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A checklist and conservation status of vascular plants in the Limestone forest of Metropolitan Ilocos Norte Watershed Forest Reserve, Northwestern Luzon, Philippines

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Abstract. *Batuyong MAR, Calaramo MA, Alejandro GJD. 2020. A checklist and conservation status of vascular plants in the Limestone forest of Metropolitan Ilocos Norte Watershed Forest Reserve, Northwestern Luzon, Philippines. Biodiversitas 21: 3969-3981*. The Metropolitan Ilocos Norte Watershed Forest Reserve (MINWFR) is among the remaining intact limestone formations and a critical protected area in northwestern Luzon. There have been few published floristic studies despite its undeniable rich biological importance. Therefore, this paper primarily aims to provide a preliminary checklist of vascular plants in MINWFR and their conservation status. Consequent field visits and surveys were made from April 2019 to March 2020. Results revealed a total of 173 species distributed in 140 genera belonging to 59 families. The most represented families are Rubiaceae, Fabaceae, Orchidaceae, and Malvaceae. This forest supports 49% or 28.65 % local endemics, five of which are narrow endemics, namely *Cyanometra warburgii*, *Pyrostria triflora*, *Syzygium ilocanum*, *Thrixspermum nicolasiorum*, and *Antirhea microphylla*. The latter, however, extends up to Ilocos Sur. Based on IUCN criteria and DENR (Department of Environment and Natural Resources of Philippines) records, a total of 18 species are threatened, one species is recorded as critically endangered, five endangered, nine vulnerable, three other threatened, two near threatened, 55 as least concern, and the rest are not evaluated. Other noteworthy species present in the area are the two dominant endangered species, *Podocarpus costalis*, and *Podocarpus polystachyus*. An interesting spinescent Rubiaceae species were recorded and currently under examination to establish its identity. This checklist serves as a basis to effectively manage this vulnerable area surrounded by human-induced disturbances and threats.

Keywords: Biodiversity, conservation, Ilocos Norte, Limestone forest

INTRODUCTION

The Philippines supports many endemic and various species from different ecosystems owing to its highly diverse topography, climate patterns, and complex geological history (Myers et al. 2000; Yap 2010; Brown et al. 2013; Dapar et al. 2020). It is listed as one of the megadiverse countries (DENR-BMB 2015; CI 2020). However, it is reported as one of the top countries affected by biodiversity loss, thus making it one of the global conservation priority areas (Rockstrom et al. 2009; Mittermeier et al. 2011; CBD 2020).

In the past years, there have been increased government initiatives recompensed by conservation successes such as the establishments and declarations of Key Biodiversity Areas (KBAs) and Protected Areas (PAs) as cornerstones to ensure biodiversity conservation in the face of threats and pandemic we are experiencing (Sinsin 2012; DENR-BMB 2015). Sadly, due to incessant deforestation and exploitations of several crucial habitats, this has led the country to be on the edge of ecological degradation and biodiversity collapse (Posa et al. 2008; Amoroso 2011; CBD 2020). One of the diverse types of forest ecosystems in the country that is gaining the need for top priority biodiversity research and urgent consideration for protection is limestone ecosystem. It is identified as a conservation focus for sustainability, especially that natural and anthropogenic disturbances are increasing (Sodhi et al. 2010). The Philippines is endowed with about 11.7% or extensive 35,000 km^2 karst total land (DENR-BMB 2019), but a large portion of this is still unknown to science. The Philippines' Biodiversity Management Bureau recognized the need for a strategic action plan to save and sustainably managed this unique ecosystem as it hosts diverse flora and fauna. The growing interest in this type of forest formation is because of its panoramic view, ecotourism and recreational value, the potential discovery of new flora and fauna, the utilization of its mineral and aquifer resources, and cultural importance.

Among the considered remaining intact and important limestone areas found in Luzon (Tolentino et al. 2020), is the Metropolitan Ilocos Norte Watershed Forest Reserve (MINWFR). It is part of the Ilocos Mountains and described as one of the critical ecosystems by Calaramo et al. (2016). It has numerous cavern systems, and most of them contain subterranean rivers (DENR-MINWFR Management Plan 2018). Initially, it is established as a component by the National Integrated Protected Area

System (NIPAS) through Presidential Proclamation No. 731, dated September 27, 1934, but currently, proposed to be a regular component**.**

Unfortunately, like any other area, its ecological aspects are also the most vulnerable and fragile (Brinkmann & Parise 2012) and under immense pressure because of the observed disturbances in all corners of the PA brought by human exploitation and numerous infrastructure developments, aggravated by the harsh climatic condition. Meager information is also available about the richness and status of plants existing in this area. Hence, this suggests an imminent need to perform a floristic survey to increase the plant diversity knowledge on this limestone forest. As underscored by Ong et al. (2002), the conduct of floristic inventories through and mapping of habitat types must be undertaken, since these areas contain specific vegetation assemblages and may be very useful in predicting and validating plant distribution. Moreover, Stockli et al. (2011) emphasized that they are crucial elements in the monitoring of programs directed at looking into the effects of climate change.

Further, they will serve as essential guides necessary for creating conservation plans and programs directed for policy formulation (Bacudo et al. 2006; UNEP 2012; PCARRD 2017) and the practical management of the area in a way where potentially invasive species may be efficiently identified, accordingly monitored, and properly contained. Thus, this study provides a preliminary checklist of vascular plants, including their conservation status in the limestone forest of MIWFR, Northwestern Luzon, Philippines.

MATERIALS AND METHODS

Study site

The study site is positioned geographically in the Metropolitan Ilocos Norte Watershed Forest Reserve (MINWFR), Municipality of Pasuquin, Province of Ilocos Norte, Philippines (Figure 1). Based on the DENR (Department of Environment and Natural Resources of Philippines) cadastral survey, it has an estimated land area of 2,075 hectares with a buffer zone of 412 hectares. It lies between geographical coordinates of 120° 37'00" -120° 41'00" North and 18° 21'00" -18° 24'00" East. It covers Barangays Sapat, Tadao, Salpad, Sulbec, Sulongan, Susugaen, and Estancia.

The climate of MINWFR sits in the type 1 climate with pronounced dry and wet season based on the Corona Classification. There is a severe dryness during the summer months from January to May, which reaches a very high temperature (39^0C). The wet months from June to October transform the vegetation into greenery, where trees create a thick canopy, and numerous seasonal herbs grow on its rocky ecosystems. Tropical cyclones and storms occasionally visit the Municipality of Pasuquin during the southwest monsoon season (May to October), and it is most dominant during July. Exposed to Southeast monsoon and cyclonic rains, this area experiences prevailing wind blowing from north to south and sometimes west to east, primarily when rainfall occurs. However, the area is shielded from the northeast and trade winds by the Northern Cordillera Ranges.

