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Elevational Pattern of Orchid Rarity and Endemism in Mt. Kalatungan, Mindanao Island, Philippines

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ABSTRACT

Despite being the Philippines most threatened group of plants, ecological studies on the orchid flora remains to be scanty and poorly studied which become an impediment to their conservation. This study aimed to identify the forest zones and species of conservation priority with an emphasis on the rare and endemic orchid species. A field investigation was carried out using a line transect and plot-sampling methods established along the elevational zones of Mt. Kalatungan Range National Park. Results showed the presence of 44 orchid species belonging to 28 genera, 39 (91%) species of orchids are Philippine endemic with eight new records. The elevational pattern of species followed a double humped-shaped pattern at 1,320-1,395 m and 1,886 – 1,965 m above sea levels (masl). Based on rarity index, 35 (83%) species are very rare, three (7%) are sparse, three (7%) common and one (3%) is common. The density of endemism was recorded to increase as elevation increases which peaked at 1,886 – 1,965 masl but declines at 2,000 masl Findings of the study suggest that the elevational pattern of orchid species follows a humped-shaped pattern wherein species richness is highest in the middle of the elevation gradient.

Keywords: *Rarity, endemism, wild orchids, elevational pattern, Mt. Kalatungan, Mindanao*

INTRODUCTION

Orchids occupy a wide range of habitat and exhibit highly specialized morphological, structural and physiological characteristics [1]. They grow in a variety of habitats throughout the globe but are very sensitive to habitat change. Some orchid species only thrive to particular elevations and forest types with unique habitat and microhabitats making them as excellent indicators of ecosystem changes [2]. In the previous survey, the various mountain regions in Mindanao have remarkable differences and similarities in the species richness and composition of wild orchids. In fact, some species are restricted in specific mountain areas [3].

Distribution patterns of individual species and communities have received a lot of attention in the ecological literature and several measures to determine changes in composition have been proposed [4, 5]. In tropical ecosystems, one of the major gradients that may exert large differences in plant species composition and richness is altitude. Moreover, the elevation also showed to influenced species evenness in negative relation (species evenness decreases significantly with increasing altitudes) [6]. Studies on elevational gradients have found three main patterns of species richness: first, a monotonic decrease in richness with increasing elevation, second, a "humped" distribution, with species richness highest near the middle of the gradient and a plateau at low elevations [7, 8].

Being an excellent biological indicator of ecological changes in the ecosystem, the species richness pattern of orchids along the elevational gradient has been studied particularly in the Himalayas [9], Reunion Island [6,10] and Borneo [11]. However, in the Philippines which harbors more than 1,100 orchid species with about 80% endemism [12], ecological studies on orchid flora remains to be unexplored and understudied

This study aimed to provide a checklist of the orchid flora of Mt. Kalatungan Range and to determine the el-

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evational pattern of species richness, rarity, and endemism. These are critical factors in identifying priority species and habitat for orchid conservation.

MATERIALS AND METHODS

Study site

Floristic documentation was conducted from October 2015 to March 2016 at Mt. Kalatungan, Barangay Portulin, Municipality of Pangantucan, Bukidnon province, Philippines (Figure 1). Kalatungan Mountain Range is one of the key biodiversity areas and Natural Park in the Philippines. Considered culturally significant, it is one of the recognized ancestral domain of the Talaandig Tribe in the village of Portulin in the Municipality of Pangantucan. The indigenous people have a delineated sacred forest and it is locally known as "Igmale'ng'en". The site is geographically located at 4°22'33.36" N latitude and 128°21'58.70" E longitude with an elevation of 2,076 m above sea level (masl).

