Flora Assessment and Total Carbohydrate Analysis on Flower Nectars of Mangrove Species in Leyte Gulf, Maqueda Bay, and Matarinao Bay, Philippines: Potential Ecosystems for Apiculture

Monique Clarice Q. Cañete*, Niña Mae C. Labitao, Marion Nicole M. Pacheco, Nicole C. Regorosa, Izabelle Trina M. Vivero, Maria Elisa B. Gerona*

Division of Natural Sciences and Mathematics, University of the Philippines Visayas, Tacloban College Tacloban City, (6500), Philippines

ABSTRACT

Tropical mangrove ecosystems are known for high productivity and extensive ecosystem services. While there has been extensive research on floristics and faunistics in mangroves, there has been limited information in community structure and carbohydrate analysis of flower nectars, which can be explored for possible apiculture. The study was conducted to assess community structure, species diversity, and total carbohydrate (TC) analysis of floral nectars in 15 mangrove sites in Maqueda Bay, Matarinao Bay, and Leyte Gulf in Samar, Eastern Samar, and Leyte, respectively. A total of 15 sites were assessed using the transect line-plot method. A total of 23 mangrove species were identified from the 15 sites (2 dominant, 17 minor, and 2 associated species) belonging to 12 families, including 21 true mangroves and 2 mangrove associates. Leyte Gulf and Maqueda Bay have 17 species, while Matarinao Bay has 13 species. In general, the mangrove sites are dominated by *Rhizophora apiculata* and *Sonneratia alba*. Rehabilitated sites are dominantly planted with *Rhizophora*. In contrast, natural mangrove stands are composed of mixed species of *Aegiceras*, *Avicennia*, *Brugueira*, *Rhizophora*, *Sonneratia*, and *Xylocarpus*. Across the three habitats, *S. alba* showed much higher nectar TC (mg) per flower than *R. apiculate* ranging from 7.45 – 0.02 mg/ flower. These data suggest that sites dominated with *S. alba* has good prospects for apiculture, considering the total carbohydrate analysis, over the popularly planted *R. apiculata.*

KEYWORDS

apiculture, mangroves, total carbohydrates

INTRODUCTION

The Philippines has one of the longest coastlines that extends to 36, 289 km (Long and Giri 2011). Due to its characteristic geographical location, mangrove species diversity is relatively high, supporting 50% of approximately 65 mangrove species in the world (Primavera et al. 2016; Kathiresan and Bingham 2001). In recent years, mangrove areas are converted to agricultural projects such as aquaculture ponds that cause the decline of mangrove ecosystems (Wolf 2012). Habitat destruction through human encroachment has been the primary cause of mangrove loss (Kathiresan and Bingham 2001). Numerous mangal areas have been destroyed for road construction, channels and converted to open land for grazing and farming purposes, income generating activities, and more recently for aquaculture, altering the nature of the habitat (Ramírez-García et al. 1998). These anthropogenic impacts are likely to continue and worsen as human populations expand. In addition, tropical cyclone landfall numbers in the Philippines varied from 3.6 to 6.0 in the period between 1902 and 2005 (Kubota and Chan 2009; Brown 2013), and the number of tropical cyclones making landfall around Leyte Island has been steadily increasing over the past 7 decades (Takagi and Esteban 2016). Last November 8, 2013,

**Corresponding Author:*
Division of Natural Sciences and Mathematics, University of the Philippines Visayas, Tacloban College (6500); email address: moniqueclaricecanete@gmail.com; mbgerona@up.edu.ph; Tel. No. +6353 3218299

Super Typhoon Haiyan, locally named as "Super Typhoon Yolanda", struck Eastern Visayas, causing destruction of 1.1 M housing facilities, displacement of 4.1 M people, and the death of over 6 000 people (National Disaster Risk Reduction and Management Council 2013; United States Agency for International Development 2014). This typhoon caused massive destruction in mangrove stands in Leyte and Samar last 2013 (Primavera et al. 2016). The essential role of mangrove for storm protection is substantial in scientific literature (McIvor et al 2012), hence in the Philippines mangrove rehabilitation started in the early 1990's in response to continuing mangrove decline.

Mangroves also provide optimum habitat for a rich assemblage of species. The muddy or sandy substrates of the mangroves, with aerial roots, trunks, leaves and branches, host the growth and development of different species of epibenthic, infaunal, and meiofaunal invertebrates, with reservoirs within the mangroves supporting communities of phytoplankton, zooplankton, and fish as well (Cañiranez and Seronay 2016). The ecological impacts of mangrove ecosystems include their capability to sequester approximately 14% of carbon as a component of the global ocean, which makes them one of the most carbon-rich biomes in the world (Alongi 2016). McLeod et al. (2011) describes the carbon assimilated in coastal and marine ecosystems as "blue carbon", further explaining that mangal vegetation contributes to greater carbon sequestration than that of terrestrial forests despite their smaller global area than the latter. These intertidal plants store carbon as large pools in soil and dead roots, thereby reducing the impact of increasing carbon dioxide concentrations in the atmosphere (Alongi 2016).

