

THREATENED LYCOPHYTES AND FERNS IN FOUR PROTECTED AREAS OF MINDANAO, PHILIPPINES

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There are nearly a thousand threatened species of vascular plants in the Philippines and of which about 12% are lycophytes and ferns. However, there are not enough data on the distribution of the species. Thus, the threatened lycophytes and ferns were determined based on field surveys in four protected areas in Mindanao, namely Mt. Apo Natural Park, Mt. Kitanglad Range Natural Park, Mt. Malindang Range Natural Park, and Mt. Hamiguitan Range Wildlife Sanctuary. The conservation status assessment was based on the Department of Environment and Natural Resources DAO 2017-11 updated list of threatened plants of the Philippines. A total of 45 species of threatened lycophytes and ferns was documented belonging to 16 families and 25 genera. Of these, three species are Critically Endangered, 23 Endangered, 15 Vulnerable, and three are other threatened species. Families with the highest number of threatened species are Cyatheaceae, Polypodiaceae, Lycopodiaceae, Ophioglossaceae, and Psilotaceae. The Critically Endangered species are *Platyserium coronarium*, *Phlegmariurus magnusianus*, and *Helminthostachys zeylanica*. The threatened species endemic to the Philippines are *Phlegmariurus magnusianus*, *Alsophila apoensis*, *A. atropurpurea*, *A. hermannii*, *A. fuliginosa*, *A. heterochlamydea*, *A. negrosiana*, *A. rufopannosa*, *Lindsaea hamiguitanensis*, *Tmesipteris zamorarum*, *Aglaomorpha cornucopia*, and *A. sagitta*. The highest number of threatened taxa was observed in the Mt. Apo Natural Park (29 species), followed by the Mt. Kitanglad Range Natural Park (28 species), Mt. Malindang Range Natural Park (27 species), with the lowest number in the Mt. Hamiguitan Range Wildlife Sanctuary (19 species). Most of the species were recorded in the lower and upper montane forests. The occurrence of threatened and endemic lycophytes and ferns in the four protected areas calls for a strict implementation of the ordinances necessary for a long term conservation and protection of the species.

Key words: endangered species, endemism, conservation, mountain ecosystems, pteridophytes

Introduction

Pteridophytes include the so-called ferns and fern allies, the latter so-called because of their shared life cycle as spore-dispersing vascular plants (Amoroso et al., 2016a,b). However, recent analyses of morphological and molecular data revealed that pteridophytes are paraphyletic, and the boundary within them has been withdrawn to distinguish lycophytes and ferns (monilophytes) (Smith et al., 2006; PPG I, 2016). There are 11 916 estimated species of ferns and lycophytes throughout the world (PPG I, 2016). About 4500 species occur in Southeast Asia, which is more than one third of the world diversity (Moran, 2008; Ebihara et al., 2012). In the Philippines, there are 1100 species of lycophytes and ferns distributed among 154 genera and 34 families (Barcelona, 2011–2020; Amoroso et al., 2016b) and ca. 632 species (57%) are found on Mindanao Island (Amoroso et al., 2009).

Mindanao Island is the second largest island in the Philippine archipelago and has an enormous numbers of endangered, endemic and economically important species of flora and fauna. This island has a total of 41 Protected Areas (PAs) classified as national parks, natural parks, natural monuments,

protected landscapes and seascapes, resource reserves, wildlife sanctuaries, marine reserves, watershed forest reserves, natural biotic areas, and wilderness areas based on the National Integrated Protected Areas System (NIPAS) Act of 1992.

Mt. Apo Natural Park (MANP), Mt. Kitanglad Range Natural Park (MKRNP), Mt. Malindang Range Natural Park (MMRNP) and Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS) are some of the Protected Areas in Mindanao Island. These mountain ecosystems are also considered as ASEAN Heritage Parks. Moreover, MHRWS was listed as a UNESCO World Heritage site in 2014. All of these four Protected Areas are also Philippine Long-Term Ecological Research (LTER) sites (Kim et al., 2017) and home to different endemic species of plants and animals (Amoroso et al., 2009; Mohagan et al., 2015, 2018; Amoroso et al., 2015, 2018). Initial listing of the plants in the area was provided by Amoroso et al. (2006) in Mt. Malindang, Amoroso et al. (2009) in Mt. Hamiguitan, and Amoroso et al. (2011) in Mt. Kitanglad. A list of the threatened plant species on Mindanao Island was provided by Lumista et al. (2016) and Aribal & Buot (2009). Also, Fernando et al. (2008) listed 202 species of ferns and lycophytes

as nationally threatened in the Philippines. However, their list did not provide complete information about the distributions of the species on Mindanao and they followed the old assessment of the Department of Environment and Natural Resources (DENR).

Thus, this paper provides a comprehensive and updated list of threatened lycophytes and ferns, species conservation assessment, their distribution through field validation in the four selected Protected Areas on Mindanao, Philippines. This paper serves as basis for strict protection and conservation of the remaining threatened endemic species of lycophytes and ferns in the four Protected Areas on Mindanao Island.

Material and Methods

Species inventory

Prior to the conduct of the field work, a gratuitous permit from the four Protected Areas on Mindanao was obtained from the DENR regional offices. An inventory of lycophytes and ferns was then conducted by the authors from January 2014 to December 2015 through repeated transect walks from the foot of the mountain to the highest point in Mt. Apo Natural Park, North Cotabato (125.275000° N, 7.260833° E), Mt. Kitanglad Range Natural Park,

Bukidnon (124.916700° N, 5.083333° E), Mt. Malindang Range Natural Park, Misamis Occidental (123.600000° N, 8.283333° E), and Mt. Hamiguitan Range Wildlife Sanctuary, Davao Oriental (126.166700° N, 6.716666° E) (Fig. 1). Another field inventory was conducted by researchers from Central Mindanao University and the Botanical Research Institute of Texas from 2016 to 2019. These sites were selected because they are considered as Long Term Ecological Research (LTER) sites on Mindanao and also designated as ASEAN Heritage Parks.

