Abundance, Structure, and Diversity of Mangroves in a Community-Managed Forest in Calatagan, Batangas, Verde Island Passage, Philippines

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Abstract – *The number of mangroves in the world has been alarming that poses a big threat to destruction of the marine ecosystem. Some of these threats include habitat destruction, invasive species, over population, over exploitation, and pollution.*

This research aimed to determine the species abundance and diversity of a community-managed mangrove forest in Calatagan Marine Protected Area through its community structure. A survey of the vegetation structure of mangrove was conducted to determine the GBH (girth at breast height), height and the tree's crown in the four (4) standard 10 m x 10 m transect plots. DBH (diameter at breast height), basal area, canopy cover, relative frequency, relative dominance and relative density were also assessed. Species diversity and abundance were computed using the Shannon-Weiner diversity index.

The results of the community structure in average revealed that the GBH is 13.57 cm, height of 3.50 m, crown 1.28 m, DBH of 4.32 cm, basal area of 0.0164 m2 and canopy cover of 5.30 m2. The study shows a very low species diversity value (H') ranging from 0.4692 to 1.2178. Seven species belonging to six families of mangroves were identified. Avicennia marina was determined to be the most dominant among the identified species in the sampling plots. With these results, conservation of mangrove forest by the local community stakeholders can be strengthened to improve the community structure towards the resiliency of the mangrove forest. It is endorsed that community-based conservation of mangroves can be considered in mangrove management, monitoring and evaluation.

Keywords – *abundance, community-managed forest, conservation, diversity of mangroves, structure,*

INTRODUCTION

Calatagan, Batangas is a corridor of the Verde Island Passage which is home to a diverse of marine organisms. One of the most valuable features of its biodiversity is the presence of mangrove ecosystem in the municipality. The forest structure of the mangroves in Calatagan experience anthropogenic threats which increase its vulnerability to the impacts of climate change [1].

Mangroves are salt-tolerant trees that have adapted to living in salt and brackish water conditions. Mangrove ecosystem plays crucial roles in the ecological integrity and services. Mangrove ecosystem serves as habitats for majority of aquatic animals as well as overall and terrestrial animals. Mangroves are unusually recognized as one of the world's richest ecosystem. Besides their direct economic contribution in forms of timber firewood, fodder, and other products that can be harvested from them [2].

There are 54 species of mangroves and 60 mangrove associates worldwide. The Philippines has around 44 "true mangroves". The number of mangroves in the world has been alarming due to anthropogenic activities that pose a big threat to destruction of the ecosystem and diversity of life in mangrove area. There are problems that the mangrove ecosystems faced such as habitat destruction, invasive species, over population, over exploitation, and pollution.

Globally half of all mangrove forests have been lost since the mid-twentieth century with one-fifth since 1980 [3]. Conversion into shrimp farms causes 25% of the total destruction, happening mostly in Southeast Asia and Latin America. Over the last 50 years, one-third of the world's mangrove forests have been lost [4].

Mangroves, nowadays, are becoming vulnerable to degradation and loss in different areas of the world. In the past several decades, numerous tracts of mangrove have been converted to other uses. Coastal development, aquaculture, pollution and overharvesting have led to loss of mangroves globally. Human impacts reduce the capacity of mangrove ecosystems to withstand other environmental change such as erosion, severe storm activity, or sea level rise. They are today a global issue because more than 100 countries have mangrove resources [3]. Of the approximately 100 countries that have mangrove vegetation, around 20 have undertaken rehabilitation initiatives [5] and establishing nurseries and replanting in degraded areas [6].

Statistics reveals an alarming global rate of destruction of 3500 ha yr^{-1} [7]. In some regions in Asia, mangroves are in danger of complete collapse [8]. Previously, the estimate of mangrove forest is around 12.1 M ha [7], which roughly around half of the 1990 estimate of 24 M [9]. Recent estimate however revealed that this has tremendously trimmed down to 153,577 ha which suggests a huge loss in biodiversity and biomass [10].

The continuous decline of mangrove forest is also true in the Philippines [7]. Based on the early estimates, mangrove forest was recorded to around 400,000-500,000 ha [11]. Mangrove ecosystems in the Philippines have suffered from severe degradation attributable to the aquaculture industry during the last century, which has led to acute deterioration of the diverse flora and fauna communities and a plethora of wide-ranging subsequent ecological and economic impacts. The remaining 35% of forests are now fully protected by national laws, however mounting pressure from an escalating human population and rising sea levels are increasing threats [12]. The country has about 18,000 km shorelines and vast areas of mangroves about 500,000 hectares in the early 1900s. But due to overexploitation, conversion of areas to various uses, and the simultaneous logging of watersheds in the uplands, the country's remaining mangrove area was only about 117,700 hectares in 1995 [10].

