DISTRIBUTION AND SOURCES OF FISH SPECIES RICHNESS IN WEST DISCOVERY BAY

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Abstract: Fish communities in coral reef ecosystems exhibit tremendous diversity, perhaps due to effective partitioning of a highly diverse resource base. We conducted day and night fish censuses in turtle grass flats and the back reefs in Discovery Bay, Jamaica, to test the hypothesis that resources in the bay are both spatially and temporally partitioned. We found 88 fish species: 37 species found only in back reef habitat and 13 species found only in turtle grass. Additionally, we found 41 fish species only during the day and 21 found only during the night. Species-area curves for back reef and turtle grass habitats suggested that the back reef displayed higher species richness, as well as higher alpha and beta diversity, indicating that the putative greater structural complexity of the back reef habitat contributes more to the overall fish community diversity than the structurally simpler turtle grass.

Key Words: resource partitioning, fish community, α- and β-diversity

INTRODUCTION

Fish communities in coral reef ecosystems are highly speciose (Horn 1989), and researchers have proposed many hypotheses to explain this high degree of diversity(Begon et al. 1990). One such hypothesis is resource partitioning, in which resources are divided among species (either temporally or spatially), reducing interspecific competition and allowing greater species coexistence (Gutierrez 1998, Pitts 1991).

We observed fish populations in 2 different habitats—turtle grass flats and the back coral reef—in Discovery Bay, Jamaica. We sampled community species richness during both daytime and night-time hours to test for both spatial and temporal partitioning. By assessing the community composition overlap spatially and temporally, we hypothesized that we would find evidence for resource partitioning within the greater coral reef fish community. We predicted that observed fish species would vary between day and night sampling in both habitats, indicating temporal partitioning. Additionally, we hypothesized that fish species would vary across habitats, showing evidence of spatial partitioning.

We also investigated the relative contributions of each habitat type to the overall fish community diversity. Determining species richness depends on the scale at which it is assessed. Therefore we attempted to quantify both alpha (mean number of species per plot) and beta (rate at which new species are included with increased samples) diversity for these two Discovery Bay habitats. We predicted that fish species richness, as well as alpha and beta diversity, will be greater in the back reef—possibly due to the increased spatial complexity found there.

METHODS

On 24 February 2006, eight volunteer pairs observed 16 turtle grass and 16 back reef plots near the Discovery Bay Marine Laboratory for 30 minutes per plot. We observed half of the plots (n = 8 turtle grass, n = 8 back reef) during daytime hours between 10:00 – 12:00, and the remaining plots during night-time hours between 21:00 – 22:00. Each volunteer pair compiled a list of fish species observed at each plot. We then generated Venn diagrams to compare the overlap in species community composition between habitats and times.

We combined night and day observations within each habitat to compare each habitat's relative contribution to overall fish community diversity. We generated a species-area curve for each habitat by pooling each habitat's daytime and night-time samples and calculating the mean number of species observed in all possible combinations of 1 through 16 samples, using PC Ord v.3 software. We estimated habitat species richness by fitting a Michaelis-Menten saturation function to the data from our species-area curves:

$$y = \frac{K * x}{d + x}$$

[Eq. 1]

Where K is an estimate of total species richness for each habitat and d is the half saturation point of the species-area curve (Raines and Stork 2006). We estimated each habitat's beta diversity using Gleason's (1922) logarithmic model:

$$\log(E[S_n]) = h\log(n) + k$$

[Eq. 2]

where k is the y-intercept and h is slope, where greater slope equals increased beta diversity (Raines and Stork 2006).

