DIEL PATTERNS IN ZOOPLANKTON ASSEMBLAGES OVER A LITTLE CAYMAN ISLAND CORAL REEF

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Abstract. Zooplankton are heavily preyed upon by diurnal planktivorous fish, and hide in the benthos during the day, emerging into the water column at night to feed. Small zooplankton often forage during the day because they are below the visual threshold of many predators, whereas large zooplankton forage only at night. We compared the day and night zooplankton communities on the back reef of Grape Tree Bay, Little Cayman Island and found a higher density of zooplankton at night than during the day. Zooplankton ≥ 1 mm length were abundant only at night. Zooplankton < 1 mm comprised 96% of day samples and were abundant both day and night. However, the density of copepod nauplii < 0.5 mm decreased slightly at night. This decrease is unusual; previous studies show increased abundances of all sizes of zooplankton at night.

Keywords: copepods, decapods, polychaete larvae, mysids

INTRODUCTION

On coral reefs such as those at Little Cayman Island, many organisms are completely planktonic, and others have planktonic larval stages. To avoid predation by diurnal predators, many zooplankton feed in the water column after dusk, when the foraging efficiency of planktivorous fishes is much reduced (Koski et al. 2003, Rickel and Genin 2005, Ohlhorst 1982).

Small zooplankton (< 1 mm) are less likely to be consumed during the day when high light allows predators to be more size selective (Brooks and Dodson 1965, Koski et al. 2003, Ohlhorst 1982). Small zooplankton are below the visual threshold of many planktivores and are thus subject to consistently lower predation risk than large zooplankton.

Based on previous studies in Discovery Bay, Jamaica (Sullan et al. 2006, Calvi et al. 2000, Chiavelli 1998, Dartmouth FSP 1995, Ohlhorst 1982), we predicted that total zooplankton abundance and density would be higher at night. We also predicted that large zooplankton (≥ 1 mm) would show the greatest difference in abundance and density between day and night, with greatest abundances at night because of the risk of size selective predation. Lastly, we predicted that small zooplankton would be found in greater or equal abundances and densities during the day than at night, because of their low predation risk.

METHODS

We sampled zooplankton in the water column along the coral reef of Grape Tree Bay, Little Cayman Island, on 25 February 2007. We used three contiguous 10 m transects running parallel to the reef, 93 m from the shore. We towed a plankton net 0.3 m in diameter, once back and forth along each transect, sampling a total of 1.41 m^3 of water per transect. Each transect was sampled twice: at 1400 (day) and at 2200 (night). Sample sizes were 3 for day and 2 for night; one night sample was lost due to sampling error.

We preserved zooplankton samples immediately in 5% formalin solution. Under a microscope, we placed organisms into nine taxonomic groups: Copepoda, Amphipoda, Isopoda, Decapoda, Polychaete larvae, Mysidacea, Cumacea, Cnidaria, and Actinoptergii larvae. Zooplankton sizes ranged from <0.5 mm to >8 mm. We grouped them into four size classes: 0-1 mm, 1-2 mm, 2-4 mm, 4+ mm. This allowed us to compare the densities of zooplankton below the visual threshold of planktivores with the densities of larger zooplankton.

For analyses, we lumped zooplankton into two size classes: small (< 1 mm) and large (≥ 1 mm). We used a MANOVA to determine whether there were significant differences in abundances of size classes between day and night. We used t-tests assuming unequal variance to determine differences in total density, in density within the two size classes of zooplankton, and in abundance within taxa between day and night. We used power analysis to determine the sample sizes necessary for significant differences. The differences between the abundances of copepods in different size classes between day and night were determined using t-tests.

RESULTS

There was a significant difference in zooplankton abundance of the two size classes between day and night (MANOVA $F_{2,2} = 18.88$, $P = 0.050$). We found a much greater mean sample density of zooplankton at night (mean ± SE = 386 ± 112 individuals per m^3) than during the day (98 ± 12); however we found no significant difference with our high variance and low sample size ($t_{1.02} = 2.55$, $P = 0.12$) Power analysis showed a sample size of 5 would yield a significant difference at $\alpha = 0.05$. We found two other marginally significant trends: a higher density of large zooplankton at night than during the day ($t_{1.00} = 3.28$, $P = 0.094$) and a higher density of small zooplankton during the day than at night ($t_3 = 1.34$, $P = 0.14$; Figure 1).

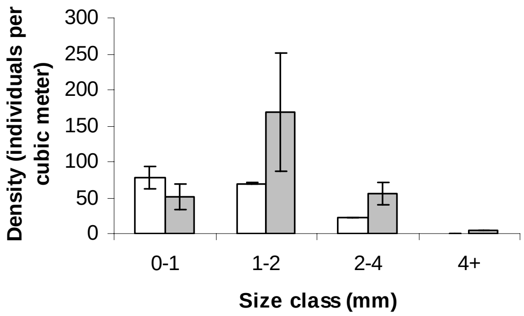

Figure 1. Density ± SE of zooplankton by size class found during day (light bars) and night (dark bars) sampling at Jackson's Bay reef, Little Cayman Island. Light and dark bars represent day and night samples, respectively.

We recorded a total of seven taxa during the day and nine at night (Table 1). The three most common taxa overall were Copepoda, Decapoda, and Polychaete larvae (Figure 2). There were no significant differences between day and night abundances for the six least abundant taxa: Amphipoda (t_1 = -1, P = 0.25), Isopoda ($t_{1.1}$ = 2.49, P = 0.11), Mysidacea (t_1 = 3.89, P = 0.08), Actinoptergii larvae ($t_{1.01}$ = 2.92, P = 0.10), Cnidaria ($t_{2.43}$ = 0.5, P = 0.66) and Cumacea ($t_{1.02}$ = 1.25, P = 0.21), though all had higher sample densities at night than during the day (Figure 3). During the day, most copepods were nauplii < 0.5 mm (t_3 = 4.53, P = 0.010) and at night were mostly larger copepods ≥ 0.5 mm (t-test assuming unequal variances $t_{1.02}$ = -2.18, P = 0.13, Table 2).

