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Cover: Indian Grey Wolf *Canis lupus pallipes* and Smooth-coated Otter *Lutrogale perspicillata* sharing the territory in Chambal basin. Digital art on Procreate by Aakanksha Komanduri.

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ARTICLE

Species richness and distribution of Hymenophyllaceae in Mindanao Island, Philippines

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Abstract: Hymenophyllaceae is the largest basal family of leptosporangiate ferns and is recognized as one of the major components of the epiphytic communities in tropical rainforests. Members of the family are distinguished morphologically from other ferns by their marginal involucre and lamina's single-cell thickness. The specific environmental requirements of Hymenophyllaceae render them vulnerable to ecological and anthropogenic threats, as well as climate change. With the alarming rate of deforestation and the escalating climate crisis, this fern family faces extreme risk of population decline. Despite these challenges, Hymenophyllaceae remain understudied due to difficulties in identification; thus, data on their richness and distribution continue to be insufficient for conservation assessment. To address this, an extensive inventory of Hymenophyllaceae was conducted, supplemented by herbarium studies, to identify the species of Hymenophyllaceae and document their distribution in Mindanao, Philippines. Results revealed that 69% (42 taxa) of the total Hymenophyllaceae recorded in the Philippines were documented thriving in Mindanao including two endemic species *Abrodictyum extravagans* and *Hymenophyllum edanoi*. Elevational distribution of Hymenophyllaceae showed a hump-pattern, with increasing richness toward montane vegetation and gradually declining at higher mossy vegetation. *Cephalomanes* species has a restricted distribution, limited only to lower elevations (500–1000 m.) while the genera *Abrodictyum*, *Crepidomanes*, and *Hymenophyllum* were well-represented across varying elevations. The results of this study provide a comprehensive account of Hymenophyllaceae in Mindanao, highlighting the importance of conducting an extensive survey of this less-studied fern taxon.

Keywords: Elevation gradient, endemism, growth forms, filmy ferns, hygrophilous, hymenophylloid, involucre, microhabitat, trichomanoid.

Editor: Anonymity requested.

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INTRODUCTION

Philippines is recognized globally for its high degree of species richness and endemism (Heaney & Regalado 1998; Myers et al. 2000). Despite being a megabiodiverse country, it is recorded as one of the world's biodiversity hotspots due to severe threats to its ecosystem and biodiversity (Langenberger 2004; Coritico et al. 2020). It is home to an estimate of 1,100 species of fern and lycophytes, and 24% (264 species) of which is endemic to the country (Pelser et al. 2011; Amoroso et al. 2016).

Numerous pteridophytes studies has been conducted in the Philippines (Aribal & Buot 2009; Amoroso et al. 2015; Delos & Buot 2015; Coritico et al. 2020; Rufila et al. 2022; Coritico et al. 2024), however there are still a few fern taxa that have been less represented in research, one of which is the filmy fern family Hymenophyllaceae. Hymenophyllaceae is the largest of the earliest diverging families of heterosporous leptosporangiate ferns, comprising around 464 species globally. They are distinguished from other fern taxa based on their marginal sori and the single-cell thickness of its delicate fronds (Smith et al. 2006). Due to their uniseriate lamina, filmy ferns are extremely hygrophilous and susceptible to desiccation; thus, they are typically found in shady and humid forests, with greatest abundance and diversity attained in the tropical montane vegetation (Kromer & Kessler 2006; Proctor 2012). The specific environmental requirements for Hymenophyllaceae make these ferns vulnerable to ecological and anthropogenic threats and with the alarming rate of deforestation and the worsening climate crisis, this fern family faces extreme vulnerability to population decline (Fernando et al. 2008).

In spite of the current ecological challenges to Hymenophyllaceae, this fern family remained understudied due to difficulty in identification (Dubuisson 1997; Hennequin 2003) thus data on its richness and distribution continues to be insufficient for conservation assessment (Parra et al. 2009). The current records of Hymenophyllaceae in the Philippines account for 61 taxa (Pelser et al. 2011). In Mindanao, the last comprehensive listing for this family was the work of Copeland (1958) which was done more than six decades ago. With the recent revisions on the classification and species circumscription (e.g., Ebihara et al. 2006; PPGI 2016) an updated checklist of the species is needed. There is also a demand for more recent explorations to further assess the status of Hymenophyllaceae, especially in Mindanao which remains to be less explored due to political instability and inaccessibility of its mountainous areas (Aribal & Buot 2009; Coritico et al. 2020; Obemio & Buot 2021). Due to these research constraints, this leaves a great gap in the data for the flora of this island. Thus, this study aimed to conduct an extensive inventory of Hymenophyllaceae to identify the filmy ferns in this island and document the distribution of Hymenophyllaceae species in the mountain ecosystems of Mindanao, Philippines.

METHODS

Species inventory and Herbarium studies

An inventory of Hymenophyllaceae was conducted in two mountain sites of Mindanao, viz., Mt. Timolan (Zamboanga del Sur) and Mt. Matutum (South Cotabato) (Image 1). These two mountain ecosystems are among the protected areas in Mindanao known for rich biodiversity. These areas have been less explored in fern research, especially for Hymenophyllaceae. Opportunistic sampling was done from the jump-off area to the peak of Mt. Timolan (553–1,143 m) and Mt. Matutum (1,042–2,274 m). Global positioning system (GPS) was used to determine the exact elevation and location of the species. Species observed during the opportunistic sampling in each mountain site were recorded and collected for identification and listing. Herbarium studies on all species of Hymenophyllaceae from 31 sites in Mindanao that are deposited at Central Mindanao University Herbarium (CMUH) were also done to enrich the data on the species richness and distribution of filmy ferns in Mindanao, Philippines.

