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Assessment of mangrove species and its relation to soil substrates in malapatan, Sarangani Province, Philippines

Earl Kevin C. Mullet*, Giuseppe Haydn Lacorte*, Rea Mae A. Hamiladan*, Clarince Eden M. Arabit[1], Shienna O. Cuales[1], Lira Grace C. Lasutan[1], NorlyJane S. Alagos[1],Haironesa G. Kamantu[1], Kristene Joy T. Protacio[1]and Jess H. Jumawan[2]

[1] *BS Biology,College of Natural Sciences and Mathematics, Mindanao State University, General Santos City 9500, Philippines*

[2]*Science Department, College of Natural Sciences and Mathematics, Mindanao State University, General Santos City 9500, Philippines*

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Abstract

Mangroves are type of trees growing along tidal mudflats and along shallow coastal areas, extending inland along rivers, streams, and their tributaries where water is generally brackish. This study was conducted from June-August, 2014 in Malapatan, Sarangani Province particularly in the coastal barangays of LunPadidu, Tuyan and Poblacion. The study area provided excellent sites for studying habitat associations because of the various substrate types observed in the sites. Five replicate plots of equal size in each forest type were encountered along these sites.There were a total of 7 identified mangrove species belonging to 6 families found along the coastal parts of the study areas. Data shows that particular species of mangrove has its own preference in soil characteristic for growth. The gravel was identified as the most dominant substrate among all the collected samples. Spearman Rank Correlation showed that mangrove diversity was positively correlated to sandy soil ranging from medium sand to silt/clay. However, bigger*S. alba* trees have been observed on gravel-rich soils compared to those found growing on medium sand, fine sand or silt/clay soils. The study provided vital information for rehabilitation actions of the mangal communities along the areas and provided baseline data as reference for mangrove researches in Malapatan, Sarangani Province, Philippines.

***Corresponding Author:** Earl Kevin C. Mullet ✉ earlkevinmullet@gmail.com

Introduction

Mangrove forests are located between land and sea in tropical and subtropical zones all around the world and are very important in coastal ecosystems. The species were known to adapt to oxygen-poor environments and nutrient-rich muddy substrates that undergo variations in salinity (Sherman *et al*, 1998; Ferreira *et al*, 2010). Extensive information has been generated about the ecological, socioeconomic, and biological functions of mangrove systems in the past decades because of is functional role in mangal community and their transitional position between marine and terrestrial environments (Constanza*et al*, 1998; Aburto-Oropeza *et al*, 2008). Mangroves contribute a wide array of fishery (seaweeds, fish, crabs, prawns, mollusks and other invertebrates) and forestry (timber, firewood, tanbark for dyes, fibres and ropes, corks etc.) products. Mangroves play important roles in coastal protection from typhoons and storm surges, erosion control, flood regulation, sediment trapping, nutrient recycling, wildlife habitat and nurseries (Primavera *et al*, 2008).

In spite of numerous articles on mangroves, there was only few published information available on mangrove forest structure. The comparative value of various studies published is not as favourable as it could be; author's contradictory research goals have led to the adoption of non-uniform measurements (English *et al*., 1997; Prof. K. Kathiresan *et al*, 2005). The area was suitable for conducting research since there wereadequate mangrove forests with diverse ecology congregating around the area.

Soil texture is commonly used to designate the proportionate distribution of the different sizes of mineral particles in a soil. Of soil characteristics, texture is one of the most important for it can influence many other properties of great significance to land use and its management. However, it is very vital to realize that texture alone does not tell all the necessary information about soil behaviour and their suitability for different uses (R.B. Brown, 2003).

In relation to this study, soil plays a vital role in the condition of mangrove species. Soilscover much ofthe earth's surface composed of mineral and organic materials whichcan support vegetation, and have inplaces been changed by human activity (Jenny, 1961).Soil sampling plan involves the selection of the well-organized method for choosingthe samples that will be used to estimate the properties of the population which is central to the preliminary formulation of the research study(Eberhardt and Thomas 1991; Pennock 2004).

The province was chosen to be the sampling site for the conduct of research because it is an ideal site to explore the mangrove and soil relationships. This study proves to be useful for future reference since only few researchers have conducted their researches in Malapatan, Sarangani Province, Philippines.

