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Francis Nuestro Baleta
Institute of Fisheries, Isabela State University, San Fabian, Echague 3309, Isabela, Philippines

Ronald Santiago Casalamitao
Institute of Fisheries, Isabela State University, San Fabian, Echague 3309, Isabela, Philippines

Correspondence
Francis Nuestro Baleta
Institute of Fisheries, Isabela State University, San Fabian, Echague 3309, Isabela, Philippines

Species composition, diversity and abundance of mangroves along the estuarine Area of Maligaya, Palanan, Isabela, Philippines

Francis Nuestro Baleta, Ronald Santiago Casalamitao, Jr.

Abstract
Present study was conducted to document the species composition, abundance and diversity of mangroves found along the river side of Maligaya, Palanan, Isabela. Seven stations were established along the study area using the line transect method.
Species composition data revealed 14 species of mangroves identified from 6 families namely: Rhizophoraceae, Acanthaceae, Avicenniaceae, Sterculiaceae, Palmae and Melianceaeare were present during the study period. The most abundant species across the seven stations are *Nypa fruticans*, *Bruguiera sexangula, Avicennia lanata* and *Xylocarpus granatum*. Highest diversity was recorded at 0.099 individuals per 500 m^2 for *Nypa fruticans*.
Station 5 revealed the highest species richness and repetition index while Station 7 recorded the highest diversity as indicated by various indices of diversity. Results revealed that the mangrove forest of Maligaya, Palanan, Isabela has a diverse species of mangroves.

Keywords: Mangrove, Species Composition, Abundance, Diversity and Distribution, Palanan, Isabela

1. Introduction
Mangrove forest can be found generally along tidal mudflats and along shallow water coastal areas extending inland along Brackish water Rivers, streams and their tributaries. It is commonly found between the lowest and the highest tide level. These plants had evolved over time by developing special adaptive features allowing them to better survive in a harsh and stressful environment [1].
The mangrove ecosystem dominated by mangrove trees are the primary producer, interacting with associated aquatic fauna, social and physical factors of the coastal environment. The mangrove ecosystem provides different ecological services such as soil erosion control and trapping of sediments, thus it may serve as protection in the coastal area. For aquaculture services, it may also serve as nursery grounds for fish, prawns and crabs. Mangroves are also a good source of wood and timber for housing materials firewood and charcoal.
Several studies on mangrove identification and diversity had been conducted from the different parts of the world. However, there is a dearth of information on species composition and diversity studies of mangroves from the different parts of the Philippines. The four coastal municipalities of the Province of Isabela consist of some shoreline where several species of mangroves thrives. The estuarine area of barangay Maligaya, Palanan, Isabela is a home to several species of mangroves, however, no study had been conducted documenting the species composition, diversity, and abundance of mangroves along this area. Hence, this study was conducted.
Knowing the mangrove species would help a lot in the ecological assessment of the study area and also on the site-species matching for the purpose of reforestation and protection of the forest. This way survival rate could be increase, unlike in the past effort where success was very limited due to the wrong choice of site/species [2].

2. Materials and Methods
2.1 Study area. The study was conducted along the mangrove forest Maligaya, (coordinates 17º06'55.64" N, 122^{0}27'48''E) Palanan, Isabela. The mangrove area is mainly characterized by muddy substratum composed of different plants and trees. Some parts of the mangroves

areas were mainly dominated by *bakauan* and *nipa*. The study was conducted along the mangrove forest of Maligaya, Palanan, Isabela, facing the Palanan River. There were seven stations established in the area. Each station has a total area of 500 m, divided into five quadrats measuring 100 m^2. The distance per station is 90 m. Transect lines were used to determine each station using rope. Seven stations were established since the mangrove forest is quite vast to cover the seaward and landward zonations of mangroves.

2.2 Identification and enumeration of samples. Field guide in the identification of mangrove species along the mangrove forest Maligaya, Palanan, Isabela was used during the study period. The research team also took pictures of roots, barks, stems, leaves, flowers and fruits of each mangroves species for validation and proper identification. Mangrove species were identified and counted at each station. The number of saplings and seedling of mangroves at each quadrat was also counted and recorded. The physical characteristics of the water, substrate and associated flora and fauna within the mangrove area were documented.

