TABLE 1. Fish abundance, richness, and diversity in barren and macroalgal zones at two sites on the forereef of Discovery Bay, Jamaica,W. I. Data represent means ± SE.

Site	Zone	N	Abundance	Richness	Diversity
Caricomp	Barren	4	87.25 ± 23.24	13.00 ± 1.68	0.83 ± 0.05
Caricomp	Macroalgal	3	107.33 ± 28.39	17.67 ± 2.40	0.88 ± 0.05
Dancing Lady	Barren	10	187.60 ±24.92	14.30 ± 1.20	0.79 ± 0.04
Dancing Lady	Macroalgal	10	99.00 ± 39.67	11.90 ± 1.39	0.87 ± 0.06

the reef habitat after the 1983 *D. antillarum* die off. However, we may have disproportionately surveyed these species due to their cryptic behavior.

Finally, our methods may not have accurately portrayed the true species richness, abundance and diversity of fish species. Although the swimming transect method is commonly used in fish censusing, it has several drawbacks. Furthermore, we were not always able to accurately distinguish fish species. Our results suggest that the increase in macroalgal cover after the 1983 *D. antillarum* die off will not strongly influence fish species assemblages in Discovery Bay, Jamaica.

LITERATURE CITED

Liddell, W. D., and S. L. Ohlhorst. 1986. Changes in benthic community composition following the mass mortality of *Diadema* at Jamaica. J. Exp. Mar. Biol. Ecol. 95. Pp. 271 – 278.

Randall, J. E. 1967. *Food habits of reef fishes of the West Indies*. Studies in Tropical Oceanography. Pp. 669 – 845.

Sale, P. F. 1977. Maintenance of high diversity in coral reef fish communities. Amer. Nature. 3. Pp. 337-359.

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, Jersey.

Variation in the species composition and schooling behavior of tropical fish communities

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Abstract: Tropical fish activity is influenced by both habitat and time of day. To determine how these factors affect species richness, species composition, and schooling behavior, we recorded fish species and schooling behavior during the day and night in turtle grass beds and the backreef of Discovery Bay, Jamaica, W. I. Species richness was higher in the reef habitat and during the day. The relative proportions of 17 common species differed with time of day, but not between habitats. Schooling behavior was more common at night than during the day, but did not differ between habitats. Our results suggest that temporal differences in fish activity may contribute more to variation in community structure than differences between habitats in Discovery Bay, Jamaica.

Key Words: community structure, coral reefs, predator avoidance, resource partitioning, turtle grass

INTRODUCTION

Tropical reefs support a wide variety of fish species that exhibit a range of foraging strategies, activity patterns, and social behaviors. Previous studies which examined fish community structure and behavior in Discovery Bay, Jamaica, W. I. found that species richness, habitat use, and schooling behavior differ between night and day (Blundell et al. 1999; Nagy et al. 2000; Alexander et al. 2002). We examined how time of day and habitat type influence fish community structure and fish activity. Specifically, we evaluated how species richness, species composition, and schooling behavior differed between night and day. We also tested whether these characteristics differed between turtle grass beds and backreef habitats.

METHODS

On 27 February 2003, we surveyed fish species on the backreef of Discovery Bay, Jamaica. During the day (08:30 – 09:30) and the night (20:30 – 21:30), nine pairs of observers each spent 25 minutes surveying both backreef and turtle grass habitats for a total of 13 observer-hours. Each combination of habitat and time was considered a separate survey, so that each observer pair conducted four separate surveys. Observers recorded every fish species seen and noted whether the fish was schooling or solitary. No attempt was made to record abundance. We used the number of surveys on which a particular fish species was seen exhibiting a particular behavior as an index of abundance. We used two-way ANOVA to determine the effects of time, habitat, and their interaction on fish species richness.

We used a G-test to determine if the relative proportions of common species differed between habitats or with time of day (Table 1). We restricted our analysis to the 17 species that were seen a minimum of eight times so that we would be able to have high quality information regarding the spatial and temporal distributions of these species.

To determine whether schooling behavior differed between habitats or with time of day we used a Chi-squared test. For each time period we calculated the proportion of fish species observed only schooling, only solitary, or both. We also compared the proportions of these behavioral strategies between habitat type with a Chi-squared test.

RESULTS

We observed a total of 95 fish species in both habitats during the day and the night. Of these, 25 species were unique to

night-time surveys, 47 were unique to day, and 22 were observed during both night and day. Species composition also differed between the two habitats: 31 species were unique to reef habitats, 17 to grass, and 46 were found in both habitats (Table 1). The distribution of the 17 common species (defined as those seen at least eight times) varied with time of day ($G = 63.64$, $df = 16$, $P < 0.001$), but not with habitat ($G = 13.26$, $df = 16$, $P = 0.65$). Species richness was significantly higher in the reef than the grass ($F = 11.90$, $df = 1, 26$, $P = 0.002$) and also higher during the day than the night (Fig. 1; $F = 35.10$, $df = 1, 26$, $P < 0.001$). There was no significant interaction between time of day and habitat type ($F = 2.80$, $df = 1, 26$, $P = 0.11$).

