Review Article

Mangrove-Epiphytic Plants in Selected Mangrove Rehabilitation Areas of Davao Occidental, The Philippines

ABSTRACT

The study was conducted in the mangrove rehabilitation sites of Davao Occidental, Philippines particularly Sitio Agdao of Brgy. Tubalan, Sitio Baybay of Brgy. Buhangin and Sitio Lahusan of Brgy. Fishing Village of Malita, Davao Occidental. The study was conducted from October to December 2020. Preliminary stations were established in the conduct of the study. Station 1 in Sitio Agdao, Station 2 in Sitio Baybay and the Station 3 in Sitio Lahusan. This site is considered to be a slightly undisturbed mangrove forest dominated by species of mangrove trees.

The free exploration method was carried out first before the conduct of the study. Samples consisted of host plants and their associates (epiphytes) are collected for proper identification. Three study areas were assessed by the number of individual species to calculate their relative abundance and density.

A total of 7 species identified individually among of the three-study areas. The study also shows that species of mangrove epiphytes in the study area composed of 3 to 5 species per station and exhibit 1 to 3 identified species per plot and individual species per station revealed that *Davalia denticulata* and *Aglaomorpha quercifold* were the most common species of mangrove epiphytic plants in almost all three study areas. However, Lahusan sampling station occurred numerous quantities ~~quantities~~ of Mangrove epiphytic plants species among 3 identified study areas including *Imprerata cycindrica* that cannot be found in Agdao and Baybay Stations.

Statistically, no significant difference was observed among study areas.

Keywords: Mangroves, Epiphytic Plants, Environment, Rehabilitation Areas

1. INTRODUCTION

Epiphyte is one of the subdivisions of the Raunkier system. The term epiphytic derives from the greek "epi" – (meaning 'upon') and "phyton" (meaning 'plant'). Epiphytic plants are sometimes called "air plants" because they do not root in soil. However, there are many aquatic species of algae that are epiphytes on other aquatic plants (seaweeds or aquatic angiosperms) (Everhart *et al*., 2009).

Most studies describing the flora of mangroves assess the diversity and community structure of trees but do not record the presence of epiphytes (Ashton and Macintosh, 2002). Although epiphytes are very abundant in dense mangroves, few studies have assessed the richness of epiphytic species or specifically of bromeliads (Robertson and Platt, 2001). To understand the distribution patterns of epiphytes and to preserve them, it is important to know not only the diversity, but also the plant host relationships (Magalhães and Lopes, 2015).

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Due to the lack of studies and information about epiphytic plants in mangrove forests, and considering that the diversity of these sensitive species can be a tool for mangrove conservation, this study aims to assess the diversity of epiphytic plants in a subtropical mangrove, evaluating their distribution and relationship with their host trees.

The study was conducted to determined and assessed the common mangrove-epiphytic plants in selected mangrove rehabilitation sites of Davao Occidental. This study aimed to: (1) Identify the common mangrove-epiphytic plants in the study areas; (2) Determine the density and abundance of mangrove-epiphytic plants in the study areas; (3) Identify the mangroves that serves as host for these epiphytes; and, (4) Measure the prevailing levels of the physico-chemical parameters in each sampling station such as water salinity, temperature and ~~water~~ water pH.

2. MATERIAL AND METHODS

2.1 Research Locale

The study was conducted in the identified mangrove rehabilitation sites of Davao Occidental, particularly Sitio Agdao of Brgy. Tubalan, Sitio Baybay of Brgy. Buhangin and Sitio Lahusan of Brgy. Fishing Village, Malita, Davao Occidental having a map coordinates a Latitu~~de: 6º 20' 59.99" N and Longitude: 125º 31' 59.99" E (www.google.com/map).~~
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Figure 1. The Map of Tubalan Cove, Malita, Davao Occidental showing the location of the study sites.(www.google.com/map).

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2.2 Research Design and Establishment of Sampling Sites

The study took place during a period of 2 months and was conducted in the coastline of Tubalan Cove in Malita, Davao Occidental where the selected mangrove rehabilitation sites is situated. Three stations were established in the conduct of the study. Station 1 in Sitio Agdao, Station 2 in Sitio Baybay and the Station 3 in Sitio Lahusan. The distance between the stations was approximately 5 km. This site was considered to be a slightly undisturbed mangrove forest dominated by species of mangrove trees. The area is regularly inundated by a normal high tide.

