DAVAO RESEARCH JOURNAL

P-ISSN 2244-4432
E-ISSN 2984-7125

Coastal ecosystem and trophic relationship of associated macrobenthos in Guang-guang, Mati City, Davao Oriental

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ABSTRACT. Coastal ecosystems are where land and water converge creating a distinct environment hosting a rich diversity of marine organisms. This study aimed to determine the zonation pattern of mangroves and the trophic relationship among the associated macrobenthos in the local coastal ecosystem of Guang-guang, City of Mati, Davao Oriental. The establishment of the study area and gathering of field data were conducted on December 2, 2017, a period of one day during low tide. There was an absence of zonation pattern on the mangal due to *Rhizophora stylosa* being the only mangrove species present. The marine gastropods observed on the mangal were *Monilea callifera, Pomalea canaliculata, Crassostrea iredalei, Trochus pyramis, Spisula solidissima, Zeacumantus lutulentus, Cominella glandiformis,Diloma subrostrata* and *Haustrum scabina.* On the adjacent intertidal zone, the seagrasses and macroalgae found were *Enhalus acoroides, Thalassia hemprichii, Padina gymnospora, Halophila ovalis,* and *Halimeda* sp., and the presence of the associated macrobenthos starfish, hermit crab, Philippine sand dollar, mud crab, blue mussel, marine gastropod, shrimp, brittle star, fish and jellyfish. The area had a high macrobenthic diversity with 1.34 on the Shannon-Wiener diversity index and 0.6 on Simpson's diversity index. On the highest trophic level of the coastal ecosystem food chain are the producers including mangroves, sea grasses and algae and the lowest on the trophic level are the tertiary consumers and apex predators are birds, turtles, and larger fishes.

Keywords: *Coastal ecosystem, food chain, food web, macrobenthos, mangroves, trophic relationship, zonation patterns*

How to cite: Salang, R. Q. M., and Macusi, E. D. (2020). Coastal ecosystem and trophic relationship of associated macrobenthos in Guang-guang, Mati City, Davao Oriental. Davao Research Journal (DRJ), 12(3), 11-19. https://doi.org/10.59120/drj.v12i3.102

OPEN ACCESS

Submitted: 19 June 2020
Revised: 20 July 2020
Accepted: 13 August 2020
Published: 16 December 2020

https://davaoresearchjournal.ph

INTRODUCTION

Mangrove and seagrass ecosystems are common and widespread coastal environments in tropical and subtropical latitudes, providing food, habitat, and shelter for numerous marine organisms (Saenger et al., 2012; Zhang et al., 2007). Mangrove ecosystems are composed of mangal or forest community of mangroves along with the associated microbes, fungi, plants, and animals as well as the abiotic factors present. These mangroves were defined by Duke (1992) as tree, shrub, palm, or ground fern and generally exceeds one half meter in height, normally growing above mean sea level in the intertidal zone of marine coastal environments or estuarine margins. Mangroves are well distributed, occurring in 112 countries, with various estimates in its global coverage ranging from 10-24 million hectares (Bunt, 1992; Schwamborn and Saint-Paul, 1996; Twilley *et al.*, 1992), roughly half of which are found in Asia (Spalding, 1997). These unique ecosystems provide ecological and economic significance (Mitsch, 2005) including stabilizing shorelines and reducing the impact of natural disasters such as hurricanes, supporting coastal fisheries, providing breeding and nursing grounds for fishes food, medicine, fuel and building materials for local communities (Parenti, 2014; Pramudji, 2001). Meanwhile, seagrass beds, consist of about 60 species of marine angiosperms worldwide are found in shallow coastal waters throughout tropical and temperate oceans. Sea grasses all have prostrate stems buried in sand or mud and produce ribbon-like leaves on erect branches that can vary in length from less than a millimeter to half a meter or more. As a result, seagrass beds can be dense and of complex structure (Orth *et al.*, 2006). Coastal ecosystems like mangroves and seagrass support various macrobenthic marine organisms that play diverse ecological roles. Macrobenthos were defined as organisms that inhabit the bottom region of a water column and are visible to the naked and are mainly composed of echinoderms, crustaceans, mollusks, polychaetes and other groups (Hutchings, 1998). These macrobenthos play significant roles in the marine community considering its involvement in mineralization, mixing of sediments, fluxing of oxygen into sediments and cycling of organic matter (Snelgrove, 1998). Most of the macrobenthos assist in the breakdown of particulate organic matter by exposing them to microbes through shredding and their waste materials contain nutrients that enrich the substrates. This study aimed to determine the zonation pattern of mangroves and the trophic relationship among the associated macrobenthos in the coastal ecosystem of Guang-guang, Dahican, Mati City, Davao Oriental. The study was all conducted at the intertidal zone of Guang-guang, Dahican, Mati City, Davao Oriental.

