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Orchid diversity across different forest types on Mt. Malindang, Philippines

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Abstract. *Labajo-Villantes Y, Cootes J, Luo Y-B, Nuneza OM. 2024. Orchid diversity across different forest types on Mt. Malindang, Philippines. Biodiversitas 25: 605-615.* Mt. Malindang Range Natural Park is one of the most significant biodiversity and conservation areas and is considered a biodiversity hotspot. There have been many biodiversity studies on Mt. Malindang, but information on orchid taxonomy and distribution is limited. This study aimed to conduct a comprehensive inventory of orchids using an exploratory method. Samplings were conducted in different forest types: montane, mossy, dipterocarp, mixed dipterocarp, and almaciga. A total of 114 orchid species with 55 endemics were recorded. Three of these (*Phalaenopsis x intermedia* Lindl., *Paphiopedilum hennisianum* (M.W.Wood) Fowlie, and *Paphiopedilum haynaldianum* (Rchb.f.) Stein) were under Appendix I (can only be exported under specific circumstances). At the same time, 78 were under the Appendix II (follow controlled trades) categories of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. *P. hennisianum* and *P. haynaldianum*, listed as endangered species globally, were observed in montane and mossy forests, respectively. Among the six sampling sites, the montane forest was the most species-rich, with the most endemics, followed by the mossy forest. Almaciga and mixed dipterocarp forests were closely related with 100% similarity. The results of this study are valuable to Mt. Malindang's ecological profile for more effective protection and conservation plans.

Keywords: Endangered, exploratory, Lake Duminagat, montane, mossy

INTRODUCTION

Orchidaceae is one of the most abundant and diverse families of beautiful and colorful flowers, including terrestrial, epiphytic, and saprophytic species. It makes up roughly 7.3% of the 381,959 flowering plant species recognized as existing worldwide (WFO 2022). This is expected to grow as more are found (Naive et al. 2019; Angeles et al. 2022).

Orchids are widely known for their multifaceted importance. They are recognizable ornamental plants for their undeniably unique and fragrant flowers, symbolizing love, luxury, and beauty for centuries. Orchids thrive in specific habitats and microhabitats, elevations, and forest types. As a result, these plants are useful biological indicators of local ecological changes. Vogt-Schilb et al. (2016) demonstrated a high rate of community turnover in Corsica during significant land-use changes, particularly in canopy closure. The number of species and the ecological range were negatively correlated, as Rocha and Waechter demonstrated in 2010. This was supported by Silveira et al. (2015), who showed a higher diversity of euglossine orchids in a heterogeneous habitat and more species in the forests. Because of their acknowledged importance, orchids caught the interest of botanists, and more research is being done.

The Philippines is one of the world's mega-diverse nations, home to two-thirds of all species. In terms of orchids, the Philippines harbors more than 1,200 species, with 85% endemic (Cootes 2011). However, the Philippines is regarded as one of the biodiversity hotspots worldwide. The Department of Environment and Natural Resources administrative order 2017-11 identified 984 threatened plant species, including 179 critically endangered, 254 endangered, 406 vulnerable, and 145 other threatened species (DENR 2023).

In Mindanao, many studies on plants have been conducted. Trees and forest structures (Coritico et al. 2020); lycophytes and ferns (Coritico and Amoroso 2020); mangrove species (Villanueva et al. 2021); pitcher plants (Buniel et al. 2023); or ethnobotanical studies (Madjos and Ramos 2021; Nuneza et al. 2021) were some of the biologists' areas of specialization. In terms of orchids, a study was conducted in five Mindanao Long-Term Ecological Research Sites, of which 79 orchid species under 34 genera were recorded. Mt. Apo was the most species-rich, followed by Mt. Kitanglad, Mt. Haguimitan, and Mt. Malindang (18 species from 16 genera). Another study by Saavedra et al. (2021) in Mt. Busa recorded 108 species of orchids from 51 genera with relatively high endemism (53 species), of which 15 are Mindanao endemics.

In the Northwestern part of Mindanao is Mt. Malindang Range Natural Park (MMRNP). It is a protected site regarded as one of the country's most significant biodiversity and conservation regions. However, more research on plant

diversity and distribution in Mindanao is still needed. Amoroso et al. (2006), Arances et al. (2004), and Alaman et al. (2020) conducted in-depth studies on plant diversity in the northern landscape of MMRNP more than ten years ago, but orchids were not included. On the other hand, Buenavista (2014) discovered 18 orchid species while studying in a single mossy forest within the MMRNP.

Previous studies could not accurately depict the richness of the orchid species due to the 53,282 hectares of MMRNP. Comprehensive taxonomic studies, specifically on orchids, are scarce. This study conducted a comprehensive inventory of orchids across different forest types (mossy, montane, dipterocarp, mixed dipterocarp, and almaciga forests) of Mt. Malindang and its environs. Generated data are valuable in enhancing Mt. Malindang Range Natural Park's ecological profile and plans for preserving and conserving its biodiversity.

MATERIALS AND METHODS

Therefore, before conducting the study, the necessary permit, known as a Wildlife Gratuitous Permit (No. R10 2022-40), was secured from the Department of Environment and Natural Resources, and other entry protocols were followed. An exploratory method was employed in the inventory of orchids. Sampling was conducted from June 2021 to May 2022 in different forest formations identified in Mt. Malindang Range Natural Park (MMRNP). These include mossy, montane, dipterocarp, mixed dipterocarp, and almaciga forests (Figure 1). Orchids were photographed ex-situ and in situ. Flower samples were collected for further identification. Specimens were identified using identification keys available in prints and on the web. Furthermore, experts were tapped to verify the identity of the orchids. Species richness, abundance, endemism, and conservation status of orchids were identified. Diversity indices such as Shannon's diversity index, Pielou's evenness index, and Hierarchical clustering analysis were determined using Paleontological Statistics Software Package for Education version 4.03 (PAST 4.03) software.

