BIODIVERSITY OF MARINE INVERTEBRATE SCAVENGERS IN DIFFERENT BENTHIC SUBSTRATES

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Abstract. This study investigates differences in the community composition of marine invertebrate scavengers in different habitats. Baited traps were designed to sample organisms attracted to carrion, and sunk on the fringing reef around Cook's Bay on sand, coral and rubble substrates. Experimental results revealed that most invertebrates found were either crustaceans or gastropods. No differences in richness between substrates were found, but there was a significant difference in abundance. Invertebrate scavengers play an important role in the nutrient cycling dynamics and are a critical part of the reef ecosystem.

Key words: marine invertebrate; scavenger; benthic substrate; baited trap; community composition

INTRODUCTION

Coral reefs are complex habitats wherein a variety of organisms coexist, interact, and compete for resources. The reef ecosystem supports a wide range of species, whose diversity rivals that of tropical rainforests (Connell 1978). Coral reefs occur in tropical areas where oceanic waters generally have low nutrient concentrations, yet paradoxically, reef ecosystems have some of the highest biomass and productivity (Lewis, 1977). Understanding nutrient dynamics on coral reefs is important because productivity is controlled by the availability of resources. It is generally believed that the main evolutionary adaptation to low nutrient conditions has been interspecies relationships that lead to efficient recycling of nutrients (Froelich, 2002).

In light of current global changes to the ecosystem (climate change, trophic cascades, overfishing, etc.) a growing awareness has emerged concerning the importance of scavengers in food web dynamics (Beasley et al 2012). Scavengers serve a critical role as stabilizing forces in food webs (DeVault et al, 2003) and in the redistribution of nutrients in the ecosystem (Payne and Moore 2006). It has been suggested that in tropical marine ecosystems, the apparent absence of carrion can be attributed to the rapid (<24hrs) attenuation by vertebrates and invertebrates; indicating that biomass is tightly recycled in the reef community (Rassweiler and Rassweiler, 2007).

Carrion is a spatially and temporally infrequent food source in the sea, and has thus shaped the evolution of facultative marine scavengers. Most marine animals die not of senescence, but of predation. As a result, scraps are only ephemerally available to scavengers, resulting in scavengers having special digestive adaptations (Britton and Morton, 1994). Marine invertebrate scavengers such as lysianassid amphipods, prevalent in colder waters, readily detect and migrate towards carrion, and can thrive on a single meal for long durations. In tropical reef ecosystems however, the invertebrate scavenging guild is observed to be much more diverse (108 species found near Lizard Island, Australia), including cirolanid isopods, cypridinid ostracods, and nassariid gastropods (Keable 1995). Macroinvertebrate scavengers have been extensively surveyed on the continental shelf near Australia (Lowry and Smith, 2003). A similar study in Panama looked at the decapod crustacean fauna in four marine habitats – sandy beach, mangrove, coral, and rocky intertidal areas. The results showed that there was more species abundance in the intertidal and coral habitats, respectively (Abele 1976). In Moorea, few studies have focused on marine invertebrate scavengers, especially in shallow water habitats.

The goal of my research was to compare the biodiversity and abundance of marine invertebrate scavengers in different benthic substrates in a coral reef ecosystem in Moorea, French Polynesia. Two main questions were addressed: What are the main scavenging invertebrates that assemble on fish carrion? Is there a difference in the diversity and abundance of scavenging organisms that assemble in sand, coral rubble, coral reef, and algae bed habitats? I hypothesized that there would be the greatest taxon richness and abundance of scavenging invertebrates in habitats with better substrate cover, and less competition with scavenging fish. Specifically, I hypothesized that there will be more scavenging organisms in coral rubble, followed by sand, and coral respectively.

METHODS

Study site

This study occurred on the island of Moorea, in the Society Islands archipelago in French Polynesia (17°29'10.68"S, 149°49'18.59"W). Moorea is a basaltic high island surrounded by a fringing reef and barrier reef, which are separated by a lagoon. This study was conducted from October to November of 2014 at the mouth of Cook's Bay, located on the north side of the island. To assess the diversity and habitat distribution of scavenging invertebrates, three types of benthic substrate were investigated–white sand, coral, and coral rubble. Areas classified as "sand" were characterized by white sandy bottom with the occasional coral head, which could be dead or live, and with some visible sand burrows. Sites classified as "coral" included a conglomeration of many different species of coral heads and abundant reef fish. Water current was noticeably stronger at coral sites. Finally, areas classified as "rubble" were characterized by broken pieces of dead coral forming the substrate, sedimentation, and assorted algae growth apparent.

