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Ferns and Lycophytes of Mt. Tago Range, Bukidnon, Southern Philippines: Species Richness, Distribution, and Conservation Status

Fulgent P. Coritico[1,2]*, **Victor B. Amoroso**[1,2], **Florfe M. Acma**[1,2], **Yvonne Love L. Cariño**[1], and **Peter W. Fritsch**[3]

[1]Center for Biodiversity Research and Extension in Mindanao
[2]Department of Biology, College of Arts and Sciences
Central Mindanao University (CMU), Musuan, Bukidnon 8710 Philippines
[3]Botanical Research Institute of Texas (BRIT)
1700 University Drive, Fort Worth, TX 76107-3400 USA

The species of ferns and lycophytes of Mt. Tago range are here documented in a checklist, along with information on their distribution and conservation status. The list is based on a comprehensive field survey conducted by the authors in 2018 and 2019 and comprises 203 species belonging to 29 families and 89 genera. Of these species, 187 are ferns and 16 are lycophytes. Eighty-six species are epiphytes, 85 are terrestrial, 12 are tree ferns, 6 are hemiepiphytes, and 14 species have more than one growth form. The number of species constitutes about 19% and 33% of the total number of pteridophyte species in the Philippines and Mindanao Island, respectively. The highest species richness was observed in the upper montane rainforest. Seventeen species are classified as broadly distributed Philippine endemics whereas four species are endemic to Mindanao. One species (*Alsophila commutata* Mett.) was newly documented for the Philippines and three species [*Pteris whitfordii* Copel., *Selliguea elmeri* (Copel.) Ching, and *Selliguea pyrolifolia* (Goldm.) Hovenkamp] were newly documented for Mindanao Island. Of the 28 threatened species recorded, one is critically endangered, 13 are endangered, nine are vulnerable, and five are considered other threatened species.

Keywords: conservation, endemism, flora, Mindanao, new records, pteridophytes

INTRODUCTION

The Philippines is one of the most important biodiversity hotspots on earth (Langenberger 2004) and one of the world's megadiverse countries, with high degrees of species richness and endemism (Heaney and Regalado 1998; Myers *et al.* 2000). It is home to an estimated 1,100 species of ferns and lycophytes distributed among 154 genera and 34 families (Amoroso *et al.* 2016a), and about 262 (24%) species are endemic to the country (Pelser *et al.* 2011). Many places in the southern Philippines have not been fully explored due to political instability and inaccessibility of its mountainous areas.

Mount Tago range – situated at 08°15.301'N, 125°09.321'E and with the highest elevation of 1,800 masl – is one of the remaining forested mountain ecosystems in Bukidnon Province of the southern Philippines. It is characterized by three forest formations following Fernando *et al.* (2008) and Amoroso *et al.* (2009) classification, *viz.* lower montane rainforest, upper montane rainforest, and mossy-pygmy forest. These vegetation types were recognized in

*Corresponding Author: cfulgent@cmu.edu.ph

accordance with the apparent change in forest structure and floristic composition (Coritico 2018). Part of the range was burned during the late 1980s and presently, with the rapid conversion of forests lands into agricultural lands, this has led to the disappearance of the lowland dipterocarp forest in the area. Mount Tago range supports the Tagoloan River watershed, a system that covers 167,793 ha and 10 municipalities in Bukidnon; Cagayan de Oro City; and Tagoloan, Misamis Oriental (BWPDC 2012). There is limited information about the flora and fauna in Mt. Tago range, like the work of Coritico and Fleischmann (2016) on a new record of *Drosera rotundifolia* L. in the Philippines and on anurans by Ates and Nuneza (2000). However, biodiversity and forest condition assessments have not been rigorously conducted.

The biodiversity of montane ecosystems in the Philippines is under extreme threat of loss. Habitat destruction through logging, shifting cultivation (Catibog-Sinha and Heaney 2006), and over-exploitation of forest resources (Amoroso *et al.* 2011) are considered the major threats to biodiversity. Despite the status of the Philippines as a biodiversity hotspot, the country's remaining forests are still poorly documented for ferns and lycophyte diversity. Therefore, there is an urgent need for a floristic study of ferns and lycophytes to serve as a basis for proper forest management by the government. Here, the species of ferns and lycophytes of Mt. Tago range are documented in a checklist, along with information on their distribution and conservation status.

MATERIALS AND METHODS

Species Inventory and Permit

An inventory of ferns and lycophytes was conducted through repeated transect walks from Barangay Kibalabag, Malaybalay District, Bukidnon (1350 masl) to the two mountain peaks of Mt. Tago range, *i.e.* Mt. Limbawon (1885 masl) and Mt. Manugawi (1750 masl) (Figure 1). These two mountain peaks are characterized by the following forest formations, *viz.* lower montane rainforest (1350–1550 masl), upper montane rainforest (1550–1750 masl), and mossy-pygmy forest (1750–1885 masl) (Fernando *et al.* 2008; Amoroso *et al.* 2009). There were five sampling stations established in the study area. These are the lower montane rainforest, upper montane rainforest, and mossy-pygmy forest of Mt. Limbawon and the lower montane rainforest and upper montane rainforest of Mt. Manugawi (Figure 2). The field inventory was conducted by researchers of CMU and BRIT in the years 2018 and 2019.

Prior informed consent was secured from the village captain and chieftain of Kibalabag, Malaybalay, Bukidnon to ask permission to conduct the research and a gratuitous permit (GP) was obtained from the Department of Environment and Natural Resources (DENR) Region 10 Office with GP number 2017-43 – allowing us to conduct the survey and collect specimens in the area.

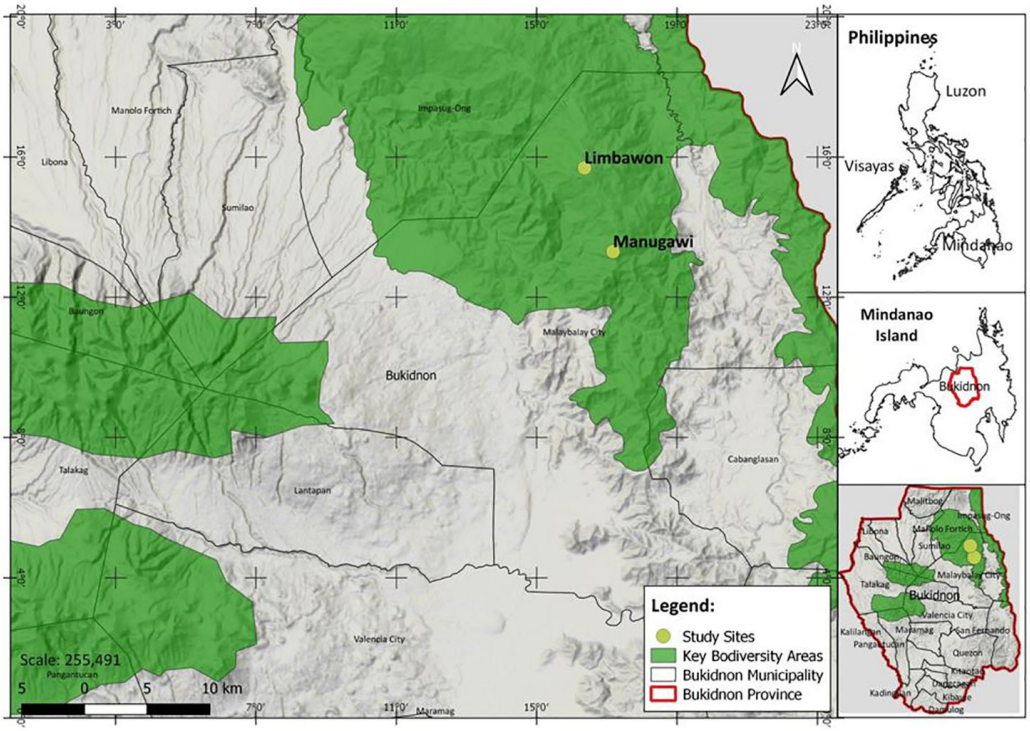

Figure 1. Location of Mt. Limbawon and Mt. Manugawi, Tago range, Bukidnon, Mindanao, Southern Philippines.

