

## Species diversity and composition of mangroves in Tacloban City, Philippines

Teofanes A. Patindol<sup>1\*</sup> and Eulito V. Casas, Jr.<sup>2</sup>

### ABSTRACT

This study reflects the present status of Tacloban City mangrove vegetation and would be useful for mangrove restoration program. Surveys of mangrove forests in Tacloban City were conducted from October to November 2017 in 12 selected sites. Quadrat method was used to assess the species composition and stand structure of the canopy layer, representing seaward, middle and landward zones. The mangrove forests in Tacloban City contain 23 mangrove species belonging to 12 families and 15 genera. Rhizophoraceae and Acanthaceae are the most dominating families. As per IUCN report, among the 23 species, 4 were recognized as threatened. These include the Endangered *Camptostemon philippinensis*, the Vulnerable *Avicennia rumpiana* and the Near Threatened *Aegiceras floridum* and *Ceriops decandra*. *Rhizophora apiculata* is the most abundant species, followed by *Sonneratia alba*. Other abundant species are *Avicennia officinalis*, *Avicennia marina* and *Rhizophora mucronata*. The least abundant are *Bruguiera gymnorhiza*, *Camptostemon philippinensis* and *Xylocarpus granatum*. The canopy layer is composed of small-sized trees with an average tree density of 1,678 per ha and stem density of 3,133 per ha. The average height and diameter are 6.15m and 8.95cm, respectively. Mangrove diversity is generally low. Shannon index of diversity value ranges from 0.762 to 1.132, with an average value of 0.914. Understory is characterized by few species of regenerants, low density and low species diversity.

Keywords: mangroves, composition, species diversity, Tacloban City, Philippines

### INTRODUCTION

Mangroves are virtually confined to the tropics. They often form a dense intertidal forest that dominates muddy intertidal shores, frequently consisting of

<sup>1</sup>Department of Forest Science, College of Forestry and Environmental Science, Visayas State University, Baybay City, Leyte

<sup>2</sup>Division of Natural Sciences and Mathematics, University of the Philippines Visayas-Tacloban College, Tacloban City

\*Corresponding Author. Address: Department of Forest Science, College of Forestry and Environmental Science, Visayas State University, Baybay City, Leyte; Email: tapatindol@yahoo.com

virtually monospecific patches or bands (Hogarth 2015). Mangroves form unique ecological environments which provide an appropriate habitat for a rich assemblage of species. Aside from its ecological function, mangroves representatives such as *Rhizophora* spp., function as a physical barrier against sea surges using their large aerial root systems and props.

Mangroves have been recognized as a primary line of defense against coastal perturbations such as typhoons, tsunamis, and storm surges. The catastrophic impacts and extent of calamity of Typhoon Yolanda in the Philippines during November 2013, has triggered the need for rehabilitation and restoration of mangrove ecosystems in Tacloban City. Such effort must be geared towards the preservation of the ecological functions of mangrove ecosystems and improvement of the economic condition of the people living in coastal areas, through sustainable livelihood activities.

A proper quantitative information of the existing mangrove resources is necessary before undertaking a well-planned restoration program, which is lacking in Tacloban City, Philippines. Thus, prior to formulating the restoration program, a scientific survey is necessary to understand the existing contribution of the mangrove resources in Tacloban City. Assessment of the current status of mangrove resources (comprising the remnant mangrove forests) within Tacloban City can provide baseline data in order to measure the intended project benefits, specifically on biodiversity, as a result of the intervention in the future. In a broader perspective, the result of this study would serve as valuable input in formulating integrated conservation strategies that would promote biodiversity conservation and at the same time, address the economic needs of the vulnerable coastal communities in the context of participatory resource management.

## METHODOLOGY

The study was conducted in 12 selected mangrove forests within the different barangays in Tacloban City (Figure 1). The study sites are located in Tagpuro, Old Kawayan, San Isidro, Cabalawan, Bagacay, Anibong and San Jose.

Quadrat method (BMB 2017) was used to assess the mangrove forests in Tacloban City. Three quadrats measuring 10mx10m were laid out to represent the seaward zone, middle zone and landward zone in each of the sample sites. Sampling areas were strategically located to represent different sites of species composition along the mangrove coastal areas. All trees inside the 10mx10m quadrat, with diameter of equal or greater than 5cm, were identified and measured for diameter at breast height (DBH) and total height (TH). While small trees (<5cm DBH) and other non-tree flora (shrubs, vines, herbs, ferns) were identified and counted inside the 2mx2m quadrat.