Materials and methods

Study sites

The study was conducted in Malapatan, Sarangani Province located at 5.97°N, 125.29°E (Fig.1). The study area provided excellent sites for studying habitat associations because of the various substrate types in the area. The study sites include different types of substrates: coral rubble, fine to coarse sand, clay, pebbles, cobbles, and boulders. The actual locations of sites were determined through GPS (Global Positioning System). Research was conducted from June to August, 2014.

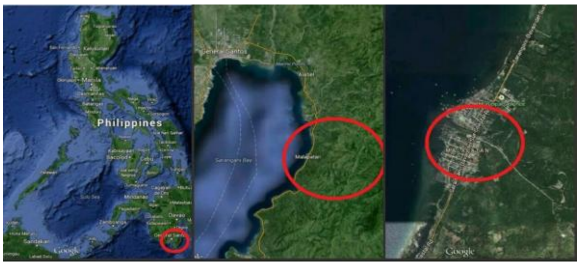

Fig. 1. Map of Malapatan, Sarangani, Province, Philippines showing the mangrove site**.**

Field Work and Methodology

Establishment of sampling plots

A total of 40 sampling plots were established in the sampling sites. The plot dimension of 10 m x 10 m constitutes the main plot. Purposive sampling was implemented in which the plots were established on locations where mangroves were sufficient. Within the main plot, three 1m X 1m were established as regeneration plots and used for counting each seedlings and saplings found.

Species inventory

Mangroves were identified in site and were evaluated for further analysis. Mangrove species observed even outside the plots were identified as part of species inventory. Reliable identification guides were used to identify mangrove species (Primavera *et al*, 2008; Calumpong, 2007).

Biodiversity measurements

Biodiversity index is a quantitative measure that reveals the totality of the different individual species seen on the area of interest. The following categories were determined in the study: Species Richness, Abundance, Dominance, Evenness and Shannon's Diversity Index. In measuring the Biodiversity Indices, the PAST software (Hammer, Ø. *et al*, 2001) was used. Species Richness is the quantity of the different species located within the plots. Abundance refers to the overall total of individual species present. Simpson's Dominance Index refers to the probability that two individual species observed may belong to the same species. Evenness implies how even the distribution of the individual species among the different species within the plots. Species diversity is described according to the Shannon Index (H) as per the following equations:

$$H = -\sum_{i=1}^{S}(p_i \times \ln p_i) = -\sum_{i=1}^{S}\left(\frac{n_i}{N} \times \ln \frac{n_i}{N}\right)$$

In this formula, S is the total number of species, N is the total number of individuals, and ni is the number of individuals of the i-th species. ni/N is equivalent to pi, the probability of finding the i-th species (Magurran, 2004).

Vegetation analysis

Vegetation analysis was used to characterized and identify the status of a plant community in a vegetation which is necessary to collect significant information at the site.Vegetation analysis objectives include the formation of a comprehensive species list, definition of plant communities and the identification of successional processes (David E. Steinfield *et al*, 2007). This is the formula used in the study:

Population density = Number of individuals / total area sampled,

Frequency = Number of plots in which a species occurs / total number of plots sampled

Dominance= total of basal area of each tree of a species from all plots/ total area of all the measured plots.

Relative density=no. of individuals of a species/total no. of individuals of all species x100

Relative dominance=total basal area of a species/basal area of all species x 100

Relative frequency= frequency of species/total frequency of all species in different plots x100

Importance Value (IV) = relative density + relative frequency + relative dominance.

Regeneration of seedlings and saplings

Seedlings and saplings inside the regeneration plots were counted and documented. Saplings (girth less than 4cm and height greater than 1m) were identified and the number of individual species was determined. Seedlings (less than 1m height) were also identified and counted.

The regeneration values were computed and its corresponding condition was evaluated based on the formula (Deguit *et al*, 2004). These were as follows: (1) Regeneration per m^2 = total regeneration count / total no. of regeneration plots, (2) Excellent condition – at least 1 regeneration per m^2. (3) Good condition – 0.76 - ‹1 regeneration per m^2. (4) Fair condition – 0.50 – 0.75 regeneration per m^2. (5) Poor condition – ‹0.50 regeneration per m^2.

