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Table 1. Coral species found in 15 transects each surveying 10 m^2 of the West Fore Reef of Discovery Bay. Corals are listed from greatest to least abundance.*

coral	common name	number of colonies seen	depth at which most colonies found
Agaricia sp.	lettuce coral	127	68 feet
Porites porites	finger coral	99	68
Porites astreoides	mustard hill coral	54	68
Montastraea annularis	boulder star coral	43	68
Siderastrea radians	lesser starlet coral	32	42
Eunicea sp.	sea rod	25	56
Madracis pharensis	star coral	20	56
Meandrina meandrites	maze coral	19	63
Millepora alcicornis	branching fire coral	19	18
Millepora complanata	blade fire coral	17	10
Gorgonia ventalina	common sea fan	15	18
Stephanocoenia mechelinii	blushing star coral	14	63
Agaricia grahamae	Graham's sheet coral	13	68
Siderastrea siderea	massive starlet coral	10	56
Acropora cervicornis	staghorn coral	9	56
Madracis mirabilis	yellow pencil coral	7	56
Stylaster roseus	rose lace coral	6	33
Madracis formosa	eight-ray fingercoral	6	56
Pseudopterogorgia bipinnata	bipinnate sea plume	5	41
Eusmilia fastigiata	smooth flower coral	5	42
Dichocoenia stokesii	elliptical star coral	4	10
Diplora strigosa	symmetrical brain coral	4	10
Favia fragum	golfball coral	3	33
Leptoseris cucullata	sunray lettuce coral	2	52
Pseudoplexaura sp.	porous sea rod	2	52
Gorgonia mariae	wide mesh sea fan	2	36
Scolymia sp.	solitary disk coral	2	42
Solenastrea hyades	knobby star coral	2	63
Montastrea cavernosa	great star coral	2	63
Manicina areolata	rose coral	1	18
Diploria labyrinthiformis	grooved brain coral	1	10

THE ENCHANTED BROCCOLI FOREST UNDER THE SEA: MACROFAUNA COMMUNITY COMPOSITION AND RECRUITMENT ON *PENICILLUS CAPITATUS*

Jamie R. Shandro and Emily B. Sohn

Abstract. The green calcareous algae *Penicillus capitatus* grows in sandy areas in both coral and turtle grass habitats in Discovery Bay, Jamaica. This study was designed to examine and compare zooplankton community composition and recruitment on *P. capitatus* between turtle grass and coral habitats. We observed a higher abundance of established zooplankton communities on *P. capitatus* in coral than in turtle grass. However, recruitment was initially higher in the turtle grass before switching over to match the pattern of established communities by the third day of the study. We suggest two possible explanations for this shift: 1) ambient zooplankton abundance is higher overall in the turtle grass, but refuges are more limited in the coral; or 2) equilibrial resource levels are higher and can support more zooplankton in the coral, but because of wave action these resources accumulate slowly in the coral. Slower zooplankton recruitment in the coral would then match this accumulation pattern.

Key words: marine invertebrates, recruitment

Introduction

High densities of zooplankton have been found over complex habitats such as coral beds and sea grasses; increased shelter from physical factors and predators as well as increased detritus and nutrient levels are factors enhancing zooplankton survival within and over the more complex substrates (Jacoby and Greenwald 1988). Macroalgae provide islands for zooplankton establishment within these larger complex habitats. Stoner (1985) examined macrofauna communities in the green calcareous macroalgae *Penicillus capitatus*, and found that the algae supported communities of zooplankton at a significantly higher density than the surrounding sediment, suggesting a role for *P. capitatus* as an establishment site for macrofauna. Known as "mermaid's shaving brush" for its distinctive brush-like capitulum of free and dichotomously branched filaments, *P. capitatus* is found scattered in shallow sandy patches within both coral beds and sea grass areas (Littler et al. 1989). The bristly, lightly calcified and silt-laden cap of *P. capitatus* provides both a refuge and a feeding ground for zooplankton. *P. capitatus* provides an ideal study organism for small-scale community and recruitment dynamics of zooplankton communities.