2.3 Determination of species abundance, density, and diversity

2.3.1 Abundance and distribution. The abundance of each species was determined by counting the total population in each station using the following scale recommended by Odum (1971) [3]. Not found; + Rare - more than 1; ++ Few - more than 10; +++ Many - more than 20; ++++ Abundant - more than 50.

2.3.2 Density. This is measured by counting the total number of individuals divided by the total area.

2.3.3 Relative Density. Relative density of a species is measured by counting the number of one kind of species and comparing these species against the total number of different species.

2.3.4 Frequency. This was measured by counting the number of quadrats that contains individuals of a species. It can be measured by determining how many quadrats a given mangroves species occur or are found in the seven stations [4].

2.3.5 Relative frequency. This is measured by counting the frequency of one Mangrove species expressed as a percentage of the sum of frequency values for all species present [4].

2.3.6 Species richness. This was measured by counting the number of different kinds of species present in a particular area [5]. It can be measured by computing the sum of number of the different kinds of species present in the seven stations.

2.3.7 Repetition Index. These represent the estimate of the minimum number of subsamples necessary to cover all diversity present in a group of samples. This is computed by dividing species richness by the number of species present in the area.

2.3.8 Simpson's Index (D). This measures the probability that two individuals randomly selected from a sample will belong to the same species. With this index, 0 represents infinite diversity and 1, no diversity. That is the bigger the value of D, the lower the diversity [6].

2.3.9 Simpson's Index of Diversity (1-D). This refers to the value ranging between 0 and 1; the greater the value, the greater the sample diversity [6].

2.3.10 Simpson's Reciprocal Index (1/D). The value of this Index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. The higher the value, the greater the diversity. The maximum value is the number of species in the sample [6].

3. Results and Discussions

3.1 Species composition. There were fourteen (14) mangrove species identified along the mangrove forest of Maligaya, Palanan, Isabela. These species are from the six (6) families namely Rhizophoraceae, Acanthaceae, Avicenniaceae, Sterculiaceae, Palmae and Melianceae (Table 1).

Table 1: Taxonomic classification of identified mangrove species

Class	Order	Family	Scientific Name	Local name
Magnoliopsida	Malpighiales		Rhizophora apiculata	Bakauan lalaki
			Rhizophora mucronata	Bakauan babae
		Rhizophoraceae	*Bruguiera cylindrica*	Pototan lalaki
			Bruguiera sexangula	Pototan babae
			Bruguiera gymnorrhiza	Busain
	Lamiales			
			Acanthus ebracteatus	Sea holly
		Acanthaceae	*Acanthus ilicifolius*	Acanthus
			Acanthus volubilis	Arctos
			Avicennia officinalis	Miapi
		Avicenniaceae	*Avicennia lanata*	Piapi
			Avicennia rumphiana	Api-api
	Malvales	Sterculiaceae	*Heritiera littoralis*	Dungon
	Arecales	Palmae	*Nypa fruticans*	Nipa
Eudicots	Sapindales	Melianceae	*Xylocarpus granatum*	Tabigi

3.2 Abundance and distribution

The abundance and distribution of mangroves found along the mangrove forest of Maligaya, Palanan, Isabela is shown in Table 2. The most abundant species along the seven stations are *Nypa fruticans, Avicennia lanata, Xylocarpus granatum* and *Bruguiera sexangula.*

Table 2: Abundance and Distribution of mangroves in Maligaya, Palanan, Isabela.