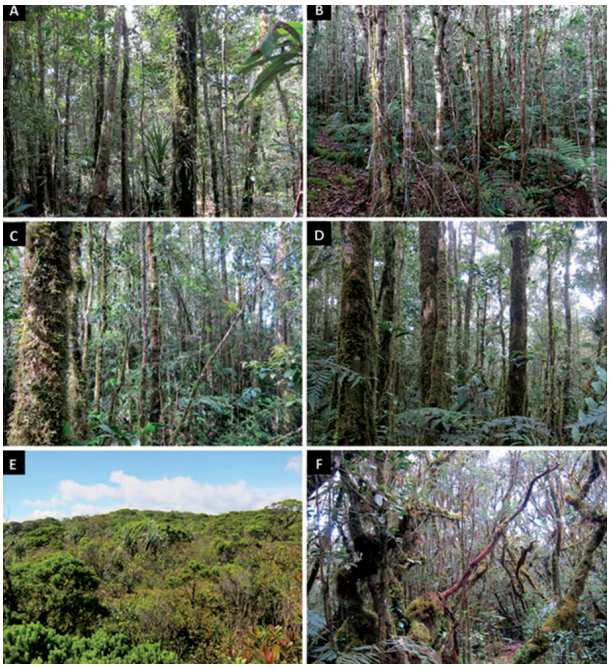

Figure 2. A) Lower montane rainforest in Mt. Limbawon, B) lower montane rainforest in Mt. Manugawi, C) upper montane rainforest in Mt. Limbawon, D) upper montane rainforest in Mt. Manugawi, E) panoramic view of mossy-pygmy forest in Mt. Limbawon, and F) inside the mossy-pygmy forest.

Collection, Processing, and Identification of Specimens

A minimum of eight fertile fronds of each species was collected with shear and trimming cutter. Small ferns were collected by uprooting the whole plant, removing the soil, and pressing the plant intact. For the tree ferns, each entire frond was collected and cut into five parts: leaf apex, middle pinna, lower pinna, basal pinna, and stipe (Amoroso *et al.* 2016a). All specimens were processed with the wet method by Hodge (1947). Herbarium specimens were deposited at the CMU Herbarium (CMUH) and, in part, at the herbarium at the Philippine National Herbarium and BRIT. The specimens collected are the first collections of ferns and lycophytes in the area since no collections for herbarium vouchers have been done in the past.

Specimens were identified by FPC and VBA with the use of the following monographs, floras, and other publications: Copeland's Fern Flora of the Philippines (1958), the Flora Malesiana Series, and digitized plant specimens available in Global Plants on JSTOR. The classification system used is the Pteridophyte Phylogeny Group I (PPG I 2016).

Species Similarity

BioDiversity Pro 2.0 software was used to determine the similarity of the species composition of the different sampling sites using the Bray-Curtis cluster analysis. In addition, four 20 x 20 sampling plots were established in each study site to determine the dominant species by obtaining the species importance values, following the computations adapted by Amoroso *et al.* (2018).

Assessment of Conservation Status

The conservation status of the recorded species were based on the national list of threatened Philippine plants (DENR-DAO 2017), which follows the criteria of the International Union for the Conservation of Nature (IUCN 2016). This information can serve as a basis for governmental agencies that set environmental policies by the DENR and local government units (LGUs) for monitoring and protecting threatened and endemic species, both within the mountain range and its vicinity.

RESULTS AND DISCUSSION

Species Richness

The survey of ferns and lycophytes documented 203 species belonging to 29 families and 89 genera. Of these, 187 are ferns and 16 are lycophytes (Table 1; Figures 3–5; Figure 6A). The family Polypodiaceae has the highest number of species (38 spp.) – followed by Pteridaceae (15 spp.), Hymenophyllaceae (15 spp.), Lindsaeaceae (14 spp.), Dryopteridaceae (13 spp.), Cyatheaceae (11 spp.), and Aspleniaceae, Athyriaceae, and Thelypteridaceae with 10 species each (Figure 6B). The lycophytes were represented by Lycopodiaceae and Selaginellaceae with 10 and six species, respectively. The most diverse genera were *Asplenium* L. (10 spp.), *Hymenophyllum* Sm., *Lindsaea* Dryand. ex Sm. and *Diplazium* Sw. (9 spp. each), *Alsophila* R.Br., *Davallia* Sm., *Phlegmariurus* Holub, *Pteris* L. and *Selaginella* P.Beauv., (6 spp. each), and *Selliguea* Bory and *Sphaeropteris* Bernh. (5 spp. each) (Figure 6C).

The species richness constitutes about 19% and 33% of the total number of pteridophyte species in the Philippines and Mindanao Island, respectively. It closely resembles that of Mt. Burnay and vicinity in northern Luzon with 199 species (Iwatsuki and Price 1977), Panay Island with 228 species (Barcelona 2004), Balinsasayao Twin Lakes Natural Park in Negros Oriental with 232 species (Amoroso *et al.* 2016b), and Mt. Malindang in Misamis Occidental with 280 species (Amoroso *et al.* 2012). It is higher than that of the Karst Forest on Bohol Island with 169 species (Barcelona *et al.* 2006), Mt. Bali-it in Balbalasang-Balbalan National Park in Northern Luzon with 167 species (Barcelona 2003), Mt. Marilog in the area of Davao City with 165 species (Amoroso *et al.* 1996), and Mt. Hamiguitan Range Wildlife Sanctuary in Davao Oriental with 152 species (Amoroso *et al.* 2016) and Mt.

Table 1. Checklist of ferns and lycophytes in Mt. Tago range, Bukidnon, Southern Philippines. Growth forms: AR – arborescent; EP – epiphytic; HE – hemiepiphytic; LI – lithophytic; SA – semi-aquatic; TE – terrestrial. Vouchers: VBA – Victor B. Amoroso; FPC – Fulgent P. Coritico.

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Aspleniaceae								
Asplenium apoense Copel.	EP	x	x		x	x	VBA 14028	00011285
Asplenium cymbifolium Christ	EP					x	VBA 14009	00011536
Asplenium horridum Kaulf	EP				x	x	FPC 756	00011471
Asplenium nidus L.	EP/LI	x	x		x	x	VBA 15349	00011134
Asplenium nigrescens Blume	EP		x		x		FPC 332	00011085
Asplenium persicifolium J.Sm. ex Mett.	EP	x	x	x			FPC 389	00011142
Asplenium tenerum G.Forst.	EP	x	x	x	x		FPC 722	00011474
Asplenium thunbergii Kunze	EP	x	x	x	x		FPC 765	00011535
Asplenium unilaterale Lam.	TE/LI		x				FPC 543	00011305
Asplenium vittiforme Cav.	EP	x	x	x	x	x	VBA 15348	00011055
Athyriaceae								
Athyrium puncticaule (Blume) T.Moore	TE	x	x				FPC 699	00011461
Diplazium costulisorum (Copel.) C.Chr.	TE		x				FPC 400	00011153
Diplazium cordifolium Blume	TE	x			x	x	VBA 14015	00011534
Diplazium davaoense Copel.	TE	x			x		FPC 723	00011472
Diplazium dilatatum Blume.	TE				x		FPC 780	00011473
Diplazium fraxinifolium C.Presl	TE		x				FPC 703	00011465
Diplazium fructuosum Copel.	TE		x				FPC 403	00011156
Diplazium lomariaceum (Christ) M.G.Price	TE	x	x			x	FPC 504	00011266
Diplazium pallidum T.Moore	TE	x			x	x	VBA 15366	00011476
Diplazium sorzogonense (C.Presl) C.Presl	TE	x	x		x	x	FPC 323	00011076
Blechnaceae								
Austroblechnum patersonii (R.Br.) Gasper & V.A.O.Dittrich	TE					x	VBA 15294	00011488
Blechnum capense (L.) Schltdl.	TE/LI	x	x	x		x	VBA 14033	00011475
Blechnopsis orientalis (L.) C.Presl	TE	x					FPC 322	00011075
Cranfillia vulcanica (Blume) Gasper & V.A.O.Dittrich	TE	x	x	x			FPC 691	00011453
Parablechnum vestitum (Blume) Gasper & Salino	TE	x					FPC 335	00011088
Cyatheaceae								
Alsophila commutata Mett.	AR	x	x	x	x	x	FPC 688	00011450
Alsophila fuliginosa Christ	AR		x	x	x	x	FPC 488	00011250
Alsophila hermannii R.M.Tryon	AR					x	FPC 724	00011538
Alsophila loheri (Christ) R.M.Tryon	AR		x			x	FPC779	00011533

