Ecology:

Diurnal Changes in *Tripneustes ventricosus* Covering Response in *Thalassia testudinum* Sea Grass Beds

MELISSA BARGER '05, JENNY JUN '05 AND TIMOTHY MATSUURA '05

Abstract: *The urchin* Tripneustes ventricosus *uses its tube feet and spines to cover itself with sea grass blades or other debris as a defense against solar radiation. We hypothesized that the degree of covering by* T. ventricosus *would change with variations in the intensity of solar radiation over the course of a 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 a greater percentage of its body surface in areas of high-density sea grass than in areas of low-density sea grass. We measured the percent of body surface covered by debris 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 covering behavior.*

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 (1). Several explanations have been suggested for this covering response, including protection from wave surge and predators (2). However, there is strong evidence that the primary purpose of covering behavior is to screen solar radiation (3,4,5). When grass fragments cover one half of an urchin and light is shown on the other half, the urchin will transfer the grass to the illuminated half (6). Additionally, when *T. ventricosus* are given the option of covering with black plastic strips or clear plastic strips, they choose the black strips (7).

Over the course of a day, there are changes in solar radiation, with radiation being highest at midday, lower in the morning and evening, and negligible at night (8). We hypothesized that the degree of covering by *T. ventricosus* would change in response 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* between habitats differing in density of turtle grass, *Thalasia testudinum*. We predicted higher coverage by *T. ventricosus* in high-density *T. testudinum* than in low-density turtle grass because, in the high-density habitat, there are more resources available for covering.

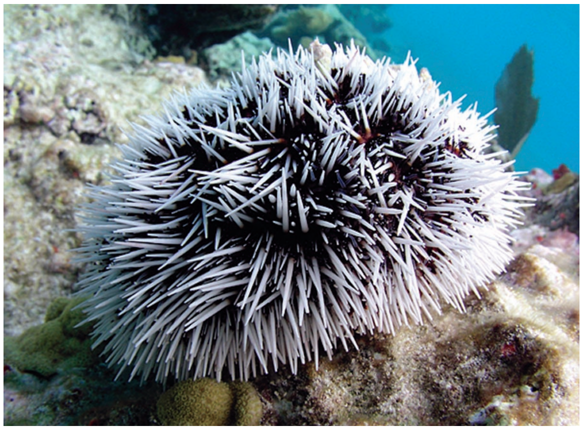

Image courtesy of Frank O'Donnell

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, or shells). We also classified the *T. testudinum* density in which each urchin was found as either high or low. We sampled at four different times: early morning (8:00), late morning (11:45), evening (17:00), and night (22:30). Times were chosen to span 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 the difficulty of locating urchins with flashlights.

All data met the assumptions of parametric tests. 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 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 (F = 9.29, df = 3, 3, P < 0.0001; Fig. 1). Percent cover changed over the course of the day, with highest cover occurring in the late morning for both high- and low-density *T. testudinum* areas (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 (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 covering behavior. 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 (9).

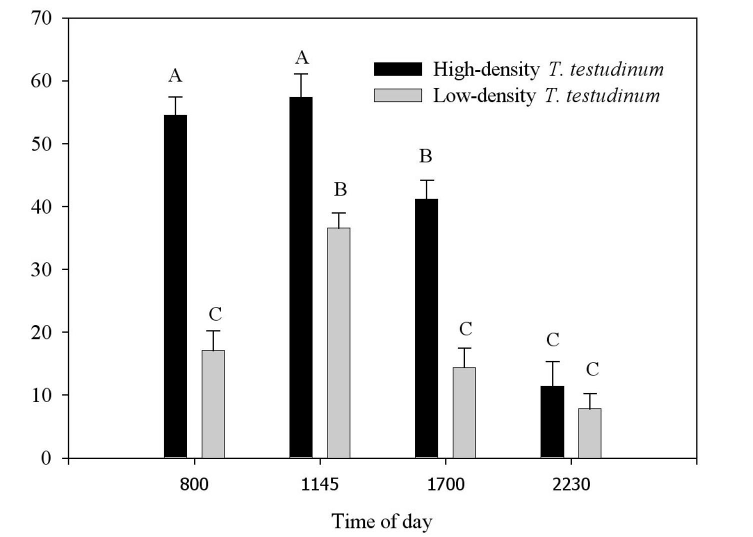

Figure 1. Mean percent of body surface covered with debris in *Tripneustes ventricosus* individuals at different times of day in high- and low-density *Thalassia testudium* beds. Error bars are +/- 1 SE. Letters above columns indicate means that are different at alpha = 0.05, Tukey's HSD post-hoc test.

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 (10), 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 consistent with our prediction that higher density of *T. testudinum* would increase the availability of covering resources and would allow *T. ventricosus* to cover its body surface 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.

Reduction of damage by UV radiation may also be achieved by migrating to different habitats or deeper depths. Future studies could consider these aspects of *T. ventricosus* behavior.

References

1. J.B. Lewis, *Can. J. Zool.* **36,** 607 (1958).
2. A.J. Kehas, K. A. Theoharides, and J. J. Gilbert, *Marine Biology* **146,** 1111 (2004).
3. S.E.B. Fierce, and H. E. Lapin, *Dartmouth Studies in Tropical Ecology 2004,* 166 (2004).
4. A.J. Kehas, K. A. Theoharides, and J. J. Gilbert, *Marine Biology* **146,** 1111 (2004).

5-6. J.B. Lewis, *Can. J. Zool.* **36,** 607 (1958).

7. S.E.B. Fierce, and H. E. Lapin, *Dartmouth Studies in Tropical Ecology 2004,* 166 (2004).
8. G. Strickler, "Solar Radiation and the Earth System" (NASA, 1999; http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/science-briefs/ed-stickler/ed-irradiance.html).
9. A.J. Kehas, K. A. Theoharides, and J. J. Gilbert, *Marine Biology* **146,** 1111 (2004).
10. J.L. Butcher, K. S. Nowak, and L. V. Reynolds, *Dartmouth Studies in Tropical Ecology 2002*, 208 (2002).