Collection and Identification of samples

A maximum of three individuals for each species of Hymenophyllaceae were collected, pressed and dried as herbarium specimens. All species from actual fieldwork and herbarium studies were identified using taxonomic keys from the monographs, flora and other publications: Flora Malesiana Hymenophyllaceae (Iwatsuki & Ebihara 2023), Fern Flora of the Philippines (Copeland 1958), and Ebihara et al. (2006) were the major references for the identification.

RESULTS AND DISCUSSION

The current study documented a total of 42 taxa (39 species and three varieties) of filmy ferns from different sites in Mindanao (31 sites) (Table 1). These taxa were

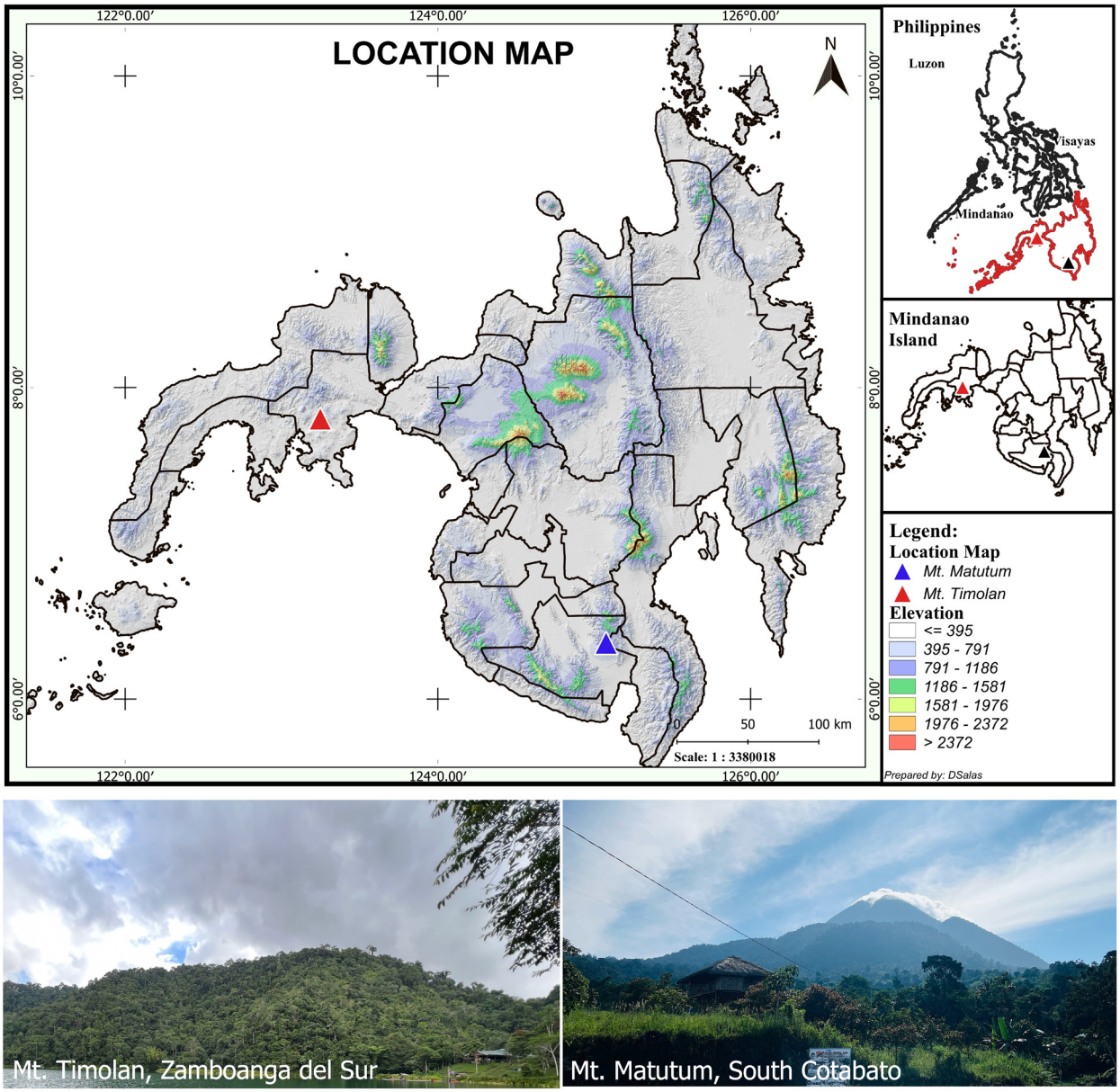

Image 1. Map of the study sites for the actual field collection of Hymenophyllaceae.

classified into six genera following the nine genera classification made by Ebihara et al. (2006) as a revision of the multigeneric system of classification of this family. The result of the study comprised 69% of the total filmy fern taxa in the Philippines.

The extensive number of Hymenophyllaceae in Mindanao is credited to the numerous mountain ecosystems found on the island, characterized by its tropical and moist conditions. Filmy ferns are typical plants of shady and constantly humid environments, especially in tropical forests where they achieve the greatest abundance (Proctor 2012). According to Proctor (2003) Hymenophyllaceae exhibits distinct ecological preferences as these species are strongly hygrophilous, showing a preference for environments that are predominantly shaded or partially shaded, where optimal levels of humidity, light, and water are available (Proctor 2003, 2010). These specific ecological requirements are necessary for the survival of filmy ferns, considering the single-cell thickness of its lamina that makes it prone to dehydration (Kromer & Kessler 2006; Proctor 2012). The large forest cover in Mindanao comprises primarily of primary forest in mountain ecosystems, forest patches, regenerated forests, and plantations, providing a wide array of conducive habitats for Hymenophyllaceae. It is essential to note that forest cover varies within different

Table 1. Distribution of Hymenophyllaceae taxa across different sites in Mindanao.