RESULTS

We observed a total of 88 fish species in both habitats (Appendix A). Fish species diversity was highest in the daytime back reef habitat (60 species), followed by night-time reef (38), daytime turtle grass (32) and night-time turtle grass (24). The community composition actually exhibited a high amount of overlap, with many species found in both habitat types and observed during both times of the day (Figure 1). Species overlap was highest when pooled daytime and night-time observations compared turtle grass and back reef habitats: we observed 38 species (or 42% of all species) in both habitats. Daytime and night-time spatial partitioning was approximately equivalent. We observed 37% of all diurnal species and 35% of all nocturnal species in both habitats. Turtle grass habitat displayed the great proportion of temporal partitioning. Of the 51 species observed in turtle grass, we found only 12% in both daytime and night-time sampling.

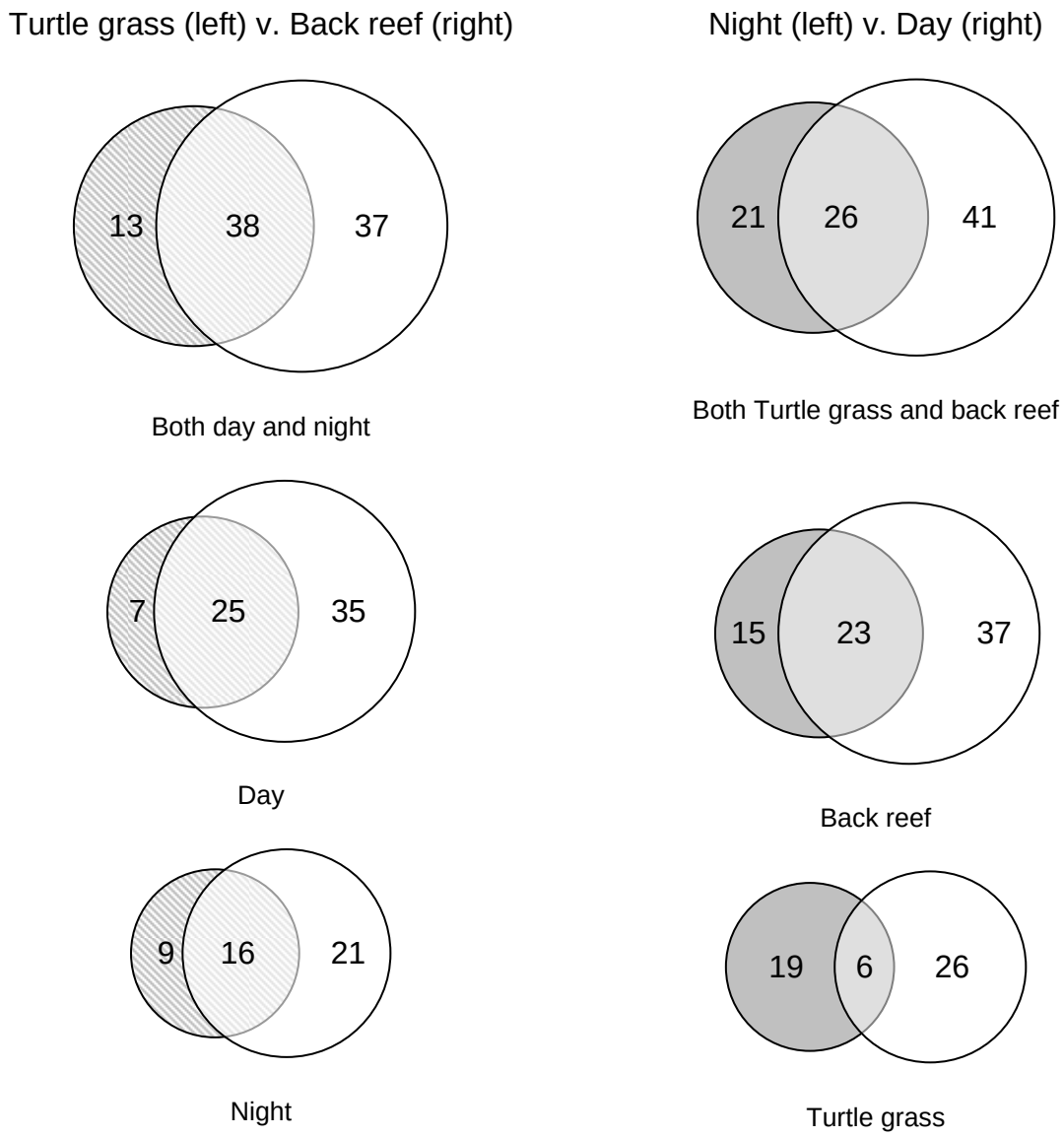

Figure 1. Number of fish species observed during day and night sampling in both turtle grass and back reef habitats in Discovery Bay, Jamaica. Size of circles is proportional to the total number of species observed in each population.

Back reef habitat displayed evidence of higher alpha diversity than turtle grass (mean species per sampled plot ± 1 SE; back reef = 15.69 ± 1.64, turtle grass = 8.38 ± 0.91;$t_{1,31}$ = 2.87, P < 0.01). Michaelis-Menton functions fit to our sample data (Figure 2) show that the species-area curve for back reef habitat approaches significantly greater species richness than turtle grass (K [Eq. 1], ± 1 SE; back reef = 100.13 ± 2.17, turtle grass = 81.32 ± 1.15, $t_{1,30}$ = 43.16, P < 0.0001). Beta diversity was actually higher in the turtle grass area than the back reef area (back reef: $\log(E[S_n]) = \mathbf{0.534}\log(n) + 2.858$, $r^2 = 0.990$; turtle grass: $\log(E[S_n]) = \mathbf{0.634}\log(n) + 2.256$, $r^2 = 0.988$; $t_{1,30}$= 4.49, p<0.001, Fig. 2).

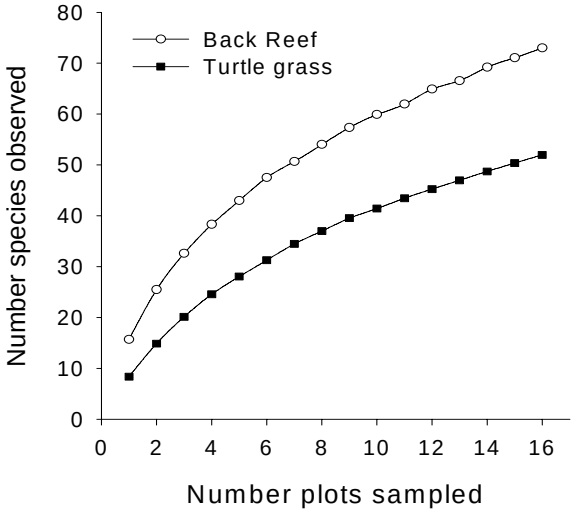

