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Composition and diversity of mangrove vascular flora in coastal area of Pangasihan, Gingoog City, Philippines

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Key words: Least concern, Mangrove associates, True mangroves, Very low diversity

Abstract

Mangrove ecosystem is a unique community of trees with substantial ecologic and economic significance. A non-destructive belt transect was utilized in determining the mangrove species composition and diversity. Different parts of the mangrove trees were photographed for proper identification, taxonomic classification and morphological description. These studies revealed that the mangrove vascular flora of Pangasihan mangrove forest consists of 11 species and were spread in three zones: landward, middle, and seaward. There were eight (8) true mangrove species, including *Avicennia marina, Ceriops decandra, Lumnitzera littorea, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Xylocarpus granatum,* and *Xylocarpus moluccensis* as well as three (3) mangrove associates, including *Hibiscus tiliaceus, Nypa fruticans* and *Pongamia pinnata* respectively. *R. apiculata* and *R. mucronata* were not observed in the landward zone while *N. fruticans* was observed both in middle and landward zones. *L. littorea, X. granatum* and *X. moluccensis* were not found in the seaward zone. All these taxa were taxonomically classified and morphologically described based on their growth form, trunk, leaf arrangement, fruit, leaves, and inflorescence type. The three zones exhibit very low diversity indexes (1.149, 1.691, and 1.609, respectively), which may be due to ongoing natural and anthropogenic processes. The middle and landward zones have a similarity rate of 34%, whereas the seaward zone has a similarity rate of only 12%. Given the study's low diversity and similarity indices, integrated conservation methods may be developed to increase biodiversity protection and conservation while also fulfilling the economic needs of vulnerable coastal communities.

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Introduction

Mangrove forest is a key feature of coastal ecosystems throughout the world's tropical and subtropical regions. It has previously been called "Coastal Woodland" and "Intertidal Forest" (Aksornkoae 1995). According to Joshi and Ghose (2014), a mangrove is a group of taxonomically diverse woody shrubs and trees that grow in the intertidal zone of tropical and subtropical coasts. Mangrove vegetations are typically dicotyledonous woody shrubs or trees found primarily in the tropics. They frequently form dense forests that dominate intertidal muddy shores, with patches that are almost entirely monospecific (Hogarth 2007). Mangroves play critical roles in coastal protection from typhoons and storm surges, erosion control, flood regulation, sediment trapping, nutrient recycling, wildlife habitat, and nursery development (Primavera *et al.*, 2008).

Despite its immense importance, mangrove ecosystems, like all other habitats, have been gradually disturbed and damaged by multifarious anthropogenic activities such as agricultural reclamation, aquaculture, and urbanization development, resulting in a slew of ecological issues (Freiss *et al.*, 2019; Guo *et al.*, 2017) that are of global concern (Freiss *et al.*, 2019; Guo *et al.*, 2017). The world's mangrove forest has been badly damaged in the last two decades of the twentieth century, with a 35 percent reduction in area (Giri *et al.*, 2011; Wang *et al.*, 2019). This significant loss of mangrove cover has become a major source of concern, particularly in Southeast Asia, where more than half of the world's mangroves thrive (Hamilton and Casey, 2016). Various government and non-government organizations have launched a variety of restoration and conservation initiatives to conserve the entire mangrove environment.

The examination of the composition, classification, and distribution of mangroves in the area is an indispensable step in the restoration and protection of the mangrove ecosystem (Wang *et al.*, 2019). Mangrove species taxonomy is crucial for detecting changes, assessing loss and regeneration, recognizing climate change indicators, and implementing government mitigation programs (Hati *et al.*, 2021). However, in a mangrove forest, this species-level classification is crucial for proper and long-term management.

Studies on mangroves in the Philippines are numerous, in Bukidnon for instance, Quimpang *et al.* (1987) described the mangrove forest structure in Pangasihan, Gingoog City with eight mangrove species. However, it has been long years since the group of Quimpang *et al.* in 1987 studied the composition and diversity of the mangrove forest of Pangasihan, Gingoog City and only on determining the phytochemical remediation potential of mangroves in the same location was the focus of the study of Toledo – Bruno *et al.* (2016). Thus, this study was carried out to add to the current knowledge and update about the Pangasihan Mangrove Forest on its recent composition and diversity. Specifically, it aimed to identify and classify mangrove vascular flora down to species level, determine their corresponding zonal distribution and conservation status, present the taxonomic classification and morphological characteristics of these identified mangroves, as well as determine their species diversity, and similarity index. As part of participatory resource management, the findings of this study could be used to design integrated conservation strategies that promote biodiversity protection and conservation while simultaneously addressing the economic needs of vulnerable coastal communities.

Materials and methods

Study Site

The research was carried out in April 2022 at Pangasihan Mangrove Forest Reserve in Gingoog City, Misamis Oriental, Philippines, with geographic coordinates of 8°51'8" N and 125°10'8" E (Fig. 1). From November to April, the climate is relatively dry, with the rest of the year being wet (DENR, 1997). Its soil is a hydrosol, which means that it is saturated with water for a long time and is often gray or greenish gray in color. The study site is located along the Macajalar Bay's coastline area, which is a combination of residential and industrial zones

dominated by manufacturing and processing plants, storage, and petroleum depots (Toledo- Bruno *et al.*, 2016). This 64-hectare mangrove reforestation project, which includes both natural and planted mangrove species, began in the 1990s. Moreover, the research location is a remnant of a previously impoverished and disturbed ecosystem, with the current vegetation being the result of restoration efforts.

