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Floristic study of an ultramafic formation in Sitio Magarwak, Sta. Lourdes, Puerto Princesa City, Palawan Island, Philippines

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Abstract. *De Castro ME, Carandang VI JS, Agoo EM. 2020. Floristic study of an ultramafic formation in Sitio Magarwak, Sta. Lourdes, Puerto Princesa City, Palawan Island, Philippines. Biodiversitas 21: 3769-3779.* A study was done to assess the floristic composition of an ultramafic formation in Sitio Magarwak, Barangay Sta. Lourdes, Puerto Princesa City Palawan. A total of 52 trees and shrubs representing 30 families and 48 genera was recorded in the overstorey while the ground cover was dominated by 10 species mostly from families Poaceae and Zingiberaceae. The most dominant tree species include *Dillenia monantha* Merr., *Xanthostemon speciosus* Merr. and *Schima wallichii* ssp. *oblata* (Roxb.) Kurz. with Important Value Indices (IVIs) of 15.96%, 15.71%, and 14.20%, respectively. Level of endemicity was considerably high with 21 species classified as indigenous, 11 of which have their population restricted only on the island of Palawan. However, most of these endemics are now under threat based on the Updated List of Threatened Philippine Plants and their Categories (DAO No 2017-11) and the International Union for the Conservation of Nature (IUCN) Red List (2020-1). Two species are classified as 'critically endangered' (*Olea palawanensis* Kiew and *Guioa palawanica* Welzen*)* while the two are 'endangered' (*Kibatalia stenopetala* Merr. and *Nepenthes philippinensis* Macfarl.). Findings from this study suggest that appropriate conservation measures must be put in place to ensure protection of the native flora's remaining population from further destruction.

Keywords: Diversity indices, endemic, hyperaccumulators, Important Value Indices, ultramafic

INTRODUCTION

Ultramafics' are igneous or metamorphic rocks that contain 45% silica and high concentration of siderophilic elements such as magnesium, chromium, manganese, cobalt and nickel (Proctor 2003). Reduced productivity, high rates of endemism and stunted vegetation are some of the most notable characteristics of ultramafic formation (Bani et al. 2010). It covers only one percent of the Earth's land surface but in the context of biodiversity, ultramafics are considered noteworthy as it favors high level of endemism in spite of the low soil fertility and drier environment (Garnier et al. 2009).

In the Philippines, Mount Bloomfield in Palawan and Mount Giting-Giting in Sibuyan Island, Romblon were among the first well-studied ultramafic forests that provided basic information on the uniqueness of its vegetation (Podzorski 1985, Baker et al. 1992, Proctor 2003, Fernando et al. 2008). Stunted sclerophyllous trees, reaching only up to 2-3 meters tall and a maximum diameter at breast height (dbh) of 46 cm, presence of more open patches dominated by grasses and absence of woody plants were found to be distinct among Philippine ultramafics. Further works confirmed that this is due to low nutrient availability, high Mg/Ca quotients, nickel and manganese toxicity, inadequate water supply, and frequent fire occurrences (Proctor 2000a, Proctor 2003). Consequently, this initial efforts inspired more botanical explorations that resulted in the documentation of more ultramafic environments in the various parts of the country (Amoroso et al. 2009; Claveria et al. 2010; Fernando et al. 2013; Fernando et al. 2014; Aribal et al. 2016; Ata et al. 2016; Sarmiento and Demetillo 2017; Lillo et al. 2018; Ocon et al. 2018; Agoo and Evardone 2020; Sarmiento 2020). These local efforts confirmed the presence of distinctively stunted vegetation and the high degree of endemicity of ultramafics which also led to the discovery of new hyperaccumulator plants most of which are associated with nickel. In addition, it also proved the importance of floristic inventories to properly identify rare, native, and endemic species that necessitates immediate protection and conservation (Killeen et al. 1998). However, more work remains to be done considering that ultramafic soil covers five percent of the country's total land area (Madulid and Agoo 1997).

Palawan Island is considered the country's last frontier due to the richness in both flora and faunal diversity (Madulid 2002). But aside from its known richness in biodiversity, Palawan also hosts considerable areas of ultramafic formations not yet fully documented except the limited botanical works done in Mts. Pulgar, Victoria Range, and Bloomfield (Podzorski 1985; Reeves et al. 1992; Proctor et al. 2000a). This means that a large portion of the island's ultramafic formation remains undocumented and not yet properly taxonomized. In 2013, a Basic Resource Inventory of Sitio Magarwak, Brgy. Sta. Lourdes was initiated by the City Government of Puerto Princesa through the City Environment and Natural Resources Office. The presence of a 'special forest' dominated by Molave (*Vitex parviflora* A. Juss.) and classified it as Midmountain or Sub-Marginal forest was highlighted in the said report. However, it made no mention of the existing ultramafic formation as well as the uniqueness of it vegetation, hence this study. This floristic study was done to assess richness, degree of endemicity, and conservation status of the existing vegetation in the lowland ultramafics of Sitio Magarwak, Sta. Lourdes, Puerto Princesa City, Palawan Island, Philippines. It is hoped that this work's salient findings will add to the limited information known about this type of forest formation that will lead to a better understanding of their ecological values.

MATERIALS AND METHODS

Study area

The study was done in an ultramafic formation (N09^{0} 51.903', E118^{0} 43.546') of Sitio Magarwak, Barangay Sta. Lourdes, Puerto Princesa City, island of Palawan, Philippines. It has an elevation of about 220 meters above sea level and located approximately 18 kilometers north of the city proper (Figure 1). The area is characterized by rolling hills and flatlands which has been subjected to reforestation of fast-growing species. The area is part of the 232.74 hectares total land area of the barangay and was considered a marginalized forest. The study site belongs to Type 1 climate characterized by having dry periods from November to April and wet during the rest of the year. March is considered the driest month of the year, though intermittent rains are also experienced during the same period. The occurrence of typhoon events is rather rare in the entire Island resulting in the presence of a relatively drier environment.