2.3 Data Gathering Procedure

The free exploration method was carried out first before the conduct of the study. Research samples were collected from an area of 300 m^2. These samples consisted of host plants and their associates (epiphytes) which are attached to the body of the hosts. The next process involved identification of the types of the host plants, the types of their associates, and the zones (parts of the host's body) on which the epiphytes grow. Each mangrove tree was surveyed in an appropriate way. In the case of epiphyte occurrence on higher sprays, it is necessary to climb the tree for the purpose of determining the epiphyte species.

The three parts (zones) of the host plants that are attached to the associated plants. The three zones consisted of zone 1 (lower part), zone 2 (middle part), and zone 3 (upper part), as illustrated in Figure 1.

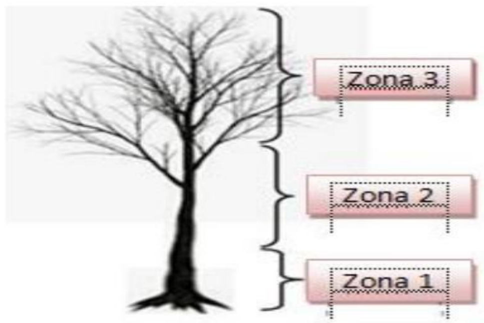

Figure 2. The Attached Zones (Usman *et al.*, 2019)

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2.4 Collection of Mangrove Epiphytes and Sampling Design

Epiphytes were collected randomly from the three stations. The samples ~~was~~were placed into ziploc polyethylene bags, which was labeled and transported back to the laboratory for proper identification and further processing.

The Transect Plot Method was employed in the conduct of the study. Three sampling areas were established in the study. In each area, there were three sampling plots established with 10m x10m in dimension. Each plot was regularly spaced from other plots at 10m. Each area has distance of 50m. Transects were plotted randomly in each sampling station.

2.5 Physico-Chemical Parameters

The Water salinity was determined using an Atago Refractometer. Water Sample from the sampling stations was placed in the slide cover for the convenient reading and recording of data.

Water temperature was determined using field thermometer. The apparatus was placed into the water for about 5 minutes to ensure proper reading and recording of data.

The pH scale measures the acidity and alkalinity of the water in the sampling stations. It was measured using the HANNA pH meter. About 50ml of sea water sample was collected for pH determination.

2.6 Statistical Tools and Analysis

The Analysis of variance was used to analyze the data using Statistical Packages for Social Sciences (SPSS). Other gathered data were analyzed using the following:

Species Density:~~.~~ All individual mangroves-epiphytic plants species that were found in each quadrat was counted per species and density and calculated with the formula (1) of Odum, 1971.

$$\text{Density} = \frac{No.of\ Individual\ of\ the\ same\ species}{Area\ (m2)} \quad (1)$$

Relative Abundance:~~.~~ Relative abundance of each mangroves-epiphytic plants species was estimated based on the formula (2) of Odum, 1971.

$$\text{Relative Abundance} = \frac{No.of\ Individual\ of\ a\ Species}{Total\ No.of\ Individual\ of\ all\ Species} X\ 100 \quad (2)$$

3. RESULTS AND DISCUSSION

3.1 Species of Mangrove-Epiphytic Plants

A total of 6 mangrove-epiphytic plants were identified and distributed among study areas namely [1]Rabbits Foot Fern (*Davalia denticulata*), [2]Oakleaf Fern (*Aglaomorpha quercifold*), [3]Bird's Nest Fern (*Asplenium midus*), [4]Java Fern (*Microsorum pteropus*), [5]Golden Anubias (*Anubias barteri*), and [6]Kugon Grass (*Imprerata cycindrica*) (Table 1). These were identified using available field guide and other references, and with consultation from technical experts.

The physico-chemical parameters of the study areas were also measured and noted for further analysis. Salinity shows slightly differences among study areas. Bagumbayan is slightly higher than Baybay and Agdao stations with general average of 34 ppt. Temperature ranges from ~~29^{0}C~~ 29°C to ~~30^{0}C~~ 30°C which makes an average of ~~30^{0}C~~30°C. Water pH also exhibits slightly difference ranges from 6.8 to 7.2. The reading of salinity and pH shows little significance in the growth of mangrove epiphytes since most of the species of epiphytes occur near the trunk area. Thus, the measurement of temperature shows tolerable limit for epiphytes.