Table 1. Mean abundances of common zooplankton taxonomic groups per sample (1.41 m^3) found during day and night sampling at Jackson's Bay reef, Little Cayman Island.

Taxa	Description	Mean Abundance ± SE	
		Day n=3	Night n=2
Copepoda	Small crustaceans	126 ±13.61	86.5 ± 28.5
Amphipoda	Small crustaceans	0	1 ± 1
Isopoda	Small crustaceans	0.67 ± 0.33	0.45 ± 1.5
Decapoda	Crustacean larvae	2.33 ± 0.88	274.5 ± 80.5
Mysidacea	Mysid shrimp	0	17.5 ± 4.5
Polychaeta	Worm larvae	6 ± 2.08	11 ± 3
Actinopterygii	Fish larvae	0.33 ± 0.33	13.5 ± 4.5
Cnidaria	Jellyfish larvae	1.67 ± 0.88	1 ± 1
Cumac	Cumacean shrimp	1.33 ± 0.66	9.5 ± 6.5
Total Zooplankton		98 ± 12	386 ± 112

Table 2. Density (individuals/m^3) of copepods by size class found during day and night sampling at Jackson's Bay reef, Little Cayman Island.

Size class (mm)	*<0.5*	*0.5-1*	*>1*
Day n=3	75.18 ± 11.66	13.48 ± 2.05	0.71 ± 0
Night n=2	6.74 ± 1.77	42.91 ± 13.12	11.70 ± 5.32

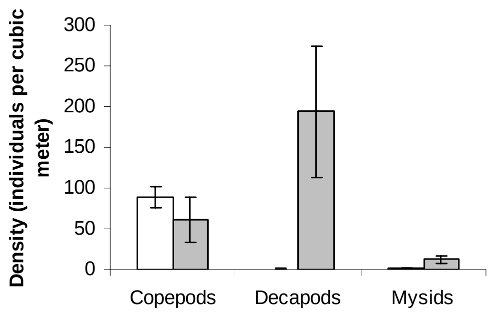

Figure 2. Density ± SE of the three most common zooplankton taxonomic groups found during day (light bars) and night (dark bars) sampling at Jackson's Bay reef, Little Cayman Island.

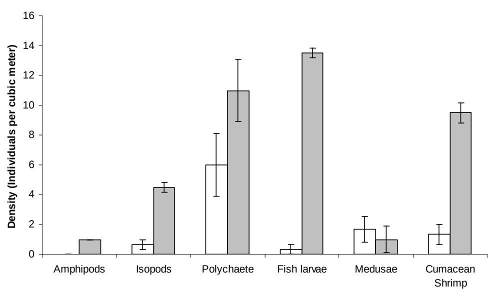

Figure 3. Density ± SE of less common zooplankton taxonomic groups found during day (light bars) and night (dark bars) sampling at Jackson's Bay reef, Little Cayman Island.

DISCUSSION

Our finding that the average total zooplankton abundance is four times greater at night demonstrates the diel movement of zooplankton and supports our first prediction. While this pattern has been documented at other reefs, such as Discovery Bay, Jamaica (Sullan et al. 2006, Calvi et al. 2000, Chiavelli 1998, Dartmouth FSP 1995, Ohlhorst 1982), the Great Barrier Reef (Roman et al. 1990), and the Florida Keys (Walters 1988), it has not previously been studied at Little Cayman Island.

Large zooplankton comprised only 4% of individuals in the day sample, compared to 81% at night. The density of large zooplankton also increased 60 fold from an average of 3.8 individuals per m^3 during the day to 241.2 individuals per m^3 at night, supporting our second prediction that large zooplankton would be found in higher densities at night.

While 84% of daytime individuals were small zooplankton (< 1mm), they made up only 11% of the nighttime individuals. Their densities decreased only slightly, from an average of 94.2 day individuals per m^3 during the day to 55.2 night individuals per m^3 at night. Our data support previous work showing that small zooplankton forage in the water column during the day when they are less vulnerable to predation; and large zooplankton emerge only at night when decreased light reduces their vulnerability to predation (Brooks and Dodson 1965, Koski et al. 2003).

Copepods were one of the most dense taxa during both the day and night, and this trend is consistent with previous Jamaican studies (Sullan et al. 2006, Calvi et al. 2000, Chiavelli 1998, Dartmouth FSP 1995, Ohlhorst 1982). The densities of our three most common daytime taxa (copepods, decapods, and polychaete larvae) fell within ranges documented in Jamaica. However, our nighttime copepod density was almost ten times lower than the lowest nighttime copepod densities found in Jamaica. Low nighttime copepod densities may be unique to Little Cayman zooplankton communities, or a result of localized sampling of patchy distributions. Because of high live coral densities at Little Cayman, small zooplankton may be subject to stronger coral predation than at Discovery Bay, resulting in lower copepod densities.

Size selective predation in high visibility conditions has resulted in clear diel patterns of zooplankton abundance in reef communities. From our study off the coast of Little Cayman Island, we conclude that established diel patterns of zooplankton densities can be broadened to apply to the reef communities there. Further investigation of abundances in different habitats will increase the understanding of the zooplankton community structure on Little Cayman Island.

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