Abundance and distribution per station							
Species Composition	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Acanthus ebracteatus	-	-	-	-	+	-	-
Acanthus ilicifolius	-	-	-	-	+	-	-
Acanthus volumbilis	-	-	-	-	+	-	-
Avicennia lanata	+	+	++	+	++++	+++	+++
Avicennia officinalis	+	++	+	-	-	-	-
Avicennia rumpiana	-	-	-	-	+	-	-
Bruguiera cylindrical	+	+++	+	-	-	--	-
Bruguiera gymnorrhiza	+	++	+++	+	-	-	-
Bruguiera sexangula	++	++	+	+	++++	+++	++
Heritiera littoralis	+	+	+	++	-	-	-
Nypa fruticans	+++	++	+	++++	++++	+++	+++
Rhizophora apiculata	+++	+++	++	+	+	-	-
Rhizophora mucronata	+++	+++	+	-	+	+	-
Xylocarpus granatum	+	+++	+++	+++	++++	+++	+

- Not found+ Rare; more than 1++ Few; more than 10 +++ Many; more than 20 ++++ Abundant; more than 50

3.3 Density and frequency parameters

The density, relative density, frequency and relative frequency of mangroves at Maligaya, Palanan, Isabela is shown in Table 3. Results showed that the species identified had density ranging from 0.00029 to 0.099. *Nypa fruticans* obtained the highest density with 0.099 individuals/ 500 m^2; followed by *Avicennia lanata* and *Xylocarpus granatum* while *Acanthus embrateatus* and *Avicennia rumpiana* had the lowest density with 0.00029 individuals/ 500 m^2. *Rhizophora mucronata* recorded the highest relative density for Station 1, *Xylocarpus granatum* for Stations 2 and 3, while *Nypa fruticans* for Stations 4 and 6.

Results of frequency analysis showed that *Nypa fruticans* had the highest total frequency, which appeared in 30 quadrats, followed by *Xylocarpus granatum* which occurred in 29 quadrats. *Avicennia lanata* is present in 28 quadrats, and *Bruguiera sexangula* appeared in 18 quadrats. *Rhizophora mucronata* occurred in 17 quadrats in most stations, except in station 4. *Rhizophora apiculata* appeared in 14 quadrats at Stations 1,2, 3, 4, and 5.

Table 3: Density, relative density, frequency and relative frequency of mangrove species at Maligaya, Palanan, Isabela.

	Density (d/D*100)	**Total Relative Density (d/D*100)**	**Total frequency**	**Total Relative Frequency (f/F*100)**
Species Composition				
Acanthus ebracteatus	0.00028	0.075	1	2.85
Acanthus ilicifolius	0.00085	0.22	2	5.71
Acanthus volubilis	0.00057	0.15	1	2.85
Avicennia officinalis	0.0054	1.43	3	8.57
Avicennia lanata	0.088	23.31	27	77.14
Avicennia rumpiana	0.00028	0.075	1	2.85
Bruguiera cylindrica	0.023	6.28	12	34.28
Bruguiera sexangula	0.045	11.96	18	51.42
Bruguiera gymnorrhiza	0.012	3.17	13	37.14
Heritiera littoralis	0.0042	1.14	8	22.85
Nypa fruticans	0.099	4.46	30	40
Rhizophora apiculata	0.016	6.20	14	48.57
Rhizophora mucronata	0.023	26.26	17	85.71
Xylocarpus granatum	0.057	15.21	29	82.85

3.4 Species Diversity

Diversity of mangrove species in Maligaya, Palanan, Isabela was measured by the following parameters: Species Richness, Repetition Index, Simpson's Index, Simpson's Index of Diversity and Simpson's Reciprocal Index. The results of the species diversity analyses is presented in Table 4.

Table 4: Diversity of mangrove species in Maligaya, Palanan, Isabela.

	Stations							
Diversity Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Overall**
No. of Species (a)	10	10	10	6	11	6	5	14
Species Richness (b)	128	170	112	153	555	136	67	188.714
Repetition Index (a/b)	12.8	17	11.2	25.5	50.45	22.66	13.4	21.859
Simpson's Index (D)	0.17	0.23	0.27	0.48	0.28	0.19	0.15	0.253
Simpson's Index of Diversity (1-D)	0.82	0.76	0.72	0.51	0.71	0.80	0.84	0.737
Simpson's Reciprocal Index (1/D)	5.61	4.32	3.59	2.07	3.46	1.24	1.18	3.067

Species Richness measures the number of the different kinds of organisms present in a particular area. In the present study, Station 5 obtained the highest species richness followed by Stations 2 and 4.On the other hand, the lowest species richness was obtained in Station 7.

