# DIEL PATTERNS OF DIVERSITY AND NICHE DIFFERENTIATION OF BACK REEF FISHES AT DISCOVERY BAY, JAMAICA.

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*Abstract.* We surveyed the diversity of fishes in the back reef of western Discovery Bay, Jamaica. We used snorkeling transects during day and night across two distinct back reef habitats to record species present, whether they were common or rare, and their activity and schooling behavior. We used published reports of species' diet to assess spatial, temporal, behavioral and dietary niche differentiation in these fishes. Fish diversity was greater during the day especially near the reef crest. Proportion of species that were found in schools and proportion that were herbivores was much higher during the day while proportion of carnivores was higher at night. There were effects of habitat type on proportions of carnivores and piscivores, with carnivores more common near the reef and piscivores more common near the shore. Interesting interactions between habitat type and time of day and between reef region and time of day on patterns of diversity are also discussed. Our results suggest that fine scale niche differentiation can explain many of the patterns in diversity of coral reef fishes.

*Key words: coral reef fishes, back reef, diel migration, niche differentiation, herbivores, carnivores, piscivores, planktivores*

## INTRODUCTION

On the North coast of Jamaica, a narrow shelf of fringing coral reef supports a diverse fish community that differs in composition and relative abundance between day and night and between habitat types (Gilbertson et al. 1997). We recognized at least two distinct habitats in the back reef adjacent to the Discovery Bay Marine Laboratory: (1) near shore shallows of mixed sand and turtlegrass beds in depths of 0 - 1.5 m, and (2) near reef crest of more vertical relief from numerous patch reefs separated by narrow stretches of sand, algae and turtle grass beds at depths of 1 - 3 m with reef crests at or near the surface. In addition to these distinct habitat types, there is also the potential for fine scale niche differentiation in fishes within and between habitats. These niche axes include time and depth of activity, differences in structural complexity, substrate preferences, diet preferences and differences in social behavior.

We examined the diversity of the fish community on the west back reef of Discovery Bay, Jamaica. We proposed fine scale niche differentiation as a mechanism to explain much of this diversity. By assessing the spatial, temporal, behavioral and dietary patterns of these fishes we can begin to characterize the composition and dynamics of the back reef fish community. This study may also contribute to the development of a long term database on community changes in Discovery Bay. The coral reefs in this region have experienced numerous natural and anthropogenic disturbances in the past 15 years (e.g. overfishing, devastating hurricanes, profound dieoffs of once dominant urchins). While it is well beyond the scope of this study to generate a picture of a baseline fish community before these changes, it is certainly possible and important to characterize the current fish community, such that future fluctuations can be seen in relation to the present.

## METHODS

We surveyed fish diversity, abundance and activity along 8 transects from near shore to reef crest in the back reef along the western rim of Discovery Bay, Jamaica (Fig. 1). Transects were spaced along the back reef from East to West (running South to North). They were grouped as replicates of 3 regions of the back reef: (a) westernmost region encompassing the canoe channel North of the marine laboratory (n = 3), (b) a middle region of well protected back reef (n = 3), and (c) easternmost region skirting the "blue hole" area of deeper back reef (n = 2). Each transect was divided into two segments representing two distinct habitat types of the back reef: (1) near shore shallows of sand and turtle grass beds at depths of 0 - 1.5 m, and (2) near reef crest with more vertical relief from numerous patch reefs separated by narrow sand and turtle grass channels at depths of 1 - 3 m with reef crests lying at or near the surface. We surveyed between 08:00 and 09:30 (day) and again between 19:30 and 21:30 (night) on 28 February 1998. Each transect was surveyed by two snorkelers, and observations were recorded during one pass in each direction (North from the shore to the reef crest and back). Fish observed were identified to species and recorded as common or uncommon, as active, inactive or hiding, and as solitary or schooling. A species encountered more than twice within a transect was initially recorded as common. In subsequent analysis, any species initially classified as uncommon, but occurring in more than two transects was reclassified as common. Dietary preferences of each species were taken from the literature (Randall 1967).

A 3 - way ANOVA tested the effects of reef region (East to West), habitat (near shore or near reef) and time of day (day or night), and interactions between these variables on species richness, and proportions of active fish found schooling and classified as herbivores, carnivores, planktivores and piscivores. The 3-way interaction (region X habitat X time of day) was not significant for any dependent variable and was excluded from the model. Proportions of herbivores, carnivores, planktivores and piscivores were arcsine transformed prior to ANOVA tests. Carnivores were defined as fish consuming benthic invertebrates such as shrimp, crabs and echinoids. All dietary-preference categories were based on diet items making up at least 90% of total diet for each fish species, as described by Randall (1967).

