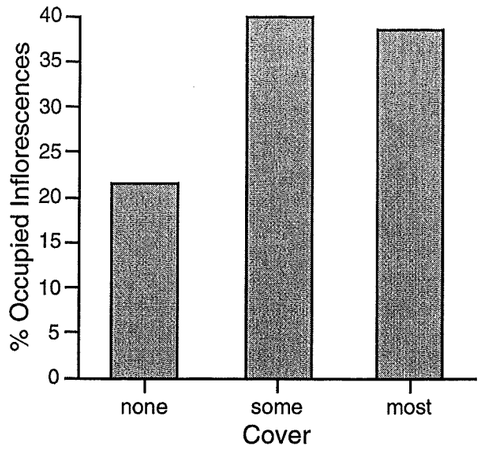

Fig. 1. Percent of inflourescences with copepods or mosquitos present. See methods for definitions of cover categories and results for sample sizes.

Copepods and mosquitos were absent more often from uncovered bracts than from covered bracts, indicating that vegetative cover is influencing aquatic invertebrate colonization or survival in each bract. Rainfall wash-out could be reducing copepod and mosquito occupancy in the bottom bracts of *H. wagneriana* inflorescences and may be even more of a negative factor for aquatic communities in the younger, higher, less protected bracts. Cover could increase colonization and survival probability in a bract by several other mechanisms as well. For example, vegetative cover may obstruct wind and filter out the wind dispersed eggs of copepods, increasing their colonization probability. Similarly, adult mosquitoes may preferentially lay their eggs into uncovered bracts. On the other hand, the abiotic factors of increased sunlight, increased temperature fluctuation (Laessle 1961) or decreased pH of bract fluid from rain (Bronstein 1986) may create less favorable conditions and a lower survival probability for copepods and mosquitoes in less covered bracts. Further study of variation between conditions in covered and uncovered bracts as well as in initial colonization and survival of copepods and mosquitoes could elucidate the mechanisms by which cover increases bract occupancy.

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Effect of Habitat on the Density and Territory Size of Two Species of Damselfish

P. Bjorn Erickson, Melissa R. Kang, and Dora J. Sugar

Abstract: Threespot Damselfish, *Stegastes planifrons*, and Dusky Damselfish, *S. fuscus*, are territorial. We observed a greater density of damselfish in the mangrove than in the back reef at Discovery Bay, Jamaica, and hypothesized that territory size is density dependent. We predicted that damselfish would have smaller territories in the more densely occupied habitat of the mangrove. We also predicted that larger fish would have larger territories. We estimated density, fish size, and territory size for the two species by observation in the mangrove and the back reef. We found greater densities and smaller territory sizes in the mangrove, but density accounted for only a small amount of variation in territory size. Fish size had no effect on territory size. These results suggest that other mechanisms may determine territory size.

Key Words: algal lawns, territoriality

Introduction

Fish of the damselfish genus, *Stegastes*, defend territories in which they maintain algal lawns (Mahoney 1981). They use the algal lawn as a source of food and a substrate on which to lay their eggs (Mahoney 1981). These damselfish chase away individuals of their own species as well as other competitive and predatory species that intrude on their territories (personal observation). We observed that the density of damselfish (primarily Threespot Damselfish, *S. planifrons*, and Dusky Damselfish, *S. fuscus*) seemed to be greater in the mangrove than in the back reef in Discovery Bay, Jamaica. We hypothesized that territory size is density-dependent and is also affected by fish size. Therefore, we predicted that territory size will be smaller in areas of higher damselfish density, and that larger fish will have larger territories. We also investigated the amount of overlap between territories, both within and between species, and its possible relationship to territory size.

Methods

We observed damselfish territories on 24-26 February 2001 at Discovery Bay, Jamaica. Ten 3 x 3 m plots which contained damselfish were haphazardly selected in both the mangrove and back reef. Within each plot, we noted the number and species of all damselfish observed. Then we haphazardly picked a focal damselfish and determined the species and size of the focal fish and all damselfish with adjoining territories. We also noted territory overlap, when two or more damselfish being observed seemed to be feeding and patrolling in the same areas. Territory size of each of these fish was determined by observing for 5 to 10 minutes and estimating the largest area where the fish was regularly patrolling and feeding. We did not include the additional distance traveled by the territory owner chasing away an intruder or the depth of any holes or crevices in our territory dimensions. Data were analyzed using ANOVA and regression. We used Welch's ANOVA to compare fish size between habitats because variances were not equal. Territory size data were normalized using a log transformation.

