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DIURNAL CHANGES IN *TRIPNEUSTES VENTRICOSUS* COVERING RESPONSE IN *THALASSIA TESTUDINUM* SEA GRASS BEDS

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Abstract: The urchin *Tripneustes ventricosus* uses its tube feet and spines to cover itself with sea grass blades or other debris. We examined this behavior as a defense against solar radiation. We hypothesized that the degree of covering by *T. ventricosus* would change according to the degree of solar radiation over the course of the day. We predicted that covering would be highest in the afternoon, lower in the morning and evening, and lowest at night. Covering response may also be affected by available material. We predicted that *T. ventricosus* would cover itself more in areas of high-density sea grass than low-density sea grass. We measured percent cover in *T. ventricosus* individuals at different times of day in high- and low-density sea grass areas. Coverage was highest in the afternoon and lowest at night for both sea grass densities. Percent cover was significantly higher for urchins in high-density sea grass areas than in low-density areas for all times during the day, but not at night. These results indicate that *T. ventricosus* is able to detect and respond to changing levels of solar radiation by changing its percent cover.

Key Words: covering behavior, salt and pepper urchin, solar radiation

INTRODUCTION

Tripneustes ventricosus, the salt and pepper urchin, uses its tube feet and spines to cover itself with shells, sea grass blades and other debris (Lewis 1958). Several explanations have been suggested for this covering response, including protection from wave surge and predators (Kehas et al. 2004); however, there is strong evidence that the primary purpose for covering behavior is to screen solar radiation (Fierce and Lapin 2004, Kehas et al. 2004, Lewis 1958). When grass fragments are covering

one half of the urchin and light is shown on the other half, the urchin will transfer the grass to the illuminated half (Lewis 1958). Additionally, when *T. ventricosus* in the lab were given the option of covering with black plastic strips or clear plastic strips, they chose the black strips (Fierce and Lapin 2004).

We examined covering behavior as a defense against solar radiation. Over the course of the day, there are changes in solar radiation with radiation being highest at midday, lower in the morning and evening, and negligible at night (Strickler 1999). We hypothesized that the degree of covering by *T. ventricosus* would change according to the degree of solar radiation. Therefore, covering should be low in the morning, peak at midday, decrease in the evening, and be lowest at night.

We also examined the covering behavior of *T. ventricosus* within different densities of turtle grass, *Thalassia testudinum*. We predicted higher coverage by *T. ventricosus* in high-density *T. testudinum* than in low-density turtle grass because there are more resources available for covering.

METHODS

On 24 February 2005, we observed the covering behavior of *T. ventricosus* in three *T. testudinum* patches in the back reef at Discovery Bay, Jamaica. Two patches were located in the west back reef; the third patch was in the central back reef near the reef crest. Water depth at each of these patches ranged from 0.5 - 1.5 m. We visually estimated percent cover for the first 40 *T. ventricosus* individuals encountered in each patch and noted covering material (i.e., seagrass blades, rocks, and shells). We also identified the *T. testudinum* density in which each urchin was found as either high or low. We sampled at three different times during the day: early morning (0800), late morning (1145) and evening (1700), and once at night (2230). Times were chosen to monitor changes in covering behavior across a range of solar radiation levels. During night sampling we found between 30 and 40 individuals; we were not able to find 40 individuals at all sites due to difficulties in locating individuals with flashlights.

All data met the assumptions of parametric tests, including normal distributions and equal variances. We used a two-way ANOVA to examine the effects of time of day, *T. testudinum* density, and their interaction on urchin covering.

RESULTS

We observed a total of 466 *T. ventricosus* individuals. All observed individuals that displayed covering behavior used only seagrass blades as covering material. Mean percent cover ranged from 7.8 ± 2.5 SE to 57.4 ± 3.7 SE across treatments (Fig. 1). The interaction between time of day and *T. testudinum* density on percent cover was significant (2-way ANOVA, $F = 9.29$, $df = 3, 3$, $P < 0.0001$; Fig. 1). Percent cover significantly changed over the course of the day, with highest cover occurring in the late morning for both high- and low-

density *T. testudinum* areas (2-way ANOVA, F = 48.51, df = 3, 3, P < 0.0001; Fig. 1). Percent cover was significantly higher for urchins in high-density *T. testudinum* areas than low-density areas for all times during the day, but not at night (2-way ANOVA, F = 94.74, df = 1, 1, P < 0.0001; Fig. 1).

DISCUSSION

We found that the degree of covering by *T. ventricosus* changed throughout the day and attributed this to changes in solar radiation. These results suggest that *T. ventricosus* is able to detect and respond to changing levels of solar radiation by changing its percent cover. At night, *T. ventricosus* sheds most of its covering material; this suggests that there is a cost associated with covering, and at night the costs of retaining the covering outweigh any benefits conferred by being covered. Covering may inhibit gas exchange through the aboral tube feet and thus decrease respiration or may inhibit release of feces and gametes into the water (Kehas et al. 2004).