Mangroves may be further developed as sources of high-value commercial products, aside from its ecological functions. Communities along the coastal areas use them for charcoal making, as fuelwood, handles for fishing implements, and materials for roofing and other construction work (Sinfuego and Buot 2013). With purposes to conserve and benefit from mangrove areas, recent sustainable livelihood projects are initiated by coastal communities worldwide. One of such is bee-keeping or apiculture, where the mangroves are used as mediums to form bee colonies. This livelihood project would contribute to the economic status of a locality without the destruction of the trees, in contrast to other projects such as aquaculture ponds and charcoal making. Protecting mangrove forests will lead to a denser flora community that serves as a barrier to increased intensity of waves during typhoons. Apiculture also improves the mutualistic relationship between mangroves and bees (Baines and Whittaker 2016).

This study aimed to assess the selected mangrove forests and provide information on its potential for apiculture in Leyte Gulf, Matarinao Bay, Maqueda Bay. The flora composition, diversity and total carbohydrate content of flower nectars are discussed. These data are necessary in the development or upgrading of management interventions for specific sites.

MATERIALS AND METHODS

Rapid assessment of the mangrove areas along Leyte Gulf, Maqueda Bay, and Matarinao Bay was done on several outings from January to April 2018 to assess the extent and species composition of mangrove vegetation. The coordinates of study sites were traced using a Garmin GPS receiver unit were plotted using QGIS 2.18.9 platform.

Study Site

The study site includes Leyte Gulf, Maqueda Bay, and Matarinao Bay of Leyte-Samar Islands. Based on the data provided by Bureau of Fisheries and Aquatic Resources VIII (BFAR 8) and Department of Environment and Natural Resources VIII (DENR 8) on coastal mangrove areas and rehabilitation projects in Eastern Visayas, a total of fifteen sites were assessed; six in Leyte Gulf, six in Maqueda Bay and three sites in Matarinao Bay (Figure 1). All sites are natural mangrove stands, except for San Joaquin, Palo (5-yr *Rhizophora* plantation). Leyte Gulf is situated in the Eastern Visayas region of the Philippines (10°50'00" N and 125°25'00" E) bordered by the Samar and Leyte Islands in the northern and western areas, respectively. Maqueda Bay (11°43'21" N, 124°58'7" E) is a marginal bay facing Samar Sea with coastal communities highly depending on aquatic resources. Matarinao Bay (11°12'35" N, 125°34'36" E) is located on the eastern side of the region, directly facing the Pacific Ocean.

Sampling Plots

The transect line-plot method was employed in the assessment of mangrove vegetation. For each site, at least three transect lines were laid perpendicularly to the shore from the seaward margin of the mangrove