Because of the values of and threats to mangroves, surveys to describe the forest composition, structure and ecosystem carbon pools are needed to monitor status and trends [13]. Community structure of mangroves is an important consideration in the rehabilitation, management, monitoring and evaluation of mangroves in community-based conservation programs especially in the degraded marine ecosystem. Furthermore, the result of this study aims to provide benefits to the following stakeholders, namely: (1) community organization or the People's Organization (PO) who protects and manages the mangroves for them to have a baseline data in monitoring and evaluation of the rehabilitation efforts implemented on mangroves; (2) scientists and mangrove experts for them to take this as an important considerations in forest vegetation analysis to identify the community structure of an ecosystem which will provide them ideas on determining patterns on vegetation structure; (3) Environmental Policy-Makers who will have baseline ideas for the appropriate enforcement, legislation and strict implementation on the policies and laws concerning mangroves and community-based management approaches; (4) Local Government Unit (LGU) officials, for them to have benchmark and basis for the establishment of more marine protected areas (MPAs) in the municipalities with degraded mangrove ecosystem; and (5) the local citizens of Calatagan to guide them in establishing awareness about mangroves and how this ecosystem affects their daily lives. More importantly is for them to be aware of their social responsibility in the environment as "stewards of nature".

OBJECTIVES OF THE STUDY

This study aimed to determine the abundance and diversity of mangroves in the marine protected area (MPA) managed by local community stakeholders at Calatagan, Batangas, a corridor of the Verde Island Passage. It also aimed to document the species composition, relative abundance, frequency and dominance which represent the over-all community structure of the forest.

It specifically aimed to assess the taxonomic profile and species abundance in terms of composition and distribution of the mangroves; to determine the community structure of the mangrove in terms of the following parameters: GBH (girth at breast height); height; crown; relative frequency; relative density; and to compute the species diversity of mangroves using Shannon-Weiner index

METHODS

Site Description

The Calatagan Mangrove Forest Conservation Park otherwise known as the "Ang Pulo" is a 7.5 ha mangrove park located within Marine Protected Area declared by the Sangguniang Bayan of Calatagan in 2007 which aims for the conservation and sustainable development of mangroves. It is different from the typical form of tourism parks and stands out from other swimming destinations since it is a mangrove forest with elevated boardwalks, signs, viewing platforms, huts and watchtowers. The area provides a venue for educational opportunities such as fieldworks and other conservation-related activities as visitors are engaged to participate in the on-going coastal reforestation in the area [14].

A portion of this MPA is the major conservation site which is characterized by an overwashed mangrove forest with an area of 4000 sq. m. It is located between 120036'56.48" longitude and 13036'56.48" latitude. This represented the study site.

Research Design

The study utilized descriptive research design to assess the community structure of the community-managed mangrove forest. Site selection was done using opportunistic sampling that highlights the areas of conservation focus made by the people's organization in Brgy. Kilitisan, Calatagan, Batangas. The research was assisted by science-student researchers from Calatagan National High School and Research Department, local people near the coastal area and the Sangguniang Barangay (SB).

Plot Establishment. A total of four 10mx10m transect plot were established for the study. Transect plot technique/quadrat sampling was employed to assess the mangrove communities [15]. The four sampling plots were representative of the10% of the total area of the conservation site. The plots were established perpendicular to the shore characterized by proximal, middle and distal zones of the mangrove forest. The first two plots were aligned parallel to the other two plots. Four corners were marked and coordinates were recorded using GPS.

Parameters measured in the community structure of mangroves include species composition and distribution, tree density, height, GBH (diameter at breast height), and crown cover. In terms of stand structure, each mangrove tree was tagged, counted and collected for herbarium and identification. GBH (girth at breast height) of each tree was recorded by measuring the trees' circumference 1.3 m above the ground. The height, crown cover, the number of seedlings (less than 1 m) and saplings (more than 1 m but with less than 4 cm DBH) were also recorded.

Species composition was determined using the field guide developed by Primavera and the BFAR [16], [2]. Assistance from the PALITAKAN (Pro-mangrove Alliance and Implementing Team and Arm as Kilitisan's Advocates of Nature), people's organization (PO), was extended for the local identification of mangrove species.

Statistical Analysis of Data

The following statistical tools were used in the present study.

1. Mangrove Community Structure and Growth Parameters

a. DBH

The DBH refers to the diameter at breast height of each mangrove tree in the plots usually measured at 1.3 m above the ground.

