Fish community diversity, structure, and niche utilization in Discovery Bay, Jamaica

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Abstract: Niche differentiation is one process that may be structuring and maintaining the high species diversity of coral reef fish communities. Previous studies in Discovery Bay have shown that community composition differs between day and night. We show that species also utilize different habitats. The high number of rare species and lack of species dominance within habitats is characteristic of a community structured both by local interactions and high rates of immigration.

Key Words: metacommunity, niche differentiation, species rank-abundance curves, species richness

Introduction

Coral reefs support a high diversity of fish. While there is some debate over the processes assembling and maintaining this diversity (Jones 1991), niche partitioning is common in tropical fish families (Anderson et al. 1981, Mcafee and Morgan 1996). Previous Dartmouth studies (Pickhardt 1999, Nagy 2000) found a change in community composition of the fish in Discovery Bay, Jamaica, between day and night and suggested that temporal niche diversification promotes species coexistence. In this study, we demonstrate community variation across habitat types as well as time of day. Additionally, we relate the structure of the Discovery Bay coral reef fish community to theories of community assembly.

Methods

Nine pairs of snorkelers recorded all fish species they found in reef, patch reef, sand, and turtle grass habitats at 9:00 and 20:00 along the West Back Reef of Discovery Bay, Jamaica on 28 February, 2001. Night sampling was conducted under a waxing crescent moon. Each pair surveyed every habitat for 15 minutes.

To test for niche differentiation, we compared fish species richness across habitats and between night and day in a two-way ANOVA. We also calculated the percent species overlap between night and day for each habitat. The proportion of pairs that saw each species was used as a measure of abundance to create a species rank-relative abundance curve illustrating community structure (Tokeshi 1993). We investigated the relationship between abundance and richness by linear regression through habitat-at-time means.

Results

We found a total of 85 species of fish in our day and night surveys; 33 were only observed during the day, 25 only during the night, and 27 species occurred during both the day and night (Table 1). Richness differed significantly across habitats between night and day (interaction $F = 5.41$, $df = 3,62$, $P < 0.003$, Fig. 1). Reefs and patch reefs harbor more species than grass or sand habitats (habitat effect $F = 19.92$, $df = 3,62$, $P < 0.0001$, Tukey pairwise comparison at the 0.05 level). More species are visible during the day than at night (time effect $F = 6.20$, $df = 1,62$, $P < 0.016$). The percentage of species overlapping day and night surveys within each habitat was 28.2% in the reef, 24.3% in the patch reef, 11.8% in *Thalassia* beds, and 26.1% the sand (Fig. 2).

The species rank-abundance curve for all observations (Fig. 3) has the shape typical of speciose communities (Hubbell 1997). Relative abundance declines rapidly with rank for common species, then plateaus for species of intermediate rank. There are many ties for rank among rare species, forcing rank values farther apart in the tail of the curve. Average species abundance increases with habitat species richness ($r^2 = 0.80$, $df = 1,6$, $P = 0.0026$, Fig. 4).

Discussion

We found fewer species of fish than past surveys (99 by Pickhardt 1999, 102 by Nagy et al. 2000), partly due to the fact that we did not see as many species that overlapped temporal niches. Sampling efforts differed in all three studies; thus this comparison may not be entirely valid.

The pattern of spatial and temporal variation in community composition of coral reef fish in Discovery Bay suggests niche partitioning by constituent species. Most species within each habitat temporally divided niche space. About a quarter of the species in reef, patch reef, and grass habitats are visible during both the day and the night, twice the fraction overlapping temporal niches in the grass habitat (Fig. 2). This pattern may owe to real differences in the degree of niche differentiation between the grass habitat and other habi

Table 1. Fish sighted during day and night surveys. Habitat shows where the fish species was observed (G = Grass, P = Patch Reef, R = Reef, S = Sand). Abundance indicates frequency of species sighting in all the habitats combined.

