THALASSIA TESTUDINUM DENSITY AND HERBIVORY AS A FUNCTION OF DISTANCE FROM CORAL HEADS

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Abstract. Turtlegrass (*Thalassia testudinum)* provides food and shelter for many organisms in marine coastal ecosystems. In the West Indies, where turtlegrass grows near coral reefs, there is a band of nearly bare sand separating these two communities. This band has been attributed to herbivory by parrotfish, surgeonfish, and the sea urchin *Diadema antillarum*, which find refuge in the coral heads. We studied the density and distribution of *T. testudinum* on Little Cayman Island and the patterns of sea urchin and fish herbivory on *T. testudinum,* as a function of distance from coral heads. We found that density of *T. testudinum* increased and total herbivory decreased with distance away from the coral head. These findings are consistent with the hypothesis that herbivory causes or reinforces this pattern of *T. testudinum* density.

Keywords: Diadema antillarum, *parrotfish, surgeonfish, Little Cayman Island, herbivory, plant density*

INTRODUCTION

Thalassia testudinum (turtlegrass) provides food and shelter for many organisms in marine coastal ecosystems (Valentine and Heck 1999). Parrotfish, surgeonfish and sea urchins consume *T. testudinum* (Dineen 2001, Kirsh et al. 2002), potentially limiting its abundance and distribution. Nearby patch reefs provide refuge for these herbivores (Ogden et al. 1973).

A band of nearly bare sand between the base of the reef and the beds of seagrass, often referred to as a halo, occurs on patch reefs in the West Indies (Randall 1965). These bands occur independent of the physical factors around the base of coral reefs, including wave surge and turbidity (Ogden et al. 1973). These halos may be created by parrotfish (*Scarus* spp. and *Sparisoma* spp.) and surgeonfish (*Acanthurus* spp.) herbivory (Randall 1965), or by sea urchin (*Diadema antillarum)* herbivory (Ogden et al. 1973).

We measured the density and distribution of *T. testudinum* on Little Cayman Island and the patterns of sea urchin and fish herbivory, and their relationships to distance from coral heads. Since the coral heads may provide refuges for *T. testudinum* herbivores, we predicted that herbivory would be highest, and density of *T. testudinum* lowest, close to the coral head.

METHODS

We studied *T. testudinum* in the lagoon along a 200 m stretch of northern Little Cayman Island in front of the Little Cayman Research Center, from 25-26 February 2007. A strip of patch reef lies parallel to and 50 m from the shore. From this patch reef, we selected 10 isolated coral heads of approximately equal size. We ran 20-m transects from the coral heads towards the shore; these transects did not pass over other coral heads. Along each transect, we placed 0.5 m X 0.5 m quadrats every 2 m starting at 0 m. In each quadrat, we counted the number of *T. testudinum* shoots, and, in one haphazardly chosen quarter of the quadrat, we counted the number of leaves. We then counted the number of leaves with fish bite marks and *D. antillarum* bite marks in each quarter-quadrat. Herbivorous fish leave scallop-shaped marks on the *T. testudinum* blades, while *D. antillarum* leave jagged marks (Ogden et al. 1973). We also counted leaves with bite marks that were neither obviously scallop-shaped, nor jagged.

We used correlation analyses to determine the relationship between *T. testudinum* density (leaves per 0.25 m^2, square-root transformed for normality) and distance from the coral head, and between *T. testudinum* herbivory and distance from the coral head. Herbivory was quantified as the total number of leaves with bite marks. Percent herbivory was calculated for each quarter-quadrat as the number of leaves with bite marks divided by the total number of leaves. There was an effect of transect on density, absolute herbivory and percent herbivory (MANOVA, Wilks' Lambda=0.47, $F_{27,269.3}$=2.98, P<0.0001). However, a nested ANOVA ($F_{19,103}$=2.10, P=0.01) showed that the transect effect on percent herbivory (F_{10}=2.07, P=0.04) did not overwhelm the effect of distance from coral head, nested within transect (F_9=2.01, P=0.04). Therefore, in the rest of our analyses, we tested the effect of distance from coral head on density and different herbivory metrics, with data from all transects combined.

RESULTS

Thalassia testudinum density increased with distance from coral head (r = 0.45, df= 109, P< 0.0001, Figure 1). But the total number of leaves with signs of herbivory did not vary with distance from coral head (r = 0.07, df= 109, P= 0.46, Figure 2). Nor did leaves with fish herbivory (r = 0.02, df= 109, P< 0.0001) or leaves with *D. antillarum* herbivory (r = -0.06, df= 109, P< 0.0001) vary with distance from coral head. The percent of leaves with herbivory decreased with distance from the coral head (r = -0.33, df= 109, P< 0.0001, Figure 3), as did the

percent of leaves with fish herbivory (r = -0.21, df= 103, P= 0.03) and with *D. antillarum* herbivory (r = -0.25, df= 103, P= 0.01).