Site 1 is the mossy forest of Mt. Malindang Peak, located in the Municipality of Tudela, Misamis Occidental. Malindang Peak, which rises to a height of 2,438 meters above sea level (masl), is considered the highest mountain in MMRNP. It has steep mountain ridges and deep canyons. The twisted trunks and branches of the trees, the roots, and the forest floor are all covered in a thick layer of moss in the forest. *Lithocarpus* sp. and *Podocarpus* sp. dominated the trees, averaging up to 10 meters in height.

Site 2 is the mossy forest located in North Peak at Brgy. Lake Duminagat, Don Victoriano, Chiongbian, Misamis Occidental. It is situated at 8°17'28.4" N 123°37'45.4" E. Numerous little trees with aerial roots and prop roots are growing just a few meters from the base of the strangely shaped tree trunks in this mossy forest. Prop roots were associated with steep slopes, which are common in this area. The crooked-stem, dwarf trees ranged in height from 5 to 20 meters. Ferns, liverworts, mosses, and epiphytes are in great quantity. The forest floor, as well as the tree trunks and branches, were heavily covered in moss. *Podocarpus*, *Dacrycarpus*, *Engelbartia*, *Myrica*, and *Syzigium* species are found in this forest.

Site 3 is the montane forest located at Lake Duminagat to Ulohan sa Dapitan Range, also in Brgy. Lake Duminagat, Don Victoriano, Chiongbian, Misamis Occidental. It is between 1,200 and 1,780 masl at 8°18'26.3" N and 123°37'18.7" E. Numerous mosses, lichens, and epiphytes are found in montane forests. The ground is covered in leaf litter, and humus is almost always present. Large, straight-trunked, evergreen trees, such as *Podocarpus* and *Casuarina* species, are common. The community of *Clethra lancifolia* Turcz., *Impatiens montalbanica* Hook.f., pitcher plants, and rattan was also observed.

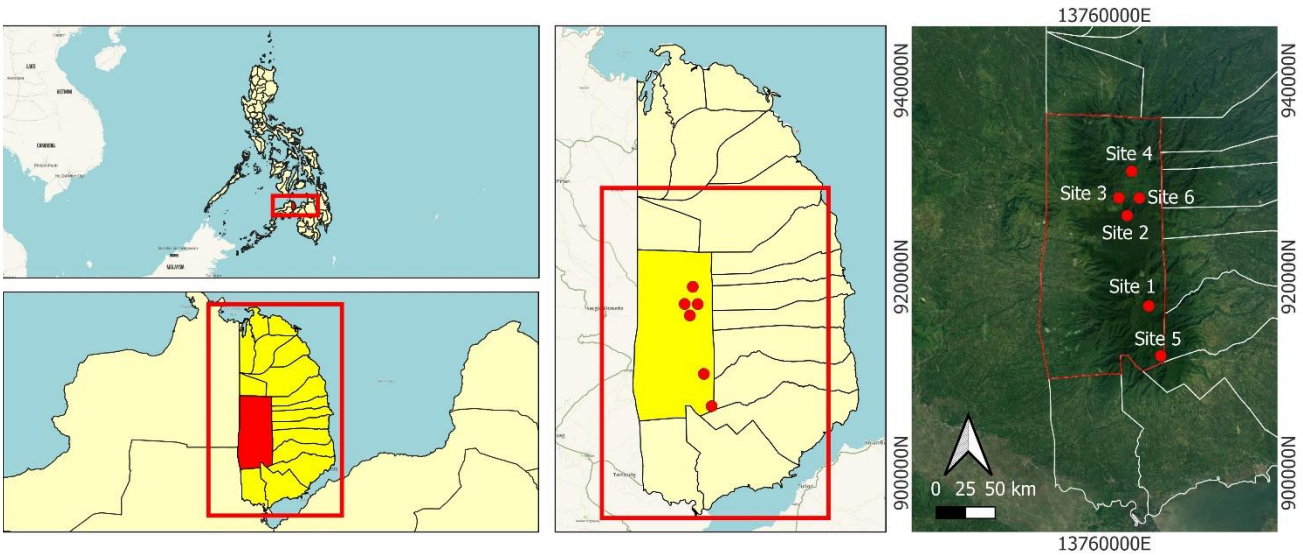


Figure 1. Location map of sampling sites on Mt. Malindang Range Natural Park, Don Victoriano Chiongbian, Misamis Occidental, Philippines

Site 4 is the dipterocarp forest located at Mt. Capole in Brgy. Sebucal, Oroquieta City. It is situated at 8°19'53.1" N 123°38'00.4" E from 900 to 1,200 masl. The forest is full of canyons and slopes that are extremely steep. In this region,

dipterocarp straight-trunk tall trees were observed, including *Pentacme contorta* (S.Vidal) Merr. & Rolfe, *Shorea negrosensis* Foxw., *Syzygium rubrovenium* (C.B.Rob.) Merr., *Shorea polysperma* (Blanco) Merr., and *Parashorea malaanonan* (Blanco) Merr.. Various pitcher plant species, rattan, and wild bananas were also seen.

Site 5 is the mixed dipterocarp forest at Hoyohoy in Tangub City with 1,000-1,500 masl. It is characterized by undulating steep slopes. The forest is dominated by *Shorea contorta*, *Lithocaprus philippinensis*, *Helicia* sp, *Cinnamomum mercadoi*, and *Syzygium* sp.

Site 6 is an almaciga forest also located in Brgy. Sebucal, Oroquieta City. Other protected areas do not contain this unique variety of forest. This is located at 8°18'25.8" N 123°38'25.7" E and lies between 800 and 1,300 masl. The communities of *Ficus minahassae* (Teijsm. & de Vriese) Miq., *Bischofia javanica* Blume, *Agathis philippinensis*, and *Cinnamomum mercadoi* S.Vidal are dominant in this forest.

