Table 1. Number of parrotfish bites on various *Thalassia* leaves.

Location on leaf	Natural control	Stapled control	Treatment
Base	0	1	11
Middle	2	3	10
Tip	35	23	19

Discussion (KAI)

In order to test for the effect of epiphytes on leaf herbivory we created *Thalassia* blades of equal epiphytic load by stapling the tips of blades together. The effect of the staples was tested by comparing herbivory on a stapled control blade (with normal epiphytic load) and a manipulated control (regular blade stapled three times). It may have been better to make the manipulated control out of three cut sections of grass stapled together, but we did not feel this was critical. We found that the presence of staples did not effect herbivory.

When we compared the position of bites (number of bites at the tip, middle, and base) on the experiment blades to the number of bites on the corresponding stapled controls, we found a highly significant difference. This suggests that the fish are feeding on the entire surface of the blade with uniform epiphytic load, whereas they concentrate their feeding only at the epiphyte-rich tips of unmanipulated blades. This indicates that herbivorous fish are not constrained in their behavior to feed at the tips of a leaf; they appear to choose areas of high epiphytic load wherever they are. We also found that fish do not graze significantly more on any portion of a blade when epiphyte distribution is uniform; herbivory is randomly distributed on all portions of the blade.

The older portions of *Thalassia* blades are at a severe disadvantage due to colonization by epiphytes. Epiphytes have two negative effects, first they decrease photosynthetic activity by shading leaves. Second, as illustrated in this paper, they cause tissue loss by increasing fish herbivory.

DIURNAL HERBIVORY ON *THALASSIA TESTUDINUM* AS A FUNCTION OF DISTANCE FROM THE REEF

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Abstract. We studied diurnal herbivory on *Thalassia testudinum* as a function of distance from the reef in three locations (reef flat, rear zone, and lagoon) at the Discovery Bay Marine Lab, Jamaica. Urchins (*Tripneustes ventricosus* and *Diadema antillarum*) and parrotfish (especially Striped Parrotfish, *Scarus croicensis*, and Stoplight Parrotfish, *Sparisoma viride*) were the most common grazers. Urchin herbivory was highest on the reef crest and lower in both the reef flat and lagoon. Intensity of parrotfish herbivory decreased as distance from the reef increased. Total herbivory was higher at the reef crest than at the reef flat or lagoon. A nocturnal study was conducted (Bizzarro and Shabel, this volume) to determine if these same patterns of herbivory are upheld at night. (JJB)

Introduction (JJB)

Thalassia testudinum (turtlegrass) and its associated epiphytes provide an important nutrient source to a large number of organisms in the nutrient poor waters of the Caribbean. Two types of organisms that utilize *T. testudinum* as a primary food source are sea urchins and parrotfish. In the waters of a North Jamaican reef, *Tripneustes ventricosus* and, to a lesser extent, *Diadema antillarum*, are the main urchin species present. Striped Parrotfish (*Scarus croicensis*) are the most abundant diurnal grazing fish with Stoplight Parrotfish (*Sparisoma uride*) also present in high numbers.

Tripneustes ventricosus aggregates in close proximity to the reef during the day, and feeds primarily at night as it migrates towards the dense turtlegrass beds of the lagoon (Tertschnig 1989). *Diadema antillarum* displays an even more extreme diel behavior, often hiding in the reef during daylight hours and migrating to denser patches of *T. testudinum* during the evening, where it obtains almost all of its daily food requirements (Ogden 1989). However, due to overcollecting the main predators of these urchins, the Queen Triggerfish (*Balistes vetula*) and the King Helmet Conch (*Cassis tuberosa*) have been effectively eliminated from Discovery Bay. Scientists familiar with the area have suggested that the feeding patterns of the urchins have been altered. Since predation pressure has been reduced or eliminated the urchins are believed to be foraging away from the protection afforded by the reef to forage in areas of more abundant *T. testudinum*. Accordingly, we hypothesized that herbivory by urchins on turtlegrass would increase with distance from the reef.