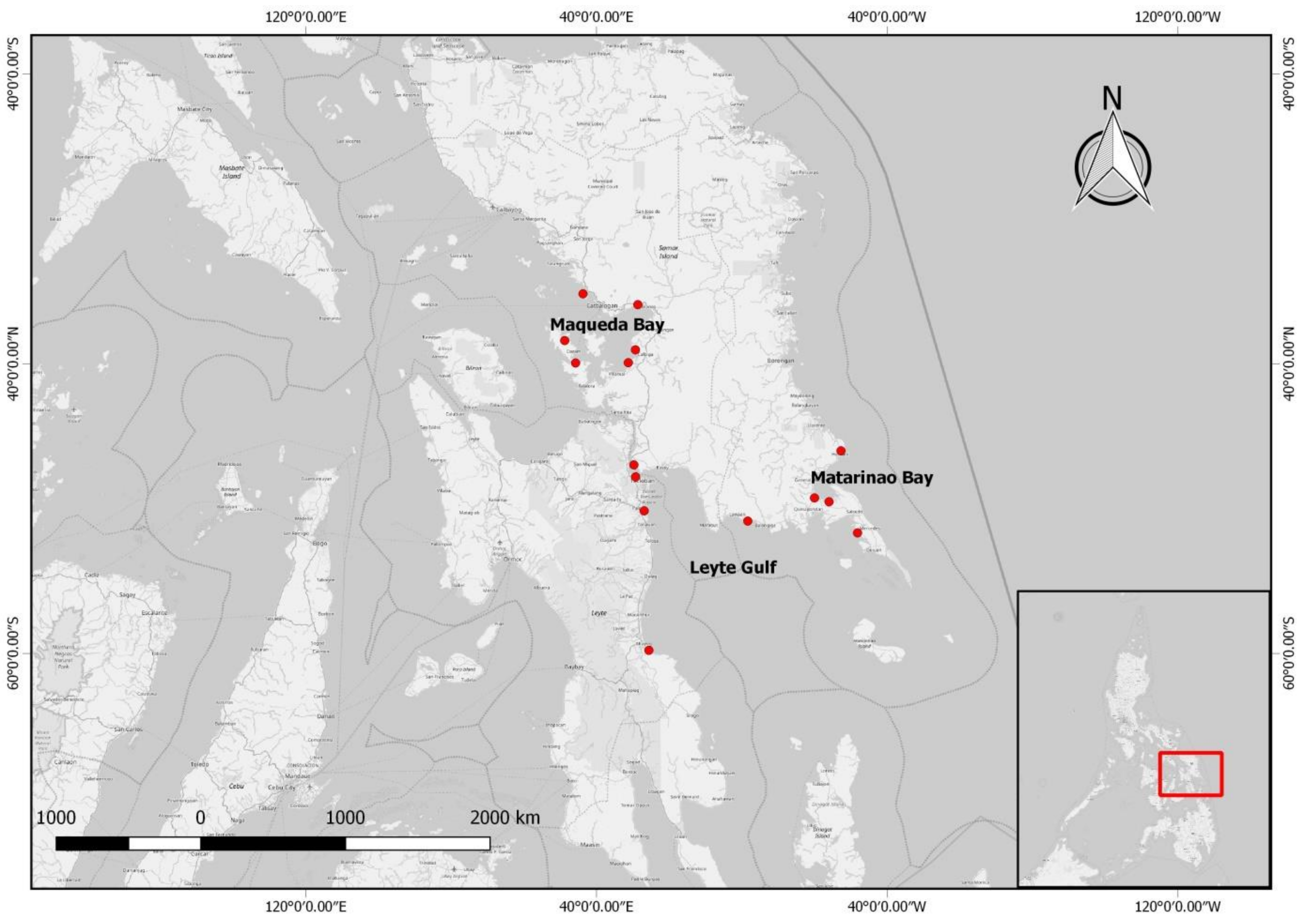

Figure 1. Map of Leyte-Samar Islands showing the selected sites in Leyte Gulf, Maqueda

to the landward margin. On each transect line, 10 m x 10 m plots were laid out with varying intervals, the number of such plots (e.g. 1-3) depended on the length of the transect line. Transect lines with a length of less than 20 m had no intervals; a length of 20-50 m had 10 m interval between each plot; and greater than 50 m had uniform intervals between one transect line from another as laid perpendicularly (English et al 1994; Kathiresan 2000; Deguit et al. 2004). At each plot, all flora encountered were identified and counted and its girth breast height was measured at 1.3 m from the ground. Mangroves were further classified as seedlings: < 1 m high and < 4 cm stem diameter; saplings: > 1 m high and < 4 cm stem diameter; and trees: > 1m high and > 4 cm stem diameter (English et al. 1997; Deguit et al. 2004). Species diversity (Shannon- Wiener index, H′), dominance (Simpson's index, D), and evenness (Pielou's index, J') were determined for each site separately using all the species present.

Total Carbohydrate Analysis of Flower Nectars

Flower of the two predominant species in the most diverse mangrove forest in each bay (*R. apiculata* and *S. alba*) were harvested for the determination of total carbohydrates. The sugar concentration of the nectar was initially measured in the field using a hand-held refractometer, however due to low floral nectar volume (< 1 mL), readings were inconsistent. Additionally, measuring low volumes of nectar is difficult with hand-held refractometers, except those with extremely sensitive prisms (McKenna and Thomson, 1988). Therefore, in this study, collection of flower nectars was done using the washing method established by Morrant et al. (2009) with minor modifications. In this procedure, flowers were placed in tubes containing distilled water, agitated in a vortex for 2 min and filtered using Whatman filter paper no. 42 to make the nectar sample. Specifically, one flower of *S. alba* was washed with 5 mL of distilled water, while one flower of *R. apiculata* was washed with 1 mL of distilled water because of its smaller size (Adagaba et al. 2017). Total carbohydrate (TC) analysis was done using phenol-sulfuric acid method of Dubois et al. (1956). An 8 μL aliquot from the nectar sample was diluted to 1 mL with distilled water and added with 1 ml 5% phenol, followed by 5 ml concentrated H_2SO_4. The absorbance of the solution was read at 490 nm using a UV-Vis spectrophotometer (UNICO-S2100UV+) Total carbohydrate was calculated by reference to the standard curve of glucose and expressed as mg of nectar per flower:

$$\text{Total carbohydrate}\left(\frac{\text{mg of nectar}}{\text{flower}}\right)=\left(\frac{\text{Concentration of nectar sample}}{\text{\# of flowers}}\right)\times 0.008\text{ mL}$$

where concentration of nectar sample (mg/mL) was calculated from the glucose standard curve.

RESULTS

Floristic Composition

The taxonomic composition of the mangrove flora along Leyte Gulf, Maqueda Bay, and Matarinao Bay is listed in Table 1. A total of 23 mangrove species were identified from the 15 sites (2 dominant, 17 minor, and 2 associated species) belonging to 12 families, including 21 true mangroves and 2 mangrove associates. Leyte Gulf and Maqueda Bay have 17 species, while Matarinao Bay has 13 species. In general, the mangrove sites are dominated by *Rhizophora apiculata* and *Sonneratia alba*. Rehabilitated sites are dominantly planted with *Rhizophora*. In contrast, natural mangrove stands are composed of mixed species of *Aegiceras, Avicennia, Brugueira, Rhizophora, Sonneratia,* and *Xylocarpus.*

Diversity and structure of mangrove vegetation

The ecological features of the mangrove sites were analyzed using parameters species diversity (Shannon- Wiener index, H′), dominance (Simpson's index, D), and evenness (Pielou's index, J'). Table 2 shows the species diversity, dominance, and evenness of the selected mangrove sites along Leyte Gulf, Maqueda Bay, and Matarinao Bay. The results showed that Maslog, Lawaan, Astorga, Daram and Buenavista, Quinapondan in Leyte Gulf, Maqueda Bay and Matarinao Bay, respectively had the highest diversity index from each bay. The most diverse mangrove sites are also the sites with the highest evenness index, J from each bay.

