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Research Article

Species Composition and Habitat Characteristics of Orchids (Orchidaceae) in the Summit Plots of Mt. Bilbogan, Davao Oriental, Philippines

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ABSTRACT

This study was carried out to determine the species composition of orchids found in the summit plots of Mt. Bilbogan, Governor Generoso, Davao Oriental, Philippines, and to characterize their habitat, including host tree identity, growth zones on host tree, light conditions and soil properties. Field sampling and data gathering were done in the two established plots (10 m × 100 m each; total area = 2,000 m²) located at higher elevations, where orchid occurrence was observed to be concentrated. Additional data recorded included the identity of host trees, the position of orchids within host growth zones, light conditions, soil properties, and associated species in the selected study plots. The results showed that 41 orchid taxa from 26 genera were identified, including 26 epiphytic species (63%), 12 terrestrial species (29%), 2 lithophytic species (5%), and 1 hemiepiphytic species (3%). Three critically endangered species—*Paphiopedilum adductum*, *P. ciliolare*, and *Phalaenopsis sanderiana*— were also recorded on the mountain. *Syzygium* sp., *Teijsmanniodendron* sp., and *Cinnamomum* sp., were frequently observed as host trees for epiphytic orchids, particularly at the basal portion (Zone 1) under shaded (calm) conditions. Orchids were also associated with bryophytes, lichens, and liverworts, which may enhance nutrient availability and improve moisture retention. Soils in Mt. Bilbogan were slightly acidic and had low levels of essential macronutrients such as nitrogen (N), phosphorus (P), and potassium (K). Therefore, orchid distribution in the area appears to be influenced by microhabitat conditions such as host trees, light availability, and substrate characteristics, highlighting the importance of targeted conservation strategies to maintain suitable habitats and safeguard endangered species.

Keywords: Edaphic condition; host trees; light abundance; microhabitat characteristics; threatened species.

INTRODUCTION

The Orchidaceae is considered as one of the most diverse plant families among angiosperms and also one of the most endangered taxa worldwide (Zhang et al., 2014). Orchids display a variety of life forms and are distributed throughout tropical and subtropical regions. The Philippines is home to a rich orchid diversity characterized by a high level of endemism. More than 90% of these species are only found in the country (Cootes, 2011). Orchids are often divided into three main groups: terrestrial, epiphytic, and lithophytic. Terrestrial orchids are species rooted in the ground, whereas epiphytic species occuron trunks, twigs, or branches of host species, and lithophytic species grow on rock surfaces (Panal et al., 2015). Orchids have intricate ecological requirements, suggesting that they are valuable bioindicators (Shibu et al., 2012).

The Orchidaceae has a high speciation rate and, paradoxically, a high extinction rate (Zhang et al., 2014). Orchids are threatened primarily by habitat loss caused by deforestation, logging, habitat fragmentation or conversion, and mining (Panal et al., 2015). They are also widely used for food, ornamentation, and medicine, making them more susceptible to poaching and illegal trade (De Leon et al., 2017). A recent botanical assessment of Fernando et al. (2022) reported that in the Philippines, 27 orchid species were classified as critically endangered, 45 as endangered, and 25 as vulnerable. These data indicate an urgent need for effective conservation measures to mitigate population decline and prevent further loss of orchid species, especially those threatened with extinction. Cootes (2011) noted that the implementation of *ex situ* and *in situ* conservation approaches, together with public awareness, can serve as effective strategies.

For many Philippine orchid species, especially those found in less-studied montane ecosystems, distributional and ecological information remains limited despite growing conservation concerns. Local-scale research is therefore crucial for documenting orchid diversity and guiding conservation planning. The purpose of this study was to determine the species composition of orchids in the summit plots at Mt. Bilbogan, Governor Generoso, Davao Oriental, Philippines, and to characterize their habitat, including host tree identity, growth zones on host trees, light conditions, and soil properties.

METHODOLOGY

Study site and sampling period

Mt. Bilbogan is situated within the barangays of Magdug and Tamban, Governor Generoso, Davao Oriental, Philippines (6°33'55" N, 126°6'25" E) at an elevation of 745 meters above sea level (m.a.s.l.) (Fig. 1). Field sampling and data collection were conducted from January to May 2018. Microclimatic conditions vary with elevation, with higher altitudes experiencing cooler temperatures and frequent fog, which create habitats favourable for orchids.

Data gathering

A total of two sampling plots were established from the peak of Mt. Bilbogan (Fig. 1C). Plot 1 was positioned at 745 m.a.s.l., and Plot 2 at 721 m.a.s.l. Each plot measured 10 m × 100 m (1,000 m^2 area), with a 20 m interval between them. Sampling was conducted at higher elevations, where orchid occurrence was more concentrated due to cooler temperatures and higher humidity, which provide favourable microclimatic conditions. The general habitat conditions of the two sampling plots are shown in Fig. 2.

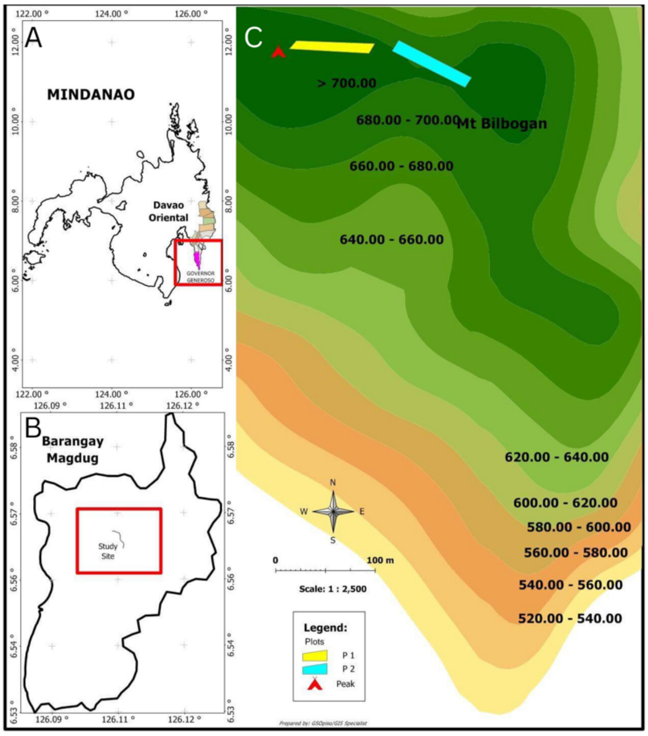

Figure 1: Maps showing the location of the study area. **A.** Mindanao Island. **B.** Davao Oriental Province. **C.** Sampling plot locations in Mt. Bilbogan, Governor Generoso, Davao Oriental, Philippines.

Figure 2: Representative habitat conditions of the summit plots in Mt. Bilbogan, Davao Oriental, Philippines: **A.** Plot 1 showing a dense canopy. **B.** Plot 2 characterized by slightly open vegetation with the dominance of *Dicranopteris* sp. on the forest floor.

In contrast, the lower sections of the mountain are predominantly coconut plantations, while some areas are characterized by open vegetation, both of which offer limited suitable habitat for epiphytic orchids. Data collection was carried out within these plots, where epiphytic orchids were surveyed from the base of host tree trunks up to 5 m in height. Opportunistic sampling outside the plots was also conducted to complement the inventory and improve documentation of overall species composition.

Identification of the specimens

Preliminary identification of the collected specimens was conducted using several references, including the book *Philippine Native Orchid Species* by Cootes (2011), Co's Digital Flora of the Philippines by Pelser et al. (2011 & 2015), and other relevant scientific literature (Panal et al., 2015; Saavedra & Pitogo, 2021). Species verification and confirmation were further validated by Jim Cootes, an expert on Philippine orchids and author of multiple publications on the group. Specimens that could not be identified to the species level due to absence of reproductive structures were classified as distinct morphospecies based on observable vegetative characteristics, including leaf morphology, pseudobulb structure, and growth habit. Each morphospecies was treated as a separate taxonomic unit in the analysis of species composition. Accepted scientific names were verified using Plants of the World Online to ensure nomenclatural accuracy and consistency.

Orchid species composition

Species composition of Orchidaceae was assessed through a complete inventory and alpha-taxonomic identification of all orchids encountered within the established plots. Each plot was systematically surveyed to record all species present and the number of individuals per species. The conservation status of each species was obtained from the IUCN Red List (2017) and Fernando et al. (2022).

Habitat types

The habitat type of each orchid species recorded was classified as terrestrial, epiphytic, hemiepiphytic, or lithophytic. Terrestrial orchids were defined as species rooted in the ground, whereas epiphytic species occur on trunks, twigs, or branches of host species, hemiepiphytic species are those that spend part of their life cycle attached to a host plant but maintain or eventually establish a connection to the ground, and lithophytic species grow on rock surfaces (Panal et al., 2015). Additional observations included ecological factors associated with orchid occurrence such as host tree identity for epiphytic species, growth position along the host tree (zones), sunlight availability, and the nature of supporting substrates such as mosses and lichens (Tirta et al., 2010).