	Mt. Apo	Mt. Apulang	Mt. Bagalbal	Mt. Binalabag	Mt. Ginanlajan	Mt. Hamiguitan	Mt. Kaatuan	Mt. Kalatungan	Mt. Kiamo	Mt. Kinasalapi	Mt. Kitanglad
I. Abrodictyum											
1. *Abrodictyum cumingii* C.Presl											+
2. *Abrodictyum obscurum* (Blume) Ebihara & K.Iwats.	+					+					+
3. *Abrodictyum obscurum* var. *siamense* (Christ) K.Iwats.											
4. *Abrodictyum extravagans* (Copel.)	+					+			+		+
5. *Abrodictyum pluma* (Hook.) Ebihara & K.Iwats.	+					+			+		+
6. *Abrodictyum* sp. 1	+										+
II. Callistopteris											
7. *Callistopteris apiifolia* (C.Presl) Copel.	+		+				+			+	+
III. Cephalomanes											
8. *Cephalomanes javanicum* var. *asplenoides* (C.Presl) K.Iwats.				+		+					+
9. *Cephalomanes javanicum* var. *sumatranum* (Alderw.) K.Iwats.											
10. *Cephalomanes atrovirens* C.Presl						+					
IV. Crepidomanes											
11. *Crepidomanes bipunctatum* (Poir.) Copel.						+		+			+
12. *Crepidomanes minutum* (Blume) K.Iwats.	+										
13. *Crepidomanes intermedium* (Bosch) Ebihara & K.Iwats.											
14. *Crepidomanes* sp.				+							+
V. Hymenophyllum											
15. *Hymenophyllum acanthoides* (Bosch) Rosenst.											
16. *Hymenophyllum angulosum* Christ	+		+								+
17. *Hymenophyllum badium* Hook. & Grev.	+					+					+
18. *Hymenophyllum blandum* Racib.											+
19. *Hymenophyllum bontocense* Copel.	+					+	+		+		+
20. *Hymenophyllum denticulatum* Sw.			+			+					
21. *Hymenophyllum digitatum* (Sw.) Fosberg											+
22. *Hymenophyllum edanoi* (Copel.) C.V.Morton						+					+
23. *Hymenophyllum emarginatum* Sw.	+	+			+				+		+

24. *Hymenophyllum fimbriatum* J.Sm.								+			+
25. *Hymenophyllum imbricatum* Blume	+					+		+		+	+
26. *Hymenophyllum javanicum* Spreng.											+
27. *Hymenophyllum johorense* Holttum											
28. *Hymenophyllum nitidulum* C.Presl						+					+
29. *Hymenophyllum pachydermicum* Ces.	+					+					+
30. *Hymenophyllum pallidum* (Blume) Ebihara & K.Iwats.	+	+	+			+			+		+
31. *Hymenophyllum paniculiflorum* C.Presl	+										+
32. *Hymenophyllum penangianum* Matthew & Christ ex Christ											
33. *Hymenophyllum pilosissimum* C.Chr.	+										+
34. *Hymenophyllum polyanthos* (Sw.) Sw.	+										+
35. *Hymenophyllum productum Kunze*	+										+
36. *Hymenophyllum reinwardtii* Bosch	+							+			+
37. *Hymenophyllum serrulatum* (C.Presl) C.Chr.									+		
38. *Hymenophyllum* cf. *serrulatum* (C.Presl) C.Chr.	+										+
39. *Hymenophyllum thuidium* Harr.	+					+					
40. *Hymenophyllum* sp. 1											
VI. Vandenboschia											
41. *Vandenboschia auriculata* (Blume) Copel.	+										+
42. *Vandenboschia maxima* (Blume) Copel.	+			+							+
TOTAL	**22**	**2**	**4**	**3**	**1**	**15**	**2**	**4**	**6**	**2**	**30**
	Mt. Kulabog	**Mt. Limbawon**	**Mt. Mahuson**	**Mt. Malambo**	**Mt. Malindang**	**Mt. Malimumu**	**Mt. Matutum**	**Mt. Nabugkasan**	**Mt. Natampod**	**Mt. Pantaron**	**Mt. Pasian**
I. Abrodictyum											
1. *Abrodictyum cumingii* C.Presl									+	+	+
2. *Abrodictyum obscurum* (Blume) Ebihara & K.Iwats.	+	+	+	+	+		+	+	+	+	+
3. *Abrodictyum obscurum* var. siamense (Christ) K.Iwats.							+				
4. *Abrodictyum extravagans* (Copel.)		+						+			
5. *Abrodictyum pluma* (Hook.) Ebihara & K.Iwats.		+			+	+					
6. *Abrodictyum* sp. 1											
II. Callistopteris											
7. *Callistopteris apiifolia* (C.Presl) Copel.	+		+	+	+		+		+		

III. Cephalomanes											
8. a. *Cephalomanes javanicum* var. *asplenoides* (C.Presl) K.Iwats.	+		+					+	+	+	+
9. *Cephalomanes javanicum* var. *sumatranum* (Alderw.) K.Iwats.	+										
10. *Cephalomanes atrovirens* C.Presl								+			
IV. Crepidomanes											
11. *Crepidomanes bipunctatum* (Poir.) Copel.	+						+		+		+
12. *Crepidomanes minutum* (Blume) K.Iwats.							+		+		
13. *Crepidomanes intermedium* (Bosch) Ebihara & K.Iwats.							+				
14. *Crepidomanes* sp.					+				+		
V. Hymenophyllum											
15. *Hymenophyllum acanthoides* (Bosch) Rosenst.	+								+		
16. *Hymenophyllum angulosum* Christ				+					+		
17. *Hymenophyllum badium* Hook. & Grev.		+	+		+				+		
18. *Hymenophyllum blandum* Racib.		+									
19. *Hymenophyllum bontocense* Copel.	+	+			+	+	+	+	+		
20. *Hymenophyllum denticulatum* Sw.			+		+		+	+	+		
21. *Hymenophyllum digitatum* (Sw.) Fosberg											
22. *Hymenophyllum edanoi* (Copel.) C.V.Morton											
23. *Hymenophyllum emarginatum* Sw.		+	+		+		+		+	+	
24. *Hymenophyllum fimbriatum* J.Sm.				+			+				
25. *Hymenophyllum imbricatum* Blume	+						+		+		
26. *Hymenophyllum javanicum* Spreng.				+							
27. *Hymenophyllum johorense* Holttum											
28. *Hymenophyllum nitidulum* C.Presl	+										
29. *Hymenophyllum pachydermicum* Ces.		+	+			+			+		
30. *Hymenophyllum pallidum* (Blume) Ebihara & K.Iwats.		+		+	+	+			+	+	
31. *Hymenophyllum paniculiflorum* C.Presl							+				
32. *Hymenophyllum penangianum* Matthew & Christ ex Christ							+				
33. *Hymenophyllum pilosissimum* C.Chr.					+						
34. *Hymenophyllum polyanthos* (Sw.) Sw.							+				