Procedure

A total of 10 plots measuring 10m x 10m were laid out approximately 200m apart and all trees, shrubs, and saplings found inside were identified, counted, and measured. The common name and the total tree height were also determined. For herbs, grasses, and sedges present in the ground cover, it was determined using line intercept method using the modified procedure of Lumbres et al. (2014). Specifically, it was done by establishing a 10-m diagonal transect line inside each established plot and all plant species that touched the line were identified and counted. Plant species that occur outside the sample plots, but inside the study area were also noted for a complete assessment of the area's diversity.

The taxonomic identities of the specimens were determined with the assistance of local experts and available published literature including Flora Malesiana Series (1995-2012) and Enumeration of Philippine Flowering Plants Volume 4 (Merrill, 1923-1926). Online literature/database like Plants of the World Online, World of Flora and Co's Digital Flora of the Philippines (Pelser et al. 2011 onwards) were likewise consulted. For the local names, Dictionary of Philippine Plant Names by Madulid (2001) was used as the main reference. Voucher specimens were kept in the herbarium of Palawan State University for future reference. Duplicate collection was made for further verification at the Philippine National Herbarium (PNH). The taxonomic/conservation status of all species collected in the field was determined using IUCN Red List (2020-1) and the Updated List of Threatened Philippine Plants and their Categories (Department of Environment and Natural Resources (DENR) Administrative Order No. 2017-11).

To determine the appropriateness of the study size that will represent the diversity of the existing vegetation, a species-area curve was plotted. This was done by getting the cumulative size of the 10 plots established and the number of species documented inside each quadrat/plot. It is expected that the larger the size of the study area, the greater is the number of species present, hence diversity is directly proportional to the size of the area covered.

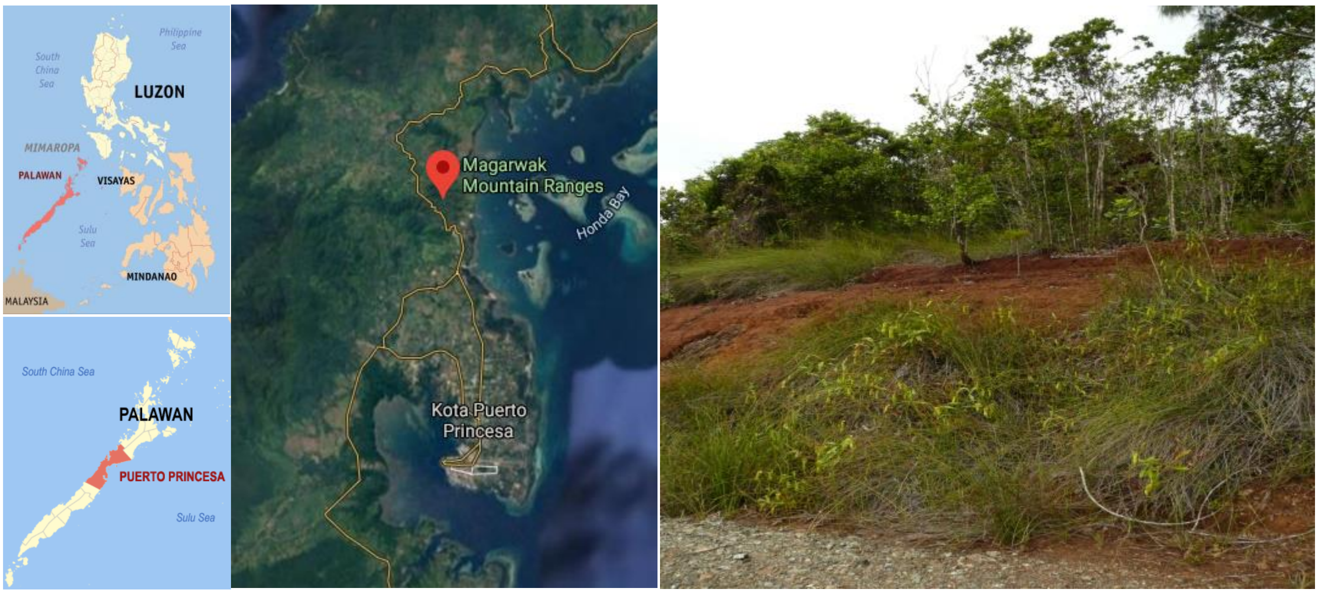

Figure 1. Location of the ultramafic formation at Sitio Magarwak, Barangay Sta. Lourdes, Puerto Princesa City (PPC), Philippines showing the vegetation and soil type

Data analysis

Plant diversity was assessed using parameters such as species frequency, density, and importance value indices (IVI). The following parameters were determined (Replan and Malaki 2014):

$$\text{Density } (D, \text{tree/m}^2) = \frac{\text{Number of individuals per species}}{\text{Area sampled}}$$

$$\text{Relative Density (RD)} = \frac{\text{Density for a species}}{\text{Total density for all species}} \times 100$$

$$\text{Frequency } (F) = \frac{\text{Number of plots in which species occur}}{\text{Total number of plots sampled}}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency value for a species}}{\text{Total frequency for all species}} \times 100$$

$$\text{Relative height (RH)} = \frac{\text{Summed height of all individuals for a species}}{\text{Summed height of all individuals for all species}} \times 100$$

Importance Value Index (IVI) = RD + RF + RH.

Due to the inherent low stature and small crowned canopy, the present work used relative height instead of relative dominance (basal area) for the computation of Importance Value (IV) as patterned from Lumbres et al. (2014).

