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Diversity of Ferns and Lycophytes in the Mt. Malambo, Southern Philippines

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Abstract: This research was carried out to study the diversity and assess the conservation status and endemism of ferns and lycophytes in the Mt. Malambo, Datu Salumay, Southern Philippines. Repeated transect walks were done with 20 sampling plots delineated on the site. Specimens were collected, identified, and assessed for their conservation status and endemism. Data gathered were analyzed employing the Shannon-Weiner Index. The inventory revealed 215 species (202 species of ferns and 13 species of lycophytes) belonging to 74 genera and 23 families. Polypodiaceae, Aspleniaceae, Hymenophyllaceae, and Pteridaceae were the species-rich families collected. *Asplenium nidus* L., *Pneumatopteris costata* (Brackenr.) Holttum, and *Asplenium thunbergii* Kunze obtained the highest species importance values. Mt. Malambo has a diversity value of H'=1.83 which is higher compared to other mountains in Mindanao. This study reports 20 Philippine endemic and 19 threatened species of ferns and lycophytes in the area. Of these, one is critically endangered, 11 are endangered, five are vulnerable, and two are other threatened species. The presence of many threatened and endemic species in the area implies that high priority should be addressed in protecting and conserving these species of ferns and lycophytes in Mt. Malambo.

Keywords: Diversity assessment, inventory, montane forest, pteridophytes, threatened species

1 Introduction

The ferns and lycophytes (monilophytes) in the Philippines consist of *ca.* 1,100 species distributed in 154 genera and 34 families. Species richness is continuously increasing as a result of discoveries of new species and new species records in the Philippines (Smith *et al.* 2008, Barcelona *et al.* 2013, Amoroso *et al.* 2019). With the highest

elevation of 1,354 m above sea level (masl) and classified as a montane forest located at 07°29'87'N and 125°15'22'E, Mt. Malambo is one of the remaining forested mountains in Datu Salumay, Marilog District but continuously faces anthropogenic disturbances, such as the conversion of forestland into residential and mountain resorts, agriculture for high-value-crops, and overharvesting of plants for ornamentals, food, and handicraft materials for livelihood or household consumption. These anthropogenic activities coupled with accessibility, the rate of forest decline in Mt. Malambo is fast resulting in a loss of biodiversity. An inventory for ferns and lycophytes has not been done in many places in the Philippines, particularly on the island of Mindanao. Therefore, an inventory of ferns and lycophytes is needed, including their diversity and assessment as a basis to protect and conserve the remaining biodiversity of Mt. Malambo. This study aimed to prepare an inventory, including diversity, conservation status, and assessment of ferns and lycophytes in Mt. Malambo, Datu Salumay, Southern Philippines.

2 Material and Methods

2.1 Study site

The research proposal was presented to the local government officials and to the members of the Matigsalug-Manobo Tribal Council for Elders City of Davao, Inc. (MAMATRIPCEDI) in Mt. Malambo, Marilog District for their information, and a Prior Informed Consent (PIC) was obtained from them after. The PIC was used as a supporting document to obtain the gratuitous permit from the Department of Environment and Natural Resources (DENR) as a requirement to conduct the study. The study site is located in the lower montane rainforest having clay and loam subrates at an elevation of 1,345 masl (Acma *et al.* 2021).

2.2 Species inventory and abundance

The inventory of ferns and lycophytes in Mt. Malambo, Datu Salumay, Marilog District in Davao, Philippines (Figure 1, 2) was conducted through repeated transect walks and the establishment of sampling plots. Twenty sampling plots of 20 x 20 m (Figure 1c, red dots) were established inside the forest of Mt. Malambo. The total number of individuals in all plots was counted to determine their abundance.

2.3 Specimen collection, processing and identification

At least four fertile fronds were collected for each species using pruning shears and a trimming cutter. Small ferns and lycophytes (*ca.* 4–20 in.) were collected by uprooting

the whole plant, removing the earthy matter, and pressing the specimens. For the epiphytic ferns and lycophytes, the whole plants were detached to the trunk and the earthy matter or barks were removed. For tree ferns, each entire frond was collected and cut into five parts: leaf apex, middle pinna, lower pinna, basal pinna and stipe. All specimens were processed using the wet method (Hodge 1974).