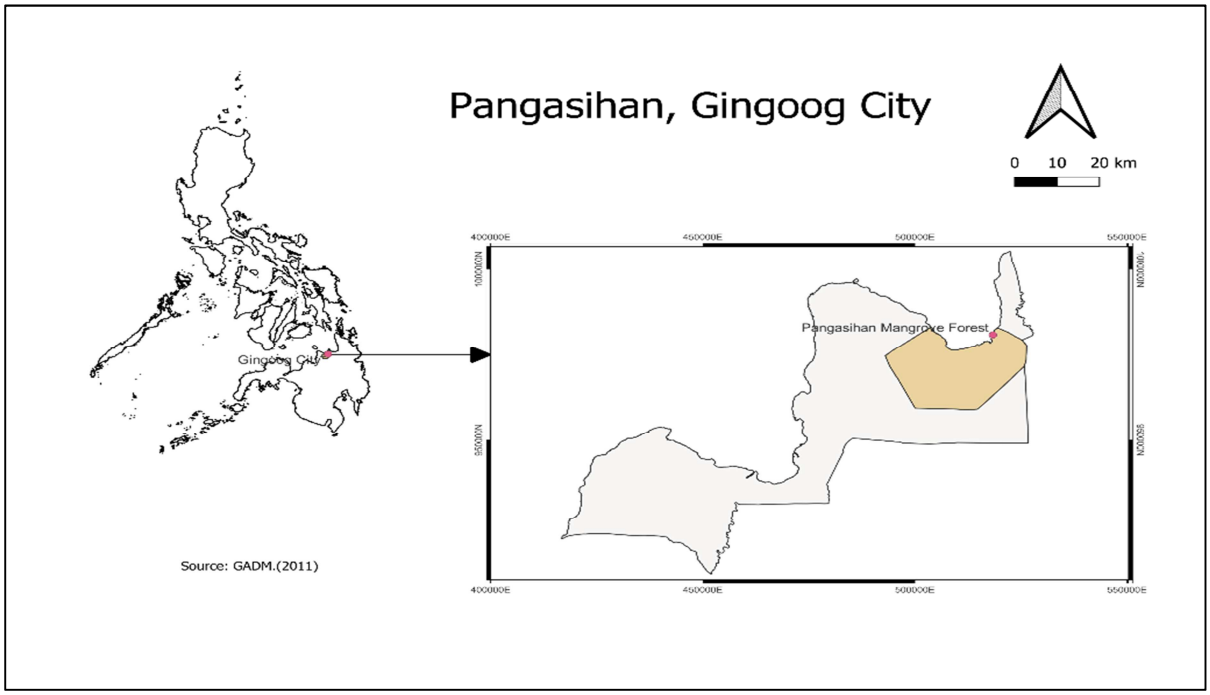

Fig. 1. The study site- Pangasihan Mangrove Forest.

Sampling Design

The species composition and diversity of the mangrove vascular flora in the reforested mangrove forest in the coastal area of Pangasihan, Gingoog City was determined using a non-destructive belt-transect method (BMB, 2017). With a compass, a 100-meter transect line parallel to the shoreline was established and served as the baseline. Three (3) 150-meter transects perpendicular to the beach were formed from the baseline, with a 50-meter spacing between them. For species diversity, five (5) 100 square meter quadrats were laid in each line transect.

Species Composition & Diversity Determination

Each plot was subjected to a complete inventory of mangrove species. The mangrove vascular flora was identified in situ with the use of a field guide to Philippine mangrove by Primavera *et al.* (2004). Photographs of each mangrove species' growth form, leaves, flowers, fruits, buttresses, and bark were used to describe morphological traits.

In each quadrant, individual mangrove species were recognized, quantified, and documented. A Paleontological Statistics (PAST) software application by Hammer, Harper, and Ryan (2001) was utilized to calculate mangrove diversity indices. As shown in Table 1, the Shannon – Weiner diversity values were classified using a scale established by Fernando (1998).

Table 1. Classification of Diversity Values (Fernando, 1998).

H' values	Relative Values
> 3.50	Very high
3.00 – 3.49	High
2.50 – 2.99	Moderate
2.00 – 2.49	Low
< 1.99	Very low

Data Analyses

Descriptive statistics and graphs were generated and plotted using the Microsoft Excel 2016 software application. A cluster analysis using Bray Curtis similarity index was also utilized to determine the similarity in the mangrove species composition between and among the established zones.

Results and discussion

Species Composition

Table 2 shows the species composition of mangroves and its associate species in barangay Pangasihan, Gingoog City, Philippines. There were eleven mangrove vascular species found in the study area. Out of 11, eight (8) are true mangrove species while three (3) species are considered mangrove associates. All mangrove species were distributed in the middle zone. *Rhizophora apiculata* and *Rhizophora mucronata* were not observed in the landward zone while *Lumnitzera littorea, Xylocarpus granatum* and *Xylocarpus moluccensis* were not also found in seaward zone respectively. For mangrove associates, Nypa fruticans species were distributed in both landward and middleward zones. As to conservation status, all, except for *C. decandra* with near threatened conservation status, are in least concern condition yet decreasing in population.