DBH = GBH ÷ pi

Where:

GBH is the girth at breast height;

pi = 3.1416

b. Basal Area (m2)

The basal area is the individual tree's area of the base expressed in m2.

Basal Area = pi * [(DBH ÷ 2)÷ 100]2

c. Canopy cover

This parameter is used to determine the circumference of the crown of a particular mangrove species.

Canopy cover (m2) = pi * (crown)2

2. Relative Density (RDen)

__no. of species in a quadrat___
total no of all species in a quadrat

3. Relative Dominance (RDom)

__basal area of species in a quadrat___
total basal area of all species in a quadrat

4. Shannon-Weiner Index (H')

The equation is:

H' = -sum (pi ln pi)

where : pi = proportion of individuals found in the i species

ln = natural Logarithm

Table 1. Categories of Species Diversity Index

Relative values	H' Values
Very high	> 3.5000
High	3.0000 – 3.4999
Moderate	2.5000 – 2.9999
Low	2.0000 – 2.4999
Very low	< 1.9999

RESULTS AND DISCUSSION

This portion of the study presents the data gathered and the results of the statistical analyses.

Table 2. Taxonomic Profile and Species Abundance

Family	Genera	Species	f
Avicenniaceae	Avicennia	*Avicennia marina (kalapinay)*	78
Myrsinaceae	Aegiceras	*Aegiceras corniculatum(saging-saging)*	2
Rhizophoraceae	Bruguiera	*Bruguiera cylindrica (pototan)*	2
	Ceriops	*Ceriops decandra (sagig-saging)*	8
	Rhizophora	*Rhizophora apiculata (bakawang lalaki)*	2
	Rhizophora	*Rhizophora mucronata (bakawang babae)*	9
Sonneratiaceae	Sonneratia	*Sonneratia alba (pagatpat)*	17
Total			**118**

The sample area of study is composed of 118 individual mangrove trees. These mangrove trees are classified into four (4) families namely: *Avicenniaceae*, *Myrsinaceae*, *Rhizophoraceae*, and *Sonneratiaceae*.

Under these families are the six (6) genera: *Avicennia*, *Aegiceras*, *Bruguiera*, *Ceriops*, *Rhizophora*, and *Sonneratia* wherein there are seven (7) species of mangroves as presented in the Table.

The figures show the relative densities of all species of mangroves in the four (4) plots. Plot 1 shows *A. marina and R. mucronata* as the densest species with 40% in the 10 x 10 m transect plot. On the other hand, *S. alba* is very dense among the species of mangroves. The relative density of Plot 2 shows that *A. marina* has the largest density of all species in the area. *A. marina* covers almost the entire plot with a percentage of 82%. *C. decandra* and *B. cylindrica* have the least number of individual trees found in the Plot 2. Figure 4 contains details about the species found in the Plot 3. The species with the highest relative density in the Plot 3 is *A. marina* with the percentage of 56% and this is the densest species followed by *S. alba*. There is moderate relative density for *C. decandra* and *S. alba*. On the other hand, *A. corniculatum*, a new recruited seedling was observed and recorded with a 6% relative density. In Plot 4, *A. marina* is very dense with of 82% of the population, which cover almost the entire plot. *S. alba* is very sparse on this plot with 18%.

