

complexity of the habitat and abundance of covering materials in that habitat may have affected the percent cover of an urchin. In addition, behaviors of urchins like clumping may serve to reduce the need for covering through increased protection from predators or surge.

In the outdoor tank experiment, the absence of diel changes in covering response in the closed treatment indicates that the covering response is triggered by an external, not an internal, stimulus. Light seems to be this external stimulus since the diurnal changes in covering in the open tank occurred in the absence of surge.

The delayed peak in percent cover in the illuminated tank as compared to the field experiment could have been a result of additional stimuli, like surge, in the field or decreased light in the laboratory due to shading of the tank by trees and cement walls. The lower overall covering by urchins in the tank experiment may have been due to a lack of available material in the tank.

Three main functional explanations for the sea urchin covering response have been suggested: 1) increased stability to withstand surge; 2) creating a physical barrier to prevent ultraviolet radiation damage; and 3) camouflage to avoid visual predators. Surge does not seem to be the primary stimulus as high surge was not consistently associated with high percent cover (field) and urchins demonstrated a covering response in the absence of surge (outdoor tank). Light appears to be a stimulus, however, both

the UV and predation hypotheses are reliant upon light as a stimulus. That sea urchins tended to prefer the shaded part of the open tank favors the UV hypothesis. Yet, the high degree of individual variation in field covering responses does not allow us to disregard the predation hypothesis. If covering response is genetically controlled, the reduced predation pressure in recent years on this reef may have allowed the survival of genotypes that cover to a lesser degree, increasing the variation in covering response within the species.

Further studies could investigate the covering of urchins just before dawn and the relation to light and other stimuli. Similar habitats that have consistently high or low surge could be compared. Light and surge should be better quantified. Additionally, it would be interesting to see if covering does increase in response to surge in the absence of light in the field. Finally, individual urchins could be followed over time to investigate individual diurnal variation in covering.

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## A STUDY OF *BUNODEOPSIS ANTILLIENSIS*: EFFECTS ON TURTLE GRASS HERBIVORY AND INTERACTIONS WITH THE PREDATOR *HERMODICE CARUNCULATA*

Eden H. Abram and Aviva E. Liebert

#### ABSTRACT (AEL)

*Bunodeopsis antillensis* is an anemone with highly toxic nematocysts that is found at the tips of turtle grass blades. We investigated the effects of the presence of these anemones on herbivory by parrotfish, and found them to be a deterrent; significantly less herbivory was found on grass blades with anemones. We also examined day vs. night interactions with the predaceous fireworm (*Hermodice carunculata*), and found the worms to be generally inactive at night. During the day they ate an equal number of anemones with extended vs. contracted tentacles, and preyed mostly on anemones at 0-10cm from the substrate. We believe a symbiotic relationship exists between *Bunodeopsis antillensis* and the turtle grass *Thalassia testudinum*; the anemone gains safety from predation as well as high light levels and water flow, while the grass is protected from herbivory on the vulnerable blade tips.

Key Words: *Bunodeopsis antillensis*, *Thalassia testudinum*, *Hermodice carunculata*, symbiosis, predator-prey interactions

#### INTRODUCTION (AEL)

The anemone *Bunodeopsis antillensis* is commonly found attached to the tips of turtle grass blades throughout the Caribbean (Hummann, 1992). Its highly toxic nematocysts are found in the tentacles as well as in large columnar vesicles which also contain 96% of the zooxanthellae. During the day, the vesicles are inflated allowing the zooxanthellae to photosynthesize while the tentacles are contracted. The vesicles are incapable of feeding behavior; at night the anemone extends its tentacles to feed (Sebens and DeRiemer, 1977). *Bunodeopsis* attaches to the epiphyte covered tips of *Thalassia testudinum* blades, which are commonly eaten by parrotfish. As suggested by Guerrerio (1992 FSP), we hypothesized that the presence of the anemones would decrease the amount of herbivory on *Thalassia* because the fish would avoid the toxic sting.

*Bunodeopsis* is preyed upon by the fireworm *Hermodice carunculata* (Guerrerio 1992 FSP, Brendan Everett, personal comment). Fireworms have been observed to eat corals, especially milleporid hydrocorals (Witman, 1988) as well as the anemone *Stoichactis helianthus* (Lizama and Blanquist, 1975). They feed by wetting the pharynx and predigesting the tissue at the site of contact before ingestion. *Hermodice* feeds in the early morning and evening (Oh and Lewis, 1972). We have also observed fireworms in *Thalassia* beds and rubble areas at night when they may have been preying on *Bunodeopsis*. When attacked by fireworms, *Bunodeopsis* with extended tentacles may release their holds on the grass blades, but show no response when tentacles were contracted (Guerrerio, 1992 FSP). We therefore hypothesized that *Bunodeopsis* would be at greater risk to predation by fireworms during the day, since their tentacles are contracted and they would be less likely to re-

lease from the leaves in time to escape predation. We also predicted that the risk of predation would decrease with increasing height from the substrate since the anemones would be further away from the fireworm and thus have more time to respond by releasing their holds from the bladetips.

