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Diversity and species composition of mangroves species in Pilar, Siargao Island, Surigao Del Norte

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Abstract

Mangroves are considered as the most significant components of the coastal ecosystem and among the most productive and biologically complex ecosystems on the planet. Assessment of mangrove species plays a critical role in the preservation and protection of the mangroves forest. The study aimed to assess the mangrove species in Pilar, Siargao Island. The belt transect was employed with a dimension of modified 10 m x 12 m and was installed per quadrat. Eight mangrove species were identified under four families, and these are *B. sexanguela*, *C. decandra*, *R. apiculata*, *R. mucronata*, *A. alba*, *A. marina*, *L. littorea*, and *X. granatum*. One species, *C. decandra* is categorized by the IUCN as a near-threatened state. Results from the mangroves vegetation structure show that *R. apiculata* got the highest relative frequency (26.32%), density (35.46%), and dominance (55.08%) therefore; it has the highest importance value (116.85%). This further implies that *R. apiculata* is the most important and acclimated mangrove species in the study area. The species diversity in Pilar, Siargao Island falls under very low diversity (H'=1.63) which might be attributed to some human-related disturbances. Thus, further consideration in future planning and conservation to increase the resiliency of the mangrove ecosystem is needed.

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Introduction

The mangrove forest is one of the vital ecosystems in tropical countries. The Philippines used to be covered by 400,000-500,000 ha of mangroves in 1920 but decreased to around 120,000 ha in 1994 (Garcia *et al.,* 2014). A study conducted by Long *et al.* (2014) using Landsat satellite data provides the most reliable estimation of total mangrove area loss in the country from 1918-2010 with a decreased by approximately half (51.8%). The Philippines alone is home to at least 39 mangrove species (Primavera and Esteban, 2008; Thompson *et al.,* 2017) and similar to other regions, the various natural products and ecological services (Barik *et al.,* 2018) of this resource are well recognized in the country, including its role in climate change mitigation (Donato *et al.,* 2011; Dangan-Galon *et al.,* 2016).

Mangroves are nearly restrained to the tropics and are characterized as dicotyledonous woody shrubs or trees. They often form a dense intertidal forest that dominates muddy intertidal shores, frequently consisting of virtually monospecific patches or bands (Hogarth, 2015) and they are distributed in subtropical to tropical regions of the world (Walstra *et al.,* 2015). According to Kamal *et al.* (2015), a large number of organisms thrive in this habitat and contribute with its lifestyle to its unique character. Besides, Huggett and Kaplan (2016) stated that apart from the various ecosystem goods and services to coastal inhabitants, mangrove forests provide ecological services such as bioprotection from littoral erosion natural breakwaters, dissipation of the energy of the waves and tsunamis, and protection from cyclonic storms (Giri *et al.,* 2015). In accord with this, Barbier (2016) indicated that mangrove ecosystems are among the most productive and biologically complex ecosystems on the planet.

Mangrove forests, due to their biophysical characteristics can mitigate the effect of storms, floods, erosion, and wind, therefore contributing to disaster risk reduction and climate change adaptation (Duarte *et al.,* 2013). For the prevention of erosion and retention of sediments, mangroves use their aerial roots while to lessen the force of inward winds and waves and decrease flooding they use canopy, roots, and trunks (McIvor *et al.,* 2016). Based on the report of Primavera *et al.* (2012), restoration is the vital management means to fight losses of mangrove and Wylie *et al.* (2016) stated that developing payments for ecosystem services (PES) projects are rehabilitated mangroves that are blue carbon-based. Marois and Mitsch (2015) reported that the significance of mangrove coastal security is progressively recognized by the governments and Primavera *et al.* (2014) specified that the national coastal greenbelt replanting programmed is now extensive after current natural disasters.

Furthermore, Kelleway *et al.* (2017) reported the important ecological services provided by the mangroves but despite this, they are threatened by land-use change (Thomas *et al.,* 2017). Several reports warn that 20–35 % of the world's mangrove area has been lost in the last two decades (Polidoro *et al.,* 2010; Feller *et al.,* 2017). Although the majority of mangrove species are widespread and not considered to be threatened with extinction, 16 % (11 species) of the 73 true mangroves are categorized as threatened by extinction (Polidoro *et al.,* 2014). Climate change influences and great vulnerability to anthropogenic activities (Primavera, 2005; Lovelock *et al.,* 2015) has, however, directed to the deteriorations of mangroves area worldwide for about 30–50% (Duncan *et al.,* 2016), with continuous damages of 0.16–0.39% per annum (Hamilton and Casey, 2016). Another reason for mangrove deforestation and the major driving force of mangrove forest loss in Southeast Asia and the Philippines is the rapid expansion of aquaculture development (Moity *et al.,* 2019). Despite greater conservation and localized replanting efforts, mangrove degradation in the Philippines is still expected (Samson & Rollon 2008; Richards and Friess, 2016). Therefore, the valuation of the continuing mangrove forest is crucial in conserving and keeping the enduring mangrove forest in the Philippines. Based on the data collected by the Department of Environment and Natural Resources-Forest Management Bureau in 2013 (Israel and Lintag, 2013; Lachica, 2014), there was a significant decrease in the total forest cover of the Philippines from 1934-2010. Recorded data for mangrove habitat area over the past decades also revealed a substantial loss of almost 75% (Primavera and Esteban, 2008; Samson, 2011) which translates very significantly especially because most Philippine villages are along or dependent on coastal resources (Richards, and Friess, 2016). If this continues to worsen, habitat loss will result in loss of biodiversity, which will soon affect specific ecosystem functions and ultimately the society (Cardinale *et al.,* 2012; Newbold *et al.,* 2015).