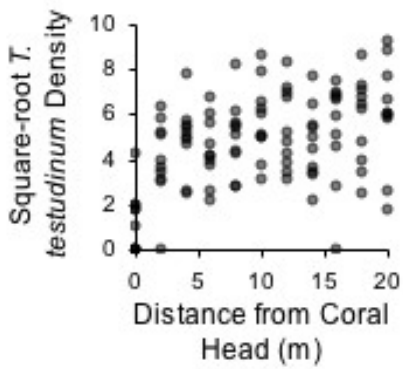

Figure 1. The number of *T. testudinum* leaves (square-root transformed) per 0.25 m^2 along 20 m transects running from coral heads perpendicular towards the northern shore of Little Cayman Island (n = 110 quadrats along 10 transects). Some dots appear darker due to overlap.

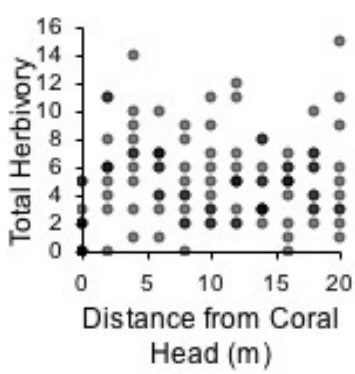

Figure 2. Total herbivory on *T. testudinum* (number of leaves with either fish bites, *D. antillarum* bites or unidentified bites) in 0.0625 m^2 subquadrats along 20 m transects running from coral heads perpendicular towards the northern shore of Little Cayman Island (n = 110 quadrats along 10 transects). Some dots appear darker due to overlap.

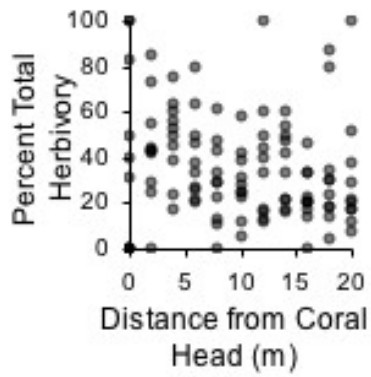

Figure 3. Percent total herbivory in *T. testudinum* (number of leaves with either fish, *D. antillarum* bites, or unidentified bites divided by the total number of leaves) in 0.0625 m^2 subquadrats along 20 m transects running from coral heads perpendicular towards the northern shore of Little Cayman Island (n = 110 quadrats along 10 transects). Some dots appear darker due to overlap.

DISCUSSION

The density of *T. testudinum* shoots increased and percent of leaves attacked by herbivores decreased with distance away from coral heads, suggesting that density is affected by and/or influences rates of herbivory. Since our transects ran perpendicular to the shore, the relationship between density and herbivory could be confounded by other gradients. *Thalassia testudinum* grows optimally in a temperature range of 20-30^{0}C (Dineen 2001) and temperature varies with water depth. While the density trend is consistent with our hypothesis and with our data on herbivore damage, a more controlled experimental design would be necessary to establish rigorously the mechanisms

responsible for the pattern in *T. testudinum* shoot density.

Since absolute herbivory, measured as the total number of leaves with herbivore damage, did not vary with distance from the coral head, our data suggest that herbivores may not seek out dense *T. testudinum* patches. Instead, they may consume whatever leaves they encounter, regardless of density. If total herbivore foraging effort were positively related to the density of *T. testudinum*, herbivory may have acted in the past to reduce the density gradient with distance from the coral head.

We calculated herbivory as the number of leaves with bite marks regardless of the number or size of marks; it might be possible to explain more of the variation in herbivory by measuring the total amount of biomass lost per leaf.

For a given patch of *T. testudinum*, the percent of leaves consumed by herbivores (which we called percent herbivory) may be more important to individual plants than the number of leaves consumed per-unit area, because the percent herbivory represents the risk of herbivory to each individual leaf. The higher percent herbivory closer to the coral head could be stunting the growth of individual *T. testudinum*, thereby decreasing its density. Alternatively, abiotic factors could be limiting *T. testudinum* density close to the coral head and herbivory may reinforce these trends.

Our study suggests that fish and urchin herbivory could be driving and/or reinforcing the pattern of increased *T. testudinum* density with distance away from the coral head. Further studies are needed to clarify causal relations between *T. testudinum* density and absolute and percent herbivory.

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