Figure 2. Species-area curves for back reef and turtle grass habitat in Discovery Bay, Jamaica, including both day and night sampling. Points represent the mean number of species found in all permutations of pooled sites, and obscure the standard error bars.

DISCUSSION

We found evidence for spatial and temporal resource partitioning in the coral reef fish communities of Discovery Bay, yet we found more species overlap between times and habitats then would be expected had there been complete resource partitioning between species. There were generally many more species during the day, potentially among more fish species depend on vision to locate food resources, find mates, and avoid predators. The diel fluctuation in the turtle grass habitat has less species overlap than in the back reef, perhaps because turtle grass primarily represents a food resource and is not a suitable refuge from predators during rest; therefore, the changeover from diurnal to nocturnal communities is more pronounced. It is possible that the observed temporal and spatial species overlap is an artifact of the sampling design: observers did not distinguish between active and resting fish, which may overestimate overlap in resource use. Moreover, it was more difficult to observe fish in the dark of night and species found in just one habitat may have gone undetected.

Both observed and projected species richness were far greater in the back reef habitat than in turtle grass, perhaps because the back reef is a more topographically complex habitat and provides more diverse food resources in the form of algal growth and invertebrate communities. This abundance and diversity of resources may result in a greater number of available niches for species to fill, and could explain the higher species richness. The overlap we observed in fish species' habitat use for our pooled daytime and night-time observations may be caused by fishes moving to and fro between turtle grass and coral reef habitats, using different habitats for either foraging or refuge.

