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Research Article

Tree Species Diversity and Stand Structure in Selected Forest Patches of Marilog Forest Reserve, Southern Philippines

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ABSTRACT

Tree species diversity and stand structure investigations were conducted in the forest patches of Barangay Baganihan (site 1) and Mt. Malambo in Barangay Datu Salumay (site 2), Marilog District, Southern Philippines. Thirty-three 20 × 20 m plots were established at 1,197–1,345 masl in the sites. A total of 900 individuals belonging to 33 families, 43 genera, and 65 species of trees were recorded. Analyses of data revealed that the two sites could be categorised as montane forests based on the forest structure and species composition. *Palaquium philippense* (Perr.) C.B. Rob., *Syzygium tula* (Merr.) Merr., and *Astrocalyx calycina* (S.Vidal) Merr. obtained the highest species importance value index in site 1, while *Palaquium* sp., *P. philippense*, and *Lithocarpus caudatifolius* (Merr.) Rehder in site 2. Shannon-Weiner indices (H') in sites 1 and 2 are relatively low with H' = 1.22 and H' = 1.38, respectively. A total of eight threatened species were recorded, *viz.*, *A. calycina* as endangered; *Agathis philippinensis* Warb., *Becarianthus pulcherrimus* (Merr.) Maxw., *Camellia lanceolata* (Blume) Seem., *Dillenia megalantha* Merr., *P. philippense* and *Shorea contorta* S.Vidal as vulnerable; and *Cinnamomum mercadoi* S.Vidal as other threatened species. A total of 14 endemic species of trees were also recorded in the study sites. The biodiversity in the two sites is under severe threat due to the different anthropogenic disturbances. A new population of *A. calycina*, a monotypic genus in the Philippines, was collected and the flowers were documented for the first time after a century. The present study is significant since it would help elucidate the patterns of tree species composition and diversity in the forest patches of Barangay Baganihan and Mt. Malambo in Barangay Datu Salumay. Further, this paper adds to the rich biological diversity in Mt. Malambo by supporting its great potential as an ecotourism site.

Keywords: angiosperms, Philippine endemics, species richness, threatened species, tree profile, Mindanao

Introduction

Tropical forests have been recognized to harbour a significant proportion of global biodiversity (Myers et al., 2000). It is also the most species-rich biome on Earth harbouring over 50% of species on just 7% of the land area (Wilson, 1988). The Philippines is one of the most important biodiversity hotspots (Lagenberger, 2004) and one of the world's megadiverse countries with high degrees of species richness and endemism (Ashton, 1993; Heaney & Regalado, 1998; Myers et al., 2000). Plant diversity is threatened by different factors that include rapidly changing land use patterns in tropical Asia (Sodhi et al., 2010), and more efforts should be made to document its biodiversity (Webb et al., 2010).

Marilog Forest Reserve in Davao City, Philippines has rich floral diversity which makes it a priority area for biodiversity studies by Conservation International. The area has a very pleasant, cool and breezy climate due to its elevation and presence of forest patches. Many have settled in the area to establish rest houses and mountain resorts. However, several disturbances have been documented, such as rampant small-scale logging activities, conversion of the forest lands into agricultural use, the proliferation of residential and mountain resorts, over-harvesting, trading of ornamental plants and spread of invasive alien species, such as *Piper aduncum* L. Due to these disturbances, the forest cover in the area has drastically changed and is now limited to a few remnants forest patches.

The present study is significant in generating valuable baseline data to conserve and manage the native tree flora in this tropical forest ecosystem. The results of this research would provide valuable data for forest assessment and identification of ecologically-useful species. This study was conducted to determine the community composition, species diversity, and tree population structure in the established plots in the forest patches of Barangay Baganihan and Mt. Malambo in Barangay Datu Salumay, Marilog District, Southern, Philippines.

Materials and Methods

Permit Statement

Necessary permits were obtained, such as Prior Informed Consent from the local people of Marilog District and gratuitous permit from the Department of Environment and Natural Resources (DENR). A memorandum of agreement (MOA) between Central Mindanao University (CMU) and the Manobo-Matigsalug Tribal

People Council for Elders of Davao, Inc. (MAMATRIPCEDI) was also done before the conduct of the study.

Study Sites

This study was carried out in Barangay Baganihan (N 07° 27'13.74"– E 125°15'1.12") and in Mt. Malambo, Barangay Datu Salumay (07°29'87" N, 125°15'22.23" E) (**Figure 1**), both at the northern part of Marilog District, Davao City in March and May 2018, respectively. The two sites are found at the montane forest at elevations ranging from 1,197–1,345 masl.