Collection of soil

In each plot, soil samples were collected for particle size analysis. Soil samples of about 100 grams were collected at 0-30 cm depth (Adepetu *et al*, 1996). The soil samples were air dried for about 4-5 days in a well-ventilated area in Biology department laboratory, MSU-General Santos. Afterwards, the soil samples were subjected to soil particle characterization using a sieve (W. S TYLER brand) with following sizes and description: 2mm (gravel), 850µm (very coarse sand), 425 µm (medium sand), 180µm (fine sand), 150µm (very fine sand), <150 µm (silt or clay). The resulting soil data were correlated to Shannon Diversity Index using Spearman Rank Correlation software (Wessa P.2012. Spearman Rank Correlation (v1.0.1) in Free Statistics Software (v1.1.23-r7)).

Results and Discussion

Table 1. List of mangrove species in the coastal areas of Malapatan, Sarangani Province, Philippines.

Family	Species
Avicenniaceae	*Avicennia marina* *Avicennia rumphiana**
Rhizophoraceae	*Rhizophora apiculata* *Rhizophora mucronata** *Bruguiera gymnorrhiza* *Bruguiera cylindrica* *Ceriops decandra**
Sonneratiaceae	*Sonneratia alba*
Palmae	*Nypa fruticans*
Meliaceae	*Xylocarpus granatum* *Xylocarpus molluccensis**
Lythraceae	*Pemphisacidula**
Myrsinaceae	*Aegicersfloridum**
Combretaceae	*Lumnitzera racemosa**
Euphorbiaceae	*Excoecaraagallocha**
Acanthaceae	*Acanthus ebracteatus**

* Species observed around the area but outside the plots

Malapatan mangroves occupy about 53 hectares, primarily composed of secondary and primary growth trees. The mangrove areas in Malapatan frequently experience flooding and other man-made disturbances. A total of 7 identified mangrove species belonging to 6 families were found inside the plots along the coastal parts of the study areas. However, a total of 16 true mangrove species belonging to 10 families (Table 1) were observed in the whole study area but outside the established plots.

Biodiversity

The species richness in each plot was 1.4 for every 100m². The average abundance was 11. 5individuals.The dominance of 0.7783 may imply that the probability of two individuals may belong to the same species category is high. On the other hand, the results for Shannon's diversity was very low as observed in the location which means, in one area roughly one species of mangrove dominates the area of interest. Evenness (0.84) was relatively high suggesting that throughout the area distribution of mangrove trees was uniform (Fig. 2 and Table 2).

Table 2. Mean Diversity Indices of Mangroves in Malapatan,Sarangani Province, Philippines.

	Species richness	Abundance	Dominance	Evenness	Shannon's diversity
Mean	1.4000	11.4750	0.7783	0.8385	0.2038

Vegetation Analysis

Of all the species, *Sonneratia alba*has the highest relative population density with 7.6 stems/ 100m². It was followed by *Rhizophora apiculata* with 2.4 stems/ 100m² and then *Bruguiera gymnorhiza* with 0.4 stems/100m². On the other hand, *Avicennia marina, Nypa fruticans, Bruguiera cylindrica* and *Xylocarpus granatum* were among the least values documented (Fig. 2 and Table 3).

Consequently, *Sonneratia alba* (63.16%), and *Rhizophora apiculata* (17.54%) have the highest frequency in all sites. These mangrove species were seen throughout the sampling plots of the study site. Those were followed by *Xylocarpus granatum* with 5.26%. The species with least relative frequency values were *Bruguiera cylindrica, Avicennia marina, Bruguiera gymnorhiza*, and *Nypa fruticans* all with 3.50% values. Those were observed growing at the seaward zone with sandy-muddy substrate and were not frequently observed in the sampling plots (Fig. 3 and Table 3).

Bigger trees of *Sonneratia alba* were observed in a bedrock substrate, with *dbh* ranging from 21cm to 650cm, compared to those in the silt-muddy substratum, with *dbh* ranging only from 15cm to140cm. Relative dominance was highest in Poblacion, Malapatan, Sarangani Province. *S. alba* has the highest relative dominance (82.21%) among all the species documented. It was then followed by *R. apiculata* with the relative dominance value of 10.91% while the rest of the species were found to have a lower relative dominance value (Fig. 4 and Table 3).