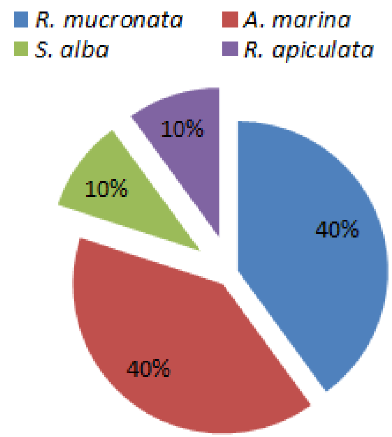

Fig. 1. Species Distribution of Mangroves in Plot 1

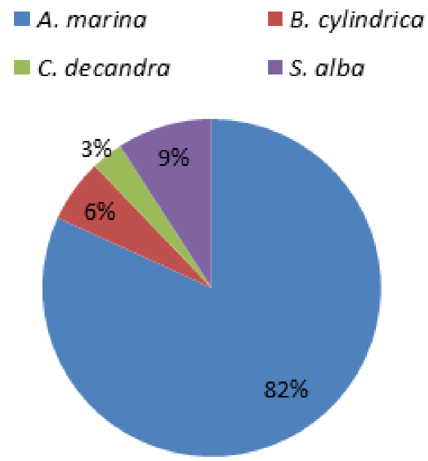

Fig. 2. Species Distribution of Mangroves in Plot 2

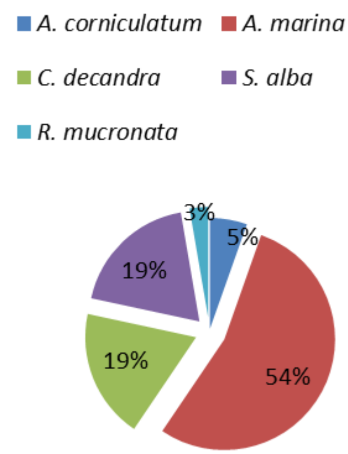

Fig. 3. Species Distribution of Mangroves in Plot 3

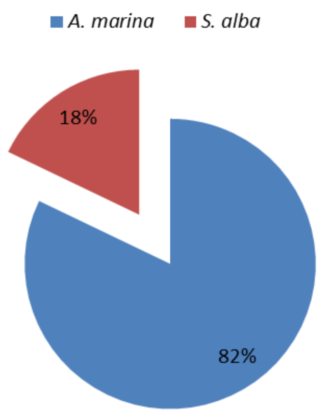

Fig. 4. Species Distribution of Mangroves in Plot 4

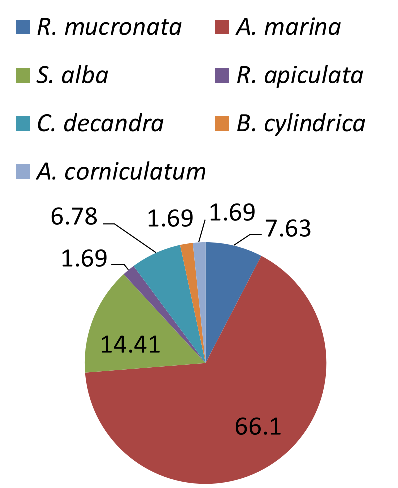

Fig. 5. Overall Species Distribution of Mangroves

The figure presents the general relative density of all the plots. *A. marina* is relatively dense followed by *S. alba*, *C. decandra* and *R. mucronata*. *A. corniculatum*, *B. cylindrica* and *R. apiculata* are sparse in the sampling site. The results show that Calatagan Mangrove Forest Conservation Park (CMFCP) is dominated by *Avicennia-Sonneratia* mangrove species.

This stand structure in the overwashed forest type is significant for climate change mitigation and adaptation and coastal resilience [17], [18]. The said species are well-adapted to saline and sandy substrate in the marine environment. The low relative density of the other species in the sampling site can be attributed to the characteristics of the substrates since most of these species thrive best in loam and muddy areas.

Table 3. Mangrove Community Structure (Growth Parameters)

Plot No.	Mean GBH(cm)	Mean Height (m)	Mean Crown (m)
1	22.05	4.13	1.55
2	9.46	3.02	1.03
3	10.91	2.75	1.05
4	11.87	4.11	1.48
Grand Mean	**13.57**	**3.50**	**1.28**

Table 3 shows the mean average of the different growth parameters of mangroves measured in the four plots. Plot 1 contains species with the highest Girth at Breast Height (GBH) which means that the average trunk of the mangrove has a size of 22.05 cm. This can be attributed to the presence of large girths of *Rhizophora mucronata* and *Avicennia marina* trees. The grand mean of the GBH is 13.57 cm among the four plots. This is smaller compared to the study of [14] in the mangroves of Balibago, Calatagan.

The height of the mangroves based on the data has an average of 3.50 m which is almost the same in the study of [14] in a fringing mangrove in Calatagan. Plots 1 and 4 contain mangrove species with greater heights compared to the other plots.

In terms of crown cover, species in Plot 4 rank the widest with an average mean of 1.48. Since *A. marina* species dominates the plot, it implies that the species are branching which is a common growth pattern of the species.

Table 4. Diameter at Breast Height, Basal Area and Canopy Cover of the Mangroves

Plot No.	Mean DBH (cm)	Mean Basal Area (m^2)	Mean Canopy Cover (m^2)
1	7.02	0.0382	7.54
2	3.01	0.0070	3.33
3	3.47	0.0093	3.46
4	3.78	0.0110	6.88
Grand Mean	**4.32**	**0.0164**	**5.30**

The data on the Table represents the mangrove community structure necessary for monitoring of the mangrove conservation effectiveness. There is no documented study pertaining to these parameters especially the canopy of mangrove forest as vegetation characteristics. This, therefore, can be a baseline data for future studies on community structure.