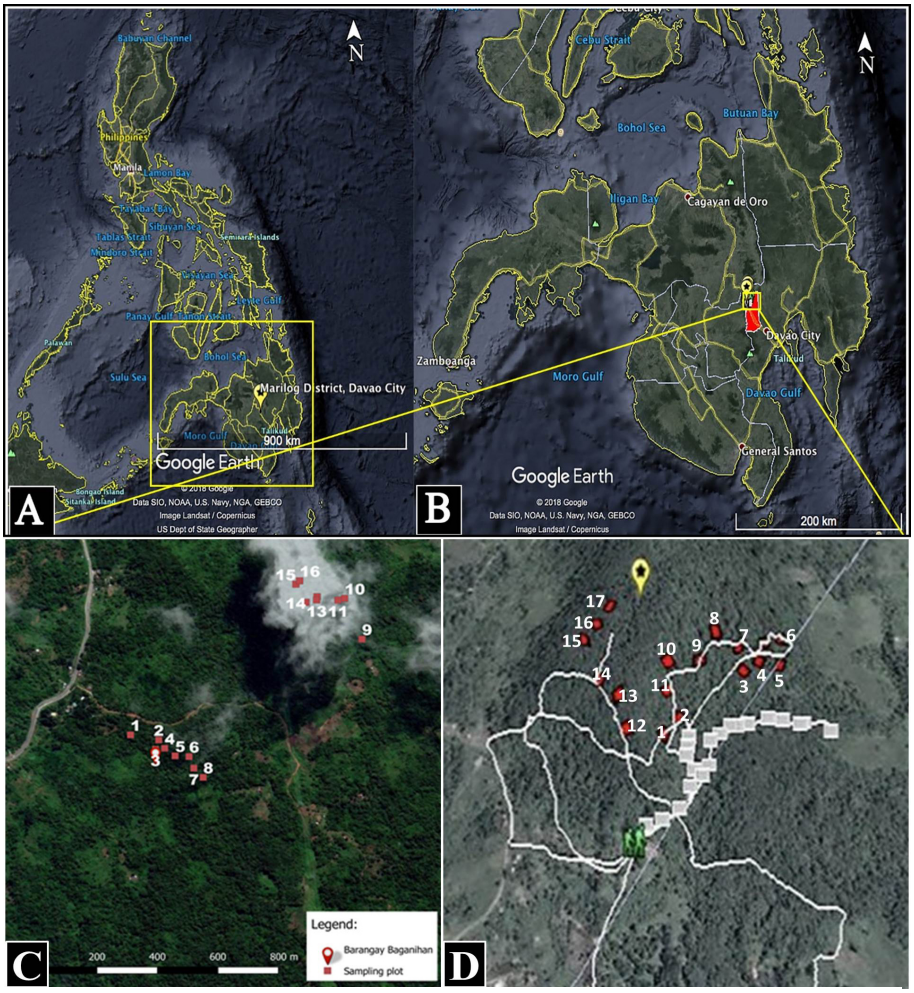

Figure 1. Study sites. **A)** Philippine map, **B)** Map of Mindanao Island, **C)** sampling plots in the forest patches of Barangay Baganihan, Marilog District, **D)** sampling plots in Mt. Malambo, Brgy. Datu Salumay, Marilog District.

Establishment of Sampling Plots and Collection of the Specimens

A total of 33 20 × 20 m plots were established, of which 16 plots were in the forest patches of Brgy. Baganihan and 17 plots in Mt. Malambo, Brgy. Datu Salumay. The established plots represent the community characteristics of a tropical montane forest in the Philippines. All trees with at least 10 cm in diameter at breast height (DBH) in each plot were measured and by taking notes of the x and y coordinates and crown cover. A minimum of four voucher specimens for each species were collected using clipper/shear and trimming cutters. Each specimen was placed inside plastic bags and labeled with necessary information. Representative voucher specimens were deposited at the Central Mindanao University Herbarium (CMUH).

Identification of the Specimens

Species of the voucher specimens were identified by cross-referencing, monographs, floras, other scientific articles, online websites (e.g., Co's Digital Flora of the Philippines (Pelser et al., 2011 onwards), and compared using the digitized plant specimens available in Global Plants on JSTOR. In addition, the identification of some species collected was validated by the experts. Classification followed the Angiosperms Phylogeny Group (APG), 2016.

Assessment of Conservation Status and Endemism

Information of the conservation status of trees was referred to Fernando et al. (2022). In contrast, the endemism to the IUCN Red List of Threatened Species (2019) and Co's Digital Flora of the Philippines (Pelser et al., 2011 onwards).

Data Treatment and Analysis

Tree diversity was calculated using the formula of Shannon-Weiner diversity index (Shannon and Weiner, 1963). All data to represent tree density and basal area were pooled by each site. Calculation for frequency, relative frequency, density, relative density and Importance Value Index (IVI) were derived from Curtis & McIntosh (1951). The following formulae were used:

$$\text{Density} = \frac{\text{number of species}}{\text{Total area sampled}}$$

$$\text{Relative Density} = \frac{\text{density for a species}}{\text{total density for all species}} \times 100$$

$$\text{Frequency} = \frac{\text{number of plots in which species occur}}{\text{total number of plots sampled}}$$

$$\text{Relative Frequency} = \frac{\text{frequency value for a species}}{\text{total frequency for all species}} \times 100$$

$$\text{Dominance} = \frac{\text{basal area or volume for a species}}{\text{area sampled}}$$

$$\text{Relative Dominance} = \frac{\text{dominance for a species}}{\text{total dominance for all species}} \times 100$$

$$\text{Importance Value Index} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance}$$

Note: basal area equation is πr^2 or $\pi (dbh/2)^2$

Results and Discussion

Species Richness and Diversity

A total of 65 species belonging to 33 families and 43 genera of trees were recorded (**Table 1**). The species richness of trees in the present study is lower compared to Mt. Apo, North Cotabato with 68 species (Silverio, 2014) and Pasonanca Natural Park, Zamboanga City with 78 species (Andas, 2015). The families with the most number of species are Euphorbiaceae and Meliaceae with five species each. These families were also commonly observed in the different Mindanao Long Term Ecological Research (LTER) Sites *viz.*, Mt. Kitanglad, Mt. Apo, Mt. Malindang and Mt. Hamiguitan (Amoroso et al., 2009; 2011; Zapanta et al., 2019) and also in Balinsasayao, Sibulan, Negros Oriental (Amoroso et al., 2017). The most dominant species found within the established plots in site 1 are *Astrocalyx calycina* (S.Vidal) Merr., *Lithocarpus caudatifolius* (Merr.) Rehder, *Lithocarpus submonticolus* (Elmer) Rehder, J. Arnold Arb. and *Syzygium tula* (Merr.) Merr., while in site 2 are *Palaquium* sp., *Palaquium philippense* (Perr.) C.B.Rob., *Syzygium* sp. 2, *Dendrocnide* sp. and *Syzygium tenuirame* (Miq.) Merr. This study supported that the pattern of the species richness may vary in different groups of plants (Kessler et al., 2011). Kromer et al., (2005) also reported different patterns of species diversity among different plant groups, such as epiphytic ferns, orchids and some tree species in tropical America.

The forest type observed in the two sites can be classified as a montane forest based on the classification of Fernando et al. (2008) and Amoroso et al. (2012). Usually, the lower montane forests in the Philippines are characterised by the presence of *Lithocarpus* spp., *Syzygium* spp., gymnosperms such as *Agathis*

philippinensis Warb., *Phyllocladus hypophyllus* Hook.f. and tree ferns of family Cyatheaceae and Dicksoniaceae (Whitford, 1911; Gruezo, 1997; Buot & Okitsu, 1998; Fernando et al., 2004; Amoroso et al., 2011). There is also an abundance of terrestrial and epiphytic ferns, lycophytes and bryophytes in the lower montane forests (Ashton, 2003).

