BIODIVERSITY OF MANGROVES IN DANGULAAN-SAN CARLOS, ANILAO, ILOILO

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SCIENCE RESEARCH 2

by

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BIODIVERSITY OF MANGROVES IN DANGULAAN-SAN CARLOS, ANILAO, ILOILO

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Biodiversity of Mangroves in Dangulaan-San Carlos, Anilao, Iloilo

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ABSTRACT

Mangroves are trees that thrive in salty conditions; they are called halophytes which mean that they are salt-tolerant trees (Duke and Allen 2006). These mangroves have a lot of uses and purposes in the ecosystem, they provide goods to the humans, provides habitat or breeding ground for marine life like fish, molluscs, and crustaceans. Mangroves also protect the shoreline against strong waves, and typhoons, according to UNEP-WCMC (2006) 70-90% energy of the waves are being absorbed by the mangroves, serves to reduce the effects of flooding. This study aims to determine the species and population of mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Brgy. Dangula-an, Anilao, Iloilo. By knowing the area, civilians around the area will know the importance of having mangrove systems in their surroundings. The mean species diversity of the mangroves thriving in the site is 0.9810 ± 0.6927 (mean ± S.D.). The Simpson's Index is 0.147618 and the Shannon-Weiner is a 2.833213 diversity index while Pielou's Evenness is 0.781845. The diversity of the mangroves in the Dangulaan-San Carlos, Anilao, Iloilo, according to the Shannon-Weiner's Index which was 2.1826, is relatively high.

Keywords: *halophytes, Mangroves, Pielou's Eveness, Shannon-Weiner Index, Simpson's Index*

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INTRODUCTION

A. Background of the Study

Mangroves are salt-tolerant trees or halophytes (Duke and Allen 2006). Mangroves cover 18.1 million km² all over the world (Spalding 1997 as cited by Kathiresan 2008), and 40% of which are in Asia (EJF 2006). Mangroves are commonly found in shallow tidal water of estuaries and coastal areas common in tropical countries.

Mangroves have a lot of uses and purposes in the ecosystem, as they provide goods to the humans, provide habitats or breeding grounds for marine lives like fishes, mollusks, and crustaceans. Mangroves also protect the shoreline against strong waves, and typhoons. According to UNEP-WCMC in 2006, 70% to 90% energy of the waves is being absorbed by the mangroves reducing the effects of flooding. But due to its many benefits to the humans, mangroves are being cut down to use as the material goods for housing.

Mangroves are highly adapted plants mainly found in the tropical intertidal forest. Mangroves are various kinds of trees up to medium height and shrubs that grow in coastal sediment habitats in the tropics and subtropics (Jayatissa and others 2008). Mangroves also have a unique ability where they can adapt to the environmental conditions. Some of the importance of mangroves: filtering nutrients, protection for marine animals and they also help in the continuous formation of soil (Adekanmbi and Ogundipe 2009).

The study will be condicted in the Dangulaan-San Carlos Mangrove Rehabilitation Project in Barangay Dangula-an, Anilao, Iloilo, a project by the Banate-Barotac Bay Resource Management Council Inc. (BBBRMCI).

The Banate-Barotac Bay Resource Management Council Inc., started back in the year 1996 to the municipalities of Anilao, Banate, and Barotac Nuevo in Iloilo, Philippines. BBBRMCI made a plan for Coastal Resource Management and was implemented and effective up until today.

B. Statement of the Problem

This study aims to determine the biodiversity of mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project in Barangay Dangula-an, Anilao, Iloilo.

C. Objectives of the Study

C.1 General Objective

This study aims to determine the biodiversity of mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project in Barangay Dangula-an, Anilao, Iloilo.

C.2 Specific Objectives

1. To determine the different species of mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo.
2. To count the number of individuls per species of the mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo.
3. To calculate the mean population density of the mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo.
4. To calculate the (a) Simpson's Index, (b) Shannon-Weiner Index, and (c) Pielou's Evenness Index of the mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo.
5. To calculate the species richness of the mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo.

D. Significance of the Study

Mangroves contribute to soil formation and help stabilize coastlines. Mangroves act as filters for upland runoff. Mangrove systems serve as habitat for many marine organisms such as fish, crabs, oysters, and other invertebrates and wildlife such as birds and reptiles. Mangroves produce large amounts of detritus that may contribute to productivity in offshore waters.

Mangrove forests serve as protection for coastal communities against storms such as hurricanes. It has been suggested that the large loss of life (300,000 to 500,000 lives) in Bangladesh during the 1970 typhoon was partly due to the fact that many of the mangrove

Mangroves – are halophytic (salt-tolerant) plants that thrive in saline conditions between sea level and high tides. Mangroves form a unique and dominant ecosystem comprised of intertidal marine plants and trees, bordering most tropical coastlines all over the world (Tomlinson 1986).

Population density - is the measurement of population per unit area or unit volume (Rosenberg 2005).

Quadrat - is a classic tool for the study of ecology, especially biodiversity. In general, a series of squares (quadrats) of a set size are placed in a habitat of interest and the species within those quadrats are identified and recorded (Census of Marine Life 2009).

Shannon-Weiner Diversity Index– is calculated by taking the number of each species, the proportion each species is of thetotal number of individuals, and sums the proportion times the natural log of the proportion for eachspecies (Nolan and Callahan 2006).

Simpson's Diversity Index –a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so diversity increases (Barcelona Fields Study Centre 2014).

Species evenness –is the relative abundance of species (Molles 1995).

Species richness –is the number of species in a community (Molles 1995).

CHAPTER 2

REVIEW OF RELATED LITERATURE

A. Mangroves

Mangrove forests, characteristic for (sub)tropical coastal zones, form unique ecosystems of high ecological and economical importance (Donato and others 2011).

Multiple adaptations, such as aerial roots, salt exclusion/secretion and vivipary, have developed which provide the needed tools and, therefore, resilience to survive in the extreme and highly dynamic intertidal environment. Vivipary is a rare phenomenon among plants. The embryo grows, without any dormancy period, first out of the seed coat and then out of the fruit, while still attached to the parent tree. (Tomlinson 1994).

After germination, hydrochorous propagules part from the parent tree as a seedling that can either plant in the shadow of their parent or propagate to nearby locations and thereby replenish existing stands. Occasionally, propagules may take advantage of estuarine, coastal and ocean currents to disperse over long distances and, if still viable, (re)colonize remote and suitable habitats. As most mangrove species are typically water dispersed by buoyant propagules, these dispersal units take advantage of estuarine, coastal and ocean currents in order to replenish existing stands and to colonize new suitable habitats (Duke and others 1998).

A.1. Distribution and Reproductive Strategies of Mangroves

Both local establishment and the potential for long distance dispersal long-distance dispersal, in the sense of propagule movement over oceanic expanses), have important implications for mangrove ecology. They are at the base of forest structure and dynamics, new populations and genetic diversity and differentiation (Sousa and others 2003; Ceron-Sousa and others 2005).

Mangrove distribution is circumglobal with the majority of populations occurring between the latitudes of 30° N and S (Tomlinson 1986 as cited by McKee). At one time, 75% of the world's tropical coastlines were dominated by mangroves. Unfortunately, mangrove extent has been significantly reduced due to human activities in the coastal zone. There are two centers of mangrove diversity: the Eastern group (Australia, Southeast Asia, India, East Africa, and the

Western Pacific) where the total number of species is approximately 40 and the Western group (West Africa, Caribbean, Florida, Atlantic South America, and Pacific North and South America) where the number of species is only 8. Thus, New World forests are relatively depauperate compared to Old World forests (McKee 1993).

Mangroves have little capacity for vegetative propagation and are thus dependent on seedlings for forest maintenance and spread (Tomlinson 1986). Although some species (*A. germinans and L. racemosa*) can resprout from stumps (coppicing), this process is not equivalent to propagation. Mangroves exhibit two relatively unique reproductive strategies: hydrochory and vivipary (Tomlinson 1986; Rabinowitz 1978). Hydrochory (dispersal by water) is a major means which mangrove spreads seeds, fruit, and/or propagules. Tidal action can carry mangrove diaspores great distances from their point of origin. Vivipary refers to the condition in which the mangrove embryo germinates while still attached to the parent tree. A number of mangrove species, including R. mangle, for example, may remain attached to the parent tree for 4 to 6 months and attain lengths of 25 to 35 cm at "maturity," they fall to the ground or into the water where they are dispersed by the tides. The embryo of A. germinans breaks through the seed coat but remains enclosed in the fruit wall until detachment. Upon falling into the water, the thin pericarp is quickly shed, leaving the seedling, which is composed of two folded cotyledons. *Languncolariaracemosa* is not considered to be viviparous, but germination often occurs during dispersal. Vivipary increases the chances of successful establishment in an unpredictable environment where germination of seeds would typically be inhibited (McKee 1993).