In this study we examined effects of different habitats on the zooplankton community composition and recruitment patterns on *P. capitatus*. A survey of demersal zooplankton over both coral and *Thalassia* (turtle grass) beds in Discovery Bay found a greater abundance of zooplankton in the water column above the turtle grass than the coral substrate (Dums et al. 1997). We predicted that existing *P. capitatus* communities would have a higher abundance of zooplankton in turtle grass than coral. We also examined both day and night communities to see if the diurnal patterns noted by Dums et al. would affect *P. capitatus* zooplankton community composition. Furthermore, we wanted to examine recruitment to *P. capitatus* for the two habitats. Expecting recruitment rates to increase with increasing abundance of zooplankton in the water column, we predicted that there would be faster recruitment to *P. capitatus* in the turtle grass habitat than in the coral habitat.

Methods

We conducted our study 7-10 March 1997 at Discovery Bay Marine Laboratory, Jamaica. All collections and manipulations were carried out at 1-2 m depth in the west back reef. Coral habitat was defined as the coral dominated area approximately 10-20 m from the reef crest, while turtle grass habitat was defined as turtle grass dominated area approximately 30-40 m from the reef crest. To examine existing community composition on *P. capitatus* we randomly selected three algae over each substrate during the day and three from each at night. Samples were collected by placing plastic bags over algae tops while still imbedded in the sand. The stalks were separated from the rhizomes at the substrate surface to avoid infauna collection. Collection bags were then sealed and returned to the laboratory for analysis. We thoroughly flushed the algae and the bags, then rinsed the sample into a 153 μm screen. We then anaesthetized the sam-

ples with CO2 (Alka-Seltzer) and preserved them in 70% ethyl alcohol. Zooplankton were classified into the following taxonomic groups: amphipods, calanoid copepods, cyclopoid copepods, decapods, isopods, and polychaetes (Newell and Newell 1977). Algae were oven-dried for 1-2 hours and weighed.

For the recruitment manipulation we first randomly collected 24 *P. capitatus* from each substrate. In this case we kept as much of the rhizome intact as possible to aid replanting. We rinsed the samples thoroughly with fresh water to remove existing populations (Stoner 1985), marked them with flagging around the base for reidentification, then placed the algae in filtered sea water until replanted in the field. On 7 March, between 14:00 and 16:00, we selected three 1x1 m sandy plots, 1-3 m apart, in each habitat. We planted eight manipulated algae approximately 15 cm apart in each plot. We collected two samples from each plot on day 1 (8 March) and one sample from each plot for days 2 and 3. All collections were done between 14:00 and 16:00, and the same procedure as described above was followed in collection, preservation, and identification of samples.

Zooplankton abundances were calculated as the number of individuals per gram of dry algae.

RESULTS

We found a higher abundance of zooplankton in the existing *P. capitatus* communities on coral habitat than in the existing P. capitatus communities on turtle grass habitat (t-test; t=2.78, df=10, P=0.02). The existing communities did not differ in zooplankton abundance between night and day in either the turtle grass (t-test; t=1.21, df=4, P=0.29) or the coral habitats (Fig. 1; t-test; t=0.70, df=4, P=0.52).

In the recruitment study, zooplankton abundance increased in *P. capitatus*, from day 1 to day 3 in both turtle grass (Tukey-Kramer; F=10.5, df=11, P<0.05) and coral (Tukey-Kramer; F=13.2, df=11, P<0.05; Fig. 2). Comparing habitats, zooplankton were more abundant in turtle grass *P. capitatus* than in coral on day 1, (t-test; t=3.96, df=10, P=0.003). On day 2, there was no significant difference between zooplankton abundance on *P. capitatus* in the two habitats (t-test; t=0.28, df=4, P=0.79). On day 3, there appeared to be a trend toward higher zooplankton abundance in coral *P. capitatus* than turtle grass. However, this difference was not statistically significant (t-test; t=1.16, df=4, P=0.31).

There was no relationship between size of *P. capitatus* (measured in dry weight) and zooplankton abundances in any of the recruitment-manipulated communities over the sampling period (Fig. 3A; r2=0.00, F=0.008, df=23, P=0.932). In existing communities, zooplankton abundance increased with increasing size of *P. capitatus* (Fig. 3B; r2=0.50, F=9.92, df=11, P=0.01).