One of the forest types in the Philippines is commonly known as mossy forest, with richness and abundance of mosses and liverworts which cover the tree trunks and branches and even the forest floor (Whitford, 1911). It occurs in mountains above 1,000 masl depending on the locality, size and height of the mountain (Fernando et al., 2008). The upper montane forest is the most common forest type in the Philippines together with the lower montane forest. It is also one of the four definable forest formations on the higher tropical mountains (Ashton, 2003). This montane forest is also similar to the different mountain ecosystems in the Philippines that have similar species composition and other structure and physiognomy characteristics, such as canopy height, emergent trees, and presence of buttresses, vascular epiphytes and non-vascular epiphytes. There is also a high abundance of terrestrial and epiphytic ferns, lycophytes, bryophytes and other understory plants observed in this vegetation.

Table 1. Checklist of trees in the forest patches of Barangay Baganihan and Mt. Malambo in Brgy. Datu Salumay, Marilog Forest Reserve, Southern Philippines.

Family	Scientific Name	Common Name	Site	
			1	2
Actinidiaceae	*Sauraia* sp.			/
Apocynaceae	*Alstonia parvifolia* Merr.	Dita-dita	/	/
	Alstonia sp.			/
Araucariaceae	*Agathis philippinensis* Warb.	Almaciga	/	
Burseraceae	*Canarium asperum* Benth.	Pili	/	
	Canarium sp.	Malabasag	/	/
Calophyllaceae	*Calophyllum* sp.	Palamanyal		/
Chloranthaceae	*Ascarina philippinensis* C.B.Rob.	Ascarina	/	/
	L			/
Clethraceae	. *Clethra canescens* Reinw.			/
Combretaceae	. *Terminalia catappa* L., Mant.	Talisay-talisay (Manili)	/	
Cunoniaceae	. *Weinmannia hutchinsonii* Merr.			/
Dilleniaceae	. *Dillenia megalantha* Merr.	Kalaambog	/	
	. *Dillenia philippinensis* Rolfe.	Kalagtimon		/
Dipterocarpaceae	. *Shorea contorta* S.Vidal	Lawaan puti		/
Ebenaceae	. *Diospyros* sp.			/

Elaeocarpaceae	. *Elaeocarpus* sp.	Kalaw		/
Escalloniaceae	. *Polyosma* sp.	Kanduli	/	
Euphorbiaceae	. *Macaranga hispida* (Blume) Müll.Arg.	Aha	/	
	. *Macaranga sinensis* Baill.ex.Mull.Arg.	Hindang	/	/
	. *Malutos* sp.	Malutos		/
	. *Omalanthus populneus* Geiseler			/
	. *Omalanthus fastuatus* (Linden) Fern.			/
Fabaceae	. *Archidendron clypearia* (Jack) Nielsen	Sili-sili like	/	
Fagaceae	. *Lithocarpus submonticolus* (Elmer) Rehder, J. Arnold Arb.	Ulayan Red	/	
	. *Lithocarpus caudatifolius* (Merr.) Rehder	Ulayan white	/	/
	. *Lithocarpus* sp.			/
Gentianaceae	. *Fagraea auriculata* Jack	Banati	/	
	. *Fagraea blumei* G.	Banati		/
Lauraceae	. *Actinodaphne apoensis* (Elmer) ined.			/
	. *Cinnamomum mercadoi* S.Vidal	Kalingag	/	
	. *Cinnamomum uteli* Kosterm	Kalingag		/
	. *Litsea segregata* Elmer	Dila sa manok	/	
Malvaceae	. *Grewia* sp.	Alimoong	/	
Melastomataceae	. *Astrocalyx calycina* (S.Vidal) Merr.	Bahawbaw	/	/
	. *Astronia ferruginea* Elmer			/
	. *Astronia* sp.	Tungaw	/	
	. *Beccarianthus pulcherrimus* (Merr.) Maxw.	Palamanyal	/	/
Meliaceae	. *Dysoxylum arborescens* (Blume) Miq.	Mahalimoko n	/	
	. *Dysoxylum parasitum* (Osbeck) Kosterm.	Kalaantos		/
	. *Dysoxylum* sp. 1	Lumbia, Kalaantas Red	/	/
	. *Dysoxylum* sp. 2	Kalaantas White		/
	. *Reinwardtia* sp.			/
Moraceae	. *Ficus benguetensis* Merr.	Tubog	/	/
	. *Ficus benjamina* L.	Baliti	/	/
	. *Ficus nota* (Blanco) Merr.	Anonang		/
	. *Ficus* sp.	Anonang	/	
Myrtaceae	. *Syzygium tenuirame* (Miq.) Merr.	Lupit	/	/
	. *Syzygium tula* (Merr.) Merr.	Sagimsim	/	
	. *Syzygium* sp. 1			/

	. *Syzygium* sp. 2			/
Phyllanthaceae	. *Bischofia javanica* Blume	Ube	/	
	. *Breynia cernua* (Poir.) Müll.Arg.	Ulingon/Kariis	/	
	. *Huberantha* sp.	Balyok	/	
Piperaceae	. *Piper aduncum* L. Var	Buyo-buyo	/	/
Pittosporaceae	. *Pittosporum ramiflorum* Zoll.			
Rubiaceae	. *Nauclea orientalis* (L.) L.			/
	. *Psychotria* sp.			/
Rutaceae	. *Melicope triphylla* (Lam.) Merr.	Kalaw/Buga	/	/
	. *Melicope* sp.			/
Sapotaceae	. *Palaquium philippense* (Perr.) C.B. Rob.	Natu	/	/
	. *Palaquium* sp.			/
Staphyleaceae	. *Turpinia ovalifolia* Elmer.			/
Theaceae	. *Camellia lanceolata* (Blume) Seem.			/
Urticaceae	. *Dendrocnide* sp.	Alingatong		/

