Diversity of mangrove species in three municipalities of Davao del Norte, Philippines

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Abstract. This study assessed mangrove forest diversity in Carmen, Panabo and Tagum, Davao del Norte, Philippines. Among parameters calculated were rank abundance and diversity index. There were 12 species representing 8 families of mangroves in Carmen, 11 species from 9 families in Tagum, and 16 species from 10 families in Panabo, repesctively. Species dominance values were low at 0.1596 (Carmen), 0.1836 (Tagum), and 0.2333 (Panabo). The Shannon H indices were low: 2.067 (Carmen), 1.968 (Tagum), and 1.906 (Panabo). Species evenness was highest in Carmen (0.6584) and lowest in Panabo (0.425). *Rhizophora mucronata* (Rhizophoraceae) and *Avicennia marina* (Avicenniaceae) were the top species found in the three municipalities. Both are species of Least Concern under IUCN classification. *Ceriops decandra* (Rhizophoraceae), a Near Threatened species was recorded in Panabo, whereas *Avicennia rumphiana* (Avicenniaceae), a Vulnerable species was recorded from all three municipalities. Majority of the species noted were of Least Concern. The assessment of mangrove forest species is important because mangroves help protect the coastline, provide food resources to communities as well as help maintain the health of the ecosystem.
Key Words: mangrove, diversity, conservation status, Shannon index, Philippines.

Introduction. Mangroves are one of the most exceptional floras in the world. They grow in the coastlines of tropical and sub-tropical countries and are well adapted to extreme conditions such as high salinity and temperature (Kathiresan & Bingham 2001). Mangroves could be utilized in a lot of practical ways like for firewood, charcoal and thatching for construction (Brown & Fischer 1918; Spalding et al 1997; Long & Giri 2011). Moreover, they provide other services such as coastal protection. Certain mangrove species help prevent flooding and erosion of unconsolidated coastlines by breaking the force of waves (FAO 1994). Mangroves are suitable homes for epibenthic, infaunal and meiofaunal invertebrates and are able to support communities of phytoplanktons, zooplanktons and fishes due to the unique environment they create (Cañizares & Seronay 2016). Mangroves are also nurseries and feeding sites for some marine species (Rönnback 1999; Long & Giri 2011) and nesting grounds for hundreds of bird species (Nagelkerken et al 2008; Garcia et al 2014).

The Philippines has been constantly listed as one of the top biodiversity hotspots of the world (Myers 1988, 1990; Myers et al 2000; Mittermeier et al 2004; Mittermeier et al 2011; Marchese 2015). This is due to its archipelagic orientation and tropical climate. Its coastline stretches to about 36,000 km covering more than 7,000 islands (Garcia et al 2014). All these intrinsic features of Philippines help make it a very adaptable location for mangroves to thrive in. In 1920, assessment of the total mangrove coverage for the entire country amassed an estimated total of 400,000-500,000 hectares (Brown & Fischer 1918; Chapman 1976; Primavera 2000; Garcia et al 2014). Furthermore, the Philippines holds approximately 50% of the known mangrove species in the world (Primavera et al 2004; Garcia et al 2014) including endangered, vulnerable and threatened ones (Spalding et al 2010).

Regardless of how critically important and beneficial mangroves are, there has been a continuous and profound decline in their population. The Philippines lost about 75% of its mangrove habitats over the past few decades with the majority of it gone within 1950-1990 (Primavera 1995, 2000; Samson & Rollon 2008). As a country with more than half of its 1,500 municipalities and 42,000 villages dependent on coastal resources (Primavera 2000), the decrease in mangrove ecosystems has been directly affecting the people. This set a lot mitigating efforts in motion to recover hectares of mangrove forests mainly for wood supply and coastal protection (Samson & Rollon 2008). However, results of past reforestation projects in the Philippines and in other places experienced high postplanting mortality (Lewis 1990; Saenger & Siddiqi 1993; Calumpong 1994; Pomeroy et al 1996; Primavera & Agbayani 1997; Walters 2004). Therefore, further assessment of the remaining mangrove ecosystems in the country is required to understand and lessen failures for future rehabilitation efforts. The main objective of this study is to assess the remaining mangrove ecosystem in Tagum City, Panabo City and municipality of Carmen in the province of Davao del Norte, Philippines.