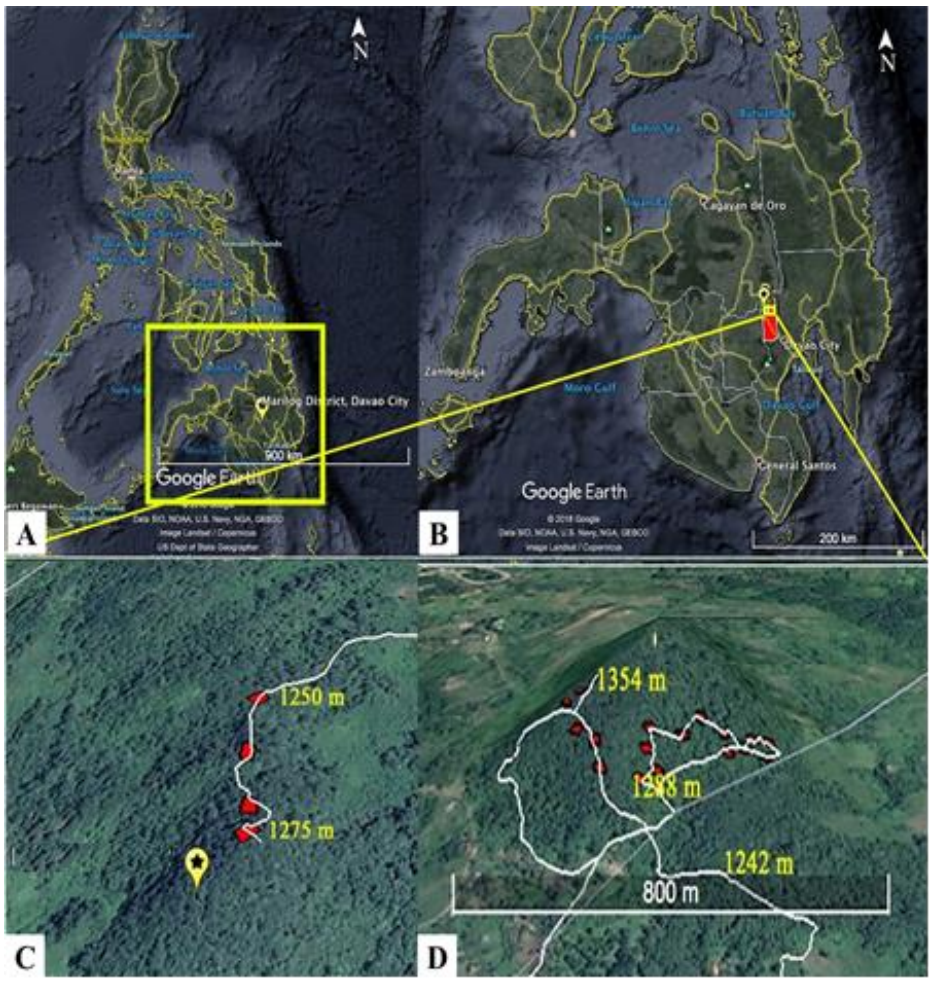

Fig 1. Study Site. A) Map of the Philippines, B) Mt. Malambo in the island of Mindanao, C) Close-up view of Mt. Malambo and sampling area, D) Sampling plots (red marks) and transect walks (white line).

Identification of the specimens was done using fresh materials from the field and compared to some Floras, monographs, field guides, scientific journal articles, such as Copeland (1958–1961), Co's Digital Flora of the Philippines of Pelser et al. (2011 onwards), and digitized plant specimens available in the Global Plants on Journal

Storage (JSTOR). The classification system used was based on the Pteridophyte Phylogeny Group (PPG I 2016). These specimens were then processed and included in the prepared voucher specimens. All specimens were accessioned and deposited at the Central Mindanao University.

Fig 2. Panoramic view of Mt. Malambo with montane vegetation.

2.4 Assessment of conservation status and endemism

Assessment of conservation status and endemism of the species was based on the recently published book of Philippine threatened plants (Fernando et al., 2022) which follows the criteria of the International Union for the Conservation of Nature (IUCN). This information is important because it serves as a basis for governmental agencies like the Protected Area Management Board (PAMB), Department of Environment and Natural Resources (DENR) and Local Government Units (LGUs) which formulate policies and guidelines for monitoring and protecting the threatened and endemic species.

2.5 Species Importance Value (SIV) and diversity values

Species richness of ferns and lycophytes was estimated by determining the number of species. Calculation for frequency, relative frequency, density, relative density and Importance Value Index (IVI) were derived from Curtis & McIntosh (1951).

$$SIV \text{ or } ni = RD + RF + Rdom$$

where, RD is relative density, RF is relative frequency, and Rdom is relative dominance.