Collection, processing, and identification of specimens

A minimum of two fertile fronds of each species was collected and processed using the wet method (Hodge, 1947). All herbarium specimens were deposited at the Central Mindanao University Herbarium (CMUH) and the California Academy of Sciences (CAS). All the specimens were identified by the authors using monographs, e-floras and other publications like Copeland (1958), the Flora Malesiana Series and digitised plant specimens available in Global Plants on JSTOR (<https://plants.jstor.org/>). The classifications were based on PPG I (2016).

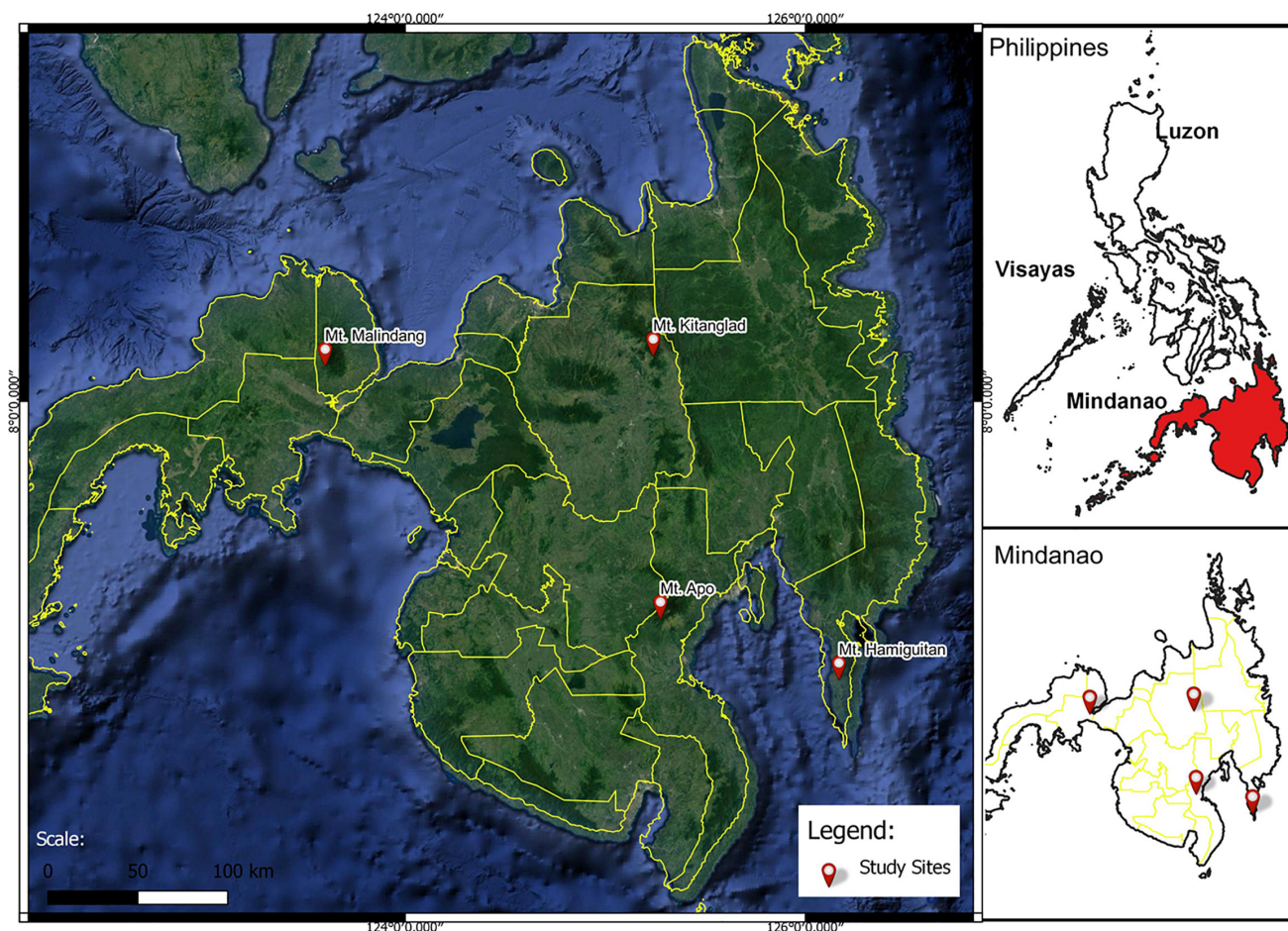


Fig. 1. Location map showing the four selected Protected Areas on Mindanao, Southern Philippines.

Assessment of the conservation status and distribution

The assessment of the conservation status of the species was based on the updated national list of threatened plants in the Philippines, following the criteria for determination of threatened plant species and their categories of the Department of Environment and Natural Resources (DENR-DAO, 2017). The categories are as follows: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Other Threatened Species (OTS), which is equivalent to Near Threatened of the International Union for Conservation of Nature (IUCN). This is the latest assessment on the national list of threatened plants in the Philippines made by the Philippine Plant Conservation Committee (PPCC) organised by DENR. The assessments of the conservation status of the species in the country are updated every five years. Information from this list serves as the basis for national environmental policy for the Protected Area Management Board (PAMB) of the Protected Areas and Local Government Units (LGUs) for strictly monitoring and protecting the endangered plant species. The general data on the distribution of species outside the four Protected Areas was based on Barcelona (2011–2020) and Lindsay & Middleton (2012–2020), with data for some species complemented by field observations of the authors.

Results

Species richness

A total of 45 species, six species of lycophytes and 39 of ferns, in the four Protected Areas are threatened, comprising 16 families and 25 genera. The families with the highest number of threatened taxa are Cyatheaceae (ten species), Polypodiaceae (nine species), Lycopodiaceae (five species), and Ophioglossaceae and Psilotaceae with three species each. In these families, some species have high economic importance as ornamental and medicinal plants (Amoroso, 2013; Magtoto & Austria, 2017). Of the 45 species recorded in the four Protected Areas on Mindanao, three species are considered as Critically Endangered taxa, 23 Endangered, 15 Vulnerable and three Other Threatened Species (Table).

