BIODIVERSITAS
Volume 23, Number 9, September 2022
Pages: 4887-4893

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d230958

Floristic composition, structure, and diversity of mangroves in the coastal areas of Mabini, Davao de Oro, Philippines

ALEXA MAE B. MANUAL, NEIL ALDEN S. GABATO, QUEZZEY B. JETUYA, JEMER A. ALIMBON♥
Department of Teacher Education, UM Tagum College, Mabini St., Tagum City 8100, Davao del Norte, Philippines.
♥email: alimbon.jemer@gmail.com

Manuscript received: 3 July 2022. Revision accepted: 18 September 2022.

Abstract. *Manual AMB, Gabato NAS, Jetuya QB, Alimbon JA. 2022. Floristic composition, structure, and diversity of mangroves in the coastal areas of Mabini, Davao de Oro, Philippines. Biodiversitas 23: 4887-4893.* Biodiversity and stand structure assessments of mangrove communities are important for their management and conservation. However, this aspect of mangrove ecology in the Davao Gulf is not yet fully explored, particularly in the coastal areas of Mabini, Davao de Oro, Philippines, despite being proclaimed as a protected area. Hence, this study assessed the species composition, structure and diversity of mangroves in the coastal areas of Mabini, Davao de Oro, Philippines. Using the belt transect method, 35 plots with 10 m x 10 m each were established and surveyed. Results revealed that the area is home to eight species belonging to six genera and five families. One vulnerable species, *Avicennia rumphiana*, was recorded on the study site. Of the identified species, *Rhizophora apiculata* was the most important species, with an importance value index of 144.41 %. Meanwhile, the surveyed mangrove communities had a mean diameter at breast height of 10.96 cm, a basal area of 27.93 m^2 ha^{-1}, and a mean density of 4192 stems ha^{-1}. Diversity analysis indicated that the sampled sites had low species biodiversity (H' = 1.098), low species richness (R = 0.9601), and less even species distribution (J = 0.5280). These results add to the existing knowledge about mangrove communities in Davao Gulf. More importantly, they serve as important baseline information relevant to the management, protection, and conservation of mangroves within the Mabini Protected Landscape and Seascape.

Keywords: *Avicennia rumphiana*, Davao Gulf, diversity, Philippine mangroves, stand characteristics

Abbreviations: BMB: Biodiversity Management Bureau, DENR: Department of Environment and Natural Resources, DBH: diameter at breast height, FMB; Forest Management Bureau, GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit, IUCN: International Union for Conservation of Nature, IVI: importance value index, Mabini PLS: Mabini Protected Landscape and Seascape

INTRODUCTION

Mangroves are assemblages of wood plants that are morphologically and physiologically adapted to extreme conditions of high salinity, strong winds, extreme tides, and muddy soils (Kathiresan and Bingham 2001). They are primarily found in the intertidal zones of the tropical and subtropical coasts (Wang et al. 2019). Further, they are known globally for their immense roles in provisioning, regulating, cultural, and supporting ecosystem services (Afonso et al. 2021; Askar et al. 2021). In fact, certain local communities have reported that they depend on mangrove ecosystems for their food needs (Quevedo et al. 2020; Alimbon and Manseguaio 2021a). Also, Bera and Maiti (2022) found that this ecosystem serves as a source of income among fringe villagers, by collecting various resources (e.g., fish, crab, prawn, firewood) and engaging in mangrove-related activities. Other ecological functions of mangroves include being a carbon sink, buffer to storm surges (Kadaverugu et al. 2021), nursery of fishes, abrasion control, and a place for education and research (Owuor et al. 2019).

The Philippines, having a coastline of about 36,289 km, is home to at least 50% of the world's approximately 65 mangrove species (Garcia et al. 2014). Primavera (2000) reported that in the past century, from 1918 to 1994, at least 75% of the Philippine mangroves were lost due to anthropogenic activities. Long et al. (2014), through remote sensing, found out that the country's mangrove area had a 10.5% decrease from 1990 to 2010. In the subsequent period, a 2.31% decline was also noted, from 310,531 ha in 2010 to 303,373 ha in 2015 (FMB 2014, 2020). These declines had been observed in most parts of the country, including Davao Region (Long et al. 2014). Hence, continued protection and conservation should be implemented.

Several studies (e.g., Cañizares and Seronay 2016; Cudiamat and Rodriguez 2017; Pototan et al. 2021) have indicated that biodiversity assessment is vital for the conservation of mangroves. Considering this rationale, several assessments were already conducted throughout the country. Just recently, in San Miguel Bay, Camarines Sur, Faustino et al. (2020) conducted a vegetation analysis and found that *Rhizophora apiculata* and *R. mucronata* were the most dominant species as they are often used in replanting activities. Goloran et al. (2020a) also did an assessment in Butuan Bay, Surigao del Norte, and reported that their sampling areas had low biodiversity, potentially due to high disturbances brought by anthropogenic activities. Low species diversity was also observed among mangrove communities in Cotabato City (Dimalen and Rojo 2018), Tacloban City, Leyte (Patindol and Casas 2019), Claver, Agusan del Norte (Goloran et al. 2020b), Binmaley, Pangasinan (Rosario et al. 2021) and Central Zambales (Serrano et al. 2022).

