity (ANOVA, *L. variegatus*: $F_{3,86} = 14.08$, $P < 0.001$; *T. ventricosus*: $F_{3,50} = 10.22$, $P < 0.001$; Fig. 3). Mean coverages at each rating were as follows: *L. variegatus*: turbidity rating 1: 47.2 ± 7.24%, rating 2: 57.7 ± 6.8%, rating 4: 81.7 ± 3.9%, rating 5: 89.0 ± 1.8%; *T. ventricosus*: rating 1: 19.2 ± 4.2%, rating 2: 24.7 ± 8.8%, rating 4: 45.9 ± 8.0%, rating 5: 75.2 ± 12.1%. As the turbidity and swell increased, urchins were also found more commonly on the turtlegrass substrate than in sandier habitats.

Data collected during field observations did not show a correlation between urchin size and percent cover (*L. variegatus*: $r^2 = 0.002$, $P = 0.67$; *T. ventricosus*: $r^2 = 0.59$, $P = 0.08$). The two species differed in size, with *T. ventricosus* and *L. variegatus* having mean test diameters of 8.48 ± 0.12 cm and 5.56 ± 0.16 cm, respectively (ANOVA, $F_{2,141} = 111.88$, $P < 0.001$). In addition, *L. variegatus* had a higher average percent cover in all conditions than *T. ventricosus* (70.2 ± 3.32 versus 37. 5 ± 4.29, $t = 6.029$, $df = 1$, $P < 0.001$, $n = 144$). Most common cover types included a combination of turtlegrass and macroalgae, followed by strictly macroalgae.

Choice Experiment

In general, urchins appear to prefer macroalgal covering materials over shells, even when on a sandy/shell substrate (Fig. 4a and 4b). When *L. variegatus* was initially placed in the shell substrate, it attained an average of 35.0 ± 7.86% cover of shells. When it was moved to a macroalgal substrate, how-

ever, the percent cover of shells decreased to 4.7 ± 1.18%, and the urchin picked up enough macroalgae to cover 69.3 ± 6.78% of its surface. *L. variegatus* placed initially in the macroalgal substrate covered an average of 97.8% (± 0.65%) with macroalgae. Upon switching them to the shell substrate, they decreased their macroalgae cover to 61.8 ± 4.67% and gained 19.8 ± 2.30% shell coverage (Fig. 4a).

T. ventricosus showed similar patterns of cover in the choice experiment. On average, 10.8 ± 2.37% of the urchin's aboral surface was covered with shells when placed initially in the shell substrate, changing to 4.7 ± 1.18% shell cover and 28.1 ± 5.28% macroalgae cover when switched to the algal substrate. Urchins from an algal-dominated substrate covered with 41.7 ± 8.38% macroalgae, and gained 3.8 ± 1.30% shell cover while keeping the same amount of algae when switched to the shell substrate (Fig. 4b).

Discussion

Several factors appear to be influencing covering behavior in *T. ventricosus* and *L. variegatus*. Exposure to light, irrespective of UV radiation, elicits a covering response. Urchins showed little covering behavior in darkness. The finding of greater percent cover in the UV-transmitting than the UV-blocking treatment, though not significant, supports earlier findings of a UV-initiated covering response. While there may be some UV sensitivity, it seems as though the majority of the response is due to a broader range of wavelengths.

There are a number of possible explanations for this light-induced behavior. Cover could be used as protection against the UV-A and UV-B rays (which can harm the urchin's living tissue). Additionally, since both the *T. ventricosus* and *L. veriegatus* are preyed on by diurnal fish, a covering response triggered by light could be selected for by protecting the urchins from visual predators through camouflage. Unlike other studies, our urchins responded to all ranges of wavelengths. Our findings may have differed from previous UV studies due to our use of ambient sunlight rather than unnaturally low wavelength UV light from UV bulbs, such as those used by Lee and Carter (1972).

Our hypothesis that urchins would cover more in turbid waters was supported by our turbidity survey. However, our corresponding sediment experiment showed no such trend. Whereas both *T. ventricosus* and *L. variegatus* tended to cover more *in situ* as turbidity increased, the urchins in our sediment experiments covered the same amount with and without sand addition.

Cover has also been hypothesized to reduce tumbling during high turbulence. High shell cover is believed to increase the urchin's specific gravity and give it a more hydro-dynamic shape (Lee and Carter 1972.) In our experimental sedimentation study, there was no surge in the experimental and control treatments; consequently, the cue that causes urchins to cover more in turbid waters is likely increased water flow or turbidity rather than increased sedimentation.

Both *T. ventricosus* and *L. variegatus* seem to prefer macroalgae as a cover regardless of the substrate type. In our choice experiment, when switched from the macroalgae to the shell treatment (after usually establishing a substantial macroalgae base) the urchins slowly began to add shells to their covering, while retaining a cover of predominantly macroalgae. Perhaps this is due to a higher abundance of macroalgae as opposed to shells in the environment from which we collected our urchins, so that the urchins may be accustomed to using predominantly macroalgal cover. Alternatively, macroalgae may be easier to lift (less dense, more surface area) and provide better protection from predators due to its greater 3-dimensional structure and camouflage effect.

To further understand the apparently complex factors that affect the urchin covering response, future research should re-examine turbidity and UV cues and whether covering is an adaptive response to increased wave action. Urchin response to turbidity could be re-examined experimentally by using finer sand, and the response to UV and photosynthetically active radiation could be tested using covers that isolate the effects of specific wavelengths of light. Though our results indicate that light is a primary cue, other factors such as turbidity, surge and predation risk still play a role in eliciting the urchin covering response.

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