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Floral diversity of a mangrove forest in Cotabato City, Philippines

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Abstract

A variety of essential goods and services can be provided by mangrove ecosystem which has significant contribution to wellbeing and security of coastal communities. Hence, conservation measures to sustain this valuable resource should be of primary concern to all stakeholders. The present study was carried out to evaluate the floral diversity of a mangrove forest in Cotabato City. There were three sampling sites purposely selected for this study. A total of 12 sampling plots with a size of 5m x 40m each were established in the three study sites. Diversity indices were computed in each site. A total of 12 mangrove species representing 8 genus and 8 families were identified during the study period viz., *Rhizophora apiculata, Rhizophora mucronata, Ceriops tagal, Lumnitzera racemose, Avicennia alba, Avicennia officinalis, Aegiceras corniculatum, Aegiceras floridum, Sonneratia alba, Sonneratia caseolaris, Xylocarpus granatum* and *Osbornia octodonta*. Most of these species are classified as least concern. Species richness ranged from 0.77 to 1.04 while diversity index is generally low ranging from 1.19 to 2.02.

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Introduction

The currently known, described and accepted number of plant species is ca 374,000 of which 308,312 are vascular plants (Christenhusz and Byng, 2016). About 5% of world's flora is found in the Philippines comprising of at least 13,500 species (PAWB, 1998). The country ranked 23rd in terms of number of species in the world and 7th in the Asian region (Ordoñez, 2006).

In mangroves Thirty-five percent of the total 18 million ha of global mangrove forests are found in the Southeast Asian countries (Honculada-Primavera, 2000).

The Philippines holds at least 50 % mangrove species of the world's approximately 65 species (Garcia *et al.,* 2014) covering 303,387 ha in which 658 ha is located in Cotabato (Philippine Forestry Statistic, 2017).

Studies showed a decreasing trend of mangrove total area in the Philippines (Long *et al.,* 2013; Fortes and Salmo III, 2017) largely due to fish pond development (Primavera, 1995) and excessive cutting for firewood and construction materials (Eusebio *et al.,* 1986) Which resulted to deterioration of seagrass and coral reef ecosystems (Melana *et al.,* 2005).

Mangroves are highly valuable ecosystems, providing an array of essential goods and services which contribute significantly to the livelihoods, well-being and security of coastal communities (Duke *et al.,* 2014) in addition, Mangroves contribute significantly to the global carbon cycle and produce large amounts of litter in the form of falling leaves, branches and other debris. Besides, mangrove habitats contribute to complex food webs and energy transfers (Kathiresan, 2012). Thus, effective management of mangrove forest to ensure its sustainability is necessary. Floristic inventory and diversity assessments are necessary to understand the present diversity status and conservation of forest biodiversity (Jayakumar *et al.,* (2011), Hence this study is conducted.

Materials and methods

Study site

The study was undertaken in a mangrove forest in Cotabato City which is located along the coastal line of three barangays namely; Kalanganan Mother, Kalanganan I and Kalanganan II. This thin strip of mangrove forest area lies within the coordinates of 7°11'30" to 7°15'25"north latitude and 123°59'30" to 124°13'00" east latitude in which a recent study stated that about 38 hectares of the total area remain as mangrove forest. The area extends towards southwest traversing Timako Hill, the highest elevated portion of Cotabato City, Philippines (LGU Cotabato City, 2002).

Sample plots were purposively selected to include bakawan-dominated portions of the study site. A total of 12 sampling plots with a size of 5m x 40m each were established in the three study sites distributed as follows: Kalanganan I- 2 plots, Kalanganan II- 8 plots, and Kalanganan Mother- 2 plots.