Information on stand characteristics is relevant to management as they relate to forest functions and conditions, such as degradation stage, recovery time, and carbon storage (Ali 2019; Fatonah et al. 2021). In Davao Region, particularly on the coasts of Davao Gulf, floristic studies of mangroves were already conducted in the provinces of Davao Oriental (Pototan et al. 2021), Davao del Norte (Galerio and Martinez 2009; Pototan et al. 2017; Alimbon and Manseguiao 2021b), and Davao del Sur (Jumawan et al. 2015; Cardillo and Novero 2018). As revealed, most of these mangrove communities had very low to low diversity. Only the mangroves in Banaybanay, Davao Oriental, had high diversity with a Shannon-Weiner index of 3.145 (Pototan et al. 2021). In addition, recent studies in the area have described the mangrove stand characteristics. For example, Pototan et al. (2021) reported that the mangrove forests in Banaybanay, Davao Oriental had mean DBH ranging from 10.7 to 30.5 cm, the average height of 2.88 to 16.5 m, a basal area of 0.01 to 3.25 m^2 ha^{-1}, and density of 1.2 to 26.4 stems ha^{-1}. Also, Alimbon and Manseguaio (2021b) found that the mangroves in Panabo Mangrove Park, Davao del Norte had a mean DBH of 7.67 cm, a stand basal area of 14.65 m^2 ha^{-1}, and a mean density of 11,835 trees ha^{-1}.

Furthermore, findings revealed that Davao Region host at least three near-threatened species, *Aegiceras floridum*, *Ceriops decandra*, and *Sonneratia ovata* (Pototan et al. 2021), a vulnerable species, *Avicennia rumphiana* (Pototan et al. 2017, 2021; Cardillo and Novero 2018), and an endangered species, *Camptostemon philippinensis* (Pototan et al. 2021) based on IUCN Red List of Threatened Species Version 2021 - 3 (IUCN, 2021). The presence of such species reinforces the call for the continued protection and conservation of mangroves in the area. However, limited information on mangrove ecology still exists in some parts of Davao Gulf. In fact, no record has been published yet about the mangroves that are currently occurring in Davao de Oro, especially in the municipality of Mabini, where coastal areas had long been declared protected through Proclamation No. 316, s. 2000. Hence, this study aimed to assess the floristic composition, structure, and diversity of mangroves in the coastal areas of Mabini, Davao de Oro, Philippines. It is hoped that the findings of this study serve as baseline information for the management, conservation, and protection of mangroves in Mabini Protected Landscape and Seascape (or Mabini PLS) and Davao Gulf, in general.

MATERIALS AND METHODS

Study area

This study was conducted in the coastal areas of the municipality of Mabini, Davao de Oro, Mindanao, Philippines (7º16'N 125º51'E). The municipality is home to the Mabini PLS, covering six coastal barangays (A *barangay* is the smallest administrative unit in the Philippines). Mabini PLS is a 6,106-ha protected area. Of which, about 80.5 ha are mangrove forests, while the rest include a diverse coral reef system, extensive beach line, rich fishing ground, and productive seagrass beds. Considering the accessibility and safety (Abino et al. 2014), we conducted data collection on four coastal barangays, namely Cuambog, Del Pilar, Pindasan, and San Antonio (Figure 1).

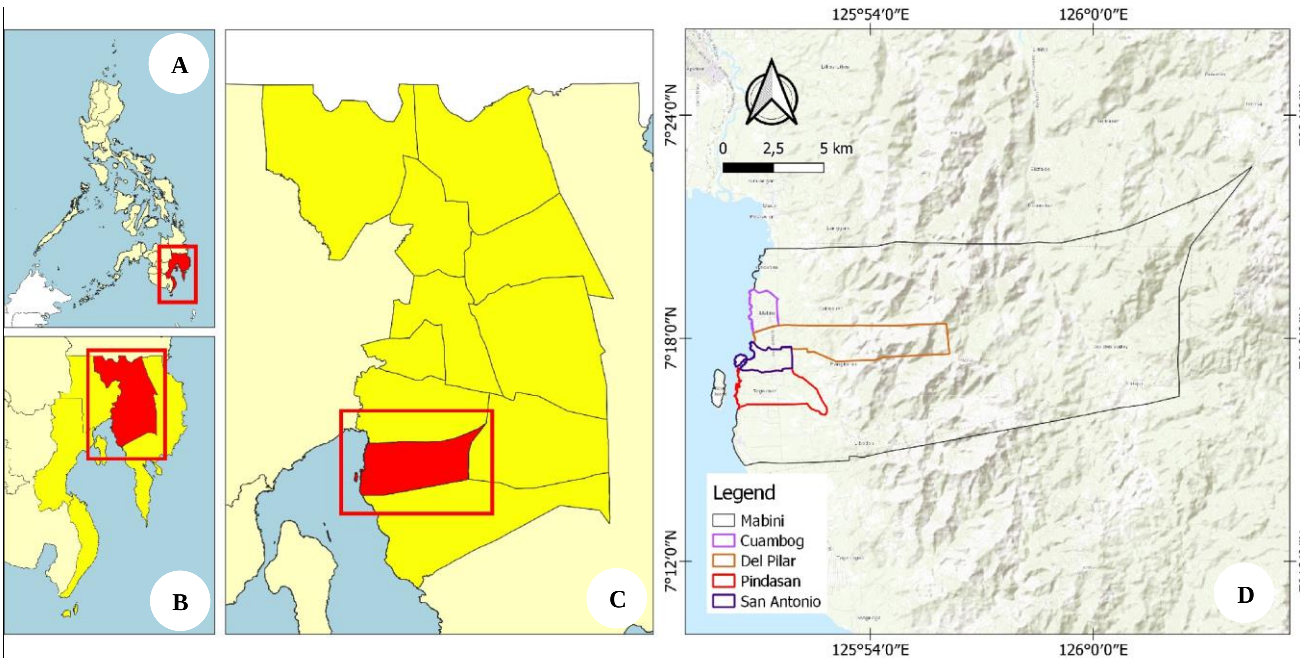

Figure 1. Location of sampling sites. A. The Philippines; B. Davao Region (in Mindanao Island); C. Compostela Valley); D. coastal barangays of Mabini, Davao de Oro, Philippines. (*Note.* The map was made with QGIS)