During the day, parrotfish are distributed primarily within the reef habitat and make brief and occasional forays into nearby turtle grass beds (Ogden 1976). They utilize the reef for protection and readily graze down the grasses in close proximity to the reef, creating what has been termed a "halo zone" of cropped turtle grass (Ogden 1976). Based on this information, we predicted that parrotfish herbivory should decrease with distance from the reef. We also predicted that total herbivory (parrotfish and urchin)

would show a similar trend due to disproportionately greater foraging activity of parrotfish.

Methods (EWG)

We conducted our experiments on 17 February 1992 in areas of the shore zone and reef crest at Discovery Bay Marine Laboratory, Jamaica. After collecting turtle grass on 16 February from the inshore zone, 20cm sections were cut from the blades that lacked herbivory damage. Thirty groups of six blades were fastened with a clothespin at the ends of the blade with lowest epiphyte density. These arrangements were attached in pairs to weights with the free grass ends upward, and were stored overnight in a tank with circulating ocean water.

The following morning at 1100, the weighted grass units were placed in sets of 5 at three different sites. Site 1 was located in the lagoon, site 2 was in the rear zone, and site 3 was in the reef flat (approximately 75m, 25m, and 5m from the breaker zone, respectively). The units were placed in a line horizontal to shore and spaced ~1m apart in areas naturally covered with turtle grass. A small floating vial was attached with string to the weight and served as a marker.

The grass was collected at 1700. The length of the blade sections from each site was measured, urchin herbivory was noted, and parrotfish bites were counted. Urchin herbivory results in a jagged edge along the grass, while parrotfish bites are much cleaner semi-circular indentations.

Results (JAR)

We found that *Thalassia* grazing by urchins was significantly higher at site three (reef flat) than at the rear zone or lagoon sites (χ^2=12.9, p<0.05; Table 1).

Table 1. Contingency table for number of leaves grazed by urchins at each site.

Site	1	2	3	4
#leaves grazed	2	2	12	16
#leaves not grazed	54	54	47	155
Total	56	56	59	171

The intensity of parrotfish herbivory, measured as the number of parrotfish bites per cm of remaining leaf, increased with decreased distance from the reef crest. Significantly more herbivory occurred at site 2 (rear zone) than at site 1 (lagoon; t=2.571, p < 0.02; Table 2) and at site 3 (reef flat) than site 2 (t=5.987, p<0.001; Table 2).

Table 2. Number of parrotfish bites per cm of remaining leaf.

Site	mean	s. d.	n
1	0.91	.095	56
2	.179	.237	56
3	.665	.575	59

Total herbivory, measured as the number of leaves that experienced either urchin or parrotfish herbivory was also significantly greater at site 3 than at the other two sites (χ^2=27.3, p<0.005; Table 3).

Table 3. Contingency table for number of leaves experiencing herbivory at each site.

Site	1	2	3	All
#leaves w/bites	34	35	58	127
#leaves w/no bites	22	21	1	44
Total	56	56	59	171

Discussion (ABS)

Contrary to our first hypothesis, urchin grazing decreased as distance from the reef crest increased. This suggests that the urchins have not altered their daily foraging/migration patterns to a great extent despite the removal of their natural predators by local fishermen. It is possible that these behaviors are not plastic and their alteration will only occur on an evolutionary time scale.

As predicted, parrotfish grazing intensity decreased from the reef crest to the rear zone to the lagoon. In other words, parrotfish tended to concentrate their feeding near the reef where the abundance of *Thalassia* appears to be low relative to the areas some distance away (pers. obs.). The fish are probably reluctant to leave the protection of the reef during the day because of the threat from diurnal predators.

Based on the urchin and parrotfish data, it is not surprising that overall herbivory also was less in the lagoon and rear zone. We are presently conducting a nocturnal study to determine if this is a diel phenomenon.

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