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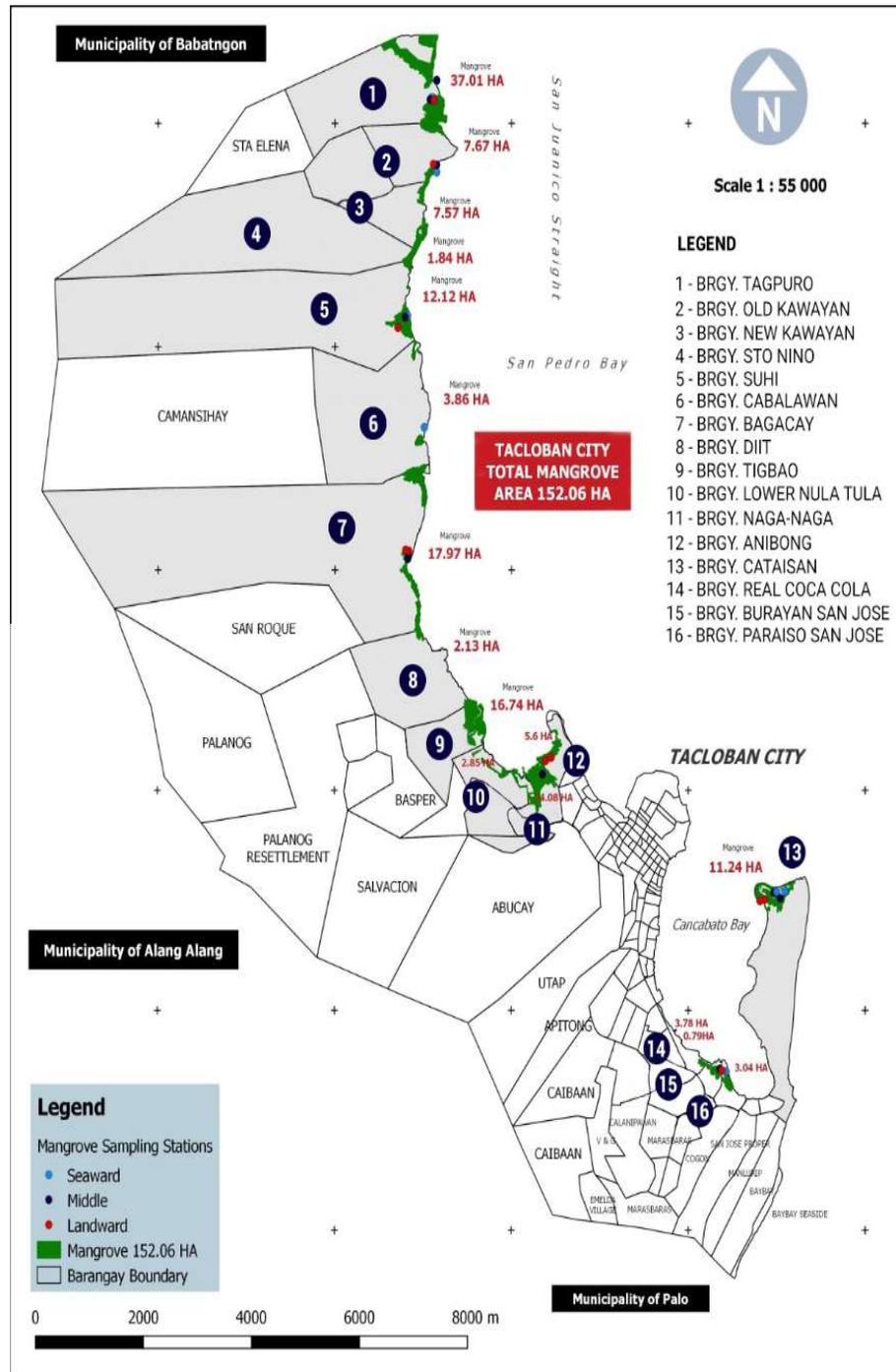


Figure 1. Map of Tacloban City showing the different mangrove sampling stations. Data Source: Mangrove Mark Lama 2017, based on the Google Satellite Image. Sampling stations - Dr. T. Patindol.

Vegetation structure was described using tree density, stem density, tree diameter, DBH (cm) and tree height (m). Identification of species was done according to the description of Primavera (2009). Species diversity was determined using the Shannon index of diversity, with the formula for the computation based on Magurran (1988):

$$H' = - \sum \left[ \frac{n1}{n} \right] \left[ \ln \frac{n1}{n} \right]$$

where:  $H'$  = Shannon index of diversity  
 $n1$  = frequency of occurrence of species within the 125 plots  
 $n$  = the total number of occurrences of all species in all plots.