Data collection

The assessment was done in June 2021. It utilized the belt transect method described in the Manual on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems (BMB and GIZ 2017). A total of 14 transects (two in Cuambog, two in Pindasan, three in Del Pilar, and seven in San Antonio) were established throughout the selected sampling sites. The number of transects varied according to the extent of vegetation, meaning that more transects were laid in barangays with greater mangrove cover. Using a transect tape, a 100-m distance between transect lines was made during the fieldwork. For each transect line, plots measuring 10x10m spaced at about 50 m were also established. The process yielded a total of 35 quadrats across study sites. The number of plots per transect varied according to the length of the transect line. In each quadrat, the researchers carefully identified and counted all mangrove individuals. Field guides by Primavera (2009) and Lebata-Ramos (2013) were utilized to identify species. DBH measurements of all mangrove trees that occurred within the quadrat were taken using a measuring tape. DBH of stilt-rooted species such as *Rhizophora* spp. were measured at 1.30-m mark above the highest stilt root (Howard et al. 2014).

Data analysis

Structural characteristics of mangroves were analyzed using the formulas presented by English et al. (1997).

Basal area per tree (cm²) = $\pi DBH^2/4$

Stand basal area ($m^2\ ha^{-1}$) = sum of basal areas/area of the plot

Density (stems ha^{-1}) = (no. of living stems in a plot x 10,000)/area of the plot

Relative density = (density of a species/total density of all species) x 100

Relative frequency = (frequency of a species/ total frequency of all species) x 100

Relative dominance = (total basal area of a species/total basal area of all species) x 100

Importance value = relative density + relative frequency + relative dominance

Further, biodiversity indices were determined using Paleontological Statistics Software (Hammer et al. 2001). The values for the Shannon-Wiener, Margalef, and Pielou indices were used to describe mangrove stands' diversity, richness, and evenness, respectively.

RESULTS AND DISCUSSION

Mangrove species composition

The floristic inventory sampled 1467 mangrove individuals in the selected coastal areas of Mabini, Davao de Oro, Philippines, representing eight species belonging to six genera of five families (Table 1). The identified species (Figure 2) are *Acanthus ebracteatus*, *Aegiceras corniculatum*, *Avicennia officinalis*, *A. rumphiana*, *Bruguiera sexangula*, *Rhizophora apiculata*, *R. mucronata*, and *Sonneratia alba*. This record showed a lower diversity compared to mangrove communities in Davao Gulf, such as Banay-banay, Davao Oriental (33 species, Pototan et al. 2021), Tagum City, Carmen, and Panabo City, Davao del Norte (11 to 16 species, Pototan et al. 2017), Sta. Cruz, Davao del Sur (17 species, Cardillo and Novero 2018), and Hagonoy, Davao del Sur (12 species, Jumawan et al. 2015). However, this is relatively higher than the five species of Panabo Mangrove Park, Davao del Norte (Alimbon and Manseguiao 2021b).

Based on the conservation status categories of the IUCN Red List of Threatened Species Version 2021 – 3 (IUCN, 2021), one species (*A. rumphiana*) is listed as Vulnerable, while the rest are of Least Concern status. Of the four study sites, *A. rumphiana* was only documented in San Antonio and only accounted for 1.02% of the sampled mangrove individuals. This record is lower than that of Banaybanay, Davao Oriental (Pototan et al. 2021) and Sta. Cruz, Davao del Sur (Cardillo and Novero 2018). The presence of such vulnerable species in the area necessitates the implementation of more protection and conservation measures. Moreover, none of the recorded species was listed as threatened in DENR Administrative Order No. 2017-11 (Updated National List of Philippine Threatened Plants and their Categories).

Table 1. Mangrove species identified in the coastal areas of Mabini, Davao de Oro, Philippines

Family	Species	Conservation status[1]	Number of individuals in study sites				Total number of sampled individuals
			Cuambog	Del Pilar	Pindasan	San Antonio	
Acanthaceae	*Acanthus ebracteatus* Vahl	Least Concern	-	-	-	13	13
Avicenniacea	*Avicennia officinalis* L.	Least Concern	-	-	13	5	18
	Avicennia rumphiana Hallier f.	Vulnerable	-	-	-	15	15
Myrsinaceae	*Aegiceras corniculatum* (L.) Blanco	Least Concern	-	-	-	2	2
Rhizophoraceae	*Bruguiera sexangula* (Lour.) Poir.	Least Concern	-	-	31	-	31
	Rhizophora apiculata Blume	Least Concern	137	185	211	400	933
	Rhizophora mucronata Lam.	Least Concern	31	36	-	181	248
Sonneratiaceae	*Sonneratia alba* J. Smith	Least Concern	11	45	59	92	207
Total			179	266	314	708	1467

