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DIEL VARIATION IN ZOOPLANKTON ABUNDANCE AND SIZE DISTRIBUTION ON A BACK REEF IN DISCOVERY BAY, JAMAICA

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Abstract. Reef zooplankton exhibited diel patterns in abundance and size distribution. These organisms are largely demersal, remaining closely associated with the reef and thus tightly cycling reef nutrients. Zooplankton abundance in the water column was much higher at night, suggesting avoidance of visually-feeding predators during the day. In addition, the relative proportion of larger organisms increased at night as did species richness. Diversity, however, decreased due to the disproportionate dominance of two taxa, copepods and decapod larvae.

Key Words: abundance, demersal zooplankton, species richness, vertical migration, visually-feeding planktivores

INTRODUCTION

Zooplankton are an important component of coral reef communities, providing food for planktivorous fishes as well as corals. Although zooplankton may not provide a dominant caloric source to reef communities (< 12% of metabolic requirements of sessile reef dwellers at Discovery Bay), they tightly cycle nutrients and thus prevent nutrient loss to the outside environment (Ohlhorst 1985).

The majority of reef zooplankton is demersal, hiding near, on or within the substrate during the day and moving freely in the water column at night. Previous studies have suggested that demersal zooplankton spend days avoiding visually feeding predators and emerge into the water column at night to feed when the risk of predation is low. By rising in the water column, zooplankton also avoid becoming prey to tentacular-feeding corals.

If zooplankton migrate vertically into the water column, then we would expect to see a greater abundance of individuals at night than during the day. We would also expect to see a greater species richness as those taxa restricted to solid substrate during the day are released from predation constraints and migrate upwards during the night. Emery (1968) showed that the most important defensive characteristic of zooplankton prey is small size. If size is an effective defense against visually-feeding fish, then we would expect to find larger individuals at night when predation risk is low. We sampled zooplankton at Discovery Bay, Jamaica during the day and night to test our predictions.

METHODS

Research was conducted on 26 January, 1996 at Discovery Bay Marine Laboratory, Discovery Bay, Jamaica. Zooplankton samples were collected at 1600 and 2100 along a single 20 m transect marked with buoys at a depth of one meter in the West Back Reef. The sample site was located 20 m from the reef crest in an area with moderate coral cover. We collected five samples during each time time period by swimming back and forth along the transect with a 153 μm mesh zooplankton net (22.5 cm opening diameter) for a total of 40 m per sample. Zooplankton were washed into a 200 ml cup attached to the net by spraying the net with sea water. Samples were transferred immediately to collecting jars where they were preserved in 10% formalin. For counting, samples were washed through a 153 μm screen with filtered (153 μm) seawater and placed back in cups containing sea water. Samples were divided and counted by five separate groups of three individuals. Each group was responsible for one day and one night sample.

Zooplankton were identified into 12 taxanomic groups. All organisms except copepods were classified into one of four size classes: 0.1 - 1.0 mm, 1.0 - 2 mm, 2.0 - 3.0 mm, and > 3.0 mm. Copepods were classified into three size classes: 0.1 - 0.5 mm, 0.6 - 1.0 mm, and 1.0 - 1.5 mm. A t-test was used to compare total abundace between day and night samples, relative distributions among size classes were compared with a G-test, and the Shannon-Wiener index was used to assess diversity.

RESULTS

Total zooplankton density was much greater at night (978.2 individual / m^3) than during the day (6.9 individuals/m3; T = 4.04, df = 4, P < 0.01). In addition, most species were more abundant at night. Cnidarians, however, were more common during the day, and polychaete worms and gastropods were found equally during the day and night samples (Table 1). Species richness was also higher at night (11) then during the day (6). Shannon-Weiner diversity index was lower at night (.66) than during the day (1.16).

There were more zooplankton present in all size classes at night, however, the relative proportions among the size classes differed between night and day (G = 23.04, df = 3, P < 0.05). The proportion of zooplankton in the 0.1-1.0mm size class was higher in the day then in the night sample (Figure 1). The proportion of zooplankton in the 1.1 - 2.0mm size class was higher in the night sample. There were no zooplankton in the day sample greater than 2 mm. Copepods, the most abundant organisms, were more abundant in all size classes at night. The proportion of copepods in the 0.1 - 0.5mm size class was higher in the day sample (Figure 2). The proportion of copepods in the 0.6 - 1.0mm size class was higher in the night sample. There were no copepods in the day sample greater than 1 mm.