Diversity indices

All mangrove species found within each sample plot were identified according to their common, scientific and family names. Each species was assessed based on its conservation status using the International Union for the Conservation of Nature (IUCN) system. Species diversity was analyzed and computed using the following formula:

$$\text{Density} = \frac{\text{Number of individuals}}{\text{Area sampled}}$$

$$\text{Relative density} = \frac{\text{Density for a species}}{\text{Total density for all species}} \times 100$$

$$\text{Frequency} = \frac{\text{Number of plots in which species occurs}}{\text{Total number of plots sampled}}$$

$$\text{Relative frequency} = \frac{\text{Frequency value for a species}}{\text{Total of frequency values for all species}} \times 100$$

$$\text{Importance value (IV)} = \frac{\text{RF+ RDE}}{2}$$

where:

IV = importance value of species

RF = relative frequency of species

RDE = relative density of species

Species richness

$D = \frac{S}{\sqrt{N}}$

where:

D= species richness

s= number of species

N= number of indivduals

Shannon-Wiener index (*H'*):

$$H' = -\sum_{1}^{N} p_i (ln\ p_i)$$

where:

p_i= proportion of total sample belonging to *ith* species

ln= log based n

The diversity values for Shannon-Weiner were classified based on the scale developed by Fernando (1998) as presented below (Table 1):

Simpson's index of dominance

$D_s = \sum (n1(n1-1)/ N (N-1)$

where:

D_s =dominance index

n= number of individuals per species

N= sum of all individuals

Shannon-Weiner's measure of evenness (*J)*:

$J = H'/H_{max}$

where:

H'= Shannon-Weiner index of diversity

$H_{max} = ln S$

S= number of species

Sorensen's coefficient of similarity

$CC = \frac{2C}{S1+S2}$

where:

C = number of species the two communities have in common

S_1 = total number of species found in community 1

S2= total number of species found in community 2

Results and discussion

Species Composition, Conservation Status and Importance Value

A total of 12 mangrove species representing eight genus and eight families were identified during the study period. This is comparable to the study of Gevaña and Pampolina (2009) which indicated a total of nine mangrove species, six genera and five families in a mangrove stand in Verde Passage, San Juan Batangas, Philippines. Most of the species collected in this study are classified as least concern except *Aegiceras floridum* which has been categorized as "near threatened" by IUCN (Table 2).

Table 1. Categories of diversity values.

Relative values	H' values
Very high	>3.5000
High	3.00-3.49
Moderate	2.50-2.99
Low	2.00-2.49
Very low	<1.99

Out of a total of 532 individuals recorded in the three sampling sites, the most numerous are the *Ceriops tagal* and *Aegiceras corniculatum* species. The species with the highest importance value include *Sonneratia caseolaris*, *Avicennia officinales*, and *Ceriops tagal* for Kalanganan I, Kalanganan Mother and Kalanganan II, respectively. On the other hand, *Sonneratia alba*, *Xylocarpus granatum*, and *Avicennia alba* had the least importance value, respectively.

Kalanganan II had the most number of species with 11 while Kalanganan I and Kalanganan Mother had only four each (Table 3).

The former sampling site also had the highest in terms of density of species which is 3,038 trees ha^{-1}. This is expected as trees recorded in Kalanganan I had relatively small diameters as compared to those in the two other sites.

The greater the number of trees in a stand, the small their diameters would become. This observation seemingly follows the concept on "self-thinning" among trees.

It is a term that refers to the progressive density-dependent mortality that occurs within an even-age group of plants as the individuals grow in size (Westoby, 1984).

Table 2. Mangrove flora recorded in the study area.

Local name	Common name	Scientific name	Family name	Conservation status*
Bakauanbabae	Bakauanbabae	*Rhizophora mucronata* Lank.	Rhizophoraceae	LC
Bakauanlalaki	Bakauanlalaki	*Rhizophora apiculata* Blume.	Rhizophoraceae	LC
Kulasi	Kulasi	*Lumnitzera racemosa* Willd.	Combretaceae	LC
Kulasiitim	Api-apiputih	*Avicennia alba* (Blume) Bakh	Avicenniaceae	LC
Kulasiputi	Api-api	*Avicennia officinalis* L.	Acanthaceae	LC
Malasaging	Saging-saging	*Aegiceras corniculatum* (L.) Blanco	Myrsinaceae	LC
Tungog	Tangal	*Ceriops tagal* (Perr.) C.B.Rob.	Rhizophoraceae	LC
Tinduk-tindukan	Tinduk-tindukan	*Aegiceras floridum* Roem. &Schult	Myrsinaceae	NT
Pagatpat	Pagatpat	*Sonneratia alba* J. Smith	Lythraceae	LC
Pararan	Pedada	*Sonneratia caseolaris* (L.) Engl.	Lythraceae	LC
Tawigi	Tabigi	*Xylocarpus granatum* Koem.	Meliaceae	LC
Kapaga-paga	Taualis	*Osbornia octodonta* F. Muel	Myrtaceae	LC

* LC – Least Concern NT – Near Threatened.