To further assess the species diversity, Shannon Diversity index (H'), Evenness (E) and Simpson Index (D) were computed as follows:

$$H' = -\sum p_i \ln(p_i)$$

Where: ***pi*** is the proportion of individual species ***i***, and **ln** is natural logarithm.

$$E = \frac{H'}{\log S}$$

Where: ***H*** is Shannon Index and **S** is the number of species

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where: **n** is the proportion (n/N) of individuals of one particular species found and **N** is the total number of individuals found, **Σ** is still the sum of the calculations, and **s** is the number of species.

RESULTS AND DISCUSSION

Floristic assessment

A total of 52 species belonging to 30 families and 48 genera occupied the overstorey layer of an ultramafic formation of Sitio Magarwak, Brgy. Sta. Lourdes, Puerto Princesa, Palawan, Philippines (Table 1). Overall, a total of 308 individuals were recorded, mostly from the family Rubiaceae with seven representative species followed by Fabaceae with four species. Apocynaceae, Ebenaceae, Moraceae, and Myrtaceae were equally represented with three species indicating the species' level of diversity present in the area. Some families' dominance is clear evidence of the adaptation formed to cope with the unusual edaphic and climatic conditions offered ultramafic environment (Brooks 2000; Proctor 2003; Van der Ent 2015). Species that cannot be identified to the species level due to insufficient features for proper and valid recognition are tentatively assigned to the most probable taxon (genus) only.

Results of this floristic work showed that high diversity is favored in an ultramafic forest as evidenced by the large number of plant species recorded per plot. On average, there are 11 individuals for every 20 m^2 plot regardless of elevation. The vegetation in Sitio Magarwak resembles that occurring in many, but not all, ultramafic formations documented in Palawan like Mt. Pulgar, Mount Bloomfield and Mt. Victoria Range as well as other parts of the country (Reeves 1992; Proctor 2003; Fernando et al. 2008; Amoroso et al. 2009; Van der Ent 2015; Aribal et al. 2016; Ata et al. 2016; Lillo et al. 2018; Ocon et al. 2018; Sarmiento 2020). In particular, the presence of species such as *Xanthostemon speciosus* Merr., *Scaevola micrantha* C. Presl, and *Brackenridgea palustris* ssp. *foxworthyi* (Elmer) P.O. Karis was observed in the area growing sparingly from each other (Fernando et al. 2008). Soils were also noticeably dry which could partly explain the shortened height of most vegetation (pers. obs.). It has been noted that the ultramafic outcrops often support populations that are morphologically and physiologically distinct from those found on non-ultramafic soils (Galey et al. 2017).

On the other hand, the ground cover comprises 56 individuals from seven families and ten genera mostly from family Poaceae and Zingiberaceae. These two families occurrence was also noted in an earlier work in ultramafics of Palawan Island indicating their natural preference for ultramafic substrate (Reeves 2003, Fernando et al. 2008). *Scleria laevis* Willd. (Cyperaceae) recorded the most number of individuals across plots (18) followed by *Nepenthes philippinensis* Macfarl. (Nepenthaceae) with 10 individuals (Figure 2). Considering that *N. philippinensis* Macfarl. is an endemic and classified as endangered species in the DAO 2017-11, it is worth noting that its natural population is relatively stable in the study site. No fern or lycophyte species was documented in the area which may be attributed to geochemistry, hydrology, and fire-frequencies in an ultramafic environment (Proctor 1999). In addition, ultramafic soils is also known to harbor significantly more herbaceous and bamboo (Poaceae: Bambusoideae) species compared to ferns and bryophytes (Galey et al. 2017).

The density, frequency, and height of tree species were used to determine the Importance Value Index (IVI), a standard measure in ecology that determines the species rank relationship (Replan and Malaki 2014). *Dillenia monantha* Merr., *Xanthostemon speciosus* Merr., *Schima wallichii* ssp *oblata* (Elmer) Bloemb. were identified as the most dominant species with IVIs of 15.96%, 15.71%, and 14.20%, respectively (Table 2). It was hypothesized that these floral species are likely to influence the growth and survival of other species in the area due to a large number of their individuals present. It is also possible that these species were able to develop specific adaptations that permit them to thrive better in metal-rich soils compared to other species present (Baker et al. 2000, Brooks 2000, Rajakanura and Baker 2004, Van der Ent et al. 2013). Therefore, it will not be surprising if further works reveal that the dominant species also possess hyperaccumulating potential, or the ability to concentrate metals in its plants tissues at concentration above the threshold level, (1,000 µg g^{-1} for the case of Ni). Eventually, they can be utilized in phytoremediation or phytomining activities, a technology that uses plants to sequester valuable metals from ore bodies (Nkrumah et al 2017).

Figure 3 presents the six most dominant species recorded in the study site. It includes *Olea palawanensis* Kiew. and *Brackenridgea palustris* ssp. *foxworthyi* (Elmer) P.O.Karis in the fourth and fifth ranks generating IVI values of 14.18% and 12.57% respectively. Both species are both endemic to the island of Palawan with the former listed as 'Critically Endangered' while the latter is under the 'Vulnerable' group. *O. palawanensis* Kiew. belongs to olive family known to produce economically-important essential oils. As for *B. palustris* ssp. *foxworthyi* (Elmer) P.O. Karis it is a known hyperaccumulator that can concentrate Ni in its foliar tissues by as much as 8,000 µg g^{-1} on dry weight basis (Reeves et al. 1992, Brooks 2000, Van der Ent et al. 2015). However, the role of hyperaccumulators in the plant community is not yet fully defined although several hypotheses were suggested most notably the defensive protection against herbivores (Proctor et al. 2000, Boyd and Jaffrè 2001, Van der Ent et al. 2015). Experts believed that large concentration of a particular metal benefited the plant as it provided protection against insect attack (Boyd 2009). An earlier work, however, proved that there exists no relationship between the rates of herbivory and leaf elemental chemistry as herbivores also attack metal-accumulating plants (Proctor 2000b). Another hypothesis for the existence of hyperaccumulators is known as 'elemental allelopathy' wherein considerable amount of leaf Ni is deposited directly to the soil under its canopy thereby preventing non-hyperaccumulators to co-exist (Boyd 2009, Boyd and Jaffrè 2001). Contrasting evidence, however, disproved this idea attesting to the mutualistic effects of high soil Ni on the seedling growth of other species thriving under the canopy of hyperaccumulator plants (Van der Ent et al. 2015). With all these possibilities, it is highly suggested that a more detailed work must be done to determine the specific ecological role of Ni hyperaccumulators in the study site.