Notes and distribution are provided below for the six prioritised species since three species are Critically Endangered taxa, namely *Platyserium coronarium* (Konig) Desv., *Phlegmariurus magnusianus* (Herter) A.R.Field & Testo,

and *Helminthostachys zeylanica* (L.) Hook., and the other three species are threatened and Mindanao Island endemics, *Alsophila hermannii* R.M.Tryon, *A. rufopannosa* (Christ) R.M.Tryon and *Lindsaea hamiguitanensis* Karger & V.B.Amoroso.

Critically Endangered species

Platyserium coronarium (König ex Müller) Desv.

Platyserium coronarium is a common, ornamental plant characterised by strongly dimorphic fronds with dichotomous nest leaves and pendulous dichotomously branched fertile fronds (Fig. 2A). It is commonly sold in flower gardens in big cities like Cagayan de Oro City and Davao City on Mindanao and Manila City on Luzon for a very expensive price. This species is considered as Critically Endangered because of its limited distribution in the wild and over-collection as an ornamental plant. In this study, it was observed only within the Mt. Hamiguitan Range Wildlife Sanctuary, Davao Oriental as an epiphyte on *Shorea polysperma* Merr. and *Tristaniopsis decorticata* (Merr.) Peter G.Wilson & J.T.Waterh. However, a new population of *P. coronarium* has recently been discovered by the authors in the Mt. Pantaron Range, Bukidnon in Central Mindanao, which is not a Protected Area.

Distribution. Borneo, Cambodia, Laos, Myanmar, Peninsular Malaysia, Singapore, Sumatra, Thailand, Vietnam. Philippines: Luzon and Mindanao (Mt. Hamiguitan Range Wildlife Sanctuary and Mt. Pantaron Range).

Phlegmariurus magnusianus (Herter) A.R.Field & Testo

Phlegmariurus magnusianus (Lycopodiaceae) is an epiphytic fern with pendulous stems, which are twice to three times isodichotomously branched, and with narrow-lanceolate, acuminate crowded leaves arranged in close spirally whorled (Fig. 2B). Species in this family are locally known as «salindugok or ikog sa iring», and commonly harvested by the local people in different parts of the country and sold very cheaply. This species was found in Mt. Apo Natural Park and Mt. Malindang Range Natural Park where it grows epiphytically on trees at about 3–10 m high. Only a few individuals of this species were observed.

Distribution. This species is endemic to the Philippines, known from Luzon and Mindanao (Mt. Apo Natural Park and Mt. Malindang Range Natural Park).

Table. List and distribution of threatened lycophytes and ferns in the four Protected Areas of Mindanao, Philippines

Family	Species	National Red List status	Accession number (CMUH)	Protected Areas				Forest types	Altitude (m a.s.l.)
				Mt. Apo	Mt. Kitanglad	Mt. Malindang	Mt. Hamiguitan		
Aspleniaceae	<i>Asplenium vittaeforme</i> Cav.	VU A1cd; B2c	00011501; 00006507; 00011481; 00011490	+	+	+	+	LM/UM/MF	1000–1500; 1500–2300; 2300–2600
Athyriaceae	<i>Diplazium costulisorum</i> (Copel.) C.Chr.	EN A1	00011508; 00011519	+	+	–	–	UM/MF	1500–2300; 2300–2600
Blechnaceae	<i>Diploblechnum fraseri</i> (A.Cunn.) De Vol	VU A1c	00007403; 00011479	–	+	+	–	LM/UM	1000–1500; 1500–2300
Blechnaceae	<i>Oceaniopteris egregia</i> (Copel.) Gasper & Salino	VU A1c	00011503; 00005890; 00011480; 00011480	+	+	+	+	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila apoensis</i> (Copel.) R.M.Tryon	EN A1cd	00008377	+	–	–	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila atropurpurea</i> (Copel.) C.Chr.	EN A1cd	00008382; 00004947; 00009634	+	+	+	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila fuliginosa</i> Christ	VU A1cd	00011502; 00004946	+	+	–	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila hermannii</i> R.M.Tryon	EN A1cd	00008375; 00011525	+	+	–	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila heterochlamydea</i> (Copel.) R.M.Tryon	VU A1cd	00009780	+	–	–	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila negrosiana</i> (Christ) R.M.Tryon	VU A1cd	00009629	–	–	+	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	* <i>Alsophila rufopannosa</i> (Christ) R.M.Tryon	EN B1	00009630	–	–	+	–	LM/UM	1000–1500; 1500–2300
Cyatheaceae	<i>Sphaeropteris elmeri</i> (Copel.) R.M.Tryon	VU A1cd	00009775; 00011514; 00009628; 00011491	+	+	+	+	LF/LM	< 1000; 1000–1500
Cyatheaceae	<i>Sphaeropteris glauca</i> (Blume) R.M.Tryon	EN A1cd	00011509; 00011528; 00009627; 00009640	+	+	+	+	LF/LM/UM	< 1000; 1000–1500; 1500–2300
Cyatheaceae	<i>Sphaeropteris lepifera</i> (J.Sm. ex Hook.) R.M.Tryon	EN A1cd	00008374; 00011561; 00008409	+	+	+	–	LM/UM	1000–1500; 1500–2300
Davalliaceae	<i>Davallia solida</i> (G.Forst.) Sw.	OTS	00011504; 00006744; 00011565; 00011492	+	+	+	+	LM/UM	1000–1500; 1500–2300
Dicksoniaceae	<i>Dicksonia mollis</i> Holttum	EN A1cd	00011511; 00006436; 00009638	+	+	+	–	LM/UM	1000–1500; 1500–2300
Lindsaeaceae	* <i>Lindsaea hamiguitanensis</i> Karger & V.B.Amoroso	VU A1c	00011505	–	–	–	+	LM	1000–1500
Lycopodiaceae	<i>Phlegmariurus carinatus</i> (Desv.) Ching	EN A1cd	00011523; 00011563	+	+	–	–	LM/UM	1000–1500; 1500–2300
Lycopodiaceae	* <i>Phlegmariurus magnusianus</i> (Herter) A.R.Field & Testo	CR A1	00011513; 00011482	+	–	+	–	LM/UM	1000–1500; 1500–2300
Lycopodiaceae	<i>Phlegmariurus phlegmaria</i> (L.) Holub	EN A2	00011515; 00004628; 00011485	+	+	+	–	LM/UM	1000–1500; 1500–2300
Lycopodiaceae	<i>Phlegmariurus salvinioides</i> (Herter) Ching	EN A1cd	00011518; 00011483	+	–	+	–	LM	1000–1500
Lycopodiaceae	<i>Phlegmariurus squarrosus</i> (G.Forst.) Á.Löve & D.Löve	EN A1cd	00011512; 00007315; 00011484; 00011474	+	+	+	+	LM	1000–1500
Marattiaceae	<i>Angiopteris evecta</i> (G.Forst.) Hoffm.	OTS	00011529; 00011567; 00011534	+	+	+	–	LM/UM	1000–1500; 1500–2300