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Alsophila lurida (Blume) Hook.	AR	x	x	x			FPC 319/ FPC 435	00011072/ 00011197
Alsophila rufopannosa (Christ) R.M.Tryon	AR	x	x		x	x	FPC 321	00011074
Sphaeropteris elmeri (Copel.) R.M.Tryon	AR	x			x	x	FPC 320	00011073
Sphaeropteris glauca (Blume) R.M.Tryon	AR	x			x		FPC 778	00011489
Sphaeropteris polypoda R.M.Tryon	AR	x		x			FPC 683	00011445
Sphaeropteris robinsonii (Copel.) R.M.Tryon	AR	x	x	x			FPC 420	00011173
Sphaeropteris tripinnata (Copel.) R.M.Tryon	AR	x			x	x	FPC 468	00011230
Davalliaceae								
Davallia denticulata (N.L.Burm.) Mett. ex Kuhn	EP	x			x	x	FPC 757	00011490
Davallia hymenophylloides (Blume) Kuhn	EP	x			x		VBA 14058	00011448
Davallia pubescens C.W.Chen	EP		x		x		FPC 777	00011479
Davallia repens (L.f.) Kuhn	EP	x	x	x	x	x	FPC 328/ VBA 14013	00011081/ 00011118
Davallia solida (Forst.) Sw.	EP		x				FPC 489	00011251
Davallia wagneriana Copel.	EP				x		VBA 15233	00011477
Dennstaedtiaceae								
Dennstaedtia scandens (Blume) T.Moore	EP		x				FPC 434	00011187
Histiopteris incisa (Thunb.) J.Sm.	EP		x		x		FPC 268	00011021
Hypolepis polypodioides (Blume) Hook.	EP				x		FPC 727	00011539
Microlepia speluncae (L.) T.Moore	EP				x		FPC 767	00011478
Microlepia sp. 1	EP				x		FPC 766	00011532
Microlepia sp. 2	EP				x		FPC 758	00011568
Paesia radula (Baker) C.Chr.	EP		x				FPC 514	00011276
Pteridium aquilinum (L.) Kuhn	EP	x					VBA 14207	00011540
Dicksoniaceae								
Calochlaena javanica (Bl.) G.B.Nair	TE	x	x	x	x	x	VBA 14234	00011022
Dicksonia mollis Holttum	AR	x			x	x	FPC 490	00011252
Diplaziopsidaceae								
Diplaziopsis javanica (Blume) C.Chr.	TE					x	FPC 755	00011567
Dipteridaceae								
*Cheiropleuria bicuspis (*Blume) C.Presl	TE				x	x	VBA 15202	
Dipteris conjugata Reinw.	TE	x	x	x	x	x	FPC 285/ FPC 529	00011038/ 00011291

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Dryopteridaceae								
Arachniodes amabilis (Blume) Tindale	TE		x	x	x	x	FPC 435	00011188
Bolbitis heteroclita (C.Presl) Ching	TE/LI				x		FPC 750	00011508
Dryopteris hendersonii (Bedd.) C.Chr.	TE		x	x			FPC 343	00011096
Dryopteris nodosa (C.Presl) Li Bing Zhang	TE	x	x			x	FPC 436	00011189
Dryopteris sparsa (D.Don) Kuntze	TE				x	x	FPC 769	00011480
Elaphoglossum blumeanum (Fée) J.Sm.	EP	x	x			x	VBA 14300	00011459
Elaphoglossum callifolium (Blume) T.Moore	EP	x	x	x			VBA 14031	00011014
Elaphoglossum petiolatum (Sw.) Urb.	EP	x			x		VBA 14299	00011482
Lomagramma pteroides J.Sm.	HE				x		FPC 768	00011483
Polystichum elmeri Copel.	EP				x	x	FPC 725	
Polystichum moluccense T.Moore	EP		x				FPC 440	00011202
Stenolepia tristis (Blume) Alderw.	TE		x				FPC 491	00011253
Teratophyllum aculeatum (Blume) Mett. ex Kuhn	HE				x	x	VBA 15213	00011507
Equisetaceae								
Equisetum ramosissimum Desf.	TE/SA	x					FPC 726	00011481
Gleicheniaceae								
Dicranopteris linearis (Burm.) Underw.	TE	x	x	x	x	x	FPC 436	00011198
Diplopterygium longissimum (Blume) Nakai	TE/HE	x	x	x	x	x	FPC 330/ FPC 573	00011083/ 00011335
Gleichenia dicarpa R.Br.	TE			x			FPC 500	00011262
Gleichenia vulcanica Blume	TE		x	x		x	FPC 776	00011492
Sticherus hirtus (Blume) Ching	TE	x		x		x	FPC 733	00011530
Sticherus loheri (Christ) Copel.	TE	x	x			x	FPC 734	00011509
Hymenophyllaceae								
Abrodictyum obscurum (Blume) Ebihara & K.Iwats.	TE	x	x				FPC 749	00011506
Abrodictyum pluma (Hook.) Ebihara & K.Iwats.	TE	x	x	x			VBA 14304	00011541
Callistopteris apiifolia (C.Presl) Copel.	TE	x	x	x	x	x	VBA 14244	00011499
Cephalomanes javanicum (Blume) Bosch	TE				x		VBA 15508	00011531
Cephalomanes atrovirens C.Presl	TE/ LI				x	x	FPC 775	00011491
Crepidomanes minutum (Blume) K.Iwats.	TE		x	x			FPC 707	00011469
Hymenophyllum acanthoides (Bosch) Rosenst.	EP	x		x		x	VBA 14006	00011542
Hymenophyllum denticulatum Sw.	EP	x	x				FPC 318	00011071

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Hymenophyllum emarginatum Sw.	EP		x				FPC 364	00011117
Hymenophyllum pallidum (Blume) Ebihara & K. Iwats.	EP	x	x		x	x	VBA 14273/ VBA 14027	00011529
Hymenophyllum inaequale (Poir.) Desv.	EP	x	x		x	x	FPC 327	00011080
Hymenophyllum reinwardtii Bosch.	EP	x	x	x	x	x	FPC649/ VBA 14004	00011411
Hymenophyllum serrulatum (C.Presl) C.Chr.	EP		x				FPC 552	00011314
Hymenophyllum sp.	EP			x			FPC 689	00011451
Hymenophyllum thuidium Harrington	EP	x		x			FPC 444	00011206
Hypodematiaceae								
Leucostegia immersa (Wall.) C.Presl	TE	x			x	x	VBA 14047	00011254
Lindsaeaceae								
Lindsaea apoensis Copel.	HE		x		x	x	FPC 431/ VBA 14252	00011193/ 00011329
Lindsaea fissa Copel.	HE	x	x		x	x	FPC 325	00011078
Lindsaea hamiguitanensis D.N.Karger & V.B.Amoroso	TE	x	x	x			FPC 367	00011120
Lindsaea lucida Blume	TE				x	x	FPC 735	00011484
Lindsaea pulchella (J.Sm.) Mett. ex Kuhn	EP	x	x	x	x	x	VBA 14008	00011084
Lindsaea ramosii Copel.	TE					x	VBA 15361	00011543
Lindsaea repens (Bory) Thwaites	EP	x	x				FPC 663/ FPC 666	00011425/ 00011428
Lindsaea rigida J.Sm. ex Hook.	TE		x	x			FPC 673/ VBA 14247	00011147/ 00011435
Lindsaea obtusa J.Sm. ex Hook.	TE		x				FPC 530	00011292
Odontosoria chinensis (L.) J.Sm.	TE			x	x		FPC 759	00011566
Odontosoria retusa (Cav.) J.Sm.	TE			x			FPC 306	00011059
Tapeinidium gracile (Blume) Alderw.	TE	x	x	x	x	x	FPC 721	00011565
Tapeinidium luzonicum (Hook.) K.U. Kramer	TE	x			x	x	VBA 14019	00011505
Tapeinidium pinnatum (Cav.) C.Chr.	TE	x	x				FPC 314	00011067
Lomariopsidaceae								
Lomariopsis lineata (C.Presl) Holttum	HE				x		FPC 754	00011527
Lycopodiaceae								
Huperzia filiformis (Sw.) Holub	EP					x	FPC 760	00011485
Huperzia javanica (Sw.) Fraser-Jenk.	TE				x	x	VBA 15231	00011510
Lycopodium casuarinoides Spring	TE			x			FPC 437	00011190
Palhinhaea cernua (L.) Vasc. & Franco	TE	x		x		x	FPC 360/VBA 14053	00011113/ 00011345

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Phlegmariurus magnusianus (Herter) A.R.Field & Testo	EP				x		VBA 15238	00011528
Phlegmariurus nummularifolius (Blume) Ching	EP	x					VBA 15293	00011544
Phlegmariurus phlegmaria (L.) Holub	EP	x					FPC 240/ VBA 15326	00010993
Phlegmariurus salvinioides (Herter) Ching	EP	x			x	x	FPC 656/ VBA 14024	00011418
Phlegmariurus squarrosus (G.Forst.) Á.Löve & D.Löve	EP	x	x		x	x	FPC 274	00011027
Phlegmariurus verticillatus (L.f.) A.R.Field & Testo	EP		x				FPC 317	00011070
Marattiaceae								
Angiopteris palmiformis (Cav.) C.Chr.	TE	x				x	FPC 744	00011512
Ptisana sylvatica (Blume) Murdock	TE				x	x	VBA 15205	00011513
Nephrolepidaceae								
Nephrolepis biserrata (Sw.) Schott	EP				x	x	FPC 736	00011569
Nephrolepis cordifolia (L.) C.Presl	TE/EP	x		x	x		FPC 248/ FPC 650	00011001/ 00011412
*Nephrolepis falcata (*Cav.) C.Chr.	EP				x		FPC 770	00011545
Nephrolepis hirsutula (G.Forst.) C.Presl	TE			x			FPC 498	00011260
Oleandraceae								
Oleandra neriiformis Cav.	TE/HE	x	x		x	x	VBA 14039	00011023
Oleandra sibbaldii Grev.	HE		x				FPC 405	00011158
Ophioglossaceae								
Botrychium daucifolium Wall. ex Hook. & Grev.	TE			x	x		VBA 15232	00011194
Ophioderma pendula (L.) C.Presl	EP		x				VBA 15368	00011259
Ophioglossum petiolatum Hook.	TE				x		VBA 14251	00011498
Ophioglossum reticulatum L.	TE			x			FPC 447	00011209
Osmundaceae								
Osmunda banksiifolia (C.Presl) Kuhn	TE		x	x			FPC 208	00010961
Plagiogyriaceae								
Plagiogyria egenolfioides (Baker) Copel.	TE	x	x	x			FPC 346	00011099
Plagiogyria euphlebia (Kunze) Mett.	TE	x	x		x	x	FPC 720	00011504
Plagiogyria glauca (Blume) Mett.	TE		x				FPC 544	00011306
Plagiogyria pycnophylla (Kunze) Mett.	TE		x				FPC 464	00011226
Polypodiaceae								
Aglaomorpha cornucopia (Copel.) M.C.Roos	EP				x		FPC 732	00011503