## RESULTS

The fish community was much more speciose during the day than at night, and there was a marginally significant interaction between habitat and time of day on number of species. There was a greater increase in species richness between night and day near the reef crest than near the shore (ANOVA results Table 1, Figure 2). The proportion of species found in schools was greater during the day but did not differ between habitats. There was a significant interaction between region and time of day on proportion of fishes found in schools (Table 1, Figure 3). There was a lower proportion of schoolers during the day in region b and a lesser difference in proportion schooling between night and day in region b than in other regions. There was a far greater proportion of herbivores during the day across all habitats and regions (Table 2, Figure 4). Herbivores were the most common functional group of fishes during the day in the back reef. There was no effect of region, habitat type or time of day on proportion of planktivorous fishes (Table 2, Figure 5), and these fish generally had lower relative abundance than any other functional group.

There was a marginally significant interaction between habitat type and time of day on proportion of fishes that were carnivores. There were also significant main effects of reef region, habitat type and time of day on this proportion(Table 2, Figure 6). Carnivorous fish made up roughly 30% of the back reef community in all regions and habitat types during the day. During the night however, proportions of carnivores increased most near the reef, and most in regions a and c. Carnivores were by far the most common functional group of fishes at night, comprising between 50% and 90% of the community at that time. There was a significant interaction between habitat and time of day on proportion of piscivores in the community, as well as a significant main effect of habitat and a marginally significant effect of region (Table 2, Figure 7). Piscivores increased in relative abundance between night and day near the shore, especially in region b. There was no change near the reef. Piscivores were the second least common functional group of fishes overall in the Discovery Bay back reef.

TABLE 1. ANOVA results for effects of reef region, habitat type, and time of day on fish species richness and proportion of species schooling found in surveys of western Discover Bay, Jamaica ($df_{error} = 24$)

| | | Species Richness | | Proportion of species schooling | |
|---|---|---|---|---|---|
| Effect | df | F | P | F | P |
| Region | 2 | 2.26 | 0.128 | 0.49 | 0.617 |
| Habitat | 1 | 1.25 | 0.275 | 0.02 | 0.902 |
| Time | 1 | 56.52 | <0.001 | 29.03 | <0.001 |
| Habitat X Time | 1 | 4.10 | 0.055 | 1.24 | 0.277 |
| Region X Time | 2 | 0.26 | 0.774 | 4.07 | 0.031 |
| Habitat X Region | 2 | 1.06 | 0.363 | 0.39 | 0.684 |

TABLE 2. ANOVA results for effects of reef region, habitat type and time of day on arcsine-transformed proportions of herbivores, carnivores, planktivores and piscivores found in the west back reef of Discovery Bay, Jamaica ($df_{error} = 24$).

| | | Arcsine Proportion of | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Herbivores | | Carnivores | | Planktivores | | Piscivores | |
| Effect | df | F | P | F | P | F | P | F | P |
| Region | 2 | 1.70 | 0.206 | 6.39 | 0.0065 | 0..70 | 0.507 | 2.76 | 0.085 |
| Habitat | 1 | 0.01 | 0.920 | 8.68 | 0.0075 | 0.36 | 0.554 | 6.10 | 0.022 |
| Time | 1 | 81.19 | <0.001 | 64.10 | <0.001 | 0.042 | 0.840 | 0.18 | 0.671 |
| Habitat X Time | 1 | 0.28 | 0.601 | 4.03 | 0.0571 | 2.63 | 0.120 | 4.70 | 0.041 |
| Region X Time | 2 | 0.99 | 0.389 | 2.39 | 0.115 | 1.66 | 0.214 | 0.49 | 0.617 |
| Habitat X Region | 2 | 0.88 | 0.429 | 0.68 | 0.515 | 0.26 | 0.772 | 0.12 | 0.886 |

## DISCUSSION

The fish diversity in the back reef at Discovery Bay shows remarkable diel patterns and also some interesting patterns among the two habitat types that we recognized. Our results showing a strong decrease in species richness from day to night, especially near the reef, are complimented by the finding of Gilbertson et al. (1997) of such a decreased in fish abundance. The much higher proportion of herbivores that we found during the day was also reported by Gilbertson et al. (1997). In contrast to our study though, they found that the relative abundance of "planktivore / invertebrate feeders" increased at night. It is likely that their study included fish in this classification that ate macroinvertebrates as well. These fish would be considered carnivores in our study. Our study found no diel change in planktivorous fish, but a strong increase in relative abundance of carnivores at night. Both plankton and macroinvertebrates increase in abundance at night in Discovery Bay (Dums et al. 1997; G.K. Eaton pers. obs.) and would contribute to a larger food base for both planktivores and carnivores. Dums et al. (1997) found that plankton increased more near the shore at night, while shrimp and sea urchins are more abundant closer to the reef at night (G.K. Eaton pers. obs.). We would anticipate a greater increase in carnivores near the reef at night if they were tracking trends in prey abundance. Planktivores and carnivores, as we have classified them, occupy very different niches in the back reef and we feel it is important to characterize their distributions separately.