Repetition Index estimates the minimum number of subsamples necessary to cover all diversity present in a group of samples. Highest Repetition Index was obtained in Station 5, followed by Stations 4 and 6, respectively. The lowest Repetition Index was obtained in Station 3.

The Simpson's Index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species, where zero represents infinite diversity and 1, no diversity. Hence, the bigger the value of D, the lower the diversity. Highest diversity was obtained in Station 7, while Station 4 revealed the lowest diversity. The mean value computed for D along the different established stations at the mangrove forest of Maligaya, Palanan, Isabela is 0.253, indicating high diversity.

The Simpson Index of Diversity (1-D) value ranges between 0 and 1, the greater the value, the greater the sample diversity. Highest Simpson's Index of Diversity in this study was obtained in Station 7, closely followed by Stations 1 and 6, respectively. The lowest value of 1-D was obtained in Station 4. This indicates that the specimens documented within the quadrat are diverse because the mean value computed for the different established stations at the mangrove forest of Maligaya, Palanan, Isabela which is 0.737 is closed to 1.

On the other hand, Simpson's (1/D) Reciprocal Index also measures the diversity of a given ecosystem; the higher the value, the greater the diversity. The maximum value is the number of species in the station. In this study, highest Reciprocal Index was obtained in Station 1, followed by Station 2 and Station 3, respectively. The lowest 1/D was obtained in Station 7.

Results of the abundance and distribution parameters indicates that the mangrove forest Maligaya, Palanan, Isabela had varied species of mangroves, which are widely distributed across the stations. The diversity indices revealed a wide diversity of mangrove species.

Among the 47 "true mangroves" and associated species belonging to 26 families in the Philippines [7], there are fourteen (14) species of mangroves identified along the mangrove forest of Maligaya, Palanan, Isabela which belongs to family Rhizophoraceae, Acanthaceae, Avicenniaceae, Sterculiaceae, Palmae and Melianceae.

The species of mangroves that are abundant *Nypa fruticans, Avicennia marina, Xylocarpus granatum* and *Bruguier a sexangula* along the mangrove forest of Maligaya, Palanan, Isabela. Mangroves can be detected by moving inland from the seaward edge: broad tidal mudbanks or shallow sand banks in the seaward edge are occupied by *Avicennia* and *Sonneratia*. *Rhizophora* is found further inland, and finally *Bruguiera*, *Ceriops*, Xylocarpus and *Heritiera* forming the back mangrove. In suitable areas, e.g. where a sand/loam substrate is available, *Nypa fruticans* may develop as the main river bank or lagoon-fringing plant [8].

The natural mangroves are growing only where environmental conditions are favorable. The more important factors controlling mangrove distribution in any region of the world are as follows: sea level, salinity and drainage are mostly important [8]. The degree of flooding, soil nature and salinity are considered to be most important and the level of tides and salinity as highly significant [9, 10].

The differences in the abundance, distribution, frequency and diversity indices of mangroves in the seven established stations along the mangrove forest of Maligaya, Palanan, Isabela may be attributed to some factors like the actual geographical location (landward, middle or seaward zone), types of substrate and the presence of a nearby residential area. It can be observed that Stations 1, 2 and 3 (seaward zone) is dominated by *Rhizophora* and *Nypa* species, which indicates that these species favors sandy muddy substrate with higher salinity as compared to other species.

On the other hand, mangrove species that thrives best at lower salinity and unexposed to strong currents prefer the landward zone (Stations 5-7). Another significant observation is the highest species richness of Station 5, which is the convergence zone of fresh and brackish waters, which somehow favors the growth of many mangrove species and mangrove-associated flora and fauna.

4. Conclusions

Different species of mangroves vary in abundance in the different stations. It is evident that there were types of species that are abundant and well distributed in most stations. The distribution of the mangrove species in the study area is defendant upon the physical characteristics of the area, and the substratum were the mangrove species thrives. There are high density number of individual species of mangroves in the study area as indicates by results of abundance, distribution and diversity of species. Results showed that the mangrove forest of Maligaya, Palanan, Isabela is diverse in terms of species composition, and abundance as revealed by various indices of diversity.

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