Family	Species	National Red List status	Accession number (CMUH)	Protected Areas				Forest types	Altitude (m a.s.l.)
				Mt. Apo	Mt. Kitanglad	Mt. Malindang	Mt. Hamiguitan		
Marattiaceae	<i>Christensenia aesculifolia</i> (Blume) Maxon	EN B1	00011564; 00011475	–	+	+	–	LM	1000–1500
Ophioglossaceae	<i>Botrychium daucifolium</i> Wall. ex Hook. & Grev.	VU A1	00011522; 00008291; 00011477	+	+	+	–	LM	1000–1500
Ophioglossaceae	<i>Helminthostachys zeylanica</i> (L.) Hook.	CR	00011478	–	–	+	–	LF	< 1000
Ophioglossaceae	<i>Ophioderma pendula</i> C.Presl	EN A1cd	00011558; 00007731; 00011476; 00011506	+	+	+	+	LM/UM	1000–1500; 1500–2300
Osmundaceae	<i>Plenasium banksiifolium</i> (C.Presl) C.Presl	OTS	00011542; 00006456; 00011548; 00011493	+	+	+	+	LM/UM	1000–1500; 1500–2300
Polypodiaceae	* <i>Aglaomorpha cornucopia</i> (Copel.) M.C.Roos	VU A1a	00011539; 00007179; 00011550	+	+	+	–	LM/UM	1000–1500; 1500–2300
Polypodiaceae	<i>Aglaomorpha heraclea</i> (Kunze) Copel.	VU A1a	00011547; 00007845; 00011543	+	+	+	–	LM/UM	1000–1500; 1500–2300
Polypodiaceae	* <i>Aglaomorpha sagitta</i> (Christ) Hovenkamp & S. Linds.	VU A1c	00011544; 00011551; 00011538	+	+	+	–	LM/UM	1000–1500; 1500–2300
Polypodiaceae	<i>Aglaomorpha splendens</i> (J.Sm.) Copel.	VU A1c	00011524; 00006677	+	+	–	–	LM/UM	1000–1500; 1500–2300
Polypodiaceae	<i>Aglaomorpha speciosa</i> (Blume) M.C.Roos	VU A1c	00011521	–	–	–	+	LM	< 1000
Polypodiaceae	<i>Lecanopteris deparioides</i> (Ces.) Baker	EN A1c; B2c	00011533; 00011494	–	–	+	+	LM/UM	1000–1500; 1500–2300
Polypodiaceae	<i>Lecanopteris sinuosa</i> (Hook.) Copel.	EN A1a	00003420	–	–	–	+	LM/UM	1000–1500; 1500–2300
Polypodiaceae	<i>Lepisorus platyrhynchos</i> (Kunze) Li Wang	EN A1a	00011530; 00007626	+	+	–	–	UM/MF	1500–2300; 2300–2600
Polypodiaceae	<i>Platynerium coronarium</i> (Konig) Desv.	CR B1a	00011557	–	–	–	+	LF	< 1000
Psilotaceae	<i>Psilotum complanatum</i> Sw.	EN A1a	00011546; 00011486; 00011560	–	+	+	+	LF	< 1000
Psilotaceae	<i>Psilotum nudum</i> (L.) P.Beauv.	VU A1a	00011526; 00011495; 00011507	+	+	–	+	LF	< 1000
Psilotaceae	* <i>Tmesipteris zamorarum</i> Gruezo & Amoroso	EN A1c	00011535; 00006720; 00011489	+	+	+	–	UM/MF	1500–2300; 2300–2600
Pteridaceae	<i>Doryopteris kirkii</i> (Hook.) Alston	EN B1a	00011565	–	–	–	+	LF	< 1000
Selaginellaceae	<i>Selaginella tamariscina</i> (P.Beauv.) Spring	EN B2a	00011520	–	–	–	+	LF	< 1000
Schizaeaceae	<i>Actinostachys inopinata</i> (Selling) C.F.Reed	EN B1a	00003309	–	–	–	+	LF/FUS	< 1000
Schizaeaceae	<i>Schizaea malaccana</i> Baker	EN B2a	00011487	–	–	–	+	LF/FUS	< 1000
TOTAL				29	28	27	19		

Note: CR – Critically Endangered, EN – Endangered, VU – Vulnerable, OTS – Other Threatened Species; CMUH – Central Mindanao University Herbarium; «+» indicates presence of species, «–» indicates absence of species, asterisk (*) before the scientific name indicates the species endemic to the Philippines; MS – mossy forest, UP – upper montane forest, LM – lower montane forest, LF – lowland forest, FUS – forest over ultramafic soil.

Helminthostachys zeylanica (L.) Hook.

Helminthostachys zeylanica (Ophioglossaceae) is a herbaceous fern usually with a solitary frond and a fertile spike that arises from the base of its frond (Fig. 2C). This species is locally known as «tung-kod-langit» and generally found at lower altitudes on wet and muddy places. It was recorded only in Mt. Malindang Range Natural Park for this study.