I. Growth zones on host trees

Growth zones on host trees for epiphytic orchids was determined following a modified method of Johansson (1975), with each host tree classified into five vertical zones (Table 1). A 5-meter improvised stick was used to measure the zones.

Table 1: Growth zones on host trees.

Growth zone	Distance from basal portion of the tree (m)
1	1
2	2
3	3
4	4
5	5

II. Light condition

Light conditions for orchids were assessed using the criteria of Tirta et al. (2010), based on the amount of sunlight received by the substrate (Table 2).

Table 2: Criteria for light conditions.

Light conditions	Criteria
Calm	If substrate closed by trees, so that get a little sunlight
Rather calm	If substrate get an enough sunlight
Open	If substrate get more sunlight

III. Soil analysis of sampling plots

Soil analysis was carried out to characterize the substrate supporting terrestrial orchids. A total of three soil samples were collected from each sampling plot at a depth of approximately 30 cm. The samples from each plot were combined, air-dried, and sieved prior to analysis for nitrogen (N), phosphorus (P), and potassium (K) at the Soil and Plant Analysis Laboratory, College of Agriculture, Central Mindanao University. For epiphytic and lithophytic orchids, associated substrate flora such as mosses and lichens were also recorded.

RESULTS

Orchid species composition

A total of 41 orchid taxa representing 26 genera were recorded from Mt. Bilbogan (Table 3). The genera *Appendicula*, *Dendrobium*, and *Flickingeria* were the most species-rich. The most frequently encountered taxa were *Cylindrolobus* sp., *Dendrobium uniflorum*, *Podochilus lucescens*, and *Podochilus plumosus*. The orchid community comprised 26 epiphytic species (63%), 12 terrestrial species (29%), two lithophytic species (5%), and one hemiepiphytic species (3%). Of the 41 taxa, 22 were identified to species level, while the remainder were classified as morphospecies because of the absence of reproductive structures.

Three orchid species (*Paphiopedilum ciliolare*, *Paphiopedilum adductum*, and *Phalaenopsis sanderiana*) were classified as threatened according to the IUCN Red List (2017) and the National List of Threatened Philippine Plants (Fernando et al., 2022). These findings underscore the conservation importance of Mt. Bilbogan as a habitat supporting nationally and globally threatened orchid taxa.

Table 3: Orchid composition in Mt. Bilbogan, Governor Generoso, Davao Oriental, including habitat number of individuals, and conservation status based on IUCN Red list (2017) and Fernando et al. (2022).

Genus/Species	Habitat					Counts			Conservation status
	T	H	E	L	ATT	P1	P2	Total	
I. Acriopsis									
1. Acriopsis indica Wight			✓			1	0	1	NE
2. Acriopsis liliifolia (J. Koenig) Ormerod			✓			1	0	1	NE
II. Apostasia									
3. Apostasia sp.	✓					1	1	2	NE
III. Ania									
	✓				✓				NE

4. Ania elmeri (Ames) A.D.Hawkes ex Senghas									
IV. Appendicula									
5. Appendicula micrantha Lindley			✓			37	5	42	NE
6. A. tembuyukenensis J.J. Wood			✓			15	14	29	NE
7. Appendicula sp. 1			✓			16	2	18	NE
8. Appendicula sp. 2			✓			29	6	35	NE
V. Bulbophyllum									
9. Bulbophyllum apodum Hook.f.			✓			22	28	50	NE
10. Bulbophyllum sp. 1			✓			19	13	32	NE
VI. Cadetia									
11. Cadetia microphyton (L.O.Williams) Christenson			✓			11	0	11	NE
VII. Calanthe									
12. Calanthe mcgregorii Ames	✓				✓				NE
VIII. Cirrhopetalum									
13. Cirrhopetalum makoyanum Reichenbach *f.*			✓			15	0	15	NE
IX. Corybas									
14. Corybas sp.	✓				✓				NE
X. Crepidium									
15. Crepidium sp.	✓				✓				NE
XI. Cylindrolobus									
16. Cylindrolobus sp.			✓			236	26	262	NE
XII. Dendrobium									
17.Dendrobium auriculatum Ames and Quisumbing			✓		✓				NE
18. D. uniflorum Griffith			✓			78	0	78	NE
19. Dendrobium sp. 1			✓			0	10	10	NE
XII. Dendrobium									
20. Dendrobium sp. 2			✓		✓				NE
21. Dendrobium sp. 3			✓		✓				NE
XIII. Dendrochilum									
22. Dendrochilum sp.			✓			12	0	12	NE
XIV. Dipodium									
23. Dipodium paludosum Griffith		✓				33	9	42	NE
XV. Euphlebium									
24. Euphlebium rhodochilum Ferreras & Cootes			✓		✓	28	10	38	NE
XVI. Flickingeria									
25. Flickingeria sp. 1			✓			0	68	68	NE
26. Flickingeria sp. 2				✓	✓				NE
27. Flickingeria sp. 3			✓			14	7	21	NE
XVII. Habenaria									
28. Habenaria sp.	✓				✓				NE
XVIII. Hetaeria									
29. Hetaeria oblongifolia Blume	✓				✓				NE
XIX. Lecanorchis									
30. Lecanorchis multiflora J.J Smith	✓				✓				NE
XX. Liparis									
31. Liparis sp.	✓					30	0	30	NE
XXI. Paphiopedilum									
32. Paphiopedilum adductum Asher	✓					1	13	14	CE
33. Paphiopedilum ciliolare (Reinchenbach*f.*) Stein	✓					6	12	18	CE

XXII. Phalaenopsis									
34. Phalaenopsis sanderiana fma. Alba Christenson			✓		✓				CE
XXIII. Podochilus									
35. Podochilus lucescens Blume			✓			63	15	78	NE
36. Podochilus plumosus Ames			✓			127	17	144	NE
XXIV. Spathoglottis									
37. Spathoglottis elmeri Ames	✓				✓				NE
38. Spathoglottis tomentosa Lindley				✓	✓				NE
XXV. Thelasis									
39. Thelasis pygmaea			✓		✓				NE
XXVI. Thrixspermum									
40. Thrixspermum angustatum L.O. Willams			✓			2	0	2	NE
41. Thrixspermum pensile Schltr			✓			4	0	4	NE
Total	**12**	**1**	**26**	**2**		**801**	**256**	**1057**	

Legend: T- Terrestrial, H- Hemiepiphyte, E- Epiphyte, L- Lithophyte, ATT- Along the trail, P- Plot, NE- Not Evaluated, E- Endangered, CE- Critically Endangered

Host tree of epiphytic orchids

A total of 26 host tree species were recorded for epiphytic orchids in Mt. Bilbogan (Table 4). Among the 993 orchid individuals observed, *Syzygium* sp. was the most preferred host, supporting 204 individuals (21%), followed by *Teijsmanniodendron* sp. with 106 individuals (11%) and *Cinnamomum* sp. with 81 individuals (8%). In contrast, *Tristaniopsis* sp., *Freycinetia* sp., and *Melicope* sp. were the least utilized, each supporting only one or two individuals.

Syzygium sp. hosted 10 orchid species, including *Appendicula micrantha*, *Appendicula* sp. 1, *Appendicula* sp. 2, *Bulbophyllum* sp. 1, *Cirrhopetalum makoyanum*, *Cylindrolobus* sp., *Dendrobium uniflorum*, *Podochilus lucescens*, *Podochilus plumosus*, and *Flickingeria* sp. 1. *Teijsmanniodendron* sp. supported species such as *Acriopsis indica*, *Appendicula micrantha*, *Appendicula tembuyukenensis*, *Bulbophyllum* sp. 1, *Cylindrolobus* sp., *Podochilus lucescens*, and *Podochilus plumosus*. *Cinnamomum* sp. hosted *Cylindrolobus* sp., *Dendrobium uniflorum*, *Podochilus lucescens*, and *Podochilus plumosus*. The least utilized hosts (*Tristaniopsis* sp., *Freycinetia* sp., *Melicope* sp.) supported only *Dipodium paludosum* and *Cylindrolobus* sp.

Table 4: Relationship between the host trees and orchids in Mt. Bilbogan, Governor Generoso, Davao Oriental.

