Reef Rugosity and Butterflyfish Community Structure in Punta Dumalag Marine Protected Area, Davao City

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Received: July 18, 2017; Accepted: December 5, 2017

Abstract

This study investigated the rugosity and butterflyfish community structure in Punta Dumalag, Davao City in twelve transects distributed in three stations. The transects were laid parallel to the shore at a depth of five to six meters in three stations. Rugosity indices, percent hard coral cover, butterflyfish species richness, abundance, diversity, biomass and density across all sampling stations registered low values, which may be attributed to a combination of fishing pressure and a strong prolonged southeast monsoon. Correlation analysis between rugosity and butterflyfish abundance showed low correlation coefficients that were statistically not significant, which may be caused by the confounding effect of interactions among fish species, territorial activities by fish species affecting reef structural complexity and low sample size.

Keywords: rugosity, butterflyfish, correlation, species richness, diversity, biomass

The coral reef is a vital component of marine protected areas. Its physical integrity and structural complexity are important physical features that provide anchorage and attachment for benthic organisms and cover and refuge for fish assemblages (Friedlander and Parrish, 1997).

Natural or anthropogenic events that reduce the structural complexity or rugosity of coral reefs dramatically alter the three dimensional reef structures by making them flatter. Changes in the surface area topography directly affect the spatial complexity of the reef which disrupts the biological interactions of reef organisms.

Butterflyfish spend their entire lives in coral reefs and occupy an important position in the web of interrelationships among reef organisms. Some species are strict corallivores and depend on coral polyps for food, while others feed on invertebrates that are associated with sponges, soft corals, and other coral reef organisms. Butterflyfish are so closely linked to coral reefs such that changes in species richness and abundance may serve as ecological indicators of the condition of coral reefs.

Reef habitat complexity has at least six components: rugosity, substratum diversity, variety of refuge, hole sizes, vertical relief of substratum architecture, percentage live cover including corals and seagrass and percentage hard substratum (Gratwike and Speight, 2004).

A study of Philippine reefs showed that fish abundance was positively correlated with increasing complexity of substrate topography. Live coral cover was also positively correlated with fish abundance and fish diversity. A positive correlation was also seen between fish biomass and index of surface complexity (Carpenter et al., 1982).

Several studies showed a positive association between rugosity and fish species richness (Gratwike and Speight, 2005; Chabanet *et al.,* 1997; Gratwicke and Speight, 2005), rugosity and fish biomass, abundance, density and diversity (Friedlander et al., 2003; Friedlander and Parish, 1997; Knudby and LeDrew, 2007; Chapman and Kramer, 1999). However, in the Red Sea, surface index appears to be a poor predictor of overall species richness and insignificantly correlated to butterfly fish abundance, but was significantly correlated with pomacentrid species richness and abundance (Roberts and Ormund, 1987).

This study investigated the butterflyfish community structure and reef rugosity in Punta Dumalag in terms of species richness, species abundance, biodiversity, percent coral cover, biomass, density and rugosity. The ecological information provided by this study may contribute to biodiversity conservation and sustainable use of Punta Dumalag Marine Protected Area.

Materials and Methods

Sampling Design

This study was conducted in Punta Dumalag Marine Protected Area, Davao City from April 2014 to March 2015. Three stations (Station 1: 7° 1'31.5" N, 125°34'24.16" E, Station 2: 7°1'25.09" N, 125°34'28.62" E, Station 3: 7°1'37.83" N, 125° 34'22.71" E) were established and four 50-meter transects were laid parallel to the shore in each station for a total of twelve transects. On either side of each fiberglass transect, a metal chain was used along the reef contour.

Fish visual census of butterflyfish was done within a 10 meter diameter of the transect line 15 minutes after other data have been gathered to allow the butterflyfish to resume their normal activity.

Data Analysis

Rugosity index was calculated using the formula $C = 1\text{-}d/l$, where d is length of the chain that follows the contour of the substrate, and l is its length when fully extended. Butterflyfish species richness and abundance were done by counting the number of individuals for each butterfly species. Butterflyfish length was estimated and used in calculating biomass by regression analysis ($W = aL^b$) using coefficients established by Kulbicki (1993).

Shannon's Index of Diversity and effective number of species were used to measure biodiversity of the butterflyfish community. Spearman's rho was used to measure correlation between reef rugosity and butterflyfish abundance.