Material and Method

Time of study and study area. This study was conducted in three different cities and municipality found in Davao Del Norte specifically Carmen, Panabo City and Tagum City from (March 13-17, 2017). These cities and municipalities are the only areas in Davao del Norte that have mangrove forest features. In each city or municipality, five survey sites were established. These survey sites were selected randomly with the help of locals and community stakeholders based on the presence of matured mangrove tree species in their area. Most of the survey sites are located in coastal areas with aquaculture features such as fishponds and aquasilviculture. In Tagum City, most of the five survey sites are part of mangrove under rehabilitation activities maintain by fisher folks organizations. While in Carmen, the survey sites belong to the municipal mangrove reserve. In case of Panabo City survey sites, it is a combination of two, there mangrove forests are all part of City mangrove reserve cared and maintained by locals with the support of Bureau of Fisheris and Aquatic Resources (BFAR) in partnership with Local Government Unit (LGU) (Figure 1).

Mangrove sampling and measurements. Plots measuring 10 x 10 m were laid in each survey site. Mangrove species inside the plot were identified and counted. Moreover, the height and diameter at breast height (dbh) were measured using the guidelines from English et al (1997).

Mangrove identification. The mangroves were identified and classified taxonomically up to the species level using the Field Guide Manual to Philippine Mangroves by Primavera et al (2004).

Diversity indices and abundance curves. Species richness, dominance, evenness and the Shannon Wiener diversity index were obtained to evaluate the diversity of mangroves in all of the areas (Cañizares & Seronay 2016). The Paleontological Statistical Software Package (PAST) developed by Hammer et al (2001) was used to compute these indices and generate the abundance curve.

Mangrove structure analysis. To analyze the mangrove structure and vegetation of the three different places, relative density, relative frequency, relative dominance and importance value were computed. These factors help identify the relevance and function of the different species found in a location.

$$\text{Relative Density} = \frac{\dfrac{\text{Total number of individuals of a species throughout the five plots}}{\text{Total plot area}}}{\text{Total density}} * 100$$

$$\text{Relative Frequency} = \left[\frac{\text{Total number of times species is present in the five plots}}{\text{Total plot frequency}}\right] * 100$$

$$\text{Relative Dominance} = \left[\frac{\dfrac{\text{Total area of a species throughout the five plots}}{\text{Total plot area}}}{\text{Total basal area}}\right] * 100$$

$$\text{Importance Value} = \left[\frac{\text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance}}{3}\right] * 100$$