Note: [1]The IUCN Red List of Threatened Species 2021-3 (https://www.iucnredlist.org/)

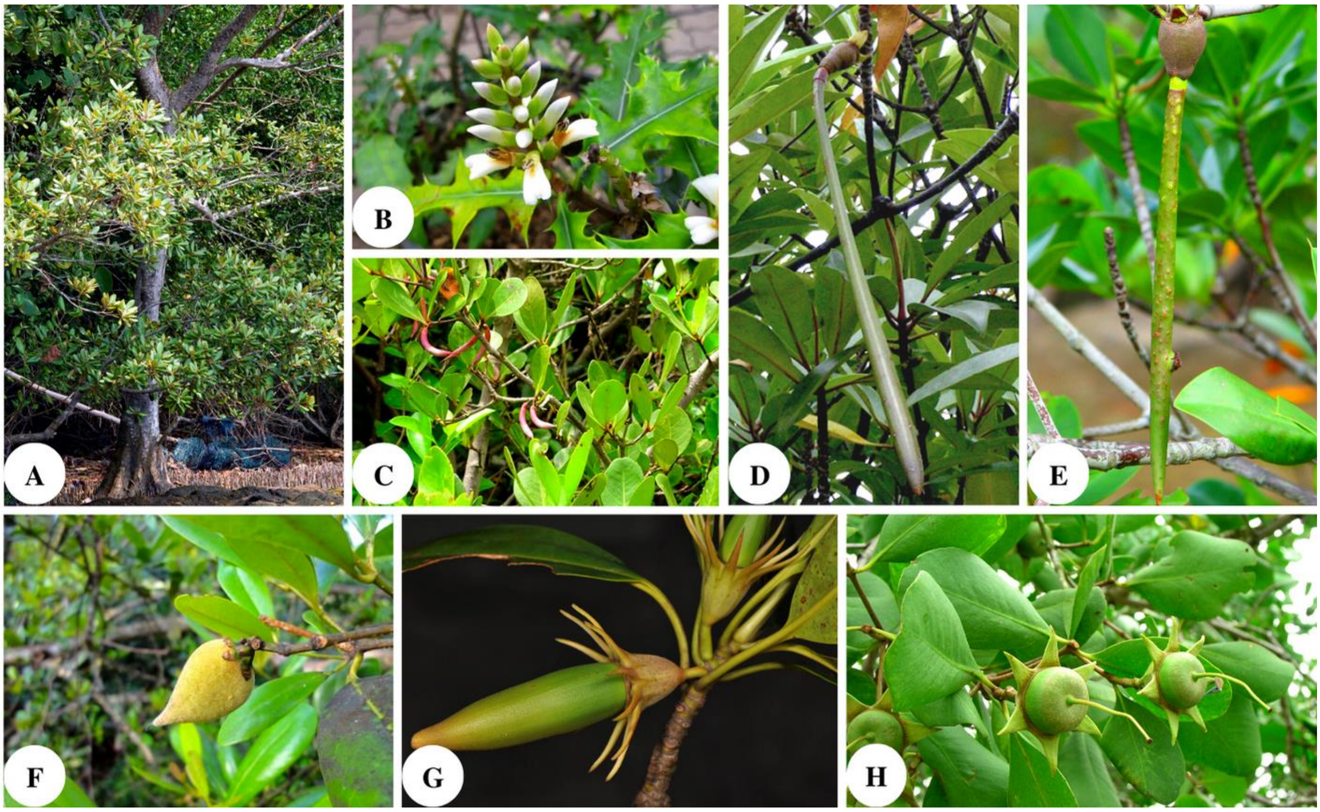

Figure 2. Mangroves in the coastal areas of Mabini, Davao de Oro, Philippines. A. *Avicennia rumphiana*; B. *Acanthus ebracteatus*; C. *Aegiceras corniculatum*; D. *Rhizophora apiculata;* E. *Rhizophora mucronata;* F. *Avicennia officinalis*; G. *Bruguiera sexangula*; H. *Sonneratia alba*

Vegetation structure of mangroves

Shown in Table 2 are the vegetation structure of mangroves in the coastal areas of Mabini, Davao de Oro. Of the identified species, *A. rumphiana* had the greatest mean DBH of 18.21 cm, and its DBH ranged from 9.49 to 19.96 cm. This record of mean DBH is lower than the findings of Pototan et al. (2021) in Banaybanay, Davao Oriental, where they recorded an average DBH of about 26 cm for the same species. *A. officinalis* ranked next with the mean DBH of 17.51 cm even though it had individuals of relatively large trunks, as evidenced in their DBH range of 13.85 to 19.26 cm. This is then followed by (in decreasing order according to recorded mean DBH) *S. alba*, *B. sexangula*, *R. mucronata*, and *R. apiculata*, respectively. *A. corniculatum* registered the smallest DBH of 8.63 cm, and its individuals only had a DBH range of 8.53 to 8.72 cm. Even so, this record for *A. corniculatum* is greater than the individuals inventoried by Alimbon and Manseguiao (2021b) in Panabo Mangrove Park, Davao del Norte.