In some countries like Brunei, it is commonly sold at the market as vegetables and medicine (de Winter & Amoroso, 2003). However, there are no reports from the Philippines that this species is edible.

Distribution. This species is widely distributed in the Palaeotropics, from Sri Lanka and India (Assam) to New Caledonia and Australia. Philippines: Palawan and Mindanao (Mt. Malindang Range Natural Park).

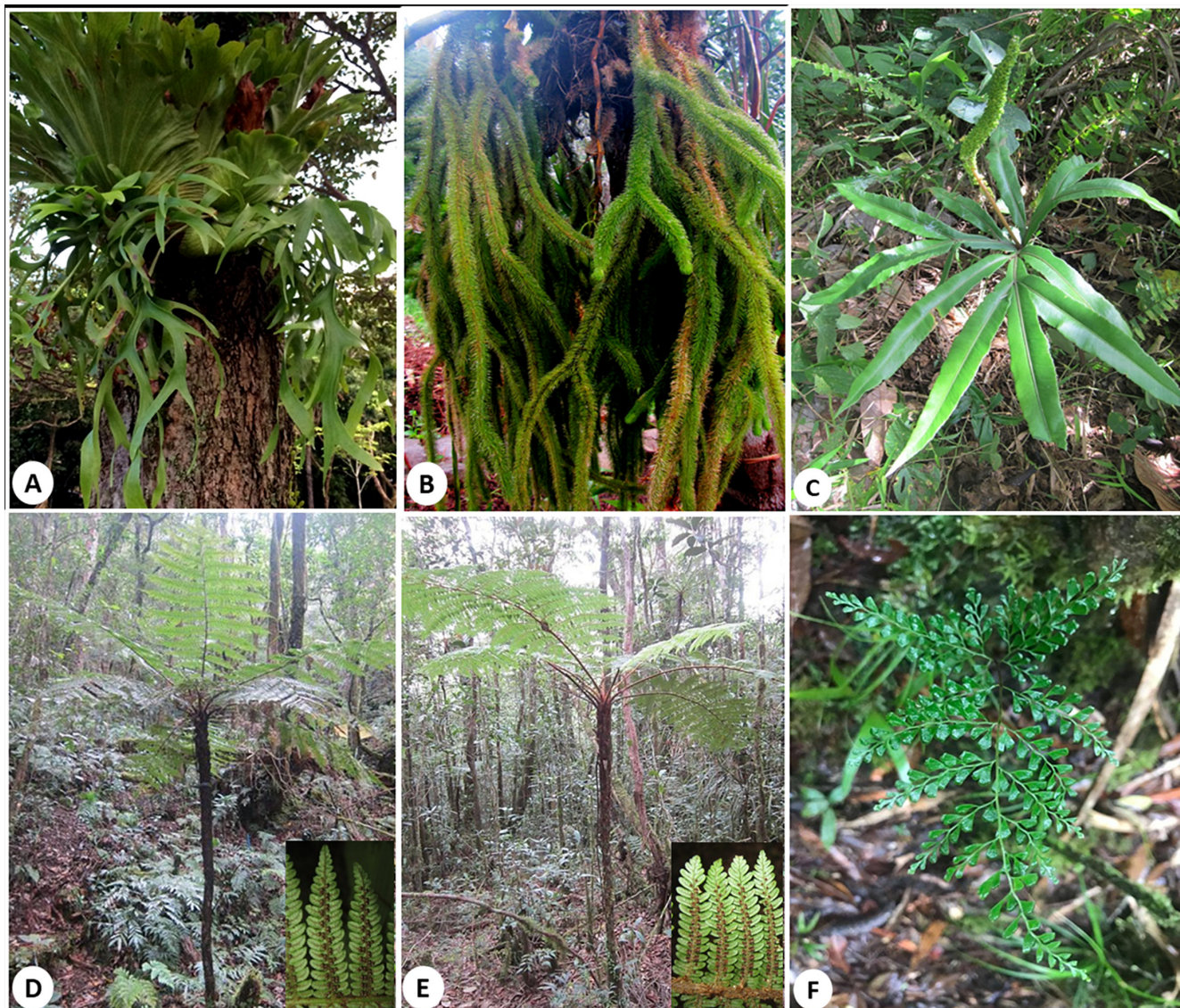


Fig. 2. Critically Endangered and Mindanao endemic lycophytes and ferns. Designations: A: *Platycerium coronarium*; B: *Phlegmariurus magnusianus*; C: *Helminthostachys zeylanica*; D: *Alsophila hermannii*; E: *Alsophila rufopannosa*; F: *Lindsaea hamiguitanensis*.

Threatened and endemic species of Mindanao

Alsophila hermannii R.M.Tryon

Alsophila hermannii is a medium-size scaly tree fern of the family Cyatheaceae. Trunks are erect to 4(–6) m height, to 24–27 cm diameter with old petiole bases and with marginate light to dark brown scales (Fig. 2D). The species was known only from its type locality on Mt. Apo. However, our study recorded this species in the Mt. Kitanglad Range Natural Park growing in the upper montane to the mossy forests (2000–2300 m a.s.l.).

Distribution. Mindanao: North Cotabato (Mt. Apo Natural Park) and Bukidnon (Mt. Kitanglad Range Natural Park).

Alsophila rufopannosa (Christ) R.M.Tryon

Alsophila rufopannosa (Cyatheaceae) is a fern endemic to Mindanao Island. It is also a medium size tree fern with trunks erect to 4(–6) m height, and to

15–18 cm diameter, without old petiole bases and with numerous marginate reddish brown scales on petioles and rachises (Fig. 2E). It was previously known only from San Ramon, Zamboanga and recently it has been recorded in Mt. Malindang Range Natural Park and Mt. Pantaron Range, Central Mindanao.

Distribution. Mindanao: Zamboanga (San Ramon), Misamis Occidental (Mt. Malindang Range Natural Park), Bukidnon (Mt. Pantaron and Mt. Kiamo).