35. *Hymenophyllum productum Kunze*							+				
36. *Hymenophyllum reinwardtii* Bosch							+				
37. *Hymenophyllum serrulatum* (C.Presl) C.Chr.		+			+				+		
38. *Hymenophyllum* cf. *serrulatum* (C.Presl) C.Chr.											
39. *Hymenophyllum thuidium* Harr.											
40. *Hymenophyllum* sp. 1											
VI. Vandenboschia											
41. *Vandenboschia auriculata* (Blume) Copel.							+				
42. *Vandenboschia maxima* (Blume) Copel.	+		+		+		+		+		
TOTAL	**10**	**10**	**8**	**6**	**12**	**4**	**18**	**6**	**17**	**5**	**4**
	Mt. Salumay	**Mt. Timolan**	**Mt. Timpoong**	**Mt. Ulahingan**	**Panagumayon Forest (Lilingayon, Valencia)**	**Panlamaan Forest (Banlag, Valencia)**	**Marilog Forest Patches**	**Davao Oriental Municipalities (Taghikop and Macambol) La Union**		**Bukidnon Municipalities (Impalutao, Malaybaylay, Namnam, Impasugong)**	
I. Abrodictyum											
1. *Abrodictyum cumingii* C.Presl		+				+	+				
2. *Abrodictyum obscurum* (Blume) Ebihara & K.Iwats.	+			+			+			+	
3. *Abrodictyum obscurum* var. siamense (Christ) K.Iwats.											
4. *Abrodictyum extravagans* (Copel.)											
5. Abrodictyum pluma (Hook.) Ebihara & K.Iwats.											
6. *Abrodictyum* sp. 1											
II. Callistopteris											
7. *Callistopteris apiifolia* (C.Presl) Copel.		+		+	+	+	+				
III. Cephalomanes											
8. *Cephalomanes javanicum* var. *asplenoides* (C.Presl) K.Iwats.		+					+	+			
9. *Cephalomanes javanicum* var. *sumatranum* (Alderw.) K.Iwats.											
10. *Cephalomanes atrovirens* C.Presl								+			
IV. Crepidomanes											
11. *Crepidomanes bipunctatum* (Poir.) Copel.		+					+	+		+	
12. *Crepidomanes minutum* (Blume) K.Iwats.					+	+					
13. *Crepidomanes intermedium* (Bosch) Ebihara & K.Iwats.		+			+		+				
14. *Crepidomanes* sp.											

V. Hymenophyllum									
15. *Hymenophyllum acanthoides* (Bosch) Rosenst.									
16. *Hymenophyllum angulosum* Christ									
17. *Hymenophyllum badium* Hook. & Grev.				+			+		+
18. *Hymenophyllum blandum* Racib.									
19. *Hymenophyllum bontocense* Copel.		+			+				+
20. *Hymenophyllum denticulatum* Sw.		+		+			+		+
21. *Hymenophyllum digitatum* (Sw.) Fosberg									
22. *Hymenophyllum edanoi* (Copel.) C.V.Morton									
23. *Hymenophyllum emarginatum* Sw.				+			+		
24. *Hymenophyllum fimbriatum* J.Sm.									
25. *Hymenophyllum imbricatum* Blume		+					+		
26. *Hymenophyllum javanicum* Spreng.		+		+	+		+		
27. *Hymenophyllum johorense* Holttum									
28. *Hymenophyllum nitidulum* C.Presl									
29. *Hymenophyllum pachydermicum* Ces.				+			+		+
30. *Hymenophyllum pallidum* (Blume) Ebihara & K.Iwats.				+			+		
31. *Hymenophyllum paniculiflorum* C.Presl									
32. *Hymenophyllum penangianum* Matthew & Christ ex Christ									
33. *Hymenophyllum pilosissimum* C.Chr.									
34. *Hymenophyllum polyanthos* (Sw.) Sw.									
35. *Hymenophyllum productum Kunze*				+			+		
36. *Hymenophyllum reinwardtii* Bosch									
37. *Hymenophyllum serrulatum* (C.Presl) C.Chr.									
38. *Hymenophyllum* cf. *serrulatum* (C.Presl) C.Chr.									
39. *Hymenophyllum thuidium* Harr.									
40. *Hymenophyllum* sp. 1									+
VI. Vandenboschia									
41. *Vandenboschia auriculata* (Blume) Copel.						+			
42. *Vandenboschia maxima* (Blume) Copel.		+	+		+		+		
TOTAL	**1**	**10**	**1**	**9**	**6**	**4**	**15**	**3**	**7**

Image 2. Hymenophyllaceae as understory epiphytes: a—*Crepidomanes minutum* | b—*Crepidomanes bipunctatum* | c—*Hymenophyllum angulosum*. © Nietes, A.D.

regions of Mindanao due to human activities, land use changes, and conservation efforts, thus also affecting the current distribution of Hymenophyllaceae species across the island.