In assessing the condition of mangrove sites, the criteria set by Deguit et al (2004) was followed using percent crown cover, regeneration per square meter and average height of trees (Fig. 3). In Leyte Gulf, the condition of the mangrove forests varies between sampling stations. In terms of percent crown cover, Buenavista has a good condition with a value of 36.70%, while San Joaquin, Palo has very poor condition in terms of crown cover (%) because there were still no trees present. Regarding the percent regenerative capacity, all sites are excellent in condition. For Maqueda Bay, the mangrove condition in Cabugawan and Oyandic have excellent percent crown cover, despite the lowest # of seedlings/m^2 of the former. In Matarinao Bay, noticeably Caridad, Salcedo has an excellent condition in all the parameters. Average height for all trees ranges from 2 to 4 meters.

To estimate the overall importance or influence of a species in a community, the importance value of each species was considered from the most diverse site per bay. The species composition, relative density, relative frequency, relative dominance, and importance values of the constituent species from each bay are shown in Table 3. In Maslog, Lawaan, *R. apiculata* obtained the highest IVI of 80.02, followed by *S. alba* with 76.88. *A. floridum* had the least IVI value of 4.16. Likewise, in Astorga, Daram, the most influential species was *R. apiculata* followed by *S. alba* having 76.78. In contrast, *S. alba* (112.05) was the most important species in Buenavista, Quinapondan, followed by *R. apiculata* (98.86).

Total Carbohydrate Content

Mangrove species used to quantify the total carbohydrate content of nectar was determined through calculation of Shannon Weiner Diversity Index values and relative dominance of species. With Shannon Weiner Diversity Index, the most diverse among 15 sampling stations in the three bays are Astorga, Daram, Samar, Buenavista, Quinapondan, Eastern Samar, and Maslog, Lawaan, Eastern Samar. The two most predominant species in these diverse stations were determined by the respective importance value index (IVI) of mangrove species. It turned out that *S. alba* and *R. apiculata* were the two most dominant species in all of the diverse stations. Flowers of mangroves vary from the powder puff like appearance of *S. alba* because of its white petals and numerous stamens on display attractive to

Table 1. Taxonomic composition of mangrove flora along Leyte Gulf, Maqueda Bay, and Matarinao Bay.

Mangrove Species	Local Name	Leyte Gulf	Maqueda Bay	Matarinao Bay
I. Major/ Dominant species				
RHIZOPHORACEAE				
Rhizophora apiculata	bakhaw lalaki	✓	✓	✓
SONNERATIACEAE				
Sonneratia alba	pagatpat	✓	✓	✓
II. Minor species				
AVICENNIACEAE				
Avicennia alba	bungalon, miapi	✓	✓	✓
A. marina	bungalon, miapi	✓	✓	✓
A. officinalis	bungalon, miapi	✓	X	X
BOMBACACEAE				
Camptostemon philippinense	gapas-gapas	X	✓	✓
COMBRETACEAE				
Lumnitzera littorea	tabao, kulasi	X	X	✓
Euphorbiaceae				
Excoecaria agallocha	lipata, buta-buta	✓	✓	X
MELIACEAE				
Xylocarpus granatum	tabigi	✓	✓	✓
X. mollucensis	piag-ao	X	✓	✓
MYRSINACEAE				
Aegiceras corniculatum	saging-sanging	✓	✓	✓
A. floridum	saging-saging	✓	✓	X
MYRTACEAE				
Osbornia octodonta	tawalis	X	✓	X
RHIZOPHORACEAE				
Bruguiera gymnorrhiza	pototan, busain	✓	✓	✓
B. cylindrica	pototan, busain	✓	X	X
Ceriops decandra	baras-baras	✓	✓	X
C. tagal	tungog, tangal	✓	✓	X
Rhizophora stylosa	bakhaw bato	✓	✓	X
R. mucronata	bakhaw babae	✓	X	✓
SONNERATIACEAE				
Sonneratia caseolaris	pedada	X	X	✓
STERCULIACEAE				
Heritiera littoralis	dungon	X	X	✓
III. Associated species				
ACANTHACEAE				
Acanthus ebracteatus	lagiwliw	✓	✓	X
ARECACEAE				
Nypa fruticans	nipa, sasa	✓	✓	X
Total no. of species		**17**	**17**	**13**

Table 2. Species diversity and evenness of selected mangrove sites along Leyte Gulf, Maqueda Bay, and Matarinao Bay.