Lindsaea hamiguitanensis D.N.Karger & V.B.Amoroso

Lindsaea hamiguitanensis is a small herbaceous fern with triangular, bipinnate to tripinnate-pinnatifid fronds that are light green when dry, with reddish brown and quadrangular rachises (Fig. 2F). This species was discovered in Mt. Hamiguitan Range Wildlife Sanctuary in 2012 and has recently

been documented in Mt. Tago and Mt. Pantaron Range in Bukidnon, Central Mindanao.

Distribution. Mindanao: Davao Oriental (Mt. Hamiguitan Range Wildlife Sanctuary) and Bukidnon (Mt. Tago and Mt. Pantaron Range).

In total there are 291 endemic species of ferns and lycophytes in the Philippines (Barcelona, 2011–2020), with about 94 of them considered also by DAO 2017-11 as threatened. In this study, the threatened endemic species include *Phlegmariurus magnusianus*, *Alsophila apoensis* (Copel.) R.M.Tryon, *A. atropurpurea* (Copel.) C.Chr., *A. hermannii*, *A. fuliginosa* Christ, *A. heterochlamydea* (Copel.) R.M.Tryon, *A. negrosiana* (Christ) R.M.Tryon, *A. rufopannosa*, *Lindsaea hamiguitanensis*, *Tmesipteris zamorarum* Gruezo & Amoroso, *Aglaomorpha cornucopia* (Copel.) M.C.Roos, and *A. sagitta* (Christ) Hovenkamp & S. Linds. Among these, *Alsophila hermannii*, *A. rufopannosa*, and *Lindsaea hamiguitanensis* are endemic only to Mindanao. The family Cyatheaceae has the most threatened endemic species, with 70% of the total number of the scally tree ferns recorded. All species in this tree fern family are listed in the Convention on Interna-

tional Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II in which the species are not necessarily threatened with extinction, but their trade must be controlled in order to avoid utilisation incompatible with their survival.

Other threatened ferns found on the study sites are species of Psilotaceae, Schizaeaceae, *Lecanopteris*, *Selaginella tamariscina* (P.Beauv.) Spring and *Ophioderma pendula* C.Presl. Members of the family Psilotaceae are unusual looking ferns that are rootless and sometimes leafless as in *Psilotum*. In the Philippines, all of the Psilotaceae species are considered as threatened, namely *Psilotum nudum* (L.) P.Beauv. (VU) (Fig. 3A), *Psilotum complanatum* Sw. (EN) and *Tmesipteris zamorarum* (EN) (Fig. 3B). *Psilotum nudum* and *P. complanatum* were observed growing on tree fern trunks of *Sphaeropteris polypoda* (Baker) R.M.Tryon in Mt. Hamiguitan Range Wildlife Sanctuary. *Tmesipteris zamorarum* also grows only on tree fern species trunks of Cyatheaceae and Dicksoniaceae. This species was recorded only in high mountain ecosystems above 2000 m a.s.l., such as Mt. Apo Natural Park, Mt. Kitanglad Range Natural Park and Mt. Malindang Range Natural Park.

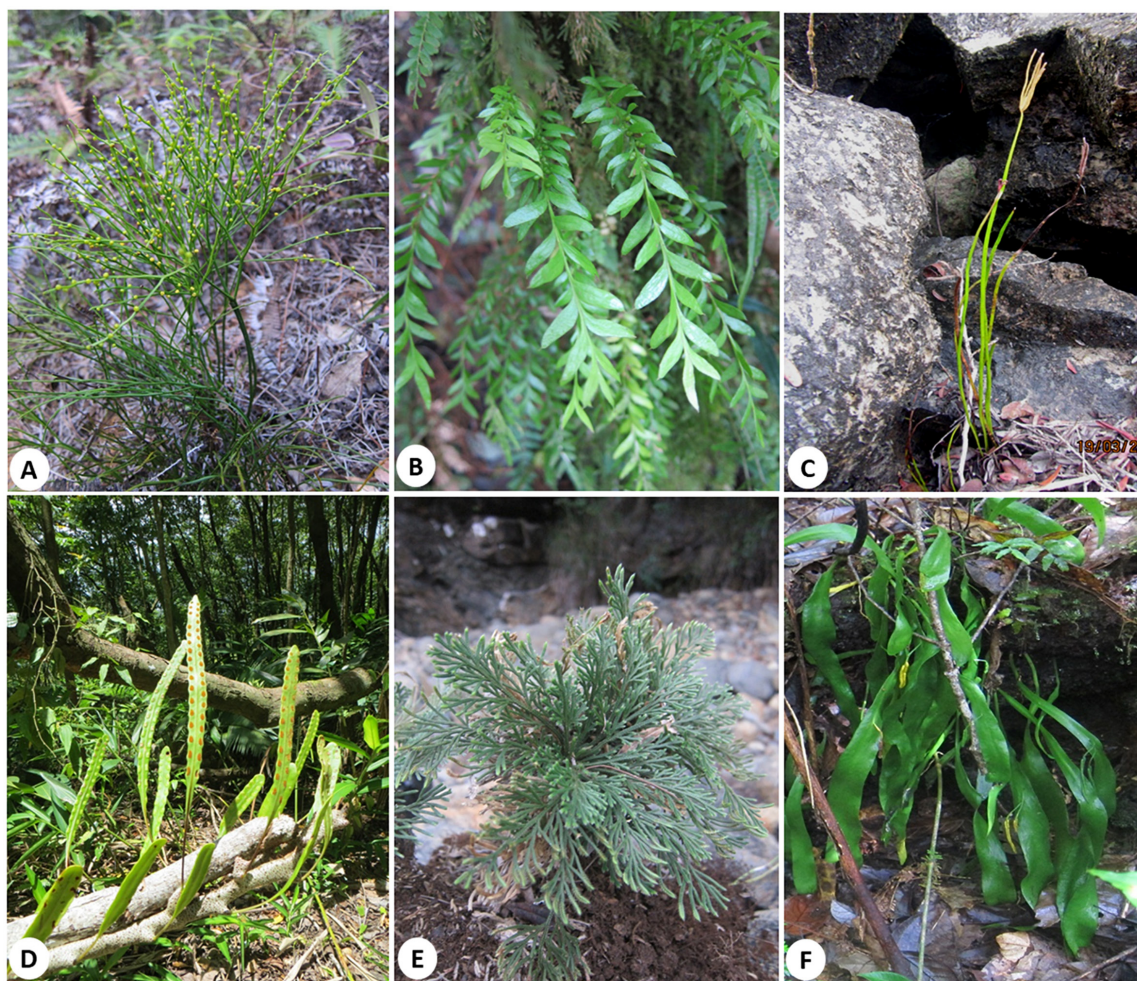


Fig. 3. Some threatened ferns and lycophytes. Designations: A: *Psilotum nudum*; B: *Tmesipteris zamorarum*; C: *Actinostachys inopinata*; D: *Lecanopteris sinuosa*; E: *Selaginella tamariscina*; F: *Ophioderma pendula*.