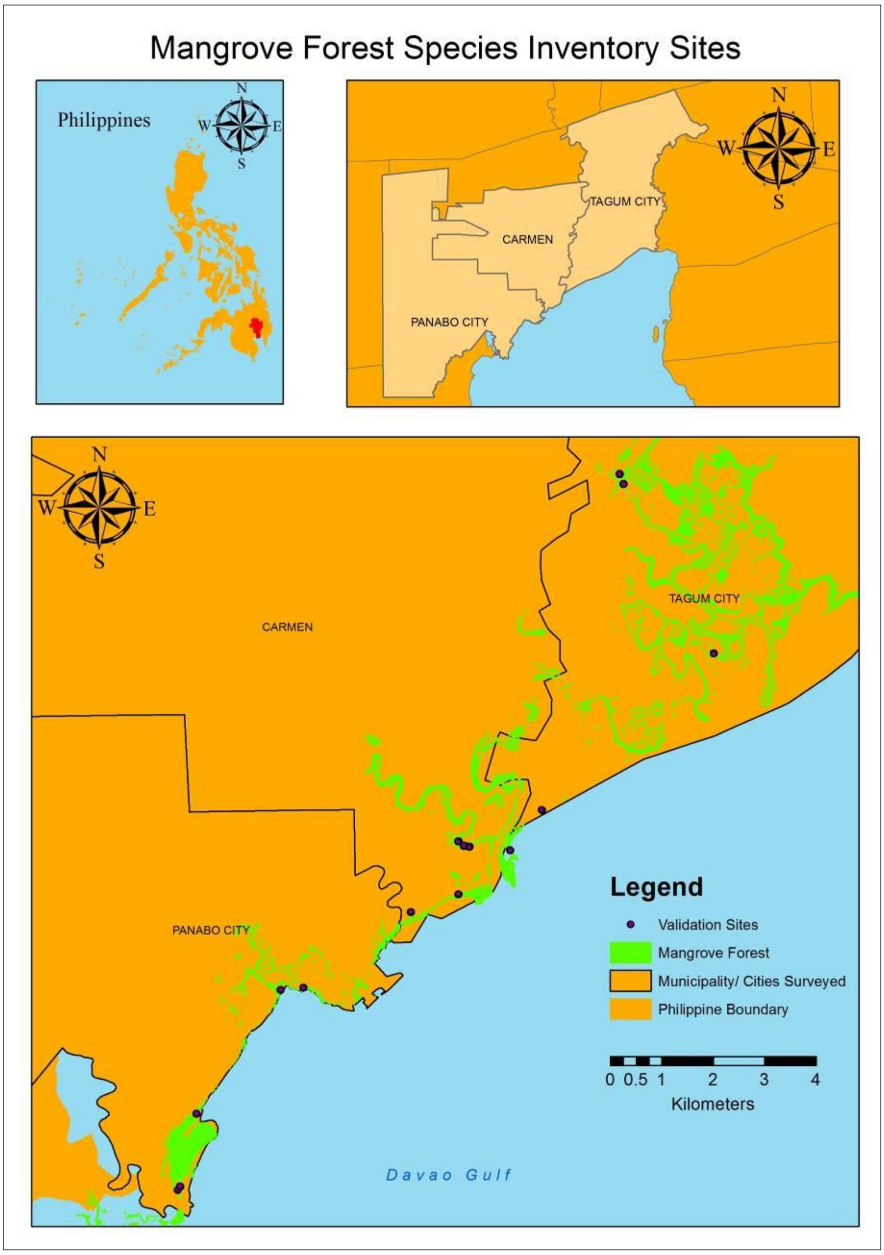

Figure 1. Location of sampling sites in Davao del Norte, Philippines.

Results and Discussion

Mangrove identification. For the municipality of Carmen, 11 mangrove species were identified under 8 families with one unidentified up to the species level (Table 1). The family with the highest number of identified species was Rhizophoraceae bearing three different species. One of the species identified, *Avicennia rumphiana*, was found to be at a vulnerable conservation status while the rest are either of least concern or not yet assessed.

In Tagum city, 11 mangrove species were identified up to the species level and are under 9 families (Table 2). Tied in the family with the most species are Avicenniaceae and Rhizophoraceae, both with two distinct species. Still, *Avicennia rumphiana* was found in the site which is of vulnerable conservation status while the others are of least concern or not assessed.

Panabo city yielded the most number of identified species (16) and most families (10) (Table 3). The family with the most species was Rhizophoraceae with three species. Again, *Avicennia rumphiana* is present which is vulnerable. Moreover, *Ceriops decandra* was identified which according to its conservation status is near threatened. The rest are still of least concern or not assessed.

Table 1

Mangrove species identified from the sample plots in Carmen with their conservation status

Family	*Mangrove species*	*Common name*	*Conservation status (IUCN*)*
Arecaceae	*Nypa fruticans*	Nypa	Least concern
Avicenniaceae	*Avicennia marina*	Miapi	Least concern
Avicenniaceae	*Avicennia rumphiana*	Api-api	Vulnerable
Bignoniaceae	*Dolichandrone spathacea*	Tui	Least concern
Euphorbiaceae	*Excoecaria agallocha*	Lipata	Least concern
Lythraceae	*Sonneratia alba*	Pagatpat	Least concern
Malvaceae	*Heritiera littoralis*	Dungon-lati	Least concern
Malvaceae	*Hibiscus tiliaceus*	Malubago	Not assessed
Meliaceae	*Xylocarpus granatum*	Tabigi	Least concern
Rhizophoraceae	*Bruguiera* sp.	Busain	-
Rhizophoraceae	*Rhizophora apiculata*	Bakauan lalake	Least concern
Rhizophoraceae	*Rhizophora mucronata*	Bakauan babae	Least concern

*www.iucnredlist.org.

Table 2

Mangrove species identified from the sample plots in Tagum with their conservation status

Family	*Mangrove species*	*Common name*	*Conservation status (IUCN*)*
Arecaceae	*Nypa fruticans*	Nypa	Least concern
Avicenniaceae	*Avicennia marina*	Miapi	Least concern
Avicenniaceae	*Avicennia rumphiana*	Api-api	Vulnerable
Bignoniaceae	*Dolichandrone spathacea*	Tui	Least concern
Combretaceae	*Lumnitzera racemosa*	Culasi	Least concern
Lythraceae	*Sonneratia alba*	Pagatpat	Least concern
Malvaceae	*Hibiscus tiliaceus*	Malubago	Not assessed
Meliaceae	*Xylocarpus granatum*	Tabigi	Least concern
Pteridaceae	*Acrostichum aureum*	Palaypay	Least concern
Rhizophoraceae	*Rhizophora apiculata*	Bakauan lalake	Least concern
Rhizophoraceae	*Rhizophora mucronata*	Bakauan babae	Least concern

*www.iucnredlist.org.