Concerning this, the study was beneficial in giving baseline data to the community of Pilar, Siargao Island, Surigao Del Norte about the current status of mangroves species in their area. Also, it provides information if there are necessary actions to protect and enhance the growth of mangroves species.

Materials and methods

Sampling Method

The study area is located at Pilar, Siargao Island, Surigao del Norte with the coordinates of 9°52′N 126°06′E. The belt transect method was used to ensure that the transect line extends from the seaward zone to the most landward zone of the mangrove forest with transect lines perpendicular to the baseline at every 100-m interval (Biodiversity Management Bureau, 2017). Quantum Geographic Information System (QGIS) was used to designated, delineated, and digitally mapped the selected quadrats as the study area. A plot measuring a modified quadrat of 10m x 12m was laid in each survey site and the actual location of each quadrat was found using Global Positioning System (GPS) (Fig. 1). Mangroves species inside each quadrat were initially identified and counted.

Mangroves identification and conservation status

With the use of the mangrove field guide by Primavera and Dianala (2009), the identification and classification of the mangrove species in the study area were completed. An expert botanist validated the identified species names. Moreover, the conservation status of each mangrove species identified was determined through the International Union for Conservation of Nature (IUCN) Red List data.

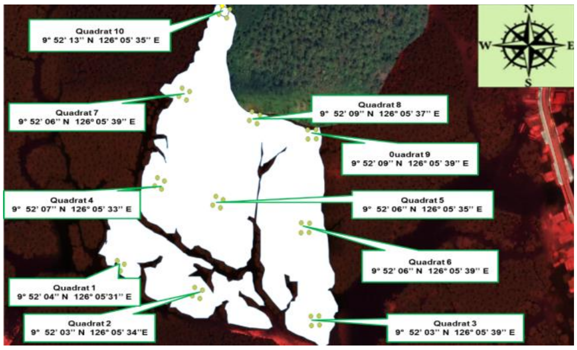

Fig. 1. Map of selected quadrats in a sampling area.

Mangrove structure analysis

To analyze the mangrove structure and vegetation of the study area the relative density, relative frequency, relative dominance, and importance value were calculated (Paz-Alberto *et al.,* 2015). This kind of analysis rank or order for a particular species within the forest community (Cañizares and Seronay, 2016).

Diversity indices

The values of the calculated species diversity index (SDI) were assessed based on the Fernando Scale (1998) that shown in the table below. The categorized value was used to determine the diversity of the study sites.

Species Diversity Index (SDI) = (Shannon Index of Diversity) Hl = Σpi1n (pi)

Where: pi = ratio of species from the total species

1n = natural logarithm

Table 1. Categorized value of Fernando Scale (1998).

Relative Values	Shannon Index (Hl)
Very High	3.5 and above
High	3.0 - 3.49
Moderate	2.5 - 2.99
Low	2.0 - 2.49
Very low	1.9 and below

Human-resource Interaction

Disturbances to mangrove forests that are linked to humans were evaluated by actual surveillance of the researcher. Disturbances observed were verified using the Key Informant Interview (KII) (Dangan-Galon *et al.,* 2016).

Results and discussions

Conservation Status of Mangrove Species

Eight mangrove species were identified and belong to four different families. All represent true mangrove species namely *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam., *Lumnitzera littorea* (Jack) Voigt, *Xylocarpus granatum* Koen., *Ceriops decandra* (Griff.) W. Theob, *Bruguiera sexangula* (Lour.) Poir., *Avicennia alba* Blume, and *Avecennia marina* (Forsk.) Vierh. Regarding the conservation status out of eight species of mangroves, seven species were assessed by the IUCN with the least concern status and one near-threatened status. The list of observed mangrove species is shown in Table 2.