There are five Schizaeaceae species reported in the Philippines. All of these are found in Mt. Hamiguitan Range Wildlife Sanctuary (Amoroso et al., 2020). Two species are considered as Endangered, namely *Actinostachys inopinata* (Selling) C.F.Reed (Fig. 3C) and *Schizaea malaccana* Baker. These species are found in forests on ultramafic soil in Mt. Hamiguitan Range Wildlife Sanctuary, growing together with *Schizaea dichotoma* (L.) Sm. Two species of «ant ferns» of the genus *Lecanopteris* are present, namely *L. deparioides* (Ces.) Baker and *L. sinuosa* (Hook.) Copel. (Fig. 3D). These species are epiphytes on trees, like *Lepidospermum polygalifolium* Salisb. subsp. *polygalifolium*, *Sphaeropteris* spp. *Lecanopteris deparioides* was recorded in Mt. Hamiguitan Range Wildlife Sanctuary and Mt. Malindang Range Natural Park while *L. sinuosa* was found only in Mt. Hamiguitan Range Wildlife Sanctuary.

Selaginella tamariscina (Fig. 3E) is the only threatened species in the family Selaginellaceae recorded in the four Protected Areas. It is known for its antibacterial, anticancer, antifungal, and antiviral activities (Gechev et al., 2014). It is widely used by the local people in the Philippines to cure diseases (Setyawan, 2009; Amoroso, 2013). Thus, there is over-exploitation of this species in the wild. This species was recorded only in the eastern side of Mt. Hamiguitan Range Wildlife Sanctuary near the river banks growing on rocks and boulders. *Ophioderma pendula* or «ribbon» fern (Fig. 3F) was recorded in all four Protected Areas on Mindanao. The species is also commonly harvested by the local people in the Philippines and sold cheaply. Most of the species were included in the threatened list of plants for the Philippines because they are widely collected in the wild for their ornamental and medical uses, thus, depleting the population of the species.

Discussion

There are many reasons why species become threatened or endangered. Habitat destruction through logging, shifting cultivation, land use/land cover change, environmental pollution, invasive species, grazing, urbanisation, hydrological disturbance, and over-exploitation of forest resources are considered as the major threats to biodiversity worldwide (Catibog-Sinha & Heaney, 2006; Amoroso et al., 2011; Monastersky, 2014; Khapugin et al., 2020). Climate change is also one of the primary causes of species endangerment (Ibrahim et al., 2013). Moreover, plants are also becoming extinct because of distinctive

sequential patterns, with agriculture, invasions, and urbanisation as significant drivers in hotspots, whereas hydrological disturbance is an important driver in coldspots (Le Roux et al., 2019).

The recent assessment of DENR was primarily based on the IUCN criteria applied to information from scientific literature (e.g. geographic distribution of the species, extent of area of occupancy, actual threats of habitat, and over exploitation of high economic or commercial value species), available herbarium specimens, biodiversity survey data and Filipino botanists' field experience and knowledge of the flora.

Most of the threatened lycophytes and ferns (71%) are found in mountain ecosystems in different parts of the country. Mt. Apo Natural Park had the highest number of taxa with 29 species, followed by Mt. Kitanglad Range Natural Park (28 species), Mt. Malindang Range Natural Park (27 species), and Mt. Hamiguitan Range Wildlife Sanctuary (19 species). The high number of threatened species in Mt. Apo and Mt. Kitanglad is caused by the diversity of vegetation types in the area like the upper and lower montane forests (Amoroso et al., 2011, 2016b). Most of the threatened tree ferns and lycopods are found in this vegetation type.

Most of the threatened lycophytes and ferns (53%) inhabited the lower and upper montane forests with an altitude range of 1000–1500 m a.s.l. and 1500–2300 m a.s.l., respectively, followed by the lowland forests (< 1000 m a.s.l.), and the mossy forests (above 2300 m a.s.l.) (Table, Fig. 4). Species richness of ferns and lycophytes increased with altitude (Acebey et al., 2017). The highest species richness of ferns in the montane forests supports the findings of Bhattarai et al. (2004), Kluge et al. (2006), Kessler et al. (2011), Salazar et al. (2015) that fern richness was the highest in mid-altitudes, usually in montane forests. This has often been linked to an optimal combination of high humidity, rainfall, and moderate temperatures at mid-altitudes (Lauer et al., 1996).

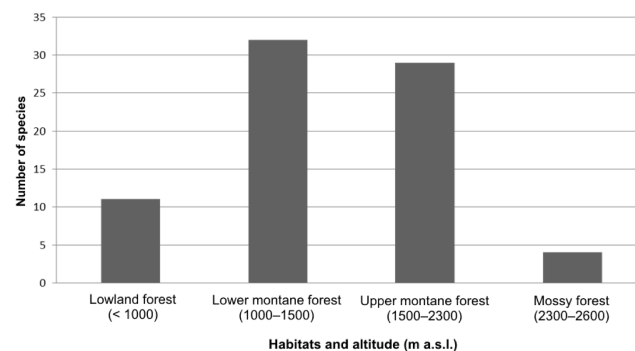


Fig. 4. Species distribution in relation to altitude and habitats in the four Protected Areas of the Mindanao.