HOST TREES Family/Species	Frequency as host tree	No. of orchid species hosted	No. of orchid individual hosted
I. Apocynaceae			
1. Rauvolfia sp.	3	4	46
II. Aquifoliaceae			
2. Ilex sp.	3	3	30
III. Burseraceae			
3. Canarium sp.	3	2	19
IV. Clusiaceae			
4. Calophyllum sp.	4	5	51
5. Garcinia sp.	1	3	21
V. Elaeocarpaceae			
6. Elaeocarpus sp.	1	2	23
VI. Fagaceae			
7. Lithocarpus sp.	1	2	18

VII. Gnetaceae			
8. Gnetum gnemon	2	1	14
VIII.Lauraceae			
9. Cinnamomum sp.	2	4	81
IX. Lamiaceae			
10. Teijsmanniodendron sp.	9	7	106
X. Myrtaceae			
11. Decaspermum sp.	1	1	14
12. Syzygium sp.	15	10	204
13. Tristaniopsis sp.	1	1	1
14. Leptospermum javanicum	2	2	39
XI. Pandanaceae			
15. Freycinetia sp.	2	1	2
XII. Podocarpaceae			
16. Falcatifolium gruezoi	1	2	22
17. Podocarpus sp.	3	6	37
XIII. Proteaceae			
18. Helicia sp.	1	1	7
XIV. Rubiaceae			
19. Neonauclea sp.	1	1	17
20. Psychotria sp.	1	1	10
21. Timonius sp.	2	3	21
XV. Rutaceae			
22. Melicope sp.	2	1	2
XVI. Sapotaceae			
23. Palaquium sp.	1	1	28
XVII. Theaceae			
24. Polyspora luzonica	4	3	46
25. Ternstroemia sp.	1	3	30
XVIII. Vitaceae			
26. Leea sp.	2	4	35
Dead log	5	7	69
Total			**993**

Vertical distribution of epiphytic orchids on host trees

A total of 993 individuals representing 25 epiphytic orchid species were recorded across Plots 1 and 2. Distribution among host tree zones was as follows: Zone 1, 495 individuals (50%); Zone 2, 283 (28%); Zone 3, 150 (15%); Zone 4, 54 (5%); and Zone 5, 11 (1%) (Fig. 3). These results indicate that most epiphytic orchids in Mt. Bilbogan preferentially occupy the lower, shaded portions of host trees.

Light conditions and orchid distribution

Most orchids in Mt. Bilbogan were found under shaded conditions. A total of 657 individuals occurred in fully shaded areas (calm), 361 individuals in partially shaded areas with filtered sunlight (rather calm), and 39 individuals in fully exposed, open conditions (Fig. 4).

Soil characteristics of sampling plots

Soil samples from two plots in Mt. Bilbogan, differing in elevation, were analyzed for selected physicochemical properties. Plot 1 had a slightly acidic pH of 6.59, total nitrogen (N) of 0.291%, extractable phosphorus (P) of 0.171 ppm, and extractable potassium (K) of 93.0 ppm. Plot 2 had a more acidic pH of 6.30, lower nitrogen content (0.180%), undetectable phosphorus, and slightly lower potassium (81.0 ppm) (Table 5).

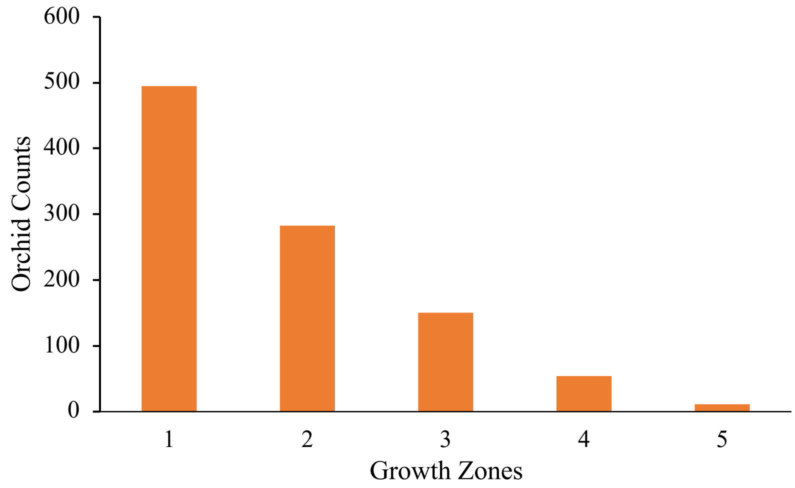

Figure 3: Orchid counts on growth zones in Mt. Bilbogan, Governor Generoso, Davao Oriental.

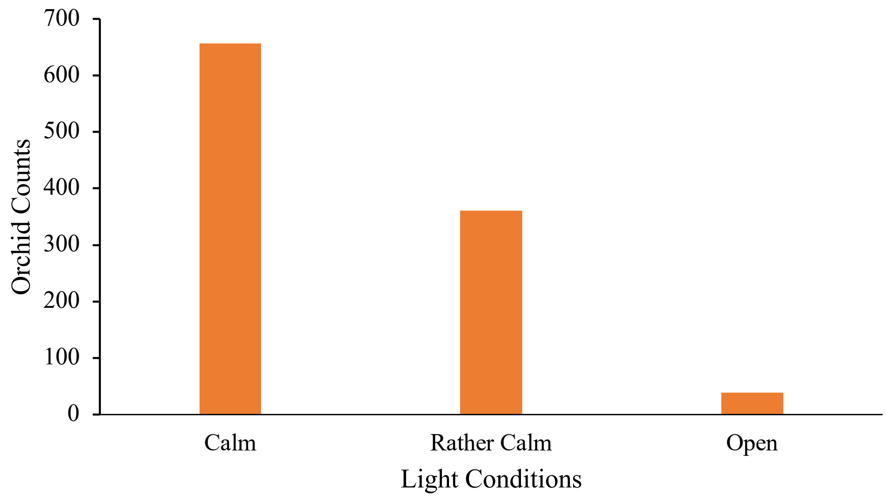

Figure 4: Orchid counts on light conditions in Mt. Bilbogan, Governor Generoso, Davao Oriental.

Table 5: Soil properties of Mt. Bilbogan, Governor Generoso, Davao Oriental.

Sample	Sample Source	Test Result			
		pH	%N	Extractable P (ppm)	Extractable K (ppm)
A	Plot 1	6.59	0.291	0.1710	93.0
B	Plot 2	6.30	0.180	BD	81.0

*BD = Below Detection

Orchid associate species

Most orchids were associated with mosses (*Leucobryum* sp.), lichens, and liverworts such as *Schistochila* sp. and *Bazzania* sp. Species including *Acriopsis indica*, *Cylindrolobus* sp., *Dipodium* sp., *Dendrobium uniflorum*, *Paphiopedilum ciliolare*, and *Podochilus plumosus* were commonly found on moss-covered substrates, while *Dipodium* sp., *Thrixspermum* *pensile*, *Flickingeria* sp. 1, and *Phalaenopsis sanderiana* attached directly to host branches or stems.

Some orchids, including *Cylindrolobus* sp., *Appendicula* sp. 1, and *Dendrobium uniflorum*, were associated with liverworts such as *Bazzania* sp. Similarly, liverworts (*Schistochila* sp. and *Bazzania* sp.) were observed alongside *Appendicula* sp., *Cirrhopetalum* sp., and *Cylindrolobus* sp. Overall, associations with mosses and liverworts suggest that moisture retention by these organisms may play a key role in epiphytic orchid growth.

DISCUSSION

Orchid species composition

A total of 41 species of orchids representing 26 genera were recorded from Mt. Bilbogan (Fig. 5-7). These included 26 epiphytes (63%), 12 terrestrial species (29%), 2 lithophytes (5%), and 1 hemiepiphyte (3%). Challe and Struik (2008) stated that the predominance of epiphytic orchids is consistent with the global patterns of orchid diversity, with epiphytes comprising almost 70% of all documented orchids. This pattern suggests that Mt. Bilbogan is a structurally complex forest ecosystem that supports orchid establishment and survival under dense canopy because of its favourable microclimatic conditions.

During specimen documentation and identification, some orchid samples could not be confidently identified to the species level despite the presence of clear floral structures in the figures (e.g., Fig. 5: N and O; Fig. 6: A, D, and M). These include *Corybas* sp. (N), *Crepidium* sp. (O), *Cylindrolobus* sp. (A), *Dendrobium* sp. 1 (D), and *Habenaria* sp. (M). Species-level delimitation was constrained by limited taxonomic resolution in certain orchid groups and the lack of updated, region-specific taxonomic references and verified herbarium materials available for direct comparison. While identification was carefully conducted using available taxonomic keys, published literature, herbarium consultations, and expert input, the available evidence was insufficient to confidently assign these specimens to the species level. Therefore, all such specimens were conservatively reported at the genus level to ensure taxonomic accuracy and avoid misidentification.

Some of the documented orchids exhibited habitat plasticity. For example, the *Spathoglottis tomentosa* usually grows terrestrially (Cootes, 2011), was also found lithophytically in Mt. Bilbogan. In addition, *Dipodium paludosum* has the unique characteristic of growing first as a terrestrial species and later elongating and climbing onto a host, making it hemiepiphytic (Cootes, 2011). *Liparis* sp., a terrestrial orchid, was also found growing on trees (epiphytic) and on rocks (lithophytically). Some *Paphiopedilum ciliolare* individuals were also observed inhabiting the basal portion of the trees in Plot 1, indicating epiphytic growth. These observations suggest that some orchids can shift among habitat types as an adaptive strategy for survival.

The two established sampling plots differed in vegetation structure. Plot 1, which was positioned at the peak (745 m.a.s.l.) of Mt. Bilbogan, had taller trees with and a more shaded, windier habitat. In contrast, Plot 2, was located at a slightly lower elevation (721 m.a.s.l.), had shorter trees and noticeable invasion of *Pandanus* sp. and *Dicranopteris* sp. on the forest floor. These variations might have an impact on orchid substrate suitability, light availability, and moisture retention.