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Aglaomorpha heraclea (Kunze) Copel.	EP	x				x	FPC 745	00011519
Aglaomorpha quercifolia (L.) Hovenkamp & S. Linds.	EP	x					FPC 737	00011571
Aglaomorpha splendens (Hook. & Bauer) Copel.	EP	x	x		x	x	FPC 363	00011116
Calymmodon cucullatus (Nees & Blume) C.Presl	EP	x	x	x			FPC 670	00011432
Goniophlebium persicifolium (Desv.) Bedd.	EP				x		FPC 743	00011547
Goniophlebium pseudoconnatum (Copel.) Copel.	EP	x	x				FPC 694	00011456
Goniophlebium subauriculatum (Blume) C. Presl.	EP					x	FPC 746	00011563
Lecanopteris deparioides (Ces.) Baker	EP			x	x		VBA 14254	00011549
Lepisorus accedens (Blume)	EP	x					FPC 738	00011500
Lepisorus mucronatus (Fée) Li Wang	EP	x	x				FPC 354	00011107
Lepisorus platyrhynchos (Kunze) Li Wang	EP	x			x		FPC 771	00011562
Lepisorus spicatus (L.f.) Li Wang	EP				x		FPC 742	00011520
Leptochilus decurrens Blume	EP		x		x		FPC 718	00011564
Leptochilus macrophyllus (Blume) Noot.	EP				x	x	VBA 15235	00011572
Loxogramme avenia (Blume) C.Presl	EP			x			FPC 719	00011522
Loxogramme sp.	EP				x		FPC 741	00011561
Microsorum congregatifolium (Alderw.) Holttum	TE/EP				x		VBA 15246	00011548
Microsorum commutatum (Blume) Copel.	TE/EP			x			FPC 409	00011162
Microsorum punctatum (L.) Copel.	EP			x	x	x	VBA 15360	00011199
Microsorum scolopendria (Burm.f.) Copel.	TE/LI	x					FPC 717	00011521
Oreogrammitis beddomeana (Alderw.) T.C.Hsu	EP		x	x			FPC 761	00011558
Oreogrammitis dolichosora (Copel.) Parris	EP			x			FPC 493	00011255
Oreogrammitis setigera (Blume) T.C.Hsu	EP			x			FPC 569	00011331
Oreogrammitis torricelliana (Brause) Parris	EP		x				FPC 729	00011559
Prosaptia celebica (Blume) Tagawa & K Iwats.	EP	x	x				FPC 326	00011079
Prosaptia contigua (Forst.) C.Presl	EP		x				FPC 540	00011302
Prosaptia obliquata (Blume) Mett.	EP		x				FPC 801	00011560
Pyrrosia sphaerosticha (Mett.) Ching	EP	x			x		VBA 15198	00011261
Scleroglossum pusillum (Blume) Alderw.	EP	x	x	x			VBA 14025	00011497

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Selliguea albidosquamata (Blume) Parris	EP		x	x	x		VBA 14282	00011094
Selliguea elmeri (Copel.) Ching	EP	x	x	x	x	x	VBA 14253	00011257
Selliguea pyrolifolia (Goldm.) Hovenkamp	EP				x		VBA 15506	00011557
Selliguea taeniata (Sw.) Parris	EP	x	x		x	x	VBA 14266	00011069
Selliguea triloba (Houtt.) M.G.Price	EP	x	x	x	x	x	VBA 14238	00011466
Tomophyllum minutum (Blume) Parris	EP		x				VBA 14310	00011263
Tomophyllum subsecundodissectum (Zoll.) Parris	EP		x				FPC 716	00011496
Pteridaceae								
Adiantum hosei Baker	TE		x				VBA 14265	00011514
Antrophyum plantagenium (Cav.) Kaulf.	EP	x					FPC 671	00011433
Haplopteris alternans Copel.	EP	x	x		x	x	FPC 329	00011082
Haplopteris ensiformis (Sw.) E.H.Crane	EP		x				FPC 494	00011256
Haplopteris scolopendrina (Bory) C.Presl	EP	x					VBA 14205	00011524
Pityrogramma calomelanos (L.) Link	TE			x			FPC 762	00011556
Pteris mertensioides Willd.	TE		x				FPC 393	00011146
Pteris pacifica Hieron.	TE			x			FPC 415	00011168
Pteris schlechteri Brause	TE				x		VBA 15510	00011551
Pteris tripartita Sw.	TE				x		FPC 739	00011516
Pteris vittata L.	TE	x		x			FPC 772	00011515
Pteris whitfordii Copel.	TE	x					FPC 408	00011161
Syngramma alismifolia (C.Presl) J.Sm.	TE				x		VBA 15240	00011550
*Taenitis blechnoides (*Willd.) Sw.	TE	x	x	x		x	FPC 315	00011068
Vaginularia junghuhnii Mett.	EP				x		FPC 730	00011501
Schizaeaceae								
Schizaea malaccana Baker	TE	x					FPC 433	00011186
Selaginellaceae								
Selaginella biformis A.Braun ex Kuhn	TE/LI			x	x		VBA 14054	00011258
Selaginella involvens (Sw.) Spring	TE/LI		x	x	x	x	VBA 14001	00011454
Selaginella magnifica Warb.	TE				x		FPC 763	00011554
Selaginella negrosensis Hieron.	TE	x			x	x	FPC 271	00011024
Selaginella ornata (Hook. & Grev.) Spring	TE		x				FPC 282	00011035
Selaginella remotifolia Spring	TE		x				FPC 565	00011327
Tectariaceae								
Tectaria angulata (Willd.) Copel.	TE					x	FPC 714	00011494

Table 1 continuation . . .

Species	Growth forms	Mt. Limbawon			Mt. Manugawi		Collection No.	CMUH Accession No.
		Lower Montane	Upper Montane	Mossy-Pygmy	Lower Montane	Upper Montane		
Thelypteridaceae								
Chingia ferox (Blume) Holttum	TE		x				VBA 14284	00011518
Christella dentata (Forssk.) Brownsey & Jermy	TE	x				x	FPC 753	00011553
Coryphopteris sp.	TE	x	x				FPC 764	00011495
Pneumatopteris laevis (Mett.) Holttum	TE			x			FPC 715	00011525
Pneumatopteris sp.	TE	x	x				FPC 774	00011526
Pronephrium granulosum (C.Presl) Holttum	TE				x	x	FPC 752	00011502
Pronephrium nitidum Holttum	TE		x			x	FPC 740	00011517
Pronephrium xiphioides (Christ) Holttum	TE		x		x		FPC 731	00011493
Sphaerostephanos unitus (L.) Holttum	TE	x			x		VBA 14295	00011414
Sphaerostephanos sp.	TE	x					FPC 748	00011555
Total		**96**	**100**	**63**	**97**	**76**		

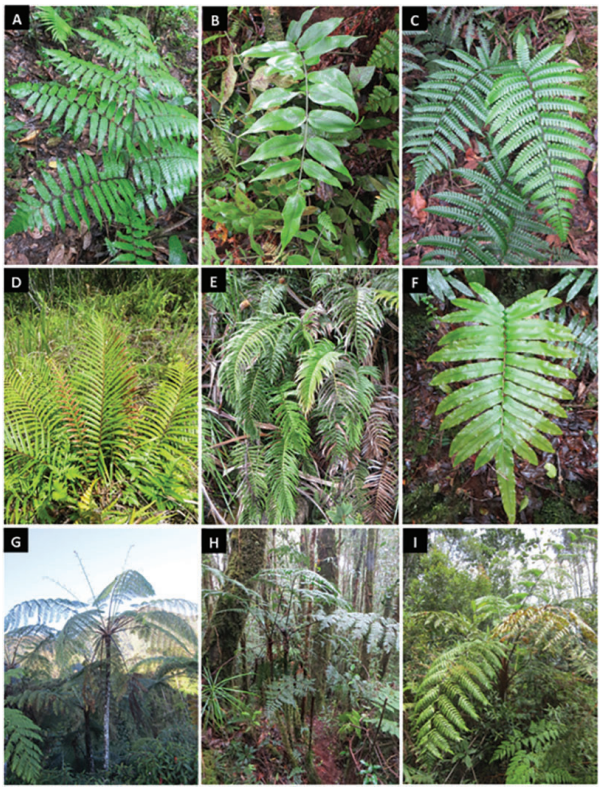

Figure 3. Some ferns in Mt. Tago range: A) *Diplazium davaoense* B) *D. cordifolium,* C) *D. sorzogonense*, D) *Blechnopsis orientalis,* E) *Parablechnum vestitum*, F) *Cranfillia vulcanica*, G) *Sphaeropteris glauca,* H) *Alsophila commutata*, and I) *S. polypoda*.