A.2. Zonation of Mangroves

Spatial variation in species occurrence and abundance is frequently observed across environmental gradients in many types of ecosystems (Davis 1940; Smith 1992; Mendelssohn & McKee 2000). Zonation of plant communities in intertidal habitats is particularly striking and often results in monospecific bands of vegetation occurring parallel to the shoreline. Although zonation patterns are usually depicted in a manner that suggests a rigid sequence proceeding from the shoreline to upland regions, many patterns resemble a mosaic with vegetational patterns occurring repeatedly where the land mass is interrupted by watercourses or other variations in topography.

Mangroves exhibit zonation patterns in a number of different geographic regions (Davis 1940; Smith 1992; Mendelssohn & McKee 2000). The large variation in floristic composition of mangrove communities means that patterns of species distribution across the intertidal zone will vary substantially among geographic regions. For example, patterns for Florida and the Caribbean often show R. mangle (red mangrove) occupying the seaward zone, followed by A. germinans (black mangrove), and L. racemosa (white mangrove) in the most landward position. That pattern may be contrasted with a profile for northeastern Australia (Queensland), which is not only more complex due to a higher number of species, but the relative position of congeneric species is reversed from that in Florida (e.g., Avicennia spp. in the seaward position and Rhizophora spp. in the landward position).

Zonation patterns in mangrove forests may also vary on a local scale. Occurrence of species may differ across an estuary, apparently in response to differences in freshwater input. For example, species found at the seaward end of the estuary may be absent from the headwaters. Although zonation typically refers to patterns created by segregation of different species, differences in stature and productivity of plants across environmental gradients may also result in readily discernible patterns. Zones may be comprised of different architectural forms that represent variations in height and vigor. Succession due to land building is not considered to be a viable explanation for zonation by many mangrove ecologists, since evidence shows that mangroves respond to, rather than cause, coastal propagation (Thom 1967). However, it's clear that some mangrove systems in sediment-poor environments have built vertically through deposition of organic matter (mangrove peat) (Woodroffe 1983; McKee & Faulkner 2000).

Mangroves are probably best viewed as steady state cyclical systems migrating toward or away from the sea depending on sea-level rise or fall, sedimentation rates, topography and tidal energy (Lugo 1980). Coastal geomorphology is important in determining physical and chemical conditions for mangrove development and may explain regional differences in zonation patterns. Geomorphology as an explanation of intertidal zonation patterns is unsatisfactory, however, because it provides no insight as to how the interaction of geomorphological processes with vegetation causes a segregation of species. The remaining four hypotheses dispersal dynamics, seed predation, physiological tolerance, and interspecific competition—offer clear explanations for mangrove zonation. The relative importance of these processes is currently uncertain, but probably varies among geographic regions.

In addition to horizontal spatial patterns, mangroves exhibit vertical stratification. There are three major strata that are readily observed along tidal creeks: supratidal, intertidal, and subtidal. A unique assemblage of organisms associated with the mangrove vegetative structures characterizes each of these strata. The supratidal stratum includes the arboreal portions of the forest and is occupied by birds, reptiles, crabs, snails, insects, and spiders. The intertidal stratum extends from the high to low water tidal heights and encompasses the aerial root systems of the mangroves and peat banks. The organisms inhabiting this zone (e.g., barnacles, isopods, crabs, oysters, amphipods, snails, and algae) experience periodic submergence by the tides. The subtidal stratum occurs below the low water mark where the mangrove roots and peat banks provide substrate for organisms adapted to constant submergence (e.g., algae, sponges, tunicates, anemones, octocorals, shrimp, polychaetes, brittlestars, nudibranchs, jellyfish, and seagrasses).

A.3. Forest Structure

In addition to zonation, mangrove forests are also characterized by attributes such as species richness, canopy height, basal area, tree density, age/size class distribution, and understory development. Lugo &Snedaker (1974) described six mangrove forest types based on size, productivity, and composition in Florida: riverine, overwash, fringe, basin, scrub, and hammock. These forest types reflect differences in geomorphology and hydrology and are generally applicable to forests in the Caribbean Region. Species richness appears to be influenced by temperature, tidal amplitude, rainfall, catchment area, freshwater seepage, and frequency of cyclones (Tomlinson 1986; Lugo &Snedaker 1974).

Another structural characteristic of mangrove forests is the frequent absence of understory species, which are usually found in other forest systems (Janzen 1985). Shrubs, grasses, lianas, and other herbaceous plant species do not usually occur under the closed canopy in the mangrove forests. The lack of understory is probably related to the combination of salinity and flooding stresses and low light levels, which exceeds the tolerance limits of plants (Lugo 1986). An understory may develop, for example, where the canopy is open (allowing light penetration to the forest floor) or where rainfall or freshwater runoff lowers salinity levels. There may also be a second layer composed of mangrove seedlings and juveniles, but densities are greatest in light gaps.

Although mangrove forests are usually described as having an even-aged size class structure, the data supporting this viewpoint are not extensive. It is thought that large-scale disturbances such as hurricanes kill large areas of forest, which then regenerate at about the same time from seedlings or previously established juveniles. This view of even-aged structure in mangrove forests does not agree with what is known about the dynamic processes in other forest ecosystems. Forest systems are now viewed as mosaics of patches that vary in size and contain individuals of different ages or stages of development. These patches have resulted from natural disturbance events that create openings or gaps in the forest. Preliminary work indicates that gap dynamics may be an important process structuring mangrove forests. Natural disturbances such as lightning strikes, wind damage and frost are often associated with the development of patches or gaps in mangrove forests. Recent work in Belize, however, demonstrates that wood-boring insects are primarily responsible for the creation of gaps in red-mangrove forests (Feller & McKee 2001).

Forest structural characteristics such as canopy height, tree density, and biomass accumulation may be influenced primarily by climatic factors such as rainfall and by nutrient input (Golley and others1975; Smith 1992). Areas characterized by high rainfall typically have tall canopies, high basal areas, and low tree densities. Similarly, larger, more productive trees typify mangrove forests receiving high inputs of nutrients—for example, those areas used as bird rookeries.

A.4. Trophic Structure

Trophic structure refers to the complex interrelationships among the various organisms in an ecosystem through the transfer of food energy from one trophic level to another. The first trophic level (the producer level) is comprised of green plants; the second trophic level (primary consumer level) is comprised of herbivores (plant-eaters); the third trophic level (secondary consumer level) is comprised of carnivores, etc. These trophic levels are linked through food chains; food chains form interlocking patterns called food webs. There are two basic types of food chains: the grazing food chain (green plants to grazing herbivores to carnivores) and the detrital food chain (dead organic matter to detritus-feeding organisms to predators of detritivores).

The traditional view is that mangrove ecosystems are based on the detrital type of food web (Odum& McIvor 1990). Work by Heald (1969) and Middleton & McKee (2001) demonstrated that the leaves of the mangroves fall into the water where they are then consumed by various detritivores, which are in turn eaten by fish and other organisms that feed on the detritus consumers. The grazing pathway is considered to be unimportant in mangroves, since it has been estimated that only 5% of the leaf material is removed by grazing insects before leaf abscission. This value may be an underestimate, however, since work by Onuf and others (1977) shows substantial variation in leaf herbivory among mangrove species and locations. In addition, the contribution of wood-feeding insects to the grazing pathway has not been quantified. Wood-boring beetles may consume living wood and in the process kill branches or whole trees (Feller & McKee 1999; Feller 2002). These activities produce standing dead wood that is then utilized by secondary wood feeders such as termites, which in turn support secondary consumers such as arthropods, lizards, snakes, and birds (Feller & Mathis 1997).

B. Measuring Biodiversity

Biodiversity is the variety of life on Earth. It includes diversity at the genetic level, such as that between individuals in a population or between plant varieties, the diversity of species, and the diversity of ecosystems and habitats. Biodiversity encompasses more than just variation in appearance and composition. It includes diversity in abundance (such as the number of genes, individuals, populations or habitats in a particular location), distribution (across locations and through time) and in behavior, including interactions among the components of biodiversity, such as between pollinator species and plants, or between predators and prey. Biodiversity also incorporates human cultural diversity, which can be affected by the same drivers as biodiversity, and which has impacts on the diversity of genes, other species and ecosystems.

Diversity is a compound quantity made up of richness and evenness components (Jost 2010).The concept of diversity, including biodiversity itself as well as the narrower concept of species diversity, is a human construct without any unique mathematical meaning. The simplest measure of species diversity is species richness, but a good case can be made for giving some weight to evenness as well.

A type of sample method is a quadrat, which is a plot of land marked off for the study of plants or animals. Although the term implies a four-sided area, this is not necessary – many shapes are satisfactory.

The most common measures of biodiversity are species richness, Simpson's index, and Shannon's index. Although it's good to know what each test helps you understand, software programs have been designed to do the math for you. The most commonly used program for measuring biodiversity is Estimates. The count of the species coupled with these tests, summarizes most of the information on biodiversity.