The diversity values were computed using the Shannon-Weiner index (H') (Shannon and Weiner 1963) by,

$$H = -\sum [ni /N] \ln [ni/N]$$

where, ni = number of individuals of each species, N = total number of individuals, ln = the natural log of the number.

3 Results and Discussion

3.1 Species richness

Repeated transect walks and sampling plots in Mt. Malambo revealed 215 species from 23 families and 74 genera of ferns and lycophytes (Table 1; Figure 3).

Table 1. Total number of families, genera and species of ferns and lycophytes in Mt. Malambo, Datu Salumay, Marilog District.

Family	Number of genera	Number of species
LYCOPHYTES		
Lycopodiaceae	2	5
Selaginellaceae	1	8
FERNS		
Aspleniaceae	1	21
Athyriaceae	4	18
Blechnaceae	1	1
Cyatheaceae	2	6
Davalliaceae	2	8
Dennstaedtiaceae	4	5
Dicksoniaceae	2	2
Dryopteridaceae	5	15
Gleicheniaceae	3	5
Hymenophyllaceae	6	19
Hypodematiaceae	1	1
Lindsaeaceae	3	10
Marattiaceae	1	1
Nephrolepidaceae	1	5
Oleandraceae	1	3
Ophioglossaceae	3	3
Polypodiaceae	16	38
Pteridaceae	5	17
Tectariaceae	4	9
Thelypteridaceae	7	15
TOTAL	74	215

Of these, 202 species are ferns and 13 are lycophytes. The species richness is *ca.* 20.8% of the total number of ferns and lycophytes in the Philippines and *ca.* 34.0% of the total number recorded in Mindanao Island (Amoroso et al., 2011). Polypodiaceae (32 species) obtained the highest number of species, followed by Aspleniaceae (21 species), Hymenophyllaceae (19 species), Athyriaceae (18 species), Pteridaceae (17 species), and Dryopteridaceae and Thelypteridaceae (both with 15 species). These families have the highest number of species in the entire country (Salgado 1990).

Data on species richness in Mt. Malambo was comparatively higher compared to the previous works of Amoroso *et al.* (1996) in the Marilog forest which documented 183 species of ferns and lycophytes and Coritico *et al.* (2020) in Mt. Tago Range in Bukidnon with 203 species, Silverio *et al.* 2021 in Mt. Sinaka, North Cotabato with 163 species, Amoroso *et al.* (2016) in Mt. Hamiguitan Range Wildlife Sanctuary in Davao Oriental with 152 species (14.1% compared to the total number of species in the Philippines), Gonzales (2000) in Mt. Matutum with 188 species (17.1%), and Silverio (2014) in Mt. Apo with 106 species (9.6%). The high species richness in Mt. Malambo may be due to its high elevation intact forest and the extensive inventory of ferns and lycophytes in the said area (Sosanika *et al.* 2022). However, the species richness of ferns and lycophytes in Mt. Malambo is relatively lower than the number of species found in Mt. Kitanglad, Bukidnon with 439 species (39.9%) (Amoroso *et al.* 2011) and Mt. Malindang in Misamis Occidental with 371 species (33.7%) (Rufila 2016).

The high species richness in these mountain forests is due to the presence of diverse habitats, such as the humid lower montane forest. Mt. Malindang Range and Mt. Kitanglad possess several vegetation types, *viz*., mossy forest, montane forest, dipterocarp forest, almaciga forest, mixed dipterocarp forest, lowland dipterocarp forest, plantation forest and agroecosystem (Amoroso *et al.* 2006; Amoroso *et al.* 2012). Several factors may affect the species richness of local montane forests in the Philippines, including the size of the area sampled, climate conditions, soil type, and geographic location (Kessler 2010). Species richness is also affected by some anthropogenic disturbances, such as the conversion of forests to agricultural or industrial lands and pollution (Amoroso *et al.* 2016). These factors are more likely to affect the variability of species richness reported in the studies on mountains in Mindanao, Philippines.

Table 2. Species checklist of ferns and lycophytes in Mt. Malambo, Datu Salumay, Marilog District, Philippines.

FERNS
Aspleniaceae
1. *Asplenium affine* Sw.
2. *A. apoense* Copel.*
3. *A. caudatum* G Forst.
4. *A. crinicaule* Hance
5. *A. cymbifolium* Christ

Table 2 continued.