MATERIALS AND METHOD

Description of study area

This study was conducted in the intertidal zone of Guang-guang, City of Mati, Davao Oriental (Figure 1). The area was characterized by the dense presence of mangroves as a part of the 21,000 ha man-made mangal with 18 mangrove species although dominated by *Rhizophora stylosa* and *Avicennia* sp. There were occasional clearings within the mangal wherever the general substrate type would be of limestone. There are sandy-muddy substrates present on the parts inhabited by the mangroves. Sea grasses were observed to be abundant in the regions near the open sea, with macroalgae interspersed with it.

Gathering of field data

To assess the seagrass and macroalgae and the macrobenthic presence in the study area with a latitude of 06º 55’01.7, 6º54’56.2 and longitude of 126º 152’2.1, 126º15’130.9, particularly on the intertidal zone adjacent to the mangal, the transect-quadrant method was employed (Figure 2B). There were six transects established in the study area, each measuring 20 m long. The six transects

DOI: https://doi.org/10.59120/drj.v12i3.102

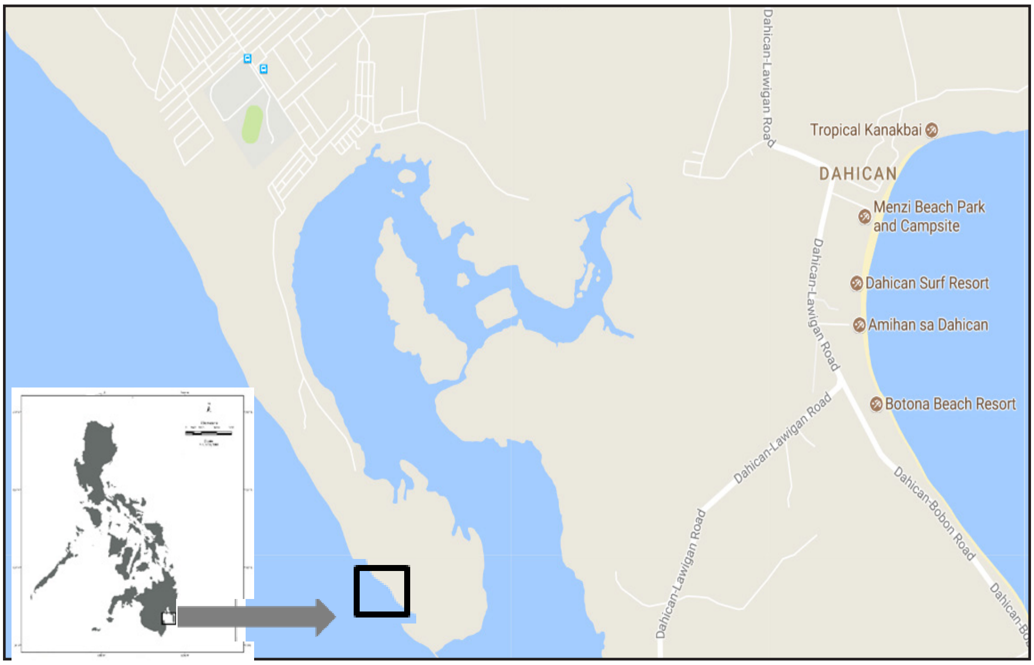

Figure 1. Location of the study area on sitio Guang-guang, Brgy. Dahican, City of Mati, Davao Oriental.

were strategically laid on the intertidal zone directly in front of the sampling site on the mangal to provide comprehensive coverage of the study area. On these transects, five quadrants measuring 1 x 1 m (1 m^2) were laid on each side of the transects. The exact establishment location of these quadrants on the transects was determined by drawing lots from papers numbered 1-20 with each number representing one meter on the transect. Upon the establishment of the quadrants, the seagrass and macroalgae present were identified and counted individually by clump. The macrobenthos present within the quadrats were also identified, counted, and calculated for diversity. To identify the species, we used "Field Guide to the Common Mangrove, Seagrasses and Algae of the Philippines" of Calumpong H. P. and E. G. Menez (1997) and "Botanical Identification Handbook on Philippine Mangrove Trees" of Aragones, et al., (1998).