Regeneration of saplings and seedlings

Among the 7 mangrove species observed, only 3 species regenerated at the very least namely: *B. cylindrica, S. alba, and R. apiculata*. Based on the formula(Deguit *et al*, 2004*), S. alba, R. apiculata* and *B. cylindrica* have saplings regenerated ‹0.50 regeneration per m², meaning all of these species were in poor condition. In terms of seedling regeneration, still, all of them were found to be in a poor condition for having a seedling ‹0.50 regenerated (Fig. 5).

Table 3. Vegetation Analysis of Mangrove Species in Malapatan,Sarangani Province, Philippines.

Species	Relative population density (%)	Relative frequency (%)	Relative Dominance (%)	Species importance value rank
S. alba	68.32	63.16	82.21	1
R. apiculata	21.79	17.54	10.91	2
B. gymnorhiza	3.59	3.50	2.11	3
X. granatum	1.57	5.26	0.72	4
A. marina	2.69	3.50	1.34	5
N. fruticans	2.47	3.50	1.35	6
B. cylindrica	1.12	3.50	1.32	7

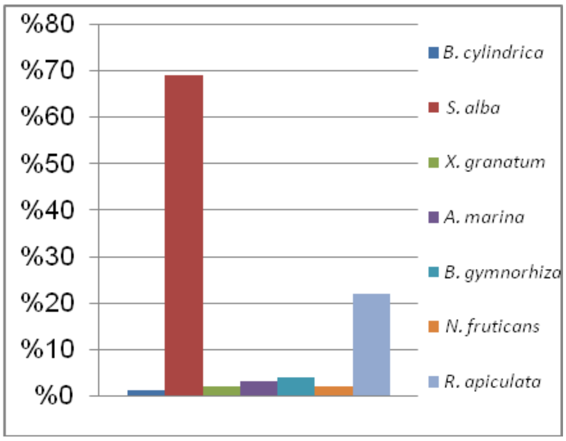

Fig. 2. Relative Population Density of mangrove in the coastal areas of Malapatan, Sarangani Province, Philippines.

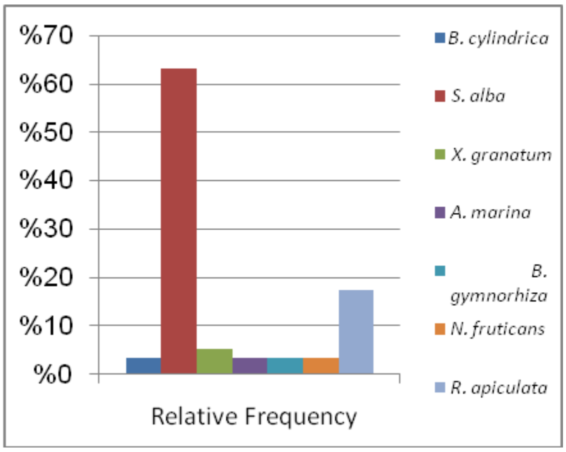

Fig. 3. Relative Frequency of mangrove in the coastal areas of Malapatan, Sarangani Province, Philippines.

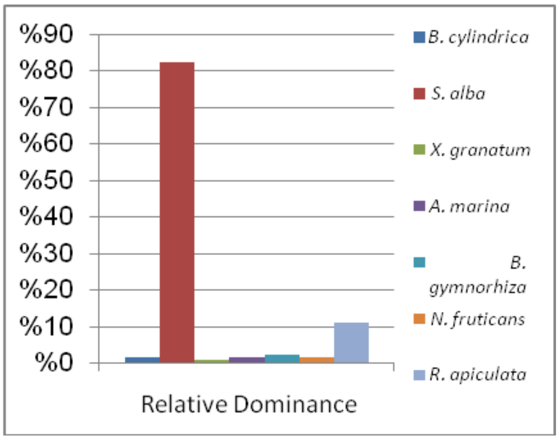

Fig. 4. Relative Dominanceof mangrove in the coastalareas of Malapatan, Sarangani Province, Philippines.