In terms of basal area, *R. apiculata* (11.72 m^2 ha^{-1}), *S. alba* (9.55 m^2 ha^{-1}), and *R. mucronata* (3.63 m^2 ha^{-1}) ranked first, second, and third, respectively. Notably, *R. apiculata* had the most significant basal area, which accounted for 41.96% of the total basal area. The basal area is not just a sum of cross-sectional surface areas, as measured by DBH, of live trees but also a measure of tree density (Bettinger et al. 2017). Such was the case for *R. apiculata*, which despite having a low DBH of 9.76 cm, its density of 2666 stems ha^{-1}, the highest among all identified species, contributed much to its basal area. As revealed in the study of Sharma et al. (2017), a mangrove's basal area is positively and significantly correlated with density.

Further analysis found that *R. apiculata* (38.82%) was the most frequent species, followed by *S. alba* (29.41%) and *R. mucronata* (20.00%), respectively. The same species registered the highest relative density (*R. apiculata* > *R. mucronata* > *S. alba*) and relative dominance (*R. apiculata* > *S. alba* > *R. mucronata*) values. The highest relative values for *R. apiculata* could be attributed to its ability to grow in various soil types and tolerate a strong saline environment (Hossain 2015). With these, *R. apiculata* was also the most important species, with an IVI of 144.40%. It was then followed by *S. alba* (77.72%), *R. mucronata* (49.91%), *A. officinalis* (9.97%), *A. rumphiana* (9.80%), *B. sexangula* (4.71%), and *A. ebracteatus* (2.06%), respectively. The least important species was *A. corniculatum*, with an IVI of 1.43%. This species was also found to be the least important in Panabo Mangrove Park, Davao del Norte (Alimbon and Manseguaio 2021b). This record for *R. apiculata* means that apart from being the most acclimatized, it had the greatest biomass contribution to the mangrove stands (Pototan et al. 2021) in the coastal areas of Mabini. Several studies (e.g., Alimbon and Manseguaio 2021b; Matatula et al. 2021) already reported that a positive correlation exists between IVI and the aboveground biomass of mangroves.

Table 2. Vegetation structure of mangroves in the coastal areas of Mabini, Davao de Oro, Philippines

Rank	Species	DBH range (cm)	Mean DBH (cm)	Basal area (m^2 ha^{-1})	Mean density (stems ha^{-1})	Relative frequency (%)	Relative density (%)	Relative dominance (%)	Importance Value Index (%)
1	*Rhizophora apiculata*	5.89-12.13	9.76	11.72	2666	38.82	63.60	41.97	144.40
2	*Sonneratia alba*	6.62-17.95	15.09	9.55	592	29.41	14.11	34.20	77.72
3	*Rhizophora mucronata*	8.31-11.78	9.84	3.63	709	20.00	16.91	13.01	49.91
4	*Avicennia officinalis*	13.85-19.26	17.51	1.46	52	3.53	1.23	5.21	9.97
5	*Avicennia rumphiana*	9.49-19.96	18.21	1.14	43	4.71	1.02	4.07	9.80
6	*Bruguiera sexangula*	9.10-10.92	10.19	0.40	89	1.18	2.11	1.42	4.71
7	*Acanthus ebracteatus*	-	-	-	38	1.18	0.89	-	2.06
8	*Aegiceras corniculatum*	8.53-8.72	8.63	0.03	6	1.18	0.14	0.12	1.43

Stand structure of mangroves across sites

Across the study sites, mangrove stand structure in terms of DBH range, mean DBH, basal area, and mean density were also assessed in this study (Table 3). Of the surveyed sites, San Antonio had individuals with relatively large trunks, as it recorded the highest average DBH of 11.39 cm. This included an *A. rumphiana* individual with a DBH of 19.96 cm, the largest of all accounted individuals. On the other hand, an individual with the smallest DBH (i.e., *R. apiculata*) was recorded in Pindasan, where most individuals with relatively smaller trunks were also found, as evidenced by its mean DBH of 10.53 cm, the lowest among study areas. The mean DBH for all mangroves in all study sites was 10.96 cm. Compared to some mangrove communities in the country, this value is relatively lower than that of Banaybanay, Davao Oriental (Pototan et al., 2021) and Bahile Village, Palawan (Abino et al. 2014), but higher than Tacloban City, Leyte (Patindol and Casas 2019), Panabo Mangrove Park, Davao del Norte (Alimbon and Manseguiao 2021b) and Calatagan Mangrove Forest Conservation Park, Batangas (Cudiamat and Rodriguez 2017).

In terms of basal area, San Antonio had the highest value of 29.63 m^2 ha^{-1}, followed by Pindasan (28.12 m^2 ha^{-1}), Cuambog (25.75 m^2 ha^{-1}), and Del Pilar (24.83 m^2 ha^{-1}), respectively. Basal area is primarily influenced by the girth and density of mangroves in the area (Samson and Tubias 2015). The average basal area of mangroves in Mabini was 27.93 m^2 ha^{-1}. This record is relatively higher than basal areas of mangroves in Olango Wildlife Sanctuary, Cebu (Lozano and Bueno 2015), and Panabo Mangrove Park, Davao del Norte (Alimbon and Manseguiao 2021b), but lower than most of the surveyed zones along Puerto Princesa Bay, Palawan (Dangan-Galon et al. 2016).