Other diel changes in the fish community that are interesting, if unsurprising, are the decrease in schooling behavior and the decrease in herbivores. We assume that schooling requires visual cues, although some chemical signaling may also be involved. This could limit schooling at night. We found that fish in region b showed less of a decrease in this behaviour at night than fish in the other regions. Region b is a well protected, structurally heterogeneous stretch of back reef. The fish community here is apparently more constant in composition than in other regions. This is supported by results indicating that diel change in proportion of carnivores is also less in this region. In contrast, region a includes the "canoe channel", an area where the fringing reef is not continuous and provides an open conduit between the back reef and fore reef. This may allow greater migration of carnivores at night and foraging schools by day, creating a more dynamic community. Region a also skirted some coastal coral substrate and mangrove habitat that contributed to slightly greater (though not significantly different) fish diversity both day and night in this region. Region c, on the other hand, includes more sand and turtle grass bed habitat that is more open and less structurally complex. This may provide easier hunting for carnivores.

Another effect of habitat and region that is interesting is that on the proportion of piscivores. These were more abundant near the shore and more abundant in regions a and b than in region c. Many of these fish depend on fast swimming speed (as opposed to ambush tactics) to catch their prey. This tactic would be more effective in the open water near the shore where reef outcrops do not hinder their movement. It is also likely that many of these fish migrate from the fore reef to the back reef. Regions a and b are closer to the canoe channel than region c, and so may harbor more of these migratory fish. Many nocturnal piscivorous fish have large eyes and presumably greater visual acuity. The proportion of piscivores did increase at night when habitat and regions were pooled, but the diel difference was not significant.





We can conclude that there is a great potential for fine-scale niche differentiation in the west back reef of Discovery Bay. We feel that this can explain much of the diversity of fishes in this environment. Future studies on spatial, temporal, behavioral and dietary differences in these fish should lead to a greater understanding of the maintenance of high species diversity in coral reefs.

## LITERATURE CITED

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APPENDIX. List of fish species found in west back reef of Discovery Bay, Jamaica, W.I.

72 species found, 48 species day active, 24 species night active. H = herbivore, C = carnivore, P = piscivore, Pl = planktivore, O = other.

**Day Active** (a = also found inactive or hiding at night, b = at least occasionally found in schools).

Common
Beaugregory, H
Blue Tang (a, b), H
Bicolor Damselfish, H
Dusky Damselfish (a), H
Three-spot Damselfish (a), H
Yellowtail Damselfish, H
Doctorfish (a, b), H
Spotted Goatfish (a, b), C
Goby, O
Bluestriped Grunt (a, b), C
French Grunt (a, b), C
Yellowfin Mojarra (a, b), C
Ocean Surgeonfish (a, b), H
Stoplight Parrotfish (a, b), H
Striped Parrotfish (a, b), H
Sergeant Major (a, b), Pl
Trumpetfish (a), P
Bluehead Wrasse (b), Pl
Yellowhead Wrasse (b), C

Uncommon
French Angelfish, H
Harlequin Bass (a), C
Fairy Basslet, Pl
Blenny (a, b), H
Four-eye Butterflyfish (a, b), C
Longsnout butterflyfish, C
Spotfin Butterflyfish, C
Blue Chromis, Pl
Coney, P
Spotted Moray Eel (a), P
Flounder, P
Yellow Goatfish (b), C
Barred Hamlet, C
Butter Hamlet, C
Indigo Hamlet, C
Houndfish (a), P
Yellow Jack, P
Lizardfish (a), P
Bucktooth Parrotfish (a, b), H
Princess Parrotfish (a, b), H
Pipefish, H
Porkfish, C
Rainbow Runner, P
Sharpnose Puffer, H
Slippery Dick (b), C
Longtail Snapper, C
Yellowtail Snapper, C
Clown Wrasse (b), Pl
Creole Wrasse (b), Pl

**Night Active** (a = also found inactive or hiding in day, b = at least occasionally found in schools)

Common
Balloonfish (a), C
Cardinalfish, C
Barred Cardinalfish, C
Flamefish (b), C
Bar Jack (a, b), P
Needlefish (a, b), P
Hardhead Silverside (a, b), Pl
Squirrelfish (a), C
Dusky Squirrelfish (a), C
Longjaw Squirrelfish (a), C
Longspine Squirrelfish (a), C
Reef Squirrelfish, C
Yellow Stingray (a), P

Uncommon
Bermuda Chub, H
Belted Cardinalfish, C
Bridled Cardinalfish, C
Sharptail Eel, C
Night Sergeant (a), H
Reef Croaker (a), C
Sand Diver (a), P
Plumed Scorpionfish (a), P
Barred-line Snapper, C
Blackbarred Soldierfish (a), C
Red Triggerfish, C