The creation of indices gives scientists a standardized tool with which to compare both ecosystem and species health. Therefore, although exact diversity numbers are difficult to yield, knowing how biological resources are distributed within a community can be extremely beneficial in determining both short- and long-term trends.

Measuring biodiversity on an ecosystem level is thought to be a better way of looking at the shape of the entire system, rather than the particular species. However, it faces many of the same challenges.

It is common practice among ecologists to complete the description of a community by one or two numbers expressing the "diversity" or the "evenness" of the community. For this purpose, a bewildering diversity of indices have been proposed and a small subset of those have become popular and are now widely used, often without much statistical consideration ot theoretical justification.

Whittaker (1972) described three terms for measuring biodiversity over spatial scales: alpha, beta, and gamma diversity. Alpha diversity refers to the diversity within a particular area or ecosystem, and is usually expressed by the number of species (i.e., species richness) in that ecosystem.

The basic idea of a diversity index is to obtain a quantitative estimate of biological variability that can be used to compare biological entities, composed of discrete components, in space or in time. In conformity with the "political" definition of biodiversity, these entities may be gene pools, species communities or landscapes, composed of genes, species and habitats respectively.

Diversity indices have become part of the standard methodology in many applied fields of ecology, such as pollution and other impact studies. They have entered environmental legislation and are again attracting attention at the turn of the century because of the surge of interest in biodiversity and the never ending quest for indicators of the statues of the environment (Hiep and others 1998).

B.1. Shannon-Weiner's Index

The Shannon-Weiner index is an information statistic index. This means that it assumes all species are represented in a sample and that they are being sampled randomly. It is a mathematical expression that combines species richness and evenness as a measure of diversity. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account.

H	Shannon's diversity index
S	total number of species in the community (richness)
p_i	proportion of *S* made up of the *i*th species
E_H	equitability (evenness)

The Shannon diversity index (*H*) is another index that is commonly used to characterize species diversity in a community. Like Simpson's index, Shannon's index accounts for both abundance and evenness of the species present. The proportion of species *i* relative to the total number of species (p_i) is calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product is summed across species, and multiplied by -1:

$$H' = \sum_{i=1}^{S} pi(\ln(pi))$$

Shannon's equitability (E_H) can be calculated by dividing H by H_{max} (here $H_{max} = \ln S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

$$E_H = H/H_{max} = H/\ln S$$

B.2. Simpson's Diversity Index

The Simpson's Diversity Index is often used to quantify the biodiversity of a habitat. It is the measure of diversity which considers the number of the species present in the area and the population of the species. It measures the probability that two individuals randomly selected from a sample will belong to the same species. The Simpson's Index is a dominance index because it consolidates to common or dominant species in the site. This means that rare species with little population will not affect the diversity. It can be measure with the following formula.

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)} \right)$$

n = the total number of organisms of a particular species

N = the total number of organisms of all species

The value of D ranges between 0 and 1. With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give.

B.3. Pielou's Evenness

Biological diversity can be measured in many different ways. The two main factors taken into account when measuring diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. For example, species richness is the number of different species present. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present. It is a relationship between the different species making up the richness of the area.

CHAPTER 3

METHODOLOGY

A. Overview of the Study

The purpose of the study is to conduct a descriptive research to determine the biodiversity of mangroves found in Dangulaan-San Carlos Mangrove Rehabilitation Project in Barangay Dangula-an, Anilao, Iloilo.

Diversity of mangroves includes species richness, population density, and species evenness of mangroves found in Banate Bay.

B. Time and Place of Study

The study was done on January 11 to 18, 2014 from 9 AM – 4 PM. The site has an area of 4 hectares, which is equal to 40000 sq. meters. In the 40000 sq meters, only 10% were used in the study site, which has an area of 4000 sq. meters. The study site (Fig 1) is located in Dangulaan - San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo inside points: Point A: N: 10° 57'16.6" E: 122° 46'2.7", Point B: 10° 57'18.8", E: 122° 46'4.9", Point C: N: 10° 57'20.3", E: 122° 46'4.7" and Point D: N: 10° 57'20.8" E: 122° 46'6.9".

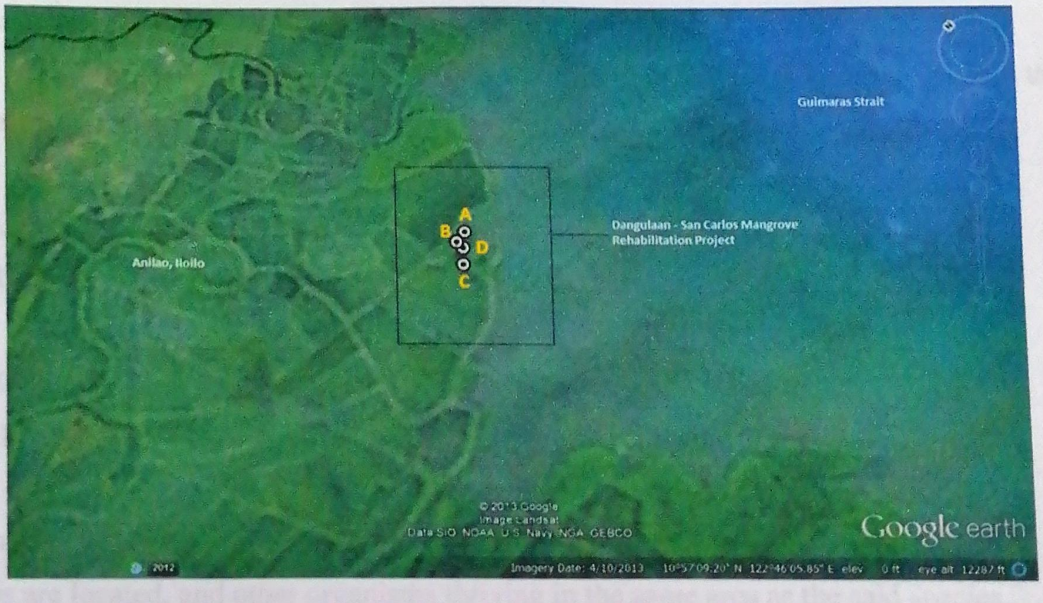

Figure 1. Aerial view of sampling site located in Dangulaan - San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao.

C. Materials and Equipment

The taxonomic reference used is the Handbook of Mangroves in the Philippines – Panay, 2004, written by Jurgenne H. Primavera, Resurrecion B. Sadaba, Ma. Junemie H. L. Lebata, and Jon P. Altamirano. The species identification was confirmed by Mrs. Doris Bagarinao, head curator of SEAFDEC-AQD, Tigbauan, Iloilo.

D. Preparation for Data Gathering

D.1. Study Area

The study area is located in the Dangulaan-San Carlos Mangrove Rehabilitation Project in Barangay Dangula-an, Anilao, Iloilo. A mangrove rehabilitation site and a green mussel culture site is managed by the Banate-Barotac Bay Resource Management Council Inc. (BBBRMCI).

D.2 Sampling and Sampling Area

Twenty quadrats were placed in the area. Each quadrat has a dimension of 10 meters by 10 meters. The 20 quadrats were divided into 4 subgroups and there was a 30-meter interval between each subgroup. In each subgroup, there were 5 quadrats and there was a 10 meter interval in between each quadrat. All the mangroves inside the quadrats were identified and their population was counted. Mangroves located in line with the quadrat are also counted.

D.3. Setting of Quadrats

The quadrats used measured 10 m x 10 m. The material used was plastic rope.

E. Data Gathering

E.1. Identification of Mangrove Species

E.1.1. General Characteristics

The general characteristics included where the plant is located, the tidal level where the mangroves are located, and other organisms thriving in the same area as the said species.

E.1.2. Leaves

The leaves were observed basing on different leaf characteristics such as:

a) Apex
b) Arrangement of leaves in the branch
c) Base
d) Blade shape
e) Lower surface of the leaf
f) Margin
g) Size of the leaf
h) Upper surface of the leaf
i) And other characteristics (ex. Existence of fine salt crystals on leaves)

E.1.3. Flowers

The flowers were observed basing on different flower characteristics such as:

a) Inflorescence
b) Petals
c) Sepals
d) Size
e) And other characteristics (ex. Number of flowers per cluster)

E.1.4. Fruits or Propagules

The fruits and propagules were observed basing on different fruits' and propagules' characteristics such as:

a) Appearance of Propagules
b) Color
c) Shape
d) Size
e) Texture
f) And other characteristics (ex. Existence of other organisms in the fruits)

E.1.5. Form of the Mangrove Plant

The flowers were observed basing on different flower characteristics such as:

a) Aerial roots (ex. Characteristics of the roots)
b) Bark characteristics (ex. Color, texture, and other characteristics)
c) Diameter at breast height (DBH)
d) Estimated height
e) Shape of plant

E2. Counting the Number of Species

The number of individuals per species per quadrat will be determined. Only live mangrove species were counted on the sampling site. Mangrove seedlings and trees were counted.