	Mangrove Sites	Shannon-Wiener Index (H')	Simpson's Index (D)	Evenness (J')
Leyte Gulf	Anibong, Tacloban	1.42	0.67	0.59
	Buenavista, Abuyog	1.48	0.70	0.62
	Tinaogan, Basey	0.72	0.34	0.40
	Maslog, Lawaan*	1.71	0.78	0.82
	Bubon, Mercedes	1.35	0.70	0.69
Maqueda Bay	Oyandic, Motiong	1.03	0.52	0.58
	San Isidro, Pinabacdao	1.35	0.65	0.56
	Astorga, Daram*	1.82	0.80	0.76
	Cabugawan, Catbalogan	0.51	0.26	0.47
	Pasigay, Calbiga	1.33	0.65	0.58
	Real, Daram	1.14	0.58	0.71
Matarinao Bay	Nagaja, Hernani	0.56	0.37	0.80
	Buenavista, Quinapondan*	1.35	0.69	0.70
	Caridad, Salcedo	1.24	0.64	0.54

Table 3. Relative density (RD), relative frequency (RF), relative dominance (RDo), and importance value index (IVI) of mangroves in the most diverse sites from the three habitats.

Site	Species	RD (%)	RF (%)	RDo (%)	IVI (%)
Maslog, Lawaan, E. Samar, Leyte Gulf	*A. floridum*	0.88	3.22	0.05	4.16
	B. gymnorrhiza	8.85	22.58	2.67	34.10
	C. tagal	17.70	6.45	14.22	38.37
	*R. apiculata**	35.40	32.26	12.36	80.02
	R. stylosa	20.35	12.90	19.27	52.52
	*S. alba**	14.16	12.90	49.82	76.88
	X. granatum	2.65	9.68	1.61	13.94
Astorga, Daram, Samar, Maqueda Bay	*A. alba*	4.81	0.62	16.60	22.03
	A. corniculatum	2.40	16.88	0.57	19.85
	A. marina	12.50	20.00	4.83	37.33
	B. gymnorrhiza	1.44	0.62	0.64	2.71
	C. decandra	0.48	0.62	0.04	1.15
	C. tagal	0.96	0.62	0.57	2.16
	*R. apiculata**	31.73	20.62	34.49	86.84
	R. stylosa	16.83	20.00	12.17	49.00
	*S. alba**	28.36	19.38	29.04	76.78
	X. granatum	0.48	0.62	1.04	2.14
Buenavista, Quinapondan, E. Samar, Matarinao Bay	*A. alba*	3.57	12.00	6.92	22.49
	A. marina	20.92	16.00	7.22	44.14
	B. gymnorrhiza	3.06	12.00	2.86	17.92
	C. philippinenses	0.51	4.00	0.02	4.53
	*R. apiculata**	44.39	28.00	26.48	98.86
	*S. alba**	27.55	28.00	56.50	112.05

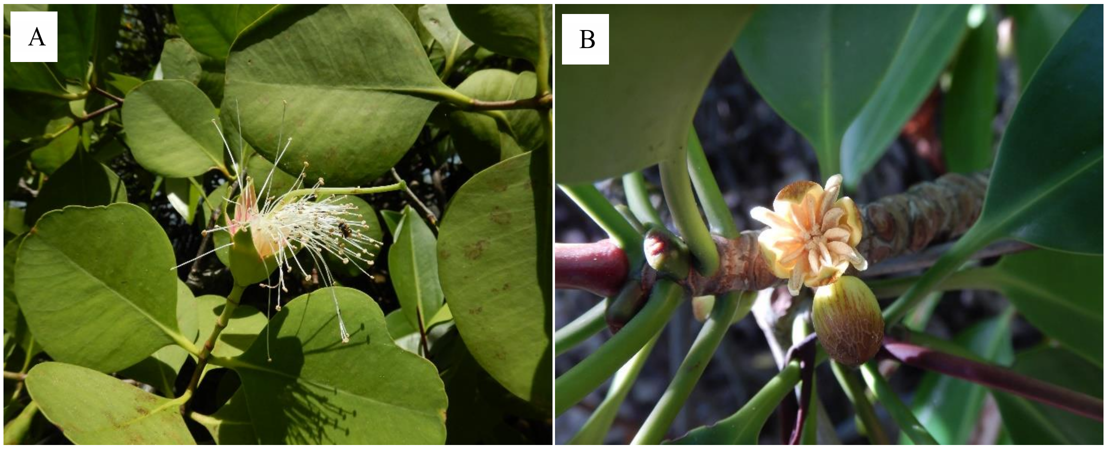

Figure 2. Flowers of the mangrove species, (A) *Sonneratia alba* with white staminal display and (B) *Rhizophora apiculata* with cream-colored linear petals.

pollinators to the distinct yellow sepals and cream-coloured, linear petals arranged in a cross-shaped pattern of *R. apiculata* (Figure 2).