It is noteworthy that the monotypic genus, *Astrocalyx calycina* (S. Vidal) Merr. (**Figure 2 (a)**) was first recorded in the area. Its flowers were also documented and collected for the first time since its first description in 1910. It is a tree measuring 8–25 m tall with bole measuring 27–65 cm in diameter and with elongated, star-like calyx lobes. This is an endemic and endangered species and can only be found in the primary rainforests in the Philippine Islands (Mancera et al., 2017). This species is previously known in different localities in the country from 300–1830 masl in Luzon; Laguna (Mount Makiling); Rizal, Quezon, Camarines Norte and Sorsogon, Catanduanes, Visayas; Samar and Leyte, Mindanao; Lanao del Norte, Bukidnon (Mount Kitanglad Range), and Davao del Sur (Mount Apo). However, because of the different threats due to deforestation, over-exploitation of forest resources and conversion of natural lowland forests to agricultural lands, this species has been listed under the endangered category. Fortunately, there are still 55 individuals of *A. calycina* found in the area. This is commonly known as "Bahawbaw" by the local people and is also a habitat for various species of epiphytic ferns *Asplenium apoense* Copel., *Davallia wagneriana* Copel., *D. repens* (Lf) Kuhn, *Elaphoglossum blumeanum* J.Sm., *Hymenophyllum acanthoides* (Bosch) Rosenstock, *Nephrolepis cordifolia* (L.) C. Presl, *Oleandra neriiformis* Cav., *Aglaomorpha heraclea* (Kunze) Copel., *Selliguea albidosquamata* (Blume) Parris and *Haplopteris alternans* (Copel.) S.Linds. & C.W.Chen), and lycophytes: *Selaginella involvens* (Sw.) Spring and *Phlegmariurus salvinioides* (Herter) Ching), and many species of mosses and liverworts (*Plagiochila* spp., *Bazzania* spp.).

Dillenia megalantha Merr. (**Figure 2 (b)**) is also an interesting species found in the area. It is a medium-sized tree up to 25 m tall, about 50 cm in diameter, with bright yellow flowers. This species has edible fruits eaten by the local people. It has been listed recently as a vulnerable species based on the IUCN assessment of 2020. This species can be found in Quezon, Albay, Sorsogon (Mt Bulusan), Samar, Dianagat, Mindanao; Zamboanga peninsula, Agusan del Norte (Mt Urdaneta), Surigao del Norte and in Mt. Apo, Davao which is the type locality (Pelser et al., 2011).

Piper aduncum L. (**Figure 2 (c)**) was found growing rampantly within Marilog District. This species is considered as an invasive alien species (IAS) and may compete with the indigenous species present in the area. It is now widely distributed in different parts of the country especially in Mindanao Island, because the seeds of this species are easily dispersed by wind and birds (Bonaccorso et al., 2002). However, the trunks and branches of this species are known to be inhabited by unique ferns, such as *Lecanopteris deparioides* (Cesati) Baker (Ant fern) and many other species of ferns and mosses.

The montane species, such as *Lithocarpus submonticolus* (Elmer) Rehder, J. Arnold Arb. and *L. caudatifolius* (Merr.) Rehder are known as "Ulayan" in the area and commonly harvested for timber and charcoal making. Furthermore, *Cinnamomum mercadoi* S.Vidal "Kalingag" is also frequently extracted from the forest for its medicinal uses.

Figure 2. Some noteworthy species of trees in the areas. **A)** *Astrocalyx calycina* (S.Vidal) Merr., **B)** *Dillenia megalantha* Merr., and **C)** *Piper aduncum* L.

The Shannon diversity index in site 1 was H' = 1.22 and site 2 was H' = 1.22. These diversity indices are higher compared to the other mountain ecosystems in Mindanao, *viz.*, Leaño (2004) in Mt. Malindang with H'=0.51, Silverio (2014) with H' = 0.59 in Mt Apo, Demetillo (2003) in Mt. Lumot with H'=0.90, and closely resembles with Polizon (2006) in Mt. Hamiguitan with H' = 1.24 and to the protected forest of Mount Masinggi, Indonesia with H'= 1.19 (Mokoginta, 2016). However, the result was relatively lower compared to Causaren et al. (2017) in the Remaining Forest Fragments in Cavite, Luzon Island with values ranging from range of H' = 1.5 to H' = 3.5; Malabrigo et al. (2018) in Mt. Calavite Wildlife Sanctuary, Mindoro Island with H'= 4.41, and in Pasonanca Natural Park with H' = 1.68 (Andas, 2015). It is also lower compared to the tropical forest of Congo (Ifo et al., 2016; Ekoungoulou et al., 2018), Pahang National Park, Malaysia (Suratman, 2012) and in Northern and Eastern Thailand (Podong & Poolsiri, 2013; Glumphabutr et al., 2006).

The low species diversity in the forest patches of the two sites is due to the anthropogenic activities present in the area as observed by the authors during repeated botanical expeditions. The area is presently subjected to small scale logging, conversion of the forests to agricultural lands, residential areas and mountain resorts, overharvesting and trading of ornamental plants from the wild, and proliferation of invasive species. Tree species diversity in tropical forests differs significantly from one location to another mainly because of the variation in ecology, habitat, and disturbance (Neumann & Starlinger, 2001; Padalia et al., 2004). Forest degradation due to anthropogenic activities or human impacts was also cited as the main driver of the decreasing diversity of plants (Malabrigo et al. 2018; Naidu & Kumar, 2016). Woody plant species are critical components of the forest ecosystem and documenting the patterns of tree diversity and distribution provides a good database, useful for management measures in the forest ecosystem (Naidu & Kumar, 2016).

Species Composition

The current result revealed that the species with the highest importance value in the areas are *P. philippense*, *S. tula*, *A. calycina*, *L. submonticolus*, and *L. caudatifolius* in site 1 and *Palaquium* sp., *P. philippense*, *L. caudatifolius*, *Diospyros* sp., and *S. tenuirame* in site 2 (**Table 2**). This conforms to the vegetation type described in Mt. Apo, North Cotabato (Silverio, 2014), Mt. Halcon Range in Mindoro (Merrill, 1907), Mt. Kiamo, Bukidnon (Coritico & Amoroso, 2017) that the montane forests are typically dominated by the *Palaquium* spp., *Lithocarpus* spp. and *Syzygium* spp. Some of the species with high species IV (e.g., *Canarium asperum* Benth., *Melicope triphylla* (Lam.)