Table 2. Species composition of mangrove vascular flora, their zonal distribution and conservation status.

Mangrove Category	Scientific Name	Local Name	Conservation Status	Zonal Distribution		
				Landward zone	Middleward Zone	Seaward zone
True mangrove species	*Avicennia marina*	Api-api	LC	/	/	/
	Ceriops decandra	Lapis - lapis	NT	/	/	/
	Lumnitzera littorea	Tabao	LC	/	/	x
	Rhizophora apiculata	Bakhaw lalaki	LC	x	/	/
	Rhizophora mucronata	bakhaw babae	LC	x	/	/
	Sonneratia alba	Pagatpat	LC	/	/	/
	Xylocarpus granatum	Tabigi	LC	/	/	x
	Xylocarpus moluccensis	Piag-ao	LC	/	/	x
Mangrove associate species	*Hibiscus tiliaceus*	Malabago	LC	/	x	x
	Nypa fruticans	Nipa	LC	/	/	x
	Pongamia pinnata	Bani	LC	/	x	x

Legend: LC- Least Concern; / - present; x - absent

Only eight mangrove species were found in the same research area in the study of Quimpang *et al.* (1987). The following species were discovered during their research: *Sonneratia caseolaris, Avicennia marina, Rhizophora apiculata, Ceriops decandria, Avicennia officinalis, Rhizophora mucronata, Xylocarpus granatum* and *Aegiceras corniculatum*. However, there were 11 different mangrove species noted in this study as listed in Table 2. The study undertaken by Quimpang *et al.* (1987) did not include three of the true mangrove species namely, *Lumnitzera littorea, Sonneretia alba* and *Xylocarpus moluccensis* and three also of the mangrove- associated species such as *Nypa fruticans, Hibiscus tiliaceus* and *Pongamia pinnata*. This area is thought to have been reforested or rehabilitated, which could account for these important observations (Toledo-Bruno *et al.*, 2016).

The distribution of mangrove vascular species varies according to zones. According to Mullet *et al.* (2014), the abundance of mangrove species is related to the soil properties in which they are found. The soil in which these mangrove trees flourished was critical to their growth, maturity, and reproduction. *L. littorea, X. granatum* and *X. moluccensis* thrive compatibly to gravel dominated soil while those mangrove species in the landward zone grow well in gravel, very coarse sand and medium -sandy type of soil.

Furthermore, as a unique ecosystem with a diverse tree community, the mangrove forest has a distinct zonation pattern. The kind of substrate and the species' resistance to salt and flooding are the most critical elements that influence its zonation pattern (BMB, 2017). Compared to terrestrial forestlands, its diversity is substantially lower. For example, a single species can dominate a specific zone, as in the case of the Rhizophoraceae family, which dominates the seaward zone.

The conservation status of most of the mangrove species does not mean that their environment is not being influenced by natural and anthropogenic disturbances.

In fact, the majority of the least concerned status is in decreasing population. This implies that continued human caused activities may lead to adverse effects to the community structure of the Pangasihan mangrove forest. As observed, there were garbage like plastic bags, broken glasses, strips of rubber and fishing nets tangled on the prop roots of mangroves as the study area was in close proximity to human settlements.

Taxonomic Classification and Morphological Characteristics of Mangrove Vascular Flora

True Mangrove Species

Taxonomic Classification

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Lamiales

Family: Avicenniaceae

Genus: *Avicennia*

Species: *Avicennia marina* (Fig. 2)

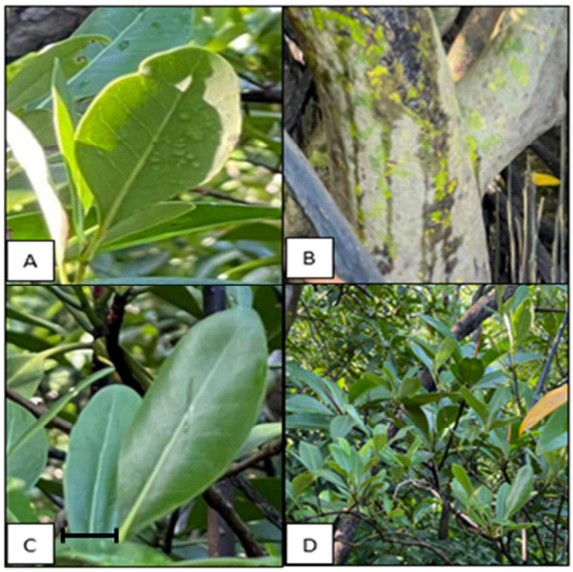

Fig. 2. Morphological characteristics of *Avicennia marina*: A. Leaf (Abaxial surface), B. Trunk, C. Leaf (Adaxial surface), D. Inflorescence.

Plant Morphology

Avicennia marina or Api-Api is a grey mangrove with a height of 3 to 10 meters as a shrub or tree, or up to 14 meters (46 feet) in tropical areas. A twisted arrangement of many branches makes up the habit. It has light grey bark that is made up of thin, stiff, brittle flakes.