Table 3

Mangrove species identified from the sample plots in Panabo with their conservation status

Family	*Mangrove species*	*Common name*	*Conservation status (IUCN*)*
Arecaceae	*Nypa fruticans*	Nypa	Least concern
Avicenniaceae	*Avicennia marina*	Miapi	Least concern
Avicenniaceae	*Avicennia rumphiana*	Api-api	Vulnerable
Bignoniaceae	*Dolichandrone spathacea*	Tui	Least concern
Combretaceae	*Lumnitzera racemosa*	Culasi	Least concern
Euphorbiaceae	*Excoecaria agallocha*	Lipata	Least concern
Lythraceae	*Sonneratia alba*	Pagatpat	Least concern
Lythraceae	*Sonneratia caseolaris*	Padada	Least concern
Malvaceae	*Heritiera littoralis*	Dungon-lati	Least concern
Malvaceae	*Hibiscus tiliaceus*	Malubago	Not assessed
Meliaceae	*Xylocarpus moluccensis*	Piagao	Least concern
Meliaceae	*Xylocarpus granatum*	Tabigi	Least concern
Myrisinaceae	*Aegiceras corniculatum*	Saging-saging	Least concern
Rhizophoraceae	*Ceriops decandra*	Malatangal	Near Threatened
Rhizophoraceae	*Rhizophora apiculata*	Bakauan lalake	Least concern
Rhizophoraceae	*Rhizophora mucronata*	Bakauan babae	Least concern

*www.iucnredlist.org.

Diversity indices and abundance curves. Results of the computation for the different diversity indices of the three sampling sites yielded nearly similar results (Figures 2, 3, and 4). Species richness refers to the total number of mangrove species accounted for in each of the three places. Carmen had 12 species, Tagum had 11 and Panabo had 16. The dominance has a range value of 0 where all taxa are equally distributed to 1 where one taxon dominates the community completely (Hammer et al 2001). Results for Carmen, Tagum and Panabo were 0.1596, 0.1836 and 0.2333 respectively. The low numbers suggest that all the taxa in the three sampling sites were fairly distributed. However, Panabo did have a larger result which means a taxon is almost dominating the place.

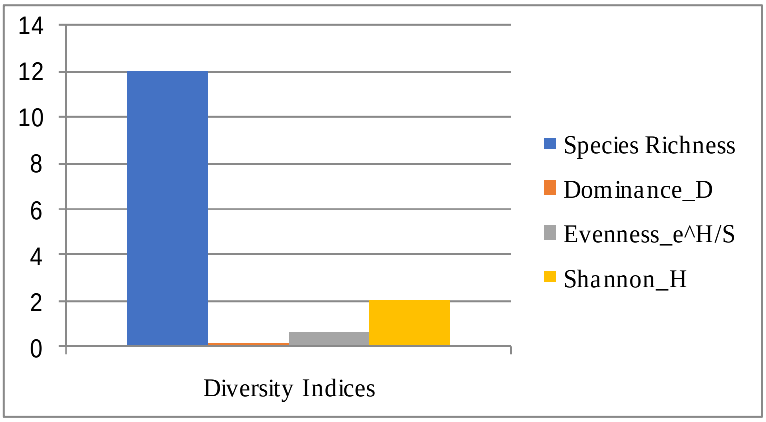

Figure 2. Diversity indices for the mangroves sampled from Carmen.

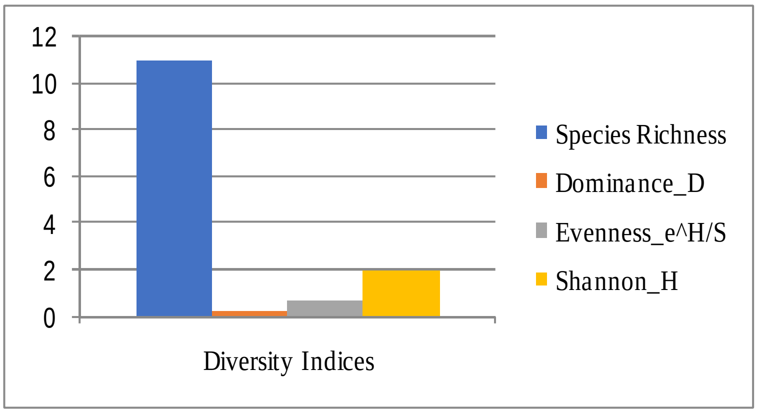

Figure 3. Diversity indices for the mangroves sampled from Tagum.