Merr.and *P. philippense*) were also observed in the permanent plots in Mindanao LTER Sites (Amoroso et al., 2014). The seeds and fruits of these tree species might be easily carried by animals or other seed dispersal agents and would eventually grow provided there is enough moisture. These tree species may also have an essential role in regulating ecosystem stability as cited by Tagupa (2006). The species with high IV determine the principal species present in the sampling area and ultimately dominate and provide overall estimates of the influence of the different plant species in a particular community. Thus, it plays an essential role in a particular community. Removal or loss of the said species of plants would significantly affect the biological and physical structure and function of the ecosystem (Amoroso et al., 2011).

Table 2. The five highest Importance Value Index (IVI) species derived from the pooled data of all plots in Site 1 in Brgy. Baganihan and Site 2 in Mt. Malambo, Brgy. Datu Salumay.

Species	Density/ba	Basal area/ba	Frequency	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	IV	Rank
SITE 1								
Palaquium philippense (Perr.) C.B. Rob.	69	1769	16	14.44	7.58	15.63	37.64	1st
Syzygium tula (Merr.) Merr.	62	1920	16	12.97	7.58	16.96	37.51	2nd
Astrocalyx calycina (S.Vidal) Merr.	55	1380	14	11.51	6.64	12.19	30.33	3rd
Lithocarpus submonticolus (Elmer) Rehder, J. Arnold Arb.	43	1054	15	9.00	7.11	9.31	25.41	4th
Lithocarpus caudatifolius (Merr.) Rehder	34	818	12	7.11	5.69	7.23	20.03	5th
TOTAL			**16**					
SITE 2								
Palaquium sp.	57	2837	13	6.02	6.02	17.18	29.22	1st
Palaquium philippense (Perr.) C.B. Rob.	38	1672	11	5.09	5.09	10.13	20.31	2nd
Lithocarpus caudatifolius (Merr.) Rehder	22	979	11	5.09	5.09	5.93	16.12	3rd
Diospyros sp.	24	713	12	5.56	5.56	4.32	15.43	4th
Syzygium tenuirame (Miq.) Merr.	25	986	2	3.24	3.24	5.97	12.45	5th
TOTAL			**17**					

Forest Structure

The mean stand density was 30 individuals/20 x 20 m^2. The highest stand density in site 1 was observed in plot 16 (39 individuals/20 x 20 m^2), while the lowest stand density was observed in plots 2 and 9 (21 individuals/20 x 20 m^2 each). The other plots showed moderate densities. For site 2, the highest stand density was observed in plot 15 (33 individuals/20 x 20 m^2) and the lowest was observed in plot 3 (16 individuals/20 x 20 m^2). The established plots comprised of tree species reaching up to 40 m high and with highest diameter of 90 cm DBH. In site 1, the highest mean diameter was at plot 1 with 26.0 cm, and the least in plot 14 with 17.5 cm, and the highest mean height was recorded at plot 2 with 20.8 m and the least in plot 6 with 11.5 m. In site 2, the highest mean diameter was obtained by plot 17 with 40.6 cm, and least in plot 1 with 18.8 cm, and the highest mean height was obtained by plot 17 with 21 m and the least in plot 14 with 13.0 m (**Table 3**). The total mean height of trees in the current study is comparably lower than the studies conducted in other mountain sites in the Philippines, *viz.*, Andas (2015) with mean height of 18.82 m in the montane forest of Pasonanca Natural Park, Zamboanga City; Tagupa (2006) with 16.57 m in Mt. Hamiguitan, Davao Oriental; and Silverio (2014) with 23 m in Mt. Apo, North Cotabato. These differences may be consistent with the report of Amoroso et al. (2011) that as altitude increases, the mean number of individuals, mean height and dbh decreases.

Table 3. The total number of species and individuals, and mean diameter and height of trees in all the plots in in Site 1 in Brgy. Baganihan and Site 2 in Mt. Malambo, Brgy. Datu Salumay.

Plot Number	Total number of species	Total number of individuals	Mean (± SE) Diameter (cm)	Min Diameter (cm)	Max Diameter (cm)	Mean Height (m)	Min Height (m)	Max Height (m)
Site 1								
1	17	33	26.0	10	45	20.8	5	25
2	13	21	25.4	10	95	20.8	5	21
3	14	20	24.0	10	95	16.6	7	26
4	14	28	19.0	10	120	13.1	8	29
5	13	38	21.2	10	100	9.49	10	25
6	14	30	21.3	10	120	11.5	10	25
7	14	26	22.5	10	80	14.0	9	25
8	10	27	21.0	10	140	12.7	8	25
9	10	21	22.6	10	70	13.0	10	23
10	16	33	24.0	10	200	14.1	10	35
11	15	33	23.6	10	80	12.0	10	26
12	18	38	19.2	10	75	12.7	10	25
13	15	31	24.2	10	100	14.0	8	25
14	14	37	17.5	10	60	13.3	10	22
15	10	33	25.0	10	100	17.1	10	27
16	14	39	22.1	10	95	13.6	10	30
	Total	**Total**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
	221	488	22.4	10	98.4	14.3	8.75	25.9

Site 2								
1	14	28	18.8	10	45	14.4	5	25
2	11	27	31.5	10	95	14.5	5	21
3	11	16	34.5	10	95	16.3	7	26
4	14	23	36.0	10	120	17.1	8	29
5	9	28	34.4	10	100	16.1	10	25
6	9	18	33.5	10	120	17.9	10	25
7	11	20	26.6	10	80	16.6	9	25
8	12	25	35.8	10	140	16.6	8	25
9	8	26	23.0	10	70	17.1	10	23
10	8	24	33.8	10	200	15.5	10	35
11	11	20	22.1	10	80	15.2	10	26
12	11	18	28.4	10	75	18.5	10	25
13	9	27	28.3	10	100	18.4	8	25
14	7	32	23.4	10	60	13.0	10	22
15	7	33	34.8	10	100	18.8	10	27
16	11	27	34.8	10	95	18.8	10	30
17	11	30	40.6	12	90	21.0	18	29
	Total	**Total**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
	174	422	28.6	10.1	97.9	16.8	9.3	26.1