The leaves are thick and 5 to 8 cm (2.0 to 3.1 in) long, with a brilliant, glossy green upper surface and a silvery-white, or grey, lower surface with very fine tangled hairs.

Taxonomic Classification

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Malpighiales

Family: Acanthaceae/Rhizophoraceae

Genus: *Ceriops*

Species: *Ceriops decandra* (Fig. 3)

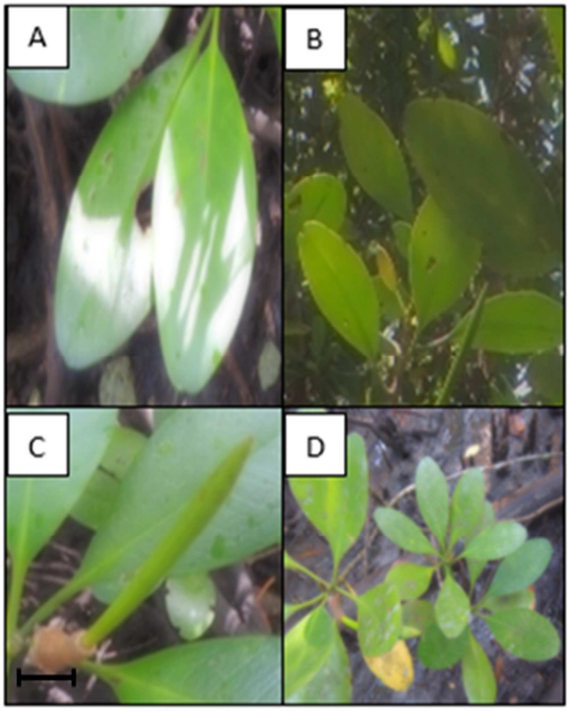

Fig. 3. Morphological characteristics of *Ceriops decandra*: A. Leaf (Adaxial surface), B. Leaf (Abaxial surface), C. Fruit, D. Inflorescence

Plant Morphology

Ceriops decandra or Lapis-Lapis is a straight, columnar tree with a narrow crown that typically grows up to 15 meters tall, while examples as large as 35 meters have been documented. The bole is typically 15 to 20 centimeters in diameter; however, some can exceed 35 centimeters; it contains short basal buttresses that appear to form from the fusion of clusters of stilt roots. Wet areas produce little pneumatophores (breathing roots).

Taxonomic Classification

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Myrtales

Family: Combretaceae

Genus: *Lumnitzera*

Species: *Lumnitzera littorea* (Fig. 4)

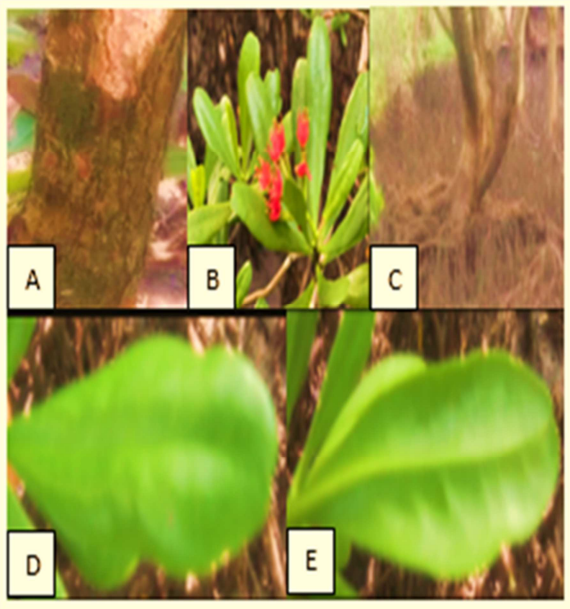

Fig. 4. Morphological characteristics of *Lumnitzera littorea*: A. Trunk, B. Inflorescence, C. Roots D. Leaf adaxial surface, E. Leaf abaxial surface.

Plant Morphology

Short shrub to tree up to 25m tall with a trunk 50-65cm in diameter. Bark dark and deeply fissured. Some may have slender knee roots. Leaves spatula shaped with oval ends (2-8cm), thick and fleshy, arranged in a spiral. There is a small gland at the leaf tip that resembles leaf nodules and is believed to contain nitrogen fixing bacteria. Flowers small (2-3cm) in dense bunches, bright red with five tiny petals (the stamens are much longer than the petals).

The flowers are fragrant and produce lots of nectar. According to Tomlinson, this species appears to be predominantly pollinated by birds, especially sunbirds and honey eaters, with bees and wasps as additional visitors. The small fruits are ribbed, corky and float, and dispersed by water. Each fruit contains one seed.