The average density of mangroves found in all study sites was 4192 stems ha^{-1}. Pindasan had the highest mean density of 4486 stems ha^{-1}. Cuambog ranked next with 4475 stems ha^{-1} and then San Antonio with 4165 stems ha^{-1}. The lowest record for mean density was in Del Pilar, with 3800 stems ha^{-1}. A higher density means more stems or individuals are found in a unit area. This density record for Mabini is lower than that of Panabo Mangrove Park, Davao del Norte (Alimbon and Manseguiao 2021b), yet higher than Banaybanay, Davao Oriental (Pototan et al. 2021).

Diversity of mangroves

Shannon-Weiner (*H'*) index of diversity can be interpreted as very low (<1.999), low (2.000-2.499), moderate (2.500-2.999), high (3.000-3.499) or very high (> 3.500) (Rosario et al. 2021). In this study, diversity analysis revealed that the sampled coastal areas of Mabini, Davao de Oro had a very low diversity (*H'* = 1.0980) (Table 4), a value that is relatively lower than Banaybanay, Davao Oriental, with an *H'* value of 3.145 (Pototan et al. 2021). Their *H'* values ranged from 0.6797 (Cuambog) to 1.1430 (San Antonio). Very low diversity in the study sites could mean that the mangrove ecosystem might be distressed and necessitates conservation, protection, or restoration (Goloran et al. 2020b). In fact, during fieldwork, a beach development activity that slightly damaged a few mangrove individuals in one of the study sites (i.e., Del Pilar) was observed. The areas' *H'* values are comparable to mangrove ecosystems in Dinagat Island (Cañizares and Seronay 2016), Dumanquillas Bay, Zamboanga (Bitantos et al. 2017), Tacloban City (Patindol and Casas 2019) and Panabo, Davao del Norte (Alimbon and Manseguiao 2021b) being in the very low category.

Table 3. Stand structure of mangroves across study sites in the coastal areas of Mabini, Davao de Oro, Philippines

Study sites	DBH range (cm)	Mean DBH (cm)	Basal area (m^2 ha^{-1})	Mean density (stems ha^{-1})
Cuambog	8.37-16.77	10.69	25.75	4475
Del Pilar	8.31-16.71	11.24	24.83	3800
Pindasan	5.89-19.26	10.53	28.12	4486
San Antonio	6.62-19.96	11.39	29.63	4165
Overall/Average	5.89-19.96	10.96	27.93	4192

Table 4. Diversity indices of selected mangrove stand in the coastal areas of Mabini, Davao de Oro, Philippines

Study sites	Shannon-Weiner Index (H')	Pielou's Index (J)	Margalef's index (R)
Cuambog	0.6797	0.6187	0.3856
Del Pilar	0.8238	0.7499	0.3582
Pindasan	0.9417	0.6793	0.5218
San Antonio	1.1430	0.5874	0.9143
Overall	1.0980	0.5280	0.9601

Results also revealed that the area had low species richness (*R = 0.9601*), with only eight species found among sampling plots. San Antonio had the highest number of species at seven, while the lowest at three species was recorded for both Cuambog and Del Pilar. However, this account is relatively higher than the mangroves in Binmaley, Pangasinan, which only registered a mean species richness of 0.63 (Rosario et al. 2021). Further analysis revealed that the mangrove species in the area are moderately distributed (*J = 0.5280*). Such was the case due to the dominance of *R. apiculata* in all sampling locations. Species evenness values range from 0 to 1 and are categorized as uneven (0.00-0.40), moderate evenness (0.41-0.60), and high evenness (0.61-1.00) (Fatonah et al. 2021). A value equal to or close to 1 means the species are evenly distributed.

In conclusion, the selected coastal areas of Mabini, Davao de Oro, Philippines, are home to at least eight mangrove species, including a vulnerable species, *A. rumphiana*. Among the identified species, *R. apiculata* was found to be the most important species and had the greatest influence over the entire mangrove community. Among the inventoried areas, the mangroves in San Antonio and Pindasan had the largest basal area and mean density, respectively. Overall, the selected stands have low species diversity, low species richness, and uneven species distribution. With the presence of vulnerable species, strict conservation and protection measures should be continued. Since mangrove planting activity has been occasionally conducted in the study area, it is recommended that a baseline suitability study should be conducted first to ascertain and ensure the appropriateness of the species to be planted. Further studies such as assessment of ecosystem services (e.g., carbon sequestration) and physicochemical characterization may also be done to understand better the current status of mangroves in the Mabini PLS.

ACKNOWLEDGEMENTS

The authors are grateful to the local government units of Mabini, Davao de Oro; the Department of Environment and Natural Resources Region XI; Community Environment and Natural Resources Office - Maco, Davao de Oro; Protected Area Management Bureau – Mabini PLS; and UM Tagum College for the support in the conduct of this study. To all who have helped in any way towards the completion of this research, thank you very much.

REFERENCES

Abino AC, Castillo JAA, Lee YJ. 2014. Species diversity, biomass, and carbon stock assessments of a natural mangrove forest in Palawan, Philippines. Pak J Bot 46: 1955-1962.

Afonso F, Félix PM, Chainho P, Heumüller JA, de Lima RF, Ribeiro F, Brito AC. 2021. Assessing ecosystem services in mangroves: Insights from São Tomé Island (Central Africa). Front Environ Sci 9: 501673. DOI: 10.3389/fenvs.2021.501673.

Ali A. 2019. Forest stand structure and functioning: Current knowledge and future challenges. Ecol Indic 98: 665-677. DOI: 10.1016/j.ecolind.2018.11.017.