DAY ONLY			NIGHT ONLY		
SPECIES	HABITAT	ABUNDANCE	SPECIES	HABITAT	ABUNDANCE
bandtail searobin	S	0.03	burrfish, bridled	G	0.03
blenny, dusky	P	0.03	cardinalfish, barred	R	0.03
blenny, hairy	P	0.06	cardinalfish, dusky	G, P, R	0.22
blenny, palehead	P	0.08	croaker, striped	S	0.03
blue tang	G, P, R	0.25	drum, spotted	R	0.03
butterflyfish, longsnout	R	0.03	eel, sharptail	P	0.03
damselfish, longfin	R	0.03	flamefish	P	0.14
doctorfish	G, P, R, S	0.33	glassy sweeper	R	0.06
fairy basslet	S	0.03	hamlet, butter	P	0.03
flounder, peacock	P, S	0.06	moray, spotted	R	0.03
goby, cleaning	P	0.03	night sergeant	G, R	0.08
goby, dash	S	0.03	parrotfish, rainbow	R	0.03
goby, goldspot	P	0.03	pipefish, harlequin	G	0.03
goby, orange spotted	P	0.03	porcupinefish	G, P	0.06
grunt, bluestriped	R	0.06	ray, lesser electric	G, R, S	0.17
grunt, striped	P, R	0.08	ray, yellow sting	G, S	0.17
grunt, white	R	0.03	sand perch	S	0.03
jack, bar	G, S	0.06	sardine	R	0.03
jack, yellow	G	0.03	scorpionfish, spotted	G	0.03
lizardfish, blue striped	S	0.03	soldierfish, blackbar	R	0.08
parrotfish, princess	G, P, R, S	0.25	soldierfish, cardinal	R	0.03
parrotfish, redband	R	0.08	squirrelfish, dusky	G, R, S	0.17
parrotfish, striped	G, P, R	0.25	squirrelfish, longjaw	G, P, R	0.31
razorfish, green	G	0.03	squirrelfish, reef	G, P, R, S	0.33
rock beauty	P	0.03	tomtate	G	0.03
seahorse	G	0.03			
slippery dick	G, P, R	0.14			
snapper, yellowtail	G	0.03			
triggerfish, ocean	S	0.03			
wrasse, bluehead	G, P, R, S	0.53			
wrasse, clown	P, R	0.11			
wrasse, yellowhead	P, R	0.06			
wrasse, yellowtail	P	0.03			

Table 1. (cont.)

DAY AND NIGHT	HABITAT		ABUNDANCE	
SPECIES	DAY	NIGHT	DAY	NIGHT
balloonfish	G, P, R, S	G, P, R, S	0.33	0.92
bass, harlequin	R	G	0.03	0.03
beaugregory	G, P, R, S	P	0.39	0.06
croaker, reef	P, R	G, R	0.06	0.06
damselfish, bicolor	P, R	P	0.33	0.03
damselfish, dusky	G, P, R	P, R	0.47	0.19
damselfish, threespot	G, P, R, S	P	0.5	0.08
damselfish, yellowtail	P, R, S	R	0.19	0.03
goatfish, spotted	G, P, R	S	0.22	0.06
goby, bridled	S	S	0.03	0.03
grunt, caesar	R	P	0.03	0.03
grunt, french	P, R	G, P	0.25	0.06
grunt, smallmouth	R	G	0.03	0.03
houndfish	R	S	0.03	0.03
mojarra, mottled	G, S	G, S	0.14	0.06
mojarra, slender	S	S	0.06	0.06
mojarra, yellowfin	G, S	G, P, R, S	0.11	0.19
parrotfish, redtail	P	R	0.03	0.03
parrotfish, stoplight	P, R	P, R	0.39	0.11
parrotfish, yellowtail	P, R	R	0.06	0.03
sand diver	S	P	0.03	0.03
sergeant major	P, R	R	0.25	0.03
silverside	G, S	G, P, R, S	0.25	0.67
squirrelfish	P, R	G, P, R, S	0.28	0.67
squirrelfish, longspine	R	P, R, S	0.03	0.22
surgeonfish, ocean	G, P, R	P, R	0.08	0.06
trumpetfish	R	R	0.11	0.06

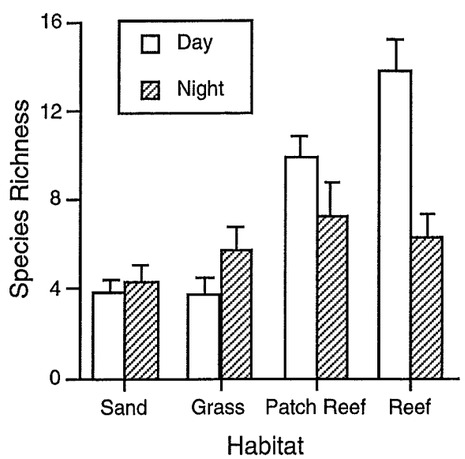

Fig. 1. Mean (± 1SE) species richness by habitat and time of day for fish in Discovery Bay, Jamaica.