Taxonomic Classification

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Malpighiales

Family: Rhizophoraceae

Genus: Rhizophora

Species: Rhizophora apiculata (Fig. 5)

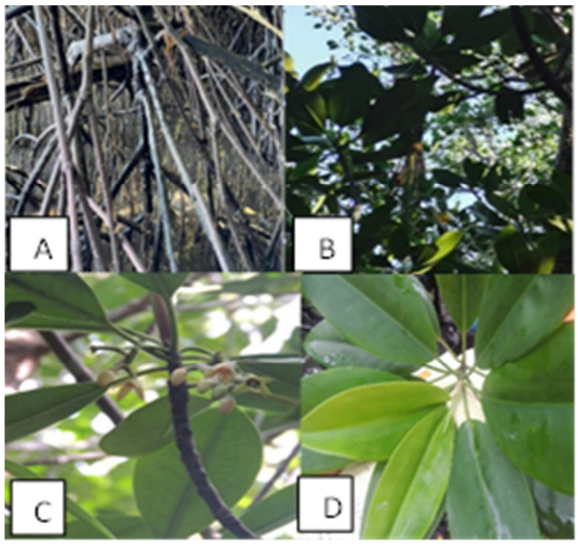

Fig. 5. Morphological characteristics of Rhizophora *apiculata*: A. Roots, B. Fruit, *C.* Inflorescence, D. Leaf arrangement.

Plant Morphology

Rhizophora Apiculata (*R. apiculata*) belongs to the Plantae kingdom under the Rhizophoraceae family. The size of *R. apiculata* is dependent on geographical factors (climate and soil specifically); on average a mature *R. apiculata* reaches between 5 – 8 metres in height however has the potential to reach up to 30 – 40 metres. The dimension of the trunk depends on the age of the plant however its maturity can be as big as 50cm in diameter alongside being typically a dark grey colour. The trunk size is highly dependent on the nutrients within the soil as they will be the underlying factor for growth with water abundance being high.

Taxonomic Classification

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Rhizophorales

Family: Rhizophoraceae

Genus: *Rhizophora*

Species: *Rhizophora mucronata* (Fig. 6)

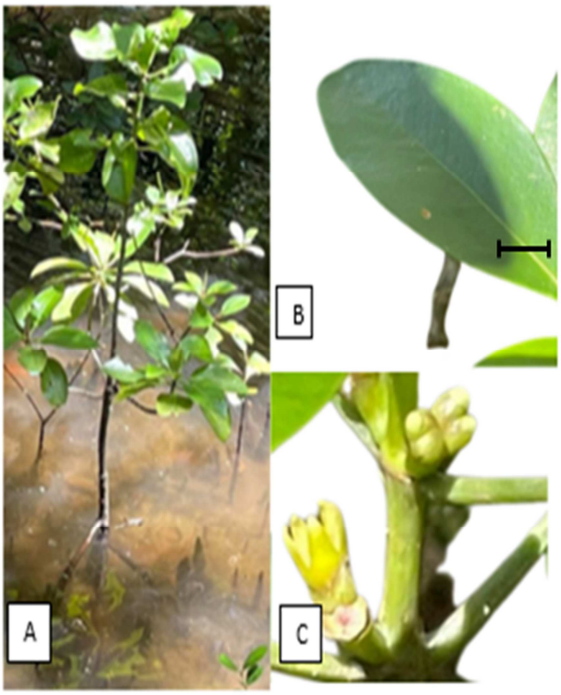

Fig. 6. Morphological characteristics of *Rhizophora mucronata:* A. Growth form (young tree), B. Leaf arrangement (Adaxial surface), C. Inflorescence bud.

Plant Morphology

The Red Mangrove, *Rhizophora mucronata,* is an evergreen tree with aerial and stilt roots that grows to a height of 10 to 15 meters. Its bark varies in hue from pale brown to dark brown. It has oppositely oriented oval-shaped, petioled, leathery dark-green elliptical leaves that are typically 0.12 meters long and 0.06 meters wide.

Their tips are extended, but they frequently break off. The pale undersides of the leaves have corky warts. On the twigs, the blooms appear in axillary clusters. Each flower has a stiff cream calyx with four sepals and four hairy white petals.

Taxonomic Classification

Phylum: Tracheophyta
Class: Magnoliopsida
Order: Myrtales
Family: Lythraceae
Genus: *Sonneratia*
Species: *Sonneratia alba* (Fig. 7)

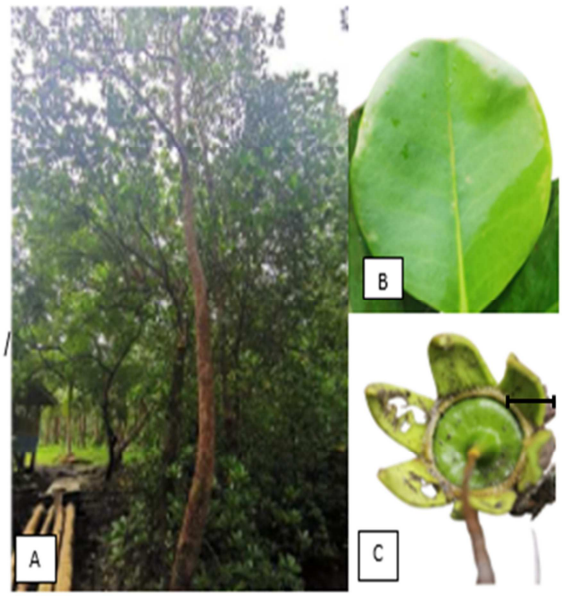

Fig. 7. Morphological characteristics of *Sonneratia alba:* A. Growth form, B. Leaf arrangement (Abaxial leaf surface), C. Fruit.