E.3. Calculation of the Population Density

The population density was calculated through the equation:

$$\frac{number\ of\ individuals\ per\ quadrat}{area\ of\ the\ quadrat}$$

E.4. Calculation of Species Richness

Species richness was calculated by measuring the number of species found in a sample.

E.5. Calculation of Diversity Index

Two diversity indices were used, namely, the Simpson's Index and the Shannon-Weiner's diversity index. This Simpson's index is calculated by the equation:

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

While the Shannon-Weiner's diversity index is computed through the equation:

$$pi = \frac{ni}{N}$$

$$H' = \sum_{i=1}^{S} pi(\ln(pi))$$

Where,

ni = number of individuals of species "i"

N = total number of individuals of all species

p_i = relative abundance of species "*i*" (see equation 1)

S = total number of species

H' = The Shannon Diversity Index (see equation 2)

E.6. Calculating Species Evenness

The Species Evenness was calculated by dividing Shannon's Diversity Index H' by the natural logarithm of species richness ln(S).

F. Precautionary Measures

F.1. Safety in the Field Work

1. Check the weather condition before conducting the field work. Do not attempt to work in the field when there is a storm.
2. Someone in the work locale (e.g. sheriff, police, local search and rescue personnel, and people who live near the area) must be informed of the field work location and the approximate time of return.
3. There should be an adult (preferably someone who knows the area well) present in order to avoid dangerous situations.
4. Wear proper attire (e.g. thin long-sleeve shirts and pants), socks, shoes, and a hat or a cap. Do not wear shorts, slippers, and accessories (e.g. necklace, bracelets and earings). Never bring an umbrella while doing field work.
5. Bring only the important things that are needed during the field work. Do not bring a heavy backpack.
6. Open wounds and the like should be treated as soon as possible.
7. Running, horse-playing and other rascal behaviors are not allowed. It might cause accidents.
8. Wear gloves and boots to avoid cuts, wounds, and saps from the leaves and branches of the mangrove trees. Apply mosquito repellent while conducting field work.

Table 1. Mangrove species in the area of the Dangulaan-San Carlos Mangrove Rehabilitation Project, Brgy. Dangulaan, Anilao, Iloilo and their corresponding population.

Family	Species	Local Name	Population
Avicenniaceae	*Avicennia alba*	*bungalon, api-api, miapi*	*259*
	Avicennia marina	*bungalon, api-api, miapi, bayabason*	*482*
	Avicennia officinalis	*bungalon, api-api, miapi*	*28*
	Avicennia rumphiana	*bungalon, api-api, miapi*	*1*
Bombacaceae	*Camptostemon philippinensis*	*gapas-gapas*	*135*
Euphorbiaceae	*Excoecaria agallocha*	*lipata, alipata, buta-buta*	*18*
Lythraceae	*Sonneratia alba*	*tabigi, tambigi*	*200*
Meliaceae	*Xylocarpus granatum*	*Piagao, lagutlot*	*42*
	Xylocarpus moluccensis	*saging-saging, tayokan, kawilan*	*73*
Myrsinaceae	*Aegiceras corniculatum*	*saging-saging, katuganung, kwasay*	*3*
	Aegiceras floridum	*bunot-bunot, tawalis, dukduk*	*1*
Myrtaceae	*Osbornia octodanta*	*bunot-bunot, tawalis, dukduk*	*1*
Rhizophoraceae	*Ceriops decandra*	*baras-baras, lapis-lapis*	*207*
	Ceriops tagal	*tungog, tangal, tagasa*	*36*
	Rhizophora apiculata	*bakhaw, bakhaw lalaki*	*169*
	Rhizophora mucronata	*bakhaw, bakhaw babae*	*297*
	Rhizophora stylosa	*bakhaw, bakhaw bato*	*18*
Total			*1970*

For the diversity indices, the results of the Simpson's Index of the mangroves is 0.147618 while for the Shannon-Weiner, a 2.833213 diversity index was computed. As for the species evenness, 0.778194 was calculated (Table 2).

Table 2. Result of Simpson's Diversity Index, Shannon-Weiner Diversity Index, and Pielou's Evenness Index.

Index	Mangroves
Simpson's Index (D')	0.147618
Shannon-Weiner (H')	2.204789
Pielou's Evenness (J)	0.778194

A.1. List and Description of Species

amily Myrsinaceae

egiceras corniculatum

Local names: *saging-saging, tayokan, kawilan* (Visayan), *tinduk-tindukan* (Tagalog)

Substrate: sandy, compact mud

Tidal level: middle

Often found with: *A. marina, B. cylindrical, C. philippinensis, S. alba*

Sampling areas: Pandan, Antique, Ibajay, Aklan and Capiz, Panay.

The species grows in isolated clumps never forming extensive stands along tidal creeks nd river mouths. Widely distributed in Panay but has never been found together with its sister pecies *A. floridum*. It can develop from a shrub to a small tree. It can grow until 2.5 meter high. The bark is dark brown to black in color and lenticellate. The aerial root are on the surface with dventitious. In Panay, the species is used for food and the bark for tanning and fish poison. Elsewhere in the Philippines, the wood is made into knife handles.

Leaves: The arrangement can be simple, alternate (rarely opposite), and spiral. The blade is obovate in shape. The margin is entirely smooth. The apex is round to emarginated while the base is acute. The upper surface is dark green and smooth and the undersurface is brownish green with prominent midrib. The size is 7 (5-12) cm long 5 (3-7) cm wide. There are salt crystals present. It is often notched and have a prominent midrib on the undersurface which emerges with the pinkish petiole.

Flowers: The inflorescence is umbel and terminal. The color of the petals is white. It has five petals that are folded outward. The five sepals are green in color. The color of the five stamens is orange to brown. It is about 0.6 to 0.7 centimeters long with a diameter of about 0.8 to 1 centimeter. The flowers are scented.

Fruit: It is cylindrical, strongly curved with a pointed tip. It is light green to purple in color. The texture is smooth. It is about 6 (4-8) centimeters long with a diameter of 0.4 to 0.6 centimeter. The strongly curved fruits hang in clusters like small bananas and are pale green to pinkish-red.

Aegiceras floridum

Local names: *saging-saging, katagung, kwasay* (Visayan), *tinduk-tindukan* (Tagalog)

Substrate: sandy, rocky

Tidal level: middle, high

Often found with: *O. octodonta, P. acidula, Rhizophora spp.*

Sampling areas: Taklong Island, Guimaras; Carles, Iloilo; Ajuy, Iloilo

It is a small tree that can grow up to 3 to 4 meters high. The bark is dark brown, mottled, and lenticellate. The aerial root is on the surface.

Leaves: The arrangement can be simple, alternate and spiral. The blade is obovate in shape. The margin is entirely smooth. The apex is round to emarginated while the base is acute. The upper surface is light green and smooth and the undersurface is whitish green and smooth. The size is 4 (3-6) cm long 2 (1-3) cm wide. There are salt crystals present and insect bites.

Flowers: The inflorescence is raceme and terminal. The color of the five petals is white to brown. The five sepals are green in color. There are five stamens. It is about 1centimeter long with a diameter of about o.7 centimeter.

Fruit: It is cylindrical, and straight like small bananas. It is pink to bright red in color. The texture is smooth. It is about 2-3 centimeters long with a diameter of 0.4 to 0.5 centimeter.

Family Avicenniaceae

Avicennia alba

Local names: *bungalon, api-api, miapi*

Substrate: soft mud

Tidal level: low, middle

Often found with: *A. marina*

Sampling areas: Makato River, Aklan; Pan-ay, Capiz; Ibajay, Aklan

They are medium- trees reaching up to 12 meters high, which tolerate high salinity and colonize the soft, muddy banks of rivers and tidal flats. This species can be found interspersed among the more widely distributed stands of *A. marina.* The whitish undersides of leaves give the canopy a silvery white appearance from a distance, differentiating it form the green to golden canopy of *A. marina*. It can grow up to 5 to 12 meters high. The bark is finely rough, dark brown to black in color. The aerial root is pencil-like pneumatophores. The wood is used for fuel and the leaves for an ointment from seeds to relieve smallpox ulceration.

Leaves: The arrangement can be simple, opposite, and decussate. The blade is elliptical in shape. The margin is entirely smooth. The apex and the base are both acute. The upper surface is green and smooth and the undersurface is silvery and smooth. The size is 10 (7-15) cm long and 4 (2-5) cm wide. There are salt crystals present and insect bites.

Flowers: The inflorescence is spiky and terminal or axillary. The color of the five petals is light yellow-orange. The five sepals are green in color and are fused. The five stamens are color yellow. It is about 0.5-0.6 centimeter long. It is slightly scented.