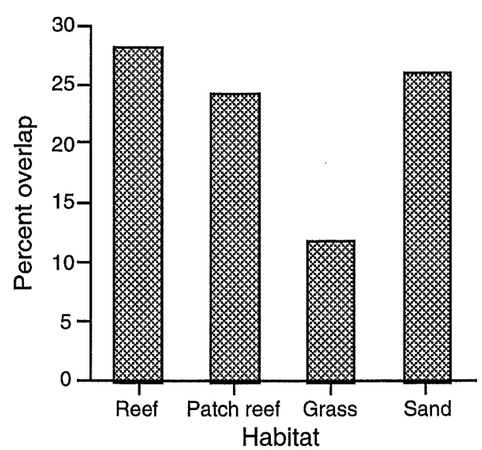

Fig. 2. Percentage of fish found both day and night in each habitat type.

tat types, or may be the result of increased crypsis of inactive fish under grass cover.

The plateau region (hollow arrow, Fig. 3) of rank-abundance curves is only present in communities of high diversity and is most exaggerated in systems characterized by local monodominance and low immigration (Hubbell 1997). While it is a qualitative measure of community structure, the small and unpronounced plateau of the Discovery Bay curve suggests that the community is structured, at least in part, by non-equilibrium processes such as dispersal.

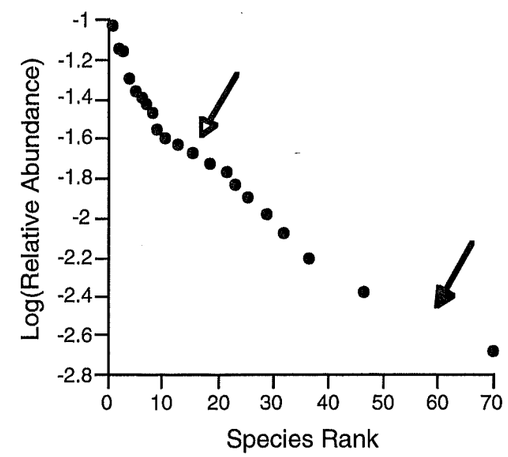

Fig. 3. Pooled species rank-abundance curve for four habitat types along the west back reef of Discovery Bay, Jamaica. The hollow arrow indicates the plateau typical of such curves. The solid arrow indicates the greatest distance between two ranks.

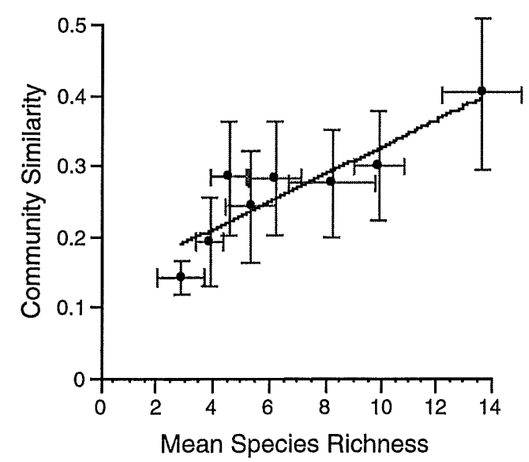

Fig. 4. The relationship between fish species richness and distribution in Discovery Bay, Jamaica. $r^2 = 0.80$.

Indeed, the positive relationship between habitat-at-time richness and mean species abundance can be interpreted as evidence that coexistence within habitats is achieved through some process other than spatial subdivision. Though we did not record the number of fish each survey team encountered in a sampling bout, our personal observation was that sand and grass habitats had the fewest individuals per area, patch reefs had more, and reef habitats had the highest density of fish. Viewed in light of this observation, the positive relationship between richness and species abundance can be interpreted three ways. First, evolutionary processes may have resulted in fewer specialists in habitats of low resource density, and therefore fewer species where fewer fish can be supported. Alternatively, habitat communities may be a random subset of the available species pool, and the probability of having multiple individuals of the same species increases with the total number of individuals in a habitat. Finally, the positive relationship may be a spurious result of the differences in abundance between habitats.

In conclusion, there is significant support for both diel and habitat niche differentiation in the fish community of Discovery Bay, but other factors contribute to the maintenance of diversity. Some doubt remains as to whether habitat differentiation is a spurious result of variation in fish population density. This question may be resolved by a study which standardizes the number of individuals sampled in each habitat or which measures diversity by some index that is independent of sample size, such as Fisher's alpha (Hubbell, 1997).

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