Quantification for total carbohydrate content in nectars of *S. alba* and *R. apiculata* was done by colorimetric method, specifically phenol-sulfuric acid method in this paper. Across the three habitats, *S. alba* showed much higher nectar TC (mg) per flower than *R. apiculata*. The highest nectar TC (7.45 mg/ flower) was recorded for S. alba from Astorga, Daram, Samar, whereas the lowest of 0.02 mg/ flower was recorded for *R. apiculata*.

DISCUSSION

The diverse mangrove sites along Leyte Gulf, Maqueda Bay, and Matarinao Bay showed good prospects for apiculture. In some parts of the Philippines, such as Tarong, Iloilo and Maliwaliw, Salcedo, beekeeping as source of livelihood has been introduced already through the efforts of non-government organizations like Guiuan Development Foundation, Inc. and is continuously expanding. Although conservation efforts on mangrove vegetation intensified with the lessons learned from ST Yolanda, its contribution to apicultural activities has not been extensively investigated. Assessing the potential contribution of the mangrove vegetation to apiculture along the Leyte-Samar Islands is important as apiculture in coastal communities is a conservationist activity with many associated benefits. Mangrove apiculture represents a potential alternative economic activity for many populations residing in the coastal regions of Leyte-Samar.

Community Structure

Mangroves are essential to barangays that are lining the sea coast, as well as the freshwater coast, especially when there are typhoons or floods. They serve as protective barriers that lessen the impact of the waves and a source of various resources such as fishes, gastropods, fuelwood and for construction. Some can build livelihood projects that could help boost the location's stability.

Assessment of mangrove ecosystem is important from time to time to keep track of the record of species in a stand. Rehabilitation of this ecosystem is ongoing in the region and it is best to monitor the newly planted seedlings if they would thrive in that specific area or not.

A total of 23 mangrove species were identified in the three bays and these species belonged to 12 different families. Family Rhizophoraceae acquired the highest species composition with seven mangrove species, namely: *Bruguiera cylindrica*, *B. gymnorrhiza*, *Ceriops decandra*, *C. tagal*, *Rhizophora apiculata*, *R. stylosa* and *R. mucronata.* The distribution of different species in a mangrove ecosystem is influenced by numerous factors in the environment where they thrive, such as temperature and salinity.

The family Rhizophoraceae is the largest family in the Philippines composed of ten species (Primavera et al. 2004), and *Rhizophora* is the most distinct genus component in tropical and coastal mangrove ecosystems (Cerón-Souza et al. 2010) because of its rapid growth and the presence of propagules that can easily generate new seedlings. Moreover, the physiological processes taking place

		CROWN COVER (%)	AVE. HEIGHT (M)	REGENERATION (# OF SEEDLINGS M^{-2})
LEYTE GULF	Buenavista, Abuyog, Leyte	36.70365641	3.998333	2.66666667
	San Joaquin, Palo, Leyte			3.282051282
	69-Anibong, Tacloban City, Leyte	22.70923013	3.58381	1.81481485
	Tinaogan, Basey, Samar	15.5331996	3.499278	4.185185
	Maslog, Lawaan, E. Samar	48.31	2.709996	1
	Bubon, Mercedes, E. Samar	28.13857162	3.49666	1.9666
MAQUEDA BAY	San Isidro, Pinabacdao, Samar	28.47662305	3.524641	6.925925926
	Oyandic, Motiong, Samar	63.44804507	6.283219	7.081481481
	Pasigay, Calbiga, Samar	17.37166657	4.061832	7.9
	Cabugawan, Catbalogan, Samar	52.1149971	2.03	1.25
	Real, Daram, Samar	22.6609984	5.08111	4.5454
	Astorga, Daram, Samar	37.01661541	4.628871	4.428571429
MATARINAO BAY	Nagaja, Hernani, E. Samar	29.87369014	3.829412	3.25
	Buenavista, Quinapondan	55.94	4.170051	3.33
	Caridad, Salcedo	80.18	3.942559	2.85

Figure 3. Mangrove habitat condition noted in selected barangays lining Maqueda Bay.