Figure 2. Establishment strategy of the transects showing its parallel deployment on the mangal clearing (A) and sampling strategy of transect-quadrat method employed for the intertidal sampling (B).

Macrobenthos assessment

To gather the data, the transects were marked with a knot in every meter. These transects were laid parallel to the general direction of the clearing, with one end placed on the mouth of the clearing and the other end where the 50 m measurement ends. From the mouth of the clearing, every mangrove tree encountered every 5 m mark was identified and assessed for the associated marine gastropods present on its leaves, trunk, and roots. These marine gastropods were identified, categorized concerning what part of the mangrove they were found, counted, and calculated for relative abundance.

DATA ANALYSIS

The data of the gastropod grazers and macrobenthos were analyzed for relative abundance and diversity respectively through the use of the appropriate formula and indices.

Relative abundance

The standard formula in getting the relative abundance was used.

$$Relative\ abundance = \frac{number\ of\ individuals\ per\ species}{total\ number\ of\ individuals} \times 100$$

Diversity

In determining the diversity of macrobenthos, Shannon-Wiener Diversity Index and Simpson's Diversity Index were used.

Shannon-Wiener diversity index

$$H' = \sum (P_i)\ (\ln P_i)$$

Where:

H' = Shannon-Wiener Diversity Index
P_i = proportion of the individuals of species $_i$
$\ln P_i$ = natural log of P_i
Σ = summation of all species

Simpson's diversity index is calculated as:

$$D = \Sigma n_i(n_i\text{-}1) \ /\ N(N\text{-}1)$$

$$Simpson's\ diversity\ index = 1\text{-}D$$

Where:

D = proportion of the individuals of species I squared.
n_i = number of organisms that belong to species $_i$
N = total number of organisms

RESULTS

Mangroves

Despite being known to host 18 mangrove species, only *Rhizophora stylosa* locally known as "bakauan-bangkau" were present at the selected study area at Guang-guang, Dahican (Figure 3). On the intertidal zone adjacent to the study area, *Avicennia* sp. was observed to be the only mangrove species present, a clear indication of the absence of natural zonation patterns attributed to the man-made nature of this protected mangrove forest particularly on the outlying intertidal zone.

Gastropod grazers

On the R*hizophora stylosa* mangroves present in the study area, there were seven (7) associated gastropod grazers found (Figure 4). These were identified as: *Cyprea moneta, Littoraria pallescens, Monodonta labio, Nerita undata, Polinices tumidas, Siphonaria serrata* and *Trochus sp.* This result was significantly lower compared to Macintosh et al. (2002) who recorded 33 species of gastropods in a mangrove rehabilitation area in Thailand, and Irma and Sofyattudin (2012) with 14 species in Indonesia.

Seagrasses and macroalgae

On the intertidal zone adjacent to the mangal forest, several species of seagrass along with macroalgae were found (Figure 5).

Davao Res J 2020 Vol. 12 | 11-19 DOI: https://doi.org/10.59120/drj.v12i3.102

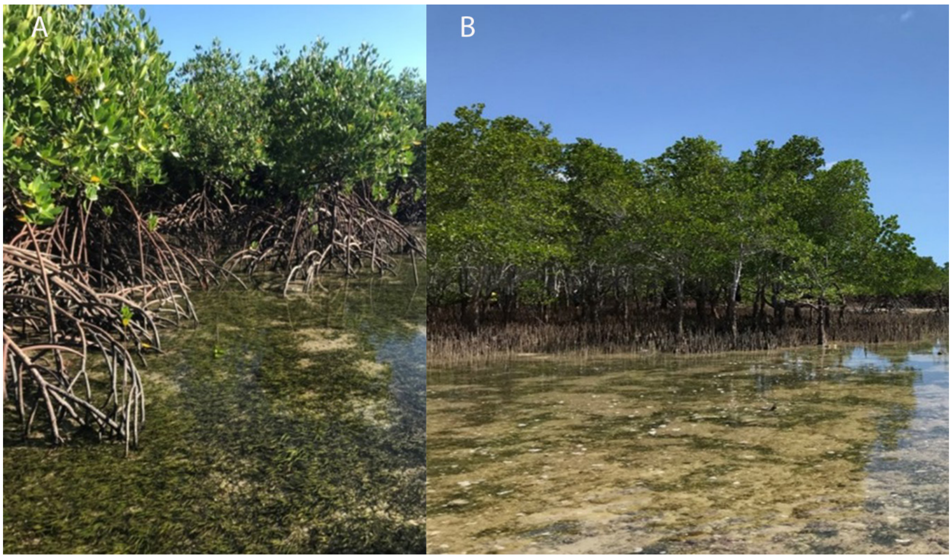

Figure 3. *Rhizophora stylosa* species on the study area (A) and *Avicennia* sp. present adjacent to the study area (B).