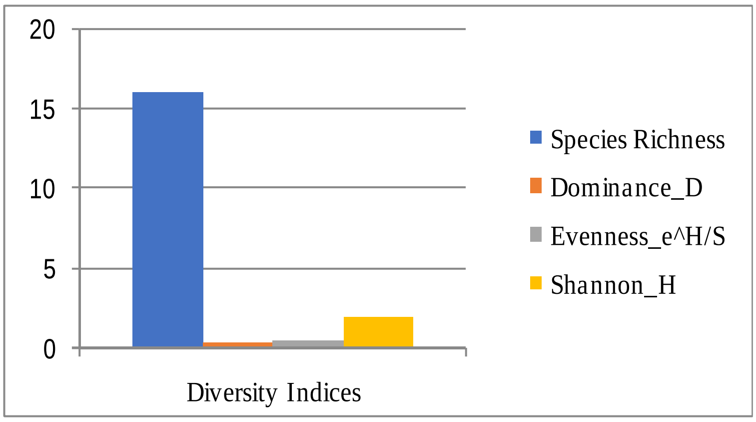

Figure 4. Diversity indices for the mangroves sampled from Panabo.

Evenness is the measure of how evenly the individuals in the community are distributed over the different species (Heip et al 1998). The lesser the number is, the more it leans toward a taxon dominating the area. According to the results, Carmen had the highest number of 0.6584 while Panabo had the lowest with 0.4205. This suggests that there is a taxon slightly dominating Panabo and this result coincides with the dominance index. Lastly, the Shannon Wiener index was calculated for the data collected from the different areas. The Shannon index is a summary of the species richness and evenness which increases as both values increase as well. Results exhibited a decreasing pattern of values from the 2.067 of Carmen to the 1.906 of Panabo. This infers that the taxa diversity in Carmen is more even and rich than that of Tagum and Panabo by a small difference.

Furthermore, abundance curves were generated to have an overview of the abundance of the different species in the mangrove vegetation. The abundance curves are presented in Figures 5, 6, and 7 while the species and their ranks for each sampling site are tallied in Table 4.

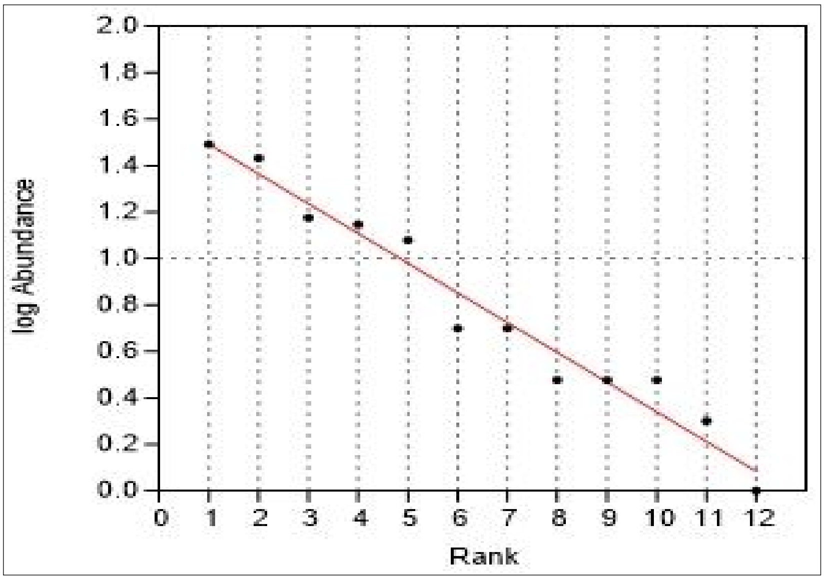

Figure 5. Rank abundance curve for mangrove species in Carmen.