Comparisons of community composition (measured as relative abundance of taxonomic groups) across habitat types and across days for recruitment revealed no major differences. Isopods numerically dominated existing communities, while isopods and calanoid copepods were found most frequently in the manipulated communities (Table 1)

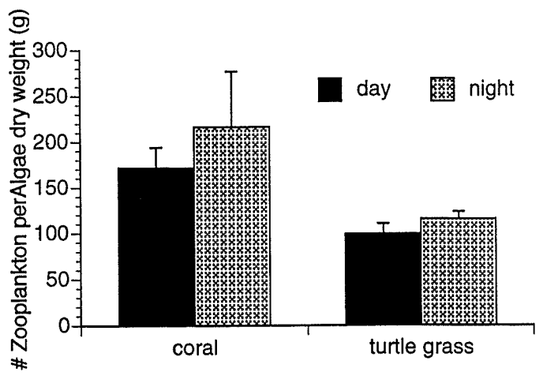

FIG. 1. Zooplankton abundances in *P. capitalus* at night and in the day in both coral and turtle grass habitats (N = 3 for each).

DISCUSSION

Although zooplankton are more abundant in the water column above turtle grass than above coral (Dums et al. 1997), we found the opposite relationship between habitat type and zooplankton abundances on the *P. capitatus*. We also observed no difference in abundance between night and day in either habitat. These results suggest that zooplankton abundance in the water column is not an indicator of zooplankton abundance on established zooplankton communities on *P. capitatus*. Additionally, our results suggest that zooplankton which have settled on the algae are not contributing to the pool of nocturnally migrating zooplankton.

In both habitats, zooplankton recruited to all *P. capitatus*, abundances increased over the three day experiment, and levels were roughly equal to those found on unmanipulated *P. capitatus* by the third day. Zooplankton initially recruited faster in the turtle grass, but by day 3, zooplankton communities were approaching the pattern observed in the existing communities, where abundances were higher in the coral habitat than the turtle grass. Our finding that the final recruitment abundances were similar to the abundances found in existing populations for each habitat suggests that there may be an equilibrial abundance for communities within each habitat, and that the time to approach this equilibrium is approximately three days.

There are two possible explanations for the shift from initial recruitment of more zooplankton in turtle grass *P. capitatus* to higher abundance in the coral *P. capitatus* later in recruitment and in established communities. First, we found that zooplankton abundance was not related to *P. capitatus* size in the recruitment communities, but in the existing communities, zooplankton abundance was positively correlated with algae size. This relationship existed in both habitats. This suggests that recruitment initially relies only on zooplankton abundances in the water and sediment surrounding the algae, and that in our study, this ambient abundance was higher in the turtle grass habitat than in the coral. The shift to higher abundances in coral communities might then occur because the coral environment is more refuge-limited for zooplankton. Refuges may be more important in the coral where wave action is more intense and planktivorous corals are abundant. The turtle grass could be a safer environment with more available refuges, making it less necessary for zooplankton to tolerate *P. capitatus* with high zooplankton densities. It would be interesting for further study to assess the availability of and competition for *P. capitatus* refuges to zooplankton.

It is also possible that there are higher nutrient and detritus levels overall in the coral habitat, where more wave action brings a constant input of sediment and organic material (Roman et al. 1990). However, the initial silt and detritus accumulation in *P. capitatus* may take longer in the coral habitat because of the increased wave turbulence. If nutrient levels in the *P. capitatus* rely on sediment caught in the algae to settle, nutrient accumulation might also be slower at first in the coral habitat. Once the sediment and nutrients have begun to accumulate in the algae, the *P. capitatus* in the coral substrate would be able to sustain more zooplankton than could the *P. capitatus* in the turtle grass because of the constant nutrient input from the wave action. Further studies should examine the sediment loads and resource levels within both existing and recruiting *P. capitatus* heads.