Species richness

Species richness is a measure of the number of species found in a sample. As shown in Fig. 1, Kalanganan II has the highest species richness (D= 1.04) while Kalanganan I had the least (D=0.77). This is expected as the former had the most number of species (11) and individuals (486) as compared with the other two sampling sites. The low species richness in Kalanganan I could be attributed to human disturbances occurring in the site due to its accessibility. Aside from crab hunting and shell picking, timber cutting for charcoal production and mangrove conversion to fishponds are prevalent in this sampling site. The result agrees with Abantao *et al* (2015) that the presence of disturbances may have considerable effects to the mangrove species.

Table 3. Total number of individuals of each mangrove species per sampling area.

Species number	Family name	Scientific name	Sampling site			Total number of individuals
			K1	KM	K2	
1	Rhizophoraceae	*Rhizophora apiculata* Blume.	0	0	57	57
2		*Rhizophora mucronata* Lamk.	0	0	36	36
3		*Ceriopstagal* (Perr.) C.B. Rob.	0	0	175	175
4	Avicenniaceae	*Avicennia alba K. Hin (*Blume) Bakh	13	3	5	21
5	Acanthaceae	*Avicennia officinales* L.	0	8	6	14
6	Combretaceae	*Lumitzera racemosa* Willd.	4	6	40	50
7	Lythraceae	*Sonneratia alba* J. Smith	2	0	0	2
8		*Sonneratia caseolaris* (L.) Engl.	8	0	9	17
9	Meliaceae	*Xylocarpus granatum* Koem.	0	2	14	16
10	Myrsinaceae	*Aegicera scorniculatum* (L.) Blanco	0	0	126	126
11		*Aegiceras floridum* Roem & Schults	0	0	2	2
12	Myrtaceae	*Osbornia octodonta* F. Muell.	0	0	16	16
Grand total			27	19	486	532

Shannon-Wiener diversity index

Among the sampling sites Kalanganan II is the most diverse (*H'*= 2.02) (Fig. 1). This value is a little higher than that of a *Rhizopora* stand in San Juan, Batangas in which diversity index (H') ranged only from 0.8165 to 1.4185 (Gevaña and Pampolina, 2009). However, the computed diversity values in this present study which ranged from 1.19 to 2.02 are found to be low when compared to the Shannon-Weiner diversity scale developed by Fernando (1998). The study of Lunar and Laguardia (2013) involving diversity of mangroves in two conservation sites of Calatagan, Batangas also indicated low diversity values (*H'*= 1.05 and 1.21). The study of Valenzuela *et al.* (2013) also yielded a low diversity value of 1.78 for a mangrove forest in Badian, Cebu Island, Philippines.

Table 4. Indices of community similarity (%) among sampling sites in the study area.

Sampling sites	Kalanganan I	Kalanganan II	Kalanganan Mother
Kalanganan I	-	40	50
Kalanganan II	40	-	53.3
Kalanganan Mother	50	53.3	-

An ecosystem with H' value greater than 2 has been regarded as having medium to high diversity in terms of species (Barbour *et al.,* 1999). On the other hand, Mohan and Padmanaban (2013) stated that a value near 0 would indicate that every species in the sample is the same whilea value near 4.6 would indicate that the number of individuals is evenly distributed between all the species.

Species evenness

In terms of species evenness, Kalanganan Mother is considered to be the most evenly distributed among the three sites (*J*=0.91) as indicated in Fig. 1.

This means that the area has an even number of individuals per species as compared to the other areas. On the other hand, Kalanganan II is the least even (*J*=0.84). This implies that although it is the most diverse in terms of species, the number of individuals in this area is not evenly distributed implying that some species have more individuals observed. In fact, one species (*Ceriopstagal*) in the site comprises about 36% of the total observed individuals in the area as compared to the rest of the species which range only from 0.4% - 26% of the total individuals observed in the area.

