Differences in covering behavior of *Lytechinus variegatus* and *Tripneustes ventricosus* sea urchins: Potential consequences for predator avoidance

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Abstract: *Lytechinus variegatus* and *Tripneustes ventricosus* are two sea urchin species known to cover their aboral surfaces with various materials found on the sea floor. Observations have suggested that this may be a method of predator avoidance and have shown that this behavior varies among individuals, between species, and on different substrates. Variation in the level and composition of aboral surface cover was examined by comparing these two species within and between two substrate types. We predicted that *L. variegatus*, the smaller urchin species, would have more cover and harder cover materials than *T. ventricosus*. We also hypothesized that both urchin species will predominantly cover themselves with materials that are most readily available in the substrate on which they are located, and that urchins will have a greater proportion of cover on the exposed sandy habitat relative to turtle grass habitats. *L. variegatus* had a higher percentage of aboral surface cover than *T. ventricosus* on both substrates, and each species had a higher percentage of surface cover in the sandy environment, with *T. ventricosus* showing the greatest difference. A majority of the surface cover was composed of grass and algae in the turtlegrass environment, while shells and rocks were predominantly used in the sandy environment. This increased aboral cover in the smaller urchin species and within the more exposed sandy environment supports the hypothesis that this covering behavior is a method of predator avoidance. The correlation between substrate type and the composition of the surface cover suggests that sea urchins may utilize the most abundant material found in their current habitat, aiding their ability to camouflage, yet differences in the two species may result in different choices of materials.

Key Words: camouflage, coral reef, echinoderms, tube feet

Introduction

Two sea urchin species, *Tripneustes ventricosus* and *Lytechinus variegatus*, use their tube feet to cover their aboral surface with shells, rocks, coral fragments, macroalgae, and seagrass (*Thalassia testudinum*) blades (Lees and Carter 1972). This covering behavior is prominent in sublittoral areas of both tropic and temperate seas, and is easily observed in the west back reef of Discovery Bay, Jamaica. We observed that the proportion of cover used varies among individuals, between species, and on different substrates.

Numerous studies have reported that these urchin species have a higher proportion of their bodies covered during the day than at night (Sakowitz 1987, Lees and Carter 1972). This trend has been interpreted as potential evidence for two different theories explaining urchin covering behavior. Covering could provide protection against tissue damage from ultraviolet (UV) radiation (Lees and Carter 1972, Sakowitz 1987) or provide protection and camouflage against urchin-feeding fish (visual predators) (Sakowitz 1887). *Tripneustes ventricosus* have been found to make micro-migrations to different habitats and higher perching spots during the night (Braden and Leander 2001). Thus, the partial shedding of cover may also be a byproduct of increased travel. It has also been proposed that covering provides protection against displacement by surge (Lees and Carter 1972). We made personal observations of *T. ventricosus* covering behavior while SCUBA diving at depths in excess of 8 meters. This behavior appeared identical to the covering behavior observed in shallow water, yet the effects of UV light and surge turbulence are presumably greatly reduced in deep water. Thus, we found the predation deterrent hypothesis to be the most reasonable explanation for covering behavior and conducted an urchin survey to quantify trends in covering. While urchin predators such as triggerfish are rare in our study area due to overfishing, their

absence is a relatively recent phenomenon. It is reasonable to assume that anti-predator adaptations are still present in this system.

McClanahan et al. (1989) found that predation pressure decreased with increasing urchin body size. We therefore predicted that *T. ventricosus*, the larger urchin species, would have less cover than *L. variegatus*. We also predicted that both urchin species will predominantly cover themselves with materials that are most readily available in the substrate on which they are located (e.g. shells/rocks in sand, grass/algae in turtle grass), as these materials will be not only easy to find, but will also most closely match the substrate, thus providing the best camouflage. We predicted that urchins would have a greater proportion of cover on the exposed sandy habitat relative to turtle grass habitats, where the turtle grass provides natural concealment. If covering provides not only camouflage, but also physical protection from predators, we also predicted that *L. variegatus* individuals will cover themselves with relatively harder materials (shells, rocks) than *T. ventricosus*.