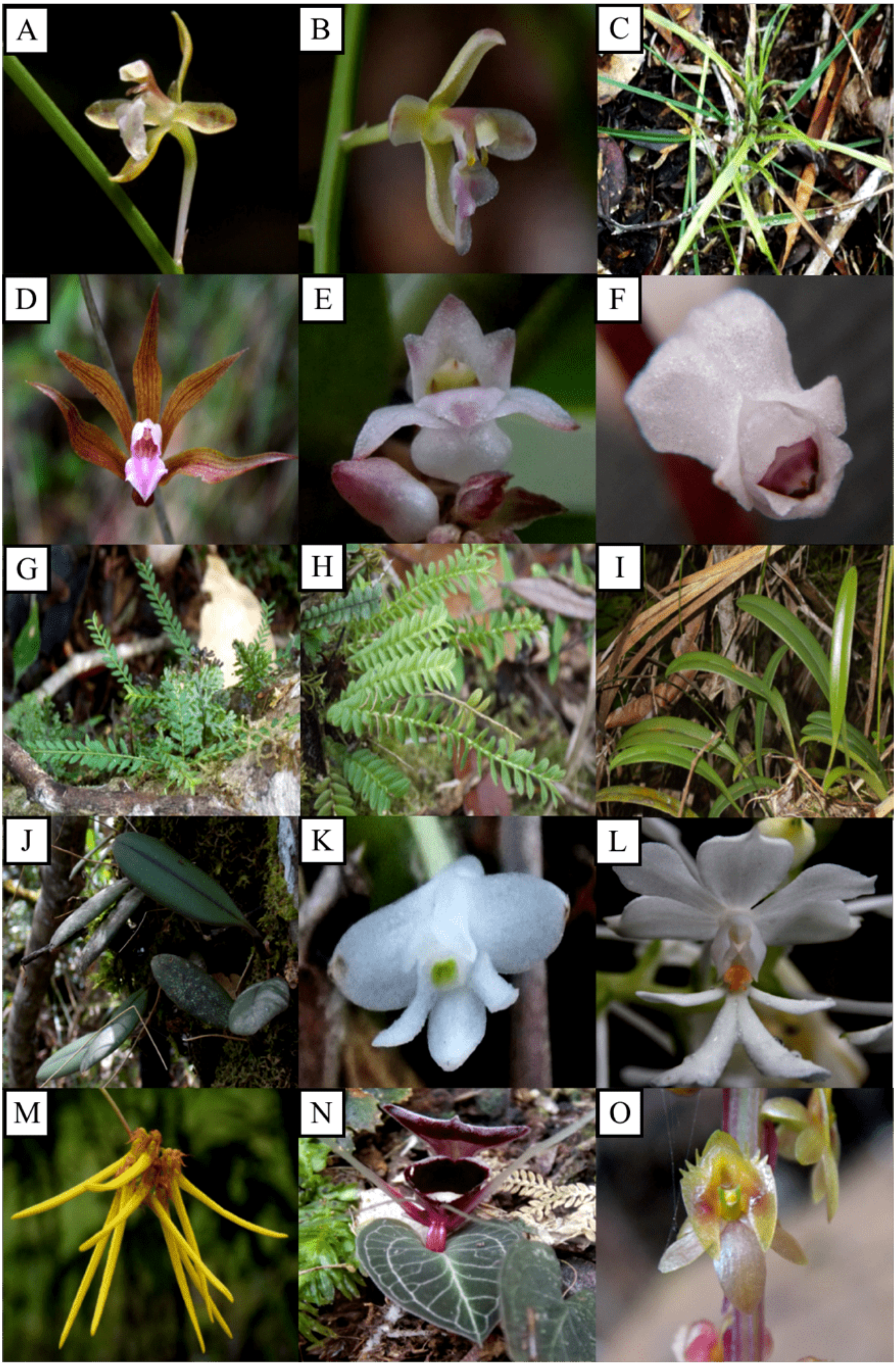

Figure 5: Orchids in Mt. Bilbogan: **A.** *Acriopsis indica,* **B.** *A. liliifolia,* **C.** *Apostasia* sp., **D.** *Ania elmeri,* **E.** *Appendicula micrantha,* **F.** *A. tembuyukenensis,* **G.** *Appendicula* sp. 1, **H.** *Appendicula* sp. 2, **I.** *Bulbophyllum apodum,* **J.** *Bulbophyllum* sp. 1, **K.** *Cadetia microphyton,* **L.** *Calanthe mcgregorii,* **M.** *Cirrhopetalum makoyanum,* **N.** *Corybas* sp., **O.** *Crepidium* sp. Photos of JGOpiso.

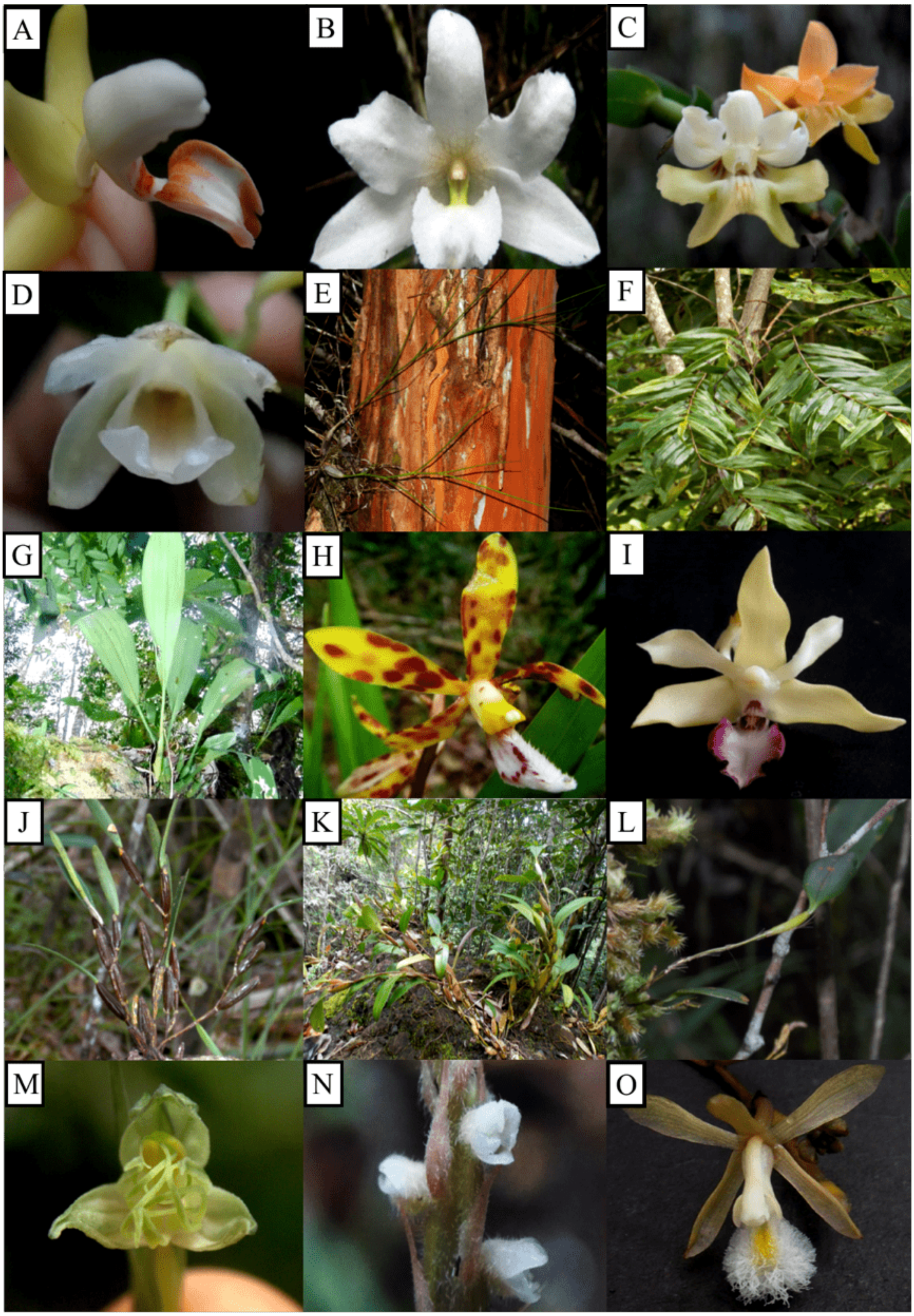

Figure 6: Orchids in Mt. Bilbogan: **A.** *Cylindrolobus* sp., **B.** *Dendrobium auriculatum,* **C.** *Dendrobium uniflorum,* **D.** *Dendrobium* sp. 1*,* **E.** *Dendrobium* sp. 2*,* **F.** *Dendrobium* sp. 3*,* **G.** *Dendrochilum* sp., **H.** *Dipodium paludosum*, **I.** *Euphlebium rhodochilum,* **J.** *Flickingeria* sp. 1, **K.** *Flickingeria* sp. 2*,* **L.** *Flickingeria* sp. 3*,* **M.** *Habenaria* sp.*,* **N.** *Hetaeria oblongifolia,* **O.** *Lecanorchis multiflora*. Photos of JGOpiso.