Fruit: It is conical and has a chili-like form. It is light green in color. The texture is finely hairy. It is about 3 to 5 centimeters long and 1-2 centimeters wide.

Avicennia marina

Local names: *bungalon, api-api, miapi, bayabason* (Iloilo)

Substrate: muddy, sandy, coralline rock

Tidal level: low, middle

Often found with: *A. alba, S. alba, Rhizophora spp*

Sampling areas: Taklong Island, Guimaras; Carles, Iloilo; Ibajay, Aklan; Pandan, Antique.

The most widely distributed mangrove species. It is found as shrubs in mudflats and abandoned fishponds. It can grow up to 2 to 10 meters high. The bark is smooth with thin flakes, and greenish brown in color. The aerial roots are pencil-like pneumatophores. Coastal dwellers plant this species to protect their homes from typhoons. It is preferred for firewood because it coppices, meaning it produces branches after cutting. The smoke of dried branches acts as mosquito repellent. Leaves are fed to livestock. Newly-sprouted seedlings are cooked as vegetables. Christmas trees are built form branches are sold along Roxas Blvd. in Manila.

Leaves: The arrangement can be simple, opposite, and decussate. The blade is elliptical in shape. The margin is entirely smooth. The apex is acute to round while the base is also acute. The upper surface is green to yellow-green and smooth and the undersurface is green to yellow-green and smooth. The size is 7 (4-11) cm long and 3 (2-6) cm wide. It has numerous insect bites, and highly variable. The leaves are curling and rolling.

Flowers: The inflorescence is spiky and terminal or axillary. The color of the four petals is light yellow-orange with a margin which is brown in color. The four sepals are green in color

and are fused. The four stamens are color yellow and very short. It is about 0.5-0.7 centimeter long. It is slightly scented.

Fruit: It is conical and has a chili-like form. It is light green in color. The texture is finely hairy. It is about 3 to 5 centimeters long and 1 to 2 centimeters wide.

Avicennia officinalis

Local names: *bungalon, api-api, miapi*

Substrate: firm mud

Tidal level: middle, high

Often found with: *A. rumphiana, B. cylindrica*

Sampling areas: Barotac Nuevo, Iloilo; Pan-ay, Capiz; Makato River, Aklan; Ibajay, Aklan

Medium to large trees that can grow up to 20 meters on firm mud of the upper intertidal in estuarine areas. The bark is rough and dark brown in color. The aerial roots are pencil-like pneumatophores. There are often stilt roots on the trunk. The trunk is not straight and its branches are irregular. Ashes of branches are placed in a funnel through which seawater is filtered. The filtrate is evaporated by boiling to obtain a solid lump of salt. The wood was used to smoke fish and build rise mortars and pestles. Fruits were used as astringent bark and roots as aphrodisiac, and seeds and roots as poultice to treat ulcer, etc.

Leaves: The arrangement can be simple, opposite, and decussate. The blade is elliptical to oblong in shape. The margin is entirely smooth. The apex is round while the base is also acute. The upper surface is shiny and dark green and the undersurface is glabrous and yellow-green and smooth. The size is 10 (6-14) cm long and 5 (3-7) cm wide. It has salt crystals. It appears slightly convex as sides bent downwards.

Flowers: The inflorescence is spiky, and terminal or axillary. The color of the four petals is dark yellow-orange. The four sepals are light green in color and are fused. The four stamens are color yellow. It has a diameter of about 0.9-1.5 centimeter.

Fruit: It is heart-shape and elongated form with a pointed tip. It is light green in color and is fused. The texture is rugose and finely hairy. It is about 3 to 4 centimeters long and 2 to 3 centimeters wide.

Avicennia rumphiana

Local names: *bungalon, api-api, miapi*

Substrate: muddy

Tidal level: low, middle

Often found with: *A. officinalis*, *B. cylindrica.*

Sampling areas: Taklong Island, Guimaras; Carles, Iloilo; Ibajay, Aklan; Pan-ay, Capiz

Formerly referred to as *Avicennia lanata*, this species forms medium to large trees. It can grow up to 5 to 20 meters high. The bark is slightly rough and brown in color. The aerial roots are pencil-like pneumatophores. The seedlings are abundant but saplings and smaller trees are rare. The canopy of an *A. rumphiana* stand looks like brown from a distance, in contrast to the silvery white appearance of *A. alba.* Sometimes it occurs with *A. officinalis,* but its young leaves and branches are typically upright, whereas those of *A. officinalis* point in all directions. Also used as woodfuel and for furniture-making with its fine-grained wood.

Leaves: The arrangement can be simple, opposite, and decussate. The blade is elliptical in shape. The margin is entirely smooth. The apex is round while the base is acute. The upper surface is dark green to yellow-green and smooth and the undersurface is densely pubescent and yellow-green in color. The size is 8 (5-11) cm long and 4 (3-5) cm wide.

Flowers: The inflorescence is spiky, and terminal or axillary. The color of the four petals is yellow-orange. The four sepals are light green in color and are fused. The four stamens are color yellow. It has a diameter of about 0.5-0.7 centimeter.

Fruit: It is heart-shape and round with a blunt tip. It is yellow green in color. The texture is woolly. It is about 1 to 3 centimeters long and 1 to 2 centimeters wide.

Family Bombacaceae

Camptostemon philippinensis

Local names: *gapas-gapas*

Substrate: soft mud

Tidal level: low, middle

Often found with: *A. marina*

Sampling areas: Barotac Nuevo, Iloilo; Ibajay, Aklan; Carles, Iloilo; Makato River, Aklan.

Small to medium-sized trees that can grow up from 5 to 15 meters tall. The DBH is 10 to 50 centimeters long. The bark is rough, brown-gray in color, has irregular flakes and has

lenticillates. The aerial roots are on the surface, gnarled, curling and with lenticels. The surface roots emanate from the base of the trunk and spread out around mature trees. It is found along rivers and tidal creeks. The ground in *C. philippinensis* grove appears white from the cottony threads of newly-fallen seeds. The wood is used for fuel and for making household utensils and carvings.

Leaves: The arrangement can be simple, alternate, or spiral. The shape of the blade is obovate. The margin is entirely smooth. The apex is round to emarginate. The base is acute. The upper surface is leathery and dark green in color. The undersurface is smooth and light green with scales. The size is 8 (5-9) cm long and 5 (3-7) cm wide. The leaves are thick covered with fine scales and crowded at the end. It has fine salt crystals on leaves.

Flowers: The inflorescence can either be cyme or terminal. The 5 petals are white to reddish brown in color. The 5 sepals are green in color. It has a diameter of about 1.0 to 1.3 centimeter. It usually has 3 to 4 flowers per cluster.

Fruits: It is round and dehiscent. It is green to brown in color and is cottony inside. It is 1.0 to 2.0 centimeters long and has a diameter of 7.0 centimeters. They are attractive to big ants.

Family Rhizophoraceae

Ceriops decandra

Local names: *baras-baras, lapis-lapis, malatangal* (Tagalog)

Substrate: sandy, muddy

Tidal level: middle, high

Often found with: *A. officinalis, A. rumphiana, N. fruticans*

Sampling areas: Barotac Nuevo, Iloilo; Carles, Iloilo; Pan-ay, Capiz; Ibajay, Aklan

It can grow up to 2 to 3 meters high. The bark is rough, gray to brown in color and has a few lenticels. The aerial roots are small and buttress-like. This species can be found interspersed among the more widely distributed stands of *A. marina.* It is commonly used as firewood, and as Christmas trees in Luzon. The bark of mature trees is harvested for the *baluk* powder used in making local *tuba.*

Leaves: The arrangement can be simple, and opposite. The blade is mostly obovate in shape. The margin is entirely smooth. The apex is round to emarginated while the base is acute.

he upper surface is green and smooth and the undersurface is light green and smooth. The size 7 (4-10) cm long and 4 (3-8) cm wide.

Flowers: The inflorescence is cyme or axillary. The color of the five petals is white and it as hairs. The five sepals are light green in color and are fused. It is about 0.3-0.5 centimeter ng and has a diameter of about 0.3-0.5 cm. It is has 6 to 8 flowers per cluster, on short thick alks.

Fruit: It is cylindrical and pencil-like in shape. It green to brown when it matures. The exture is smooth, slender, and slightly ribbed. It is about 13.5 (10-18) centimeters long and has a iameter of 0.5 to 0.9 cm. It has a reddish brown cotyledonary collar.