Methods

All sampling was conducted between 24-26 February 2001 on the West back reef of Discovery Bay, Jamaica. We haphazardly selected two habitat patches, one of turtle grass and one of sand, approximately 10 m from the reef crest. Within each habitat, we haphazardly selected *L. variegatus* and *T. ventricosus* individuals and estimated the percentage of aboral cover. We also counted objects attached to the aboral surface and grouped them into one of two categories (shells/rocks or algae/turtlegrass), and converted these counts to percentages of cover items used. All percentages were arcsine-transformed for analysis. We also measured urchin diameter (including spines) across the oral surface.

Two-way ANOVA tests were used to determine differences in percentage cover both within and across species between the two substrates. In addition, we used 2-way ANOVA tests to compare aboral surface composition between species and substrates.

Results

L. variegatus had a higher percentage of aboral surface cover than *T. ventricosus* in both turtle grass and sandy habitats (2-way ANOVA, $F = 192.39$, $df = 1, 156$, $P < 0.0001$; Fig. 1). Among habitats, both species had a higher percentage of surface cover in the sandy environment (2-way ANOVA, $F = 66.82$, $df = 1, 156$, $P < 0.0001$; Fig. 1). There was a significant interaction between substrate type and sea urchin species in that *T. ventricosus* was much more affected by substrate type than was *L. variegatus* (2-way ANOVA, $F = 22.03$, $df = 1, 156$, $P < 0.0001$; Fig. 1).

There was a significant difference in the choice of materials used in aboral surface cover between species and between substrate types (2-way ANOVA, $F = 96.55$, $df = 1, 156$, $P < 0.0001$; $F = 445.99$, $df = 1, 156$, $P < 0.0001$, respectively; Fig. 2). In the turtlegrass habitat, on average, 82% of *L. variegatus'* surface

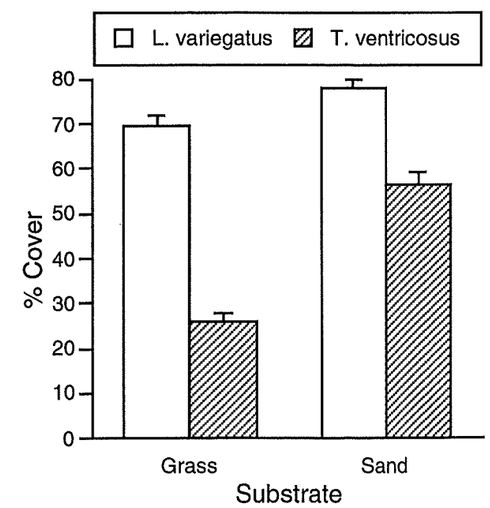

Fig. 1. Mean percent (± 1 SE) of aboral surface covered on *Lytechinus* (n = 80) and *Tripneustes* (n = 80) sea urchins on sand and turtle grass substrates on the west back reef, Discovery Bay, Jamaica.

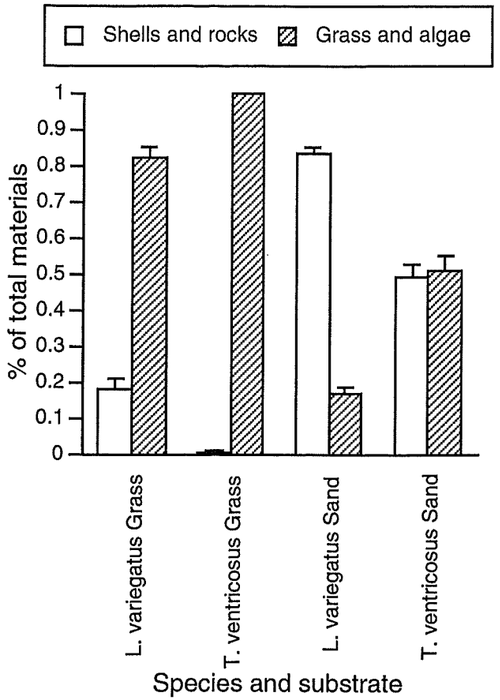

Fig. 2. Mean percentage (± 1 SE) of materials used as cover for *L. variegatus* (n = 80) and *T. ventricosus* (n = 80) on grass and sand substrates on the west back reef, Discovery Bay, Jamaica.

cover was composed of shells and rocks, while the other 18% was composed of algae and grass. In turtlegrass, 100% of *T. ventricosus*' surface cover was composed of algae and grass. Within the sandy environment 83% of *L. variegatus*'s surface cover consisted of shells and rock, while the other 17% consisted of rocks and algae. *T. ventricosus* surface cover was composed of 48% shells and rocks, while the other 51% was composed of grass and algae.