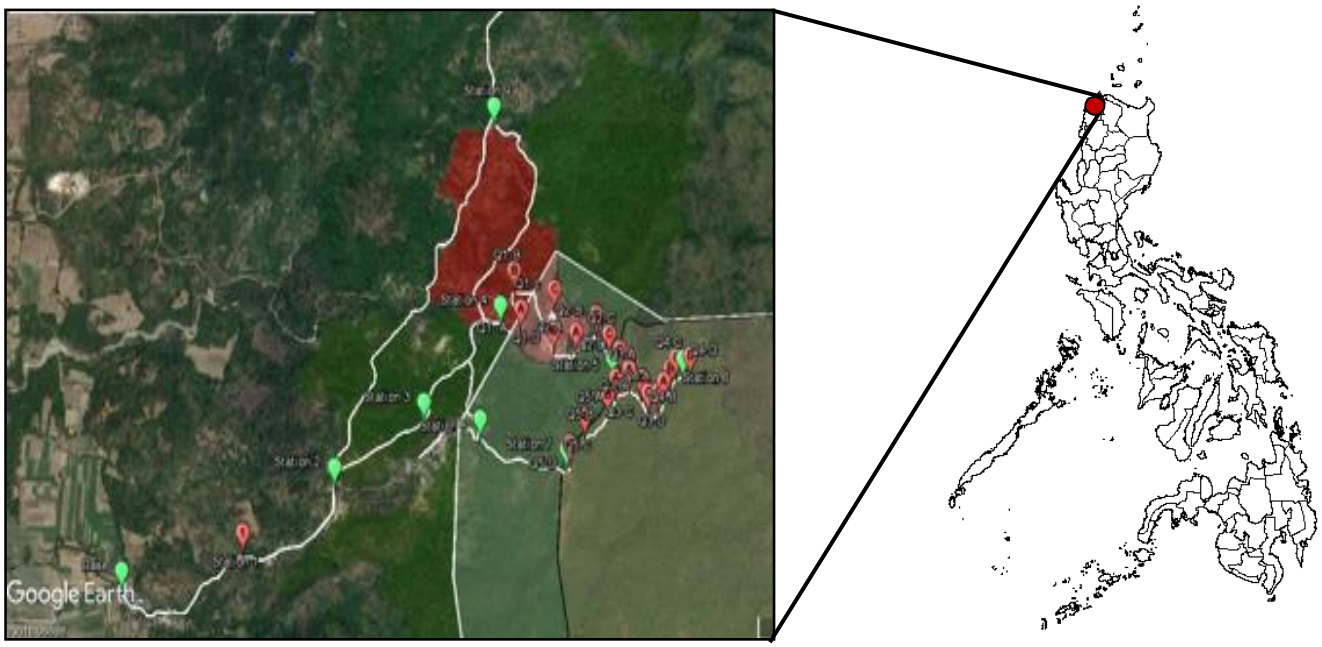

Figure 1. Map of the study sites in Metropolitan Ilocos Norte Watershed Forest Reserve (MINWFR), Northwestern Luzon, Municipality of Pasuquin, Province of Ilocos Norte, Philippines. Surveyed areas are marked in green and red

MINWFR is generally mountainous with rugged terrain. Terrain ranges from 0-8% level to undulating, 8 - 18% undulating to rolling, 18-30% rolling to hilly, 30-50% hilly to mountainous, and 50% very steep. The highest elevation of the protected area is 539 meters above sea level (asl). The highest altitude in the Municipality is 564 meters located within the military reserve, which is directly adjacent to the PA. MINWFR mainly consists of Bolinao Clay with relatively small portions of San Fernando Clay Loam and Umingan Clay Loam (DENR-MINWFR Management Plan 2018).

The survey, collection, and processing of specimens

Before the actual field survey and to fulfill the legal requirements of EO 247 (Bioprospecting) and RA 9174 (Wildlife Resource Conservation and Protection Act), a research proposal was presented to the members of the Protected Area Management Board (PAMB) of MINWFR for their approval and eventual issuance of the Gratuitous Permit from the Department of Environment and Natural Resources of Region 1.

The consequent field visit was made in the area from April to October of 2019 to map and identify the sites and trails, and for the initial listing and photo documentation of plant species in the area. Then, the actual surveys, data gathering, and the collection were conducted in November 2019 to February 2020, where there are more observed plants that are in their flowering and/or fruiting stage. A revisit in the area was done in March 2020 for the final documentation of plants with their mature fruits.

The plant specimens were collected and assessed along and approximately 10 m in the accessible and identified trails in the site (Figure 1) as surveyed areas. Representative specimens collected were pressed, cured, and mounted following standard procedures for herbarium vouchers. Field data as to the habitat, physiognomy, characteristics of the plants that will be lost after drying, local names, and coordinates were noted. Herbarium specimens were labeled and kept at the Herbarium of Northwestern Luzon (HNUL) and University of Santo Tomas Herbarium (USTH).

Identification of plant materials

Relevant literature such as *Enumeration of Philippine Flowering Plant*s (Merrill 1925) and some open-access websites such as *Co's Digital Flora of the Philippines* (www.philippineplants.org), or digital herbarium specimen was accessed mainly through *JSTOR* (https://plants.jstor.org/) and the *Global Biodiversity Information Facility*, GBIF (http://www.gbif.org/) to confirm for the identification. The collections from the following local herbaria such as National Museum of the Philippines (PNH), University of the Philippines Los Banos- Museum of Natural History (CAHUP), University of Santo Tomas-Herbarium (USTH), and Herbarium of Northwestern Luzon (HNUL) were also accessed for the validation of the identity of the collected plants.

The nomenclatural status of the species identified was reviewed through *The Plant List* (http://www.theplantlist.org) and *International Plant Name Index*, IPNI (https://www.ipni.org/). Online databases such as *The Global Biodiversity Information Facility* ((http://www.gbif.org/)) and *Co's Digital Flora* (Pelser et al. 2011 onwards) of the Philippines were used to identify the occurrence and distribution of the plants collected. The classification of the conservation status was based on the *International Union of Conservation of Nature* (IUCN) *Red List* of Threatened Species (https://www.iucnredlist.org/) and the *Updated National List of Threatened Plants in the Philippines* (DENR DAO 2017-11) to determine the status, whether Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Other Threatened (OT), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE).