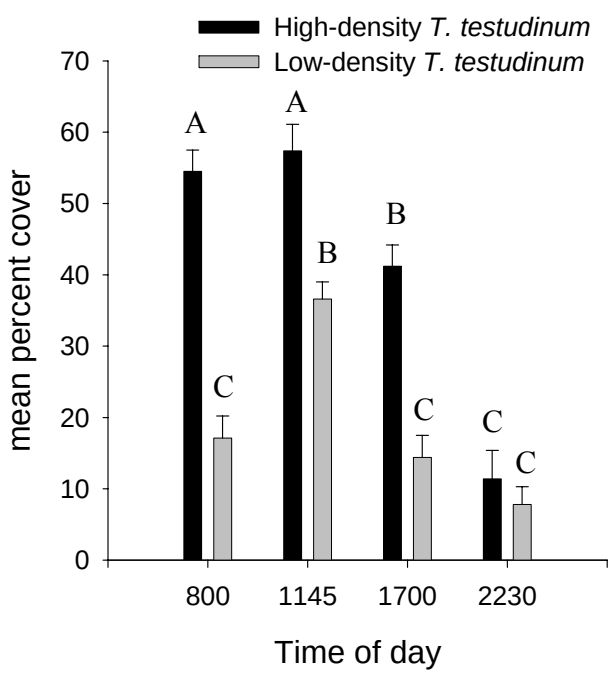

Figure 1. Mean percent cover of *Tripneustes ventricosus* at different periods during the day in high- and low-density *Thalassia testudinum*. Letters indicate significant differences in mean percent cover (Tukey test, α = 0.05).

Percent cover did not differ significantly between early- and late-morning treatments in high-density grass but did differ in low-density grass. Greater resource availability in the high-density areas may facilitate a quick covering response to increasing light intensity earlier in the day, whereas individuals in low-density areas may need more time to accrue covering materials. Sampling times for the early morning and late morning were also closer together than the evening sampling time (differences were 3.75 and 5.25 hours, respectively). It is likely that light intensity was more similar between the early- and late morning treatments, which further accounts for similarities between early- and late morning percent cover.

It is also possible that covering behavior may have evolved as a response to changing levels of light, but not specifically to damaging UV radiation. Although urchins do not respond directly to UV radiation (Butcher et al. 2002), responding to solar radiation allows them to avoid UV radiation as the intensity of UV radiation tracks the intensity of full spectrum solar radiation.

During the day, individuals covered themselves more in high-density grass areas than low-density grass areas. This is

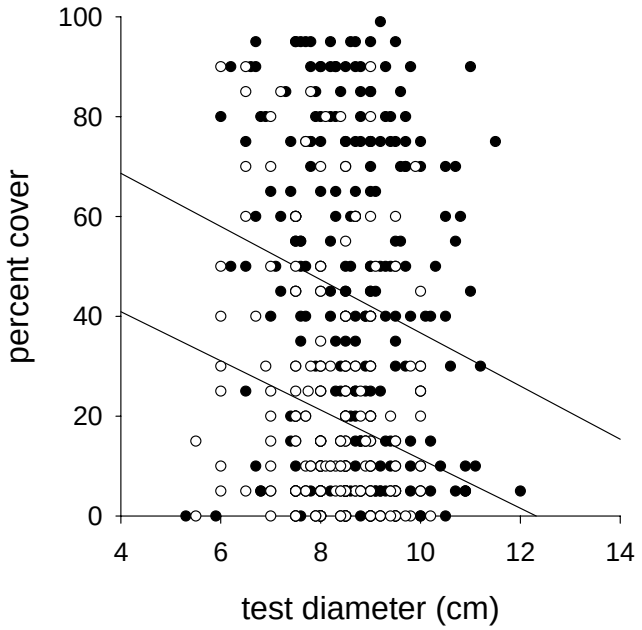

Figure 2. Relationship between percent cover in *Tripneustes ventricosus* and test diameter. Percent cover decreased with increasing diameter in both high density (closed dot) and low density (open dot) *Thalassia testudinum*. High density: y = -5.14x + 88.30; Low density: y = -5.14x + 62.47.

consistent with our prediction that higher density of *T. testudinum* would increase the availability of covering resources and would allow *T. ventricosus* to cover more fully. There was no effect of grass density on percent cover at night. High and low resource availability should not affect the ability to shed cover, only to acquire it. It follows that grass density would not affect the degree to which *T. ventricosus* sheds unnecessary cover at night.

Covering behavior may be augmented with a migration of individuals to different habitats as well as to deeper depths to increase avoidance of harmful radiation. Future studies could consider these aspects of *T. ventricosus* behavior.

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Addendum

We were also interested in the effect of sea urchin size on *T. ventricosus* covering behavior within the two *T. testudinum* densities. We measured test diameter for each *T. ventricosus* individual in our main experiment.

We examined the effect of urchin test diameter on percent cover between the high- and low-density *T. testudinum* using an indicator variables regression. The regression model was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \varepsilon$$

where Y is the response variable (percent cover), X_1 is the urchin test diameter, X_2 is a binary indicator variable of analysis, β_0 is the intercept, β_1 is the slope, β_2 is the change in intercept between high- and low-density *T. testudinum*, and β_3 the change in slope between high- and low-density *T. testudinum* (Neter et al. 1996). We confirmed that data met the assumptions of normality and homogeneity of variances. Data were analyzed using JMP 5.0.1.

Percent cover decreased with increasing diameter in both high and low *T. testudinum* density areas. The high-density *T. testudinum* regression had an intercept significantly higher than that of the low-density *T. testudinum* regression ($P < 0.0001$), but no significant differences in slope were detected ($P = 0.8697$; Fig 2).

Small individuals in both grass densities covered themselves more than large individuals. Perhaps there is greater pressure on small individuals to cover due to greater susceptibility to radiation or inability to recover from damage. Additionally, there may be a greater risk of predation associated with being small, and a greater need to cover regardless of light intensity.