Based on the definition of Tomlinson (2016) regarding true mangroves species they are not located in terrestrial communities and only take place in mangrove forests; they play a major role in the organization of the mangrove community, at times creating pure stands; they have physical specialisms to the mangrove setting, and have some way for salt elimination. Additionally, the same author described true mangroves as the key constituents of mangrove forests globally and these comprise of all mangrove species under the genera of *Avicennia*, *Bruguiera*, *Ceriops*, *Kandelia*, *Lumnitzera*, *Rhizophora*, and *Sonneratia*, and the species *Nypa fruticans* and *Laguncularia racemose*. Furthermore, based on Baba *et al.* (2016), *Xylocarpus granatum* is considered as true mangroves and are found at the landward side of mangrove forests and in associated brackish-water habitats.

Table 2. Mangrove species composition and conservation status in Pilar, Siargao Island, Surigao del Norte.

Family	Scientific name	Common name	Conservation Status (IUCN*)
Avicenniaceae	*Avecennia alba*	Bungalon	Least concern
Avicenniaceae	*Avecennia marina*	Bungalon	Least concern
Combretaceae	*Lumnitzera littorea*	Tabao	Least concern
Meliaceae	*Xylocarpus granatum*	Tabigi	Least concern
Rhizophoraceae	*Bruguiera sexangula*	Pototan	Least concern
Rhizophoraceae	*Rhizophora mucronata*	Bakhaw-babae	Least concern
Rhizophoraceae	*Ceriops decandra*	Baras baras	Near Threatened
Rhizophoraceae	*Rhizophora apiculata*	Bakhaw lalaki	Least concern

Only *C. decandra* was identified as nearly threatened based on the data of IUCN, comparable results were observed with Abino *et al.* (2014) and Pototan *et al.* (2017). Canizares and Seronay (2016) reported Rhizophoraceae as the leading family of mangroves in the Dinagat Islands, the same goes for Carmen and Panabo in Davao del Norte (Pototan *et al.,* 2017), Samar (Abino *et al.,* 2014), and in Puerto Princesa, Palawan (Dangan-Galon *et al.,* 2016). This proposes that species in the family Rhizophoraceae are further plentifully extent all through the archipelago and that it is the species best modified to the Philippine seaside environment.

Ecological and Economic Functions of Mangrove Species

The given ecological and economic functions of mangroves species were based from the information obtained from the qualified key informant, which is a sea patrol and a forest ranger from the Department of Environment and Natural Resources (DENR) and representative of Siargao Island Protection of Landscape and Seascape (SIPLAS) in the municipality of Pilar, Siargao Island. Some of the ecological functions are for flood reduction, protection barrier, maintenance of the water quality, retention of nutrients and sediments, storm buffering, and habitat and nursery of some plants and animal species in the end can sustain the diversity of these organisms. While the identified economic functions are source of food, ecotourism purposes, source of herbal medicine, material for house building, profitable fishing and hunting, provide timber for fuel, and for boatbuilding, house post, wood gate, and furniture.

Barbier (2007) reported that mangroves offer a shield of beaches and coastlines from storms, waves, and floods; beach and soil erosion decline; and carbon confiscation. The study of Lee *et al.* (2014) and Duke and Schmitt (2015) informed that they also deliver nursery grounds, food, housing, and home for an extensive variety of water species and in this manner rise profits through fisheries. The part of mangrove forests to requisite considerable quantities of atmospheric carbon dioxide and stock carbon in its biomass has been emphasized (Chen *et al.,* 2012). Cañizares and Seronay (2016) study informed that the mangrove forests are recognized homes for invertebrates while supporting other smaller communities like phytoplankton and zooplankton. They are also confirmed to be good nurture spots for marine juveniles (Long and Giri, 2011) which retains the population of marine animal's constant seeing that fishing is a significant living in the Philippines. Likewise, mangroves are laying place to numerous bird species (Garcia *et al.,* 2014) and it helps avoid the erosion of unconsolidated coastlines and ensuing flooding (Schmitt and Duke, 2015). It can be used for charcoal, firewood, and timber (Long and Giri, 2011), and they act as blue carbon descends, and pulls noteworthy attention from the global community (Lawrence, 2012).

Mangrove vegetation structure

The species *R. apiculata* occur most in the study area having the highest relative frequency (26.32%), population density (35.46%), relative dominance (55.08%), and importance value (116.8%) is shown in Table 3. This implies that *R. apiculata* is the most important and acclimated mangrove species in the study area. It chiefly offers a good index than density only, taking into account the meaning or purpose of a species in its home (Rotaquio *et al.,* 2007).

The same results were reported from Paz-Alberto *et al.* (2015) stated that *R. apiculata* showed the highest relative density, relative dominance, and species importance value in Triboa Mangrove Park, Subic Bay. However, contrast results were obtained from the studies of Pototan *et al.* (2017) showed that *R. mucronata* and A. *marina* were the top species found in the three municipalities of Davao del Norte. And Cardillo and Novero, (2018) reported that *R. mucronata* have relatively high dominance and density in Sta. Cruz, Davao del Sur. Pacyao and Llameg (2018) described that the *Rhizophora* species select places with clay loam soil type.