Dillenia monantha Merr. and *X. speciosus* Merr. are both endemic species classified as 'Vulnerable' under the 2017 Updated National List of Threatened Plants (DAO 2017-11). Despite their conservation status, these species managed to thrive well in unusual soil chemistry present in ultramafic forest indicating the favorable environment provided by ultramafic soils to these native species. *D. monantha* Merr. is valued in landscaping due to its attractive foliage and brightly-colored flowers while *X. speciosus* Merr. belongs to the Ironwood family hence with superior wood quality (Madulid 2002). These two species also contribute to the rich biodiversity of the island hence the proliferation of their population may be considered essential to maintains a stable community.

It will be observed that the IVIs of the five most dominant species are not very distant from each other. One plausible reason is the unique preference of these species for soils enriched with trace elements like nickel (Ni) and iron (Fe) (Proctor 2003). In addition, these dominant species are the ones most likely to maximize their ability to capture more resources' over time resulting in the proliferation of their population compared to others (Brazaz, 1996). But there is also evidences proving that to maintain survival, neighboring species engage themselves in commensalism relationships. In the ultramafics of Sabah, Malaysia, it was observed that some fern species that colonized branches of Ni hyperaccumulator *Phyllanthus* accumulated Ni in its tissues thereby some enhanced herbivory protection (Van der Ent et al. 2015).

For species with low IVIs, the following scenarios are possible: (i) inherent stunted growth of the species, (ii) distance of individual plants from each other, and (iii) varying age of the individual plants during the period of collection (sapling and wildling stage). The plant's ability to accumulate necessary nutrients from the soil varies not only on the plant parts, but also on the phenological development stages of its biological cycle (Xhaferri et al. 2018). As for species with lone representative, it is assumed that they are not naturally growing in the area and was only carried by various agents of dispersal and they have not yet adjusted well to the condition of the area. Therefore, more work must be done to elucidate their ecological role and contribution to the community.

A B

Figure 2. Dominant ground cover species present in the study site. A. *Scleria laevis*, B. *Nepenthes philippinensis*

Table 1. Complete list of plant species in the ultramafic formation at Sitio Magarwak, Brgy. Sta. Lourdes, Puerto Princesa City with their corresponding conservation status. (Species are arranged by family)

Family	Scientific name	Local Name	Conservation status	
			DAO 2017-11	IUCN (2020-1)
Trees and shrub				
Anacardiaceae	*Buchanania arborescens*	Balinghasai		NA
	Mangifera sp.			NA
Annonaceae	*Orophea creaghii*	Tabingálang	VU	NA
Apocynaceae	*Kibatalia stenopetala*	Pasnit-kitid	EN	EN
	Amphineurion marginatum	Tandis-tandis polon		NA
	Urceola laevis		VU	NA
Burseraceae	*Protium connarifolium*	Márangub	VU	VU
Calophyllaceae	*Calophyllum inophyllum*	Bitaog		LC
Cannabaceae	*Trema eurhynchum*			LC
Casuarinaceae	*Gymnostoma nobile*	Palawan agohó	VU	NA
Clethraceae	*Clethra pulgarensis*	Tagobàhi	VU	NA
Dilleniaceae	*Dillenia monantha*	Kátmon-bugtóng	VU	NA
Ebenaceae	*Diospyros hebecarpa*	Tulican		LC
	Diospyros kurzii	Katlima		NA
	Diospyros transita		OTS	NA
Ericaceae	*Vaccinium brachytrichum*		VU	NA
Fabaceae	*Kunstleria forbesii*		VU	NA
	Derris sp.			NA
	Archidendron clypearia			LC
	Dalbergia densa			LC
Goodeniaceae	*Scaevola micrantha*			LC
Hypericaceae	*Cratoxylum sumatranum*	Panagulingon		LC
Lamiaceae	*Vitex pinnata*	Malayan Teak		LC
	Premna serratifolia	Alagaw		NA
Lauraceae	*Dehaasia cairocan*	Malakadios		NA
Loganiaceae	*Geniostoma rupestre*			LC
Malvaceae	*Grewia multiflora*	Danglin		NA
Moraceae	*Ficus pustulata*			LC
	Ficus sp.			NA
	Streblus ilicifolius			LC
Myrsinaceae	*Ardisia* sp.			NA
Myrtaceae	*Xanthostemon speciosus*	Malapiga	VU	NT
	Syzygium sp.			NA
	Tristania sp.			NA
Ochnaceae	*Brackenridgea palustris* ssp. *foxworthyi*	Bansilai	VU	NA
	Campylospermum serratum	Alas		LC
Oleacaceae	*Olea palawanensis*	Palawan olive	CE	NA
Phyllanthaceae	*Phyllanthus balgooyi*	Manglás	VU	NA
Pittosporaceae	*Pittosporum ramosii*	Albòn	OTS	NA
Rubiaceae	*Mussaenda philippica*	Humbabuyin		LC
	Diplospora sessilis			NA
	Canthium sp.			NA
	Antirhea caudata			NA
	Psydrax dicoccos	Malakape		VU
	Psydrax gynochthodes	Malakape		NA
	Psychotria sp.			NA
	Morinda sp.			NA
Sapindaceae	*Guioa palawanica*	Palawan alàhan	CE	CR
Sapotaceae	*Planchonella obovata*			NA
	Pleioluma firma	Bagomaho		LC
Theaceae	*Schima wallichii* ssp. *oblata*		VU	NA
Thymelaeaceae	*Wikstroemia indica*	Salago		NA
Herb, grass, sedges, aroids				
Asteraceae	*Gynura vidaliana*			NA
Cyperaceae	*Scleria oblata*			NA
Dioscoreaceae	*Dioscorea palawana*	Palawan ube	VU	NA
Nepenthaeaceae	*Nepenthes philippinensis*	Kuong-kuong	EN	LC
Poaceae	*Dinochloa palawanensis*	Palawan bikal	VU	NA
	Panicum sp.			NA
	Dinochloa sp.			NA
Rubiaceae	*Hedyotis* sp.			NA
Zingeberaceae	*Alpinia foxworthyi*	Langkawas	VU	NA
	Wurfbainia palawanensis	Tagbak	VU	NA
Total number of species 62				