Results and Discussion

Butterflyfish Diversity

The number of butterflyfish species recorded across three stations ranged from four to five species (Table 1). Station 1 revealed the highest species diversity among three stations with a Shannon Diversity Index of 1.354 which is equivalent to 3.87 species with equal abundances. Butterflyfish species diversity in Station 2 had a Shannon Diversity Index of 0.956 which is equivalent to 2.6 species with equal abundances. In Station 3 butterfly fish diversity had a Shannon Index of 0.896 which is equivalent to 2.45 species with equal abundances. A total of 53 species of butterflyfish is recorded in Philippine waters (Froese and Pauly, 2017) and the butterflyfish species observed in Punta Dumalag represents only 9.4% of the Philippine total.

Results further show that *Chaetodon kleinii* is the most abundant butterflyfish species in all stations. It is a tropical species found throughout the indo-pacific and feeds mainly on polyps of *Sarcophyton*, a soft coral species (Breder and Rosen, 1966). The other butterflyfish species are *Coradion melanopus*, a reef-associated species that feeds on sponges and is distributed throughout the Western Pacific (Burgess, 1978); *Chaetodon octo-*

Table 1. Butterflyfish abundance and diversity at three stations in Punta Dumalag Marine Protected Area.

Station	Butterflyfish Species	Counts	Shannon Diversity Index	Effective Number of Species
One	*C. kleinii* Bloch, 1790	10	1.354	3.87
	C. melanopus Cuvier, 1831	2		
	F. longirostris Broussonet, 1782	2		
	C. octofasciatus Bloch, 1787	6		
	C. lineolatus Cuvier, 1831	2		
Two	*C. kleinii* Bloch, 1790	14	0.956	2.6
	C. melanopus Cuvier, 1831	1		
	F. longirostris Broussonet, 1782	2		
	C. octofasciatus Bloch, 1787	4		
Three	*C. kleinii* Bloch, 1790	19	0.896	2.45
	C. melanopus Cuvier, 1831	1		
	F. longirostris Broussonet, 1782	4		
	C. octofasciatus Bloch, 1787	3		

fasciatus, also found in the western pacific and feeds exclusively on coral polyps including *Acropora* (Myers, 1991); *Chaetodon lineolatus,* the largest of the genus which feeds on coral polyps, sea anemones, algae, and small invertebrates (Steene, 1978); and *Forcipiger longirostris,* a monogamous species which feeds mainly on small crustaceans and can be found throughout the Indo-Pacific (Myers, 1991).

Rugosity and Butterflyfish Abundance

The underwater topography of Punta Dumalag is characterized by sandy stretches interspersed with patches of hard coral, soft coral, and sponges. Percent hard coral cover across all stations is poor ranging from 10-20% (Table 2). Consequently, rugosity is low and percent hard coral cover appears to be the major contributor in the low rugosity indices calculated across all stations. Correlation analyses between rugosity and butterflyfish abundance showed a low and insignificant Spearman's rho value (Figure 1). Spearman's rho was used because the data failed to meet the parametric assumption of normality. The results of correlation indicate a lack of association between rugosity and butterfly fish abundance and implies the presence of confounding factors. According to Roberts and Ormund (1987) fish community and substratum complexity are interdependent, thus the relationship between rugosity and fish species abundance may be confounded by interactions among fish species and by territorial activities of fish species affecting reef structural complexity. The small sample size of the present study (n=12) may have also influenced the magnitude of the correlation coefficient. Carpenter et al. (1982) stated that a large sample size may be required to adequately reflect fish-substrate relationships.

Table 2. **Rugosity index and *hard coral cover at three stations in Punta Dumalag Marine Protected Area.

Transect	Fiberglass Transect Length (m)	Mean Chain Length (m)	Rugosity Index (1-d/l)	Percent Hard Coral Cover (%)
Station 1				
One	50	59.50	0.190	10
Two	50	56.75	0.135	20
Three	50	58.75	0.175	15
Four	50	54.50	0.090	20
Mean	50	57.38	0.148	16
Station 2				
One	50	59.50	0.19	15
Two	50	59.00	0.18	20
Three	50	57.00	0.14	10
Four	50	57.50	0.15	15
Mean	50	58.25	0.17	15
Station 3				
One	50	61.00	0.22	15
Two	50	58.75	0.18	25
Three	50	57.25	0.15	10
Four	50	56.00	0.12	20
Mean	50	58.25	0.17	16

*poor = 0-24.9%, *fair = 25-49.9%, good = 50-74.9%, and excellent = 75-100%
**low < 0.17, moderate = 0.171 to 0.275, high> 0.275