Numerical abundance and relative abundance for every species encountered both in the canopy layer and understory layer were determined. Numerical abundance was determined by simply counting the number of individuals of a species that appeared in all plots while relative abundance was determined by counting the number of plots that a species was encountered, regardless of the number of individuals.

## RESULTS AND DISCUSSION

### **Species Composition**

A total of 23 mangrove species were recorded in Tacloban City (Table 1). These species comprise about 70% of the total number of mangrove species recorded in the country (Garcia et al 2014). These species belong to 12 families and 15 genera. Rhizophoraceae is the most represented family with seven species, followed by Acanthaceae with four species. Species belonging to Rhizophoraceae include *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, *Ceriops decandra* and *Ceriops tagal*, while those of Acanthaceae includes *Avicennia marina*, *Avicennia officinalis* and *Avicennia rumpiana*.

The conservation status of the species appeared online in the IUCN Red List Category of Species. Of the 23 species recognized by IUCN, 1 is considered Endangered (E), 1 Vulnerable (VU) and 2 Near Threatened (NT). The Endangered species is *Camptostemon philippinensis* (Plate 1), while the Vulnerable species is *Avicennia rumpiana* (Plate 2). The Near Threatened species are *Aegiceras floridum* (Plate 3) and *Ceriops decandra* (Plate 4).

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Table 1. Mangrove species composition in Tacloban City, c. 2017

Family	Scientific Name	Common Name	Conservation Status
Acanthaceae	<i>Acanthus ebracteatus</i>	Lagiwliw	Least Concern
Acanthaceae	<i>Avicennia marina</i>	Bungalon	Least Concern
Acanthaceae	<i>Avicennia officinalis</i>	Api-api	Least Concern
Acanthaceae	<i>Avicennia rumpiana</i>	Miapi	Vulnerable
Arecaceae	<i>Nypa fruticans</i>	Nipa	Least Concern
Bombacaceae	<i>Camptostemon philippinensis</i>	Gapas-gapas	Endangered
Combretaceae	<i>Lumnitzera littorea</i>	Tabao	Least Concern
Euphorbiaceae	<i>Excoecaria agallocha</i>	Lipata	Least Concern
Meliaceae	<i>Xylocarpus granatum</i>	Tabigi	Least Concern
Meliaceae	<i>Xylocarpus moluccensis</i>	Piag-ao	Least Concern
Myrsinaceae	<i>Aegiceras corniculatum</i>	Saging-saging	Least Concern
Myrsinaceae	<i>Aegiceras floridum</i>	Tinduk-tindukan	Near Threatened
Myrtaceae	<i>Osbornia octodonta</i>	Tawalis	Least Concern
Pteridaceae	<i>Acrostichum speciosum</i>	Palaypay	Least Concern
Rhizophoraceae	<i>Bruguiera gymnorrhiza</i>	Busain	Least Concern
Rhizophoraceae	<i>Bruguiera cylindrica</i>	Pototan	Least Concern
Rhizophoraceae	<i>Ceriops decandra</i>	Malatangal	Near Threatened
Rhizophoraceae	<i>Ceriops tagal</i>	Tangal	Least Concern
Rhizophoraceae	<i>Rhizophora apiculata</i>	Bakauan lalaki	Least Concern
Rhizophoraceae	<i>Rhizophora mucronata</i>	Bakauan babae	Least Concern
Rhizophoraceae	<i>Rhizophora stylosa</i>	Bakauan bato	Least Concern
Sonneratiaceae	<i>Sonneratia alba</i>	Pagatpat	Least Concern
Sterculiaceae	<i>Heritiera littoralis</i>	Dungon late	Least Concern

### Abundance and Distribution

Overall total of 604 individuals of true mangroves were recorded from the 12 sapling sites (Table 2). *R. apiculata* (Plate 1) is the most abundant, having the highest number of individuals (222). *S. alba* is the second most abundant (Plate 2) with 143 individuals. The next most abundant are *A. officinalis*, *A. marina* and *R. mucronata*, while the least abundant are *B. gymnorrhiza*, *C. philippinensis* and *X. granatum*.

Two species (*R. apiculata* & *S. alba*) were observed to occur in all sampling sites. One species (*Avicennia officinalis*) appeared in seven sites, while another two species (*A. marina* & *R. mucronata*) occurred in six sites. Six species (*R. stylosa*, *X. moluccensis*, *A. floridum*, *B. gymnorrhiza*, *C. philippinensis* & *X. granatum*) occurred in a single site only. The result shows that the abundant species are also widely distributed species, while the less abundant species are those with limited distribution.