Results

When data for Threespot and Dusky Damselfish were pooled, damselfish density and territory size differed between habitats. Density was significantly higher (ANOVA, $F = 122.8$, $df = 1, 112$, $P < 0.0001$; Fig. 1) and territory size was smaller (ANOVA, $F = 11.19$, $df = 1, 111$, $P = 0.0011$; Fig. 2) in the mangrove than in the back reef. However, fish density

accounted for only 8% of the variation in territory size ($r^2 = 0.08$, df = 1, P = 0.0017). There was no difference in territory size between the two species in either habitat (ANOVA, F = 2.1, df = 1, 111, P = 0.15). Fish size was not correlated with territory size ($r^2 = -0.007$, df = 1, P = 0.60) and did not differ between the mangrove and back reef (Welch's ANOVA, F = 0.93, df = 1, 111, P = 0.34). Dusky Damselfish territories overlapped with either of the other damselfish territories more often (68 % of the time) than did Threespot territories (45 %, $\chi^2 = 6.5$, df = 1, P = 0.01). Dusky damselfish was the most common damselfish species in the back reef while Threespot was most common in the mangrove ($\chi^2 = 23.40$, df = 1, P < 0.0001; Table 1).

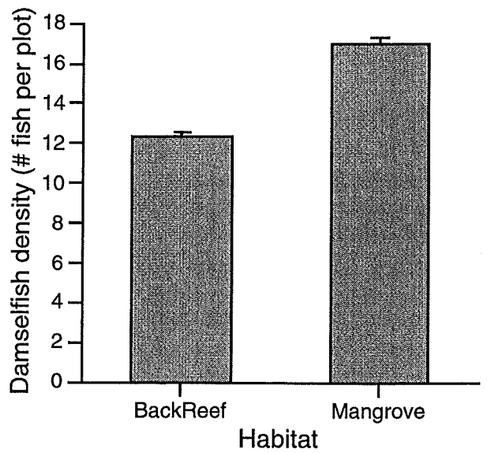

Fig. 1. Mean density of damselfish (1 ± SE) as number of fish per 9 m^2 plot measured in Discovery Bay, Jamaica. We measured 10 plots in each habitat.

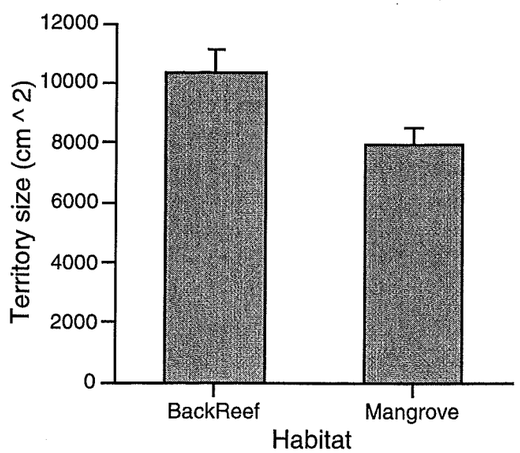

Fig. 2. Mean territory size (1 ± SE) of damselfish (Threespot and Dusky combined) estimated in two habitats (n = 114).

Table 1. Number of individuals of 4 species of damselfish by habitat type (n = 10 for each habitat type).

	Damselfish Species				
Habitat	Threespot	Dusky	Bicolor	Yellowtail	Total #
BackReef	49	64	6	4	123
Mangrove	139	32	0	0	171

Discussion

Territory size decreased with increasing fish density as expected, but the high degree of scatter around this relationship indicates that other factors besides density may be more important in determining territory size. The fact that the mangrove can support a higher density of damselfish of size comparable to those in the back reef suggests that the mangrove may have more or higher quality resources, and thus that fish may need to defend smaller territories. Alternatively, the mangrove is more sheltered from waves and turbulence, and so fish there may need to expend less energy swimming, allowing a smaller territory to provide sufficient resources. Additionally, differences in predation pressure between the two habitats may contribute to territory size. We observed more Bluehead Wrasse, which are damselfish egg predators (J. Gilbert pers. comm.), in the mangrove than in the back reef; higher predation may force damselfish to reduce territory size in order to better defend the territory.

The difference in species abundance between habitats suggests that niche partitioning may be occurring. Duskies are relatively more abundant in the back reef than Threespots and so may outcompete Threespots in that habitat while Threespots

may outcompete Duskies in the mangrove habitat. The variation in amount of territory overlap between species implies that the two species may have different strategies for territory defense. Perhaps Duskies use overlap as a means to increase territory size without proportionally increasing individual defense effort, while Threespots expend greater energy on defense in order to retain exclusive access to territory resources.

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