**Conservation Status: NA: Not Assessed, NE: Not Evaluated, DD: Data Deficient, LC: Least Concern, OTS: Other Threatened Species, NT: Near threatened, VU: Vulnerable Species, EN: Endangered Species, CR: Critically Endangered Species, EW: Extinct in the Wild, EX: Extinct

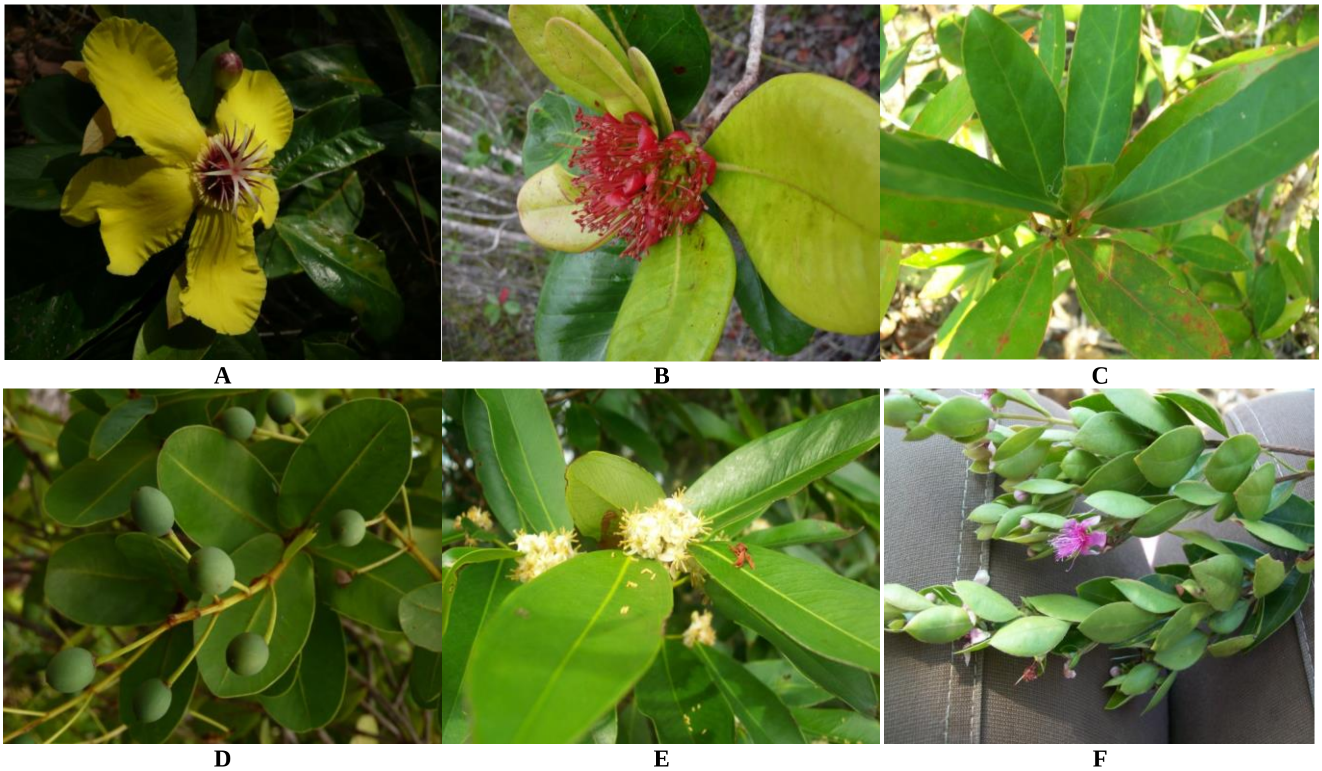

Figure 3. Species with the highest Importance Value Index (IVI) in the study site. A. *Dillenia monantha,* B. *Xanthostemon speciosus,* C. *Schima wallichii* ssp. *oblata,,* D. *Olea palawanensis,* E. *Brackenridgea palustris* ssp. *foxworthyi,* F. *Vaccinium brachytrichum*

Table 2. Top 10 species with the highest Importance Value Index (IVI)