#### METHODS (EHA)

On 2-5 March, 1994, we conducted herbivory experiments in the west back reef, Discovery Bay, Jamaica. On the morning of 2 March, we haphazardly chose *Thalassia* blades on which at least one anemone was residing, marking these blades with a hole punch. We then haphazardly chose *Thalassia* blades without anemones (within 5 meters of a blade with anemones) and marked them as our controls. Neither treatments nor controls showed any previous signs of herbivory (blades were intact). We marked each area with floating scintillation vials and flagging.

After six hours, we collected both treatments and measured herbivory on each blade. Blades were classified as grazed or not grazed. For a more accurate measure of herbivory we quantified parrotfish bites, determining the mean bites per blade for each treatment. We repeated the experiment on 3 March, pooling our data. A G-test was used to compare grazed and ungrazed blades for treatments and controls.

On 4 March, we ran a final herbivory experiment to confirm the fact that anemones do not simply settle on unpalatable blades. We removed the anemones from our treatment

blades and grouped these blades with into three bundles. We made similar bundles from the control blades, and set these six bundles out in our study site for 24 hours. At this time we noted that all blades had been grazed at least 50%. Thus, we felt confident that anemones were not sitting on unpalatable blades.

The second part of our study was conducted March 6-8 in the wet lab at Discovery Bay Marine Laboratory. We set up a 50 gallon tank simulating a microcosm of back reef anemone habitat. It consisted of sediment, small rubble, *Thalassia* of varying heights heights anchored to bolts, and a constant water flow. The anemone density within the tank was roughly consistent with or slightly higher than patches we had observed in the field. We simulated natural light conditions by covering the tank with black plastic from 19:00 until 07:00.

For each trial, we introduced a fireworm, between 7 and 13cm in length, that had been starved for 24 hours. We observed for one hour periods, recording both predator and prey behaviors. We focused particularly on the escape response/mechanisms of the anemones. Each worm was used in both a day and a night trial, and each was starved for 36 hours between trials. In total, we logged 11 hours of observation.

#### RESULTS (EHA)

The presence of anemones on *Thalassia* blades significantly reduced herbivory by parrotfish on those blades (Table 1). For the total over two days, blades with anemones present

Table 1: Total blades eaten and not eaten in treatments with anemones present and controls.

	Anemones Present	Controls
Eaten	9	27
Not Eaten	41	16
Total:	50	43

G<sub>adj</sub>=20.78

p<0.001

experienced 18% herbivory, while control blades with no anemones experienced 63% herbivory. The mean number of parrotfish bites per blade (0.38 for treatments, 3.72 for controls) also differed significantly between treatments and controls (Figure 1).

Three out of four fireworms showed no predation activity during the night observations; instead they hid under coral rubble or in the sediment. One worm did eat three anemones at night, but it had not successfully captured any during its day trial, and therefore had not eaten for 60 hours. Two out of the three captures were passive interactions; the worm happened to land on an anemone when it was dropped into the tank, and another fell directly on the worm's head after releasing its hold on a leaf from above. Because of this lack of activity at night, we focused on the daytime predation interactions.

Sixteen anemones were captured and eaten by the fireworm during eleven hours of observation. 50% of these had tentacles extended and 50% were contracted (Table 2), although 75% of the latter group extended their tentacles immediately upon being attacked. 69% of captures were accomplished by the worm "sneak-

Table 2: Position of tentacles of *Bunodeopsis antillensis* captured by and escaped from *Hermodice carunculata* during eleven hours of observation in our aquarium.

	Extended	Contracted	Total
captures	8	8	16
escapes	11	1	12

ing up" on their anemone (moving slowly towards it from above or below). Of the anemones that successfully escaped capture by the fireworm, 92% had their tentacles extended (Table 2). For each observation period the *Bunodeopsis* distribution in 30cm high tank was about evenly divided into three levels (0-10, 10-20, 20-30cm). There were always 25 anemones in the tank, with 6-10 at each level. 89% of successful captures by the fireworm occurred between 0-10cm, and the mean height of predation attempts was 6.7cm ( $\pm 8.2$ ). Only one attempt was made at 20-30cm, and in this case the worm had crawled up the glass wall of the tank.