Alimbon JA, Manseguiao MRS. 2021a. Community knowledge and utilization of mangroves in Panabo Mangrove Park, Panabo City, Davao del Norte, Philippines. Intl J Bonorowo Wetl 11: 51-57. DOI: 10.13057/bonorowo/w110201.

Alimbon JA, Manseguiao MRS. 2021b. Species composition, stand characteristics, aboveground biomass, and carbon stock of mangroves in Panabo Mangrove Park, Philippines. Biodiversitas 22: 3130-3137. DOI: 10.13057/biodiv/d220615.

Askar H, Tahang H, Sutinah S, Fakhriyyah S, Bahar A, Tresnati J, Tuwo A. 2021. Short Communication: Using ecological parametersto assess the sustainability of mangrove ecotourism in Jeneponto, South Sulawesi, Indonesia. Biodiversitas 22 (8): 3571-3577. DOI: 10.13057/biodiv/d220858.

Bera R, Maiti R. 2022. Mangrove dependency and livelihood challenges - A study on Sundarbans, India. Reg Stud Mar Sci 50: 102135. DOI: 10.1016/j.rsma.2021.102135.

Bettinger P, Boston K, Siry JP, Grebner DL. 2017. Valuing and characterizing forest conditions. Forest Management and Planning. Elsevier. DOI: 10.1016/b978-0-12-809476-1.00002-3.

Biodiversity Management Bureau. 2017. Manual on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Manila.

Bitantos BL, Abucay MD, Dacula JA, Recafort RD. 2017. Mangrove in the grove: diversity, species composition, and habitat in Pamintayan, Dumanquillas Bay, Philippines. Adv Environ Sci 9: 183-192.

Cañizares LP, Seronay RA. 2016. Diversity and species composition of mangroves in Barangay Imelda, Dinagat Island, Philippines. AACL Bioflux 9: 518-525.

Cardillo J, Novero AU. 2018. Assessment of mangrove diversity in Santa Cruz, Davao del Sur, Philippines. J Biodivers Environ Sci 14: 53-62.

Cudiamat MA, Rodriguez RA. 2017. Abundance, structure and diversity of mangroves in a community-managed forest in Calatagan, Batangas, Verde Island Passage, Philippines. Asia Pac J Multidiscip Res 5: 27-33.

Dangan-Galon F, Dolorosa RG, Sespene JS, Mendoza NI. 2016. Diversity and structural complexity of mangrove forest along Puerto Princesa Bay, Palawan Island, Philippines. J Mar Isl Cult 5: 118-125. DOI: 10.1016/j.imic.2016.09.001.

Department of Environment and Natural Resources Administrative Order No. 11. 2017. Updated national list of threatened Philippine plants and their categories.

Dimalen FK, Rojo MJ. 2018. Floral diversity of a mangrove forest in Cotabato City, Philippines. J Biol Environ Sci 13: 117-123.

English S, Wilkinson C, Baker V. 1997. Survey Manual for Tropical Marine Resources (2nd ed.). Australian Institute of Marine Science, Townsville.

Fatonah S, Hamidy R, Mulyadi A, Efriyeldi. 2021. Floristic composition and stand structure of mangrove forests with varying vegetation conditions in Sungai Apit, Siak, Riau, Indonesia. Biodiversitas 22: 3972-3983. DOI: 10.13057/biodiv/d220945.

Faustino AZ, Madela HL, Castor RG, Muroda AP, Chavez MNP. 2020. Community mapping and vegetational analysis of the mangrove forest in Calabanga, San Miguel Bay, Philippines. E3S Web Conf 147: 02017. DOI: 10.1051/e3sconf/202014702017.

Forestry Management Bureau. 2014. 2014 Philippine forestry statistics.

Forestry Management Bureau. 2020. 2020 Philippine forestry statistics.

Galerio LP, Martinez CP. 2009. Profile of mangrove forest along Davao Gulf, Tagum City. Southeast Philippines J Res Dev 18: 27-37.

Garcia KB, Malabrigo PL, Gevaña DT. 2014. Philippines' mangrove ecosystem: status, threats and conservation. In: Faridah-Hanum I, Latiff A, Hakeem KR, Ozturk M (eds). Mangrove Ecosystems of Asia. Springer, New York. DOI: 10.1007/978-1-4614-8582-7_5.

Goloran AB, Calagui L, Betco G, Mulgado AT. 2020a. Species composition, diversity and habitat assessment of mangroves in the selected area along Butuan Bay, Agusan Del Norte, Philippines. Open Access Libr J 7: 1-11. DOI: 10.4236/oalib.1106249.

Goloran AB, Demetillo MT, Betco GL. 2020b. Mangroves assessment and diversity in coastal area of Barangay Cagdianao, Claver, Surigao Del Norte, Philippines. Intl J Environ Sci Nat Res 26: 69-77. DOI: 10.19080/IJESNR.2020.26.556188.

Hammer O, Harper D, Ryan P. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontol Electron 4: 9.

Hossain M. 2015. Handbook of selected plant and species of the Sundarbans and the embankment ecosystem. Sustainable Development and Biodiversity Conservation in Coastal Protection Forests, Bangladesh (SDBC-Sundarbans) Project implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), Dhaka.

Howard J, Hoyt S, Isensee K, Pidgeon E, Telszewski M. 2014. Coastal blue carbon: methods of assessing carbon stocks and emission factors in mangroves, tidal salt marshes, and seagrass meadows. Conservation International, Intergovernmental Oceanographic Commission of UNESCO. International Union for Conservation of Nature, Arlington, VA, USA.