Figure 4. Some ferns in Mt. Tago range: A) *Dipteris conjugata*, B) *Pteris whitfordii,* C) *Selliguea elmeri*, D) *S. pyrolifolia,* E) *Ophioderma pendula*, F) *Lindsaea hamiguitanensis*, G*) Abrodictyum obscurum,* H) *A. pluma*, and I) *Hymenophyllum pallidum*.

Figure 5. Some lycophytes in Mt. Tago range: A) *Palhinhaea cernua*, B) *Lycopodium casuarinoides*, C) *Phlegmariurus magnusianus*, D) *P. verticillatus,* E) *Selaginella biformis*, F) *S. involvens*, G) *S. negrosensis,* H) *S. ornata*, and I) *S. remotifolia.*

Pinamantawan in Quezon of Bukidnon Province with 121 species (Sumagaysay 2012) (Figure 7). This suggests that the inventory of fern and lycophyte flora of the country has not been thoroughly documented, and most of the studies were confined only to a specific mountain ecosystem or island in a particular region.

The families of ferns recorded in Mt. Tago range are also the same families of ferns found in the Philippines with the highest number of species (Salgado 1990), and they are also the common families that are widely distributed in Mindanao (Amoroso *et al.* 2009, 2012, 2016). The families Aspleniaceae, Cyatheaceae, Dryopteridaceae, Hymenophyllaceae, Polypodiaceae, Pteridaceae, and Thelypteridaceae also have the most number of species in tropical Asian countries like Myanmar (Kine *et al.* 2017), Bangladesh (Haque *et al.* 2017), Nepal (Bhattarai *et al.* 2004; Shrestha and Rajbhandary 2019), Pakistan (Gul *et al.* 2017) and Malaysia (Maideen *et al.* 2019). Moreover, these are also the common families of ferns in tropical America like Brazil (Matos *et al.* 2020; Gonzatti 2016; Mazziero and Nonato 2015) and Mexico (Acebey *et al.* 2017). In addition, *Asplenium*, *Hymenophyllum*, *Lindsaea*, and *Selaginella* were also reported to be the most diverse genera in Reserva Natural Guaricica, Brazil (Matos *et al.* 2020).

There are many factors that may influence species richness, such as the size of the area sampled, climatic condition, soil type, geographical location (Kessler 2010),

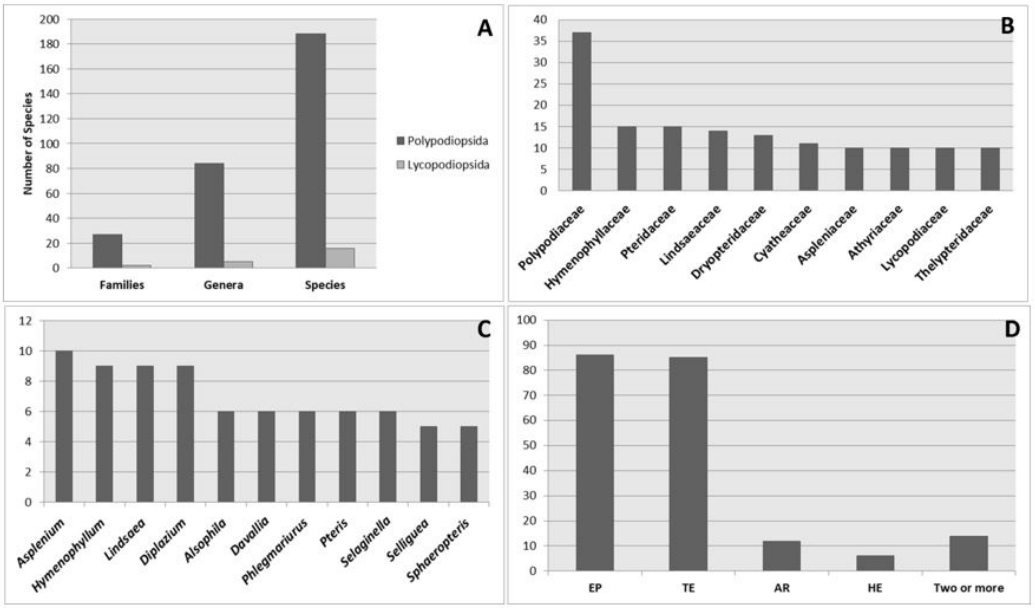

Figure 6. Numbers of ferns and lycophytes in Mt. Tago range by classes, families, genera, and growth forms: A) proportion of families, genera, and species of Lycopodiopsida and Polypodiopsida; B) 10 most diverse families of ferns; C) 11 most diverse genera of ferns and lycophytes; D) number of species per growth forms (EP – epiphyte, TE – terrestrial, AR – arborescent, HE – hemiepiphyte).

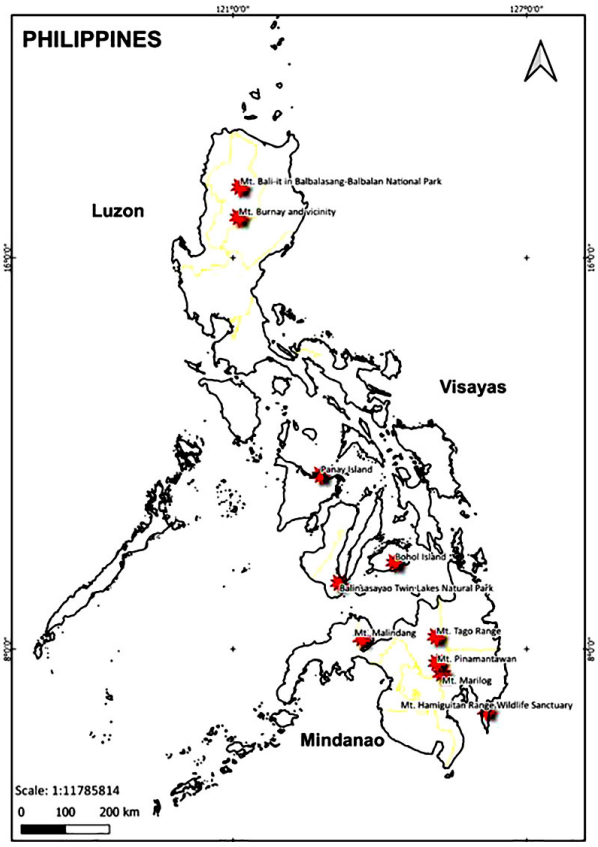

Figure 7. Map showing the studied regions for ferns and lycophytes in the Philippines.

human activities and pollution (Amoroso *et al.* 2016), and accessibility of the mountains (Coritico *et al.* 2017). The high species richness observed in Mt. Tago range may be due to the different forest types present in the area and the climatic conditions, which are relatively cool and humid throughout the year.

The majority of the growth forms were epiphytes (86 species, 42.36%) – followed by terrestrial (85 spp., 41.87%), arborescent (tree ferns) (12 spp., 5.9%), and hemiepiphytic (6 spp., 2.95%) – and other species were observed to have more than one growth forms (14 spp., 6.89%) (Figure 6D). *Equisetum ramosissimum* Desf. was the only species noted to have a terrestrial and semi-aquatic habit growing in sandy places along rivers.

The growth forms showed that the ferns and lycophytes in the area are mostly epiphytes and terrestrial. Some species like *Microsorum congregatifolium* (Alderw.) Holttum, *M. commutatum* (Blume) Copel., and *Nephrolepis cordifolia* (L.) C.Presl can be terrestrial and epiphytes on trees, while *Oleandra neriiformis* Cav. can also grow terrestrially and as hemiepiphyte. About one-third of the pteridophytes are epiphytes, while two-thirds are mostly terrestrial (Schuettpelz and Pryer 2009; Dubuisson *et al.* 2008).

Distribution of Ferns and Lycophytes and Associated Plants

The highest species richness was observed in the upper montane rainforest of Mt. Limbawon, followed by the lower montane rainforest in Mt. Manugawi; the lowest species richness was found in the mossy-pygmy forest in Mt. Limbawon and upper montane rainforest in Mt. Manugawi (Table 1). Both the mossy-pygmy forest and upper montane rainforest in Mt. Limbawon (1885 masl) and Mt. Manugawi (1654 masl), respectively, are the highest peaks of these mountain ranges.