Regarding the species richness of Hymenophyllaceae across the different mountain sites in Mindanao, Mt. Kitanglad (30 spp.) recorded the highest number of species, followed by Mt. Apo with 22 species (Table 1). The high species richness of Hymenophyllaceae in these mountain ecosystems is linked to the eco-physiological characteristics of the sites, particularly the altitude range, diverse vegetation, and varied habitats offered by these ecosystems (Amoroso et al. 2009, 2011, 2012). These mountain sites reach an altitude of more than 2,000 m and are comprised of at least three types of vegetation (Amoroso et al. 2011; Azuelo et al. 2020; Coritico et al. 2022) dominated by angiosperms and gymnosperms, therefore offering different types of microhabitats for varying filmy ferns to grow both as epiphytes on trunks and branches and as terrestrial in a limited light environment formed by the forest canopy (Image 2) (Sharpe et al. 2010).

Frequent precipitation together with low evaporation appears to be the key requirement for the successful growth of Hymenophyllaceae (Proctor 2003). These mountain sites have a Type IV climate characterized by a more or less even distribution of rainfall throughout the year (Agpao et al. 1975; Quimpang et al. 2018). The rainforest environment of Mt. Kitanglad and Mt. Apo marked by regular precipitation with foggy conditions allows the successful growth of filmy ferns in these mountain sites. Such environmental condition limits transpiration and, therefore maximize water retention of the filmy ferns.

According to Mehltreter (1995) & Kessler (2010), in terms of elevational distribution, members of Hymenophyllaceae show distinct elevational preferences. Trichomanoid ferns *Abrodictyum*, *Cephalomanes*, *Crepidomanes*, *Callistopteris*, *Vandenboschia*, *Didymoglossum*, and *Polyphlebium* typically occur at low to mid-elevations (Kessler 2010), whereas hymenophylloid (*Hymenophyllum*) ferns are mainly distributed from mid to high elevations (Dubuisson et al. 2023). The specific elevational distribution is primarily determined by the species-specific ecological requirements.

The altitudinal distribution of Mindanao Hymenophyllaceae is shown in Table 2. Only 36 species and three varieties were considered in this table since the other three species were represented by herbarium samples that lacks data on its elevational distribution. Species under the genus *Vandenboschia* were found below 2,000 m. The genus *Callistopteris* is restricted at 1,000–2,500 m and *Cephalomanes* is limited within 500–1,500 m. The genera *Abrodictyum*, *Crepidomanes* and *Hymenophyllum* have a wider altitudinal range, as some species under these genera were found at 500–2,500 m.

Among the filmy ferns recorded, *Crepidomanes minutum* (Blume) K.Iwats. and species of *Abrodictyum*: *A. pluma* Ebihara & K.Iwats. and *A. cumingii* Presl. are the most widely distributed species found at 500–2,500 m. *Crepidomanes minutum* and *A. cumingii* are epiphytes

Table 2. Growth forms and elevational distribution of Hymenophyllaceae in Mindanao.

Species	Growth forms	Micro-habitat	Elevation (m)	Conservation status/ Endemism/ New record
I. *Abrodictyum*				
1. *Abrodictyum cumingii* C.Presl	E	TR	500–2,500	
2. *Abrodictyum obscurum* (Blume) Ebihara & K.Iwats.	T	SO	1,000–2,000	
3. *Abrodictyum obscurum* var. *siamense* (Christ) K.Iwats.	T/L	SO/RS	1,500–2,000	**New Record: South Cotabato (Mt. Matutum)** (previous distribution: China, Thailand, Cambodia, Japan, Peninsular Malaysia, Borneo and Sulawesi)
4. *Abrodictyum extravagans* (Copel.)	T	SO	500–2,000	Endemic
5. *Abrodictyum pluma* (Hook.) Ebihara & K.Iwats.	T/L	SO/RS	500–2,500	
6. *Abrodictyum* sp. 1	T/L	SO/RS	1,500–2,000	
II. *Callistopteris*				
7. *Callistopteris apiifolia* (C.Presl) Copel.	T/E/L	SO/TR/RS	1,000–2,500	
III. *Cephalomanes*				
8. *Cephalomanes javanicum* var. asplenoides (C.Presl) K.Iwats.	T	SO	500–1,500	
9. *Cephalomanes javanicum* var. *sumatranum* (Alderw.) K.Iwats.	T/L/R	SO/TR/WB	500–1,000	**New Record: Zamboanga del Sur (Mt. Kulabog)** (previous distribution: China, Vietnam, Sumatra, Borneo and Java)
10. *Cephalomanes atrovirens* C.Presl	T	SO	500–1,500	
IV. *Crepidomanes*				
11. *Crepidomanes bipunctatum* (Poir.) Copel.	E	TR	500–2,000	
12. *Crepidomanes minutum* (Blume) K.Iwats.	E	TR	500–2,500	
13. *Crepidomanes intermedium* (Bosch) Ebihara & K.Iwats.			100–1,000	
14. *Crepidomanes* sp.	E	TR	2,000–2,500	
V. *Hymenophyllum*				
15. *Hymenophyllum acanthoides* (Bosch) Rosenst.	E	TR	500–1,500	
16. *Hymenophyllum angulosum* Christ	E	TR	1,000–2,000	
17. *Hymenophyllum badium* Hook. & Grev.	E	TR	1,000–2,000	
18. *Hymenophyllum blandum* Racib.*	E	TR	No data in herbarium	
19. *Hymenophyllum bontocense* Copel.	E	TR	1,000–2,500	OWS
20. *Hymenophyllum* cf. *serrulatum* (C.Presl) C.Chr.	E	TR	1,500–2,500	
21. *Hymenophyllum denticulatum* Sw.	E	TR	50–2,000	
22. *Hymenophyllum digitatum* (Sw.) Fosberg *	E	TR	No data in herbarium	
23. *Hymenophyllum edanoi* (Copel.) C.V.Morton	E	TR	1,500–2,500	OWS, Endemic
24. *Hymenophyllum emarginatum* Sw.	E	TR	1,000–2,500	
25. *Hymenophyllum fimbriatum* J.Sm.	E	TR	2,000–2,500	
26. *Hymenophyllum imbricatum* Blume	E	TR	1,000–2,500	
27. *Hymenophyllum nitidulum* C.Presl	T	SO	500–1,500	OWS
28. *Hymenophyllum javanicum* Spreng.	E	TR	50–1,500	
29. *Hymenophyllum johorense* Holttum	E	TR	1,000–1,500	
30. *Hymenophyllum pachydermicum* Ces.	E	TR	1,000–2,000	
31. *Hymenophyllum pallidum* (Blume) Ebihara & K.Iwats.	E	TR	1,000–2,000	
32. *Hymenophyllum paniculiflorum* C.Presl	E	TR	2,000–2,500	
33. *Hymenophyllum pilosissimum* C.Chr.	E	TR	1,500–2,000	
34. *Hymenophyllum polyanthos* (Sw.) Sw.	E	TR	1,500–2,000	
35. *Hymenophyllum productum* Kunze	E	TR	2,000–2,500	
36. *Hymenophyllum reinwardtii* Bosch	E	TR	1,000–2,500	
37. *Hymenophyllum serrulatum* (C.Presl) C.Chr.	E	TR	1,500–2,000	
38. *Hymenophyllum thiudium* Harr.	E	TR	1,000–2,000	