Figure 4. The gastropods found on the *Rhizophora stylosa* mangroves: *Cyprea moneta* (A), *Littoraria pallescens* (red, zebra-striped and yellow color variations) (B), *Monodonta labio* (C), *Nerita undata* (D), *Polinices tumidas* (E), *Siphonaria serrata* (F) *Terebralia sulcata* (G) and *Trochus sp.* (H).

Figure 5. Seagrasses and macroalgae found on the intertidal zone: *Thalassia hemprichii* (A), *Halophila ovalis* (B), *Halimeda* sp. (C) and *Padina gymnospora* (D).

These include the seagrasses *Enhalus acoroides, Thalassia hemprichii,* and *Halophila ovalis* and the macroalgae *Halimeda* sp. *and Padina gymnospora.*

It was observed that the seagrass *Thalassia hemprichii* was present in all transects and the most abundant as well (Table 1), comprising 54.45-98.16% of the overall marine plants present in the four stations. The second most abundant was the macroalgae *Padina gymnospora* followed by *Enhalus acoroides*, both present only on transect 3. These were followed by the seagrass *Halophila ovalis* which were present only on transect 2, with the least abundant being the macroalgae *Halimeda* sp. on transect 1.

Table 1. Number of seagrasses and macroalgae and their averaged percent cover on the intertidal zone of the study area.

Common name	Scientific name	All transects
Tape seagrass	*Enhalus acoroides*	81
Turtle grass	*Thalassia hemprichii*	5402
Funnelweed	*Padina gymnospora*	162
Dugong grass	*Halophila ovalis*	10
Small-leafed halimed	*Halimeda* sp.	7
Sea grapes	*Caulerpa lentillifera*	1
TOTAL		**5663**

The seagrass *Thalassia hemprichii* was observed to dominate the intertidal zone of the study area, present in dense meadows disrupted only by the presence of a different substrate such as the characteristic limestone seafloor on the intertidal zone of the study area. The other seagrass and macroalgae were observed to be present in small numbers and often interspersed either on their own or alongside the dominant *Thalassia hemprichii.*

Macrobenthos and trophic relationship

Various macrobenthos were found and identified in the intertidal zone of the study area. These macrobenthos observed include bivalves, fish, gastropods, sand dollar, sea cucumber, and starfish.

From the table presented below, it could be observed that marine gastropods had the highest abundance present followed by hermit crab and sand dollar. The calculation of macrobenthic diversity from the different transects revealed that the area had high biodiversity with 1.34 on the Shannon-Wiener diversity index and 0.6 on Simpson's diversity index. This diversity index of the macrobenthos in the study area supports the result of the study conducted by Zhou et al., (2008) which revealed that mangrove habitats have a positive influence on macrobenthic diversity.

Table 2. Various macrobenthos present in the intertidal zone of the study area.

Represented taxa	Transects
Asteroidea	5
Paguroidea	18
Clypeasteroida	16
Echinoidea	8
Holothuroidea	15
Muricidae	94
Synapta maculata	9
Total	**80**
Shannon-Wiener diversity index	**1.34**
Simpson's diversity index	**0.6**

These macrobenthos are involved in the marine food web of the coastal environment in the study area, interacting through the different trophic levels and forming a complex food web. In the study area, the major macroscopic producers observed were the sea grasses which were present abundantly, and macroalgae. These marine autotrophs harness the energy from the sun which is the primary energy source to manufacture their food, eventually utilizing the resulting product in the form of glucose or storing it in the form of starch. These producers pass the energy to the higher trophic levels once they are foraged by the primary consumers, which in the study area are usually fishes, shrimps, brittle stars, hermit crabs, and marine gastropods. Secondary consumers in the study area such as larger fishes, sea stars, and crabs get their energy by feeding on these primary consumers. The common tertiary consumers that were known to be present in the study area were birds, turtles, and larger fishes.