Table 1. Identified Species in the Davao Occidental

Scientific Name	English Name
Davalia denticulate	Rabbit Foot Fern
Aglaomorpha quercifold	Oakleaf Fern
Asplenium midus	Bird's Nest Fern
Microsorum pteropus	Java Fern
Anubias bacteri	Golden Anubias
Imprerata cycindrica	Kugon Grass

It was also noticed that matured mangrove trees (approximately 2 meters height starting from the base) serves as common host for most mangrove-epiphytic plants. Probable reason is that these mangrove-epiphytic plants attain ~~favourable~~favorable light conditions enough to

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grow under the dense canopy of mangrove trees. These epiphytic-plants do not acquire water and minerals from their host (tree) (Yong ~~J.W~~ *et al.*, 2014). Further, it was also observed that most mangrove-epiphytic plants were found mostly in the middle zone (trunk) of the trees.

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3.2 Relative Abundance of Mangrove-Epiphytic Plants

3.2.1 Sitio Agdao

Results of the study shows that species of mangrove epiphytes in the study area composed of 3 to 5 species per station and exhibit 1 to 3 identified species per plot. The species of *Davalia denticulata* and *Aglaomorpha quercifold* were the most common species of mangrove-epiphytic plants in the Agdao Station with relative abundance higher than 50% followed by *Asplenium midus* in 33.33%.

Plate 1. *Davalia denticulata*

Plate 2. *Aglaomorpha quercifold*

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3.2.2 Sitio Baybay

Baybay station exhibited 3 mangrove-epiphytic plants species namely *Anubias barteri, Microsorum pteropus* and *Asplenium midus.* The most common species that can be found in all plots was *Anubias barteri* with relative abundance of 46%.

Plate 3. *Anubias barteri*

3.2.3 Sitio Lahusan

Among 3 stations, Sitio Lahusan has the most numbered of mangrove-epiphytic plants with 4 species identified (*Imprerata cycindrica, Aglaomorpha quercifold, Microsorum pteropus,* and *Davalia denticulata*). Of these mentioned species, *Aglaomorpha quercifold* still exhibited as the most abundant with 54%. In this station, the species of *Imprerata cycindrica* can be noticed, in which this cannot be found in other 2 stations.

Plate 4. *Aglaomorpha quercifold*

3.3 Density of Mangrove-Epiphytic Plants

The Agdao station shows much higher density of 0.01 to 0.04 species per $100m^2$ with *Davalia denticulata* and *Aglaomorpha quercifold* as the most popular species followed by *Asplenium midus*.

Sitio Baybay station's exhibited 0.02 to 0.03 species per $100m^2$ of density with *Microsorum pteropus*, *Anubias barteri* and *Asplenium midus* as the most commonly found mangrove-epiphytic plants.

The case of Lahusan station revealed species density with 0.01 to 0.02 species per $100m^2$. This station was observed the presence of *Imprerata cycindrica* that cannot be seen in other two stations.

Table 2. Density of Mangrove-Epiphytic Plants among stations

Station	Mangrove-Epiphytic Plants	Density ($100m^2$)
Sitio Agdao, Brgy. Tubalan, Malita, Davao Occidental	*Davalia denticulate* *Aglaomorpha quercifold* *Asplenium midus*	0.01 – 0.04
Sitio Baybay, Brgy. Tubalan, Malita, Davao Occidental	*Microsorum pteropus* *Anubias barteri* *Asplenium midus*	0.02-0.03
Sitio Lahusan, Brgy. Fishing Village, Malita, Davao Occidental	*Imprerata cycindrica* *Aglaomorpha quercifold* *Microsorum pteropus* *Davalia denticulata*	0.01-0.02

3.4 Identified Mangroves as Host for Epiphytic Plants

There are 2 mangrove species that serves as host of epiphytic plants namely *Sonneratia sp.* and *Avicennia sp*. (Table 3). Most of the identified mangrove-epiphytic plants attached to *Sonneratia* species. The species of *Anubias bacteri* and *Imprerata cycindrica* are thriving in the body of *Avicennia* species.

Table 3. Identified Mangroves as host of epiphytic plants.

Station	Mangrove-Epiphytic Plants	Mangroves
Sitio Agdao, Brgy. Tubalan, Malita, Davao Occidental	*Davalia denticulata* *Aglaomorpha quercifold* *Asplenium midus*	*Sonneratia sp.* *Sonneratia sp.* *Sonneratia sp.*
Sitio Baybay, Brgy. Tubalan, Malita, Davao Occidental	*Microsorum pteropus* *Anubias barteri* *Asplenium midus*	*Sonneratia sp.* *Avicennia sp.* *Sonneratia sp.*
Sitio Lahusan, Brgy. Fishing Village, Malita, Davao Occidental	*Imprerata cycindrica* *Aglaomorpha quercifold* *Microsorum pteropus* *Davalia denticulata*	*Avicennia sp.* *Sonneratia sp.* *Sonneratia sp.* *Sonneratia sp.*

These mangrove-epiphytic plants mostly can be found in the Zone 2 (Middle Part) of the mangrove trees.