For the height classes of trees in site 1, out of 478, a total of 255 individuals (53.4%) attained a height range of 11–20 m, followed by 171 individuals (35.8%) with height ranging from 1–10 m, 42 individuals (8.8%) with 21–30 m height range, and the least with only 10 individuals are the tallest trees with height ranging from 31–40 m. In terms of diameter, species with diameter range of 11–20 cm had the highest records with 203 individuals comprising 42.5% and the least are species with 51–102 cm with one to six numbers of individuals. The species with the widest DBH recorded in the area include *P. philippense*, *S. tula*, *M. triphylla* and *L. caudatifolius* ranging from 61–90 cm, while the tallest species include *P. philippense* with 40 m and *Syzygium* spp. with 30–35 m. For the height classes of trees in site 2, trees in the area reached about 31–40 m tall. About 67% of all individuals fall under 11–20 m height. The tallest trees in the area are *L. caudatifolius* and *Weinmannia* sp. with a mean height of 35 m. Moreover, DBH reaches about 150–200 cm in width. The species with the widest DBH is *Weinmannia* sp. at 200 cm. **Figures 3 and 4** represent the height and diameter classes of all tree species recorded in the established plots in sites 1 and 2.

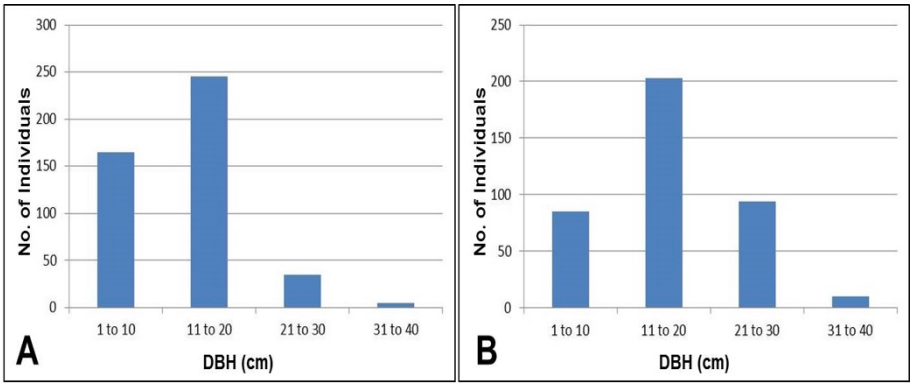

Figure 3. Height classes of tree species in the established plots. **A)** site 1: Forest patches in Barangay Baganihan, **B)** site 2: Mt. Malambo, Barangay Datu Salumay.

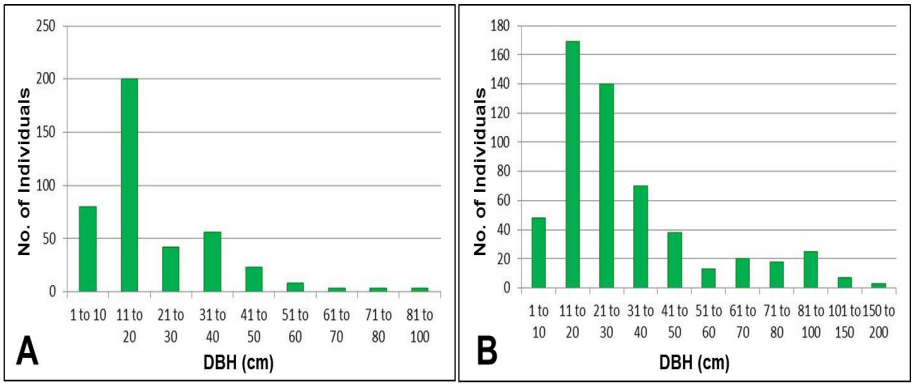

Figure 4. Diameter classes of tree species in the established plots. **A)** site 1: Forest patches in Barangay Baganihan, **B)** site 2: Mt. Malambo, Barangay Datu Salumay.

Conservation Status and Endemism

There are eight threatened and 14 endemic species recorded in the forest patches of Brgy. Baganihan and Mt. Malambo, Brgy. Datu Salumay. The threatened species include *Astrocalyx calycina* as endangered; *Agathis philippinensis*, *Becarianthus pulcherrimus*, *Camellia lanceolata*, *Palaquium philippinense* and *Shorea contorta* as vulnerable, while *Cinnamomum mercadoi* as other threatened species based on Fernando et al. (2022). *Dillenia megalantha* was recently assessed by IUCN (2020) as a vulnerable species. The endemic species consists of *viz.*, *Actinodaphne apoensis*, *Alstonia parvifolia*, *Astrocalyx calycina*, *B. pulcherrimus*, *Cinnamomum uteli*, *D. megalantha*, *D.*

philippinensis, *Lithocarpus submonticolus*, *Cinnamomum mercadoi*, *Litsea segregata*, *Syzygium tula*, *Aidia pulcherrima*, *P. philippense*, and *Weinmannia hutchinsonii*.

The threatened species of trees in the two sites are comparatively lower compared to the threatened species in the forest fragments in Cavite with 39 species (Causaren et al., 2018). The endemism is also low compared to the study of Causaren et al. (2018) with 19 endemic species and Lillo et al. (2019) in Mt. Lantoy, Agrao, Cebu with 76 Philippine endemics and eight species being island endemics. The preservation of the forest patches in Brgy. Baganihan and Mt. Malambo is very crucial for conservation of the remaining threatened and endemic species of plants.

Figure 5. Some threatened and endemic species of trees in the forest patches of Brgy. Baganihan and Mt. Malambo, Brgy. Datu Salumay, Marilog District. **A)** *Astrocalyx calycina* (S.Vidal) Merr., **B)** *Cinnamomum mercadoi* S.Vidal, **C)** *Dillenia philippinensis* Rolfe., **D)** *Ficus benguentense* Merill., **E)** *Palaquium philippense* (Perr.) C.B. Rob., **F)** *Piper aduncum*

Management recommendation

Assisted Natural Regeneration (ANR) activity was employed to support the remaining natural habitat of the disturbed forest patches in Barangay Bahanihan

and Mt. Malambo, Barangay Datu Salumay. The trees with the highest IVI in the two sites, such as *P. philippense*, *S. tula*, *A. calycina*, *L. submonticolus*, *L. caudatifolius*, *Palaquium* sp., *L. caudatifolius*, *Diospyros* sp., and *S. tenuirame* were prioritized for ANR, and the wildlings of these species were collected as base models. As it is a low-cost and straightforward method for forest restoration (Shono et al., 2007), ANR activity will help conserve the natural forest patches in the areas as it increases forest cover and attains the recovery of the native ecosystem or some of its functions. With some assistance, native species of trees that have adapted to the natural conditions achieve accelerated growth by natural progression, leading to the recovery of native ecosystems (FAO, 2019). Monitoring of high conservation value of the threatened and endemic tree species found in the study sites should be given specific attention.