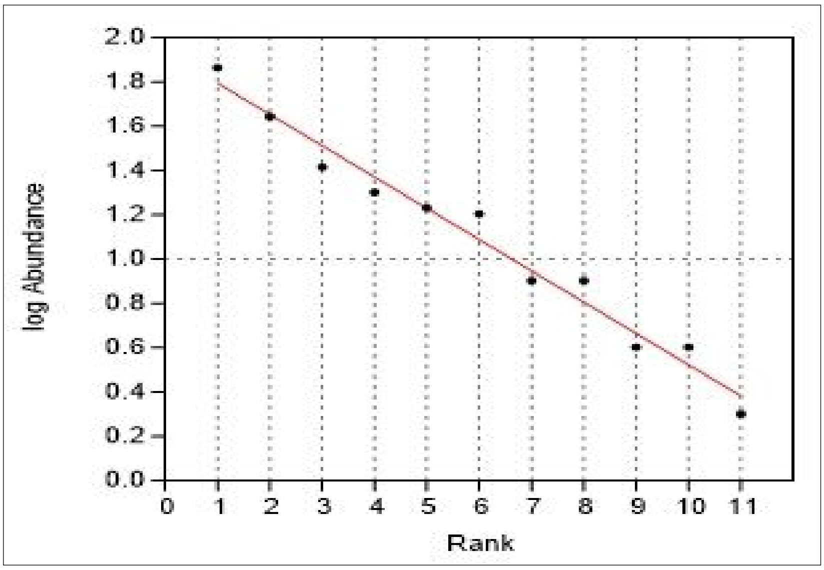

Figure 6. Rank abundance curve for mangrove species in Tagum.

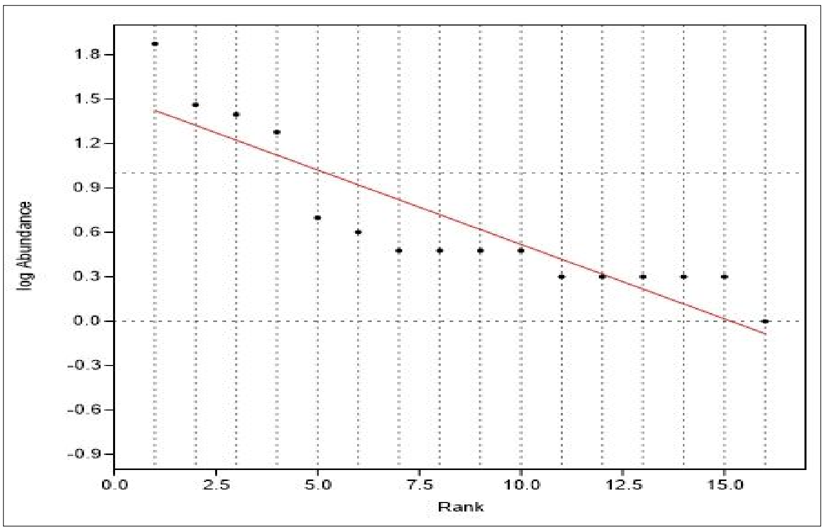

Figure 7. Rank abundance curve for mangrove species in Panabo.

Table 4
Species identified from the different sampling sites and their respective abundance ranks

Sampling site	*Species*	*Rank*
Carmen	*Avicennia marina*	1
	Rhizophora mucronata	2
	Rhizophora apiculata	3
	Nypa fruticans	4
	Dolichandrone spathacea	5
	Bruguiera sp.	6
	Sonneratia alba	7
	Avicennia rumphiana	8
	Excoecaria agallocha	9
	Xylocarpus granatum	10
	Heritiera littoralis	11
	Hibiscus tiliaceus	12
Tagum	*Rhizophora mucronata*	1
	Rhizophora apiculata	2
	Sonneratia alba	3
	Avicennia marina	4
	Nypa fruticans	5
	Lumnitzera racemosa	6
	Dolichandrone spathacea	7
	Xylocarpus granatum	8
	Avicennia rumphiana	9
	Acrostichum aureum	10
	Hibiscus tiliaceus	11
Panabo	*Avicennia marina*	1
	Rhizophora mucronata	2
	Sonneratia alba	3
	Rhizophora apiculata	4
	Avicennia rumphiana	5
	Dolichandrone spathacea	6
	Ceriops decandra	7
	Excoecaria agallocha	8
	Heritiera littoralis	9
	Sonneratia caseolaris	10
	Hibiscus tiliaceus	11
	Lumnitzera racemosa	12
	Nypa fruticans	13
	Xylocarpus granatum	14
	Xylocarpus moluccensis	15
	Aegiceras corniculatum	16