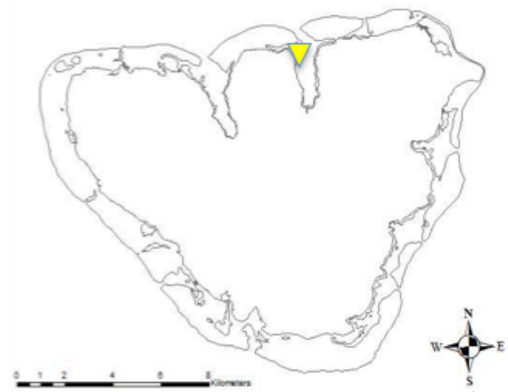

FIG. 1. Study site located on the fringing reef at the mouth of Cook's Bay. Base map courtesy of the Geospatial Innovation Facility, University of California, Berkeley.

FIG. 2. Sites markers represent sand (yellow), coral (green), and rubble (red) sites. Photo courtesy of Google Earth ©2006

Invertebrate Sampling

To characterize the community of scavenging invertebrates associated with each of the substrate types, traps were deployed for a set period of time, retrieved, and the organisms were subsequently identified. Specifically, I designed a cylindrical trap with inverted funnels at each end that allowed small organisms to easily enter, but not exit. Traps were 13 cm in diameter and 45 cm long, and both funnel apertures allowed for only a 2.5cm diameter. Traps were built with plastic cage material and lined with 0.5mm mesh. Additional weights and plastic buoys were attached.

Collected organisms were taken back to Gump Station to identify and quantify. Immediately following retrieval, traps and remaining bait scraps were rinsed thoroughly with ocean water through a 0.5 mm sieve at the wet lab to separate out macroinvertebrates. Diversity and abundance of invertebrate organisms were then catalogued to the lowest possible taxon level and photographed under the microscope. Voucher specimens were placed in 70% ethanol

Statistical Analysis

All data analyses were conducted on the statistical analysis program "R" (R Development Core Team 2013). A Shapiro-Wilk test was used to determine the normality of the data. The results were not normally distributed, therefore, all further tests were non-parametric. A Kruskal-Wallis rank sums test was performed to investigate differences between control and experimental traps, as well as differences between substrates. A pairwise Wilcoxon rank sum test was then used to determine what which two substrates differed the most. A non-metric multidimensional scaling (NMDS) ordination in the Picante package (Kembel 2012) was used to compute a resemblance matrix among scavenging communities between substrates. The ordination was used as a tool to visualize the data in a multidimensional space. Ordiellipses were used to create a confidence ellipse around each of the substrate communities. In addition, betadiversity, or the variability in species composition, was also calculated. Betadiversity was analyzed as the average steepness of the species area curve in the Arrhenius model (Oksanen 2013).

RESULTS

A Shapiro-Wilk normality test resulted in p- values less than 0.05 for both abundance (p=0.00762) and richness (p=0.00217). The null-hypothesis was therefore rejected and the data was assumed not to be from a normally distributed population.

Baited vs. Control

A Kruskal-Wallis rank sum test, the non-parametric analog to an analysis of variance, resulted in a significant difference in richness (p=0.0236) between baited and non-baited traps, but no significant difference in abundance of organisms (p=0.2086) (Fig. 3)

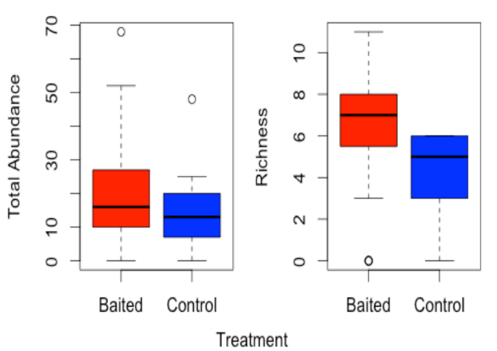

FIG. 3. Box-plot comparing the abundance and richness between baited and control treatments. Significant difference in richness only (p<0.05)

Community Composition

695 organisms total were found from 36 experimental traps in which 45 taxonomic groups were identified. The invertebrate scavenging community was almost exclusively dominated crustaceans and gastropods, but also included some annelids and echinoderms. Of the crustaceans, two of the most abundant suborders present in the traps were dendrobranchiata (shrimp), decapod megalopae larvae, and gammaridea amphipods. (Fig. 4) A full table of identified organisms can be found in Appendix A.