Species	Growth forms	Micro-habitat	Elevation (m)	Conservation status/ Endemism/ New record
39. *Hymenophyllum penangianum* Matthew & Christ ex Christ	E	TR	1,500–2,000	**New Record : South Cotabato (Mt. Matutum)** (previous distribution: Peninsular Malaysia and Borneo)
40. *Hymenophyllum* sp. *	E	TR	No data in herbarium	
VI. *Vandenboschia*		TR		
41. *Vandenboschia auriculata* (Blume) Copel.	E	TR	1,000–2,000	
42. *Vandenboschia maxima* (Blume) Copel.	T/L	SO/RS	500–2,000	

*—lacks data on its elevational distribution | **—new record (Nietes et al. in preparation) | T—terrestrial | E—epiphyte | L—lithophyte | R—rheophyte | TR—tree | SO—soil | RS—rock surfaces | WB—water banks | OWS—other wildlife species.

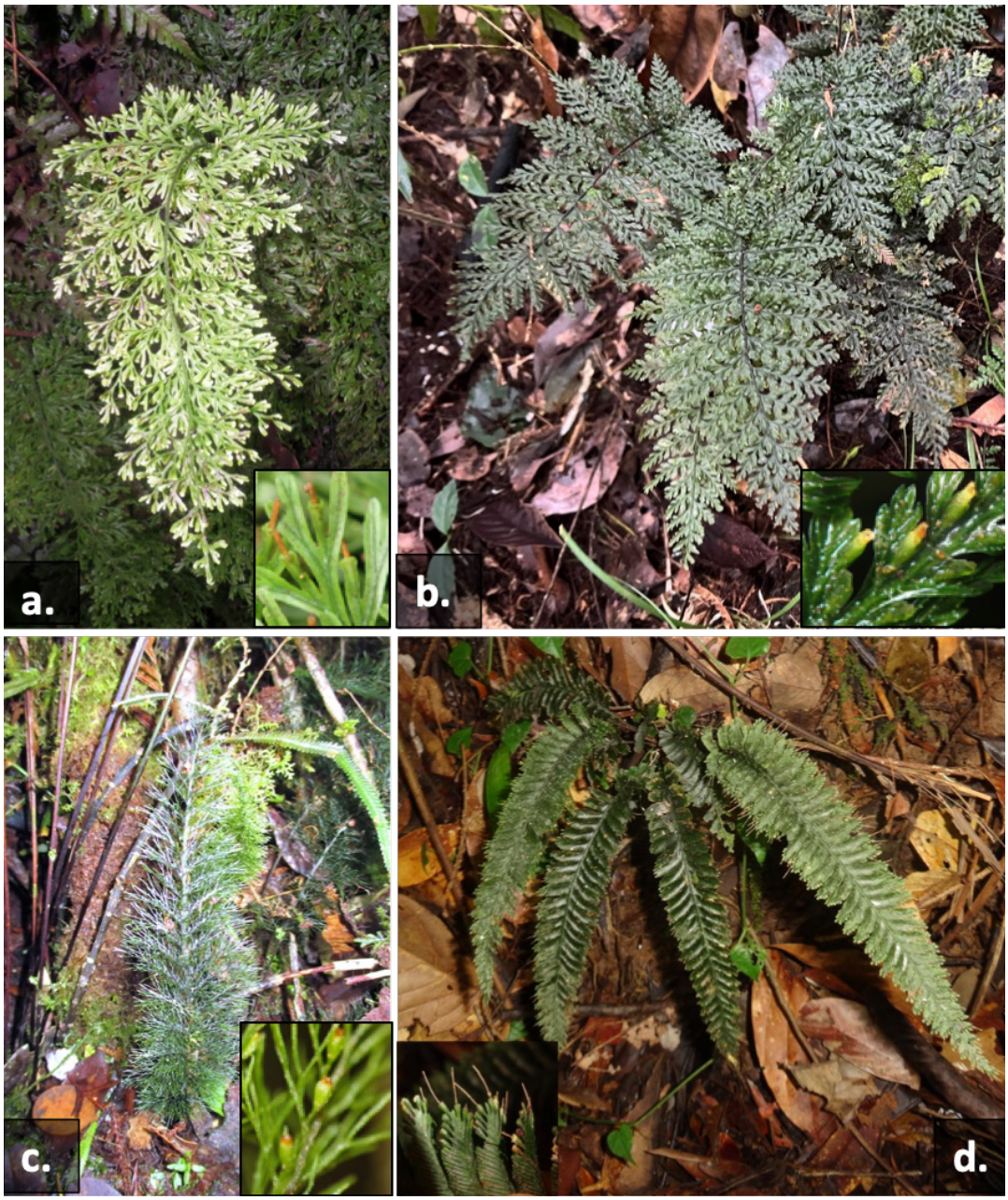

Image 3. Terrestrial species of Hymenophyllaceae: A—*Vandenboschia maxima* | b—*Abrodictyum obscurum* | c—*Abrodictyum pluma* | d—*Callistopteris apiifolia*. © Nietes, A.D.