Mangrove structure analysis*.* The results for the mangrove structure analysis for Carmen are shown in Figure 8. Among the samples recorded, the species with the highest relative density was *A. marina* (25.62%) the implication being that it is the species with highest count per unit area. Additionally, it is also the species with the highest relative dominance which suggests that it makes up the largest part of the mangrove biomass for the entire sampling site. For relative frequency, *R. apiculata* had the highest one with 17.24%. This indicates that it is the species which appears the most out of the five transect plots. All these translate to the importance values where *A. marina* and *R. apiculata* both had the largest value of 19 and 7 percent respectively away from the next largest value. Therefore, they are both the most important and dominant species in the mangrove area of Carmen. This also implies that they are the most acclimated to their place.

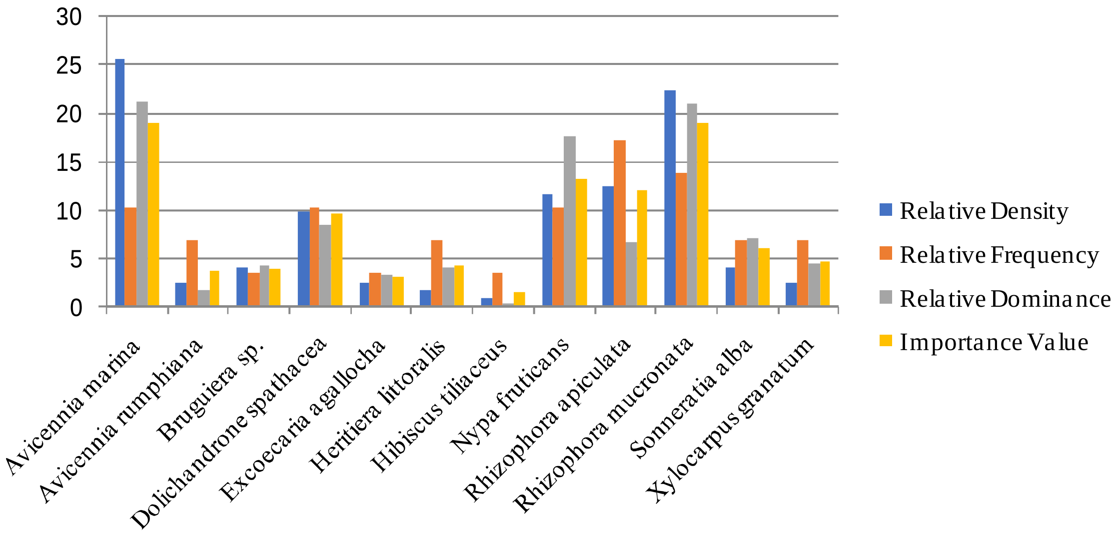

Figure 8. Mangrove structure analysis for Carmen.

Results for Tagum are shown in Figure 9. *R. mucronata* had the highest relative density percentage of 32.58 and relative dominance percentage of 22.76. For relative frequency, the highest percentage was of *R. apiculata* (18.18%). This justifies *R. mucronata* for having the highest importance value for the species found in Tagum (21.48%). This further implies that *R. mucronata* is the most important and acclimated mangrove species for Tagum.