RESULTS AND DISCUSSION

Moreover, 114 different orchid species from 49 different genera were discovered throughout the study on MMRNP and its environs (Table 1). Most of these orchids are epiphytes and sympodial. Of the species recorded, 55 are endemic, consisting of 38 Philippine and 17 Mindanao endemics. This finding supported the notion that the Philippines is home to a significant proportion (80%) of endemic orchid species (Cootes 2001). Orchid endemism in the country is very high compared to other Asian nations such as India's 35% (Chowdhery 2015), Thailand's 7% (Thaitong and Khunwasi 2005) and Mongolia with no endemic species (Baasanmunkh et al. 2021).

Threatened species are identified based on the listings recognized worldwide. These include the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (World Flora Online 2022) and The World Conservation Union (IUCN 2022). The National List of Threatened Flora in the Philippines is provided by the Department of Environment and Natural Resources (2017) through its Administrative Order (DENR-DAO 2017-11). Results showed that 71% (81) of the orchid species on Mt. Malindang are listed in CITES, and 68% (78) are under Appendix II. Species listed in Appendix II are not necessarily in danger of extinction but must follow controlled trades. On the other hand, three species are recognized under Appendix I, and these orchids are among the most threatened species and can only be exported under specific circumstances under CITES. These include *Phalaenopsis x intermedia* Lindl, *Paphiopedilum hennisianum* (M.W. Wood) Fowlie, and *Paphiopedilum haynaldianum* (Rchb.f.) Stein. Additionally, the Department of Environment and Natural Resources (2017) has declared *P. haynaldianum* and *P. hennisianum* critically endangered (Figure 3), while *P. x intermedia* is vulnerable (DENR 2023). The two *Paphiopedilum* species have been designated as endangered by the IUCN (2022).

Compared to other areas in montane Mindanao, especially Mt. Apo and Mt. Haguimitan in Davao, Mt. Kitanglad, and Mt. Musuan in Bukidnon, Mt. Malindang has a far higher number of species documented. These four ecological research sites have 79 sp. / 34 genera, 19 sp/ 11 genera, 25 sp./16 genera, and 2 sp/2 genera, respectively (Buenavista 2017). This study included more species than Mt. Busa in Saranggani Province, where 108 orchids from 51 genera were reported.

The presence of large forest blocks in Mt. Malindang paves the way for the presence of a high number of orchid species. Approximately 33,000 hectares (has.) of the total Mt. Malindang's land area (53,262 ha) comprise forest, most of the park's Core Area. Closed canopy (first growth) forests only cover about 18,000 ha or less. The forest's plant life comprises a very wide variety of species, with dipterocarps dominating. The lower portions of its forests are home to various species, including enormous, straight-trunk evergreens, *Podocarpus* sp., and *A. philippinensis*. In contrast, dwarf and crooked-stem trees populate the mossy forest in the mountains' upper regions.

The environment of a forest provides a suitable habitat for orchids. Compared to other habitats, orchids are more likely to live in forests. Numerous authors have demonstrated this (e.g., Wraith and Pickering 2017). The orchids can find enough light, cool temperatures, moisture, and other micronutrients they need in the forest to survive. These factors, together with elevation and the presence of soil nitrogen, are the primary determinants of the distribution and abundance of orchids, according to Djordjević et al. (2020). Some orchid species become habitat specialists due to these ecological factors (Kirillova et al. 2022). Orchids are restricted to particular ecosystems or microhabitats. Therefore, species may perish or mutate into different forms when environmental changes lead to changes in ecological parameters.

With 35 endemic orchids, the montane forest likewise has the highest number of endemic species. The mossy forest of North Peak, which has 31 species, is next. There are 24 endemic species in dipterocarp. Malindang Peak mossy forest and mixed dipterocarp forests have 20 recorded endemics, while almaciga forest has 16. Endemic orchid species are the only ones naturally occurring in a certain region and are well adapted. Among the endemic orchids recorded in Mt. Malindang, *A. malindangensis*, *C. pristina*, *C. prasina*, *C. datuguinai*, *D. butchcamposii*, *D. zamboangense*, *D. mindanaense*, and *M. candoonensis* are some examples of Mindanao endemics (Figure 2). These are only found in Mindanao and nowhere else in the Philippines and the world. The montane forest offers unique climate conditions and is in the average elevational range; hence, these have higher endemic species. Compared to the mossy forest at higher elevations, the climate, very low temperatures, and strong winds are unsuitable for tree growth.

Table 1. Consolidated list of orchids recorded in different forest types on Mt. Malindang, Philippines and its environments