Discussion

Our results support our prediction that *L. variegatus* maintains a greater percentage of cover on its aboral surface than *T. ventricosus*. *L. variegatus* may experience greater predation pressure due to its smaller size (McClanahan et al. 1989), and if covering is indeed a type of camouflage from predators, it may be that *L. variegatus* has a greater need for covering. Sakowitz (1987) also suggested that a lack of pigments on the epithelial surface of *L. variegatus* may result in an increased need for covering as protection from sunlight. Further study is needed to more conclusively determine the functional significance of covering in urchins. Such study could compare the condition, fitness, and covering response between urchins exposed to direct sunlight and urchins exposed to sunlight from which UV radiation has been filtered. Alternatively, covered and uncovered urchins could be exposed to urchin predators (such as triggerfish) to determine the effectiveness of covering as camouflage.

Our prediction that urchins of both species would be more covered on a sandy substrate was also supported. Sandy areas may be more open and exposed than grassy areas, thus making the urchins more exposed to predation and increasing their need to cover. Alternatively, urchins may be feeding more in grassy areas than in sandy areas, and may therefore devote fewer resources to covering and maintaining cover in grass. *T. ventricosus* appeared to increase its cover more on sand than did *L. variegatus*, which maintained a high percentage of cover in both substrates. This may be because *L. variegatus*, the smaller species, has a high risk of predation on both substrates, while *T. ventricosus* is at risk only when exposed on sand.

Our prediction that urchins of both species would cover themselves with materials that were most readily available in a given substrate was also supported. In grass, both species were most covered with grass and algae, and in sand both species were most covered with shells and/or rocks. Not only were these materials the most readily available in these substrates, but they were also the materials that most closely matched the substrates. Although this may suggest that covering is a means of camouflage, it does not rule out the

possibility of other reasons for covering, such as protection from sunlight or turbulence. Further study could test the camouflage hypothesis by offering urchins a choice between equal quantities of materials in given substrates to see if they choose those that most closely match the substrate. Additionally, urchins covered with different materials on different substrates could be exposed to urchin predators to test the effectiveness of different materials as camouflage.

While both species generally chose materials that were most readily available, there was a distinct difference between species in the relative percentages of materials chosen. Our hypothesis that *L. variegatus* would choose harder materials as a further predator avoidance strategy was supported. In sand, *L. variegatus* overwhelmingly chose rocks and shells. *T. ventricosus* also chose some rocks and shells in sand, but the remainder of its coverage was composed of algae and turtle grass, items that were not as readily available in sand as rocks and shells. In grass, both species appeared to prefer *Thalassia* blades, but *L. variegatus* again chose more rocks and shells than did *T. ventricosus*. *L. variegatus* may choose harder materials as a predator avoidance strategy, but there may be other possible reasons for this behavior. *L. variegatus* generally feeds on *Thalassia* epiphytes and detritus, while *T. ventricosus* feeds almost exclusively on *Thalassia*, and to a lesser extent on some algae (Sakowitz 1987). Thus, *T. ventricosus* may be better able to cut *Thalassia* blades and algae fragments, while *L. variegatus* must rely on loose items (rocks and shells).

As important herbivores of algae and seagrass, sea urchins play a major role in determining seagrass and coral reef community composition and dynamics (Rose et al. 1999). The effect of predation on sea urchin abundance, therefore, is also highly important. If covering behavior is indeed a mechanism for predator-avoidance, then by understanding this behavior we may better understand the ways in which sea urchin populations affect seagrass and coral reef communities.

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