Of all the species recorded, *Sphaeropteris glauca* (Blume) R.M.Tryon has the widest altitude range of distribution, from the lowland forests up to the upper montane forests. It is also common on all sites where it can grow in full exposure to the sun and very abundant in clearings and open places in the forest. *Lepisorus platyrhynchus* (Kunze) Li Wang and *Tmesipteris zamorarum* are restricted to the upper montane and mossy forests. They are epiphytes on tree ferns and trees in association with mosses and liverworts. Moreover, the two Schizaeaceae species are restricted to the forests on ultramafic soil below 1000 m a.s.l. in Mt. Hamiguitan Range Wildlife Sanctuary.

Some of the threatened endemic species were also recorded in other Protected Areas in the Philippines, like *Angiopteris evecta* (G.Forst.) Hoffm., *Oceaniopteris egregia* (Copel.) Gasper & Salino, *Platynerium coronarium* and *Psilotum nudum* in Adams, Northern Luzon (Magtoto & Austria, 2017), *A. evecta* in Mt Makiling, Laguna (Alcala et al., 2019), *Aglaomorpha splendens* (J.Sm.) Copel., *Alsophila negrosiana*, *Dicksonia mollis* Holttum, *Botrychium daucifolium* Wall. ex Hook. & Grev., *Lecanopteris deparioides*, *Ophioderma pendula*, *Oceaniopteris egregia*, *Plenasium banksiifolium* (C.Presl) C.Presl, *Psilotum nudum* and *Sphaeropteris glauca* in Balinsasayao Twin Lakes Natural Park, Negros Oriental (Amoroso et al., 2016a), *Aglaomorpha heraclea* (Kunze) Copel., *Aglaomorpha speciosa* (Blume) M.C.Roos, *Asplenium vittaeforme* Cav., *Davallia solida* (G.Forst.) Sw., *Lecanopteris sinuosa*, *Psilotum nudum*, *Sphaeropteris glauca*, and *Actinostachys inopinata* in Rajah Sikatuna Protected Landscape, Bohol Island (Barcelona et al., 2006), *Aglaomorpha splendens*, *Platynerium coronarium*, *Phlegmariurus squarrosus* (G.Forst.) Á.Löve & D.Löve, *Sphaeropteris glauca* in Mindoro Island (Villanueva & Buot, 2015).

Conclusions

The presence of threatened lycophytes and ferns on the study sites should be given high priority for conservation and action by the government to prevent their extinction. Communication, education and public awareness about fern diversity and its importance should be done to enhance the awareness of the local communities and of the public in general. Propagation protocols should also be developed to mass propagate these threatened and endemic species of lycophytes and ferns. A complete database about the distribution of threatened

lycophytes and ferns in the Philippines should be prepared for easy monitoring of the species. Finally, effective forest management and strict implementation of the ordinances are necessary for the long term conservation and protection not only to lycophytes and ferns but the whole flora and fauna within these Protected Areas.

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ПЛАУНОВЫЕ И ПАПОРОТНИКОВЫЕ РАСТЕНИЯ, НАХОДЯЩИЕСЯ ПОД УГРОЗОЙ ИСЧЕЗНОВЕНИЯ, НА ЧЕТЫРЕХ ОСОБО ОХРАНЯЕМЫХ ПРИРОДНЫХ ТЕРРИТОРИЯХ В МИНДАНАО (ФИЛИППИНЫ)

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На Филиппинах известно около 1000 видов сосудистых растений, находящихся под угрозой исчезновения, из которых около 12% составляют плауновые и папоротниковые. Однако данных о распространении этих видов недостаточно. В связи с этим целью настоящего исследования стало изучение находящихся под угрозой исчезновения плауновых и папоротниковых растений на основании полевых исследований на четырех особо охраняемых природных территориях Минданао: Природный парк горы Апо, Природный парк горного хребта Китанглад, Природный парк горного хребта Малинданг и Заказник дикой природы горного хребта Хамигутан. Оценка природоохранного статуса видов была основана на списке находящихся под угрозой исчезновения растений Филиппин, обновленном Департаментом окружающей среды и природных ресурсов DAO 2017-11. Было зарегистрировано 45 видов плауновых и папоротниковых растений, находящихся под угрозой исчезновения, принадлежащих к 16 семействам и 25 родам, в том числе три вида, находящихся под угрозой исчезновения (CR), 23 исчезающих (EN) вида, 15 уязвимых (VU) вида, а также три других угрожаемых (предположительно, NT) вида. Следующие семейства включают наибольшее число видов, находящихся под угрозой исчезновения: Cyatheaceae, Polypodiaceae, Lycopodiaceae, Ophioglossaceae, Psilotaceae. К видам, находящимся под угрозой исчезновения (CR) относятся *Platyserium coronarium*, *Phlegmariurus magnusianus*, *Helminthostachys zeylanica*. Следующие находящиеся под угрозой исчезновения виды являются эндемичными для Филиппин: *Phlegmariurus magnusianus*, *Alsophila apoensis*, *A. atropurpurea*, *A. hermannii*, *A. fuliginosa*, *A. heterochlamydea*, *A. negrosiana*, *A. rufopannosa*, *Lindsaea hamiguitanensis*, *Tmesipteris zamorarum*, *Aglaomorpha cornucopia*, *A. sagitta*. Наибольшее число находящихся под угрозой исчезновения таксонов было отмечено в Природном парке горы Апо (29 видов), меньшее число – в Природном парке горного хребта Китанглад (28 видов), Природном парке горного хребта Малинданг (27 видов) и Заказнике дикой природы горного хребта Хамигутан (19 видов). Наибольшее число видов плауновых и папоротниковых было отмечено в нижних и верхних поясах горных лесов. Произрастание находящихся под угрозой исчезновения и эндемичных видов плауновых и папоротниковых растений на четырех особо охраняемых природных территориях требует строгого выполнения постановлений, необходимых для долгосрочного сохранения и защиты этих видов.

Ключевые слова: горные экосистемы, исчезающий вид, папоротникообразные, сохранение, эндемизм