Overall, solitary behavior was more common than schooling. Schooling behavior differed among species: only 10 species were observed schooling, 58 were solitary, and 26 exhibited both behaviors. The proportions of schooling and solitary fish species differed significantly between day and night (Fig. 2; $X^2 = 9.08$, $df = 1$, $P < 0.001$). However, schooling behavior did not differ between habitat type (Fig. 3; $X^2 = 0.03$, $df = 1$, $P = 0.86$).

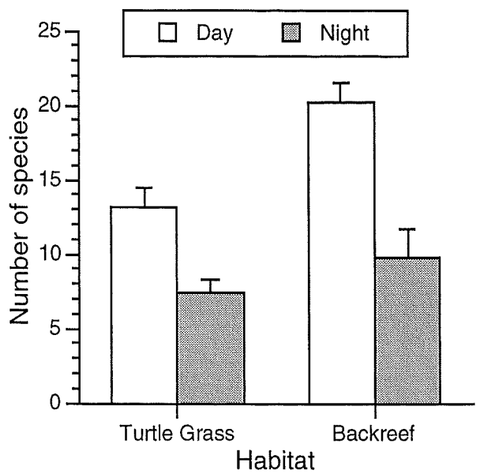

FIG. 1. Fish species richness varied with time of day and habitat in Discovery Bay, Jamaica, W.I.

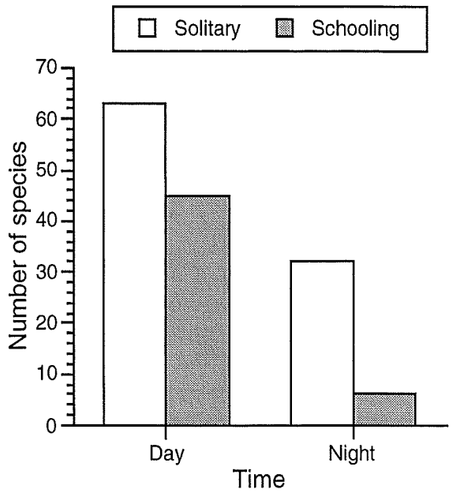

FIG. 2. The proportion of schooling fish species was higher during the day than the night in Discovery Bay, Jamaica, W.I.

Discussion

Time of day had a greater effect than habitat type on the distribution of common species and species richness. Species-specific differences in day and night activity patterns may depend on predator avoidance or food availability. Diel variation in food availability has been shown to contribute to temporal activity patterns in fish. For example, Blundell et al. (1999) found that herbivorous fish are more active during the day, while carnivorous fish are more active at night when plankton are present in the water column.

Our finding that the distribution of common species was similar across the turtle grass and reef habitats suggest that many fish in Discovery Bay may be habitat generalists. Observer bias may have contributed to our observations of greater species richness during the day and in the back reef, because it is possible that fish detectability was higher during the day and on the reef. In addition, species overlap between day and night was probably overestimated when observers recorded day-active fish that were resting at night.

TABLE 1. Fish species observed during day and night surveys of turtle grass and backreef habitats in Discovery Bay, Jamaica. R = backreef, G = turtle grass. Asterisk (*) indicates common species, defined as those seen at least eight times during the entire survey.