Plant Morphology

Sonneratia alba, often known as Mangrove Apple, is a tree with dense and many pneumatophores surrounding it. S. Alba is a 3-15 meters tall evergreen tree with a trunk diameter of 0.4 meters, brown bark that is vertically and horizontally fissured and covered by a thin waxy covering.

The leaves are simple, opposite, somewhat thick, pale green in color, elliptic to ovate or obovate in shape, 0.12 meters long and 0.08 meters wide, with rounded and mucronate (terminating in a sharp point, extension of the midrib) apex, on a short petiole. The fruits are green globular-depressed berries surrounded by persistent sepals with a diameter of 0.05 meters, containing a population of up to 200 little white seeds that are flat, falcate, and floating, allowing them to disperse.

Taxonomic Classification

Phylum: Tracheophyta
Class: Magnoliopsida
Order: Sapindales
Family: Meliaceae
Genus: *Xylocarpus*
Species: *Xylocaprus granatum* (Fig. 8)

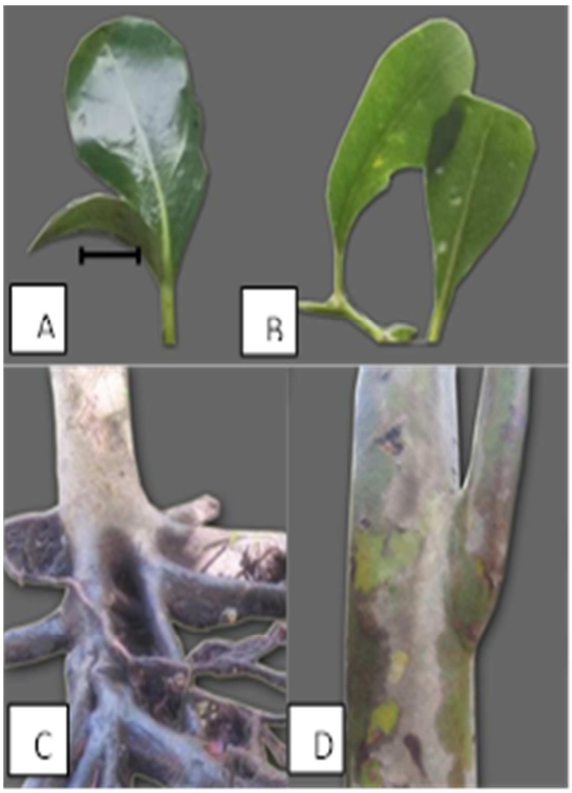

Fig. 8. Morphological characteristics of *Xylocarpus granatum*: A. Leaf (Abaxial surface), B. Leaf (Adaxial surface), C. Trunk, D. Roots.

Plant morphology

Xylocarpus granatum is also known as the cannonball mangrove, or cedar mangrove, or puzzlenut tree. This type of mangrove could reach a height of 12m. The bark can be characterized as smooth but flaky. Its roots are above the ground and extend long distances to either side.

The fruit is a woody capsule. The ripe fruits split into four parts from the apex which contains up to 20 seeds each. It has petioled and alternately oriented pinnate leaves. The leaflets with short petioles are positioned oppositely and oval in form which usually measures 3.5-12 by 2-6cm.

Taxonomic Classification

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Sapindales

Family: Meliaceae

Genus: Xylocarpus

Species: *Xylocarpus. Moluccensis* (Fig. 9)

Fig. 9. Morphological characteristics of *Xylocarpus moluccensis*: (A) Leaf arrangement (Abaxial), B. Trunk.

Plant Morphology

The name of *Xylocarpus moluccensis* was taken from the Moluccas archipelago, now Maluku Islands. This tree is in the family Meliaceae. It grows up to 30 meters with a trunk diameter of up to 70 cm. The bark, particularly the cork layer appears to be rough and dark brown in color. It has pointed and conical-shaped pneumatophores at the base portion of the trunk. The leaves are spirally arranged and usually have 2-3 leaflets. These leaflets are usually paired and are oval shaped. The leaflets usually measure 4-12 by 2-6.5 cm.

Mangrove Associates

Taxonomic Classification

Phylum: Spermatophyta

Class: Dicotyledonae

Order: Malvales

Family: Malvaceae

Genus: *Hibiscus*

Species: *Hibiscus tiliaceus* (Fig. 10)

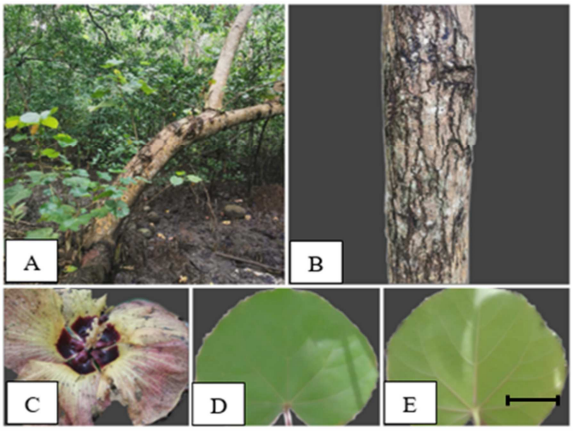

Fig. 10. Morphological characteristics of *Hibiscus tiliaceus*: A. Growth form, B. Trunk, C. Inflorescence, D. Leaf adaxial surface, E. Leaf abaxial surface.