Lahusan station with the most numbered mangrove-epiphytic plant species revealed that these plants can be found in the middle part (100%) of the tree. Sitio Agdao with 83.33%, and Sitio Baybay (66.66%), are observed to be found at the middle area of the mangrove trees. Others are located in zone 3 (upper part of the mangrove trees) (Table 4).

Table 4. Zonation for Mangrove-Epiphytic Plants.

Station	Total No. of Samples	Zone 1 (lower part near the roots)	Zone 2 (middle part of the body near trunk)	Zone 3 (upper part near twigs and leaves)
Sitio Agdao, Brgy. Tubalan, Malita, Davao Occidental	6	-	83.33%	16.66%
Sitio Baybay, Brgy. Tubalan, Malita, Davao Occidental	6	-	66.66%	33.33%
Sitio Lahusan, Brgy. Fishing Village, Malita, Davao Occidental	7	-	100%	-

3.5 Physico-Chemial Parameters

The physico-chemical parameters of the study areas were also measured and noted for further analysis (Table 5).

Salinity shows slightly differences among study areas. Bagumbayan is slightly higher than Baybay and Agdao stations with general average of 34 ppt.

Temperature ranges from ~~29⁰C~~ 29˚C to ~~30⁰C~~ 30˚C which makes an average of ~~30⁰C~~30˚C. Water pH also exhibits slightly difference ranges from 6.8 to 7.2.

Many epiphytes require high exposure and others and cannot endure either as much sun or the associated aridity. Water deficit and high light intensity might hinder the growth of epiphytes and any state of environmental change, photosynthesis and growth processes are likely be affected (Hietz and Briones, 2008).

Table 5. The physico-chemical parameter of the study area.

Station	Salinity	Temperature	pH
Sitio Agdao, Brgy. Tubalan, Malita, Davao Occidental	*33ppt*	30.0 degree celsius	6.8
Sitio Baybay, Brgy. Tubalan, Malita, Davao Occidental	*35ppt*	*29.9* degree celsius	7.2
Sitio Lahusan, Brgy. Fishing Village, Malita, Davao Occidental	*34ppt*	30.6 degree celsius	6.9

I continue to add a paragraph that summarizes the importance, usefulness and social relevance, contemporary of the study, specifically pointing out the Impact, Benefit and Social Projection, something like this (for example):

The marine environment, together with the atmosphere, plays a fundamental role in regulating the temperature on the planet (Medina Contreras et al. 2018; Casana and Olivares, 2020). Among other environmental factors, the temperature conditions in the different regions of the Earth allow the existence of a great diversity of climates and a high variety of ecosystems and organisms (Olivares and Hernández, 2019). Temperature is a particularly important factor in life processes and in the distribution of species, which are greatly affected when their habitats are altered. Although throughout its 4.6 billion years, the Earth has undergone great variations in its climates (Olivares et al. 2018; Olivares, 2018; Olivares and Zingaretti, 2019), global warming is currently occurring much faster than expected . The results of the numerous scientific investigations that have been carried out in recent years (Olivares and Zingaretti, 2018), allow us to say that the activities generated by man are largely responsible for this increase in temperature, especially carbon dioxide emissions. carbon resulting from the burning of fossil fuels, and other greenhouse gases into the atmosphere (Yang et al. 2011; Hayasaka et al. 2012).

In the mangroves, the different species do not appear randomly, but rather grow following a natural distribution depending on the distance from the sea. This zonation is mainly regulated by two environmental factors: salinity and the amount of water in the sediment (Olivares et al. 2017c; Olivares et al. 2017b). The species that are best adapted to growing near the sea are generally the red mangroves. At a greater distance from the sea live representatives of the other typical families of these forests. In the Caribbean, the black mangrove occurs in partially submerged swampy places; and the white mangrove prefers places higher above sea level, where the sediment is less waterlogged. Behind these true

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mangroves other accompanying species grow, generally trees and shrubs that cannot withstand the excessively severe conditions to which mangroves are subjected (Olivares et al. 2016).