Species Name	Family	RD	RF	RH	IVI
Dillenia monantha	Dilleneaceae	6.76	6.06	3.14	15.96
Xanthostemon speciosus	Myrtaceae	8.11	5.05	2.55	15.71
Schima wallichii ssp. *oblata*	Sapotaceae	4.05	5.05	5.10	14.20
Olea palawanensis	Oleacaceae	7.77	5.05	1.36	14.18
Brackenridgea palustris ssp. *foxworthyi*	Ochnaceae	4.05	7.07	1.44	12.57
Vaccinium brachytrichum	Ericaceae	6.42	4.04	0.76	11.22
Guioa palawanica	Sapindaceae	3.04	4.04	1.36	8.44
Cratoxylum sumatranum	Hypericaceae	1.69	1.01	5.10	7.80
Streblus ilicifolius	Moraceae	4.73	2.02	1.70	8.45
Diospyros hebecarpa	Ebenaceae	0.34	1.01	3.57	4.92

Species-area curve

Based from the plotted species-area curve, the sampling size used in the study (1000 m^2) was sufficient to represent the diversity of the ultramafic formation in Sitio Magarwak (Figure 4). As the sampling size reached 1000 m^2, the line started to plateau indicating that no additional species exists with the increasing sampling size. However, it should be noted that the species-area curve is a product of several factors more importantly the clumping or clustering of captured species in the established quadrats/plots. In general, organisms tend to concentrate in a small area due to restrictions of dispersal mechanism and available food supply. As a result, the habitat becomes less heterogeneous and uniform (Green and Ostling 2003). The type of community interactions (predatory or mutualistic) and the size of the species should also be taken into account in the assessment of species-area curves. Specific for floral species, the different strata occupied by the existing vegetation may likewise be considered a contributing factor for a highly diverse community to occupy just a small piece of land. For the case of the present study, it was noted that the area is characterized by relatively dispersed vegetation as such a larger sampling size was utilized to document the diversity of the area.

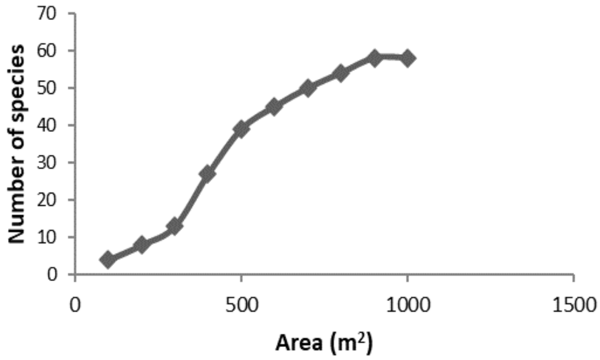

Figure 4. Species area curve of the sampling site in Sitio Magarwak, Brgy. Sta. Lourdes, Puerto Princesa City, Philippines

Table 3. Summary of Diversity Indices for the ultramafic formation of Sitio Magarwak

Diversity Index	Overstorey	Ground cover
Shannon Index (H)	3.498	1.822
Shannon Evenness/Equitably (S)	0.885	0.840
Simpson Diversity Index (D)	0.963	0.791

Diversity index

Using species abundance and frequency, diversity indices such as Shannon (H'), Evenness (E), and Simpson's (D) were also determined in this study. The ultramafic formation of Sitio Magarawak can be considered highly diverse with an H'value of 3.498 for the overstorey and 1.822 for the ground cover (Table 3). This result is similar to the diversity of the lowland scrub ultramafic forest in Dinagat Island with an exceptionally high H' value of 3.46 (Lillo et al. 2018). Our findings only indicate that the ultramafic of Sitio Magarwak is relatively mature as older stands are expected to host more species that interact with each other (Galey et al. 2017). But not all tropical ultramafics behave the same way. In fact, the rapid assessment of the ultramafics of Zambales and Surigao del Norte recorded a low H' value of 0.6500 and 1.1071, respectively. This scenario may be attributed to the limited number of species and the level of disturbance experienced by the species in the area. In a similar work conducted in Cagdianao, Claver Surigao del Norte, an average H' value of 0.9867 was generated reflecting the low diversity in the area (Ocon et al. 2018). The shortage of major soil nutrients and the absence of mycorrhizal association of the plant species in the area are being considered as the main reasons cited by the authors. Our result showed evidence that despite the presence of several edaphic stressors, the community can still be diverse and complex (Quinetala-Sabaris et al. 2020).

The computed Simpson index (D) value for the overstorey vegetation was also high at 0.963 implying the presence of several dominant species in the community that is likely to control the community. As for the 15 species with lone representative, although their significance has not yet been fully assessed, it is possible that are equally important to the stability of the community since some of them occupied the canopy layer like *Gymnostoma nobile* Whitmore L.A.S. Johnson (Casuarinaceae) that provide some protection to the low lying vegetation. Likewise, Evenness (E) Index for overstorey (0.885) and ground cover (0.840) concur with the results of the other diversity indices giving an overall impression that ultramafic soil is highly productive and stable. However, it should be pointed out that there is an array of factors that influence diversity in an ultramafic environment (Ata et al. 2016). Soil chemistry, particularly soil pH and organic matter content has been considered as the most critical factor for the survival of the vegetation in the ultramafic forest. It was noted that there is an indirect relationship between metal solubility and soil pH, that is, higher uptake of certain elements at a much lower pH level (Kabata-Pendias 2001). Frequent rainfall events likewise favor higher diversity due to the presence of water needed for fast growth (Proctor 1999). Therefore, ultramafics with frequent rainfall events may expect to have higher diversity compared to drier areas. In addition, geologic events related to the formation of an ultramafic also accounts for the difference in the diversity of ultramafic formations. A comparison of species diversity in ultramafic forest of Zambales and Surigao del Norte noted the difference in the species composition which was partly attributed to the ultramafic complexes' ages and possible lithospheric sources (Ata et al. 2016). Ultramafic formations regardless of location may share a distinct suite of chemical and physical features but tropical ultramafic soils are unique in elemental content, moisture, organic matter content, and soil pedology (Lewis and Bradfield. 2003, Galey et al. 2017). Based on these generalizations, it is safe to assume that the high diversity of the ultramafic formation in Sitio Magarwak is a product of all the contributing factors mentioned above.