Table 5. Relative Density and Relative Frequency of Mangroves

Species	Density	RDen (%)	F	RF (%)
A. marina	0.1950	66.10	1.00	26.67
A. corniculatum	0.0050	1.69	0.25	6.67
B. cylindrica	0.0050	1.69	0.25	6.67
C. decandra	0.0200	6.78	0.50	13.33
R. apiculata	0.0050	1.69	0.25	6.67
R. mucronata	0.0225	7.63	0.50	13.33
S. alba	0.0425	14.41	1.00	26.67

Legend: F = frequency; RF = relative frequency

A. marina and *S. alba* significantly have the highest relative density and relative frequency in all plots. The conservation site is considered to have a dense stand structure of these two species.

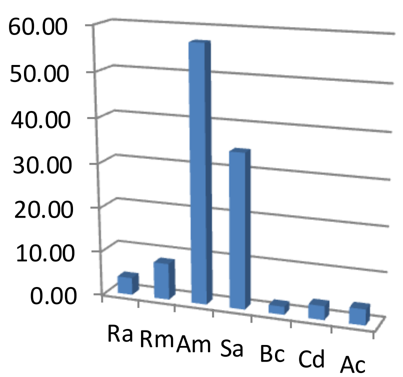

Fig. 6. Relative Dominance of Mangroves

This graph represents relative dominance of the forest. Based on the graph, *A. marina* and *S. alba* are the most dominant species in the plot. This is explained by the large basal area of the two species in the conservation site.

Table 6 shows the species diversity (H') using Shannon-Weiner Diversity Index of mangroves in each plot. Plot 1 has four (4) species namely: *A. marina, R. mucronata, S. alba,* and *R. apiculata*. *A. marina* and *R. mucronata*. The overall computed species diversity is 1.1936 which is very low**.** In Plot 2, there are four (4) species of mangrove namely: *A. marina, B. cylindrica, C. decandra,* and *S. alba. A. marina* represents the most number of species. The diversity value is also very low. In Plot 3 there are five (5) species of mangrove. This plot contains the most number of species and the most diverse among the plot. It is composed of *A. corniculatum, A. marina, C. decandra, S. alba,* and *R. mucronata.* Plot 4 shows the least species diversity in all plots. Although Plot 1 has the least number of species it is more diverse than Plot 4 because different species are present.

Table 6. Species Diversity (H') of Community-Managed Mangrove Forest

Plot No. 1	SPECIES	*n*	*H'*
	Avicennia marina	8	-0.3665
	Rhizophora mucronata	8	-0.3665
	Sonneratia alba	2	-0.2303
	Rhizophora apiculata	2	-0.2303
	Total (T)	20	-1.1936
Plot No. 2	SPECIES	*n*	*H'*
	Avicennia marina	27	-0.16419
	Bruguiera cylindrica	2	-0.1699
	Ceriops decandra	1	-0.10595
	Sonneratia alba	3	-0.21799
	Total (T)	33	0.6580
Plot No. 3	SPECIES	*n*	*H'*
	Aegiceras corniculatum	2	-0.15772
	Avicennia marina	20	-0.33253
	Ceriops decandra	7	-0.315
	Sonneratia alba	7	-0.315
	Rhizophora mucronata	1	-0.09759
	Total (T)	37	-1.2178
Plot No. 4	SPECIES	*n*	*H'*
	Avicennia marina	23	-0.16158
	Sonneratia alba	5	-0.30764
	Total (T)	28	0.4692

CONCLUSIONS AND RECOMMENDATIONS

The community structure and growth parameters of the mangroves indicate a relatively young forest ecosystem. *A. marina* has the highest relative density. It covers more than 50% of the mangroves which is attributed to the sandy substrate as its ecological adaptation. In terms of relative dominance, *A. marina* and *S. alba* are relatively dominant. The species diversity is very low which can be a consideration in future planning to increase resiliency of the mangrove ecosystem. From these findings, it is hereby endorsed that management and conservation of mangroves is an important consideration in monitoring and evaluation of the community structure and growth performance of the mangroves. More MPA or marine protected area can be established and managed through community-based approach. Close monitoring and assessment of mangrove growth is needed to ensure the effectiveness of the management and conservation implemented. Furthermore, ecological adaptation of mangroves, relative density, frequency and relative dominance must be considered in community-based management programs to determine the appropriate mangroves species for a particular substrate. Incorporation of species diversity and abundance of mangroves be made in establishing priority of conservation focus to increase resiliency and assess the vulnerability of the ecosystem to climate change.

However, further studies may be done to compare the forest structure and diversity of mangroves in natural or undisturbed habitat and in fringing location. It is suggested that more transect plots be used in sampling larger mangrove protected area.

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