Conclusions

The forest patches of Brgy. Baganihan and Mt. Malambo, Brgy. Datu Salumay can be categorised as montane forests based on forest structure and species composition. The species index in this study is low compared to the other sites, mainly because of its ecological reasons. However, the sites have Philippine endemic and threatened species, such as *A. calycina*, *P. philippense*, and *D. philippinensis* to name a few. It is highly recommended that the protection and conservation of these areas should be enhanced. Conservation action to propagate the Philippine endemic and threatened species is crucial with *in situ* and *ex situ* conservation. Results of this study will be used to support the designation of the areas as local conservation sites by the officials of the local government units of Brgy. Baganihan and Brgy. Datu Salumay for long-term conservation and protection of biological diversity.

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Appendix 1. Summary table of the diversity indices of trees in the forest patches of Barangay Baganihan, Marilog District.

Scientific Name	No. of Individual	Occurrence	Total DBH	Density	Relative Density	Frequency	Relative Frequency	Dominance	Relative Dominance	IV	Diversity Values
Alstonia parvifolia Merr.	10	8	206	2.092	0.500	3.791	0.032	1.820	7.703	2.092	0.032
Agathis philippinensis Warb.	2	2	98	0.418	0.125	0.948	0.015	0.866	2.232	0.418	0.018
Canarium asperum Benth.	20	10	345	4.184	0.625	4.739	0.054	3.047	11.971	4.184	0.046
Canarium sp.	6	3	92	1.255	0.188	1.422	0.014	0.813	3.490	1.255	0.017
Ascarina philippinensis C.B.Rob.	5	3	93	1.046	0.188	1.422	0.015	0.821	3.289	1.046	0.017
Terminalia catappa L., Mant.	4	4	97	0.837	0.250	1.896	0.015	0.857	3.589	0.837	0.018
Dillenia megalantha Merr.	5	4	120	1.046	0.250	1.896	0.019	1.060	4.002	1.046	0.021
Polyosma sp.	16	9	331	3.347	0.563	4.265	0.052	2.924	10.536	3.347	0.045
Macaranga hispida (Blume) Müll.Arg.	1	1	15	0.209	0.063	0.474	0.002	0.132	0.816	0.209	0.004
Macaranga sinensis Baill.ex.Mull.Arg.	10	9	160	2.092	0.563	4.265	0.025	1.413	7.771	2.092	0.026
Lithocarpus submonticolus (Elmer) Rehder, J. Arnold Arb.	43	15	1054	8.996	0.938	7.109	0.165	9.310	25.415	8.996	0.096
Lithocarpus caudatifolius (Merr.) Rehder	34	12	818	7.113	0.750	5.687	0.128	7.226	20.026	7.113	0.082
Fagraea auriculata Jack	8	6	181	1.674	0.375	2.844	0.028	1.599	6.116	1.674	0.029
Cinnamomum mercadoi S.Vidal	10	6	176	2.092	0.375	2.844	0.028	1.555	6.490	2.092	0.028
Litsea segregata Elmer	13	8	177	2.720	0.500	3.791	0.028	1.563	8.075	2.720	0.028
Archidendron clypearia (Jack) Nielsen	2	2	36	0.418	0.125	0.948	0.006	0.318	1.684	0.418	0.008
Grewia sp.	3	1	56	0.628	0.063	0.474	0.009	0.495	1.596	0.628	0.011
Astrocalyx calycina (S.Vidal) Merr.	55	14	1380	11.506	0.875	6.635	0.216	12.190	30.331	11.506	0.111
Astronia sp.	3	2	25	0.628	0.125	0.948	0.004	0.221	1.796	0.628	0.006
Beccarianthus pulcherrimus (Merr.) Maxw.	7	3	97	1.464	0.188	1.422	0.015	0.857	3.743	1.464	0.018

(Continued on next page)

Appendix 1 (*continued*)

Dysoxylum arborescens (Blume) Miq.	11	4	162	2.301	0.250	1.896	0.025	1.431	5.628	2.301	0.026
Dysoxylum sp.	8	6	168	1.674	0.375	2.844	0.026	1.484	6.001	1.674	0.027
Ficus benguetensis Merr.	2	2	20	0.418	0.125	0.948	0.003	0.177	1.543	0.418	0.005
Ficus benjamina L. Mant.	5	3	323	1.046	0.188	1.422	0.050	2.853	5.321	1.046	0.044
Ficus sp.	10	5	205	2.092	0.313	2.370	0.032	1.811	6.273	2.092	0.032
Syzygium tula (Merr.) Merr.	62	16	1,920	12.971	1.000	7.583	0.300	16.960	37.513	12.971	0.131
Syzygium tenuirame (Miq.) Merr.	8	6	107	1.674	0.375	2.844	0.017	0.945	5.462	1.674	0.019
Bischofia javanica Blume	3	3	78	0.628	0.188	1.422	0.012	0.689	2.738	0.628	0.015
Breynia cernua (Poir.) Müll.Arg.	15	10	278	3.138	0.625	4.739	0.043	2.456	10.333	3.138	0.040
Huberantha sp.	5	3	125	1.046	0.188	1.422	0.020	1.104	3.572	1.046	0.022
Piper aduncum L. Var	3	2	36	0.628	0.125	0.948	0.006	0.318	1.893	0.628	0.008
Melicope triphylla (Lam.) Merr.	20	13	573	4.184	0.813	6.161	0.090	5.061	15.407	4.184	0.066
Palaquium philippense (Perr.) C.B. Rob.	69	16	1769	14.435	1.000	7.583	0.276	15.626	37.644	14.435	0.126
TOTAL	**478**		**11321**	**0.074**	**100**	**13.187**	**100**	**1.768**	**100**	**300**	**1.220**

Appendix 2. Summary table of the diversity indices of trees in Mt. Malambo, Barangay Datu Salumay, Marilog District.