Table 3. Diversity indices of the mangrove species from Pilar, Siargao Island.

Mangrove Species	RF (%)	RD (%)	RDo (%)	IVI (%)
Rhizophora apiculata	26.32	35.46	55.08	116.85
Rhizophora mucronata	23.68	18.53	15.04	57.25
Bruguiera sexangula	21.05	19.72	17.04	57.81
Ceriops decandra	7.89	15.14	10.04	33.08
Xylocarpus granatum	10.53	7.57	2.51	20.61
Avicennia marina	5.26	1.00	0.04	6.30
Lumnitzera littorea	2.63	2.39	0.25	5.27
Avicennia alba	2.63	0.20	0.00	2.83

Note: RF=Relative Frequency, RD=Relative Density, RDo=Relative Dominance, IVI=Importance Value Index

Diversity Index of Mangrove Species

The results indicated a very low diversity of mangroves species with H'=1.63 Shannon Diversity Index. Numerous mangroves forest in the Philippines has been reported having low or very low diversity. Paz-Alberto *et al.* (2015) obtained the species diversity index (H'=0.64) in Triboa Mangrove Park Subic Bay indicate low diversity. Paz-Alberto *et al.* (2014) obtained similar findings on the low diversity and population of mangroves in Masinloc, Zambales due to human activities. Abino *et al.* (2014) reported that the community's species diversity (H'= 1.6365) in Samar was very low with eight true mangrove species recorded. The diversity index (H'= 0.8165 to 1.4185) in San Juan, Batangas is very low with nine species recorded (Gevańa and Pampolina 2009). The same results were observed in Calatagan, Batangas, Verde Island with very low (H'=1.1936) species diversity (Cudiamat and Rodriguez (2017). Canizares and Seronay (2016) which yielded a value of H'=1.856 for Dinagat Islands, and Dangan-Galon *et al.* (2016) reported that several barangays in Puerto Princesa Bay, Palawan Island have a diversity index of 0.912, 0.768, 0.760, and 0.349 (H') indices despite having a total of twenty-eight mangrove species. Furthermore, the Shannon index (H'=2.209) in Santa Cruz, Davao Del Sur (Cardillo and Novero, 2018) is comparatively higher than the cited studies.

Human-Related Disturbance to Mangroves Forest

The same key informant was questioned regarding the human-related environmental disturbances in mangroves forest in the municipality of Pilar, Siargao Island.

Some of the human interventions are mangroves deforestation for firewood, charcoal production, and wood construction. Disposal of plastics and garbage in the water; cutting or elimination of mangroves roots to collect crabs and fish for food; for human settlements, and building of infrastructure such as ports for the tourist boat. Direct dumping of used oil from the boat, uncollected plastics, and remain used fishing nets are the sources of water pollution observed.

Human-related disturbances in the study were comparable to the study of Dangan-Galon *et al.* (2016) in Puerto Princesa Bay, Palawan Island such as garbage dumping, occasional cutting of the tree, soil erosion, and encroachment of human settlers. In addition, Paz-Alberto *et al.* (2015) specified that the settlement of humans, aquaculture pollution, and wastes from households might contribute to the destruction of the mangrove ecosystem.

The Philippines is one of the countries with a great number of true mangrove species, having about 42 species demonstrating 18 families (Samson and Rollon, 2011). Though, because of their availability, these coastal forests have a very high risk of being subjected to many stresses linked to growing activities and are often over-exploited.

Mangroves were converted to other forms of land use and have been degraded on a large scale (Giri *et al.,* 2015). Enormous areas of mangroves in this country have been vacant and rehabilitated to aquaculture ponds (Lawrence 2012). If this stays to deteriorate, home damage will end in loss of biodiversity that will rapidly disturb specific ecosystem roles and finally the society (Cardinale *et al.,* 2012). This loss increases to the notable decrease in forest biomass, giving consideration to the already disturbing amount of carbon dioxide in the atmosphere (Abino *et al.,* 2014).

Conclusion

Eight mangrove species are identified and classified under four families in the mangroves forest at Pilar, Siargao Island and only *Ceriops decandra* is categorized by the IUCN as a near-threatened state. The most vital and acclimated mangrove species in the study area is *R. apiculata* by having the highest relative frequency (26.32%), density (35.46%), and dominance (55.08%), and importance value (116.85%). The species diversity falls under very low diversity (H'=1.63) which might be attributed to some human-related disturbances. Thus, further consideration in future planning and conservation to increase the resiliency of the mangrove ecosystem is needed.

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