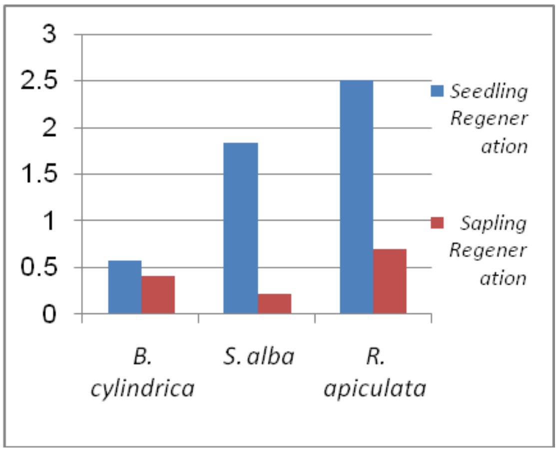

Fig. 5. Regeneration of mangrove in the coastal areas of Malapatan,Sarangani Province, Philippines

Soil particle analysis

Across all sampling plots, the soil substrate with highest composition was gravel (2mm) with the mean value of 26.7807 grams, followed by medium-sized sand (425µm) with the mean value of 22.1635 grams. Next to that was the coarse sand substratum (850µm) with the mean value of 21.5480 grams.

The least mean value of all the substrates was very fine sand (150µm) with the mean value of 4.6458 grams. Therefore, gravel substratum consists most of the soil samples gathered from the sampling areas of Malapatan, Sarangani Province, Philippines (Fig. 6).

Relationship between abundant mangrove species observed in different soil types

Data showed that some mangrove species were abundantly presents with respect to the properties of the soil they were located. The soil with which these mangrove trees thrive was a vital component for growth, maturity and reproduction. The results showed that gravel has the highest composition compared to other soil characteristics. Seven species were noted to be growing abundantly in gravel dominated soil and these were*: Bruguiera cylindrica, Sonneratia alba, Xylocarpus granatum, Avicennia marina, Bruguiera gymnorhiza, Nypa fruticans,* and *Rhizophora apiculata*. The species Sonneratia alba was observed to be growing abundantly in all soil types. While *Rhizophora apiculata* was dominantly observed in gravel, very coarse sand and medium sand. The data gives information on the species that abundantly thrive in relation soil particle size. The information can be applied in rehabilitation efforts where replanting of mangrove species were conducted (Table 4).

Table 4. Relationship between mangrove species observed in different soil types in Malapatan, Sarangani Province, Philippines.

The Abundant Mangrove Species Observed in Different Soil Types	
Soil types	**Abundant species around the area**
Gravel	*Bruguieracylindrica, Sonneratia alba, Xylocarpusgranatum, Avicennia marina, Bruguieragymnorhiza, Nypafruticans, Rhizophoraapiculata*
Very Coarse Sand	*Sonneratia alba, Rhizophoraapiculata*
Medium Sand	*Sonneratia alba, Rhizophoraapiculata*
Fine Sand	*Sonneratia alba*
Very Fine Sand	*Sonneratia alba*
Silt/ Clay	*Sonneratia alba*

Spearman Rank Correlation between Shannon's Diversity and soil characteristics

Spearman Correlation was employed to correlate Shannon's diversity to soil characteristics. It is a non-parametric tool that utilizes ranked variables. The

resulting data gives a rho value (ρ) as the basis of correlation. Shannon's diversity has the highest positive correlation to medium sand (ρ=0.3043).
Shannon's diversity was positively correlated to medium sand; very fine sand and silt/clay, suggesting that highest biodiversity values of mangroves were observed in this predominantly soil types. On the other hand, Shannon's diversity was negatively correlated to gravel, very coarse sand, and fine sand. Shannon's diversity was not to be highly expected on those soil types (Table 5).

Table 5. Correlation between Shannon's Diversity and soil characteristics using Spearman Rank Correlation.

Soil Characteristics	Spearman correlation (ρ) to Shannon's Diversity
Gravel	-0.2775
Very coarse sand	-0.1072
Medium sand	0.3043
Fine sand	-0.0218
Very fine sand	0.0580
Silt/Clay	0.0745

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