Plant Morphology

Hibiscus tiliaceus is a tree with glabrous or sparsely to densely stellate-pubescent stem, becoming brown-grey with prominent lenticels. Its leaves are ovate to orbicular, unlobed or rarely 3-lobed. Its apex is acuminate or rounded with a cordate base and an entire to obscurely dentate leaf margin. Its leaf adaxial surface appears darker green than its abaxial surface. Its petiole is sparse to densely stellate-tomentose while its stipules are lanceolate to narrowly ovate, caducous. The species' inflorescence in terminal 3-6 flowered cymes. The pedicel is articulated at base and densely stellate-pubescent, angular in the upper part. The calyx has lanceolate lobes fused in the lower part each with prominent median vein on which a gland occurs, acute, and densely tomentose.

Taxonomic Classification

Phylum: Spermatophyta
Class: Monocotyledonae
Order: Arecales
Family: Arecaceae
Genus: *Nypa*
Species: *Nypa fruticans* (Fig. 11)

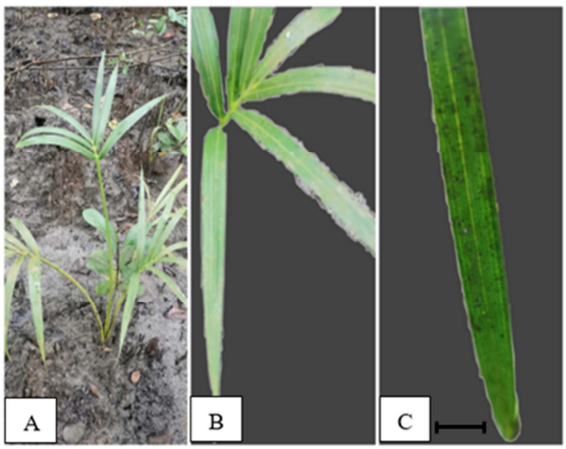

Fig. 11. Morphological characteristics of *Nypa fruticans:* A. Growth Form, B. Leaf adaxial surface, C. Leaf abaxial surface.

Plant Morphology

Nypa fruticans is a medium to large-sized, clumping stemless palm with rhizomes, with large, erect leaf fronds above ground. Its leaf fronds possess stout leaf stalks that are bulbous at the base. Its foliage is alternate, stalked with large, erect leaves, slightly recurved, pinnate with lanceolate leaflets arranged regularly on each side of the rachis. Leaflets are, pointed, shiny green on the upper surface and somewhat powdery on the lower surface. The midrib of each leaflet is marked with regular linear brown scales.

Taxonomic Classification

Phylum: Magnoliophyta
Class: Magnoliopsida
Order: Fabales
Family: Fabaceae
Genus: *Pongamia*
Species: *Pongamia pinnata* (Fig. 12)

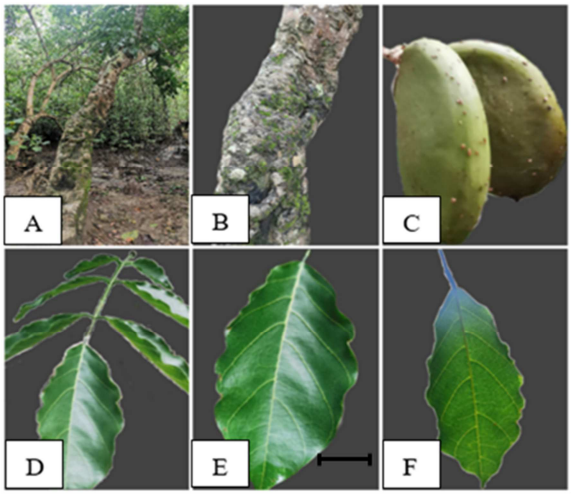

Fig. 12. Morphological characteristics of *Pongamia pinnata:* A. Growth form, B. Trunk, C. Fruit, D. Leaf Arrangement, E. Leaf adaxial surface, F. Leaf abaxial surface.

Plant Morphology

Pongamia pinnata is a medium-sized evergreen or briefly deciduous, glabrous shrub or tree with straight or crooked trunk and broad crown of spreading or drooping branches. Its leaves are alternate, imparipinnate with long slender leafstalk. Its leaf's adaxial surface is glossy dark green while its adaxial surface is dull green with prominent veins beneath when mature. Leaflets are paired except at end, short-stalked, ovate elliptical or oblong. It has obtuse-acuminate apex, rounded to cuneate at base, not toothed at the edges and slightly thickened.

The species' fruits are born in quantities, smooth, oblique oblong to ellipsoid, flattened but slightly swollen, slightly curved with short, curved point, brown, thick-walled, thick leathery to subwoody, hard, indehiscent.