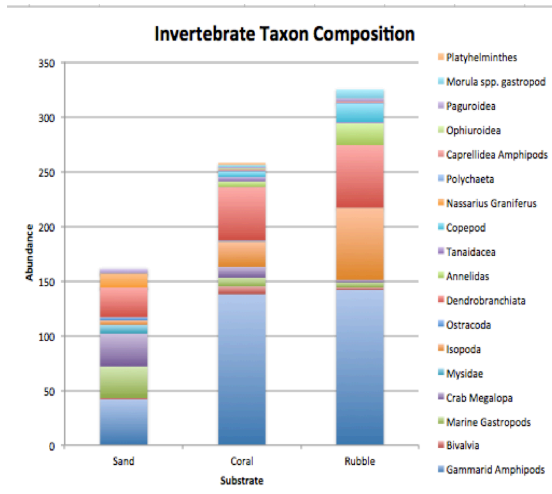

FIG. 4. A stacked bar graph of the community composition at each substrate type. Some taxon groups were grouped together at higher classification for clearer visualization in this figure

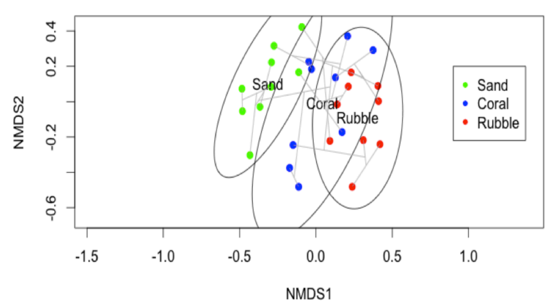

FIG. 5. NMDS Ordination of scavenging communities at different substrates. Sand and Rubble were most dissimilar.

Non-metric multidimensional scaling was used as a tool to visualize the multivariate dimensions of the scavenger community. The ordiellipses created by the ordination shows that there are distinct similarities within each substrate community. There are also overlapping similarities between sand and coral, and coral and rubble. (Figure 5)

Substrate Analysis

To determine differences in the community composition between the three substrates, several statistical measures were used. A Kruskal-Wallis test resulted in a significant difference between substrates for total abundance, but not richness ($p=0.0318$ and $p=0.7808$ respectively). To investigate which substrates were the most different, a pairwise Wilcoxon rank sum was used to show that the significant difference was between coral and sand substrates ($p=0.039$). (Figure 6)

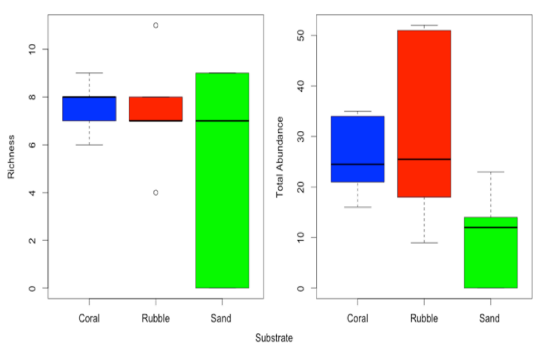

FIG. 6. Comparison of taxon richness and total abundance at coral, rubble, and sand substrates. Significant difference in abundance between coral and sand substrates ($p<0.05$)

Betadiversity is one measurement of biodiversity can be defined as the variability in species composition among sampling units. The centroid is the weighted mean of multivariate data, and represents heterogeneity, with closer distances representing higher betadiversity. The average distances to centroid for the substrates were as follows: coral ($d=0.4813$), rubble ($d=0.4154$) and sand ($d=0.4282$). (Figure 7)

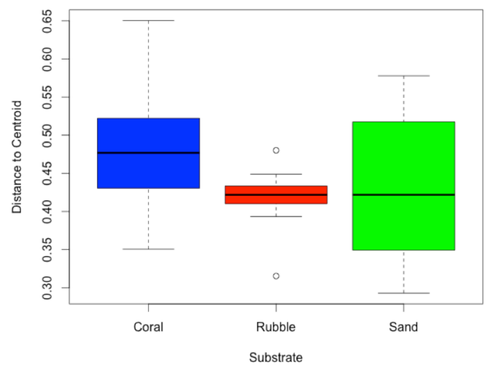

FIG. 7. Box plots of betadiversity between different substrates show that coral had the greatest distance from centroid ($d=0.4813$), while rubble and sand were approximately the same distances.