RESULTS AND DISCUSSION

Description of the vegetation and flora in the area

The high floral richness recorded on forest over limestone is considered still as underestimated (Clements et al. 2006). Moreover, according to Tolentino et al. (2020), a few existing studies focusing on limestone forests in the country were conducted. The forest structure in MINWFR showed differences in vegetation just a few kilometers apart from one area to another; (i) some portions of the forest are open brushland, while others have been converted into agroforestry and reforestation areas, (ii) other areas are observed as seasonal dry with tall trees and small understory trees, (iii) to forested thickets with the presence of ferns, herbaceous plants, and shrubs in dense population with high growing trees, which makes the upper canopy, at the same time, limestone is present on the ground scape, (iv) while another site is dominated by sparse and small stunted trees over rocky ridges with numerous herbaceous plants on the ground, which indicate drought-tolerant population, some of the trees and shrubs tend to have leathery and thick leaves. This diverse ecological niches, specific vegetation and complex terrains that could be found existing within the limestone landscape (Clements et al. 2006; Saw et al. 2010; Tolentino et al. 2020) is similarly observed in the area. According to Perez-Garcia et al. (2009), the observed high environmental heterogeneity found within the forest is attributed to its unusual soil condition. Taking also into consideration the geological history, hydrology, micro-climatic conditions, and the prevailing climate of the area as this forest vary from other types of rainforest, with regards to its structure, species richness as well as species composition (Whitmore 1984; Fernando et al. 2008).

The result of the plant survey done revealed that MINWFR has notable plant composition. Overall, the preliminary list of recorded families of vascular plants, ferns and their allies (angiosperms and gymnosperms) from the area composed a total of 173 species, 140 genera belonging to 59 families. The recorded species comprised of 106 small to large trees, 30 shrubs, 17 herbs, six vines, and 14 epiphytes (Table 1).

Table 1. Taxonomic inventory of vascular plants documented in MINWFR, Northwestern Luzon, Philippines

	Total number of		
	Families	**Genera**	**Species**
Trees	39	81	106
Shrubs	16	22	30
Herbs	11	16	17
Vines	2	3	6
Epiphytes	5	15	14
Total			173

Of the 59 families, two were gymnosperms represented by Cycadacea and Podocarpacea. The Angiosperm family having the most number of genera, is Rubiaceae (17), followed by Fabaceae (12), Orchidaceae (7), Lamiaceae, Malvaceae, Poaceae (6), and Phyllantaceae (4), while the rest of the families each having three or fewer genera (Table 2; Figure 4). Some of these families are among the included typical families observed in a forest over limestone (Pedregosa et al. 2006; Kiew 2014; Replan and Malaki 2017). The Rubiaceae represents the world's fourth-largest flowering plant family, after Orchidaceae, Asteraceae, and Fabaceae (Govaerts et al. 2006) that are widely distributed in the tropics. Besides, species of Rubiaceae were also found in the forest over limestone of Eastern Samar Visayas based on a checklist by Ordas et al. (2018).

The dominant genera *Ficus* L. and *Syzygium* R. Br. ex Gaertn belonging to the family Moraceae and Myrtaceae, respectively, are highly represented, having four species each. Other genera with abundant species were *Albizia* Durazz. and *Callophyllum* L. having three species each. Whereas, a single genus represented 27 of the families or 45.76 %. This number of plants represents 1.70 % out of the 10,158 species of vascular plants in the Philippines (Pelser et al. 2011 onwards).

Some of the frequently occurring species encountered were *Antirhea microphylla* (Bartl. ex DC.) Merr, *Ixora philippinensis* Merr., *Psychotria luzoniensis* (Cham. & Schltdl.) Fern.-Vill, *Syzygium simile* (Merr.) Merr., *Ziziphus talanai* (Blanco) Merr. and the spinescent species that were not identified to the species level but assigned under the genus *Canthium* Lam. of Rubiaceae (Figure 2). This interesting species is currently being ascertained through morphological and molecular studies to establish its identity. The pitcher plant (*Nepenthes alata* Blanco) was also among the flora thriving in the area but restricted in one site.

Notably, the forest as well carries primitive species with the presence of Cycads and sprawling and abundant century-old trees *Podocarpus costalis* C. Presl and *Podocarpus polystachyus* R.Br. ex Endl.) (Figure 4).

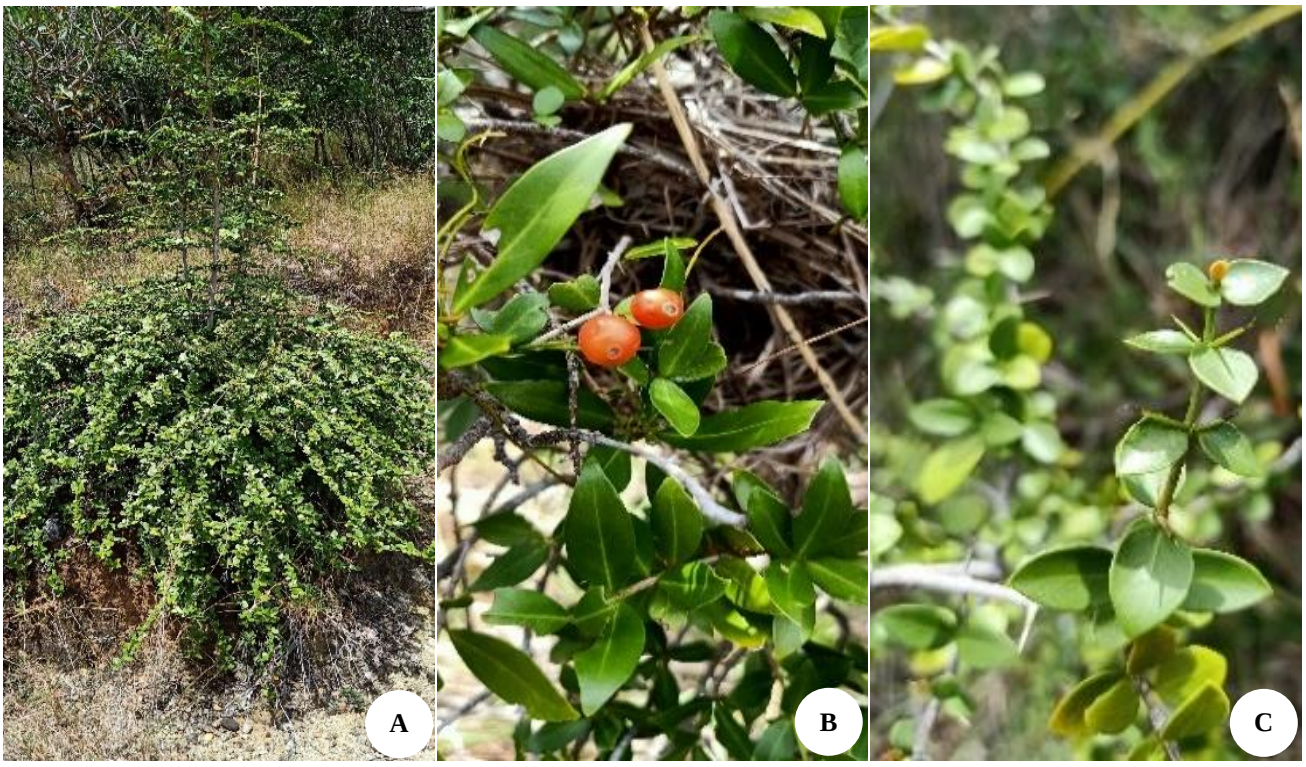

Figure 2. The unidentified *Canthium* sp. (Rubiaceae) collected in MINWFR, Northwestern Luzon, Philippines during the dry season (November). A. Whole plant, B. Flower bud and fruit at maturity, C. Close-up of the leaves showing the spines.