Biodiversity value

The ecological significance of any land formation relies not only on species richness but also on the number of native, endemic, and even threatened species present. Native species may include both endemic and non-endemic indigenous species that can extend its population outside its natural geographic range while endemics are those whose distribution is strictly confined within specific geographic range or areas like island or land formation (Replan and Malaki 2017, Lillo et al. 2018). The Philippines is home to more than 3500 indigenous (native) species, 89.96% of which are classified as angiosperms, 0.17% are gymnosperm and 9.87% are pteridophytes (Madulid 1991, Amoroso et al. 2009, Lillo et al. 2018). In the present work, 22 species are indigenous to the Philippines, 11 of which have their population restricted only on the island of Palawan (Table 4). Included in the list are six endemic herbs and grasses and their presence can be influential for the survival of its associated species as they dominate the ground cover. In a similar study done in Carrascal, Surigao del Sur, a total of 46 out of 48 recorded species were found to be native to the Philippines of which 50% are endemic or exclusively found in the country (Sarmiento 2020).

It must be pointed, however, that the category of ″endemic″ is largely based on the published biodiversity data, recent taxonomic revisions, nomenclatural changes, and new evidence from various disciplines used in systematics (Replan and Malaki 2017). This means that there is a high possibility that a large number of native species remain undiscovered and not yet taxonomized, hence, the actual number of endemics may even be higher than what is currently reported.

Table 4. List of Philippine Endemic Species in the study site arranged according to family. Asterisk (*) means the species is endemic to Palawan Island only

Species name	Family	Local name
Kibatalia stenopetala	Apocynaceae	Pasnit-kitid
Gynura vidaliana	Asteraceae	
*Protium connarifolium**	Burseraceae	Marangub
*Clethra pulgarensis**	Clethraceae	Tagobahi
Dillenia monantha	Dilleneaceae	Katmon bugtong
*Dioscorea palawana**	Dioscoreaceae	Palawan ube
*Diospyros transita**	Ebenaceae	
Vaccinium brachytrichum	Ericaceae	
Scaevola micrantha	Goodeniaceae	
Ficus pustulata	Moraceae	
Xanthostemon speciosus	Myrtaceae	Malapiga
Nepenthes philippinensis	Nepenthaceae	Kuong-kuong
Brackenridgea palustris ssp *foxworthyi**	Ochnaceae	Bansilai
*Olea palawanensis**	Oleaceae	Palawan olive
Pittosporum ramosii	Pittosporaceae	Albòn
*Dinochloa palawanensis**	Poaceae	Palawan bikal
Mussaenda philippica	Rubiaceae	Humbabuyin
Diplospora sessilis	Rubiaceae	
*Antirhea caudata**	Rubiaceae	
*Guioa palawanica**	Sapindaceae	Palawan alahan
*Alpinia foxworthyi**	Zingiberaceae	Langkawas
Wurfbainia palawanensis *	Zingiberaceae	Tagbak

Langenberger (2004) emphasized the diversity of Philippine endemic flora is not properly reported due to the following: (i) most of the floristic studies done focused only on trees (dbh >10 cm) or large species but in reality, smaller trees and other life forms account for the bulk of species present in any forest formation, (ii) plant diversity studies are usually conducted in higher elevation with little attention to the lowland forest that experience a more serious threat brought about by anthropogenic forces, (iii) irresponsible use of local names resulting to confusion in understanding Philippine forest vegetation and ecology, and (iv) existence of several independent floristic studies that are not properly published in a way that the science community can access the study. Unless these problems are addressed, the rich diversity of Philippine flora will not be recognized properly by the international scientific community.

The condition of most endemic species in the study site may be considered alarming. In particular, a total of 22 species are in the DAO 2017-11 list while 20 species were assessed by IUCN and included in their Red List (2020-1). *Kibatalia stenopetala* Merr. (Apocynaceae) and *Guioa palawanica* Welzen (Sapindaceae) are both noteworthy species as the two references used concur in their classification, with the former classified under 'Critically Endangered' while the latter was identified as an 'Endangered' species. This means that *K. stenopetala* Merr. faces an extremely high risk of extinction in the wild if no conservation measures will be done soon. Unfortunately, local people serve as one of the major threats to conservation as indiscriminate collection of valuable plant species for house construction and charcoal-making are quite rampant in the area (pers. obs.). Another species under the 'Endangered' category (DAO 2017-11) is *O. palawanensis* Kiew (Oleaceae) but surprisingly it was not listed in the IUCN Red List. As noted earlier, the species ranks fourth among the most important species in the area with an IVI of 14.18%, and its continuous proliferation in the ultramafic soils only proved its preference to such type of soil (Table 2). On the other hand, *N.philippinensis* Macfarl. is the only ground cover vegetation included in the 'Endangered' list of DAO 2017-11 but it is considered dominant ground cover species in the area next to *S. laevis* Willd. This species was recorded as early during the 1984 botanical expedition in Palawan (Podzorski 1985, Fernando et al. 2008), hence it can be used as an indicator species of ultramafic environment.

Under the 'Vulnerable' category of DAO 2017-11, three species with the highest IVIs are identified together with four species of herbs and bamboo such as *Dioscorea palawana* Prain & Brukill, *Dinochloa palawanensis* (Gamble) S. Dransf., *Alpinia foxworthyi* Ridl. and *Wurfbainia palawanensis* (Elmer) Skornick. & A.D.Poulsen. In the IUCN Red List, however, only three species were classified as 'Vulnerable' category and the rest were either placed under 'Least Concern' or completely not assessed indicating the need for a more extensive review. Nevertheless, the result of this work should serve as a red flag to the concerned institutions to come up with specific conservation plans to prevent the worsening of the situation which can be in the form of local directives that must be enacted by the local government units (LGUs).