Day Only		Night Only		Day and Night	
Species	Habitat	Species	Habitat	Species	Habitat
Angelfish, French	G	Bigeye	R	Balloonfish*	G,R
Bass, Harlequin	R	Bonefish	G	Beaugregory*	G,R
Basslet, Fairy	G,R	Burrfish, Striped	R	Damselfish, Dusky*	G,R
Beauty, Rock	G,R	Cardinalfish, Barred	G,R	Damselfish, Three-spot*	G,R
Blenny, Redlip	R	Cardinalfish, Belted	R	Doctorfish*	G,R
Butterflyfish, Foureye	G	Cardinalfish, Bigtooth	R	Grunt, French*	G,R
Butterflyfish, Spotfin	G,R	Cardinalfish, Bridle	R	Hamlet, Indigo	G,R
Butteryflyfish, Banded	G,R	Cardinalfish, Dusky	G,R	Lizardfish*	G,R
Chromis, Blue	G	Cardinalfish, Pale	R	Major, Sergeant*	G,R
Chromis, Brown	R	Cardinalfish, Twospot	R	Moray, Purplemouthed	G,R
Damselfish, Bicolor	G,R	Chub, Bermuda	R	Parrotfish, Rainbow	G,R
Damselfish, Cocoa	G	Croaker, Reef	G,R	Parrotfish, Redband*	G,R
Damselfish, Longfin	R	Flamefish	R	Parrotfish, Stoplight*	G,R
Damselfish, Yellowtail	G,R	Hamlet, Barred	G	Parrotfish, Yellowtail	R
Dick, Slippery	G,R	Hamlet, Butter	G	Parrotfish, Princess*	G,R
Eel, Moray	R	Porcupinefish	G	Silverside*	G,R
Filefish, Orange-spotted	R	Ray, Lesser Electric	G,R	Squirrelfish*	G,R
Flounder, Peacock	R	Scorpionfish, Spotted	G	Squirrelfish, Dusky	G,R
Goatfish, Spotted	G,R	Sergeant, Night	R	Squirrelfish, Longjaw	G,R
Goby, Bridled	G,R	Snapper, Glasseye	R	Squirrelfish, Longspine	G,R
Goby, Cleaning	G,R	Snapper, Mutton	G	Squirrelfish, Reef	G,R
Goby, Sharknose	R	Soldierfish, Blackbar	G,R	Surgeon, Ocean*	G,R
Great Barracuda	R	Stingray, Yellow	G,R	Trumpetfish	R
Grouper, Tiger	R	Sweeper, Glassy	R		
Grunt, Bluestriped	G,R				
Grunt, Smallmouth	G				
Grunt, Striped	R				
Hogfish, Spanish	G				
Houndfish	R				
Jack, Bar	G				
Parrotfish, Bucktooth	G				
Parrotfish, Greenblotch	R				
Parrotfish, Redtail	R				
Parrotfish, Striped*	G,R				
Puddingwife	R				
Pufferfish, Bandtailed	G				
Razorfish, Green	G,R				
Snapper, Gray	G				
Snapper, Yellowtail	G,R				
Sunshinefish	G				
Tang, Blue*	G,R				
Trunkfish, Smooth	R				
Wrasse, Blackeared	R				
Wrasse, Blueheaded*	G,R				
Wrasse, Clown	G,R				
Wrasse, Rainbow	R				
Wrasse, Yellowhead	G,R				

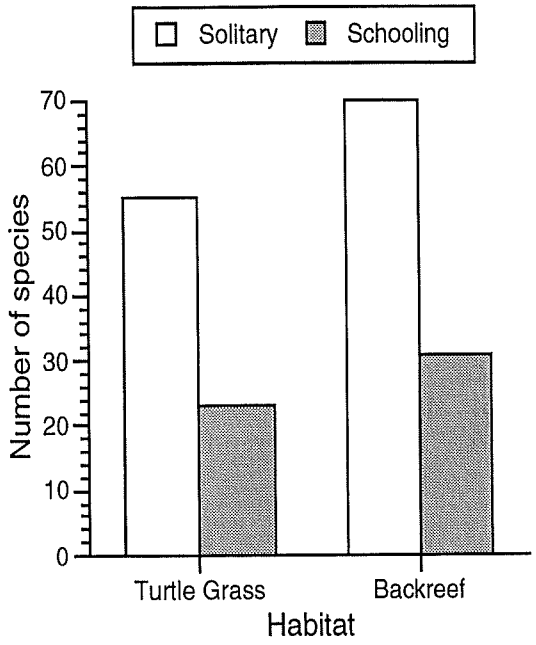

FIG. 3. The proportions of schooling and solitary fish species did not differ between backreef and turtle grass habitats in Discovery Bay, Jamaica, W.I.

Time of day influenced schooling behavior as well as species composition and richness. Most species that schooled were also observed as solitary individuals, suggesting that schooling is not a fixed behavior and it may vary with age or environmental conditions. The proportion of schooling species was higher during the day than the night. This may be because daytime schooling reduces predation by visual predators. Alternatively, damselfish activity may influence schooling behavior. Territorial damselfish defend their algal turfs during day, therefore schooling may be a strategy for overwhelming these defenses and exploiting these resources. However, schooling behavior did not appear to differ between habitat type. This behavioral strategy may be equally important and effective in both habitats.

Fish community structure, species richness and fish behavior were strongly influenced by time of day. Surprisingly, only species richness differed between habitat type. These results imply that temporal shifts in community structure may better facilitate resource partitioning and predator avoidance among tropical fish species. Detailed study of how foraging strategies and predation risk differ between day and night would improve our understanding of the mechanisms that contribute to daily variations in fish activity.

Literature Cited

Nagy, L. R., M. N. Conte, C. B. Shannon, A. C. Brown, and 2000 Dartmouth FSP class. 2000. Diel variation in fish community composition and habitat distribution in Discovery Bay, Jamaica. Dartmouth Studies in Tropical Ecology. Dartmouth College, Hanover, NH.

Blundell, A. G., M. E. Lepene, J. D. Maniscalco, and the 1999 Dartmouth FSP class. 1999. A comparison between the day and night fish communities on the back reef of Discovery Bay, Jamaica. Dartmouth Studies in Tropical Ecology. Dartmouth College, Hanover, NH.

Alexander, K. M., R. W. Hofstetter, F. E. Krivak-Tetley, K. N. Podolak and E. Schoen. 2002. Diel variation in fish community composition and schooling behavior on the back-reef of Discovery Bay, Jamaica. Dartmouth Studies in Tropical Ecology. Dartmouth College, Hanover, NH.