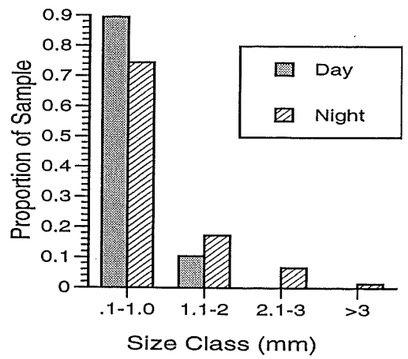

Figure 1. Relative propotion of zooplankton in four different size classes. Samples collected during the day and night at Discovery Bay, Jamaica. Day n = 105; Night n = 9874.

DISCUSSION

The distribution of zooplankton is extremely patchy with respect to time and space (Lewis and Boer 1991) and thus, our results yield only a narrow view of zooplankton behavior. Nonetheless, the results are striking. Zooplankton abundance in the water column increased dramatically between day and night, primarily due to the increased presence of copepods and decapod larvae. Together, these groups accounted for 99% of the organisms present in the water column at night. Therefore, although species richness was greater during the night, diversity was greater during the day due to a more equitable distribution of individuals between species. Only one group (Cnidaria) was represented in the day sample alone. Both the paucity of species and numbers of individuals inhabiting the upper strata of the water column during the day seems to suggest that the risk of predation by visually feeding fish may outweigh the benefits to planktonic organisms of feeding during the day when competition is reduced.

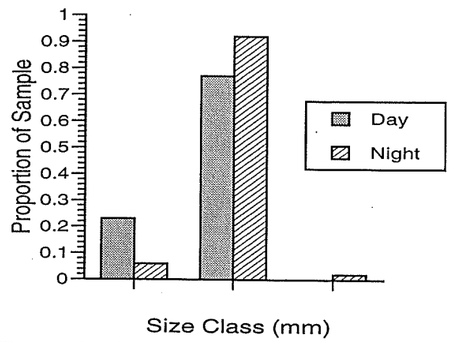

Figure 2. Relative proportion of copepods in three different size classes. Samples taken during the day and night at Discovery Bay, Jamaica. Day n = 43; Night n = 7262.

The shift in size distribution of zooplankton suggests that pressure from visually feeding predators is indeed important in driving zooplankton behavior. As observed in copepods and the entire zooplankton population, larger individuals comprised a larger proportion of the population at night while smaller individuals were relatively more abundant during the day. Visual predators have been shown to take large organisms in proportions far exceeding their relative abundance (Robertson and Howard 1978) and thus, vertical migration may be increasingly beneficial for larger organisms. Given the small size of the day sample, however, conclusions drawn from differences in the proportion of large and small individuals between sampling periods are tentative at best. In addition, the distinction between small and large is arbitrary and may not represent the size at which planktivorous fish can visually locate prey. Nonetheless, the dramatic nocturnal increase in zooplankton density suggests that these masses are not as susceptible to predation during the night, compared with illuminated periods.

Predator avoidance may only partially explain zooplankton behavior. Alternative functions of diel migrations may include horizontal dispersion, bioenergetic advantages, and increased probability of contacting a mate (Robertson and Howard 1978). Quantifying zooplankton abundance on a broader scale of time and space might yield more insight into the reasons behind migration behavior.

Table 1. Zooplankton taxa abundance in day and night samples collected at Discovery Bay, Jamaica.

Phylum	Class	Subclass	Order	Size Range (mm)	Day Abundance (# / m^3)	Night Abundance (# / m3)
Annelida	Polychaeta	-	-	0.8 - 10	0.8	0.7
Arthropoda	Crustacea	Cirripedia	Barnacle nauplius	0.5	-	0.1
Arthropoda	Crustacea	Copepoda	-	0.5 - 1.5	4.3	712.0
Arthropoda	Crustacea	Malacostraca	Amphipod	1.0 - 2.0	-	2.2
Arthropoda	Crustacea	Malacostraca	Cumaceae	-	-	0.6
Arthropoda	Crustacea	Malacostraca	Decapod	0.5 - 3.5	0.2	244.1
Arthropoda	Crustacea	Malacostraca	Isopod	0.7 - 2.5	1.3	2.6
Arthropoda	Crustacea	Malacostraca	Mysid	0.8 - 9.0	-	3.1
Cnidaria	-	-	-	0.2 - 1.0	0.3	-
Mollusca	Gastropoda	-	-	0.5 - 0.8	0.1	0.1
Sarcomastig-ophera	Sarcodina		Foraminifera	0.3	-	0.3
Vertebrata	Osteichthyes larvae	-	-	1.0 - 3.0	-	3.3

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