Ceriops tagal

Local names: *tungog, tangal, tagasa* (Tagalog)

Substrate: firm mud, sandy

Tidal level: middle, high

Often found with: *A. corniculatum*, *A. rumphiana, S. alba, R. apiculata*

Sampling areas: Taklong Island, Guimaras; Carles, Iloilo; Ibajay, Aklan

The trees are taller with a single straight trunk, and longer fruits pointing downwards compared to *C. decandra.* It can grow up to 2 to 6 meters high. The DBH is 5 to 10 cm. The bark is rough, and light brown to grey in color and flaky. The aerial roots are low buttresses with knee roots. The dried bark gives the best quality *baluk* powder used in making *tuba, bahalina,* and *basi* and house posts. The big trees provide hard, fine-textured wood furniture and house construction. The bark was used to treat hemorrhages and ulcers; older folks chewed on dried bark.

Leaves: The arrangement can be simple, and opposite. The blade is mostly obovate in shape. The margin is entirely smooth and curls downwards. The apex is round while the base is acute. The upper surface is green to yellow-green and smooth and the undersurface is yellow-green and smooth. The size is 8 (5-12) cm long and 4 (2-6) cm wide. The leaves are brittle and directed upwards. It turns yellowish green in sunlight.

Flowers: The inflorescence is cyme or axillary. The color of the four to six petals is white with brownish hair. The four to six sepals are light green in color and are fused. The four to six

stamens has a brown tip. It is about 0.6-0.9 centimeter long and has a diameter of about 0.6-0.9 centimeter.

Fruit: It is cylindrical and pencil-shaped. It is dark green to brown in color when it matures. The texture is ridged with a few warts. It is about 20.5 (16-30) centimeters long and a diameter of 0.6 to 1.0 centimeter wide. I has a pendulous and a yellow cotyledonary collar. The calyx is spread.

Rhizophora apiculata

Local names: *bakhaw, bakhaw lalaki, bulubaladaw* (Antique)

Substrate: muddy

Tidal level: low, middle

Often found with: *A. marina, S. alba, R. stylosa, R. mucronata*

Sampling areas: Taklong Island, Guimaras; Zarraga, Iloilo; Kalibo, Aklan; Libertad, Antique.

It can grow from 4 up to 20 meters high. The DBh is 10-40 cm. The bark is rough and grayish to brown in color. The aerial roots are prop roots.Its wide distribution in Panay and elsewhere in the Philippines is due to its pioneering nature and popularity for replanting. It is the referred species for plantations because of availability of propagules and fast growth. The buds are compact and used by children s bullet for toy guns. The leaves may be fed to pigs.

Leaves: The arrangement can be simple, and opposite. The blade is elliptical in shape. The margin is entirely smooth. The apex is apiculate while the base is acute. The upper surface is smooth and dark green and the undersurface is green and smooth. The size is 13 (9-19) cm long and 5 (4-7) cm wide. It has dark red stipules.

Flowers: The inflorescence is cyme or axillary. The color of the four petals is white. The four sepals are yellow to red in color outside. The twelve stamens are color brown. It is 1.2 to 1.4 centimeters long. It has 2 flowers per cluster with no style.

Fruit: It is cylindrical and has s straight form. It is dark green in color. The texture smooth. It is about 24 (22-26) centimeters long and has a diameter of about 0.9 to 1.0 centimeter long. It is viviparous and short (-1 cm). It looks like a penduncle so the upper part tends to be curved. It has a yellowish cotelydonary collar.

Rhizophora mucronata

Local names: *bakhaw, bakhaw babae*

Substrate: sandy, muddy

Tidal level: low

Often found with: *A. marina, R. apiculata, R. stylosa, S. alba*

Sampling areas: Taklong Island, Guimaras; Kalibo, Aklan; Ibajay, Aklan; Pandan, Antique

It can grow up to 4 to 15 meters high. The DBH is 8 to 20 centimeters. The bark is rough and grayish to brown in color. The aerial roots are prop roots. It is favored for fuelwood and charcoal because of its high heating value, like the other *Rhizophora* species. The dried hypocotyls were smoked as cigars.

Leaves: The arrangement can be simple, and opposite. The blade is elliptical in shape. The margin is entirely smooth. The apex is mucronate while the base is acute. The upper surface is dark green and smooth and the undersurface is smooth and yellow-green in color. The size is 14 (11-19) cm long and 7 (6-10) cm wide. It has broader leaves compared to the other *Rhizophora* species. It has black dots and light green stipules.

Flowers: The inflorescence is cyme or axillary. The color of the four petals is white and hairy. The four sepals are light yellow in color. The 8 stamens are color brown. It is 1.0 to 2.2 centimeters long. It has a diameter of about 1.0-1.5 centimeter. The peduncle is 3.0 to 5.0 cm long. It has 2 to 6 flowers per cluster and has a 1 mm style.

Fruit: It is cylindrical in shape. It is dark green in color. The texture is warty. It is about 57 (34-70) centimeters long and 1 to 2 centimeters in diameter. It is viviparous and has a yellow collar.

Rhizophora stylosa

Local names: *bakhaw, bakhaw bato, bangkao*

Substrate: sandy, muddy

Tidal level: low, middle

Often found with: *A. marina, R. apiculata, R. mucronata, S. alba*

Sampling areas: Taklong Island; Oton, Iloilo; Pandan, Antique.

It can grow up to 3 to 10 meters high. The DBH is 6 to 15 centimeters. The bark is rough and grayish to brown in color. The aerial roots are prop roots. The roots are often overgrown by

epiphytic algae. It is widely distributed and overlaps with the habitat of *R. apiculata*. It is used for fuel wood and dyes.

Leaves: The arrangement can be simple, and opposite. The blade is elliptical in shape. The margin is entirely smooth. The apex is apiculate while the base is acute. The upper surface is light green and waxy and the undersurface is smooth and yellow-green in color. The size is 11 (8-14) cm long and 5 (3-7) cm wide. The leaves on terminal branches slant or point upward. Its sides are curling and the stipules are light green in color.

Flowers: The inflorescence is cyme or axillary. The color of the four petals is white and hairy. The four sepals are light yellow in color. The 8 stamens are color brown. It is 1.1 to 1.5 centimeters long. It has a diameter of about 1.4-2.0 centimeters. The peduncle is long. It has 7 flowers per cluster and has a 6 mm style.

Fruit: It is cylindrical and has a straight form. It is light green to green in color. The texture is warty. It is about 34 (26-42) centimeters long and 1 to 2 centimeters in diameter. It is viviparous and has a greenish collar.

Family Euphorbiaceae

Excoecaria agallocha

Local names: *lipata, alipata* (Visayan), *buta-buta* (Cebuano)

Substrate: sandy, muddy

Tidal level: middle, high

Often found with: *A. officinalis, A. rumphiana, N. fruticans,* Rhizophora spp

Sampling areas: Zarraga, Iloilo; Pan-ay, Capiz; Ibajay, Aklan; Pandan, Antique

Trees that can grow up from 5 to 15 meters tall. The DBH is 10 to 60 centimeters long. The bark is grayish brown in color, and slightly rough and often mottled sue to lichens. The aerial roots are on the surface. The twigs are used as pest repellent, burnt ashes for salt extraction, and leaves to treat epilepsy. Its milky sap, which flows from any cut surface on the leaf, twig, or trunk can cause skin irritation and alleged blindness. The sap is used to treat toothache and ulcers and as fish poison.

Leaves: The arrangement can be simple, alternate, or spiral. The shape of the blade is elliptical. The margin is entirely smooth. The apex is acute. The base is acute. The upper surface

and the undersurface are both smooth and green and light green respectively. The size is 5 (3-8) cm long and 3 (2-4) cm wide. It has a milky sap. It is deciduous.

Flowers: The inflorescence can either be catkin or axillary. The petals are yellow. The stamens are yellow. The male is about 1.9 to 3.0 centimeters long and the female is 0.3 to 0.7 centimeter long.

Fruits: It is round with three lobes. It is green in color and brown when it matures. Its texture is smooth. It has a diameter of about 0.4 to 0.6 centimeter. It has a short style that splits into curling strands.

Family Myrtaceae

Osbornia octodonta

Local names: *bunot-bunot, tawilis, dukduk* (Negros)

Substrate: rocky, sandy

Tidal level: middle, high

Often found with: *P. apiculata, A. floridum, L. littorea*

Sampling areas: Taklong Island, Guimaras; Tangalan, Aklan; Carles, Iloilo

Shrubs to small trees that can grow up from 3 to 6 meters tall with surface roots, and often has multiple irregular stems. The DBH is 5 to 15 centimeters long. The bark is brown to gray in color, thick, spongy, and rough with long fissures. The aerial roots are on the surface. It can tolerate high salinity. Aside from fuelwood, the dried twigs are made into baskets and used as fish-aggregating devices by local fishers.

Leaves: The arrangement can be simple, decussate, or opposite. The shape of the blade is obovate. The margin is entirely smooth. The apex is emarginate. The base is sessile. The upper surface and the undersurface are both pale green and smooth. The size is 4 (3-6) cm long and 2 (1-3) cm wide. The leaves are thin and brittle and has an aroma when crushed.