Our study shows that epiphytic terrestrial plants are particularly abundant in mangroves, especially climbing species, as well as algae and marine invertebrates that grow attached to the submerged roots of mangroves, forming unique communities. In parts of Vietnam, Thailand, India and the Philippines (Yang et al. 2011; Hayasaka et al. 2012; Olivares et al. 2017a) these forests purify the waters that are transported by rivers and tributaries to the sea, immobilizing large amounts of sediments rich in organic matter that arrive by runoff from the land, and act as a filter for polluting substances (Olivares et al. 2021a; Olivares et al. 2021b).El medio marino, junto con la atmósfera, juega un papel fundamental en la regulación de la temperatura en el planeta, (Medina Contreras et al. 2018; Casana y Olivares, 2020). Entre otros factores ambientales, las condiciones de temperatura en las diferentes regiones de la Tierra permiten la existencia de una gran diversidad de climas y una elevada variedad de ecosistemas y organismos, (Olivares y Hernández, 2019). La temperatura es un factor especialmente importante en los procesos vitales y en la distribución de las especies, que se ven muy afectadas cuando sus hábitats son alterados. Aunque a lo largo de sus 4.600 millones de años, la Tierra ha sufrido grandes variaciones en sus climas, (Olivares et al. 2018; Olivares, 2018; Olivares and , B., Zingaretti, 2019), actualmente está ocurriendo un calentamiento global mucho más rápido de lo esperado. Los resultados de las numerosas investigaciones científicas que se han realizado en los últimos años, (Olivares y Zingaretti, 2018), permiten decir que las actividades generadas por el hombre son responsables en gran medida de este aumento en la temperatura, especialmente las emisiones de dióxido de carbono resultado de la quema de combustibles fósiles, y de otros gases de efecto invernadero hacia la atmósfera, (**Yang et al. 2011; Hayasaka et al. 2012).**

En los manglares las diferentes especies no aparecen al azar, sino que crecen siguiendo una distribución natural en función de la distancia al mar. Esta zonación está regulada principalmente por dos factores ambientales: la salinidad y la cantidad de agua en el sedimento (Olivares et al. 2017c; Olivares et al. 2017b). Las especies que están mejor adaptadas a crecer próximas al mar son generalmente los mangles rojos. A mayor distancia del mar habitan representantes de las otras familias típicas de estos bosques. En el Caribe, el mangle negro aparece en lugares pantanosos parcialmente sumergidos; y el mangle blanco prefiere lugares más elevados sobre el nivel del mar, donde el sedimento está menos anegado. Detrás de estos verdaderos mangles crecen otras especies acompañantes, generalmente árboles y arbustos que no soportan las condiciones excesivamente severas a las que están sometidos los mangles (Olivares et al. 2016).

Nuestro estudio refleja que son particularmente abundantes las plantas terrestres epífitas en los mangles, sobre todo especies trepadoras, así como las algas e invertebrados marinos que crecen fijos a las raíces sumergidas de los mangles, formando comunidades únicas. En zonas de Vietnam, Tailandia, India y Filipinas (**Yang et al. 2011; Hayasaka et al. 2012; Olivares et al. 2017a)** estos bosques purifican las aguas que son transportadas por los ríos y afluentes hacia el mar, inmovilizan grandes cantidades de sedimentos ricos en materia orgánica que llegan por escorrentía desde tierra, y actúan de filtro de sustancias contaminantes (Olivares et al. 2021a; Olivares et al. 2021b).

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4. CONCLUSION

There were 7 species were identified among study areas individually among of the three-study area. The study also shows that species of mangrove epiphytes in the study area composed of 3 to 5 species per station and exhibit 1 to 3 identified species per plot.

Individual species per station revealed that *Davalia denticulata* and *Aglaomorpha quercifold* were the most common species of mangrove epiphytic plants in almost all three study areas.

The results of the study and statistical analysis in regards with the relative abundance and relative density of Mangrove epiphytic plants species in the study areas exhibits no significant difference.

In all stations most epiphytic plants can be seen in the middle part of the mangrove the body near trunk.

Physico-chemical parameters shows having slightly differences among study areas.

REFERENCES

The bibliography cited does not correspond to the list of references. This is very serious and ~~delicate,~~delicate; the manuscript does not have the scientific support to discuss the results.

I suggest the authors update the bibliography, many of the citations are more than 15 years old, therefore I suggest adding recent references which address the issue in question. Suggested citations are for genuine scientific reasons that emphasize the current topic of study in context

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