The mossy-pygmy vegetation is categorized by a decrease in height of the trees, with the highest at 15 m. This vegetation is located at 080°16.604'N, 1250°11.012'E, with elevations ranging from 1750–1885 masl, the high extreme of which is the highest peak of the mountain range. The dominant tree species found in this vegetation are *Dacrydium beccarii* Parl., *Leptospermum amboinense* Reinw. ex Blume, and *Tasmannia piperita* (Hook.f.) Miers. The dominant ferns and lycophytes include *Abrodictyum pluma* (Hook.) Ebihara & K.Iwats. (Figure 4H), *Cranfillia vulcanica* (Blume) Gasper & V.A.O.Dittrich (Figure 3F), *Dicranopteris linearis* (Burm.) Underw., *Dipteris conjugata* Reinw. (Figure 4A), *Gleichenia dicarpa* R.Br., *Oreogrammitis dolichosora* (Copel.) Parris, *Palhinhaea cernua* (L.) Vasc. & Franco (Figure 5A), *Oreogrammitis setigera* (Blume) T.C.Hsu, and *Sphaeropteris robinsonii* (Copel.) R.M.Tryon. The other understory plants include *Aeschynanthus* sp., *Alpinia apoensis* Elmer, *A. musifolia* Ridl., *Freycinetia* sp., *Medinilla myrtiformis* Triana, and the site-endemic pitcher plants *Nepenthes ceciliae* Gronem. *et al.* and *N. pulchra* Gronem. *et al.*

The upper montane rainforest is located at 080°15.694'N, 125°10.712'E, with elevations ranging from 1350–1550 masl. It consists of tree species reaching up to 50 m high and with the highest diameter of 60 cm dbh. The dominant tree species found in this vegetation are *Agathis philippinensis* Warb., *Ascarina philippinensis* C.B.Rob., *Calophyllum blancoi* Planch. & Triana, *Cinnamomum mercadoi* S.Vidal, *Dacrycarpus imbricatus* (Blume) de Laub., *Lithocarpus philippinensis* (A.DC.) Rehder, *L. apoensis* (Elmer) Rehder, *Neolitsea apoensis* Elmer, *Palaquium* sp., *Phyllocladus hypophyllus* Hook.f., and *Syzygium* spp. The dominant ferns in this vegetation include *Alsophila commutata* Mett. (Figure 3H), *A. rufopannosa* (Christ) R.M.Tryon, *Davallia repens* (L.f.) Kuhn, *Dryopteris nodosa* (C.Presl) Li Bing Zhang, *Elaphoglossum callifolium (*Blume) T.Moore, *E. blumeanum* (Fée) J.Sm., *Hymenophyllum* spp., *Lindsaea pulchella* (J.Sm.) Mett. ex Kuhn, and *Plagiogyria egenolfioides* (Baker) Copel. The other understory plants include the site endemic pitcher plant *Nepenthes pulchra* and other species such as *Agalmyla persimilis* Hilliard

& B.L.Burtt, *Coelogyne salvaneraniana* W.Suarez, *Dendrochilum longilabre* (Ames) Pfitzer, *Freycinetia cumingiana* Gaudich., *Hornstedtia lophophora* Ridl., *Lasianthus clementis* Merr., *M. myrtiformis*, *Sarcandra glabra* (Thunb.) Nakai, and *Pinanga insignis* Becc.

The lower montane rainforest comprises tree species reaching up to 50 m high and with the highest diameter of 60 cm dbh, and basically near the pygmy forest area. The dominant tree species found in this vegetation are *Alstonia parvifolia* Merr., *A. philippinensis*, *Gymnostoma rumphianum* (Miq.) L.A.S.Johnson, *L. philippinensis*, *Macaranga dipterocarpifolia* Merr., *Palaquium* spp., and *Syzygium* sp. The dominant ferns and lycophytes in this vegetation include *A. commutata*, *A. rufopannosa* (Mindanao endemic scaly tree fern), *Alsophila lurida* (Blume) Hook., *Davallia repens*, *Hymenophyllum inaequale* (Poir.) Desv., *P. cernua*, *P. egenolfioides*, *Selliguea taeniata* (Sw.) Parris, *Selaginella involvens* (Sw.) Spring (Figure 5F), and *Tapeinidium pinnatum* (Cav.) C.Chr. The other understory plants include *Calamus microcarpus* Becc., *Coelogyne candoonensis* Ames, *Dendrochilum apoense* T.Hashim., *Freycinetia cumingiana*, *Osmoxylon simplicifolium* (Elmer) Philipson, and *Smilax reticulata* Desv. ex Ham.

Species Similarity Between Vegetation Types

The mossy-pygmy forest in Mt. Limbawon was found to have a distinct species composition of ferns and lycophytes from other sampling sites (Figure 8), which can be attributed to the vegetation present in the area. This unique forest type is uncommon in the Philippines and constitutes only about 5% of the total land area in the archipelago (Baker *et al.* 1992). The forest over ultramafic rocks in Palawan includes those referred to by Weidelt and Banaag (1982) as "stunted forest" with diameters too small for utilization by humans, and "bonsai field" by Amoroso *et al.* (2009) in Mt. Hamiguitan, Davao Oriental. The upper montane rainforest of Mt. Limbawon also exhibits a unique species composition (Figure 8). This forest type in the Philippines is commonly called "mossy forest," a name used by Whitford (1911) because of the richness and abundance of bryophytes that cover the tree trunks, branches, and even the forest floor. It occurs in mountains above 1000 m asl depending on the locality, size, and height of the mountain (Fernando *et al.* 2008). The upper montane rainforest is the most common forest type in the Philippines, together with the lower montane rainforest. It is also one of the four definable forest formations on the higher tropical mountains (Ashton 2003). There is also a high abundance of terrestrial and epiphytic ferns, lycophytes, bryophytes, and other understory plants observed in this vegetation.

Species found in the lower montane rainforest of Mt. Limbawon closely resembles the lower and upper montane rainforests of Mt. Manugawi, as based on its structure and floristic composition. This lower montane rainforest is comparable in species composition to the other mountain ecosystems on the Island of Mindanao, such as on Mt. Kitanglad in Bukidnon and Mt. Malindang in Misamis Occidental (Amoroso *et al.* 2011, 2012).

The highest species richness of ferns and lycophytes in the montane forests supports the findings of Hemp (2001, 2002), Kessler (2001), Bhattarai *et al.* (2004), Kluge *et al.* (2006), and Hernández-Rojas *et al.* (2018) that the maximum fern richness was highest in mid-elevation forests. Also, fern species occupy more vertical habitats

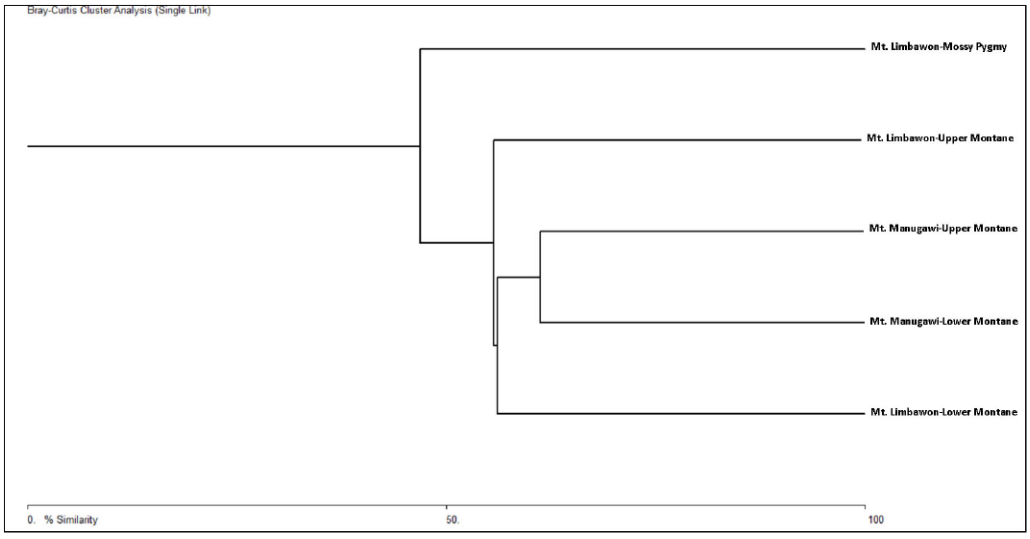

Figure 8. Bray-Curtis cluster analysis showing species similarities among the studied sites.

in montane than in lowland forest (Acebey *et al.* 2017). This has often been linked to an optimal combination of high humidity, rainfall, and moderate temperatures at mid-elevations (Lauer *et al.* 1996). The spatial pattern of fern species richness is also related to life form, as evidenced by the different patterns of distribution between epiphytic and terrestrial species along the elevational gradient (Watkins *et al.* 2006). Moreover, latitudinal and elevational patterns of range size in fern assemblages are driven by different factors for wide-ranging species, and species with restricted ranges with more variation introduced by the specific conditions of mountain ranges (Hernández-Rojas *et al.* 2020).