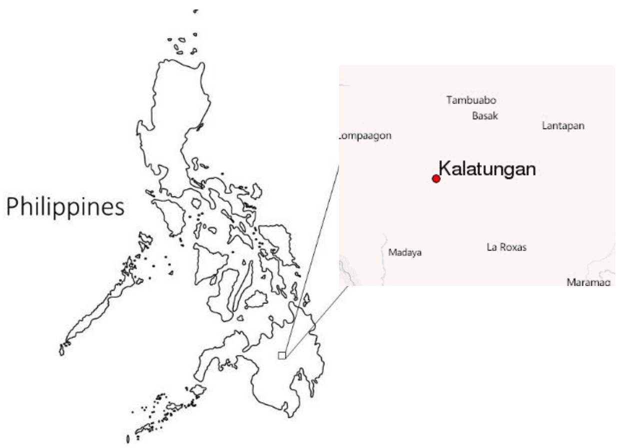

Figure 1. Location map of Mt. Kalatungan Range in Mindanao Island, Philippines

Data gathering

Zonation was done along Nabukalan trail from the base to the peak of Mt. Kalatungan Range using a line transect method. Following the procedure employed in investigating the species richness and distribution of ferns along an elevational gradient, each zone measures 240m with an interval of 100 m in between. Within each zone, two sampling plots (100 m × 2 m) with 20 m distance between transects were considered for sampling terrestrial and low-trunk epiphytic orchids to a height of eight meters from the ground [13]. The total area sampled was 400 m^2 - a minimum area considered for the sampling [14]. This notion was postulated upon the facts that ferns and orchids occupy the same range of micro habitats and both exhibit various life forms (i.e. from the ground to canopy epiphytes). Relevant data such as the date and place of collection and collection number were noted. In every elevational zone, spatial information was recorded i.e. coordinates elevation and distribution of orchid species.

Rarity index

The rarity of orchid species was determined following the formula [2] with some modifications, to assign a status at the local level to each orchid species. Six quantification parameters (Table 1) were considered for assessing the rarity of orchids. For getting the rarity value (R) (on the scale of rarity index: 1 – 5), the sum of all six parameters was divided by six.

$$R = \frac{h^1 + s^1 + a^1 + m^1 + p^1 + p^2}{6}$$

Where h^1— the number of habitats, s^1— the number of sites, a^1—altitudinal distribution, m^1—distribution in Mindanao, p^1—phytogeographical distribution within Malesia sub-continents, p^2—phytogeographical distribution globally. Rarity ranking (very rare: 1 – 2, sparse: 2.1 – 3, occasional: 3.1 – 4, common: 4.1 – 5). The data for assessing the distribution in Mindanao and phytogeographical distributions were based on the books and monographs [15, 12, 16,] and through a scientific online database such as Co' Digital Flora of the Philippines [17].

Assessment and density of endemism

Assessment of endemism whether its Mindanao Endemic (ME), Philippine Endemic (PE) or Widespread Species (WS) was based from the known distribution of each species as published in various floras, monographs, online databases and herbarium records [17, 18, 12]. The elevational distribution of the absolute number of endemic orchid species was recorded in every sampling zone. The density of endemism was calculated using the formula [20] wherein:

$$Density\ of\ endemism = \frac{Number\ of\ endemic\ species}{Area\ per\ site} \times 100$$

RESULTS AND DISCUSSION

We recorded 44 wild orchid species belonging to 28 genera from all the transect stations and elevational zones in the Nabukalan trail of Mt. Kalatungan. The highest species richness was observed at an elevation

Table 1. Quantitative parameter for rarity of orchids

No.	*Parameters*	*Documentation*	*Scoring (Quantification)*
1.	Number of Habitats (h^1)	Number of habitats occupied by each orchid species (*This is only applied to host trees with a DBH not > 50 cm, fallen trees and young trees considering an average height of 8 meters above the ground.*)	1 to 8 habitats depending on how many habitats, a particular orchid occurred in. (e.g., ground, tree base/low trunk epiphytes, upper trunk, lower canopy, middle canopy, upper canopy, lithophytes, hemi-epiphytes)
2.	Number of Sites (s^1)	Number of sites the orchid species occur	"1" for single site; "2" for < 4 sites; "3" for < 6 sites; "4" for < 8 sites and "5" for >10 sites.
3.	Altitudinal distribution (a^1)	< 1,400 to > 2,000 masl (total of 9 zones) depending on how many species occurred in a particular zone.	1 to 9 zones depending on how many zones a particular species was found in.
4.	Distribution in Mindanao (m^1)	Divided in to 5 divisions: Western Mindanao (*Zamboanga del Sur, Zamboanga del Norte and Zamboanga Sibugay*) Northern Mindanao (*Camiguin, Lanao del Norte, Misamis Occidental, Misamis Oriental and Bukidnon*) Southern Mindanao (*Davao del Norte, Davao del Sur, Davao Oriental, Davao Occidental and Compostela Valley*) Eastern Mindanao (*Surigao del Norte, Surigao del Sur, Agusan del Norte, Agusan del Sur and Dinagat Islands*) Central Mindanao (*North Cotabato, South Cotabato, Sultan Kudarat and Sarangani*)	1 to 5 divisions depending on the occurrence of species in a particular division.
5.	Phytogeographical Distribution (p^1)	Malesia sub-continents (*Philippines, Singapore, Malaysia, Brunei, Indonesia, Papua New Guinea*)	Depending on how many species are spread in a particular region.
6.	Phytogeographical Distribution (p^2)	Europe, Sino-Japan, China, Indo-Malaya, Africa, Australia, North and South America	Depending on how many species are spread in a particular region.