DISCUSSION

For this study, richness was defined as the number of different taxon groups found. Total abundance was defined as the number of organisms collected. These two measurements were used to represent the ecological community of invertebrate scavengers.

Baited vs. Control

The results showed that there was a significant difference between baited and control in terms of taxon richness, but not a significant difference for the total abundance of organisms (Fig 3). This could indicate that although the traps served to collect a wider range of scavengers, there may have been simply a higher relative abundance of certain mobile scavengers that got caught in traps. Another possible explanation for an incongruous control result is shortcomings in the sampling methodology. Possible cross contamination of baited and non-baited traps during preparation and transportation could have led to confounding biases.

Community Composition

The NMDS ordination (Fig. 5) of the scavenger community showed that overall community composition had more similarities than dissimilarities as illustrated by the overlap between ordiellipses of each substrate type. Sand and rubble were most dissimilar, with coral showing overlap with both. The similarity in community composition is to be expected as the invertebrates sampled came study sites that were relatively close in distance. Another possible explanation for why substrates, especially coral and rubble, were similar could be that the substrates themselves are similar. Coral heads in this part of Moorea were not as vibrant and healthy and quickly transitioned to rubble, which could lend to the similarities in invertebrate community.

Substrate Analysis

The results indicate that there was no statistically significant difference between substrates in richness, but there was for abundance. (Fig. 6) This differs from my hypothesis that there would be a gradient of taxon richness and total abundance of scavenging invertebrates from rubble to coral to sand substrate habitats. The results could suggest that the tropical scavenging guild may not have a specific habitat, but are mobile and aggregate towards sources of food. As nutrients are so scarce in tropical ecosystems, scavengers are known to assemble and feed on food scraps rapidly. The results of the study could imply that many scavenging invertebrates, especially ones in high abundance such as the gammarid amphipods and shrimp, are pelagic and live in the water column.

The differences in abundance agree with my expectations. The significant difference in abundance between sand and coral substrates could reflect a change in resource or predation. Because sand has lower median abundance than coral, it could imply that sand offers less protection and resources than does the coral substrate. Coral may provide more protection, but is also host to a much larger range of organisms, which could be disadvantageous to small invertebrate scavengers competing for food resources.

Coral also showed the greatest distance from centroid (Fig. 7), and thus lower betadiversity. This suggests that there was less change in taxon composition in the coral substrate compared to rubble. It is another way of looking at the diversity of the invertebrates. A possible explanation for less diversity could be, again, competition with vertebrates in the dynamic reef ecosystem for carrion scraps.

Since there have been no previous studies on the invertebrate scavenger composition in Moorea, my research could contribute to the existing body of literature about the tropical scavenging guild. Many of the organisms found in previous studies on Lizard Island, Australia were also found in my experimental traps. For example, *Nassarius graniferus* gastropods were consistently found in my sand substrate traps (Keable 1995).

Further studies could investigate the marine invertebrate scavenging community outside of Cook's Bay. Healthier coral heads and different substrates, such as algal beds and mangroves, are available around Moorea. Another interesting direction for study would be to compare the scavenging community between marine protected areas (MPAs) and common fishing sites or docks. Fisheries often discard carcasses back into the ocean, which provide great hot spots for scavengers. It would also examine our anthropogenic impact on just a small, yet important, community of organisms.

CONCLUSION

The results of my study showed that composition of the invertebrate scavenging community was more similar in richness and abundance than it was dissimilar. Specifically, richness was not different between substrates due to the possible mobility of invertebrate scavengers, and abundance differed only slightly between coral and sand. Understanding the composition of scavenging invertebrates in tropical reef ecosystems will give us greater insight into which organisms are important and how nutrients are recycled. This topic has come to be increasingly important with dramatically changing global ecosystem.