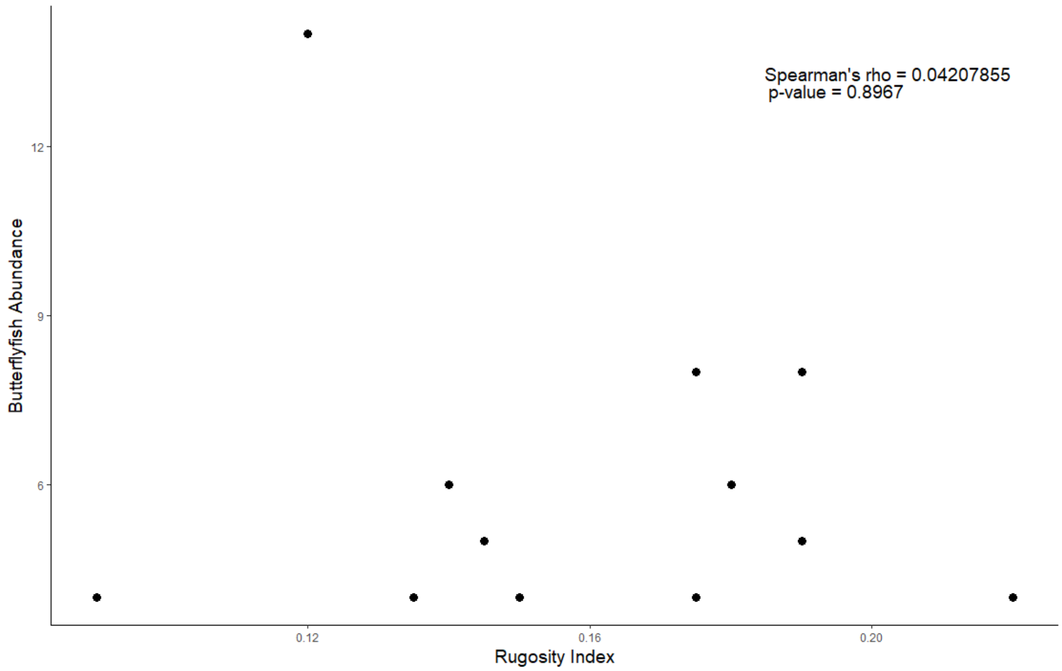

Figure 1. Rugosity index and butterflyfish abundance scatterplot at three stations in Punta Dumalag Marine Protected Area.

Table 3. Butterflyfish biomass and density at three stations in Punta Dumalag Marine Protected Area.

Transect	Area (m^2)	Butterflyfish Total weight (g)	Butterflyfish Biomass (g/area)	Butterflyfish Abundance	Butterflyfish Density (abundance/ area)
Station 1					
One	500	20.76	0.042	8	0.016
Two	500	16.44	0.033	4	0.008
Three	500	27.18	0.054	8	0.016
Four	500	03.84	0.008	4	0.008
Total	2000	68.22	0.034	24	0.012
Station 2					
One	500	07.95	0.016	5	0.010
Two	500	12.06	0.024	6	0.012
Three	500	05.76	0.012	6	0.012
Four	500	03.84	0.008	4	0.008
Total	2000	29.61	0.015	21	0.010
Station 3					
One	500	03.84	0.008	4	0.008
Two	500	03.84	0.008	4	0.008
Three	500	07.95	0.016	5	0.010
Four	500	19.74	0.039	14	0.028
Total	2000	35.37	0.018	27	0.014

Butterflyfish Community Structure

Butterflyfish size estimates, number of individuals, and number of species in stations are shown in Table 3. The very low biomass, density, and abundance values are similar in all stations. It is probable that strong wave action may negatively influence fish biomass (Friedlander et al., 2003). This implies that the strong southwest monsoon (Habagat) that appears in Punta Dumalag from June to December and generates waves that roil the shallow coastal waters may have a negative effect not only on fish biomass but also fish species richness and abundance. Because Punta Dumalag Marine Protected Area is near a local community, it is plausible that fishing pressure could be a contributing factor to the results of this study.

Conclusion

Five butterflyfish species were observed to be represented by a few individuals of relatively small size. Analyses showed low species diversity, low biomass, low density, low rugosity, and poor coral cover. Fishing activities and a strong prolonged southeast monsoon may partly account for the results of this study. Low and statistically insignificant correlation between rugosity and butterfly fish abundance may be attributed to interactions between fish species, territorial activities by fish species affecting substrate complexity, and small sample size. The results of this study provide ecological information that is important to achieve biodiversity conservation and sustainable use of the ecological resources in Punta Dumalag Marine Protected Area.

Acknowledgments

The author would like to thank the University of Southeastern Philippines for funding this research.

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