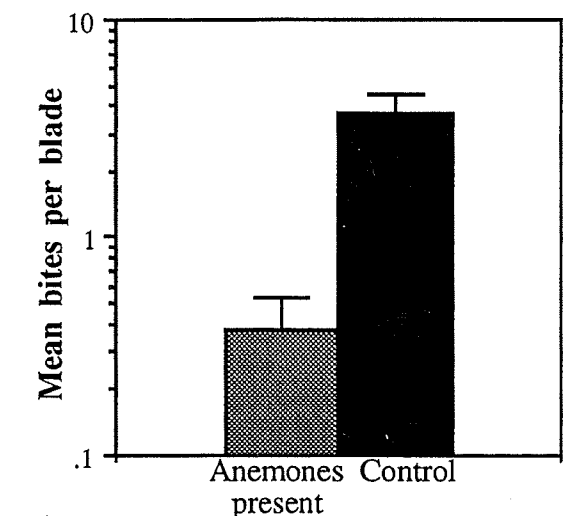


Figure 1. 95% confidence intervals for treatments with anemones present and controls.

We observed 15 anemones which released their holds on leaves or walls of the tank during periods of heavy fireworm activity. All of these had their tentacles extended. Most of them moved to a higher position in the tank; however, we did not quantify this trend because our focus during the observation was on the fireworm predation attempt. Handling time of the prey by the fireworms (time from attack to complete ingestion) ranged from less than 30s to five minutes and 42 seconds. This appeared to vary with the size of the anemone.

#### DISCUSSION (EHA)

We found little or no feeding activity at night by fireworms. Furthermore, of the anemones eaten during the day, 50% had open tentacles and 50% had closed tentacles. Thus, our original hypothesis that fireworms would be more effective predators during the day on closed anemones was not supported. However, our results may reveal a possible symbiotic relationship between *Thalassia testudinum* and *Bunodeopsis antilliensis*. The presence of anemones on *Thalassia* blades significantly deterred grazing by parrotfishes. The anemones tend to settle on the tips of blades (with heavy epibiont loads also located at the tips) which experience the most grazing pressure. Therefore, an individual *Thalassia* blade is better protected if it is harboring anemones than if it is not. Possible costs to the *Thalassia* for harboring these anemones have not been studied.

Anemones may benefit in several ways by living on or near the tips of *Thalassia*. From

observations of predator-prey interactions between fireworms and anemones, it appears that anemones may avoid predation by living off of substrates commonly used by fireworms such as rubble and rock, coral, or sediment.

Fireworms use an sensitive olfactory organ called a caruncle to "taste" the water, aiding in prey detection (Kaplan, 1982). We observed that fireworms appear to sense their prey before contact and are able to sneak up and attack quickly, reducing the prey's chance of escape. We also observed that worms appear less able to sense prey further away from the substrate on which the worm was foraging. We found that it was more difficult for fireworms to sneak up on anemones at the tips of *Thalassia* blades as opposed to if they were near or on a solid substrate. Our findings conflict with Lizama and Blanquet (1975), who found that fireworms tend to run into their prey by chance.

Our results imply that higher substrates, such as *Thalassia* afford reduced predation risk to anemones. Although fireworms are capable of crawling on *Thalassia*, they often disturb the blade, alerting extended anemones, which initiate escape responses. Thus it seems a higher position on a blade is beneficial in terms of predation, among other possible benefits.

Living near tips rather than closer to the sediment may increase water flow past the anemones, possibly increasing the number of food items passing by per unit time. Furthermore, increased light levels at the tips of blades may increase the capacity of the anemones symbiotic zooxanthellae to photosynthesize. Guer-

rerio (1992 FSP) suggested that increased wave action and higher light intensities at this level may be harmful to anemones. This seems unlikely, considering that most anemones we found in the field were attached on or near blade tips.

The interactions we have observed and quantified between herbivorous fishes, *Thalassia*, *Bunodeopsis* and fireworms reveals what may be a relationship mutually beneficial to both *Thalassia* and the anemones, perhaps evolved under the predation or herbivory pressure of organisms such as fireworms and fishes. The presence of anemones on *Thalassia* affects the risk of predation to both organisms, and this may affect the fitness of these organisms. Further investigation of the predation preferences of the fireworm, specifically on corals versus anemones, could shed more light on this relationship.

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