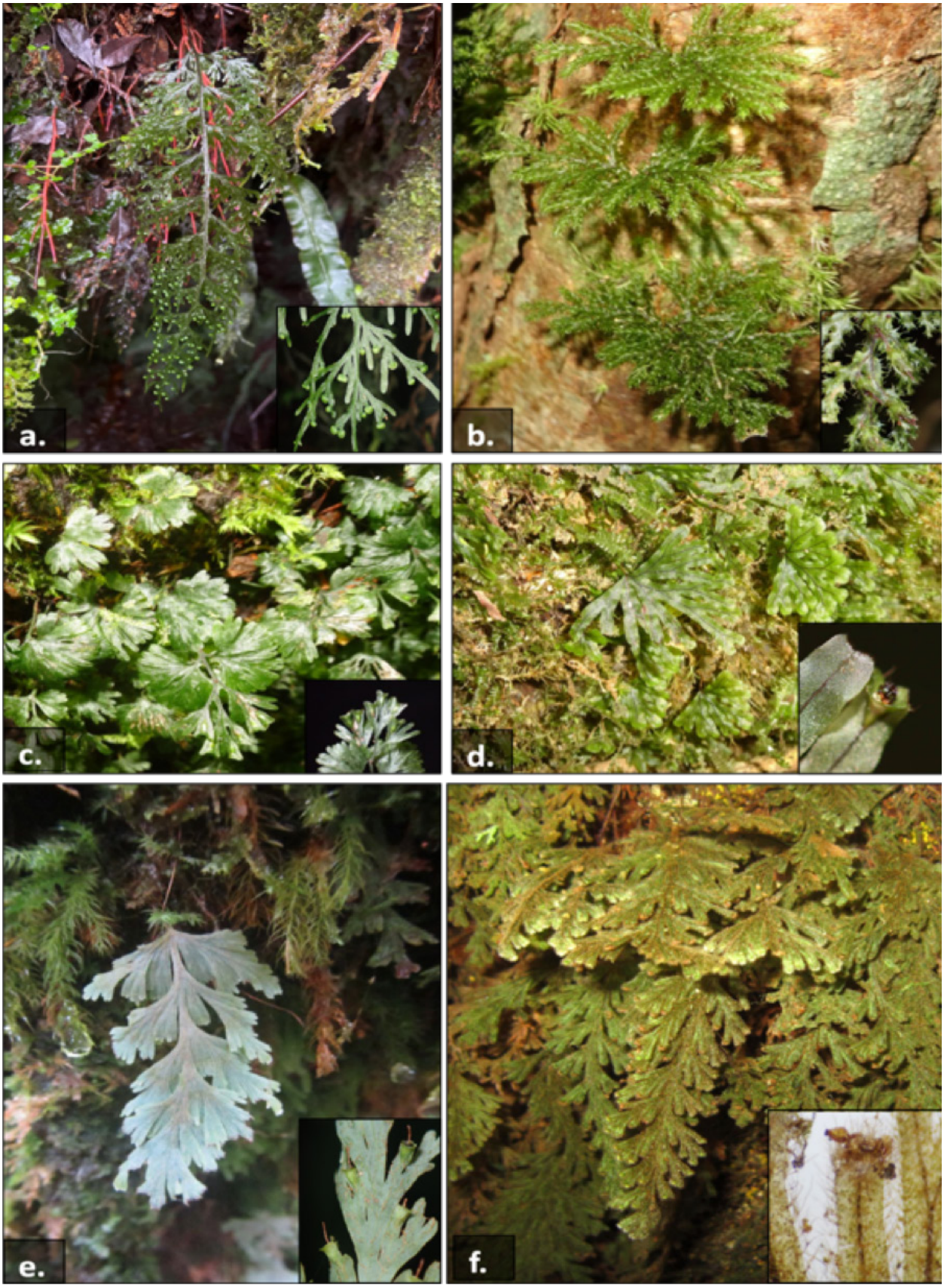

Image 4. Epiphytic species of Hymenophyllaceae: A—*Hymenophyllum imbricatum* | b—*Hymenophyllum acanthoides* | c—*Crepidomanes minutum* | d—*Hymenophyllum nitidulum* | e—*Hymenophyllum pallidum* | f—*Hymenophyllum pilossisimum*. © Nietes, A.D.

Image 5. Epiphytic species of Hymenophyllaceae: A—*Abrodictyum cumingii* | b—*Hymenophyllum reinwardtii* | c—*Hymenophyllum emarginatum* | d—*Vandenboschia auriculata* | e—*Hymenophyllum bontocense* | f—*Crepidomanes bipunctatum* | g—*Hymenophyllum badium*. © Nietes, A.D.