DISCUSSION

Rhizophora stylosa is known for its adaptability and tolerance to climate and soil which allowed this species to inhabit a wide variety of areas ranging from muddy, sandy, stony soil as well as in the corals. *Rhizophora stylosa* prefers muddy, oxygen-poor soils along estuarine banks or along the coast but are also known to colonize stony and/or sandy soil. These substrate preferences were observed in the area since both were present. This was attributed to the man-made nature of this mangal, wherein many of the mangroves planted were *Rhizophora stylosa* for their economic value (Uddin et al., 2003). In a natural mangal, mangroves grow in a monospecific band parallel to the shoreline with a definitive spatial variation. This natural zonation pattern among mangrove species is primarily attributed to tidal flooding, land elevation, and salinity. Previous studies have attempted to expound the controlling factor to mangrove zonation through various hypotheses including land building and plant succession (Davis, 1940), geomorphological influences (Thom, 1967), propagule dispersal and zonation (Rabinowitz, 1978), propagule predation and forest structure (Smith, 1987; Mckee, 1993), competition and forest structure (Ball, 1980) and the physicochemical gradient in the area.

Trophic relationships in an ecosystem are commonly illustrated through food chains and food webs. This would be a food chain if it is a linear sequence of organisms through which nutrients and energy pass as one organism eats another, and it would be a food chain if it is complex and shows all the trophic interactions between various species in an ecosystem (Starr and Taggart, 2006). In the study area, the observed food web was revealed to be consistent with the typical food web of coastal ecosystems (mangrove and seagrass ecosystems) in the Philippines. Locally abundant mangrove trees, seagrasses, and macroalgae serve as producers, utilizing the energy directly from the primary energy source, the sun, to manufacture their own foods. These autotrophic producers either use the resulting product of photosynthesis as glucose or store it as starch (Arnon, 1971). The primary consumers observed in the study area are the herbivores and omnivores such as small and juvenile fishes, shrimps, brittle stars, hermit crabs, and marine gastropods. These primary consumers directly derive their nutrients and energy from the producers. Secondary consumers are carnivores or omnivores such as larger fishes, sea stars and crabs get their energy through preying and foraging on these primary consumers. The tertiary consumers observed to be present in the study area were birds, turtles, and larger fishes. From these observed trophic relationships among the locally present macrobenthos in this coastal ecosystem, the tertiary consumers are considered the apex predators.

These different trophic levels of consumers are all considered crucial for the role they play, as Ripple et al. (2014) have emphasized, in the maintenance of stability of an ecosystem through subjecting the plants and consumers of the lower trophic level to efficient predation thereby keeping their population at the appropriate number not exceeding and pressuring the ecosystem's natural carrying capacity. The primary reason why there are fewer apex predator populations than the primary and secondary consumers are due to the greatly reduced energy passed to their trophic level (Wallach et al., 2015) as demonstrated by the 2nd law of thermodynamics (Galucci, 1973). If the number of apex predators exceeds that of their prey, it would create a deficit in the energy that they acquire to what is present, thereby resulting in an unbalanced food chain and food web. It has been observed that *Littoraria* like to graze on young mangrove leaves (Reid, 1986). This could account for the high diversity and abundance of *Littoraria* spp. at all transects where the plantation trees are still young and small.

CONCLUSION

In conclusion, *Rhizophora stylosa* was the most commonly observed species in the area and no distinct zonationa pattern were observed because the study area was largely a reforested zone. While the marine species observed on the mangal trees were *Monilea callifera, Pomalea canaliculata, Crassostrea iredalei, Trochus pyramis, Spisula solidissima, Zeacumantus lutulentus, Cominella glandiformis, Diloma subrostrata,* and *Haustrum scabina.* However, on the adjacent intertidal zone, the seagrasses and macroalgae found were *Enhalus acoroides, Thalassia hemprichii, Padina gymnospora, Halophila ovalis,* and *Halimeda* sp., and the presence of the associated macrobenthos starfish, hermit crab, sand dollar, mud crab, blue mussel, shrimp, brittle star, fish, and jellyfish were found in the area. The area had a moderately high macrobenthic diversity, with 1.34 on the Shannon-Wiener diversity index and 0.6 on Simpson's diversity index. On the highest trophic level of the coastal ecosystem food chain are the producers, including mangroves, seagrasses, and algae, and the lowest on the trophic level are the tertiary consumers, and apex predators are birds, turtles, and larger fish.

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