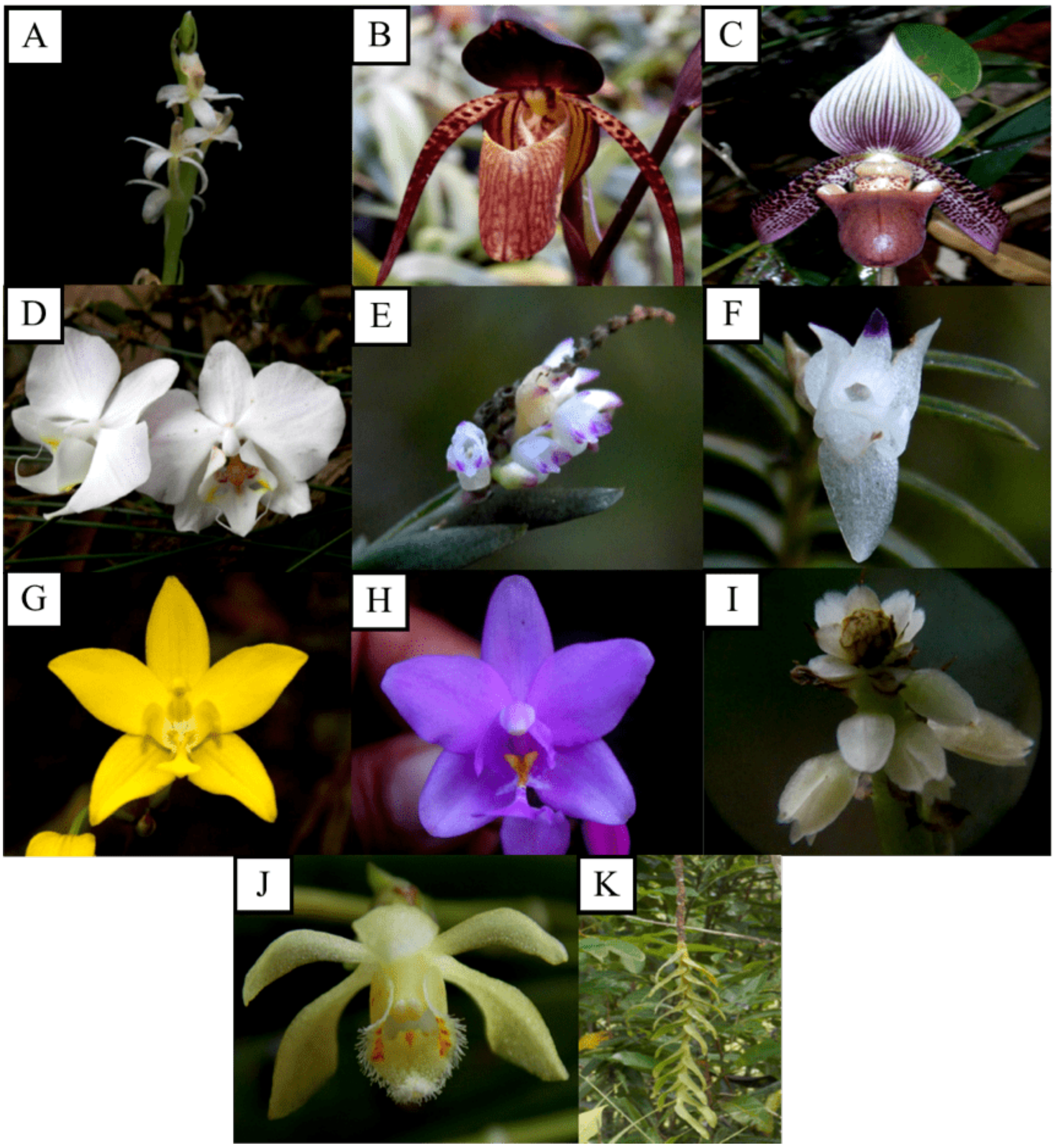

Figure 7: Orchids in Mt. Bilbogan: **A.** *Liparis* sp. **B.** *Paphiopedilum adductum,* **C.** *Paphiopedilum ciliolare,* **D.** *Phalaenopsis sanderiana,* **E.** *Podochilus lucescens,* **F.** *Podochilus plumosus,* **G.** *Spathoglottis elmeri*, **H.** *Spathoglottis tomentosa*, **I.** *Thelasis pygmaea,* **J.** *Thrixspermum angustatum*, and **K.** *Thrixspermum pensile.* Photos of JGOpiso.

Plot 1 supported significantly higher species abundance, with 801 individuals from 16 genera and 24 different species. Meanwhile, Plot 2 had 256 individuals from 10 genera and 17 species. This study recorded lower species richness than other orchid studies conducted on Mindanao island, particularly those of Panal et al. (2015) and Saavedra and Pitogo (2020), which also reported higher number of species at higher elevations. Hirata et al. (2008) and Yulia et al. (2011) reported that higher elevations frequently experience less anthropogenic disturbance and prolonged humidity, which encourage the buildup of litter and the formation of humus on rock surfaces and tree bark, thereby creating ideal substrates for epiphytic orchids. In addition, regions with greater precipitation typically have higher orchid abundance (Manzano et al., 2014).

The distribution of orchids is influenced by microhabitat conditions, as demonstrated by the differences in orchid occurrence between the two established sampling plots. A broader environmental tolerance was exhibited by *Apostasia* sp., *P. adductum*, and *P. ciliolare* as these species were found in both sampling plots. Species such as *Acriopsis indica*, *A. liliifolia*, *T. angustatum*, and *C. microphyton* were recorded only in Plot 1, indicating sensitivity to site-specific factors such as moisture content, humidity, and light availability. Similar trends were also observed in other orchid communities (Hirata et al., 2008).

Orchid species show different ecological preferences, as further illustrated by their abundance patterns. The *Cylindrolobus* sp. was the most abundant taxon, comprising about 22% of all the individuals observed, and was found in the humid and shaded area of Plot 1. In contrast, *A. indica*, *A. liliifolia*, and *T. pensile* were least frequently encountered, which likely reflects their preference for more open habitats, a condition not often found under a dense forest canopy (Cootes, 2011).

There species were classified as critically endangered species (CE) classified under IUCN Red list and the latest botanical assessment of Fernando et al. (2022): *Paphiopedilum adductum*, *Paphiopedilum ciliolare*, and *Phalaenopsis sanderiana*. The presence of these threatened species highlights the need for effective conservation and protection of this forest ecosystem. The remaining taxa, treated as morphospecies due to the absence of reproductive structures, were not assigned IUCN conservation status. The challenge in assessing the conservation status of this family lies in the limited information available. Furthermore, the National List of Threatened Philippine Plants of Fernando et al. (2008) evaluated only 5% of Philippine orchid flora. Therefore, despite their dominance in the Philippine flora, orchids remain understudied. This highlights the need for more thorough ecological and taxonomic research on this plant family.

Orchids in Mt. Bilbogan face multiple anthropogenic pressures, particularly habitat disturbances associated with agricultural land conversion and nearby mining activities. The base of the mountain has been cultivated by farmers, with coconut among the major crops. Moreover, a mining site was detected near the study area. The vulnerability of these species is further increased by unsustainable harvesting practices driven by both ornamental and commercial interests (Cribb et al., 2003; Zhang et al., 2014; Mirani et al., 2017). Therefore, maintaining natural habitats and starting propagation efforts beyond their natural environments are essential for the long-term survival of orchid populations. Increasing public awareness of the cultural and ecological importance of orchids may also strengthen conservation efforts.

Host tree of epiphytic orchids

Host trees provide suitable substrates for attachment, moisture retention, and nutrient uptake for epiphytic orchids (Hirata et al., 2008; Yulia et al., 2011). The distribution of orchids in Mt. Bilbogan was closely associated with the host tree characteristics. It was observed that *Syzygium* sp., *Teijsmanniodendron* sp., and *Cinnamomum* sp. supported the highest numbers of orchids. Host trees utilized by epiphytic orchids in Mt. Bilbogan are shown in Fig. 8–9.

In Senturan Forest, epiphytic orchids predominantly occurred on *Syzygium racemosum*, *Syzygium* sp., *Glochidion rubrum*, *Artocarpus* sp., *Baccaurea* sp., *Trema orientalis*, and *Shorea* sp. (Tirta et al., 2010). Meanwhile in Lamedai Nature Reserve, Southeast Sulawesi, the most preferred hosts were *Metrosideros* spp. and *Syzygium* sp. (Lestari & Santoso, 2011).