Aspleniaceae
6. *A. excisum* C.Presl
7. *A. lobulatum* Mett.
8. *A. longissimum* Blume.
9. *A. nigrescens* Blume
10. *A. nidus* L.
11. *A. normale* D. Don
12. *A. persicifolium* J.Sm. ex Mett.
13. *A. phyllitidis* D. Don.
14. *A. polyodon* G. Forst.
15. *A. rhizophyllum* L.
16. *A. subnormale* Copel.
17. *A. tenerum* G Forst.
18. *A. thunbergii* Kunze
19. *A. unilaterale* Lam.
20. *A. vittaeforme* Cav.
21. *Asplenium* sp.
Blechnaceae
22. *Blechnopsis orientalis* (L.) C.Presl
Athyriaceae
23. *Athyrium brevipinnulum* Copel.
24. *A. elmeri* Copel.
25. *A. puncticaule* (Blume) Moore.
26. *Cornopteris decurrenti-alata* (Hook.) Nakai.
27. *Deparia confluens* (Kunze) M.Kato.
28. *D. lancea* (Thunb.) Fraser-Jenkins
29. *D. petersenii* (Kunze) M.Kato.
30. *Diplazium altum* (Copel.) C.Chr.
31. *D. cordifolium* Blume
32. *D. costulisorum* (Copel.) C.Chr.
33. *D. davaoense* Copel.*
34. *D. dilatatum* Blume
35. *D. esculentum* (Retz.) Sw.
36. *D. forbesii* (Baker) C.Chr.
37. *D. geophilum* (Copel.) Alderw.
38. *D. melanopodium* Fée*
39. *D. oligosorum* Copel.
40. *D. pallidum* (Blume) Moore
41. *D. sorzogonense* (C.Presl) C.Presl
Cyatheaceae
43. *Alsophila commutata* Mett.
44. *A. fuliginosa* Christ*
45. *A. loheri* Christ
46. *Sphaeropteris elmeri* (Copel.) R.M.Tryon
47. *S. glauca* (Blume) R.M. Tryon
48. *S. tripinnata* (Copel) R.M. Tryon
Davalliaceae
49. *Davallia denticulata* (NL Burm.) Mett., ex Kuhn
50. *D. hymenophylloides* (Blume) Kuhn
51. *D. embolostegia* Copel.

Table 2. Continued.

Davalliaceae
52. *D. pubescens* C.W.Chen
53. *D. repens* (L.f.) Kuhn/ *Humata repens* (L.f.) Diels
54. *D. solida* (Forst.) Sw.
55. *D. trichomanoides* Blume.
56. *D. wagneriana* Copel.
Dennstaedtiaceae
57. *Dennstaedtia hooveri* Christ.
58. *Histiopteris incisa* (Thunb.) J.Sm.
59. *Pteridium aquilinum* (L.) Kuhn
60. *Microlepia protracta* Copel.*
61. *M. speluncae* (L.) T.Moore.
Dicksoniaceae
62. *Calochlaena javanica* (Blume) M.D.Turner & R.A.White
63. *Dicksonia mollis* Holttum
Dryopteridaceae
64. *Arachniodes aristata* (Forster) Tindale
65. *Bolbitis heteroclita* (C.Presl) Ching.
66. *Dryopteris formosana* (Christ) C.Chr.
67. *D. nodosa* (C.Presl) Li Bing Zhang
68. *D. pseudocaenopteris* (Kunze) Li Bing Zhang
69. *D. purpurascens* (Blume) Christ.
70. *D. sparsa* (Don) Kuntze.
71. *Dryopteris* sp.
72. *Elaphoglossum blumeanum* (Fée) J.Sm.
73. *E. callifolium* (Bl.) Moore.
74. *E. latifolium* (Sw.) J. Sm.
75. *E. luzonicum* Copel.*
76. *E. petiolatum* (Sw.) Urb.
77. *Polystichum elmeri* Copel.*
78. *P. nudum* Copel.*
Gleicheniaceae
79. *Dicranopteris curranii* Copel.
80. *D. linearis* (Burm.) Underw.
81. *Diplopterygium longissimum* (Blume) Nakai
82. *Sticherus loheri* (Christ) Copel.*
83. *S. truncatus* (Willd.) Nakai
Hymenophyllaceae
84. *Abrodictyum setaceum* (Bosch) Ebihara & K.Iwats
85. *A. obscurum* (Blume) Ebihara & K.Iwats.
86. *Callistopteris apiifolia* (C Presl) Copel.
87. *Cephalomanes extravagans* Copel.
88. *Crepidomanes bipunctatum* (Poir.) Copel.
89. *C. brevipes* (C. Presl) Copel.
90. *Hymenophyllum acanthoides* (Bosch) Rosenst.
91. *H. angulosum* Christ
92. *H. badium* Hook. & Grev.
93. *H. denticulatum* Sw.
94. *H. digitatum* (Sw.) Fosberg
95. *H. emarginatum* Sw.