New Records

Many remarkable fern and lycophyte species were found in the range. One species of fern previously known only in Malay, Peninsula, Sumatra, and Borneo was documented for the Philippines: *Alsophila commutata* Mett. (Coritico *et al.* 2017). There were new records for Mindanao Island, such as *Selliguea pyrolifolia* (Goldm.) Hovenkamp, *S. elmeri* (Copel.) Ching (Figure 4C), and *Pteris whitfordii* Copel. (Figure 4B) – previously known only in Luzon and Visayas Islands, respectively. In addition, *Lindsaea hamiguitanensis* (Figure 4F) – previously known only from Mt. Hamiguitan, San Isidro, Davao Oriental – was newly documented for the area.

Endemism and Conservation Status

There are 21 endemic species recorded in Mt. Tago range. Of these, 17 are widespread Philippine endemics and four are Mindanao endemics. This is about 8% of the total endemic species found in the country. The broadly distributed Philippine endemic species are *Aglaomorpha cornucopia* (Copel.) M.C.Roos, *Asplenium apoense* Copel., *Alsophila fuliginosa* Christ, *A. hermannii* R.M.Tryon, *Diplazium fructuosum* Copel., *Lindsaea apoensis* Copel., *L. fissa* Copel., *L. ramosii* Copel., *Phlegmariurus magnusianus* (Herter) A.R.Field & Testo (Figure 5C), *Pneumatopteris laevis* (Mett.) Holttum, *Polystichum moluccense* T.Moore, *Pronephrium xiphioides* (Christ) Holttum, *P. whitfordii*, *Selaginella negrosensis* Hieron., *Sphaeropteris robinsonii* (Figure 5G), *S. elmeri*, and *S. pyrolifolia* (Figure 4D). The Mindanao endemic species are *A. rufopannosa*, *Diplazium davaoense* Copel. (Figure 3A), *L. hamiguitanensis*, and S*elaginella magnifica* Warb.

Mt. Tago range in Bukidnon is one of the remaining intact forests in the Bukidnon Province and the mountain range is prone to over-collection and exploitation of floral resources, especially during the "Kaamulan," a local annual festival in the province. Many plants such as orchids (*Paphiopedilum* spp., *Bulbophyllum* spp., and *Dendrobium* spp.), ferns, and lycopods (*Huperzia*) are being sold in flower markets and garden shows during fiestas and provincial celebrations. Twenty-eight threatened species of ferns and lycophytes were recorded in the area. One is critically endangered, 13 are endangered, nine are vulnerable, and five are other threatened species (Table 2). It is strongly recommended that these remaining species be given a high priority for

Table 2. Conservation status of ferns and lycophytes in Mt. Tago range, Bukidnon, Southern Philippines. Conservation status: CR – critically endangered, EN – endangered, VU – vulnerable, OTS – other threatened species.

Species	Conservation status
Phlegmariurus magnusianus (Herter) A.R.Field & Testo	CR; A1
Diplazium costulisorum (Copel.) C.Chr.	EN; A1
Alsophila hermannii R.M.Tryon	EN; A1
Alsophila rufopannosa (Christ) R.M.Tryon	EN; B1
Sphaeropteris glauca (Blume) R.M. Tryon	EN; A1cd
Dicksonia mollis Holttum	EN; A1
Polystichum nudum Copel.	EN; A1
Ophioderma pendula (L.) C.Presl	EN; A1cd
Lecanopteris deparioides (Ces.) Baker	EN; A1c, B2c
Phlegmariurus phlegmaria (L.) Holub	EN; A2
Phlegmariurus salvinioides (Herter) Ching	EN; A1c
Phlegmariurus squarrosus (G.Forst.) Á.Löve & D.Löve	EN; A1c
Selaginella magnifica Warb.	EN; B2a
Schizaea malaccana Baker	EN; B2a
Asplenium vittaeforme Cav.	VU; A1cd, B2c
Alsophila fuliginosa Christ	VU; A1cd
Sphaeropteris elmeri R.M.Tryon	VU; A1
Sphaeropteris robinsonii R.M.Tryon	VU; A1
Lindsaea hamiguitanensis D.N.Karger & V.B.Amoroso	VU; A1c
Botrychium daucifolium Wall. ex Hook. & Grev.	VU; A1
Aglaomorpha cornucopia (Copel.) M.C.Roos	VU; A1
Aglaomorpha heraclea (Kunze) Copel.	VU; A1
Aglaomorpha splendens (Hook. & Bauer) Copel.	VU; A1
Davallia denticulata Burm. f.) Mett. ex Kuhn	OTS
Davallia solida (Forst.) Sw.	OTS
Angiopteris palmiformis (Cav.) C. Chr.	OTS
Osmunda banksiifolia Pr.	OTS
Stenolepia tristis (Blume) Alderw.	OTS

protection and conservation. There are many reasons why the species become threatened or endangered. Habitat destruction through logging, shifting cultivation, land use/land cover change, environmental pollution, invasive species, and over-exploitation of forest resources are considered the major threats to biodiversity (Catibog-Sinha and Heaney 2006; Monastersky 2014). Moreover, climate change is also one of the primary causes of species endangerment (Ibrahim *et al.* 2013).

CONCLUSIONS

Mt. Tago range is home to 203 species of ferns and lycophytes belonging to 29 families and 89 genera. Species richness of ferns and lycophytes in the area is about 19% of the total number of pteridophyte species in the Philippines and nearly 33% of the total number in Mindanao Island. High species richness was observed in the upper montane rainforest. Twenty-one species are endemic to the Philippines and three are new records for the island. Twenty-eight threatened species were also recorded, *viz.* one is critically endangered, 13 are endangered, nine are vulnerable, and five others are threatened. The results of this study support the designation of the site as a local conservation area that can be co-managed by the local people and LGU for long-term conservation and protection of the entire mountain range.

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REFERENCES

ACEBEY A, KROMER T, KESSLER M. 2017. Species richness and vertical distribution of ferns and lycophytes along an elevational gradient in Los Tuxtlas, Veracruz, Mexico. Flora 235: 83–91.

AMOROSO VB, ACMA FM, PAVA HP. 1996. Diversity status and ecology of Pteridophytes in three forests in Mindanao. In: Pteridology in perspective. Canus JM, Johns RJ eds. Royal Botanic Gardens, London. 53–60.

AMOROSO VB, OBSIOMA LD, ARLALEJO JB, ASPIRAS RA, CAPILI DP, POLIZON JJA, SUMILE EB. 2009. Inventory and Conservation of Endangered, Endemic and Economically Important Flora of Hamiguitan Range, Southern Philippines. Blumea 54(1–3): 71–76.

AMOROSO VB, LARAGA SH, CALZADA BV. 2011. Diversity and assessments of plants in Mt. Kitanglad Range Natural Park, Bukidnon, Southern Philippines. Garden's Bulletin Singapore 63(1&2): 219–236.

AMOROSO VB, AMOROSO CB, CORITICO FP. 2012. Diversity and Status of Plants in Three Mountain Ecosystems in Southern Mindanao, Philippines. Asian Journal of Biodiversity 3(1): 50–73.

AMOROSO VB, CORITICO FP, FRITSCH PW. 2016a. Species Richness and Conservation Status of Ferns and Lycophytes in Mt. Hamiguitan Range Wildlife Sanctuary, Davao Oriental, Philippines. Philippine Journal of Science 145(2): 17–23.

AMOROSO VB, CHEN CW, FP CORITICO, LU PF, ALCALA EL, CHIOU WL. 2016b. Guide to Lycophytes and Ferns of Balinsasayao, Negros, the Philippines. Pintung, Taiwan: KBCC Press.

AMOROSO VB, ACMA FM, CORITICO FP, GORME FS, LAGUNDAY NE, SALOLOG MCS, COLONG RD. 2018. Floral diversity assessment of the buffer zones and vicinity of the Mt. Hamiguitan Range Wildlife Sanctuary (MHRWS), Davao Oriental: basis for inclusion to protected area zone. Philippine Journal of Systematic Biology 12(2): 36–51.

ASHTON P. 2003. Floristic zonation of tree communities on wet tropical mountains revisited. Perspectives in Plant Ecology, Evolution and Systematics 6(1,2): 87–104.

ATES FB, NUNEZA OM. 2000. Endemic Species of Mt. Kimangkil, Bukidnon, Mindanao Island, Philippines. Retrieved on 24 Jan 2020 from http://cal.man.ac.uk/studentprojects/2000/mnzo7cas/references.htm

BAKER AJM, PROCTOR J, VAN BALGOOY MMJ, REEVES RD. 1992. Hyperaccumulation of nickel by the flora of the ultramafics of Palawan, Republic of the Philippines. In: The vegetation of ultramafic (serpentine) soils. Baker AJM, Proctor J, Reeves RD eds. Proceedings of the First International Conference on Serpentine Ecology. Andover, UK: Intercept. p. 291–304.