ranging from 1,886 – 1,965 masl with 18 species. However, a number of species also peaked at a lower elevation ranging from 1,381 – 1,456 masl with 12 species. On the other hand, it was at 1,555 – 1,608 masl the elevation that the least number of species was recorded with only four species (Figure 2).

There could be two major factors affecting the species richness: the area and the geometric constraints [21]. Generally, in a region with a larger area, habitat is heterogeneous and more diverse than with smaller area, thus can support more species to coexist. Since Mt. Kalatungan has two major vegetation types, that is the montane and the mossy forest, this indicates the habitat is heterogeneous therefore implying that it can support more species.

In terms of species richness per elevation zone, Zone 8 (1,886 – 1,965 masl) holds the highest number of 18 species from 12 genera. The high richness could be due to the abundance of host trees that provides the substrate for epiphytes and possibly the availability of

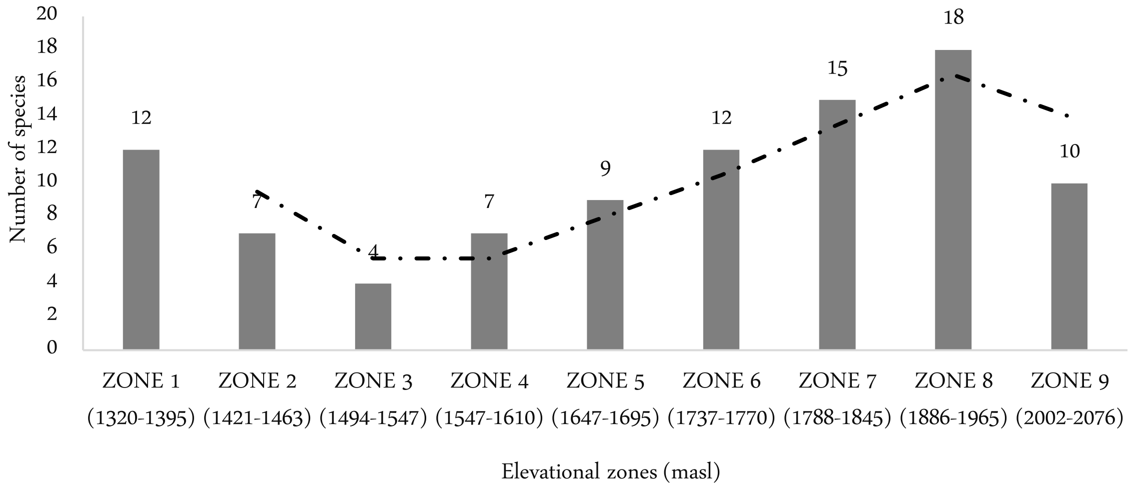

Figure 2. Elevational pattern of species richness

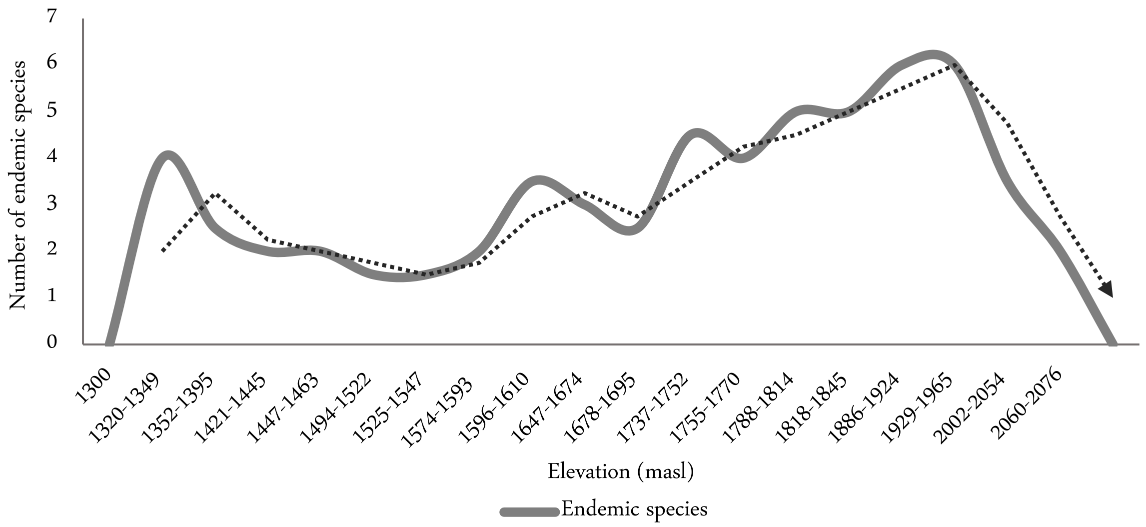

Figure 3. Density of Endemism pattern of Orchid species in Mt. Kalatungan

more mycorrhizal fungi for some nutrients [22]. Zone 3 (1,494 – 1,547 masl) had the lowest number of species richness with only 4 species belonging to 4 genera, this may be explained by the absence of host trees since the zone is an open-canopy area dominated by wild gingers which are unfavourable to any epiphytes including orchids that mainly associates with host trees to thrive. About 92% of orchid species present in the area are epiphytes.

Dendrochilum orchids had the highest number of species with six. It is also the most widely distributed group occurring along the trail from Zones 1 – 9. This was followed by the following genera: *Ceratostylis* (3 spp.), *Dendrobium* (3 spp.), *Goodyera* (3 spp.), *Oberonia* (3 spp.), *Appendicula* (2 spp.) and *Pinalia* (2 spp.). The other 21 genera are represented by a single species confined in different elevational zones. Some orchid species were restricted to a certain elevation range of 1,900 – 2,000 masl including *Ceratostylis latipetala*, *Dendrochilum mearnsii*, *Goodyera* sp., *Hippeophyllum wenzellii*, *Kuhlhasseltia yakushimensis*, *Mycaranthes cadoonensis*, *Octarrhena parvula*, and *Robiquetia* sp. This may be attributed to the fact that some orchids were auto-pollinating species and can thrive at a higher elevation ranging from 1,400 – 2,000 masl however; the species dispersal is limited due to geometric constraints which result in species restriction to a specific elevation. The trend of the species richness of orchids in Mt. Kalatungan followed a two humped-shaped pattern (Figure 2). The first peak was observed at Zone 1 with an elevation range of 1,320 – 1,395 masl, this elevation was at the basal part of the mountain with many host trees