Table 2. Continued.

Hymenophyllaceae
96. *H. fimbriatum* J.Sm.
97. *H. nitidulum* (Bosch) Ebihara & K.Iwats.
98. *H. pallidum* (Blume) Ebihara & K. Iwats.
99. *H. paniculiflorum* C.Presl
100. *H. polyanthos* (Sw.) Sw.
101. *H. productum* Kunze
102. *Vandenboschia maxima* (Blume) Copel.
Hypodematiaceae
103. *Leucostegia truncata* (D.Don) Fraser-Jenk
Lindsaeaceae
104. *Lindsaea adiantoides* J.Sm.
105. *L. apoensis* Copel.*
106. *L. fissa* Copel.*
107. *L. lucida* Blume
108. *L. pulchella* (J.Sm.) Mett. ex Kuhn.
109. *L. repens* (Bory) Thwaites
110. *L. rigida* J.Sm. ex Hook.
111. *Odontosoria chinensis* (L.) J.Sm.
112. *Tapeinidium luzonicum* (Hook.) Kramer
113. *T. pinnatum* (Cav.) C.Chr.
Marattiaceae
114. *Angiopteris evecta* (G.Forst.) Hoffm.
Nephrolepidaceae
115. *Nephrolepis bisserrata* (Sw.) Schott.
116. *N. cordifolia* (L.) Presl.
117. *N. exaltata* (L.) Schott.
118. *N. falcata* (Cav.) C. Chr.
119. *N. hirsutula* (G Forst.) C. Presl
Oleandraceae
120. *Oleandra maquilingensis* Copel.*
121. *O. neriiformis* Cav.
122. *O. nitida* (Copel.) Copel.*
Ophioglossaceae
123. *Botrychium daucifolium* Wall. ex Hook. & Grev.
124. *Ophioderma pendulum* C.Presl
125. *Ophioglossum ramosii* Copel.*
126. *O. reticulatum* L.
Polypodiaceae
127. *Aglaomorpha cornucopia* (Copel.) Roos*
128. *A. descensa* (Copel.) Hovenkamp & S.Linds.
129. *A. heraclea* (Kunze) Copel.
130. *A. splendens* (Hook. & Bauer) Copel.
131. *A. sparsisora* (Desv.) Hovenkamp & S. Linds.
132. *A. quercifolia* (L.) Hovenkamp & S. Linds.
133. *Calymmodon gracilis* (Fée) Copel.
134. *Dasygrammitis mollicoma* (Nees & Blume) Parris
135. *Goniophlebium persicifolium* (Desv.) Bedd.
136. *G. pseudoconnatum* (Copel.) Copel.*
137. *G. subauriculatum* (Blume) C.Presl

Table 2. continued.