BARCELONA J. 2003. Preliminary report on the ferns and fern allies (pteridophytes) of Mt. Bali-it, Balbalasang-Balbalan National Park, Kalinga, Northern Luzon, Philippines. Sylvatrop 13(1&2): 81–92.

BARCELONA J. 2004. Collection and conservation status of pteridophytes in Panay Island, Philippines. Philippine Scientist 41: 57–73.

BARCELONA J, DOLOTINA N, MADROÑERO G, GRANERT W, SOPOT D. 2006. The ferns and fern allies of the karst forests of Bohol Island, Philippines. American Fern Journal 96(1): 1–20.

BHATTARAI K, VETAAS O, GRYTNES J. 2004. Fern species richness along a central Himalayan elevational gradient, Nepal. Journal of Biogeography 31: 389–400.

[BWPDC] Bukidnon Watershed Protection and Development Council 2012. Retrieved on 15 May 2020 from https://essc.org.ph/content/archives/tag/bukidnon-watershed-protection-and-development-council/

CATIBOG-SINHA C, HEANEY L. 2006. Philippine Biodiversity: Principles and Practice. Quezon City: Haribon Foundation for the Conservation of Natural Resources Inc.

COPELAND E. 1958. Fern flora of the Philippines. Vol. 1–3. Manila Bureau of Printing. p. 1–555.

CORITICO FP, FLEISCHMANN A. 2016. The first record of the boreal bog species *Drosera rotundifolia* L. (Droseraceae) from the Philippines, and a key to the Philippine sundews. Blumea 61: 24–28.

CORITICO FP, AMOROSO VB, LEHNERT M. 2017. New records, names and combinations of scaly tree ferns (Cyatheaceae) in eastern Malesia. Blumea 62: 92–96.

CORITICO FP. 2018. Plant Diversity and Forest Structure in Mt. Limbawon, Tago Range, Malaybalay, Bukidnon, Philippines [Dissertation]. Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines. 259p. (Available at the CMU Library)

[DENR-DAO] Department of Environment and Natural Resources Administrative Order. 2017. Updated National List of Threatened Philippine Plants and their Categories. 30p.

DUBUISSON JY, SCHNEIDER H, HENNEQUIN S. 2009. Epiphytism in ferns: diversity and history. Comptes Rendus – Biologies 332(2–3): 120–128.

FERNANDO ES, SUH MH, LEE J, LEE DK. 2008. Forest formations of the Philippines. ASEAN – Korea Environmental Cooperation Unit, Seoul National University, Seoul. 232p.

GONZATTI F, MACHADO L, WINDISCH P. 2016. Distribution patterns of ferns and lycophytes in the Coastal Region of the state of Rio Grande do Sul, Brazil. Acta Botanica Brasilica 30(2): 239–253.

GUL A, ALAM J, MAJID A, AHMAD H, QAISER M. 2017. Diversity and distribution patterns in the Pteridophyte flora of Pakistan and Azad Kashmir. Pakistan Journal of Botany 49(SI): 83–88.

HAQUE AKM, KHAN SA, UDDIN SN, MOHAMMOD AR. 2017. Taxonomic checklist of the pteridophytes of Rajkandi Reserve Forest, Moulvibazar, Bangladesh. Jahangirnagar University Journal of Biological Sciences 5(2): 27–40.

HEANEY L, REGALADO JC JR. 1998. Vanishing Treasures of the Philippine Rain Forest: A Comprehensive Introduction to the Biodiversity of the Philippines. Chicago, IL: The Field Museum University of Chicago Press. 88p.

HEMP A. 2001. Ecology of the pteridophytes on the southern slopes of Mt. Kilimanjaro. Part II: habitat selection. Plant Biology 3: 493–523.

HEMP A. 2002. Ecology of the pteridophytes on the southern slopes of Mt. Kilimanjaro I. Altitudinal distribution. Plant Ecology 159: 211–239.

HERNÁNDEZ-ROJAS AC, KESSLER M, KRÖMER T, CARVAJAL-HERNÁNDEZ C, WEIGAND A, KLUGE J. 2018. Richness Patterns of Ferns Along an Elevational Gradient in the Sierra de Juárez, Oaxaca, Mexico: A Comparison with Central and South America. American Fern Journal 108(3): 76–94.

HERNÁNDEZ-ROJAS AC, KLUGE J, KRÖMER T, CARVAJAL-HERNÁNDEZ C, SILVA-MIJANGOS L, MIEHE G, LEHNERT M, WEIGAND A, KESSLER M. 2020. Latitudinal patterns of species richness and range size of ferns along elevational gradients at the transition from tropics to subtropics. Journal of Biogeography 47(6): 1383–1397.

HODGE W. 1947. The use of alcohol in plant collecting. Rhodora 49: 207–210.

IBRAHIM MA, NA M, OH J, SCHINAZI RF, MCBRAYER TR, WHITAKER T, DOERKSEN RJ, NEWMAN DJ, ZACHOS LG, HAMANN MT. 2013. Significance of endangered and threatened plant natural products in the control of human disease. Proceedings of the National Academy of Sciences USA 10(42): 16832–16837.

IWATSUKI K, PRICE M. 1977. The pteridophytes of Mt. Burnay and Vicinity, Northern Luzon. Southeast Asian Studies 14(4): 540–572.

[IUCN] International Union for the Conservation of Nature. 2016. The IUCN Red List of Threatened Species, Version 2016–2.

KESSLER M. 2001. Pteridophyte species richness in Andean forests in Bolivia. Biodiversity and Conservation 10: 1473– 1495.

KESSLER M. 2010. Biogeography of ferns. In: Fern Ecology. Mehltreter K, Walker L, Sharpe J eds. Cambridge: Cambridge University Press. p. 22–60.

KINE P, FRASER-JENKINS C, LINDSAY S, MIDDLETON D, MIEHE G, THOMAS P, KLUGE J. 2017. A Contribution Toward the Knowledge of Ferns and Lycophytes from Northern and Northwestern Myanmar. American Fern Journal 107(4): 219–256.

KLUGE J, KESSLER M, DUNN R. 2006. What drives elevational patterns of diversity? A test of geometric constraints, climate and species pool effects for pteridophytes on an elevational gradient in Costa Rica. Global Ecology and Biogeography 15: 358–371.

LANGENBERGER G. 2004. A review on Philippine forest vegetation, particularly work since 1990. Agham Mindanao 2: 11–24.

LAUER W, RAFIQPOOR M, FRANKENBERG P. 1996. Die Klimate der Erde. Eine Klassifikation auf ökophysiologischer Grundlage der realen Vegetation. Erdkunde 50: 275–300.

MAIDEEN H, FARHANA N, NADIRAH N, KHADUWI NU, NORHAZRINA N. 2019. Ferns and lycophytes of Palau Pangkor and its vicinity. The Malaysian Forester 82(1): 77–86.

MATOS F, BOHN A, LABIAK P. 2020. The ferns and lycophytes of Reserva Natural Guaricica, Antonina, Paraná, Brazil. Check List 16(1): 183–206.

MAZZIERO FFF, NONATO FR. 2015. Ferns and lycophytes from Jaú, São Paulo, Brazil. Check List 11(6): 1798.

MONASTERSKY R. 2014. Biodiversity: life—a status report. Nature 516: 158–161.

MYERS N, MITTERMEIER R, MITTERMEIER C, FONSECA G, KENT J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

PELSER PB, BARCELONA JF, NICKRENT DL eds. 2011 onwards. Co's Digital Flora of the Philippines. Retrieved from www.philippineplants.org

[PPG I] Pteridophyte Phylogeny Group I. 2016. A community-derived classification for extant lycophytes and ferns. Journal of Systematics and Evolution 54: 563–603.

SALGADO E. 1990. A checklist of Philippine ferns. Philippine Journal of Science 119: 107–148.

SCHUETTPELZ E, PRYER K. 2009. Evidence for a Cenozoic radiation of ferns in an angiosperm-dominated canopy. Proceedings of the National Academy of Sciences USA 106(27): 11200–11205.

SHRESTHA HS, RAJBHANDARY S. 2019. Floristic Study of Fern and Fern Allies Along Altitudinal Gradient from Besishahar to Lower Manang, Central Nepal. Journal of Plant Resources 17(1): 29–34.

SUMAGAYSAY C. 2012. Pteridophyte Diversity of Mount Pinamantawan, Tangkulang Range, Quezon, Bukidnon [MS thesis]. Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines. 150p. (Available at the CMU Library)

WATKINS JE JR, CARDELUS C, COLWELL RK, MORAN RC. 2006. Species Richness and Distribution of ferns along an elevational gradient in Costa Rica. American Journal of Botany 93(1): 73–83

WEIDELT L, BANAAG V. 1982. Aspects of Management and Silviculture of Philippine Dipterocarp Forests. Eschborn: Deutsche Gesellschaft für Technische Zusammenarbeit. 302p.

WHITFORD H. 1911. The Forests of the Philippines. Part I, Forest Types and Products. Philippine Bureau of Forestry Bulletin No.10. Bureau of Printing, Manila. 94p.