Genus	Species	Type	Growth habit	Distribution	Conservation		
					DENR-DAO 2017-11	CITES (cites.org)	IUCN, 2023 (iucnredlist.org)
Acanthephippium	*Acanthephippium pictum* Fukuy	Ground	Sympodial	Widespread		II	
Aeridostachya	*Aeridostachya robusta* (Blume) Brieger	Epiphytic	Upright, sympodial	Widespread		II	
Agrostophyllum	*Agrostophyllum majus* Hook.f.	Epiphytic	Sympodial	Widespread		II	
	Agrostophyllum sp. 1	Epiphytic	Sympodial				
	Agrostophyllum sp. 2	Epiphytic	Sympodial				
Anoectochilus	*Anoectochilus* sp.	Ground	Sympodial				
Appendicula	*Appendicula malindangensis* (Ames) Schltr	Epiphytic	Sympodial	Mindanao endemic		II	
	Appendicula reflexa Blume	Epiphytic	Sympodial	Philippine endemic		II	
Arundina	*Arundina graminifolia* (D. Don) Hochr	Ground	Sympodial			II	
Ascidieria	*Ascidieria cymbidiifolia* (Ridl.) W.Suarez & Cootes	Epiphytic	Sympodial	Widespread			
Bryobium	*Bryobium* sp.						
Bulbophyllum	*Bulbophyllum aeolium* Ames	Epiphytic	Sympodial	Widespread		II	
	Bulbophyllum alsiosum Ames	Epiphytic	Sympodial	Widespread		II	
	Bulbophyllum dearei Rchb. f.	Epiphytic	Sympodial	Philippine endemic		II	
	Bulbophyllum escritorii Ames	Epiphytic	Sympodial	Philippine endemic		II	
	Bulbophyllum flavescens (Blume) Lindl.	Epiphytic	Sympodial	Widespread		II	
	Bulbophyllum mindanaense Ames	Epiphytic	Sympodial	Philippine endemic		II	
	Bulbophyllum sanguineomaculatum Ridl.	Epiphytic	Sympodial	Widespread		II	
	Bulbophyllum saurocephalum Rchb.f.	Epiphytic	Sympodial	Philippine endemic		II	
	Bulbophyllum sec Stachysanthes		Sympodial				
	Bulbophyllum sempiternum Ames	Epiphytic	Sympodial	Philippine endemic		II	
Calanthe	*Calanthe angustifolia* (Blume) Lindl.	Ground	Sympodial	Widespread		II	
	Calanthe furcata Bateman ex Lindl	Ground	Sympodial	Widespread		II	
	Calanthe pulchra (Blume) Lindl.	Ground	Monopodial Sympodial	Widespread		II	
	Calanthe sp.1						
	Calanthe sp.2		Sympodial				
Ceratostylis	*Ceratostylis latipetala* Ames	Epiphytic	Sympodial	Mindanao endemic			
	Ceratostylis pristina M.Leon, Naive & Cootes	Epiphytic	Sympodial	Mindanao endemic		II	
	Ceratostylis subulata Blume	Epiphytic	Sympodial	Widespread		II	
	Ceratostylis wenzelii Ames	Epiphytic	Sympodial	Philippine endemic		II	
Coelogyne	*Coelogyne candoonensis* Ames	Epiphytic	Sympodial	Widespread		II	
	Coelogyne chloroptera Rchb.f.	Epiphytic	Sympodial	Philippine endemic		II	
	Coelogyne prasina Ridl.	Epiphytic	Sympodial	Mindanao endemic		II	
	Coelogyne sp. 1	Epiphytic	Sympodial				
	Coelogyne sp. 2	Epiphytic	Sympodial				
Crepidium	*Crepidium quadridentatum* (Ames) Szlach	Ground	Sympodial	Philippine endemic		II	
	Crepidium ramosii (Ames) Szlach	Ground	Sympodial	Philippine endemic			

Crystostylis	*Cryptostylis arachnites* (Blume) Blume	Ground	Sympodial	Widespread	II
	Cryptostylis taiwaniana Masam.	Ground	Sympodial	Widespread	
Cylindrilobus	*Cylindrolobus datuguinai* Naive, M.Leon & Buenavista	Epiphytic	Sympodial	Mindanao endemic	
Cymbidium	*Cymbidium lancifolium* Hook.	Epiphytic	Sympodial	Widespread	II
	Cymbidium pubescens Lindl	Epiphytic	Sympodial	Mindanao endemic	
Cymboglossum	*Cymboglossum cymbidiifolium* (Ridl.) Ormerod & Cootes	Epiphytic	Sympodial	Widespread	
Cystorchis	*Cystorchis aphylla* Ridl.	Ground	Sympodial	Widespread	II
	Cystorchis luzonensis Ames	Ground	Sympodial	Philippine endemic	II
Dendrobium	*Dendrobium butchcamposii* Cootes, M.Leon & R.Boos	Epiphytic	Sympodial	Mindanao endemic	
	Dendrobium crumenatum Sw. in Schrad.	Epiphytic	Sympodial	Widespread	II
	Dendrobium milaniae Fessel & Lückel	Epiphytic	Sympodial	Philippine endemic	II
	Dendrobium pterocarpum Ames, Sched.	Epiphytic	Sympodial	Mindanao endemic	
	Dendrobium rhombeum Lindl.	Epiphytic	Sympodial	Philippine endemic	II
	Dendrobium schettleri Cootes, Cabactulan, R.B.Pimentel & M.Leon	Epiphytic	Sympodial	Mindanao endemic	
	Dendrobium tiongii Cootes	Epiphytic	Sympodial	Mindanao endemic	II
	Dendrobium uniflorum Griff	Epiphytic	Sympodial	Widespread	II
	Dendrobium ventricosum Kraenzl.	Epiphytic	Sympodial	Philippine endemic	II
	Dendrobium zamboangense Ames	Epiphytic	Sympodial	Mindanao endemic	II
	Dendrobium sp.	Epiphytic	Sympodial		
Dendrochilum	*Dendrochilum arachnites* Rchb.f.	Epiphytic	Sympodial	Mindanao endemic	
	Dendrochilum cobbianum Rchb.f.	Epiphytic	Sympodial	Philippine endemic	II
	Dendrochilum mindanaense (Ames) L.O.Williams	Epiphytic	Sympodial	Mindanao endemic	II
	Dendrochilum wenzelii Ames	Epiphytic	Sympodial	Philippine endemic	
Dendrolirium	*Dendrolirium ornatum* Blume *(syn Eria ornata)*	Epiphytic	Sympodial	Widespread	II
Epiblastus	*Epiblastus merrillii* L.O.Williams	Epiphytic	Sympodial	Mindanao endemic	II
Epidendrum	*Epidendrum radicans*	Ground/epiphytic	Sympodial	Widespread	II
Epigeneium	*Epigeneium stella-silvae* (Loher & Kraenzl.) Summerh	Epiphytic	Sympodial	Philippine endemic	II
Habenaria	*Habenaria hystrix* Ames	Ground	Sympodial	Widespread	
	Habenaria lingulosa Ames	Ground	Sympodial	Philippine endemic	II
Lepidogyne	*Lepidogyne longifolia* (Blume) Blume	Ground	Sympodial	Widespread	II
Liparis	*Liparis condylobulbon* Rchb.f., Hamb. Gartenz	Epiphytic	Sympodial	Philippine endemic	II
	Liparis dumaguetensis Ames	Ground	Sympodial	Philippine endemic	II
	Liparis jarensis Ames	Ground	Sympodial	Mindanao endemic	II
	Liparis latifolia (Blume) Lindl.	Ground/epiphytic	Sympodial	Widespread	II
	Liparis negrosiana Ames	Ground	Sympodial	Philippine endemic	II
Luisia	*Luisia tristis* (G.Forst.) Hook.f.	Epiphytic	Monopodial	Widespread	II
Malaxis	*Malaxis* sp.	Ground	Monopodial		
Mycaranthes	*Mycaranthes candoonensis* (Ames) Cootes & W.Suarez	Epiphytic	Sympodial	Mindanao endemic	II
	Mycaranthes citrina (Ridl.) Rauschert	Epiphytic	Sympodial	Widespread	II
	Mycaranthes gigantea (Ames) Cootes & W.Suarez	Epiphytic	Sympodial	Philippine endemic	II
	Mycaranthes longibracteata (Leav.) Cootes & W.Suarez	Epiphytic	Sympodial	Philippine endemic	II
	Mycaranthes sp.	Epiphytic	Sympodial		