Polypodiaceae
138. *Lecanopteris deparioides* (Cesati) Baker
139. *Lemmaphyllum accedens* (Blume) Donk
140. *Lepisorus mucronatus* (Fée) Li Wang
141. *L. platyrhynchos* (Kunze) Li Wang
142. *L. spicatus* (L.f.) Li Wang
143. *Leptochilus* sp.
144. *Loxogramme scolopendrioides* (Gaudich.) C.V.Morton
145. *Microsorum commutatum* (Blume) Copel.
146. *M. congratifolium* (Alderw.) Holttum
147. *M. insigne* (Blume) Copel.
148. *M. monstrosum* (Copel.) Copel.
149. *M. musifolium* (Blume) Copel.
150. *M. phanerophlebium* (Copel.) Copel.
151. *Oreogrammitis reinwardtii* (Blume) Parris
152. *Platycerium grande* (Fée) Kunze*
153. *Prosaptia celebica* (Blume) Tagawa & K Iwats
154. *P. contigua* (Forst.) C.Presl
155. *P. nutans* (Blume) Mett.
156. *P. obliquata* (Blume) Mett.
157. *Pyrrosia adnascens* (Sw.) Ching.
158. *P. sphaerotricha* (Mett.) Ching.
159. *Selliguea albidosquamata* (Blume) Parris
160. *S. taeniata* (Sw.) Parris
161. *S. triloba* (Houtt.) M.G.Price
162. *Scleroglossum pusillum* (Blume) Alderw.
Pteridaceae
163. *Antrophyum plantagineum* (Cav.) Kaulf.
164. *Haplopteris alternans* (Copel.) S.Linds. & C.W.Chen
165. *H. ensiformis* (Sw.) E.H. Crane
166. *H. elongata* (Sw.) E.H. Crane
167. *H. scolopendrina* (Bory) E.H. Crane
168. *Pteris blumeana* J Agardh.
169. *P. longipinnula* Wall. ex J Agardh.
170. *P. mertensioides* Willd.
171. *P. oppositipinnata* Fée.
172. *P. pacifica* Hieron.
173. *P. schlechteri* Brause.
174. *P. tripartita* Sw.
175. *P. vittata* L.
176. *Syngramma alismifolia* (C.Presl) J.Sm.
177. *S. wallichii* (Hook.) Bedd.
178. *Vaginularia paradoxa* (Fee) Mett.
179. *V. trichoidea* (J.Sm.) Fée
Tectariaceae
180. *Ctenitis submarginalis* (Langsdorff & Fischer) Ching
181. *Pleocnemia irregularis* (C.Presl) Holttum
182. *P. leuzeana* (Gaudich.) C.Presl
183. *P. macrodonta* (C.Presl) Holttum
184. *Pteridrys syrmatica* (Willd.) C.Chr. & Ching.

Table 2. continued.

Tectariaceae
185. *Tectaria angulata* (Willd.) Copel.
186. *T. athyriosora* M.G.Price.
187. *T. decurrens* (C.Presl) Copel.
188. *T. griffithii* (Baker) C.Chr.
Thelypteridaceae
189. *Chingia ferox* (Blume) Holttum.
190. *Christella dentata* (Forssk.) Brownsey & Jermy.
191. *C. hispidula* (Decne.) Holttum.
192. *C. parasitica* (L.) Lév.
193. *Coryphopteris pubirachis* (Baker) Holttum var. *philippinensis* Holttum*
194. *Plesioneuron savaiense* (Baker) Holttum
195. *Pneumatopteris costata* (Brackenr.) Holttum
196. *P. laevis* (Mett.) Holttum*
197. *P. nitidula* (C.Presl) Holttum*
198. *Pronephrium amphitrichum* Holttum*
199. *P. clemensiae* (Copel.) Holttum*
200. *Sphaerostephanos heterocarpus* (Blume) Holttum
201. *S. polycarpus* (Blume) Copel.
202. *S. unitus* (L.) Holttum
LYCOPHYTES
Lycopodiaceae
203. *Phlegmariurus nummularifolius* (Blume) Ching
204. *P. pinifolius* (Trevis.) Kiew
205. *P. salvinioides* (Herter) Ching
206. *P. squarrosus* (G.Forst.) Á.Löve & D.Löve
207. *Palhinhaea cernua* (L.) Vasc. & Franco
Selaginellaceae
208. *Selaginella aristata* Spring, Bull.
209. *S. cupressina* (Willd.) Spring
210. *S. delicatula* (Desv.) Alston
211. *S. eschscholzii* Hieron.
212. *S. flagellifera* Hieron
212. *S. intermedia* (Blume) Spring
214. *S. involvens* (Sw.) Spring
215. *S. ornata* (Hook. & Grev.) Spring

Legend: Asterisk (*) after the scientific names indicates that the particular species is endemic to the Philippines.

3.2 Species Importance Values (SIV)

The five species of ferns that obtained the highest SIV include *Asplenium nidus* L., *A. thunbergii* Kunze*, Lindsaea fissa* Copel.*, Davallia hymenophylloides* (Blume) Kuhn, *Oleandra neriiformis* Cav., and *Hymenophyllum polyanthos* (Sw.) Sw. (Table 3). Among these species, *A. nidus* and *D. hymenophylloides* are the most frequently

collected species. These species ultimately play an important role in regulating the ecological stability of the forest ecosystem. Some ferns with higher SIV conform to the reports of Amoroso *et al.* (2015) and Amoroso *et al.* (2018) revealing *Nephrolepis hirsutula* (G Forst.) C. Presl and *Asplenium* spp. as the species with high SIV in the montane forest of Mt. Kitanglad, Bukidnon and Mt. Apo, North Cotabato.