Species Diversity of Mangrove Vascular Flora

The mangrove forest ecosystem of Pangasihan, Gingoog City has six (6) genera of mangroves namely: *Avicennia, Ceriops, Lumnitzera, Rhizophora, Sonneratia* and *Xylocarpus*. The transect established in the study was divided into three (3) parts, seaward zone, middleward zone, and landward zone. The Shannon-Weiner diversity indices showed that the middleward zone has higher species diversity with an H value of 1.691, followed by the landward zone with an H value of 1.609, and the least was the seaward zone with an H value of 1.149. However, the diversity indices of the three (3) zones show very low mangrove species diversity in the area based on the scale developed by Fernando (1998). This could be attributed to mangrove's unique stand formation compared to other tropical forest ecosystems (Osing, 2019).

Table 3. Diversity indices of mangrove vascular flora in coastal area of Pangasihan, Gingoog City, Philippines.

Diversity Indices	Zones		
	Landward	Middleward	Seaward
Species richness	9	9	5
Evenness_e^H/S	0.5554	0.6027	0.6313
Dominance	0.2819	0.2282	0.3741
Shannon_H	1.609	1.691	1.149

Among the three zones, the highest species diversity value is in the middle zone. This finding could be due to its low exposure to both man-made and natural disturbances. In contrast, the low species diversity of the seaward zone could be characterized by its high exposure to disturbances. This is supported by the claim of Nor Syahira *et al.* (2018) that undisturbed mangrove forest ecosystems show higher diversity indices as compared to disturbed areas. While the relatively low diversity index of the landward zone as compared to the seaward zone could be due to its inherent proximity to the land-based community that allows integration of species from both adjoining communities (Patindol and Casas, 2019).

Similarity Index in the Zonal Distribution of the Mangrove Vascular Flora

Cluster analysis was utilized to find similar groups within the sampling zones identified during the research period. The Bray-curtis similarity index was used to produce the dendrogram, which revealed the similarity index of the three zones: the landward, middle and seaward zones (Fig. 15). The Bray–Curtis dissimilarity ranges from 0 to 1, with 0 indicating that the two sites have the same mangrove species composition (i.e., they share all species) and 1 indicating that they do not.

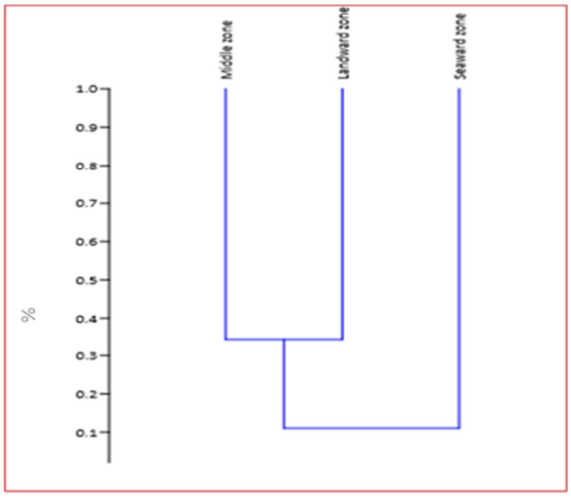

Fig. 15. Similarity index in the zonal distribution of mangrove vascular flora in Pangasihan, Gingoog City.

It can be gleaned in Fig. 13 that the middle and landward zones have 34% similarity rate for mangrove species, while the seaward zone has 12% similarity rate which is closer to zero indicating sameness of mangrove species composition in the zone. This finding is consistent with the mangrove species' zonal distribution (Table 2) in the research area, where Rhizophora species dominate the seaward zone. According to Urrego *et al.* (2014), the presence or absence of vegetation types can be linked to natural and anthropogenic disturbances, as well as the geomorphology and hydrology of the site. Environmental variables such as light intensity, substrate composition and tidal inundation may have

contributed a significant impact on the structural composition of the Pangasihan forest although these variables were not empirically measured and may be considered for future studies.

Conclusion and recommendation

The observed 11 species of mangrove vascular flora identified in the Pangasihan mangrove forest were distributed in three zones: landward, middle, and seaward. There were eight (8) true mangrove species, including *Avicennia marina, Ceriops decandra, Lumnitzera littorea, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Xylocarpus granatum* and *Xylocarpus moluccensis,* as well as three (3) mangrove associates, including *Hibiscus tiliaceus, Nypa fruticans* and *Pongania pinnata* respectively. *R. apiculata* and *R. mucronata* were not observed in the landward zone while *N. fruticans* was observed both in the middle and landward zones. *L. littorea, X. granatum* and *X. moluccensis* were not found in the seaward zone.

All these species were taxonomically classified and morphologically described based on growth form, trunk, leaf arrangement, fruit, leaves, and type, and they were all of least concern conservation status. The very low diversity scores in all three zones can be linked to continuous natural and anthropogenic activity. The middle and landward zones have a 34 percent similarity rate, whereas the seaward zone has a 12 percent.

Given the low diversity and similarity indices found in this study, integrated conservation methods may be developed to enhance biodiversity protection and conservation while still satisfying the financial needs of vulnerable coastal communities. It is necessary to broaden the scope of preservation beyond simple planting, which requires: 1) integrated and ecosystem-based approaches; 2) participation of local people in planning, monitoring, and implementation; 3) clarity in the roles and responsibilities of different stakeholders; and 4) selection of plantation species based on ecological considerations. Hence, effective and sustainable mangrove preservation depends on active cooperation between residents, government officials, non-governmental organizations, funding organizations, and research institutes.

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