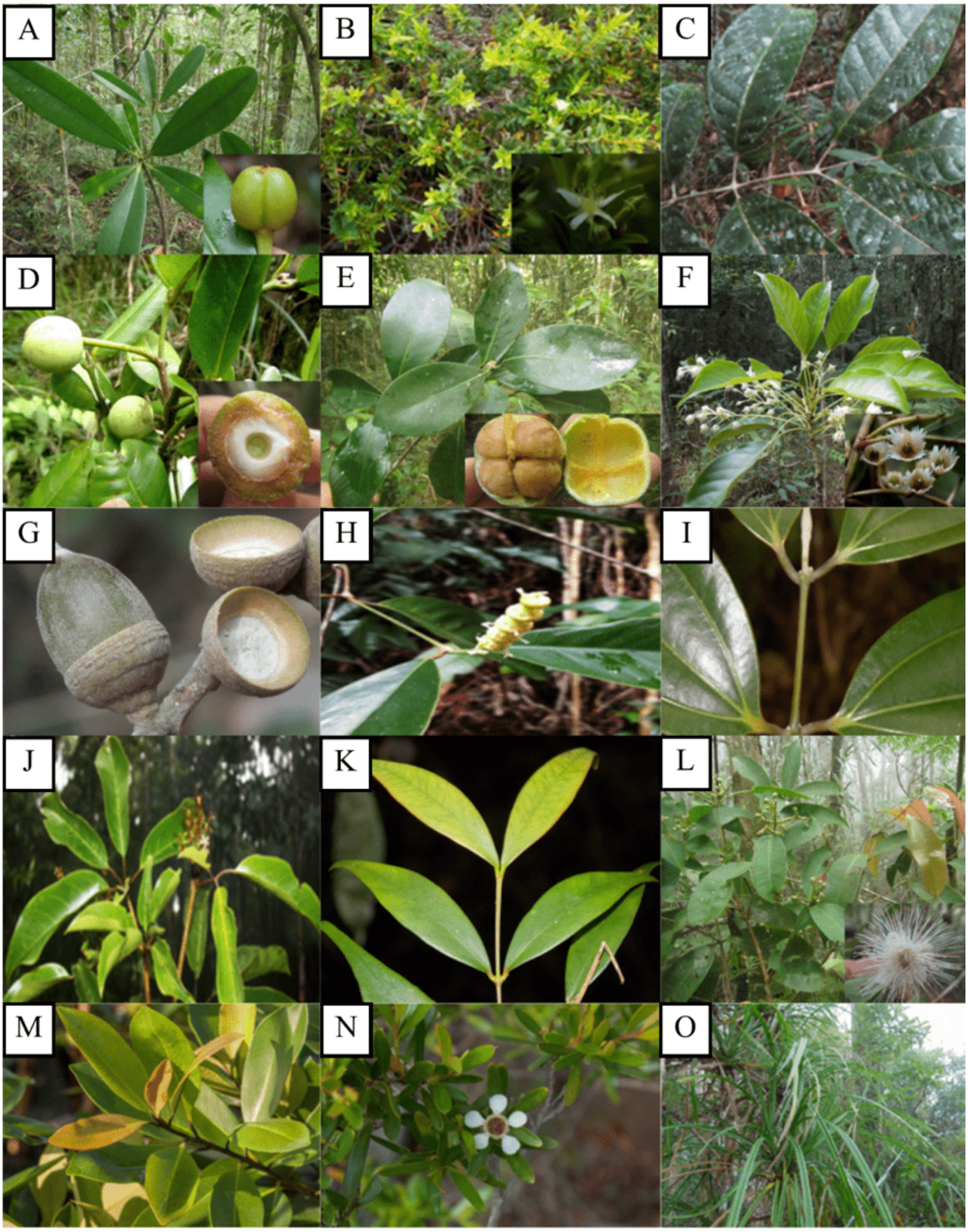

Figure 8: Host trees of orchids in Mt. Bilbogan: **A.** *Rauvolfia* sp., **B.** *Ilex* sp., **C.** *Canarium* sp., **D.** *Calophyllum* sp., **E.** *Garcinia* sp., **F.** *Elaeocarpus* sp., **G.** *Lithocarpus* sp., **H.** *Gnetum gnemon*, **I.** *Cinnamomum* sp., **J.** *Teijsmanniodendron* sp., **K.** *Decaspermum* sp., **L.** *Syzygium* sp., **M.** *Tristaniopsis* sp., **N.** *Leptospermum javanicum*, **O.** *Freycinetia* sp. Photos by J. G. Opiso.

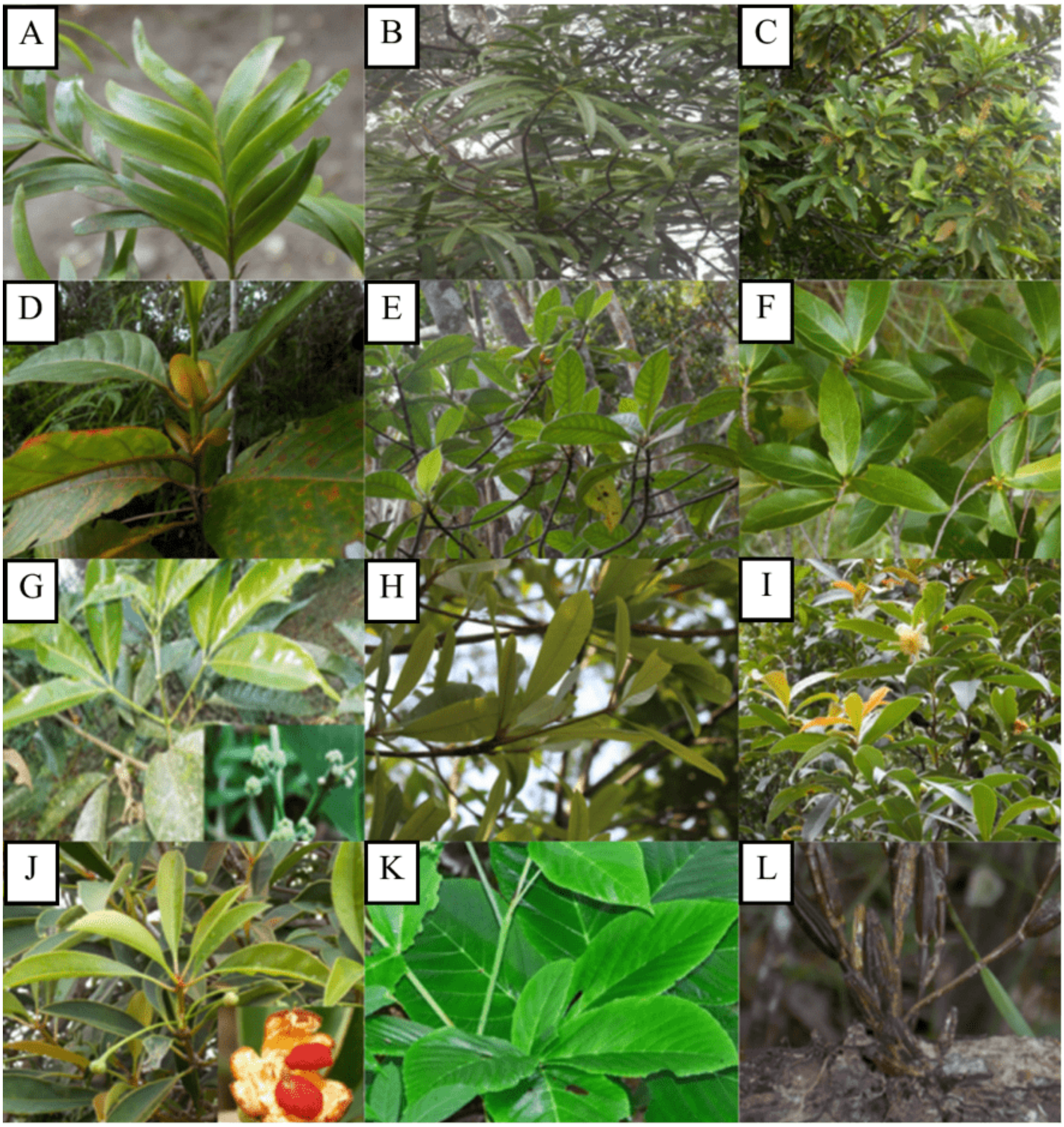

Figure 9: Host trees of orchids in Mt. Bilbogan: **A.** *Falcatifolium gruezoi*, **B.** *Podocarpus* sp., **C.** *Helicia* sp., **D.** *Neonauclea* sp., **E.** *Psychotria* sp., **F.** *Timonius* sp., **G.** *Melicope* sp., **H.** *Palaquium* sp., **I.** *Polyspora luzonica*, **J.** *Ternstroemia* sp., **K.** *Leea* sp., and **L.** dead log. Photos by J. G. Opiso.

However, the *Durio* sp. was the most preferred host in Sibolangit (Hartini & Puspitaningtyas, 2009), whereas in Gunung Manyutan Forest Reserve, orchids predominantly grew on *Pinus merkusii*, *Schima wallichii*, and *Engelhardia spicata* (Yulia & Budiharta, 2011). On the other hand, in Kathmandu, Nepal trees like *Myrsine capitellata*, *Pyrus pashia*, and *Prunus cerasoides* hosted more orchids (Adhikari et al., 2012).