Table 2. Rarity index and assessment of endemism of wild orchids

Genus/Spescies	*R Value*	*VR*	*S*	*O*	*C*	*Endemism*
I. *Agrostophyllum* Blume						
1. *Agrostophyllum* sp.	1.92	✓				Philippine Endemic
II. *Appendicula* Blume						
2. *Appendicula* sp. 1	1.83	✓				Philippine Endemic
3. *A. malindangensis* Ames	1.83	✓				Philippine Endemic
III. *Ascidiera* Seidenf.						
4. *Ascidiera* sp.	1.67	✓				Philippine Endemic
IV. *Bulbophyllum* Thouars						
5. *Bulbophyllum* sp. 1	1.33	✓				Philippine Endemic
6. *Bulbophyllum* sp. 2	1.75	✓				Philippine Endemic
V. *Calanthe* R.Br.						
7. *C. davaensis* Ames	1.17	✓				Mindanao Endemic
VI. *Ceratostylis* Blume						
8. *Ceratostylis* sp. 1	1	✓				Philippine Endemic
9. *C. latipetala* Ames	1.5	✓				Philippine Endemic
10. *C. ramosa* Rolfe ex Ames	1.75	✓				Philippine Endemic
VII. *Coelogyne* Lindl						
11. *C. candoonensis* Ames,	1.33	✓				Mindanao Endemic
VIII. *Crepedium* Blume						
12. *Crepedium* sp.	1.17	✓				Philippine Endemic
IX. *Cryptostylis* R.Br.						
13. *Cryptostylis* sp.	1.33	✓				Philippine Endemic
X. *Dendrobium* Sw						
14. *Dendrobium* sp. 1	1.17	✓				Philippine Endemic
15. *D. diffisum* LO Williams	1.83	✓				Philippine Endemic
16. *D. tiongii* Cootes	3.58			✓		Philippine Endemic
XI. *Dendrochilum* Blume						
17. *D. arachnites* Rchbc.f	3.41			✓		Philippine Endemic
18. *D. coccineum* H.A. Pedersen & Gravend	1.5	✓				Philippine Endemic
19. *D. glumaceum* Lindl	4.25				✓	Philippine Endemic
20. *D. malindangense* Ames	2.42		✓			Mindanao Endemic
21. *D. mearnsii* Ames	1.17	✓				Philippine Endemic
22. *D. mindanaense* Ames	3.58			✓		Mindanao Endemic
XII. *Epiblastus* Schltr						
23. *Epiblastus merrillii*	1.75	✓				Philippine Endemic
XIII. *Goodyera* R.Br.						
24. *Goodyera* sp. 1	1	✓				Philippine Endemic
25. *Goodyera* sp. 2	1	✓				Philippine Endemic
26. *G. viridiflora* Blume	1.83	✓				Widespread
XIV. *Hippeophyllum* Schltr						
27. *H. wenzellii* Ames	1	✓				Philippine Endemic
XV. *Kuhlhasseltia* J.J.Sm.						
28. *K. yakushimensis* Rendle	1.33	✓				Widespread
XVI. *Mycaranthes* Blume						
29. *M. candoonensis* Ames	1	✓				Mindanao Endemic
XVII. *Myrmechis* Blume						
30. *M. perpusilla* Ames, Sched	1	✓				Philippine Endemic

Continue ...

Table 2. Rarity index and assessment of endemism of wild orchids (continued)

Genus/Spescies	*R Value*	*VR*	*S*	*O*	*C*	*Endemism*
XVIII. *Oberonia* Lindl						
31. *Oberonia* sp. 1	1.5	✓				Philippine Endemic
32. *Oberonia* sp.2	1	✓				Philippine Endemic
33. *Oberonia* sp. 3	1	✓				Philippine Endemic
XIX. *Octarrhena* Thwaites						
34. *O. parvula* Thwaites	1.67	✓				Widespread
XX. *Oxystophyllum* Blume						
35. *Oxystophyllum* sp.1	1.33	✓				Philippine Endemic
XXI. *Phreatia* Lindl						
36. *P. densiflora* Blume	2.17		✓			Widespread
XXII. *Pinalia* Buch.-Ham ex Don						
37. *Pinalia* sp. 1	1.17	✓				Philippine Endemic
38.*Pinalia* sp. 2	1.83	✓				Philippine Endemic
XXIII. *Rhomboda* Lindl						
39. *Rhomboda sp.*	1.33	✓				Philippine Endemic
XXIV. *Robiquetia*						
40. *Robiquetia* sp.1	1.33	✓				Philippine Endemic
XXV. *Spathoglottis* Blume						
41. *S. plicata* Blume	2.83		✓			Widespread
XXVI. *Stichorkis*						
42. *Stichorkis* sp.1	1.5	✓				Philippine Endemic
XXVII. *Trichotosia* Blume						
43. *Trichotosia* sp.1	1.75	✓				Philippine Endemic
XXVIII. *Cylindrolobus* Blume						
44. *Cylindrolobus* sp. 1	1.17	✓				Philippine Endemic
TOTAL		37	3	1	3	

Note: VR-very rare, S-sparse, O- occasionally, C- common or widespread

which contributed to the higher number of species richness. The Bagik-ikan River in Zone 1 also creates boundary habitat that allows for greater biodiversity [23]. However, the species richness decreased in the next zone (Zone 2) due to forest fragmentation brought by human activities. Such disturbance was considered to negatively influence the species richness in an area [24]. The second peak with the highest number of species was observed in Zone 8 with an elevation range of 1,886 – 1,965 masl followed by a clear decrease of species richness going further toward increasing elevation. The patterns of taxon richness and density in which richness increased steeply at low elevations and then decreased at high elevation after peaking at intermediate elevations between 1,900 – 2,000 masl [21].