Oberonia	*Oberonia elmeri* Ames	Epiphytic	Sympodial	Philippine endemic		II	
	Oberonia equitans (G.Forst.) Mutel	Epiphytic	Sympodial	Widespread		II	
	Oberonia lycopodioides (J.Koenig) Ormerod	Epiphytic	Sympodial	Widespread		II	
Orchipedum	*Orchipedum wenzelii* (Ames) J.J.Sm.	Ground	Sympodial	Philippine endemic		II	
Paphiopedilum	*Paphiopedilum haynaldianum* (Rchb.f.) Stein	Ground	Sympodial	Philippine endemic	CE	I	En
	Paphiopedilum hennisianum (M.W.Wood) Fowlie	Ground	Sympodial	Philippine endemic	CE	I	En
Phaius	*Phaius flavus* (Blume) Lindl.	Ground	Sympodial	Widespread		II	
	Phaius philippinensis N.E.Br.	Ground	Sympodial	Philippine endemic		II	
	Phaius tankervilleae (Banks) Blume	Ground	Sympodial	Widespread		II	
Phalaenopsis	*Phalenopsis x intermedia* Lindl.	Epiphytic	Monopodial	Philippine endemic	VU		
Pholidota	*Pholidota* Blume) Rchb.f.	Epiphytic	Sympodial	Widespread		II	
Phreatia	*Phreatia densiflora* (Blume) Lindl.	Epiphytic	Sympodial	Widespread		II	
	Phreatia listrophora Ridl.	Epiphytic	Sympodial	Widespread		II	
	Phreatia plexauroides Rchb.f.	Epiphytic	Sympodial	Widespread		II	
Pinalia	*Pinalia cylindrostachya* (Ames) W.Suarez & Cootes	Epiphytic	Sympodial	Philippine endemic		II	
	Pinalia dagamensis (Ames) W.Suarez & Cootes	Epiphytic	Sympodial	Philippine endemic		II	
	Pinalia longicruris (Leav.) W.Suarez & Cootes	Epiphytic	Sympodial	Mindanao endemic		II	
	Pinalia sec Urostachya	Epiphytic	Sympodial				
Platanthera	*Platanthera angustata* (Blume) Lindl.	Ground	Sympodial	Philippine endemic		II	
Robiquetia	*Robiquetia cerina* (Rchb.f.) Garay	Epiphytic	Monopodial	Philippine endemic		II	
	Robiquetia dutertei Cootes, Naive & M.Leon	Epiphytic	Monopodial	Mindanao endemic		II	
	Robiquetia sp. 1	Ground	Monopodial				
	Robiquetia sp. 2	Epiphytic	Monopodial				
Spathoglottis	*Spathoglottis plicata* Blume	Ground	Sympodial	Widespread		II	
Stichorkis	*Stichorkis gibbosa* (Finet) Cootes	Epiphytic	Sympodial	Widespread		II	
	Stichorkis gracilis (Ames) Naive & Ormerod	Epiphytic	Sympodial	Philippine endemic			
	Stichorkis leytensis (Ames) Cootes	Epiphytic	Sympodial	Philippine endemic		II	
Strongyleria	*Strongyleria hirsutipetala* (Ames) Schuit.	Epiphytic	Sympodial	Philippine endemic			
Taeniophyllum	*Taeniophyllum philippinense* Rchb.f.	Epiphytic	Monopodial	Philippine endemic		II	
Thelasis	*Thelasis carinata* Blume	Epiphytic	Sympodial	Widespread		II	
Thrixspermum	*Thrixspermum* sp.1	Epiphytic	Sympodial				
	Thrixspermum sp.2	Epiphytic	Monopodial				
Trichoglottis	*Trichoglottis latisepala* Ames	Epiphytic	Monopodial	Philippine endemic		II	
Trichotosia	*Trichotosia vulpina* (Rchb.f.) Kraenzl.	Epiphytic	Sympodial	Widespread		II	
Tropidia	*Tropidia* sp.	Ground	Sympodial				

Notes: *I: Appendix I; II: Appendix II; CE: Critically Endangered; En: Endangered; VU: Vulnerable