Microhabitat conditions as well as vegetation type, affect orchid preference for host trees (Lestari & Santoso, 2011). Orchid colonization is influenced by host tree properties, including branch structure, bark texture, and the presence of moss. (Hirata et al., 2008). *Syzygium* sp. was the most preferred host tree of orchids in Mt. Bilbogan because of its rough bark, tall stature, and large trunk diameter, which provide greater surface area and promote debris accumulation that enhances the humus formation. In contrast, hosts with smaller branches and smoother bark, such as *Tristaniopsis* sp., *Freycinetia* sp., and *Melicope* sp. Supported few orchids, likely because they limit root attachment and substrate stability.

Vertical distribution of epiphytic orchids on host trees

Epiphytic orchids in Mt. Bilbogan were most commonly found in Zone 1, the basal portion of trees, suggesting a preference for more shaded and humid environments. *Appendicula micrantha*, *Cylindrolobus* sp., *Dendrobium uniflorum*, *Podochilus lucescens*, and *Podochilus plumosus* were the most prevalent in this zone. Species of *Appendicula* were found in zones 1, 2, and 3. Meanwhile, the *Cylindrolobus* sp. which exhibits tolerance to a range of environmental conditions, was recorded across all zones. The only orchids found in Zone 5, which receives the highest light levels, were *Cylindrolobus* sp. and *Flickingeria* sp. 1. In zones 2 and 3, which receive moderate sunlight exposure, the most frequently observed orchids were *Acriopsis* sp. and *Thrixspermum* sp. consistent with their known preference for relatively exposed environments (Cootes, 2011).

The vertical distribution of epiphytic orchids on host trees was greatly affected by the light conditions. Zone 1, which supported the highest number of orchids, received the least amount of sunlight, whereas Zone 5 received the most. The concentration of species in the lower zones indicates low tolerance for direct sunlight and strong dependence on humid conditions. Epiphytic orchids occupy shaded basal trunks or intermediate branches to balance light availability with moisture needs. A similar pattern has been observed in other forest ecosystems (Hirata et al., 2008; Solikin et al., 2010; Tirta et al., 2010).

The distribution of epiphytic orchids in Mt. Bilbogan reflects their tendency to occupy zones that provide optimal microclimatic conditions for survival. Although some species, such as *Dendrobium capra*, are capable of tolerating higher light levels (Yulia & Ruseani, 2008), the majority of orchids in Mt. Bilbogan were observed in shaded or partially exposed habitats, mainly within Zones 1 to 3.

Light conditions and orchid distribution

Because of Mt. Bilbogan's dense upper canopy, epiphytic orchids were concentrated in Zone 1, where light intensity is low. The most prevalent orchids in shaded areas were *Cylindrolobus* sp., *Podochilus lucescens*, and *Podochilus plumosus*.

The distribution of orchids was significantly influenced by light availability. Species such as *Phalaenopsis* sp. and *Paphiopedilum* sp. are adapted to low-light environments and are rarely found in areas with high light exposure. Similarly, *Calanthe mcgregorii*, *Euphlebium* sp., *Podochilus* sp., and *Habenaria* sp. were typically associated with shaded conditions. By contrast, *A. liliifolia* showed a preference for slightly exposed areas, although then majority of orchids tended to avoid direct sunlight (Cootes, 2011; Islam & Dash, 2014; Rankou, 2015). Several epiphytic orchids occurred under more exposed conditions. Species like *Cadetia microphyton* and *Bulbophyllum* sp. 1 exhibit xeromorphic characteristics, such as thick cuticles or waxy leaf surfacesthat minimize water loss. Although orchids in Mt. Bilbogan show a range of ecological tolerances, light availability remains a major factor influencing their growth, survival, and distribution (Jalal & Rawat, 2009; Lestari & Santoso, 2011).

Soil characteristics of sampling plots

A total of 11 terrestrial orchids were recorded in Mt. Bilbogan. *Apostasia* sp., *Liparis* sp., *P. adductum*, and *P. ciliolare* were the most abundant terrestrial orchids. Soil samples were obtained from two plots and analyzed by Soil and Plant Analysis Laboratory (SPAL) of the College of Agriculture, Central Mindanao University.

Soils from both sampling plots were slightly acidic and had low concentration of essential macronutrients, particularly nitrogen (N), phosphorus (P), and potassium (K) (Table 5). Compared with Plot 1, the soils in Plot 2 were more acidic and supported fewer terrestrial orchids. According to Naik et al. (2009), an N content of 1.5% is considered adequate for plant growth. This suggests that the soils on Mt. Bilbogan are nutrient-poor and probably restrictive for the growth of many terrestrial plants, including orchids. The soil conditions are comparable to those reported in ultramafic forest ecosystem similar to those found in Mt. Hamiguitan, where soils are slightly acidic, deficient in essential nutrients, and have low water-holding capacity (Van der Ent, 2011). *Liparis* sp. and *Paphiopedilum* spp. are terrestrial orchids that show physiological traits allowing them to survive under challenging edaphic conditions (Rankou, 2015).

Orchid associate species

Epiphytic and lithophytic orchids rely on external sources rather than their hosts for water or nutrients. Instead, they obtain essential sources from suspended soils or aerial inputs, including mist, rain, dead plant material, airborne dust, falling detritus, or bryophytes (O'Malley, 2009).

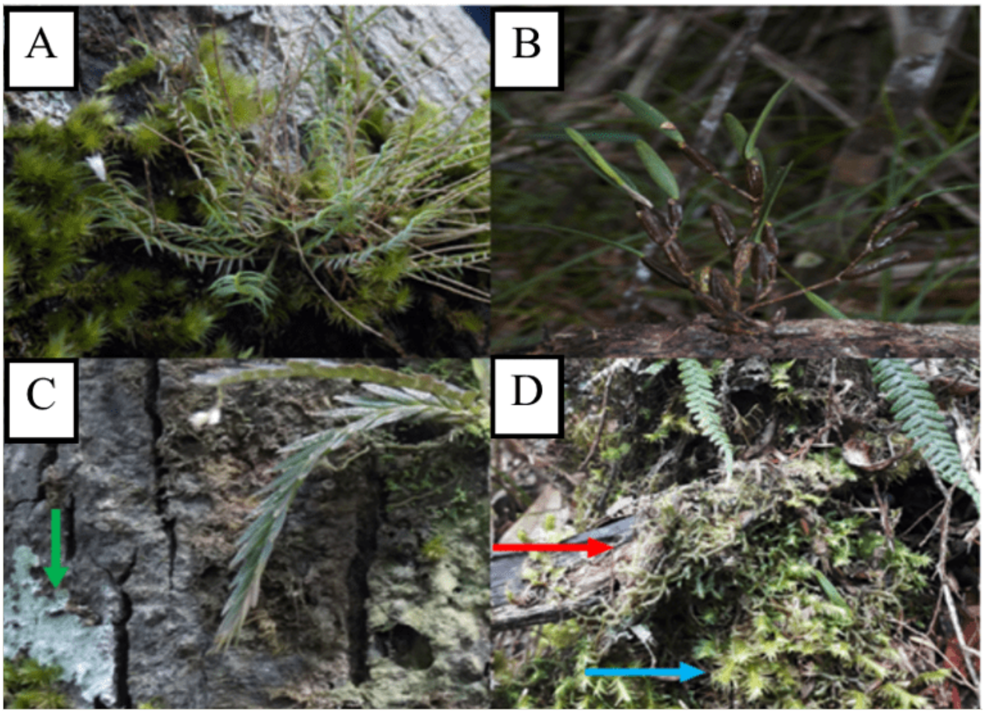

Figure 10: Associate species of orchids showing **A.** *Podochilus plumosus* associated with *Leucobryum* Moss, **B.** *Flickengeria sp.* directly attached to tree, **C.** lichen (green arrow), and **D.** *Schistochila sp.* (Blue arrow) and *Bazzania sp.* (Red arrow) Liverwort.

Associate species of orchids in Mt. Bilbogan are shown in Fig. 10, which illustrates the common substrate interactions of epiphytic orchids in the study area, particularly their frequent association with bryophyte mats and lichen-covered bark surfaces that enhance moisture retention and nutrient availability.

Bryophytes are ectohydric, obtaining water and nutrients directly from the air instead of soil or substrate. They contribute to cation cycling, retain moisture, soil formation, and can withstand periods of dryness (Lestari & Santoso, 2011). These characteristics help create suitable conditions that support orchid seed germination and seedling establishment.

Epiphytic orchids tend to establish on substrates with light to heavy humus rather than on bare bark, as humus provides greater nutrient availability (Jovan, 2008). Orchid seeds are extremely small and contain limited nutrient reserves, making them reliant on symbiotic fungi to supply carbohydrates and essential nutrients until seedlings become autotrophic (Aguilar et al., 2012). Bryophytes often have these fungi supporting epiphytic orchid growth and development.