Discussion

Our study presented both similarities and uniqueness of the ultramafic formation of Sitio Magarwak with other ultramafic formations documented. The high diversity of the area which was found to be similar in the ultramafics of Dinagat Island indicates the association of several species to a metal-rich soil (Lillio et al. 2018). It was evident in both sites it was evident that specific morphological adaptations are present among native vegetation that allows them to survive in the unusual edaphic and climatic conditions present. Among these adaptations include low plant stature, small crowned canopy, and glaucous (dark-green) leaves (Brady et al. 2005). The high diversity of the ultramafic formation in Sitio Magarwak is also comparable to other forest types documented in the Philippines as well as other parts of the world (Amoroso et al. 2009; Lumbres et al. 2014; Replan and Malaki 2017; Medecilo and Lagat 2017; Tadesse et al. 2017; Lillo et al. 2018). Endemism was also highly evident in the ultramafics of Magarwak with the presence of more than 20 out of 62 species documented in the area. Similar findings were also noted in other ultramafic formations in the country as well as those observed in New Caledonia, Cuba, Mediterranean as well as South Africa and Australia. (Arabal 2016; Galey et al. 2017; Sarmiento and Demetillo 2017; Sarmiento 2020). The restriction of several endemic species in an ultramafic environment is being considered as a direct result of their slow growth compared to other species that can thrive in soil with more favorable conditions (Anacker 2014).

Most of the early works that documented the vegetation in ultramafics in the country noted the distinct variation but failed to explain the mechanism behind it (Baker et al. 1992; Proctor et al. 1999; Fernando et al. 2008; Ata et al. 2016; Sarmiento and Demetillo 2017; Lillo et al. 2018; Sarmiento 2020). In the present work, we provide information on the distinct floral composition in one of the lowland ultramafic formations of Palawan which has not yet been reported. Ultramafic formations in Palawan are one of the earliest explored in South East Asia, however, much of the works were done on high elevation mountains hence different plant composition was characterized. The ultramafic of Sitio Magarwak is highly accessible to humans therefore a distinct formation was documented. It is noteworthy that at least two of the identified Ni hyperaccumulator plants are thriving well in the study site, which is a good indication that other potential metal-eating plants may also be present and remains undiscovered. Most of the recent explorations done in Philippine ultramafics led to the discovery of new Ni hyperaccumulator plants that can be utilized for phytoremediation or phytoextraction activities. In fact, the assessment of Acoje mine site in Zambales (Luzon) resulted in the identification of 28 Ni hyperacumulators that has the capacity to absorb Ni >10,000 µg/g Ni in its aboveground (Van der Ent et al. 2012; Fernando et al. 2013). In Manacani Island, Eastern Samar, Evardone, and Agoo (2020) also identified fifteen (15) hemi-accumulators (>100-1,000 µg/g) with *Vitex parviflora* considered as the most notable. In a similar effort, new metallophytes were discovered in Fe and Cu enriched environments of Brookes Point, Palawan, and Mankayan, Benguet (Claveria et al. 2010).

The presence of species that were only identified up to genus level indicates that the level of endemism in the study site may even be higher than the current estimate. This in turn necessitates more extensive taxonomic works and botanical exploration to properly account endemic species in the area. However, since most of the endemics documented are now facing threats due to over-exploitation and indiscriminate collection among local people, the risk of losing valuable species is relatively high. Such is the case of the newly discovered Ni hyperaccumulator *Phyllanthus rufuschaneyi* in Kinabalu Park, Sabah, Malaysia (Bouman et al. 2018). The natural population of the said species was found only in patches of the remaining scrub that are severely affected by over-exploitation and human-induced forest fires. The lack of awareness and proper recognition of the ecological significance of the endemic species may be considered as one of the major reasons for the continuous decline in the population of native species in the wild. Similar situation was faced by the newly-discovered Ni hyperaccumulator plant *Rinorea niccolifera* Fernando (Violaceae) in Zambales, Luzon, Philippines (Fernando et al. 2014). Due to serious habitat fragmentation, the IUCN Red List (IUCN 2012) classified it under 'Endangered'. It is possible that the ultramafic forest of Sitio Magarwak houses a plant with contrasting hyperaccumulation potential like *Dichapetalum gelonioides* (Roxb) Engl. but this remains to be undiscovered (Nkrumah et al. 2018). A much better possibility is the occurrence of a multi-element hyperaccumulating plant-like *Glochidion* cf. *sericeum* J.R.Forst. & G.Forst. that can be utilized for environmental clean-up (Van der Ent et al. 2018), hence, more follow-up works is needed. The information presented in this work suggests that appropriate conservation management strategies must be imposed immediately to ensure the protection and conservation of the endemic species. Given the accessibility of the area, this ultramafic formation should also be considered as a long-term ecological plot that will be devoted to more studies that will provide strong evidence on the significance of its unique vegetation.

In conclusion, a total of 62 species belonging to 37 families were documented in the ultramafic forest of Sitio Magarwak, Brgy. Sta. Lourdes, in Puerto Princesa City, island of Palawan. The results of this present work complement the findings of the 2013 Resource Basic Inventory of Sitio Magarwak which documented the presence of several valuable endemic species in the area. However, since most of the native species recorded are now facing threats a strict implementation of necessary protection measures must be put in place immediately. Concerned government agencies in the locality should also restrict access to the area to prevent further destruction and disturbance of the existing vegetation.

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