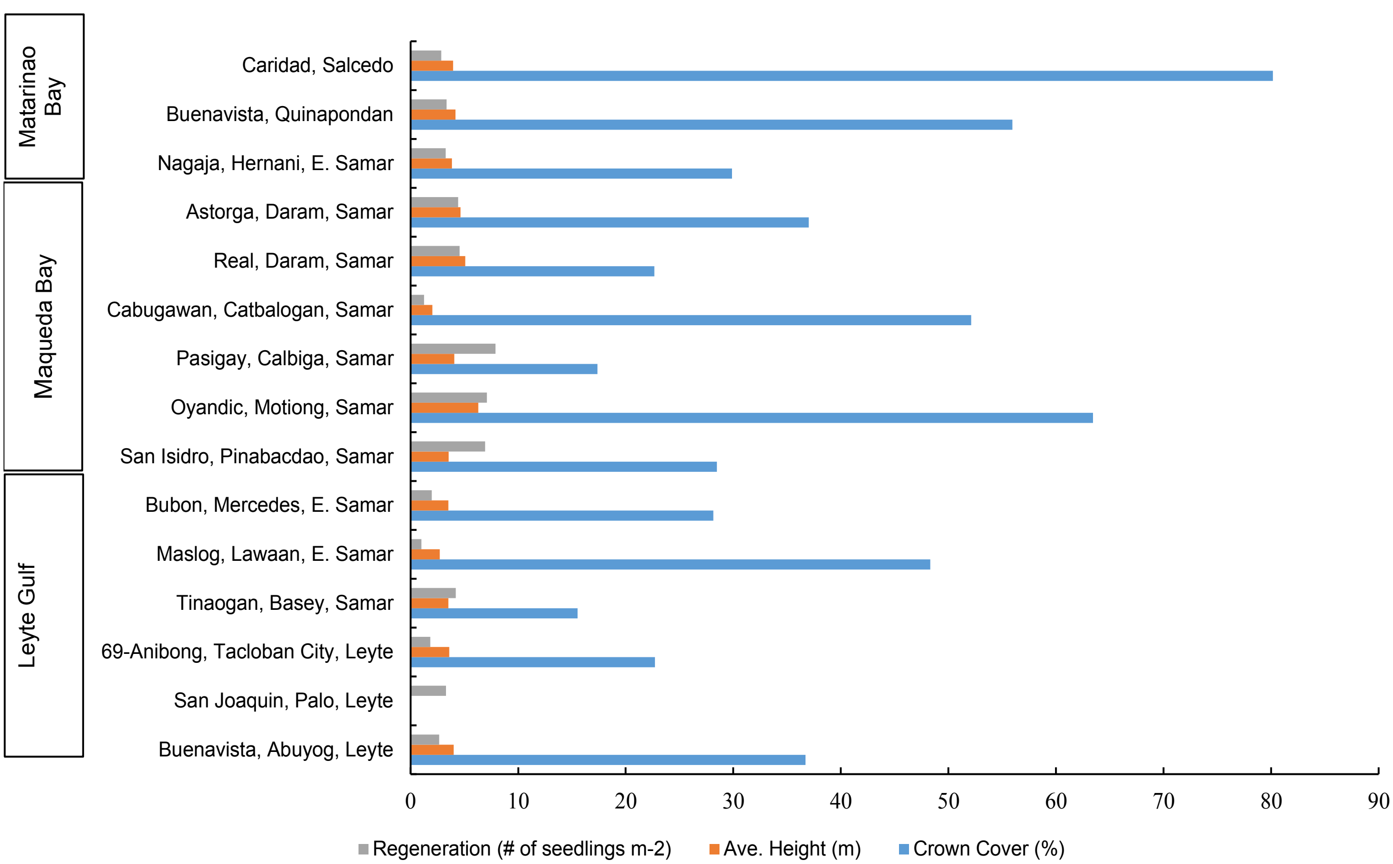

Figure 4. Mangrove habitat condition noted in selected barangays lining Maqueda Bay.

in the *Rhizophora* such as photosynthesis proceed at a temperature ranging from 25°C-35°C. The range of temperatures obtained from the three bays were 25°C-29°C, a range that is suitable for *Rhizophora* and other members of the Rhizophoraceae to proliferate.

Three criteria were taken into consideration in order to determine the condition of the mangrove area. One is the regenerative capacity that indicates the chances of having mature trees after a couple of years when the seedlings and saplings continue to grow in suitable conditions and environment. Second is the percent crown cover which indicates how much is the coverage of the leaves of the trees and how the trees provide shade to other macro and microorganisms living beneath them. This also indicates whether a tree is healthy or dying by observations of foliation or defoliation. Third, the average tree height of the mangrove area that indicates how the trees have grown in accordance to the amount of sunlight and sufficient nutrients absorbed from the soil and water. It also determines how susceptible the forest is to strong winds or typhoons.

Importance value index (IVI) measures the dominance of species in a given area. This is influenced by three factors including relative frequency, relative density, and relative dominance, which each value ranges from 0-100. Basically, IVI is just the summation of these three factors and value ranges from 0-300 (Venerable Trees 2014). The higher the value of importance value index (IVI), the more dominant the species is.

Relative frequency affects IVI in a way that it measures the occurrence of a single species as a percentage from the occurrence all species present. Another factor is relative density, which basically is the totality of the number of individuals per species expressed as a percentage of total number of individuals of all species. Lastly, relative dominance affects IVI by measuring the dominance of species through basal area. Basal area is the summation of cross-sectional areas of all individuals within species. This is done by measuring the girth approximately 1.3 meters above the ground (Venerable Trees 2014). All these three factors add up to give the value of IVI.

Predominance of mangrove species was determined by the values of importance value index of the species present in the most diverse station. In Table 3, it is shown that *Sonneratia alba* and *Rhizophora apiculata* are the two-dominating species in the assessed mangrove sites in all three bays, which includes the mangrove areas of Astorga, Daram, Samar in Maqueda Bay, Buenavista, Quinapondan, Eastern Samar in Matarinao Bay, and Maslog, Lawaan, Western Samar in Leyte Gulf.