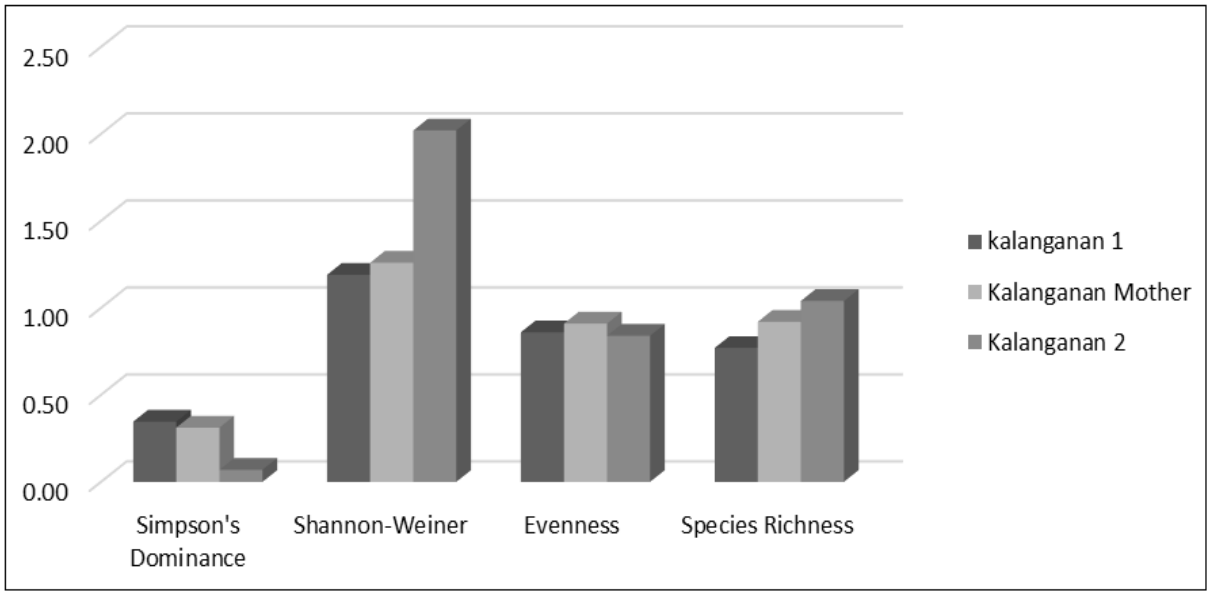

Fig. 1. Comparison of diversity indices among sampling sites.

Simpson's dominance index

Kalanganan I has the highest dominance value (Ds= 0.35) while Kalanganan II had the lowest (Ds= 0.07) (Fig. 1). This indicates that Kalanganan II has the least probability of having two random individuals belonging to the same species as compared to the other two sites. Simpson's dominance index gives more weight to common and dominant species, this index is not affected by a few rare species with few representatives (Sharma *et al.,* 2009; Partosa and Delos Reyes, 2013).

The generally low dominance index value is an indication that there is no single species that is dominant among the said sites. It is also noted that the dominance and diversity indices are inversely proportional with each other. This observation is consistent in this study.

Percent similarity

Meanwhile, Sorensen's coefficient of community similarity among sampling sites in the study area was determined (Table 4).

This is most useful when the major interest is the presence or absence of species. When two stands are identical, that is index of similarity (S) is 100, the stands are 100% alike, while when they have no species in common, S would be zero. In the case of this study, Kalanganan II and Kalanganan Mother were most alike (53.3%) while Kalanganan I and Kalanganan II were least alike (40%).

Conclusion

A total of 12 mangrove species representing 8 genera under 8 families were identified in the study area *viz*., *Rhizophoraapiculata, Rhizophoramucronata, Ceriopstagal, Lumnitzeraracemose, Avicennia alba, Avicennia officinalis, Aegicerascorniculatum, Aegicerasfloridum, Sonneratia alba, Sonneratiacaseolaris, Xylocarpusgranatum*and *Osborniaoctodonta*. These species are mostly categorized as "least concern" by the IUCN. Species richness ranged from 0.77 to 1.04 while diversity index is generally low.

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