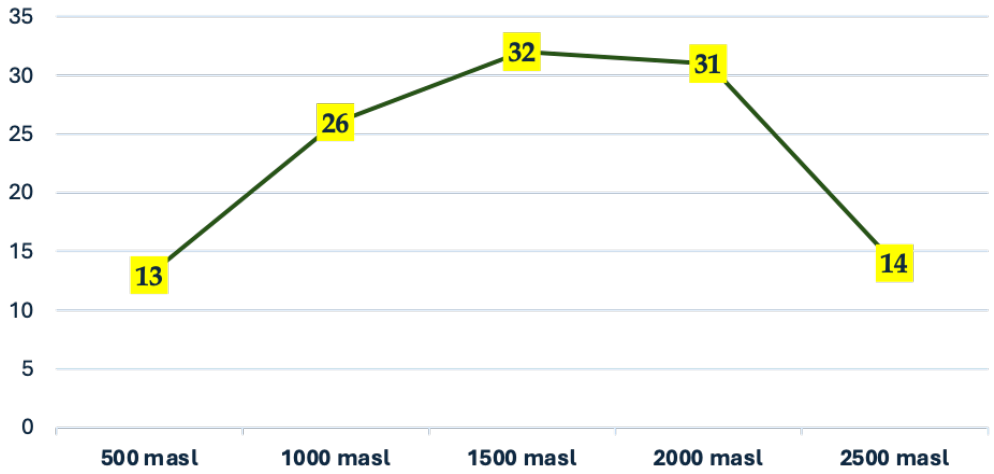

Image 6. Distribution of Hymenophyllaceae species across the elevation gradient.

on branches and trunks of trees, shrubs, and tree ferns. *Crepidomanes minutum* forms a close association with mosses, whereas *A. cumingii* is observed to have a high affinity to tree ferns (Cyatheaceae), and this observation is supported by the work of Ebihara et al. (2006). *Abrodictyum cumingii* relies on the water stored in the adventitious roots in the trunk of tree ferns to sustain its moisture requirements (Iwatsuki & Ebihara 2023). The dependence of this species on tree ferns implies that the removal of tree ferns will also lead to the loss of *A. cumingii* in the forest community (Cano-Mangaoang 2020). The reliance of epiphytes on tree ferns as a substrate could lead to simultaneous extinction if the population of the host is eliminated (Colwell et al. 2012).

Abrodictyum pluma is a terrestrial species, and according to Dubuisson et al. (2023), terrestrial trichomanoid ferns tend to have a wider distribution than epiphytes (Image 3). This observation by Dubuisson et al. (2023) coincides with this study, as the distribution of *Abrodictyum* includes low to high elevations.

The thick monocaulous rhizome of terrestrial species is considered as an adaptation against desiccation caused by limited water supply (Dubuisson et al. 2003). The robust roots attached to this thick rhizome enable terrestrial species to maximize water absorption in the substrate. Whereas epiphytic filmy ferns (Images 4 & 5) are highly restricted by the availability of water. These species have not developed adaptive morphological features to prevent desiccation and/or store water. Thus, these ferns are restricted to very wet places where humid climates and a close canopy are considered the optimal environment for these filmy ferns to diversify (Hennequin et al. 2008).

In general, the distribution of Hymenophyllaceae along the elevation gradient revealed the highest richness at mid-elevations and a lesser number of species at low and high elevations (Image 6). Kessler (2010) stated that this pattern of distribution mostly reflects the maximum humidity of the elevation or the ideal combination of humidity and mild temperatures. Hymenophyllaceae also follows the hump pattern of distribution exhibited by seed plants, by which this seed plant-dominated vegetation served as a conducive microhabitat for both terrestrial and epiphytic filmy ferns (Kessler 2010).

The specific environmental requirement for Hymenophyllaceae makes these ferns vulnerable to ecological and anthropogenic threats. Hence, the reason most of its members are classified as other wildlife species (OWS) in the assessment made by Fernando et al. (2008) but they have an increased tendency to become threatened due to habitat destruction (Fernando et al. 2008; DAO 2017). Habitat destruction through logging, land use/land cover change, environmental pollution, invasive species, and over-exploitation of forest resources are considered to be the main threats to biodiversity (Catibog-Sinha & Heaney 2006), together with climate change (Ibrahim et al. 2013).

And with the alarming rate of forest conversion and degradation occurring in the country, the chances of Hymenophyllaceae being affected by such anthropogenic threats are imminent. If these environmental threats continue to progress, this may lead to the loss of a big portion of Philippine biodiversity. Thus, calls for a more extensive and heightened implementation of biodiversity protection and habitat preservation.

CONCLUSION

Hymenophyllaceae has been less represented in research due to its problematic taxonomy and the difficulty of its identification. In this present study, a total of 42 taxa (39 species and three varieties) of Hymenophyllaceae were recorded in Mindanao, which comprises 69% of the total filmy ferns in the country, including two endemic species— *A. extravagans* and *H. edanoi*.

Out of the 31 Mindanao mountain sites included in this study, the tropical rainforest of Mt. Kitanglad (30 spp.) recorded the highest number of species, followed by Mt. Apo (22 spp.), which provides a suitable ecology for Hymenophyllaceae, particularly the microhabitats, canopy shade and the regular precipitation in these forest ecosystems, which prevents these extremely hygrophilous species from desiccation. The elevational distribution of Hymenophyllaceae shows a hump-pattern of distribution with increasing richness as elevation reaches the montane vegetation and gradually declines towards mossy vegetation. This pattern of distribution mostly reflects the ideal combination of humidity and mild temperatures and the availability of microhabitats for filmy ferns, given that montane vegetation is a seed plant-dominated vegetation serving as a conducive microhabitat for the epiphytic and terrestrial species of Hymenophyllaceae. The results of this study reveal the high richness of Hymenophyllaceae in the island of Mindanao, implying that the island represents a significant floral resource of the country. This research also provided a comprehensive checklist of Hymenophyllaceae in Mindanao, highlighting the importance of conducting an extensive survey on these less-studied fern taxa. Additionally, the findings suggest the extreme dependency of Hymenophyllaceae on forest ecosystems; therefore, to protect these species from extinction or population decline, a more stringent enforcement of policies for the preservation and conservation of forests should be implemented.

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