Table 2. List of recorded species in MINFWR, Northwestern Luzon, Philippines

Family	Species	Local name	Habit	Conservation Status	Endemicity
Acanthaceae	*Strobilanthes viridis* (Merr.) Y.F. Deng		H	NE	E
Anacardiaceae	*Buchanania microphylla* Engl.		T	NE	N
	Buchanania aborescens (Blume) Blume		T	NE	N
	Dracontomelon dao (Blanco) Merr. & Rolfe		T	VU*	N
	Semecarpus cuneiformis Blanco	Ligas	T	NE	N
	Semecarpus longifolius Blume	Anagas	T	LC	N
Annonaceae	*Goniothalamus amuyon* (Blanco) Merr.	Amoyun	T	NE	N
	Pseudouvaria luzoniensis (Merr.) Y.C.F.Su & R.M.K.Saunders	Allagat	T	NE	E
	Uvaria grandiflora Roxb. Ex Hornem		T	NE	N
Apocynaceae	*Alstonia macrophylla* Wall. Ex G.Don	Dalipawen	T	LC	N
	Alyxia luzoniensis Merr.		V	NE	E
	Alyxia monticola C.B.Rob.		V	NE	N
	Dischidia luzonica (Schltr.) Arshed, Agoo & Rodda		V	NE	E
	Hoya benguetensis Schltr.		V	NE	E
	Vincetoxicum elmeri (Schltr.) Meve & Liede		V	NE	E
Araceae	*Colocasia esculenta* (L.) Schott.	Aba	H	LC	N
Araliaceae	*Polyscias nodosa* (Blume) Seem.		T	LC	N
Arecaceae	*Areca catechu* L.	Bua	T	NE	N
	Areca ipot Becc.	Bua	T	VU*/VU	E
	Caryota cumingii Lodd. ex C. Mart	Anibong	T	NE	E
	Heterospathe cagayanensis Becc.	Bagobo	T	NE	E
Asparagaceae	*Dracaena multiflora* Warb. ex Sarasin		T	LC	N
Begoniaceae	*Begonia rufipila* Merr.		H	NE	E
Bignoniaceae	*Radermachera coriacea* Merr.		T	VU*	E
Burseraceae	*Canarium asperum* Benth.	Anteng	T	LC	N
Calophyllaceae	*Calophyllum blancoi* Planch. & Triana	Pamitaogen	T	NE	N
	Calophyllum inophyllum L.	Bittaog	T	LC	N
	Calophyllum pentapetalum (Blanco) Merr.	Bittaog bantay	T	NE	E
Cannabaceae	*Celtis philippinensis* Blanco		T	NE	N
	Trema orientalis (L.) Blume	Agandong	T	LC	N
Capparaceae	*Capparis micracantha* DC.	Pacpacaw-it	S	NE	N
	Capparis sepiaria L.		S	NE	N
Casuarinaceae	*Cassuarina equisetifolia* L.	Aro-o	T	NE	N
Celastraceae	*Salacia korthalsiana* Miq.		S	NE	N
Clusiaceae	*Garcinia binucao* (Blanco) Choisy		T	NE	N
Combretaceae	*Terminalia catappa* L.	Binucaw	T	LC	N
	Terminalia nitens C. Presl	Salaysay	T	VU	N
Cycadaceae	*Cycas riuminiana* Porte. ex Regel	Parangipang	T	VU*/E	E
Dipterocarpaceae	*Shorea astylosa* Foxw.	Yakal	T	CR*/E	E
	Shorea contorta S.Vidal	White Lauan	T	LC	E
Droseraceae	*Drosera burmannii* Vahl		H	NE	N
Ebenaceae	*Diospyrus maritima* Blume		T	NE	N
	Diospyrus montana var. timorensis Bakh.	Ballatinaw	T	NE	E
	Diospyros pilosanthera Blanco	Bolong-eta	T	VU*	N
Erythroxylaceae	*Erythroxylum cuneatum* (Miq.) Kurz		T	NE	N
Euphorbiaceae	*Acalypha cardiophylla* Merr.		S	LC	N
	Macaranga tanarius (L.) Müll. Arg.	Samac	T	LC	N
	Mallotus philippensis (Lam.) Müll		T	LC	N
Fabaceae	*Abrus precatorius* L.	Bugayong	H	NE	N
	Acacia auriculiformis A.Cunn. ex Benth.	Auri	T	LC	N
	Acacia mangium Willd.	Mangium	T	LC	N
	Albizia lebbekoides (DC.) Benth.	Carisquis	T	LC	N
	Albizia procera (Roxb.) Benth.	Adaan	T	LC	N
	Albizia saman (Jacq.) F. Muell.	Algarlubo	T	NE	N
	Cynometra warburgii Harms	Marabalitbitan	T	NE	E
	Entada phaseoloides (L.) Merr.	Lipay	T	OTS*	N
	Gliricidia sepium (Jacq.) Kunth ex Steud.	Cacaoate	T	LC	N
	Leucaena leucocephala (Lam.) de Wit	Ipil-ipil	T	NE	N
	Mimosa pudica L.	Bain-bain	H	LC	N
	Pterocarpus indicus Willd	Dungon	T	EN	N
	Senna spectabilis (DC.) H.S.Irwin & Barneby		T	LC	N
	Tamarindus indica L.	Salamagi	T	LC	N
	Vachellia farnesiana (L.) Wight & Arn.	Kandaruma	T	LC	N