Scientific Name	No. of Individuals	Occurrence	Total DBH	Density	Relative Density	Frequency	Relative Frequency	Dominance	Relative Dominance	IV	Diversity Values
Actinodaphne sp.	11	5	176	0.595	2.315	0.238	2.315	0.021	1.066	5.696	0.021
Alstonia parvifolia Merr.	2	1	29	0.119	0.463	0.048	0.463	0.003	0.176	1.102	0.005
Alstonia sp.	12	7	272	0.833	3.241	0.333	3.241	0.032	1.648	8.129	0.030
Arthocarpus sp.	1	1	23	0.119	0.463	0.048	0.463	0.003	0.139	1.065	0.004
Ascarina philippinensis C.B. Rob.	6	4	122	0.476	1.852	0.190	1.852	0.014	0.739	4.443	0.016
Ascarina sp.	18	8	406	0.952	3.704	0.381	3.704	0.048	2.459	9.867	0.040
Astronia ferruginea (Elmer)	3	1	100	0.119	0.463	0.048	0.463	0.012	0.606	1.532	0.013
Beccarianthus sp.	1	1	20	0.119	0.463	0.048	0.463	0.002	0.121	1.047	0.004
Calophyllum sp.	10	6	368	0.714	2.778	0.286	2.778	0.044	2.229	7.785	0.037
Canarium sp.	19	7	529	0.833	3.241	0.333	3.241	0.063	3.204	9.686	0.048
Cinnamomum mercadoi S.Vidal.	18	9	372	1.071	4.167	0.429	4.167	0.044	2.253	10.587	0.037
Clethra sp.	6	1	72	0.119	0.463	0.048	0.463	0.009	0.436	1.362	0.010
Dendrocnide sp.	28	7	523	0.833	3.241	0.333	3.241	0.062	3.168	9.649	0.047
Dillenia philippinensis Rolfe.	7	3	253	0.357	1.389	0.143	1.389	0.030	1.532	4.310	0.028
Diospyros sp.	24	12	713	1.429	5.556	0.571	5.556	0.085	4.319	15.430	0.059
Dysoxylum parasitum (Osbeck) Kosterm.	5	3	136	0.357	1.389	0.143	1.389	0.016	0.824	3.602	0.017
Dysoxylum sp. 1	3	3	75	0.357	1.389	0.143	1.389	0.009	0.454	3.232	0.011
Dysoxylum sp. 2	3	2	153	0.238	0.926	0.095	0.926	0.018	0.927	2.779	0.019
Elaeocarpus sp.	8	6	246	0.714	2.778	0.286	2.778	0.030	1.490	7.046	0.027
Fagraea sp.	3	3	66	0.357	1.389	0.143	1.389	0.008	0.400	3.178	0.010
Ficus benguentense Merill.	24	10	474	1.190	4.630	0.476	4.630	0.056	2.871	12.130	0.044
Ficus benjamina L.	3	3	255	0.357	1.389	0.143	1.389	0.030	1.545	4.322	0.028
Ficus sp. 1	11	8	361	0.952	3.704	0.381	3.704	0.043	2.187	9.594	0.036
Ficus sp. 2	5	4	185	0.476	1.852	0.190	1.852	0.022	1.121	4.824	0.022

(Continued on next page)

Appendix 2. *(continued)*

Lithocarpus caudatifolius (Merr.) Rehder	22	11	979	1.309	5.093	0.524	5.093	0.117	5.930	16.115	0.073
Lithocarpus sp.	21	8	673	0.952	3.704	0.381	3.704	0.080	4.077	11.484	0.057
Macaranga sinensis Baill. Muell. Arg.	33	7	605	0.833	3.241	0.333	3.241	0.072	3.665	10.146	0.053
Malutos sp.	23	8	530	0.952	3.704	0.381	3.704	0.063	3.210	10.618	0.048
Melicope triphylla (Lam.) Merr.	2	1	49	0.119	0.463	0.048	0.463	0.006	0.297	1.223	0.008
Melicope sp.	2	1	35	0.119	0.463	0.048	0.463	0.004	0.212	1.138	0.006
Nauclea sp.	1	1	10	0.119	0.463	0.048	0.463	0.001	0.061	0.986	0.002
Omalanthus populneus Geiseler	1	1	14	0.119	0.463	0.048	0.463	0.002	0.085	1.011	0.003
Omalanthus sp.	4	2	50	0.238	0.926	0.095	0.926	0.006	0.303	2.155	0.008
Palaquium philippinense (Perr.) C.B. Rob.	38	11	1672	1.309	5.093	0.523	5.093	0.199	10.128	20.313	0.101
Palaquium sp.	57	13	2837	1.548	6.019	0.619	6.019	0.338	17.185	29.222	0.131
Piper aduncum L.	6	4	85	0.476	1.852	0.190	1.852	0.010	0.515	4.219	0.012
Pittosporum sp.	3	2	65	0.238	0.926	0.095	0.926	0.008	0.394	2.246	0.009
Psychotria sp.	9	5	175	0.595	2.315	0.238	2.315	0.021	1.060	5.690	0.021
Saurauia sp.	1	1	28	0.119	0.463	0.048	0.463	0.003	0.170	1.096	0.005
Shorea contorta S.Vidal	1	1	40	0.119	0.463	0.048	0.463	0.005	0.242	1.168	0.006
Syzygium tenuirame (Miq.) Merr.	25	7	986	0.833	3.241	0.333	3.241	0.117	5.972	12.454	0.073
Syzygium sp. 1	3	2	95	0.238	0.926	0.095	0.926	0.011	0.575	2.427	0.013
Syzygium sp. 2	31	5	1100	0.595	2.315	0.238	2.315	0.131	6.663	11.293	0.079
Thea sp.	4	2	77	0.238	0.926	0.095	0.926	0.009	0.466	2.318	0.011
Turpinia sp.	2	2	100	0.238	0.926	0.095	0.926	0.012	0.606	2.458	0.013
Weinmannia sp.	9	6	375	0.714	2.778	0.286	2.778	0.045	2.271	7.827	0.037
TOTAL	**529**	**216**	**16509**	**0.026**	**100**	**10.286**	**100**	**1.965**	**100**	**300**	**1.378**