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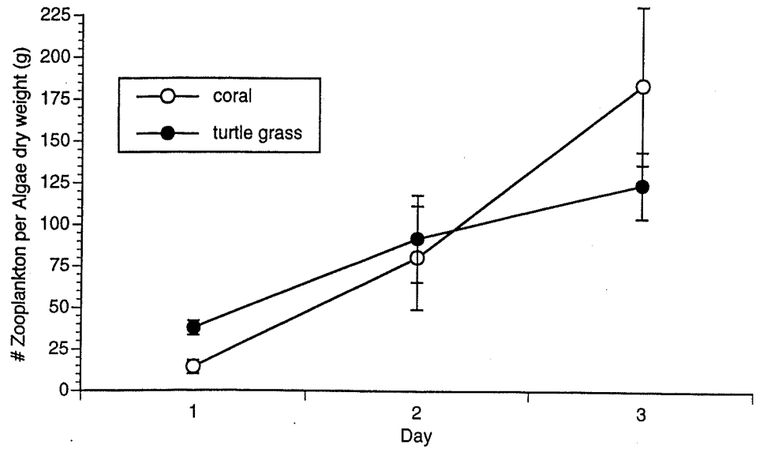

FIG. 2. Zooplankton recruitment over time on *Penicillus capitatus* located in two habitats, coral and turtle grass. N=3 for each.

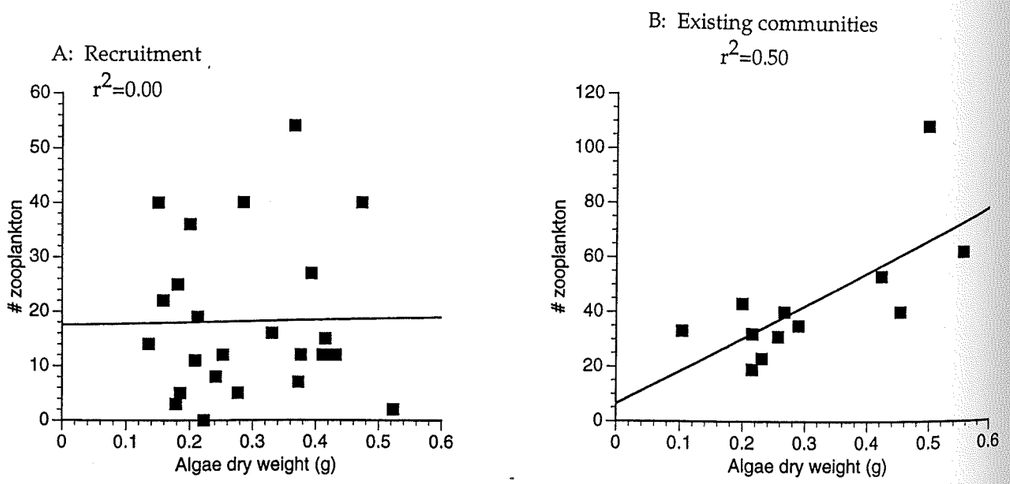

FIG. 3. Number of zooplankton in a community versus dry weight of *Penicillus capitatus* in (A) recruitment manipulation (N=24) and (B) existing communities (N=12).

TABLE 1. Mean percent of each zooplankton order and total abundance of zooplankton over two different habitats, coral and turtle grass. The top of the table shows zooplankton found in existing *Penicillus capitatus* communities in the day and at night. The bottom shows zooplankton recruitment over three days on *P. capitatus* whose existing zooplankton communities had been rinsed off. (AMPH = amphipod, CALA = calanoid copepod, CYCL = cyclopoid copepod, DECA = decapod, ISO = isopod, POLY = polychaete).

		AMPH	CALA	CYCL	DECA	ISO	POLY	total
NATURAL ABUNDANCES		%	%	%	%	%	%	indiv/g
Coral	Day	5.0	15.9	0.2	3.9	65.9	5	171.8
	Night	9.3	27.6	0.9	1.1	55.4	4.1	216.5
Turtle grass	Day	23.4	13.1	1.1	4.3	47.2	9.5	99.3
	Night	17.7	15.2	0.5	20.1	42.7	2.1	115.6
RECRUITMENT								
Coral	Day 1	20.34	9.7	0	14	55.9	0	14.1
	Day 2	14	20.3	0	19.3	45.0	1.3	91.8
	Day 3	6.0	36.4	5.6	1.7	44.4	5.9	183.5
Turtle grass	Day 1	7.0	47.4	4.3	9.5	30.7	0	37.7
	Day 2	9.6	56.6	4.2	4.2	24.0	0	80.4
	Day 3	16.8	31.4	0.6	1.7	45.0	4.5	124.2