Fig 3. Some ferns and lycophytes in Mt. Malambo, Datu Salumay, Southern Philippines. A) *Lindsaea apoensis* Copel., B) *Lindsaea fissa* Copel., C) *Lindsaea pulchella* (J.Sm.) Mett. ex Kuhn., D) *Sphaeropteris glauca* (Blume) R.M.Tryon, E) *Angiopteris palmiformis* (Cav.) C.Chr., F) *Oleandra neriiformis* Cav., G) *Botrychium daucifolium* Wall. ex Hook. & Grev., H) *Ophioderma pendula* C.Presl, I) *Phlegmariurus salvinioides* (Herter) Ching, J) *Phlegmariurus squarrosus* (G.Forst.) Á.Löve & D.Löve, K) *Palhinhaea cernua* (L.) Vasc. & Franco, L) *Selaginella involvens* (Sw.) Spring.

3.3 Diversity value

Mt. Malambo is classified as a montane forest based on the apparent change in forest structure and floristic composition. The ferns and lycophytes in the area have a diversity value of H'=1.83 which closely resembles that of the montane forests of Mt. Malindang with H'=1.80 (Rufila 2016). Also, the montane forest of Mt. Kitanglad (Amoroso *et al.* 2011) and Mt. Apo (Silverio 2014) showed the highest diversity values for pteridophytes. The diversity value is relatively higher compared to Balinsasayao Twin Lakes Natural Park in Negros Oriental with H'=1.41 (Amoroso *et al.* 2018) and Mt. Hamiguitan in Davao Oriental with H'=1.01 (Amoroso *et al.* 2015). This suggests that the montane forest is the most diverse vegetation for the ferns and lycophytes.

Fern and lycophyte diversity is much higher in mid-elevation of the mountain, usually in the montane forests. This pattern of distribution is affected by different abiotic factors, such as climate and edaphic features. Adean tropical forests also revealed that elevational richness patterns for ferns and lycophytes are symmetrically hump-shaped and overall richness is virtually equal along most of the tropical latitudinal gradient (Salazar *et al.* 2013). Mehltreter *et al.* (2018) also mentioned that fern diversity is highest in the mid-elevation with utmost richness and diversity and lesser in the lower and higher elevations. In addition, the peak of fern species richness at mid-elevations has often been interpreted as reflecting the ambient conditions of a balanced climate without extremes, such as drought at low elevations and frost at high elevations (Bhattarai *et al.* 2004; Krömer 2007; Kluge *et al.* 2008; Kessler *et al.* 2011). In addition, it has often been linked to an optimal combination of high humidity, rainfall, and moderate temperatures at mid-elevations (Lauer *et al.* 1996).

Table 3. Ferns and lycophytes with highest species importance value (SIV) in Mt. Malambo, Datu Salumay, Southern, Philippines.

Species	(%)
1. *Asplenium nidus* L.	17.98
2. *Pneumatopteris costata* (Brackenr.) Holttum	11.54
3. *Asplenium thunbergii* Kunze	11.53
4. *Davallia hymenophylloides* (Blume) Kuhn	11.21
5. *Lindsaea fissa* Copel.	10.43
6. *Oleandra neriiformis* Cav.	9.94
7. *Dryopteris nodosa* (C.Presl) Li Bing Zhang	9.58
8. *Polystichum elmeri* Copel.	8.90
9. *Nephrolepis hirsutula* (G Forst.) C. Presl	7.94
10. *Selaginella involvens* (Sw.) Spring	7.76

3.4 Endemism and conservation status

A total of 20 Philippine endemic species of ferns are recorded in Mt. Malambo. These species include *A. apoense* Copel., *D. davaoense* Copel., *D. melanopodium* Fée,

Alsophila fuliginosa Christ, *Microlepia protracta* Copel., *Elaphoglossum luzonicum* Copel., *Polystichum elmeri* Copel., *P. nudum* Copel., *Sticherus loheri* (Christ) Copel., *Lindsaea apoensis* Copel., *L. fissa* Copel., *Oleandra maquilingensis* Copel., *O. nitida* (Copel.) Copel. *Ophioglossum ramosii* Copel., *Aglaomorpha cornucopia* (Copel.) Roos, *Goniophlebium pseudoconnatum* (Copel.) Copel., *Coryphopteris pubirachis* (Baker) Holttum, *Pneumatopteris laevis* (Mett.) Holttum, *P. nitidula* (C. Presl) Holttum, *Pronephrium amphitrichum* Holttum and *P. clemensiae* (Copel.) Holttum (Table 2).