Table 2. Distribution and abundance of mangroves in Tacloban City, c. 2017

Scientific Name	Common Name	Abundance	Relative Frequency
<i>Rhizophora apiculata</i>	Bakauan lalaki	222	12
<i>Sonneratia alba</i>	Pagatpat	143	12
<i>Avicennia officinalis</i>	Api-api	48	7
<i>Avicennia marina</i>	Bungalon	39	6
<i>Rhizophora mucronata</i>	Bakauan babae	29	6
<i>Excoecaria agallocha</i>	Lipata	25	5
<i>Avicennia rumpiana</i>	Miapi	32	4
<i>Lumnitzera littorea</i>	Tabao	9	4
<i>Ceriops decandra</i>	Malatangal	9	4
<i>Osbornia octodonta</i>	Tawalis	5	3
<i>Heritiera littoralis</i>	Dungon late	5	3
<i>Aegiceras corniculatum</i>	Saging-saging	12	2
<i>Bruguiera cylindrica</i>	Pototan	7	2
<i>Ceriops tagal</i>	Tangal	5	2
<i>Rhizophora stylosa</i>	Bakauan bato	7	1
<i>Xylocarpus moluccensis</i>	Piag-ao	2	1
<i>Aegiceras floridum</i>	Tinduk-tindukan	2	1
<i>Bruguiera gymnorrhiza</i>	Busain	1	1
<i>Campostemon philippinensis</i>	Gapas-gapas	1	1
<i>Xylocarpus granatum</i>	Tabigi	1	1

Abundance=Numerical Abundance in 12 sampling sites

Relative frequency=Occurrence in 12 sampling sites

*R. apiculata* is generally widespread throughout the mangrove swamp, although it prefers soft mud normally flooded by tidal water. *R. mucronata* usually occurs along tidal streams and, river banks with soils rich in humus. *A. marina* is abundant in exposed areas facing the sea and has high tolerance to hyper saline conditions. *A. officinalis* sporadically occurs on river banks on firm mud and rare on the seaward zone. *S. alba* usually occurs in newly formed sandy mudflats in estuaries and tidal streams and can tolerate salinity (Melana & Gonzales 2000). It is important to note that these five widespread and most abundant species have enough potential for mangrove reforestation in Tacloban City. *R. apiculata* can be planted in all zones within the mangrove swamp. *A. marina* and *S. alba* are best recommended for seaward zone, while *R. mucronata* and *A. officinalis* can be planted along river banks or on zones away from the sea.

Among the five species of limited distribution, and at the same time very low abundance, are the Endangered *C. philippinensis* and the Near Threatened *A. floridum* (according to IUCN Redlist Categories) have been traced out in this part of the region. This indicates that restoration and rehabilitation of mangrove ecosystems in Tacloban City is a mere responsibility for the protection

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of these species, along with the other threatened species like the Vulnerable *A. rumpiana* and Near Threatened *C. decandra*.

### Stand Structure and Species Diversity

The stand structure of mangroves in Tacloban City is shown in Table 3. The canopy layer was composed of small-sized trees with an average tree density of 1,678 per ha and stem density of 3,133 per ha. Highest tree density was observed in the seaward zone while the lowest was observed in the landward zone. The same trend was observed for the stem density. The average total height was 6.15m and average diameter was 8.95cm. In terms of tree height and tree diameter, the seaward zone had the lowest values while the landward zone had the largest values.

Table 3. Mangrove vegetation structure in Tacloban City, c. 2017

	Seaward	Middle	Landward	Mean
Tree Density per Hectare	2,025	1,525	1,483	1,678
Stem Density per Hectare	3,850	3,050	2,500	3,133
Tree Diameter DBH (cm)	8.01	8.11	10.72	8.95
Tree Height (m)	4.77	5.93	7.75	6.15
Index of Diversity (H')	0.84	0.76	1.13	0.91
Number of Species per plot	3.17	3.08	4.33	3.53

Generally, the seaward zone is characterized by high tree and stem densities but composed of small-diameter and short trees. Such condition must have resulted from the long history of cutting of mangroves so that what remain today are mostly multi-stem *Avicennia* and *Sonneratia* that must have regenerated after heavy cutting in the past years. The landward zones, especially the less accessible sites from the inland side, are generally protected for years as evidenced by the low-density stand which is composed mainly of big-diameter trees.