Lamiaceae	*Clerodendrum minahassae* Teijsm. & Binn.	Bagawac puraw	S	NE	N
	Gmelina elliptica Sm. in Rees	Melina	T	LC	N
	Mesosphaerum suaveolens (L.) Kuntze	Mara-erva	H	NE	N
	Premna odorata Blanco	Alagao	T	NE	N
	Tectona grandis L.f	Teak	T	NE	N
	Vitex negundo L.	Dangla	T	LC	N
	Vitex parviflora Juss.	Sagat	T	LC	N
Lauraceae	*Cinnamomum anacardium* Kosterm	Ikmo	T	NE	E
	Litsea glutinosa (Lour.) C.B.Rob.	Sablot	T	LC	N
Loranthaceae	*Amyema incarnatiflora* (Elmer) Danser	Kanonong	S	NE	E
	Scurrula parisitica L.	Kankanonong	S	NE	N
Lycopodiaceae	*Phlegmariurus phlegmaria* (L.) Holub	Aroy-uy	E	E*	N
	Lycopodium sintenisii (Herter) Maxon ex C. Chr.		E	NE	N
Malvaceae	*Grewia bilamellata* Gagnep		S	NE	N
	Helicteres hirsuta Lour.		S	NE	N
	Kleinhovia hospital L.		T	NE	N
	Pterocymbium tinctorium (Blanco) Merr.		T	LC	N
	Pterospermum diversifolium Blume	Bayok	T	LC	N
	Pterospermum obliquum Blanco	Bayok-bayok	T	LC	E
	Sterculia foetida L.	Bangar	T	NE	N
	Urena lobata L.	Maratinta	S	NE	N
Melastomataceae	*Memecylon edule* Roxb.	Candon	T	NE	N
Meliaceae	*Dysoxylum gaudichaudianum* (A.Juss.) Miq.	Igyo	T	LC	N
	Swietenia mahagoni (L.) Jacq.	Mahogany	T	NT	N
Moraceae	*Artocarpus blancoi* (Elmer) Merr.	Antipolo	T	VU	E
	Artocarpus ovatus Blanco		T	NE	E
	Ficus nota (Blanco) Merr.	Tibbeg	T	LC	N
	Ficus parvifolia (Miq.) Miq.	Balliti	T	NE	N
	Ficus septica Burm.f.	Raya-raya	T	LC	N
	Ficus variegata Blume	Tagisang-bayawak	T	LC	N
Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	Kamal	T	NT	N
	Eucalyptus deglupta Blume	Bagras	T	VU	N
	Leptospermum amboinense Blume	Marabayawas	T	NE	N
	Syzygium cumini (L.) Skeels	Lumboy	T	LC	N
	Syzygium ilocanum (Merr.) Merr.	Panlungbuyen	T	NE	E
	Syzygium simile (Merr.) Merr.	Panlungbuyen	T	NE	N
	Syzygium xanthophyllum (C.B.Rob.) Merr.	Panlungbuyen	T	NE	E
Nepenthaceae	*Nepenthes alata* Blanco	Batbatidor	E	LC	E
Oleaceae	*Chionanthus coriaceus* (S.Vidal) Yuen P.Yang & S.Y.Lu	Bangbanglo	S	NE	N
	Fraxinus griffithii C.B.Clarke		T	LC	E
Opiliaceae	*Champereia manillana* (Blume) Merr.	Pannalayapen	S	LC	N
Orchidaceae	*Corybas ramosianus* J.Dransf.		H	E*	E
	Dendrobium uniflorum Griff	Sangumay	E	NE	N
	Pteroceras philippinense (Ames) Garay		E	NE	E
	Plocoglottis bicomata L.O.Williams		E	NE	E
	Spathoglottis kimballiana Hook.f.	Yellow round orchids	H	NE	N
	Spathoglottis vanoverberghii Ames		H	NE	E
	Trichoglottis amesiana L.O.Williams		E	NE	E
	Thrixpermum elongatum Ames		E	NE	E
	Thrixspermum nicolasiorum Calaramo, Cootes & Naive	Nicolas Orchid	E	NE	E
Orobanchaceae	*Lindenbergia philippensis* (Cham. & Schltdl.) Benth.		S	NE	N
Pandanaceae	*Pandanus tectorius* Soland	Pandan siitan	T	LC	N
Pentaphyllaceae	*Ternstroemia toquian* (Blanco) Fern.		T	LC	N
Phyllanthaceae	*Antidesma ghaesembilla* Gaertn.	Arusip	T	LC	N
	Antidesma montanum Blume	Bignay pugo	T	LC	N
	Flueggea virosa (Roxb. ex Willd.) Royle		T	LC	N
	Glochidion psidioides C.B.Rob		S	NE	E
	Phyllanthus cf. blancoanus Mull.Arg.		S	NE	E
	Phyllanthus erythrothrichus C.B.Rob.		S	NE	E
	Phyllanthus reticulatus Poir		S	NE	N
Pittosporaceae	*Pittosporum moluccanum* (Lam.) Miq.		T	NE	N
Plantaginaceae	*Bacopa monnieri* (L.) Wettst		H	LC	N

Poaceae	*Dinochloa acutiflora* (Munro) S.Dransf.	Bikal	T	OTS*	N
	Gigantochloa levis (Blanco) Merr.	Bolo	T	NE	N
	Imperata cylindrica (L.) P.Beauv.	Kogon	H	LC	N
	Sacharrum officinarum L.	Ledda	T	NE	N
	Schizostachyum lumampao (Blanco) Merr.	Bolo	T	NE	E
	Themeda intermedia (Hack.) Bor		H	NE	N
Podocarpaceae	*Podocarpus costalis* C.Presl	Igem dagat	T	E*/E	N
	Podocarpus polystachyus R.Br. ex Endl.	Igem	T	VU*/VU	N
Primulaceae	*Ardisia elliptica* Thunb.	Lumamani	T	NE	N
	Ardisia pyramidalis (Cav.) Pers.		S	NE	N
	Myrsine oblongibacca (Merr.) Pipoly		S	NE	E
Pteridaceae	*Adiantum philippense* L.		E	NE	N
	Ceratopteris thalictroides (L.) Brongn.	Water Sprite	E	LC	N
	Pteris vittata L.		E	LC	N
Rhamnaceae	*Ziziphus talanai* (Blanco) Merr.	Talanay	T	OTS*/VU	E
Rubiaceae	*Argostemma solaniflorum* Elmer		H	NE	N
	Antirhea microphylla (Bartl. ex DC.) Merr.		S	NE	E
	Canthium sp.		S	NE	N
	Ixora cummingiana S. Vidal	Cuming Santan	S	NE	E
	Ixora philippinensis Merr.	Mutang-ulang	S	NE	N
	Kanapia monstrosa (A.Rich) Arriola & Alejandro	Santan siitan	T	NE	E
	Morinda citrifolia L.	Apatot	T	NE	N
	Mussaenda philippica A. Rich	Musaenda	T	LC	E
	Nauclea orientalis (L.) L.	Bulala	T	LC	N
	Neonauclea bartlingii var. cumingiana (S.Vidal) Ridsdale	Bulala Bantay	T	LC	E
	Oldenlandia corymbosa L.		H	LC	N
	Paederna foetida L.		V	NE	N
	Pyrostria triflora Arriola, Calaramo & Alejandro	Psychotria Sigatlo	S	NE	E
	Psychotria luzoniensis (Cham. & Schltdl.) Fern.-Vill	Luzon Psychotria	S	NE	E
	Spermacoce exilis (L.O Williams) C.D. Adams ex W.C. Burger & C.M. Taylor		H	NE	N
	Tarrenoidea wallichii (Hook. F.) Tirveng. & Sastre		T	NE	N
	Timonius ternifolius (Bartl. ex DC.) Fern.		T	NE	E
	Wendlandia luzoniensis D.C. y	Maratabako	T	NE	N
Rutaceae	*Lunasia amara* Blanco		S	LC	N
Salicaceae	*Casearia grewiifolia* Vent.		T	LC	N
	Scolopia luzonensis (C.Presl) Warb.		T	NE	N
Sapindaceae	*Dodonaea viscosa* (L.) Jacq.		S	NE	N
	Guioa koelreuteria (Blanco) Merr.	Owas	T	LC	N
	Sapindus saponaria L.	Kusibeng	T	LC	N
Sapotaceae	*Palaquium philippense* (Perr.) C.B.Rob.	Paak-palak	T	VU*/VU	E
	Planchonella duclitan (Blanco) Bakh.f.	Duklitan	T	LC	N
	Xantolis parvifolia (A.DC.) Royen	Siitan	T	NE	E
Schizaeaceae	*Lygodium circinatum* (Burm. f.) Sw.	Nito	E	NE	N
	Lygodium japonicum (Thunb.) Sw.	Nito puraw	E	NE	N
Thymelaeaceae	*Wikstroemia indica* (L.) C.A.Mey.	Salago	S	NE	N
Urticaceae	*Oreocnide trinervis* (Wedd.) Miq.	Budobudo	T	NE	N
Verbenaceae	*Lantana camara* L.	Bangbangsit	S	NE	N
Zingiberaceae	*Alpinia brevilabris* C.Presl	Maralaya	H	NE	E