CONCLUSIONS

The study revealed that Mt. Bilbogan harbours 41 orchid species under 26 genera, consisting of 26 epiphytes, 12 terrestrial species, 2 lithophytes, and 1 hemiepiphyte. Three orchids were identified as critically endangered: *Paphiopedilum adductum*, *P. ciliolare*, and *Phalaenopsis sanderiana*, emphasizing the need for immediate protection and preservation of this mountain ecosystem.

Epiphytic orchids were typically found in host trees such as *Syzygium* sp., *Teijsmanniodendron* sp., and *Cinnamomum* sp. Orchids in Mt. Bilbogan preferred low-light and shaded conditions and commonly occupied Zone 1, at the base of the host tree. Associated species included bryophytes, lichens, and liverworts, which help retain moisture in substrates that support orchid establishment and survival. The slightly acidic soils of Mt. Bilbogan, together with low phosphorus, nitrogen, and potassium levels, suggest that microclimatic conditions and nutrient-poor substrates strongly influence orchid distribution patterns.

These results showed that orchid distribution in Mt. Bilbogan is closely shaped by microhabitat characteristics, host tree availability, and substrate conditions. Continued monitoring, extended seasonal surveys, and targeted conservation strategies are necessary to protect threatened species and maintain the ecological integrity of this biodiverse site.

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DECLARATIONS

Research permit(s). Wildlife Gratuitous Permit–WGP No. XI-2018-18, issued by the Department of Environment and Natural Resources (DENR) Region XI, Davao City, Philippines.
Ethical approval/statement. Not applicable.

Generative AI use. The authors declare that generative AI has been used in compliance with the JTBC policies, and that we have reviewed and edited the content after using this tool/service and we take full responsibility for the content of the publication.

REFERENCES

Adhikari YP, Fischer HS, Fischer A (2012) Host tree utilization by epiphytic orchids in different land-use intensities in Kathmandu Valley, Nepal. Plant Ecology 213: 1393–1412. https://doi.org/10.1007/s11258-012-0099-0.

Aguilar J, Xanco B, Kenicer G, Mchaffie H (2012) Establishing ex situ conservation methods for *Dactylorhiza ebudensis* and *D. traunsteinerriodes*, a combination of in situ turf removal and in vitro germination. The Journal of Botanic Garden Horticulture 71–83. https://doi.org/10.24823/Sibbaldia.2012.68.

Challe JFX, Struik PC (2008) The impact on orchid species abundance of gathering their edible tubers by HIV/AIDS orphans: A case of three villages in the Southern Highlands of Tanzania. NJAS-Wageningen Journal of Life Sciences 56(3): 261–279. https://doi.org/10.1016/S1573-5214(08)80011-5.

Cootes J (2011) Philippine Native Orchid Species. Quezon: Katha Publishing Co Inc. 289 pp.

Cribb PJ, Kell SP, Dixon KW, Barrett RL (2003) Orchid conservation: A global perspective. In: Dixon KW, Kell SP, Barret RL, Cribb PJ (eds.). Orchid Conservation. Kota Kinabalu (Malaysia): Natural History Publications (Borneo): 1–124.

De Leon M, Cootes J, Naïve M (2017) *Grastidium ginalopeziae* spec. nov. Cootes, M D De Leon et Naïve, a new *Grastidium* species (Orchidaceae) from Bukidnon, Philippines. Die Orchidee: 1–6.

Fernando ES, Co LC, Lagunzad DA, Gruezo WS, Barcelona JF, Madulid DA, Lapis AB, Texon GI, Manila AC, Zamora PM (2008) Threatened plants of the Philippines: a preliminary. Asia Life Sci. 3:1–52.

Fernando ES, Amoroso VB, Tandang DN, Banag CI, Lapis AB, Gruezo WS, Coritico FP, Pollisco FA Jr, Palijon AM, Ching MM, Lansigan FP, Garcia-Francisco C, Litan M, Tagtag Am, De Leon JL (2022) Threatened Plants of the Philippines. Department of Environment and Natural Resources, Biodiversity Management Bureau 149.

Hartini S, Puspitaningtyas DM (2009) Plant Diversity in Sumatra Island. Bogor Botanic Garden, Indonesian Institute of Science (LIPI) Bogor. Indonesia. 253 pp.

Hirata A, Kamijo T, Saito S (2009) Host trait preferences and distribution of vascular epiphytes in a warm-temperate forest. Plant Ecology 201(1): 247–254. https://doi.org/10.1007/s11258-008-9519-6.

Islam M, Dash P (2014) Growth performance of orchid (*Dendrobium* sp.) as influenced by different NPK spray concentration. International Journal of Biosciences: 15–27. http://dx.doi.org/10.12692/ijb/4.7.15-27.

IUCN (2017) The IUCN Red List of Threatened Species. Version 2017-3. https://www.iucnredlist.org. (Accessed 18 June 2018).

Jalal J, Rawat G (2009) Habitat studies for conservation of medicinal orchids of Uttarakhand, Western Himalaya. African Journal of Plant Science: 200–204.

Johansson J (1975) Ecology of epiphytic orchids in West African rainforests. American Orchid Society Bulletin 44: 125–136.

Jovan S (2008) Lichen bioindication of biodiversity and environmental stress. The Bryologist, 111(4): 659–667.

Lestari D, Santoso W (2011) Inventory and habitat study of orchid species in Lamedai Nature Reserve, Kolaka, Southeast Sulawesi. Biodiversitas 12(1): 28–33. https://doi.org/10.13057/biodiv/d120106.

Manzano E, Andrade JL, Zotz G, Reyes-garcía C (2014) Epiphytic orchids in tropical dry forests of Yucatan, Mexico – Species occurrence, abundance, and correlations with host tree characteristics and environmental conditions. Flora 209(2): 100–109. dx.doi.org/10.1016/j.flora.2013.12.002.

Mirani AA, Abul-soad AA, Markhand GS (2017) Effect of different substrates on survival and growth of transplanted orchids (*Dendrobium nobile* cv.) into net house. International Journal of Horticulture and Floriculture 5(4): 310–317.

Naik S, Barman D, Bharathi U, Devadas R (2009) Status of mineral nutrition of orchid – a review. Journal of Ornamental Horticulture 12(1): 1–14.

O'Malley K (2009) Patterns of abundance and diversity in epiphytic orchids on *Parashorea malaanonan* trees in Danum Valley, Sabah. The Plymouth Student Scientist 2(2): 38–58.

Panal C, Opiso J, Opiso G (2015) Conservation status of the family Orchidaceae in Mt. Sinaka, Arakan, North Cotabato, Philippines. Biodiversitas 16(2). http://dx.doi.org/10.13057/biodiv/d160217

Pelser P, Barcelona J, Nickrent D (2015) Co's Digital Flora of the Philippines. Available from: www.philippineplants.org (accessed 21 August 2016).

Pelser PB, Barcelona JF, Nickrent DL (2011) Co's digital flora of the Philippines. Available from www.philippineplants.org (accessed 21 August 2016).

Rankou H (2015) *Paphiopedilum ciliolare*. The IUCN Red List of Threatened Species 2015: e.T46347A43318143. https://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T46347A43318143.en (accessed 21 August 2016).

Saavedra AJL, Pitogo KME (2021) Richness and distribution of orchids (Orchidaceae) in the forests of Mount Busa, Sarangani, Southern Mindanao, Philippines. Philippine Journal of Science 150(S1): 151–163.

Shibu S, Devi C, Wesley S, Moin S (2012) Ex situ conservation of endemic orchids of Western Ghats, Tamil Nadu, India via asymbiotic seed germination. Advanced Applied Science Research 3: 3339–3343.

Solikin D, Suhartono R, Tarmudji S (2010) Composition and dispersal of orchid species in Lejja, South Sulawesi. In Proceedings of the National Seminary on Basic Science. Brawijaya University, Malang, Indonesia. 21 February 2010. I-1–I-6.

Tirta I, Lugrayasa I, Irawati C (2010) A study on epiphytic orchids at three locations in Malinau District, East Kalimantan. Buletin Kebun Raya 13: 35–39.

Van der Ent A (2011) The ecology of ultramafic areas in Sabah: Threats and conservation needs. Gardens' Bulletin Singapore 63(1–2): 385–393.

Yulia N, Ruseani N (2008) Inventory and habitat study of *Dendrobium capra* J Smith in Madiun and Bojonegoro. Biodiversitas 9: 190–193.

Yulia ND, Budiharta S (2011) Epiphytic orchids and host trees diversity at Gunung Manyutan Forest Reserve, Wilis Mountain, Ponorogo, East Java. Biodiversitas 12(1): 22–27.

Yulia N, Budiharta S, & Yulistyarini T (2011) Analysis of epiphytic orchid diversity and its host tree at three gradient of altitudes in Mount Lawu, Java. Biodiversitas: 225–228. DOI: 10.13057/biodiv/d120407.

Zhang Z, Yan Y, Tian Y, Li J, He J, Tang Z (2014) Distribution and conservation of orchid species richness in China. Biological Conservation: 64–72.