About 83% of the total orchid species were under the "very rare" category followed by 7% "sparse" and "occasionally" and lastly 3% of the total species were "widespread" (Table 3). Approximately 91% of the orchid species were only known in the Philippines and 12% of which were endemic and very rare within Mindanao. Rare species were considered to be localized, habitat-specific and sparse. These three criteria make species rarer from the others [25]. Some orchid species required unique habitat and microhabitats so they are confined to particular elevations and forest types that makes some of them naturally rare [2]. Some of the very rare species which were only confined to a specific and higher elevation like the species of *Pinalia* (1,788 – 1,965 masl) as well as *H. wenzellii* (2,076 m.a.s.l), *D. mearnsii* (2,002 masl), *Dendrochilum coccineum* (1,845 masl), *M. candoonensis* (1,788 masl), and *Calanthe davaensis* (1,886 – 1,965 masl).

Thirty-nine Philippine endemic species were recorded in all established zones (Table 3). Five species are only known to occur in Mindanao [12] namely: *C. da-*

vaensis, *Coelogyne candoonensis*, *Dendrochilum malindangense*, *Dendrochilum mindanaense* and *M. candoonensis*. Zone 8 (1,886 – 1,965 masl) holds the highest record of endemic species with 15. Results showed that the high number of endemic species can be found in areas with high species richness (Figure 3). The different vegetation types may also explain the high levels of endemism. It was observed that some orchid species thriving at the very high elevation are isolated, habitat-dependent and may become more specialized than those species found at lower elevation [22, 6]. Eight endemic species present a new record in Bukidnon province, these include *C. davaensis*, *Ceratostylis ramosa*, *Dendrobium diffusum*, *Dendrochilum coccineum*, *D. mindanaense*, *D. malindangense*, *Octarrhena parvula* and *Phreatia densiflora*. Moreover, a new species of *Cylindrolobus* was recently discovered [27]. The other undetermined species were recollected by other researchers and recently described as new to science such *Ceratostylis* sp. 1 which is recently named *Ceratostylis pristina* De Leon, Naive & Cootes hence, it is designated as Philippine endemic in this study. With limited information on the distribution of many newly named species i.e. Bulbophyllum spp., we classified it as Philippine endemic instead of Mindanao endemic species. The highly elevated zones like Zone 7 (1,788 – 1,845 m.a.s.l) and 8 (1,886 – 1,965 masl) had the highest endemic species compared to other zones with relatively low endemic species situated at lower elevation specifically zones 2 and 3 (1,421 – 1,547 masl). The elevational pattern of endemism generally shows increasing endemism with elevation, peaking at mid- to high elevations and declining above the timberline.

Recent ecological models have shown that climatic and topographic variables are among the best predictors of species richness of orchids in tropical archipelagos [28]. As such, the vegetation type in every zones may provide important insights into the habitat preference as well as the coexistence of certain species. The hump-shaped relationship of orchid species richness with the elevational gradient as affected by microclimate variables has also been ascertained in studies conducted in Mexico [29] as well as in Himalayan regions of Nepal and Bhutan [9]. This pattern has been observed in other tropical vascular plants [6, 29] including trees and other epiphytes. In the Philippines, however, ecological studies on orchids and other vascular plants remain to be scanty in the literature. Hence, comparative analysis of the distribution of floras in various mountain ecosystems remains a challenge, especially with the country's archipelagic geographical setting.

CONCLUSION

Mt. Kalatungan harbors a total of 44 species of wild orchids of which (83%) are very rare, (7%) are sparse, (7%) found occasionally and (3%) are common. This represents 4% of Philippine orchid flora with 91% endemism and many of which are site endemic and new records in the province of Bukidnon. The results support the current notion that orchid species richness is influenced by elevational gradients, availability of host trees, and the regions' microclimate condition. The pattern of distribution followed a humped-shaped model wherein the maximum species richness for orchids was reached at 1,500 – 2,000 masl. and after which, species richness level decreases. In addition, the present study also shows that endemism and rarity level of orchid species becomes higher as the elevation increases and that more endemic and rare species can be found with increasing elevational gradient.

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