IUCN. 2021. The IUCN Red List of Threatened Species. Version 2021-3. International Union for the Conservation of Nature. www.iucnredlist.org.

Jumawan J, Flores FL, Aragon RT, Villamor JMC, Sagot JC, Taguse, HC, Genecera J, Banas GG, Depamaylo AMV. 2015. Diversity assessment and spatial structure of mangrove community in a rehabilitated landscape in Hagonoy, Davao del Sur, Philippines. AES Bioflux 7: 475-482.

Kadaverugu R, Dhyani S, Dasgupta R, Kumar P, Hashimoto S, Pujari P. 2021. Multiple values of Bhitarkanika mangroves for human well-being: synthesis of contemporary scientific knowledge for mainstreaming ecosystem services in policy planning. J Coast Conserv 25 (2): 1-15. DOI: 10.1007/s11852-021-00819-2.

Kathiresan K, Bingham BL. 2001. Biology of mangroves and mangrove ecosystems. Adv Mar Biol 40: 81-251. DOI: 10.1016/S0065-2881(01)40003-4.

Lebata-Ramos M. 2013. Field Guide to Mangrove Identification and Community Structure Analysis. SEAFDEC Aquaculture Department, Iloilo, Philippines.

Lozano EB, Bueno RG. 2015. Species composition, diversity and stand structure of mangroves in Olango Island Wildlife Sanctuary, Cebu, Philippines. CNU J High Educ 9: 28-38.

Long J, Napton D, Giri C, Graesser, J. 2014. A mapping and monitoring assessment of the Philippines' mangrove forests from 1990 to 2010. J Coast Res 30: 260-271. DOI: 10.2112/JCOASTRES-D-13-00057.1.

Matatula J, Afandi AY, Wirabuana PYAP. 2021. Short communication: A comparison of stand structure, species diversity and aboveground biomass between natural and planted mangroves in Sikka, East Nusa Tenggara, Indonesia. Biodiversitas 22: 1098-1103. DOI: 10.13057/biodiv/d220303.

Owuor MA, Mulwa R, Otieno P, Icely J, Newton A. 2019. Valuing mangrove biodiversity and ecosystem services: A deliberative choice experiment in Mida Creek, Kenya. Ecosyst Serv 40: 101040. DOI: 10.1016/j.ecoser.2019.101040.

Patindol T, Casas Jr E. 2019. Species diversity and composition of mangroves in Tacloban City, Philippines. Ann Trop Res 41: 67-75. DOI: 10.32945/atr4126.2019.

Pototan BL, Capin NC, Tinoy MRM, Novero AU. 2017. Diversity of mangrove species in three municipalities of Davao del Norte, Philippines. AACL Bioflux 10: 1569-1579.

Pototan BL, Capin NC, Delima AGD, Novero AU. 2021. Assessment of mangrove species diversity in Banaybanay, Davao Oriental, Philippines. Biodiversitas 22: 144-153. DOI: 10.13057/biodiv/d220120.

Proclamation No. 316. 2000. Declaring the Pindasan Island Mangrove Wilderness Area, Kopiat Island and surrounding portions of Davao Gulf situated in the municipality of Mabini, province of Davao del Norte as a protected area pursuant to RA 7586 (NIPAS Act of 1992) and shall be known as Mabini Protected Landscape and Seascape. https://www.officialgazette.gov.ph/2000/05/31/proclamation-no-316-s-2000/.

Primavera JH. 2000. Development and conservation of Philippine mangroves: Institutional issues. Ecol Econ 35: 91-106. DOI: 10.1016/S0921-8009(00)00170-1.

Primavera JH. 2009. Field guide to the Philippine mangroves. Philippine Tropical Forest Conservation Foundation, Inc. and Zoological Society of London, UK.

Quevedo JMD, Uchiyama Y, Kohsaka R. 2020. Perceptions of local communities on mangrove forests, their services and management: Implications for Eco-DRR and blue carbon management for Eastern Samar, Philippines. J For Res 25 (1): 1-11. DOI: 10.1080/13416979.2019.1696441.

Rosario GR, dela Peña RV, de Guzman R, Abalos RS, Tamayo KE. 2021. Species composition and diversity of mangroves in the riverbanks of barangay Basing, Binmaley, Pangasinan. J Nat Allied Sci 5: 51-59.

Samson JJ, Tobias EG. 2015. Status of mangroves in Naawan, Misamis Oriental and prospects for vegetative expansion. J Environ Aquat Resour 3: 102-112. DOI: 10.48031/msunjear.2015.03.10.

Serrano SC, Tangtham N, Bualert S, Janyasuthiwong S. 2022. Species diversity of mangroves in Central Zambales, Philippines. J Environ Manag Tour 13: 782-789. DOI: 10.14505/jemt.13.3(59).17.

Sharma S, Nadaoka K, Nakaoka M, Uy WH, MacKenzie RA, Friess DA, Fortes MD. 2017. Growth performance and structure of a mangrove afforestation project on a former seagrass bed, Mindanao Island, Philippines. Hydrobiologia 803 (1): 359-371. DOI: 10.1007/s10750-017-3252-x.

Wang L, Jia M, Yin D, Tian J. 2019. A review of remote sensing for mangrove forests: 1956-2018. Remote Sens Environ 231: 111223. DOI: 10.1016/j.rse.2019.111223.