Flowers: The inflorescence can either be cyme or axillary. The petals are apetalous. The sepals are yellow green in color and are fused. The stamens have numerous white and yellow pollens. It is about 0.5 to 1.0 centimeter long and has a diameter of 0.2 to 0.5 centimeter. It usually has 3 flowers per cluster.

Fruits: It is like that of a capsule. It is pale green in color and has a hairy texture. It is 0.7 to 1.0 centimeter long and has a diameter of about 0.3 to 0.5 centimeter. The calyx completely encases the fruit.

Family Sonneratiaceae

Sonneratia alba

Local names: *pagatpat*

Substrate: coralline-sandy

Tidal level: low

Often found with: *A. marina, Rhizophora spp.*

Sampling areas: Taklong Island, Guimaras; Pan-ay, Capiz; Pandan, Antique; Kalibo, Aklan

It can grow up from 5 to 20 meters high. The DBH is 20 to 120 centimeters. The bark is rough, brown in color, fissured, and flaky. Its aerial roots are conical and corky. It has pneumatophores. This species hosts colonies of fireflies, a northern Agusan settlement was called Masawa (now Masao). Past uses include housing construction materials, furnishing, and musical instruments. Due to salt content, woodwork required copper nails and screws.

Leaves: The arrangement can be either simple or opposite. The blade is obovate to round in shape. The margin is entirely smooth. The apex and the base are both round. The upper surface is smooth and dark green. The undersurface is smooth and light green. The size is 8 (6-12) cm long and 7 (3-11) cm wide. The leaves are leathery, succulent, and brittle.

Flowers: The inflorescence can either be cyme or terminal. There are 4 to 6 petals. The color of the petals is white and it is thin. It has 4 to 7 sepals. The sepals are green in color and are fused. The stamens have more than 300 white filaments that are 3.0 to 5.0 centimeters long. It is about 5.0 to 7.0 centimeters long and has a diameter of 6.0 to 9.0 centimeters. It has a long style of about 5 to 6 centimeters long and is light green in color.

Fruits: It is round and dark green. The texture is smooth. It is 3.0 to 4.0 centimeters high and has a diameter of about 3.0 to 5.0 centimeters. It contains many V- and U-shaped seeds.

Family Meliaceae

Xylocarpus granatum

Local names: *tabigi, tambigi*

Substrate: sandy, muddy

Tidal level: middle

Often found with: *X. moluccensis, N. fruticans, B. cylindrica*

Sampling areas: Ibajay, Aklan; Pandan, Antique; Makato River, Aklan

It can grow up from 3 to 17 meters high. The DBH is 10 to 70 centimeters. The bark is smooth, light brown in color, and has thin flakes. Its aerial roots are low buttresses, plank or ribbon. Its low buttresses extend as distinctive, snake-like plank roots. The inner bark is red and a source of dye for tanning. Oil from seeds is used for lamps and for grooming hair, the fruits and seeds are used to cure diarrhea, and a bark decoction for cholera.

Leaves: The arrangement can either be opposite or paripinnate compound. The blade is obovate in shape. The margin is entirely smooth. The apex is round to emarginated and the base is acute. The upper surface is smooth and dark green. The undersurface is smooth and light green. The size is 12 (7-19) cm long and 6 (4-9) cm wide. It has 2 to 3 pairs of leaflets and is sometimes deciduous.

Flowers: The inflorescence can either be panicle or axillary (a few terminal). It has a 4 petals, and sepals. The color of the petals is white. The sepals are lobed and yellowish green in color. The stamens are tubular. It is about 1.1 to 1.2 centimeters long and has a diameter of 1.1 to 1.4 centimeters. The flowers are unisexual.

Fruit: It is like a cannon ball or a bowling ball. Its color is from green to brown. Its texture is smooth to slightly rough. It is 8.0 to 13 centimeters long and 8.0 to 14 centimeters in diameter. It also has 10 to 12 irregularly-shaped seeds.

Xylocarpus moluccensis

Local names: *piagao, lagutlot*

Substrate: firm, sandy, muddy

Tidal level: middle

Often found with: *X. granatum, R. apiculata, N. fruticans, B. cylindrica*

Sampling areas: Ibajay, Aklan; Pan-ay, Capiz

It can grow up from 3 to 10 meters high. The DBH is 10 to 50 centimeters. The bark is rough, dark brown in color, and is fissured. Its aerial roots are cone or peg roots and they arise from cable roots. Its low buttresses extend as distinctive, snake-like plank roots. Seeds were used

or insect bites, diarrhea, and as astringent, the fruits for diarrhea, and the bark as astringent. In he past, the wood was used to make poles, railroad ties, posts, beams, and for interior finish, nusical instruments and high grade furniture.

Leaves: The arrangement can either be opposite or paripinnate compound. The blade is elliptical in shape. The margin is entirely smooth. The apex and the base are both acute. The upper surface is smooth and green. The undersurface is smooth and light green. The size is 8 (5-12) cm long and 4 (2-5) cm wide. It usually has 3 to 4 pairs of leaflets and is deciduous.

Flowers: The inflorescence can either be panicle or mainly axillary. It has a 4 petals, and sepals. The color of the petals is white. The sepals are lobed and pale yellow green in color. The stamens are white and fused. It is about 0.6 to 0.7 centimeter long and has a diameter of 0.9 to 1.0 centimeter. The flowers are unisexual.

Fruit: It is like a small cannon ball. Its color is light green. Its texture is smooth to slightly rough. It is 8.0 to 9.0 centimeters long and 9.0 to 10 centimeters in diameter.

B. Discussion

A total eighteen mangrove species was found. Seventeen species were identified among eight mangrove families. One species was not identified and is locally known as "Baliskog".

The mean population density is 9.85 individuals per square meter. This suggests that there are at least ten mangroves growing for every square meter of the area. The Simpson's Index is 0.147618. The Simpson's indices show the diversity within the range of 1 and 0. This index is near 0 and this suggests that it is relatively low. However, the Shannon-Weiner's Index is 2.204789. The higher the index, the higher the diversity. The Pielou's Evenness is 0.778194. The species evenness ranges from zero to one, with zero signifying no evenness and one, a complete evenness. This suggests that the species of mangroves are evenly distributed throughout the area.

A study by Lunar and others in comparing the diversity of two mangrove conservation sites of Calitagan, Batangas, Philippines shows their results of Shannon-Weiner indices of 1.05 and 1.21. Another study by Avila and others in measuring species composition of fauna in mangrove forests in Palompon, Leyte, Philippines shows 0.57 and 0.52 Shannon-Weiner indices. The calculated Shannon-Weiner index of the study site in Dangula-an, Anilao, Iloilo is 2.2 and is

relatively higher compared to all studies conducted in different mangrove forests and mangrove conservation sites mentioned above. Because the Shannon-Weiner index in the study site in Anilao, Iloilo is higher, this indicates that the Dangulaan-San Carlos Mangrove Rehabilitation Project has a more diverse mangrove ecosystem compared to the mangrove forests in Calitagan, Batangas and Palompon, Leyte.

CHAPTER 5

SUMMARY, CONCLUSION, RECOMMENDATIONS

A. Summary

The findings of this study are as follows:

1. The different species identified in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Brgy. Dangulaan, Anilao, Iloilo are *Aegiceras corniculatum, Aegiceras floridum, Avicennia alba, Avicennia marina, Avicennia officinalis, Avicennia rumphiana, Camptostemon philippinensis, Ceriops decandra, Ceriops tagal, Excoecaria agallocha, Osbornia octodanta, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa, Sonneratia alba, Xylocarpus granatum,* and *Xylocarpus moluccensis.*
2. *Avicennia marina* had the highest population of 482 while the species that had the lowest population are *Aegiceras floridum*, *Avicennia rumphiana,* and *Osbornia octodanta* with a total of one individual per species.
3. The mean population density of the mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Brgy. Dangulaan, Anilao, Iloilo is 9.85 individuals per square meter.
4. The Simpson's Index is 0.147618 and the Shannon-Weiner is a 2.204789 diversity index while Pielou's Evenness is 0.778194.
5. The species richness of the mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Brgy. Dangulaan, Anilao, Iloilo is 2.833213.

B. Conclusion

Eighteen species of mangroves was found in the area. Based on the results, the diversity of mangroves thriving in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Barangay Dangulaan, Anilao, Iloilo is high.

C. Recommendations

It is recommended to observe the distribution pattern of the different species of mangroves in the Dangulaan-San Carlos Mangrove Rehabilitation Project, Brgy. Dangulaan, Anilao, Iloilo.

Aegiceras floridum, *Avicennia rumphiana,* and *Osbornia octodanta* had the lowest population in the area. Planting more of these species is also recommended in order to increase its population.

It is also recommended to use different sampling methods and to study on the factors that affect the growth and distribution of mangroves.

It is also recommended to conduct this study in other places such as Antique, Aklan, Capiz in order to determine the biodiversity of mangroves in the whole island of Panay.