Note: Plant families are alphabetically arranged, followed by species for each family, local name, habit (T: tree, S: shrub, H: herb, V: vine, E: epiphyte), proposed conservation status based on *DENR Administrative Order 2017-11 and IUCN Red List (NE: Not Evaluated, DD: Data Deficient, LC: Least Concern, Near Threatened: NT, OTS: Other Threatened Species, VU: Vulnerable, EN: Endangered, CR: Critically Endangered) and endemicity (E: Philippine endemic, N: non-endemic). MAR Batuyong and MA Calaramo did the collections

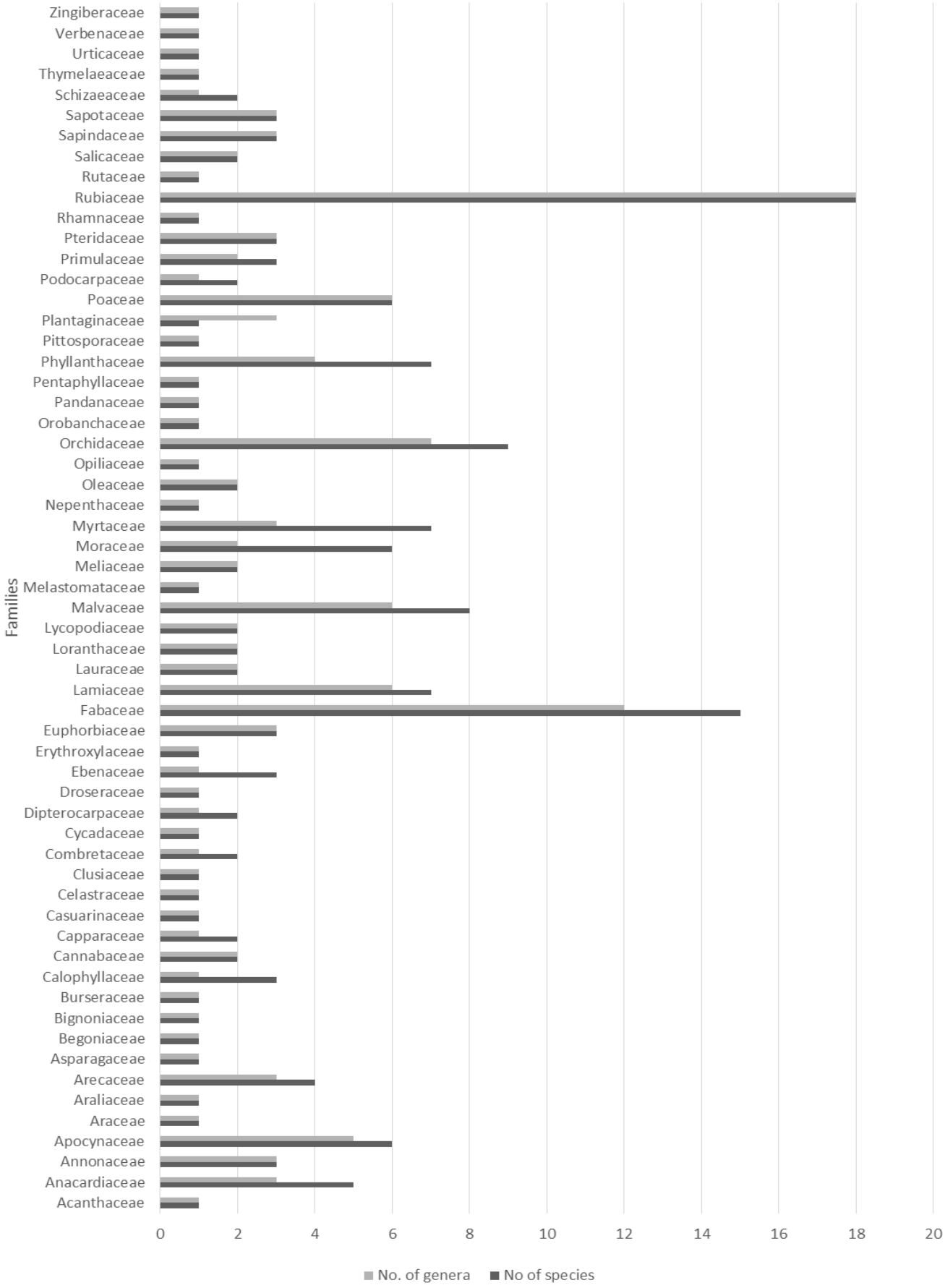

Figure 3. Representation of vascular families and species recorded in MINFWR, Northwestern Luzon, Philippines

Figure 4. The panoramic view of MINFWR, Northwestern Luzon, Philippines showing the dominant *Podocarpus* species in the rocky ecosystem. (A) During the dry season, (B) Wet season