Among the 215 species of ferns and lycophytes, 19 species were recorded as threatened. Of these threatened species, one is critically endangered, 11 are endangered, five are vulnerable and two are other threatened species (Table 4). Furthermore, of the 24 threatened species, three are Philippine endemics namely: *A. cornucopia, M. protracta* and *P. grande*. Local assessment revealed that there are 37 species classified as very abundant, 21 are abundant, and 76 are rare. Local assessment of the Mindanao endemic species is rare except for *Ophioglossum ramosii*.

Table 4. Conservation status and endemism of ferns and lycophytes in Mt. Malambo, Datu Salumay, Marilog District.

Species	Conservation Status
1. *Aglaomorpha cornucopia* (Copel.) M.C. Roos	Vulnerable
2. *Aglaomorpha heraclea* (Kunze) Copel	Vulnerable
3. *Aglaomorpha splendens* (Hook. & Bauer) Copel.	Vulnerable
4. *Alsophila fuliginosa* (H. Christ) Copel.	Endangered
5. *Asplenium vittiforme* Cav.	Vulnerable
6. *Davallia embolostegia* Copel.	Other threatened Species
7. *Davallia solida* (Forst.) Sw.	Other Threatened Species
8. *Dicksonia mollis* Holttum	Endangered
9. *Diplazium costulisorum* (Copel.) C.Chr.	Endangered
10. *Lecanopteris deparioides* (Cesati) Baker	Endangered
11. *Lepisorus platyrhynchos* (Kunze) Li Wang	Endangered
12. *Microlepia protracta* Copel.	Endangered
13. *Ophioderma pendula* C.Presl	Endangered
14. *Phlegmariurus salvinioides* (Herter) Ching	Endangered
15. *Phlegmariurus squarrosus* (G.Forst.) Á.Löve & D.Löve	Endangered
16. *Platycerium grande* (Fée) Kunze	Critically Endangered
17. *Polystichum nudum* Copel.	Endangered
18. *Sphaeropteris elmeri* (Copel.) R.M. Tryon	Vulnerable
19. *Sphaeropteris glauca* (Blume) R.M. Tryon	Endangered

Ten (10) endangered species were recorded inside the sampling plots, *viz.*, *D. mollis, L. platyrhynchos, A. fuliginosa*, *S. glauca, P. nudum, O. pendulum, D. costulisorum, P. squarrosa*, and *P. salvinioides*. These threatened species were also documented on different protected areas in Mindanao Island (Coritico & Amoroso 2020; Amoroso *et al.* 2018). Other endangered species were seen along the trail from the foot of the mountain to the peak of Mt. Malambo. Furthermore, *P. grande,* a highly priced

ornamental plant, was recorded while doing the repeated transect walks. *P. grande* is a Mindanao Island endemic species and may become extinct in the wild if no conservation measures are adopted in the area. Alombro (1999) documented the endangered *Tmesipteris zamorarum* Gruezo and Amoroso in the area. However, present exploration revealed the absence of this endangered fern species together with *Phlegmariurus banayanicus* (Herter) A.R.Field & Bostck. The absence of *T. zamorarum* could be due to the loss of its only habitat, which are the tree ferns (*Alsophila* spp. and *Sphaeropteris* spp.). Tree ferns are widely collected and sold commercially as a potting medium to grow other plants and as posts. Mt. Malambo and its vicinity show a high number of threatened and endemic species; therefore, high priority should be given to the protection of these species by the local stakeholders. Regulation on the collection and the need to propagate the economically important species should be addressed. Further, data from this research can be used as a sound basis in the formulation of policies that are effective for the conservation and protection of the whole Mt. Malambo.

4 Conclusions and Recommendations

Mt. Malambo in Barangay Datu Salumay, Marilog District is home to 215 species of ferns and lycophytes belonging to 74-genera and 23 families. The species richness of this group of flora is *ca.* 23% of the total number of species in the Philippines and *ca.* 39% compared with the total number of species in Mindanao. Mt. Malambo has a diversity value of H'=1.83, which is higher compared to the other mountains in Mindanao Island. Twenty endemic species and 24 species are threatened. Of these, one species is critically endangered, 12 species are endangered, seven species are vulnerable and four are other threatened species. The high species richness and high diversity of ferns and lycophytes in Mt. Malambo represent a significant floral resource of the Philippines but should be protected and conserved by the stakeholders since some species are placed in the threatened category.

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