The higher alpha diversity of the back reef can be explained by (1) more complex topographic structure and more diverse food resources, and (2) a combination of both foraging grounds and refuge habitats over a 24-hour period. The higher beta diversity in the turtle grass can be explained by the larger scale of topographic complexity within this habitat, with different topographies found tens of meters apart as opposed to tens of centimeters apart in the back reef.

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Appendix A. Fish species observed in two Discovery Bay habitat types on February , 2006.

	Back reef		Turtle Grass	
Species	Day	Night	Day	Night
Angel, French	X	X	X	
Balloonfish	X	X		X
Bass, Harlequin	X			
Basslet, Fairy			X	
Bigeye		X		
Blenny, Dusky			X	
Blenny, Hairy	X			
Blenny, Redlip	X			
Blenny, Rosey	X			
Blenny, Saddled	X			
Blue tang	X		X	
Butterflyfish, Foureye	X		X	
Cardinalfish, Dusky		X		X
Cardinalfish, Mimic		X		
Cardinalfish, Roughlip		X		X
Coney		X		
Damselfish, Beaugregory	X	X	X	
Damselfish, Bicolor	X			
Damselfish, Cocoa	X			
Damselfish, Longfin	X			
Damselfish, Three spot	X	X	X	
Damselfish, Yellowtail	X	X	X	
Damslefish, Dusky	X	X	X	
Doctorfish	X	X	X	X
Eel, Gold Stopped				X
Flamefish		X		X
Flounder, Eyed	X			
Goatfish, Dwarf		X		
Goatfish, spotted	X		X	X
Goby, Bridled			X	
Goby, Cleaning			X	
Goby, Goldspot			X	
Grunt, Bluestriped	X			
Grunt, French	X			X
Hamlet, Barred	X			
Hamlet, Black		X		
Hamlet, Blue	X			
Hamlet, Indigo	X	X		
Herring				X
Hound Fish	X			
Lizardfish, Bluestriped	X		X	
Major, Sargeant	X	X	X	
Moray, Spotted		X		
Morray, Goldentail				X
Needlefish, Keeltail	X			
Ocean surgeonfish	X	X	X	
Parrotfish, Bluelip	X			
Parrotfish, Bucktooth	X		X	
Parrotfish, Greenblotch	X			

Parrotfish, Princess	X		X	
Parrotfish, Queen	X			
Parrotfish, Redband	X	X	X	X
Parrotfish, Redfin	X			
Parrotfish, Stoplight	X	X	X	X
Parrotfish, Striped	X		X	X
Parrotfish, Yellowtail	X			
Pinfish	X			
Pipefish, Harlequin	X		X	
Porcupinefish	X			
Porgy, Sheepshead		X		X
Ray, Lesser Electric				X
Reef croaker		X		X
Rock beauty	X			
Rock hind			X	
Sand Diver	X	X		
Scorpionfish, Spotted	X	X	X	
Sergeant, Night	X	X		
Silversides	X	X	X	X
Slippery dick	X		X	
Snapper, Glasseye		X		
Snapper, Yellow Fin	X			
Snapper, Yellow Tail			X	
Soapfish, Greater		X		
Soldierfish, Blackbar	X	X		
Squirrelfish	X	X		X
Squirrelfish, Dusky		X		X
Squirrelfish, Longjaw	X	X		X
Squirrelfish, Reef	X	X		X
Squirrlefish, Longspine	X	X		X
Stingray, southern	X			
Stingray, Yellow				X
Sweeper, Glassy		X		X
Trumpetfish	X	X	X	
Wrasse, Blackear	X			
Wrasse, Bluehead	X	X	X	
Wrasse, Clown	X		X	
Wrasse, Yellowhead	X		X	