Mangrove diversity is generally low. Shannon index of diversity value ranges from 0.762 to 1.132 with an average value of 0.914, which is considered very low based on the classification postulated by Fernando et al (BMB 2017). Low diversity is attributed to the few number of species and the uneven distribution of individuals among the different species. Number of individuals per species is extremely high for the most dominant species. Number of species is low, with an average of 3.53 per plot. Highest value for both species diversity and number of species were observed in the landward zone, followed by the seaward zone. Lowest values were observed in the middle layer. Higher values in the landward zone could be attributed to its inherent proximity to the land-based community that allows integration of species from both adjoining communities. On the other hand, the higher value in the seaward zone could be attributed to the disturbance regime from both man-made and natural forces.

### Frequency and Abundance of Mangrove Regenerants

A total of 17 species of mangroves were encountered in the understory as regenerants (Table 4). The most frequently occurring and most abundant species in

the understory layer was *R. apiculata*, followed by *A. corniculatum*. Only three other species showed higher occurrence and abundance. These were *A. marina*, *R. mucronata*, and *C. decandra*.

Table 4. Distribution and abundance of mangrove regenerants in Tacloban City, c. 2017

Scientific Name	Common Name	Abundance	Relative Frequency
<i>Rhizophora apiculata</i>	Bakauan lalaki	223	9
<i>Aegiceras corniculatum</i>	Saging-saging	192	7
<i>Avicennia marina</i>	Bungalon	112	4
<i>Rhizophora mucronata</i>	Bakauan babae	45	4
<i>Ceriops decandra</i>	Malatangal	31	4
<i>Avicennia officinalis</i>	Api-api	40	3
<i>Bruguiera cylindrical</i>	Pototan	24	3
<i>Ceriops tagal</i>	Tangal	31	2
<i>Aegiceras floridum</i>	Tinduk-tindukan	28	2
<i>Osbornia octodonta</i>	Tawalis	8	2
<i>Heritiera littoralis</i>	Dungon late	5	2
<i>Lumnitzera littorea</i>	Tabao	5	2
<i>Avicennia rumpiana</i>	Miapi	9	1
<i>Rhizophora stylosa</i>	Bakauan bato	9	1
<i>Sonneratia alba</i>	Pagatpat	6	1
<i>Xylocarpus moluccensis</i>	Piag-ao	3	1
<i>Bruguiera gymnorrhiza</i>	Busain	3	1

Abundance=Numerical Abundance in 12 sampling sites

Relative frequency=Occurrence in 12 sampling sites

Understory is characterized by few species of regenerants, low density and low species diversity (Table 5). The average number of species per plot was 2.39 with a density of 7.22 individuals per sq. meter. The index of diversity was very low at 0.595. Highest values were observed in the landward zone while lowest values were observed in the seaward zone.

Table 5. Species diversity and density of mangrove regenerants in Tacloban City, c. 2017

	Seaward	Middle	Landward	Mean
Number of species per plot	1.83	1.83	3.50	2.39
Density per m <sup>2</sup>	5.23	5.44	10.98	7.22
Index of Diversity (H')	0.458	0.468	0.860	0.595

The results showed that the understory contains very few regenerants. Thus, rehabilitation of the mangrove stands in Tacloban City would take time if only rely on the natural regeneration process. There is, therefore, a need to initiate a more comprehensive program on mangrove rehabilitation to consider speeding up the natural regeneration process and at the same time, address both anthropogenic and natural disturbances.

## CONCLUSION

Based on the result of the study, the following conclusions are drawn:

1. The mangrove forests in Tacloban City contain a total of 23 mangrove species belonging to 12 families and 15 genera. Rhizophoraceae and Acanthaceae were the most represented families.
2. Of the 23 species, four were recognized by IUCN as threatened. These include the Endangered *Camptostemon philippinensis*, the Vulnerable *Avicennia rumpiana* and the Near Threatened *Aegiceras floridum* and *Ceriops decandra*.
3. *Rhizophora apiculata* was the most predominant species followed by *Sonneratia alba*. Other abundant species were *Avicennia officinalis*, *Avicennia marina* and *Rhizophora mucronata*. The least abundant were *Bruguiera gymnorhiza*, *Camptostemon philippinensis* and *Xylocarpus granatum*
4. The canopy layer was composed of small-sized trees with an average tree density of 1,678 and stem density of 3,133 per ha. The average total height was 6.15m and average diameter was 8.95cm.
5. Mangrove species diversity was generally low. Shannon index of diversity value ranges from 0.762 to 1.132 with an average value of 0.914.
6. Understory was characterized by few species of regenerants, low density and low species diversity.

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