Total Carbohydrate (TC) Content

Honeybees mainly feed on nectar as their main fuel to conduct actions in their daily routines. Sugar contained in nectars is a very important attractant to bees and an essential stimulator to their various activities such as breeding and foraging. Worker bees, for example, requires 11 mg of dry sugar on a daily basis (Huang et al. 1989). About 50% of sugar syrup is needed by bees for daily nutrition (Huang et al. 1989).

In the three bays, Matarinao, Maqueda, and Leyte Gulf, *Sonneratia alba* and *Rhizophora apiculata* are the two dominating mangrove species. Based on the analysis of total carbohydrate content, *S. alba* contains higher carbohydrate content than *R. apiculata*. This is probably due to the floral morphology of *S. alba*, which flowers are fully functional for 12 hrs after opening and produces large amounts of nectar considering that its pollinators are nectarivorous bats and moths (Azuma et al. 2002). In the mellittopalynological study of Yao et al. (2006), pollen analysis from the corbicular and gut contents of *Apis* revealed that species of *Sonneratia* had the highest representation. Furthermore, field observations of Hyatt (2011) reported *Sonneratia* species as the preferred floral sources of *Apis*. Bees and birds are one its common visitors as well during the day (Mohamed and Adzemi 2017). On the other hand, *R. apiculata* has less carbohydrate content because this species is mainly wind pollinated and small amounts of nectar is produced for its minor visitors such as small insects (Azuma et al. 2002). Solomon and Aluri (2013) described the foraging visits of bees on *R. apiculata* flowers. Interestingly, these bees first landed on the sepals, then investigated the flower for pollen and nectar; while doing so, their head and ventral side of the body touched the stamens and stigma and, in the process, got coated with pollen. However, due to its smaller size, bees made visits to different trees to collect more forage from as many flowers as possible.

Flower nectars of *S. alba* may suffice the minimum carbohydrate requirement of honeybees. Adgaba et al. (2017 reported the average nectar sugar amount of the *Acacia* and *Ziziphus* species varied from 0.01 mg/flower to 7.7 mg/flower. On the other hand, 3.61

mg/flower to 14.33 mg/flower were reported for *Glycine max*. In this study, mangrove species have 0.02 – 7.45 mg TC/ flower. These variations may be caused by biotic and abiotic factors in their respective environments. However, lower carbohydrate in the nectars of *R. apiculata* does not guarantee that it cannot supply the needs of honeybees. Honeybees, such as the common species *Apis mellifera*, are known to forage on large flower fields (Chen 2001) and *R. apiculata* occur in abundance because it is one of the common mangrove species. Thus, the carbohydrate requirement for honeybees may still be satisfied. It has been found that if the honeybee confines its nourishment to a single species of pollen, its growth, development, and reproductive activity will stop and collects many different types of pollen to achieve a nutritional balance (Yao et al. 2006). In this study, the predominance of *S. alba* and *R. apiculate* along with the diverse mangrove site can be a good floral source of bees for potential apiary.

CONCLUSION

A total of 23 mangrove species from 12 different families were noted in Maqueda Bay, Matarinao Bay and Leyte Gulf, Philippines with Family Rhizophoraceae obtaining the highest species composition in the three bays with seven mangrove species. Astorga, Daram, Samar (H'=1.82), Buenavista, Quinapondan, Eastern Samar, (H'=1.35) and Maslog, Lawaan, Eastern Samar (H'=1.71) were identified to be the most diverse among the representative barangays lining Maqueda Bay, Matarinao Bay and Leyte Gulf. The two most predominant mangrove species in Maqueda Bay, Samar were noted to be *Rhizophora apiculata* and *Sonneratia alba* with Importance Value Indices (IVI) of 86.84% and 76.78% respectively. The same was true for Matarinao Bay where *R. apiculata* and *S. alba* obtained 98.86% and 112.05% IVI, respectively, and for Leyte Gulf were *R. apiculata* obtained 80.02% IVI and *S. alba* obtained 76.88% IVI. The total carbohydrate contents of the predominant species in Maqueda Bay were calculated and showed that *S. alba* has a total carbohydrate content of 37.26 mg/mL and *R. apiculata* of 2.71 mg/mL. The same were true for the total carbohydrate contents of the predominant species in Matarinao Bay and Leyte Gulf. A total carbohydrate value of 4.18 mg/mL was obtained from *R. apiculata* and 29.01 mg/mL from *S. alba* in Matarinao Bay and 3.24 mg/mL and 22.47 mg/mL of the same species obtained in Leyte Gulf respectively. The species *S. alba* contained a higher total carbohydrate content than *R. apiculata* for all the total carbohydrate contents of flower nectars from the representative barangays in Maqueda Bay, Matarinao Bay and Leyte Gulf, Philippines. These findings reveal the potential of *S. alba* to be utilized as a medium for culturing honeybees. The predominance of the species in all the sampling sites, Leyte Gulf, Maqueda Bay and Matarinao Bay, further strengthens the potential of these habitats to be used as apiaries.

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