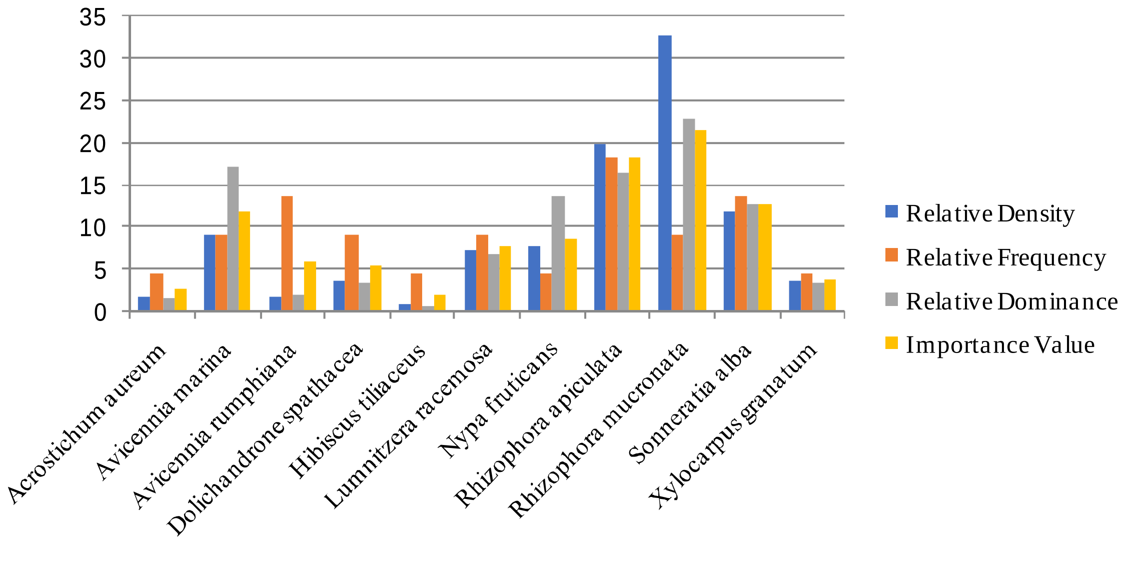

Figure 9. Mangrove structure analysis for Tagum.

Figure 10 summarizes the results for Panabo city. *A. marina* had the highest percentage for relative density and relative frequency (41.67% and 17.24% respectively). For relative dominance, both *A. marina* and *A. rumphiana* got the highest percentage of 29.9%. However, importance value singles out *A. marina* for bearing the highest percentage of 29.59%. This makes it the most important and acclimated mangrove species for Panabo.

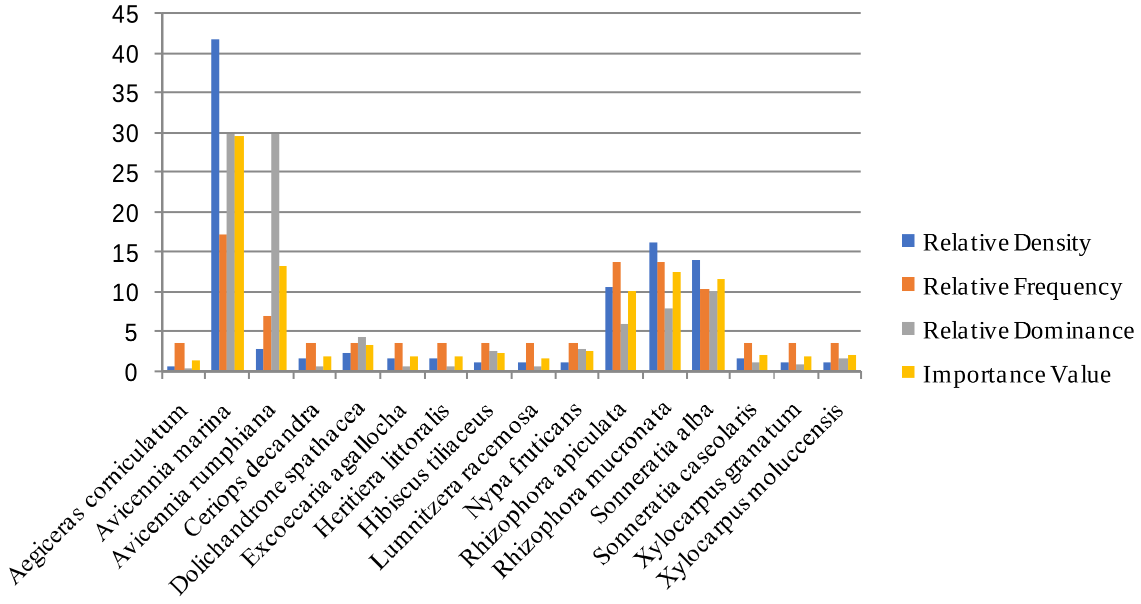

Figure 10. Mangrove structure analysis for Panabo.

Conclusions. The diversity indices implied that among the three locations studied, Panabo has mangrove taxa that are slightly dominant. Carmen has a more even and rich taxa diversity than Panabo and Tagum. Further, from the 11 mangroves found in Carmen, it was determined that *A. marina* and *R. apiculata* were both the important, dominant and most acclimated mangrove species (19% species importance value). *R. mucronata* was the most important species in Tagum (21.48% importance value) and *A. marina* for Panabo (29.59% importance value).

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