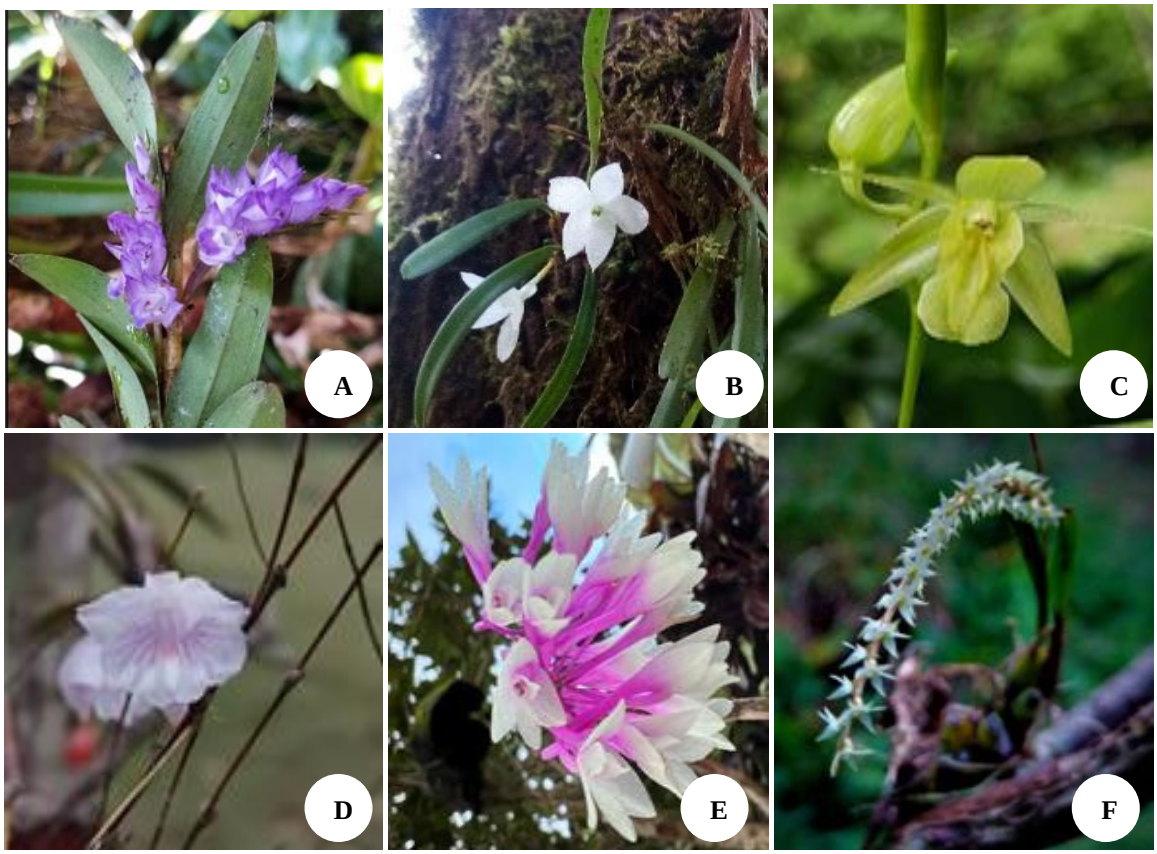


Figure 2. Some Mindanao endemic orchids were recorded on Mt. Malindang, Philippines. A. *Appendicula malindangensis* (Ames) Schltr, B. *Ceratostylis pristina* M.Leon, Naive & Cootes, C. *Coelogyne prasina* Ridl., D. *Dendrobium butchcamposii* Cootes, E. *Dendrobium zamboangense* Ames, F. *Dendrochilum mindanaense* Ames

Figure 3. Critically endangered species (DENR 2023) and as endangered species (IUCN 2022): A. *Paphiopedilum haynaldianum* and; B. *Paphiopedilum hennisianum*

A large variety of orchid species with comparatively high endemism is found on Mount Malindang. However, numerous threatened species are recognized locally and internationally. Montane and mossy forests are home to *P. haynaldianum* and *P. hennisianum*, respectively (Figures 3A and 3B). Both species are critically endangered in the Philippines (DENR 2017). These orchids are classified as endangered globally (IUCN 2022), and based on the CITES listing in 2022, montane and mossy forests in Mt. Malindang noted 45 and 38 species, respectively. Most species are unlikely to go extinct, but control procedures should be strictly followed when trading.

The montane forest has the highest species diversity score of 3.886, indicating a relatively high diversity, with various species present (Figure 4). Hence, a relatively unequal distribution of orchids is shown with its lower

evenness value of 0.7166. Areas with a lower evenness index than others indicate that the area has an unequal distribution of resources, leading to greater disparities in resource access (Ulfah et al. 2019). The mossy forest in North Peak is the second most diverse area with a value of 3.744 and evenness of 0.7549. The lowest diversity is recorded in almaciga, with an index of 2.93. However, it has a higher evenness index value of 0.749, indicating a relatively equal distribution of orchid species within the area compared to the other forest types.

The hierarchical clustering diagram (Figure 5) shows that the almaciga, the mixed dipterocarp, the montane, and the mossy forests in North Peak are closely related. These two clusters have a similarity of 80% and 100%, respectively. The montane-mossy and dipterocarp cluster is slightly less related, with a similarity of 60%. The mossy forest cluster is the most distant from the other clusters. Hierarchical clustering can identify patterns and relationships between different types of forests. By looking at the diagram, we can see that the almaciga and mixed dipterocarp forests are more closely related than the montane and the mossy 2 forests. This can be explained by the 13 orchid species that are common and abundant in almaciga and mixed dipterocarp, as shown in the seriation distribution table (Table 2).