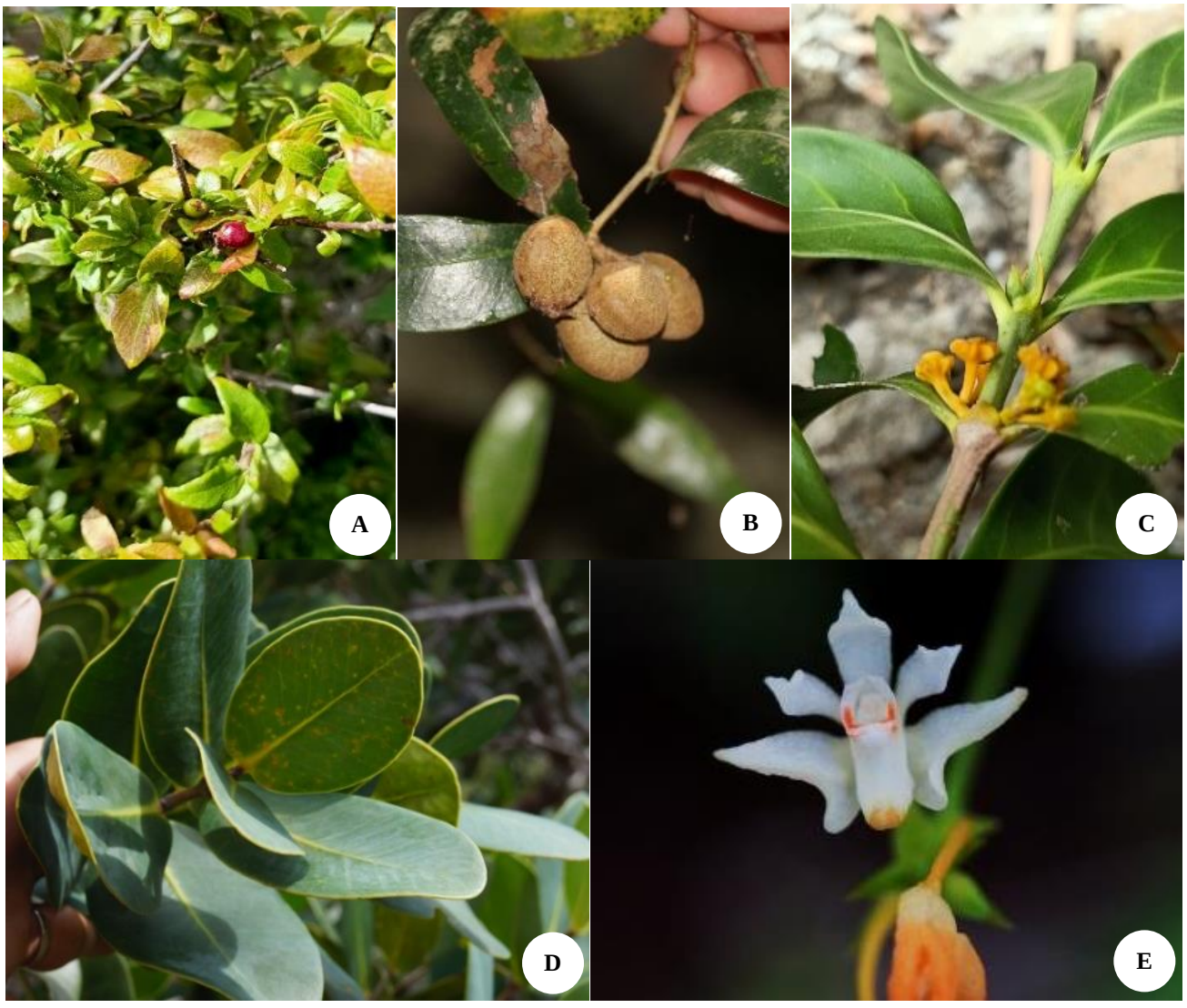

Figure 5. The narrow endemic species recorded in MINFWR, Northwestern Luzon, Philippines. A. *Antirhea microphylla* showing the leaves and fruits, B. *Cyanometra warburgii* fruiting branch, C. *Pyrostria triflora* reproductive branch showing the developing flower, D. *Syzygium ilocanum* vegetative part, E. *Thrixspermum nicolasiorum* flower. Photographs by M.A.Batuyong and M.A. Calaramo.

Endemism

Assessing the geographical distribution of plant species is essential in defining the biodiversity value of an area which typically measured in terms of species richness and the number of endemic and threatened species present (Clergue et al. 2005; Bruchmann 2014). Species confined or restricted to a particular site should be provided with specific conservation management strategies as they are more vulnerable to disturbance and higher risk for loss due to their narrow range (Haq et al. 2010). Moreover, for their high value and importance in genetic diversity.

Of the171 identified plants to species level, 49 species or 28.65 % are Philippine endemics (Table 3; Figure 3). This is 1.03% out of the 4742 Philippine endemics identified based on Co's Digital Flora of the Philippines data (Pelser et al. 2011 onwards). Remarkably, 5 of which are known to be narrow endemics or have natural habitat confined only in the Province. These include *Cyanometra warburgii* Harms, *Pyrostria triflora* Arriola, Calaramo & Alejandro, *Syzygium ilocanum* (Merr.) Merr., and *Thrixspermum nicolasiorum* Calaramo, Cootes & Naïve (Figure 5). Also, to add *Antirhea microphylla* (Bartl. ex DC.) Merr., which is supposedly endemic to Ilocos Norte but has extended its distribution in Ilocos Sur.

The Rubiaceae family had the highest number of endemic species (8), followed by Orchidaceae (7), Apocynaceae (4), and Arecaceae (3), Phyllanthaceae (3). Endemism was principally at the species level. The families and most genera in the study were all widespread or broadly found in the tropics. Thus, no family was endemic to the Philippines. The only endemic genus found was the *Kanapia* of the family Rubiaceae (Arriola et al. 2015). The presence of endemic species in this area also connoted ecological significance and considered a good indication of the status of habitats and vegetation of this limestone forest. It should also be emphasized that categorizing species as endemic is very much dependent on the availability of published biodiversity data, recent taxonomic revisions, nomenclatural changes, and new pieces of evidence from various disciplines used in systematics among others. Thus, estimates of endemism should be interpreted within the context of the methodologies and limitations imposed by contributing factors aforementioned.

Introduced species are also observed in the area, such as the cogon grass *Imperata cylindrica* (L.) P. Beauv., large leaf *Lantana camara* L., and *Leucaena leucocephala* (Lam.) de Wit as listed among Philippine invasive alien species (IAS) (Joshi 2006) and are also included in the Global Compendium of Weeds. These IAS are introduced both by intentional or accidental by human activity from outside its normal territorial range of distribution. Also, control has become difficult because they are prolific, good dispersers (UNEP 2013; DENR-BMB 2016), and can aggressively displace or outnumber indigenous species in their natural habitats, which may result in alteration of ecosystem structure and function (Pysek et al. 2017; Garces 2019). They have been considered as the second most prominent threat to biodiversity after habitat destruction (Bellard et al. 2018). The presence of these species in the PA are noted and can be utilized and integrated for the management strategies as an early recognition effort in the existing monitoring and surveillance programs being implemented.