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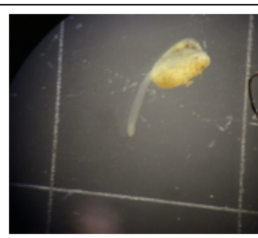
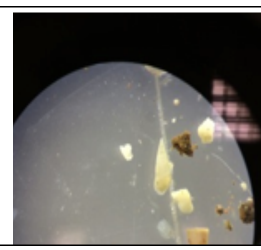
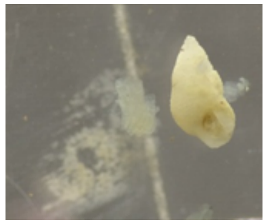
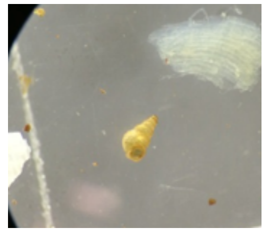
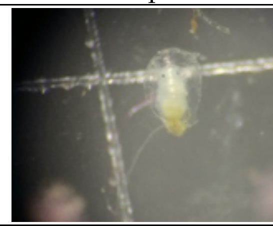
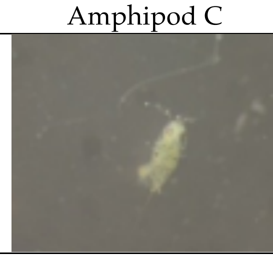
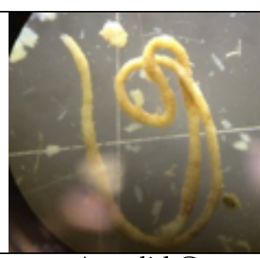
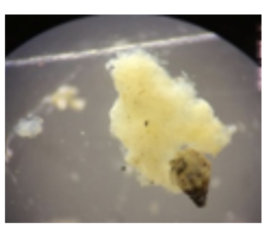
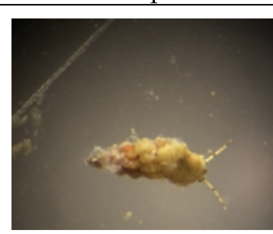
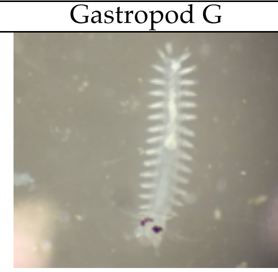
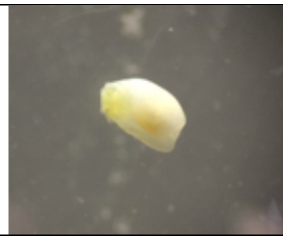
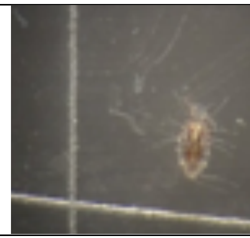
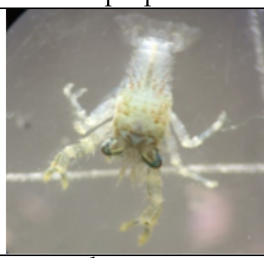
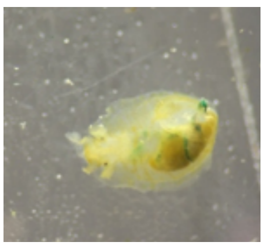
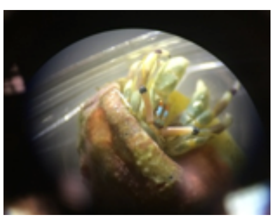
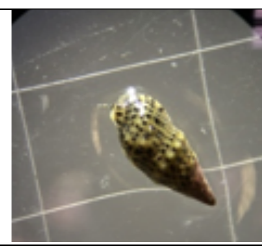
APPENDIX A

Table 1. Catalogue of invertebrate specimens found in traps, photographed through a dissecting microscope

			
Gammaridea Amphipod A	Bivalve	Grapsidae Crab Megalopae	Gastropod A

			
Mysidae	Gastropod B	Gastropod C	Decapod A
			
Amphipod B	Isopod A	Ostracod A	Gastropod D
			
Dendrobranchiata	Gammaridea Amphipod B	Gammaridea Amphipod C	Annelid A
			
Gammaridea Amphipod D	Tanaidacea	Copepod	Annelid B
			
Gastropod E	Annelid C	Gastropod F	Gastropod G
			
Nassarius graniferus	Gastropod H	Gastropod I	Polychaete A

			
Gammaridea Amphipod E	Ostracod B	Isopod B	Brachyura Crab Megalopae
			
Galatheoidea Crab Megalopae	Annelid D	Platyhelminthe	Gastropod J
			
Nudibranch	Caprellidea Amphipod	Ophiuroid	Polychaete B
			
Hermit Crab	Morula gastropod	Gastropod K	Decapod B