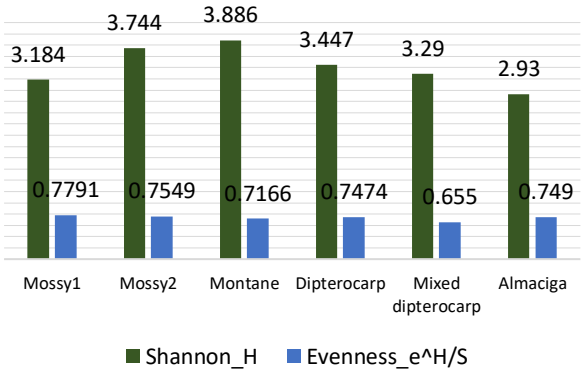
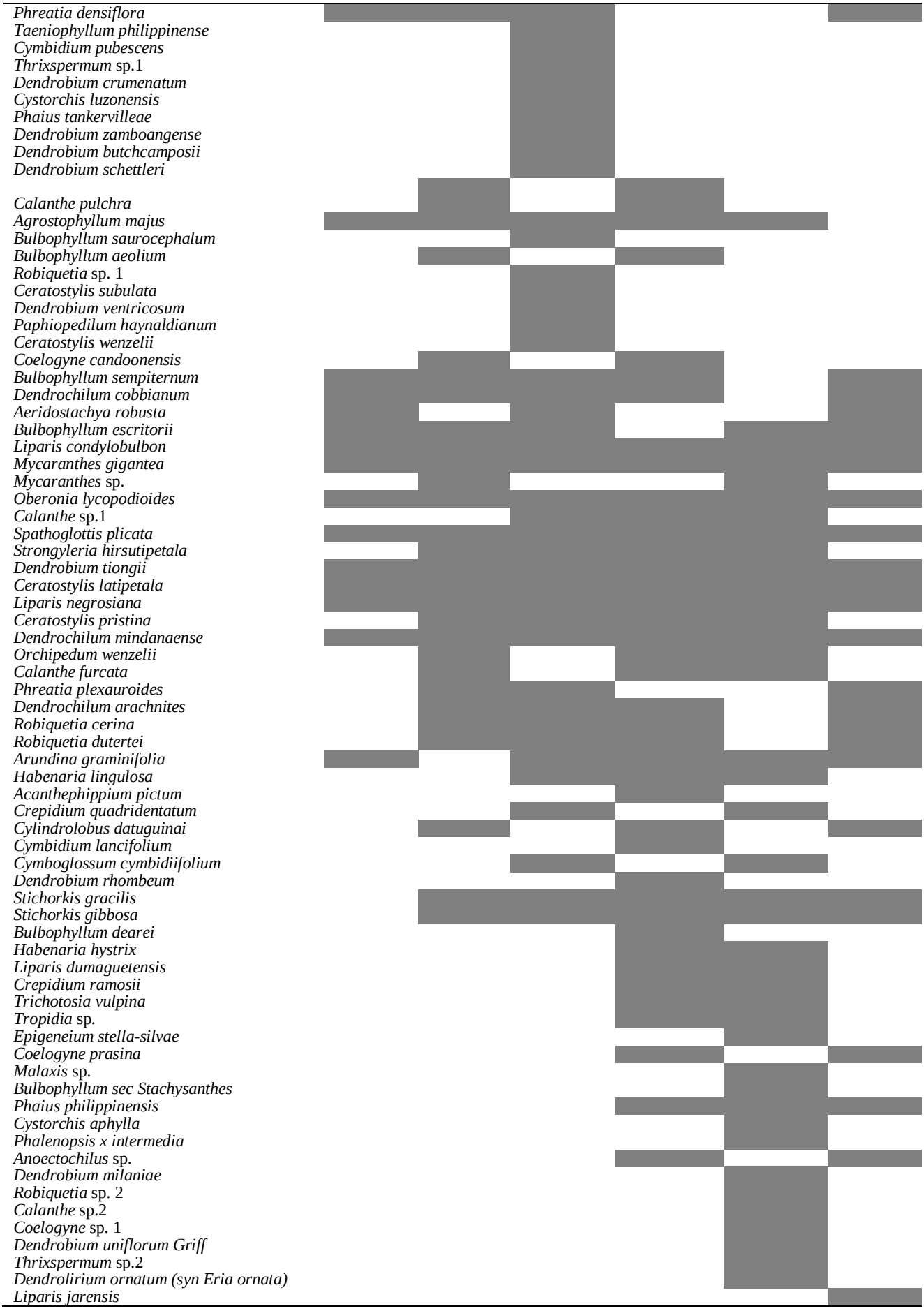


Figure 4. Diversity indices of the different forest types on Mt. Malindang, Philippines

Table 2. Seriation distribution of orchids in different forests on Mt. Malindang and its environs

Orchids	Mossy1	Mossy2	Montane	Dipterocarp	Mixed dipterocarp	Almaciga
Bulbophyllum mindanaense	■					
Paphiopedilum hennisianum	■					
Lepidogyne longifolia	■					
Dendrobium pterocarpum	■	■				
Mycaranthes longibracteata	■	■				
Pinalia dagamensis	■	■				
Trichoglottis latisepala	■	■	■			
Oberonia equitans	■	■	■			
Mycaranthes candoonensis	■	■	■			
Platanthera angustata		■				
Pholidota Blume)		■				
Calanthe angustifolia		■				
Bryobium sp.		■				
Phaius flavus	■		■			
Pinalia longicruris	■	■	■			
Thelasis carinata		■				
Epiblastus merrillii		■				
Cryptostylis arachnites		■				
Stichorkis leytensis		■	■			
Phreatia listrophora		■	■			
Appendicula malindangensis	■	■	■	■		
Agrostophyllum sp. 2		■	■			
Appendicula reflexa	■			■		
Cryptostylis taiwaniana		■	■			
Oberonia elmeri		■	■			
Dendrochilum wenzelii		■	■			
Bulbophyllum flavescens	■	■	■	■		
Coelogyne chloroptera		■	■			
Bulbophyllum alsiosum		■	■			
Bulbophyllum sanguineomaculatum		■	■			
Ascidieria cymbidiifolia	■	■	■		■	
Pinalia cylindrostachya	■	■	■		■	
Epidendrum radicans			■			
Pinalia sec Urostachya			■			
Agrostophyllum sp. 1			■			
Coelogyne sp. 2			■			
Liparis latifolia			■			
Dendrobium sp.			■			
Luisia tristis			■			
Mycaranthes citrina			■			