Assessment of conservation status

The conservation status of each species was noted and recorded based on the most recent recommendations issued by DENR as Administrative Order No. 2017-01 and the listing of threatened species of the IUCN as reference. This was carried out to provide a foundation on their conservation status, thereby, necessary in the establishment of their protection and conservation as priority measures locally and globally.

Out of the 173 total species identified in the limestone forest, DENR-DAO 17 and IUCN Red list considered 14 and 13 threatened plant species, respectively. Following the list of DAO 2017-11 marked 1 CR, 3 EN, 7 VU, and 3 OTS while IUCN Redlist included 4 EN, 7 VU, 2 NT, and 55 LC. Both DENR and IUCN categorized *Areca ipot* Becc., *P. polystachyus,* and *Palaquium philippense* (Perr.) C.B. Rob. as VU species, while *P. costalis* as EN. For the other species, *Corybas ramosianus* J.Dransf. and *Phlegmariurus phlegmaria* (L.) Holub were reported by DENR as EN, whereas *Shorea astylosa* Foxw. as CR, although these Dipterocarp species are frequent, as reported by Quimio (2016) in the Samar Island Natural Park. Besides, *Cycas riuminiana* Porte ex Regel, *Dracontomelon dao* (Blanco) Merr & Rolfe, *Diospyrus pilosanthera* Blanco, *Radermachera coriacea* Merr. and *Shorea contorta* S. Vidal were included by DENR all under VU. In contrast with IUCN, *S. astylosa* is considered as EN. Moreover, IUCN assessment for *C. riuminiana* and *S. contorta* are EN and LC, respectively. Lastly, IUCN evaluated the following species, *Pterocarpus indicus* Willd. as EN while *Artocarpus blancoi* Merr., *Eucalyptus deglupta* Blume, and *Terminalia nitens* C. Presl. were considered as VU, but these species were not included in DENR DAO-17. Lastly, both *Eucalyptus camaldulensis* Dehnh. and *Swietenia mahagoni* (L.) Jacq. were categorized as NT. The rest of the plant species were marked as not evaluated (NE) (Table 3). As ascertained during this study, IUCN and DENR have different categories for a selected species, and this can be because of their variations in scope or level of assessment (Villanueva and Buot 2015).

Moreover, it is interesting to note the following species, i.e., *A. ipot, A. blancoi, C. ramosianus, C. riuminiana, P. philippense, R. coriacea, S. astylosa,* and *Z. talanai* are all endemic plants that have been identified as threatened by DENR and IUCN (v. 3.1), therefore, an immediate and ensured appropriate management and monitoring strategies should as well be developed to warrant for their protection and the continued survival of their population.

Table 3. Summary of Threatened species recorded in MINWFR, Northwestern Luzon, Philippines

Categories	IUCN	DENR	Total
Critically Endangered (CR)	0	1	1
Endangered (EN)	4	3	*5
Vulnerable (VU)	7	7	*9
Other Threatened (OT)	0	3	*3
Near Threatened (NT)	2	0	2
Least Concern (LC)	55	0	55
Data Deficient (DD)	0	0	
Not Evaluated (NE)	103	157	
Total (CR, EN, VU, OT)			18

Note: * If IUCN or DENR listed same plant species, the plant is counted as one

During the fieldworks, several threats were also observed, such as the expansion of some areas into agricultural lands, built infrastructures like transmission lines at different locations within the PA, extensive dam construction, and conversion of the pristine ecosystem to residential areas. Added to this is the concrete road that intersects the middle portion of the protected area, which serves as access to the Paredes Air Station and Brgys. Sulbec, Salpad, and Sapat. The unregulated tourist visits, resulting in improper waste disposal and picnic litters within the area. And other human activities such as timber poaching, bonsai collection, wildlife hunting, and mortar rock collection.

The protected area has much potential for ecotourism because of its caves, springs, waterfalls, and view overlooking the Municipality of Pasuquin and various livelihood programs and projects, with its rich biodiversity. However, this critical area will be lost without proper management and monitoring.

In conclusion, the result of the preliminary checklist of vascular plants in MINFWR revealed that it is home to 173 plant species, belonging to 140 genera distributed in 59 families. Forty-nine or 28.65% of the identified species are exclusively found in the country, which represents 1.03% from species identified as Philippine endemics. Based on IUCN criteria and DENR records, 18 species are threatened, one species is recorded as critically endangered, five as endangered, nine vulnerable, three other threatened, two near threatened, and fifty-five as least concern and the rest are not evaluated. Other noteworthy species present in the area, which are considered narrow endemics, include *A. microphylla*, *C. warburgii*, *S. ilocanum*, *T. nicolasiorum*, and *P. triflora*. The presence of an unusual spinescent Rubiaceae species initially placed under genus *Canthium* is being examined for its identity.

Though there were only a few documented plant species under threat, it cannot be denied, it is justifiable to consider MINFWR as an ecologically critical area. Also, because of the presence of invasive alien species and naturalized species in the area. There is a need to intensify further research to strengthen the conservation plans and programs and management intervention being implemented. All stakeholders should work together to safeguard and ensure the balance between sustainably protecting the biodiversity of this area, with economic development. All sectors must take proactive actions and participate, coupled with strong support to monitor, ensure, and evaluate the progress and implementation of programs.

With the concerted efforts and extensive works done, the research group finally attained the initial target of this study, and further steps are being considered and will be undertaken, such as the reassessment and continued monitoring of this area in the years to come.

Several management options can be worked out in the area, such as the development and dissemination of Instruction, Education, and Communication (IEC) materials of the species and the placing of labels and other relevant information regarding the species, particularly those along the commonly traversed trail as part of the ecotourism and general public awareness campaign of PAMB to gain broader support for its protection and eventual awareness and appreciation.

Another is the creation of the distribution map of threatened species. This map bears the critical spots where these threatened species are located and the application of a geographic information system (GIS) as a tool to map the specific locations of threatened species so that easy monitoring can be carried out immediately. The inventory of other plants, such as bryophytes, is also recommended for future studies. Also, it should be considered to do the detailed taxonomic work of the flora of MINFWR to provide identification keys to all species and, in general, to contribute to the update of Philippine diversity. This study has significantly increased the plant biodiversity data of the protected area that can be used to intensify environmental regulations and strengthen management programs on the utilization and conservation of MINFWR.

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