LITERATURE CITED

Avila, S.T.R, Marababol, M.S., Picardal, J.P. 2011. The Species Composition and Associated Fauna of the Mangrove Forest in Tabuk and Cabgan Islets, Palompon, Leyte, Philippines. CNU Journal of Higher Education. Vol. 5 No.1.

Browne, F.G. 1968. Pests and diseases of forest plantations trees. Clarendon Press, Oxford.

Burkill, J.H. 1966. A dictionary of economic products of the Malay Peninsula. Art Printing Works, Kuala Lumpur. 2 vols.

Cahill, J.F. and Molles M.C. 1995. Ecology: Concepts and applications.

Cannell, M.G.R. 1982. World forest biomass and primary production data. Academic Press, New York.

CSIR (Council of Scientific and Industrial Research). 1948–1976. The wealth of India. 11 Vols. New Delhi.

Delgado P., Hensel P.F., Jimenez J.A., Day, J.W. 2001. The Importance of Propagule Establishment and Physical Factors in Mangrove Distributional Patterns in a Costa Rican Estuary. Aquatic Botany. 71, 157-178.

Duke, J.A. and Wain, K.K. 1981. Medicinal plants of the world. Computer index with more than 85,000 entries. 3 vols.

Duke N., Allen J. 2006. *Rhizophora mangle, R. samoensis, R. racemosa, Rx harrisonii* (Atlantic East Pacific Red Mangrove). Species Profiles for Pacific Island Agro forestry. 2(1).

Hou, D. 1958. Rhizophoraceae. p. 429–493. In: van Steenis, C.G.G.J. (ed.), 1955–1958, Flora Malesiana. series 1, vol. 5, P. Nordhoff Ltd., Republic of Indonesia.

Johnson, L., Herren, L. 2008. Re-establishment of Fringing Mangrove Habitat in the Indian River Lagoon.

Lewis, R. 2004. Ecological Engineering for Successful Management and Restoration of Mangrove Forests. Ecological Engineering. 24. 2005. 403-418

List, P.H. and Horhammer, L. 1969–1979. Hager's handbuch der pharmazeutischen praxis. vols 2–6. Springer-Verlag, Berlin.

Little, E.L. Jr. 1983. Common fuel wood crops: a handbook for their identification. McClain Printing Co., Parsons, WV.

Laguardia, M.A. and Lunar, B.C. 2013. Comparative study of Diversity of Mangroves in Two Conservation Sites of Calatagan, Batangas, Philippines. Iamure Multidisciplinary Research Vol 1 No 1.

NAS. 1980. a. Firewood crops. Shrub and tree species for energy production. National Academy of Sciences, Washington, DC.

Perry, L.M. 1980. Medicinal plants of East and Southeast Asia. MIT Press, Cambridge.

Watt, J.M. and Breyer-Brandwijk, M.G. 1962. The medicinal and poisonous plants of southern and Eastern Africa. 2nd ed. E.&S. Livingstone, Ltd., Edinburgh and London.

APPENDIX A

RAW DATA

Table 3. Raw data of the mangrove species found in quadrats 1 to 10.

Species	Population of Mangrove Species										
	Quadrat										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Aegicerascorniculatum	0	0	0	0	0	0	0	0	0	0	**0**
Aegicerasfloridum	1	0	0	0	0	0	0	0	0	0	**1**
Avicennia alba	0	0	0	0	2	0	0	0	0	0	**2**
Avicennia marina	7	11	7	110	1	15	56	117	4	2	**330**
Avicenniaofficinalis	0	0	0	0	0	0	0	0	0	0	**0**
Avicenniarumphiana	0	0	0	0	0	0	0	0	0	0	**0**
Camptostemonphilippinensis	108	7	2	8	0	0	5	0	0	0	**130**
Ceriopsdecandra	0	0	0	0	2	0	56	5	0	0	**63**
Ceriopstagal	6	4	0	11	0	0	13	0	0	0	**34**
Excoecariaagallocha	0	0	7	0	4	2	0	0	0	0	**13**
Osborniaoctodanta	0	0	0	1	0	0	0	0	0	0	**1**
Rhizophoraapiculata	7	4	7	11	0	8	25	4	10	0	**76**
Rhizophoramucronata	5	21	5	28	0	11	3	1	21	10	**105**
Rhizophorastylosa	0	0	0	0	0	0	4	2	0	1	**7**
Sonneratia alba	0	0	0	12	0	0	0	0	1	0	**13**
Xylocarpusgranatum	0	0	0	0	0	0	0	0	0	0	**0**
Xylocarpusmoluccensis	0	0	0	1	36	16	16	0	0	0	**69**
Unidentified Species	0	0	0	0	0	0	0	0	0	0	**0**
Total	134	47	28	182	45	52	178	129	36	13	

able 4. Raw data of the mangrove species found in quadrats 11 to 20.

Species	Population of Mangrove Species										
	Quadrat										
	11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Total**
Aegicerascorniculatum	0	0	0	0	0	3	0	0	0	0	**3**
Aegicerasfloridum	0	0	0	0	0	0	0	0	0	0	**0**
Avicennia alba	0	0	0	6	76	31	55	62	1	26	**257**
Avicennia marina	9	1	5	24	25	25	16	21	9	17	**152**
Avicenniaofficinalis	0	0	0	0	0	0	3	3	7	15	**28**
Avicenniarumphiana	0	0	0	0	0	1	0	0	0	0	**1**
Camptostemonphilippinensis	0	0	0	0	0	0	1	0	0	4	**5**
Ceriopsdecandra	0	0	0	0	0	55	64	3	12	10	**144**
Ceriopstagal	0	0	0	0	2	0	0	0	0	0	**2**
Excoecariaagallocha	0	0	0	0	0	0	0	0	0	5	**5**
Osborniaoctodanta	0	0	0	0	0	0	0	0	0	0	**0**
Rhizophoraapiculata	0	7	7	21	24	18	1	5	0	10	**93**
Rhizophoramucronata	41	32	41	49	20	9	0	0	0	0	**192**
Rhizophorastylosa	1	0	0	0	0	8	0	2	0	0	**11**
Sonneratia alba	46	3	1	29	88	0	13	5	0	2	**187**
Xylocarpusgranatum	0	0	0	0	0	2	3	4	16	17	**42**
Xylocarpusmoluccensis	0	0	0	0	0	0	2	2	0	0	**4**
Unidentified Species	0	0	0	0	0	0	0	0	12	3	**15**
Total	97	43	55	129	235	152	158	112	57	109	

APPENDIX B

PICTURES

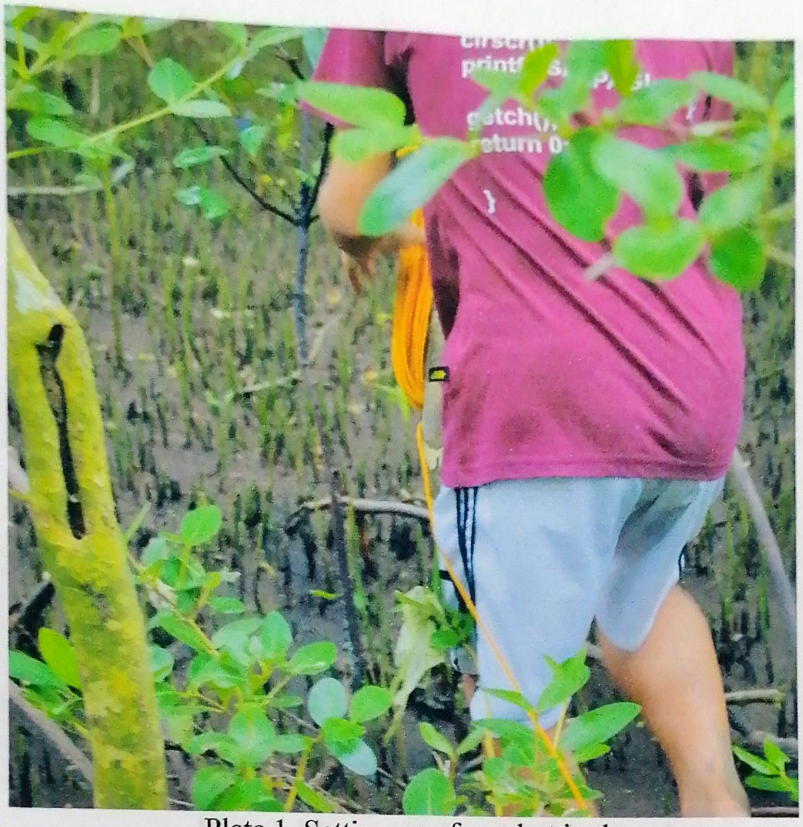

Plate 1. Setting up of quadrat in the area

Plate 2. Mangroves found inside a quadrat.

Plate 3. Unidentified mangrove species locally known as “baliskog”.