Phreatia densiflora
Taeniophyllum philippinense
Cymbidium pubescens
Thrixspermum sp.1
Dendrobium crumenatum
Cystorchis luzonensis
Phaius tankervilleae
Dendrobium zamboangense
Dendrobium butchcamposii
Dendrobium schettleri
Calanthe pulchra
Agrostophyllum majus
Bulbophyllum saurocephalum
Bulbophyllum aeolium
Robiquetia sp. 1
Ceratostylis subulata
Dendrobium ventricosum
Paphiopedilum haynaldianum
Ceratostylis wenzelii
Coelogyne candoonensis
Bulbophyllum sempiternum
Dendrochilum cobbianum
Aeridostachya robusta
Bulbophyllum escritorii
Liparis condylobulbon
Mycaranthes gigantea
Mycaranthes sp.
Oberonia lycopodioides
Calanthe sp.1
Spathoglottis plicata
Strongyleria hirsutipetala
Dendrobium tiongii
Ceratostylis latipetala
Liparis negrosiana
Ceratostylis pristina
Dendrochilum mindanaense
Orchipedum wenzelii
Calanthe furcata
Phreatia plexauroides
Dendrochilum arachnites
Robiquetia cerina
Robiquetia dutertei
Arundina graminifolia
Habenaria lingulosa
Acanthephippium pictum
Crepidium quadridentatum
Cylindrolobus datuguinai
Cymbidium lancifolium
Cymboglossum cymbidiifolium
Dendrobium rhombeum
Stichorkis gracilis
Stichorkis gibbosa
Bulbophyllum dearei
Habenaria hystrix
Liparis dumaguetensis
Crepidium ramosii
Trichotosia vulpina
Tropidia sp.
Epigeneium stella-silvae
Coelogyne prasina
Malaxis sp.
Bulbophyllum sec Stachysanthes
Phaius philippinensis
Cystorchis aphylla
Phalenopsis x intermedia
Anoectochilus sp.
Dendrobium milaniae
Robiquetia sp. 2
Calanthe sp.2
Coelogyne sp. 1
Dendrobium uniflorum Griff
Thrixspermum sp.2
Dendrolirium ornatum (syn Eria ornata)
Liparis jarensis

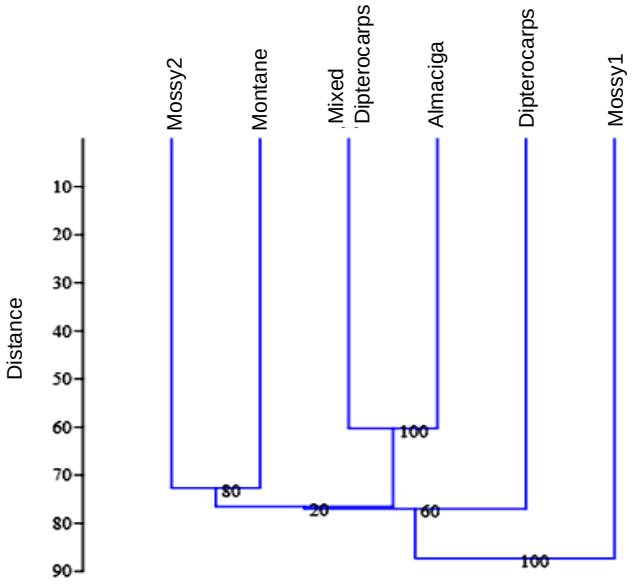


Figure 5. Classical hierarchical clustering diagram analysis of forest types on Mt. Malindang, Philippines

On the other hand, montane and mossy 2 forests have 10 common orchid species. Montane/mossy and dipterocarp forests are less related than the other two clusters, and the mossy 1 cluster is the most distant from the other clusters. Mossy 1 has fewer orchid species and three unique species than the other five forest types. These include *B. mindanaense*, *P. hennisianum*, and *L. longifolia*.

Mt. Malindang has had to contend with enormous risks. The area covered by forests has continuously decreased over time and continues to be in danger. The MMRNP is threatened by human encroachment, resource extraction/collection of species with high commercial value (orchids, rattan), and unsustainable infrastructure development. In numerous forests and forestlands, epiphytic orchids are prevalent, and epiphytic orchid microhabitats can be destroyed when trees are cut down for domestic use. Because various forest resources, including orchids, were being gathered without restriction for commerce and others, the variety of orchids on Mount Malindang is at risk. Of all the flowering plants, orchids are the most endangered. Orchids often draw the attention of so many poachers with their distinctive and vibrant blossoms. Most of these plants have been classified as Appendix II by the CITES due to the overharvesting of orchids. Due to their high market value and value to the horticulture industry, these flowers are vulnerable to unlawful poaching. Several government-built access roads that ascend the slopes of MMRNP pose another threat to the survival of several orchid species. A direct threat is also posed by the fact that 20,000 people live in the core and buffer zones of the MMRNP. They belong to the marginalized sector, lack adequate education, and have few employment opportunities. As a result, they engage in unsustainable agricultural methods that eventually erode the soil and the forest's edge.

In conclusion, this study demonstrates that Mt. Malindang Range Natural Park is a significant site for biodiversity and conservation. It has a wide variety of orchid species with high endemism. The montane and mossy forests are home to the most known orchid species. Numerous species are regarded as being both locally and globally threatened. Therefore, for the benefit of future generations, Mt. Malindang's forest and forest lands should be strictly protected and conserved. Communication, Education, and Public Awareness (CEPA) activities should also be conducted, particularly on orchids and orchid conservation on Mt. Malindang. A 10-year interval studies can be conducted for monitoring and evaluation.

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