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Diversity of orchids in Taman Eden 100, Lumban Julu District, Toba Regency, North Sumatra, Indonesia

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ABSTRACT

Orchid diversity in tropical forest ecosystems is increasingly threatened by habitat degradation and land-use change, highlighting the importance of biodiversity assessments in conservation areas. This study aimed to determine orchid species composition, species diversity, and the physical environmental conditions supporting orchid habitats in Taman Eden 100, North Sumatra, Indonesia. The research was conducted from August to October 2023 using a descriptive–exploratory approach with purposive sampling. Five plots measuring 20 × 20 m were established in representative orchid habitats. Data were analyzed descriptively using relative density, relative frequency, relative dominance, the Important Value Index (INP), and the Shannon–Wiener diversity index. A total of 77 orchid species were recorded, comprising 51 epiphytic species (66%) and 26 terrestrial species (34%). *Thelasis micrantha* was the most abundant species, with 178 species and the highest INP (12.99%), whereas *Bulbophyllum odoratum* was the least abundant species, represented by a single species with an INP of 0.22%. The orchid habitats were characterized by air temperatures of 21-27°C, relative humidity of 94-97%, soil pH of 6.5-6.8, and elevations ranging from 1,200 to 1,350 m asl, providing favorable conditions for orchid growth. These findings demonstrate that Taman Eden 100 supports high orchid diversity and serves as an important conservation area for preserving native orchid resources in North Sumatra.

Keywords: Conservation, epiphytic and terrestrial orchids, habitat characteristics, orchid diversity, species composition

INTRODUCTION

Orchids (Orchidaceae) represent one of the most diverse families of flowering plants and are widely distributed in tropical and subtropical regions, including Indonesia (Gaskett & Gallagher, 2018; Prapitasari et al., 2024; Wang et al., 2024). Indonesia is recognized as one of the global centers of orchid diversity because of its tropical climate, complex topography, and extensive forest ecosystems (Comber, 1990; Labajo-Villantes et al., 2024). Sumatra is known to harbor a high diversity of orchid species, including both epiphytic and terrestrial orchids, many of which are associated with tropical montane forests characterized by high humidity, dense canopy cover, and abundant host trees (Hartini, 2019; Suminarsih & Puspitaningtyas, 2024). Recent studies have shown that the number of orchid species reported from Sumatra and Java continues to increase due to ongoing botanical exploration and the description of new taxa. Nevertheless, information regarding orchid diversity in several conservation areas of North Sumatra remains limited.

North Sumatra possesses extensive tropical forest ecosystems that support diverse orchid habitats, ranging from lowland forests to montane environments. Several studies have reported orchid diversity in protected and conservation forests of this region, indicating that North Sumatra is an important habitat for native orchid species. For example, previous research in Sicike-cikeh Forest, North Sumatra, documented 21 orchid genera, demonstrating the ecological importance of this region for orchid conservation (Hartini, 2019). Orchids in North Sumatra generally grow as epiphytes attached to host trees or as terrestrial species associated with humid forest floors and mycorrhizal fungi. However, the sustainability of these habitats is increasingly threatened by deforestation, land conversion, forest fragmentation, illegal collection, and climate change (Azhar et al., 2021). Habitat degradation may reduce the availability of host trees, pollinators, and mycorrhizal associations that are essential for orchid survival and regeneration (Besi et al., 2023; Fay, 2018; Li et al., 2021).

Taman Eden 100, located in Lumban Julu, North Sumatra, is a privately managed conservation and ecotourism area dominated by tropical montane forest vegetation. The area functions as an important habitat for various native plant species, including orchids, because it maintains relatively natural forest conditions, cool temperatures, and high humidity. Despite its ecological importance, reports regarding orchid diversity and morphological variation in Taman Eden 100 are still limited. Previous studies in Indonesia have mainly focused on species inventories in other regions such as Java, Bali, and Papua, while information concerning orchid diversity in Taman Eden 100 remains poorly documented. This indicates a research gap related to the diversity, abundance, and morphological relationships of orchids in this conservation area.

Research on orchid diversity in Indonesia has demonstrated varying levels of species richness among regions depending on habitat conditions and forest conservation status. Previous studies reported orchid diversity ranging from a few species in disturbed habitats to more than twenty species in relatively intact forest ecosystems (Hartini, 2019; Pammai et al., 2022). However, many studies were limited to species inventories and did not examine morphological relationships among orchid taxa. Morphological characterization is important for taxonomic identification, conservation planning, and understanding variation among orchid species based on vegetative and generative characters (Hartati & Samanhudi, 2024; Freudenstein & Chase, 2015; Labajo-Villantes et al., 2024). Morphological data are also useful for supporting conservation strategies and future orchid breeding programs.

Considering the ecological importance of orchids and the limited information available from Taman Eden 100, this study was conducted to analyze the orchid species composition, species diversity, and the physical environmental conditions supporting orchid habitats in Taman Eden 100, North Sumatra, Indonesia. The study was carried out through field exploration and direct observation in several forest areas within Taman Eden 100. The findings are expected to provide baseline data for orchid conservation and contribute to biodiversity management efforts in North Sumatra.

METHOD

Study area

This research was conducted in Taman Eden 100 from August to October 2023. The study area is located in Lumban Rang Village, Lumban Julu District, Toba Regency, North Sumatra Province, Indonesia. Geographically, the area is situated at 02°39'32.8" N and 99°02'23.0" E, at an altitude ranging from 1,100–1,750 m above sea level. The area is approximately 16 km from Parapat and 55 km from Balige. Taman Eden 100 covers approximately 1,980 ha, of which around 1,800 ha consist of natural forest vegetation. The area is recognized as a

conservation-based ecotourism forest with high biodiversity richness, including orchid diversity (Manurung et al., 2023).

The tools used in this study included notebooks, label paper, newspapers, alcohol 70%, ruler, pen, compass, thermohygrometer, soil tester (pH), soil thermometer, measuring tape, plastic rope, hand lens, digital caliper, and a Canon EOS 1500D DSLR camera and Garmin eTrex 30x GPS device, plastic, hanging labels and plant scissors. Environmental parameters measured directly in the field during the research period included air temperature, relative humidity and soil pH. The climatic and environmental data presented in this study were obtained from direct field measurements conducted during the sampling period. Relative humidity ranged from 72-92%, soil pH from 5.4-6.8, and soil temperature from 16-24°C. Orchid species identification was conducted based on morphological characteristics, including leaf shape, pseudobulb structure, flower morphology, root type, and growth habit. Species identification was carried out by comparing field specimens and photographic documentation with taxonomic references and orchid identification guides, including Orchids of Sumatra by Comber (2001) and Orchids of Java. Scientific names were further validated using the Plants of the World Online (POWO) database managed by the Royal Botanic Gardens, Kew. The data obtained were analyzed descriptively by tabulating orchid species composition and growth habit, while environmental variables were used to support the ecological interpretation of orchid distribution in the study area. The research location can be seen in Figure 1.

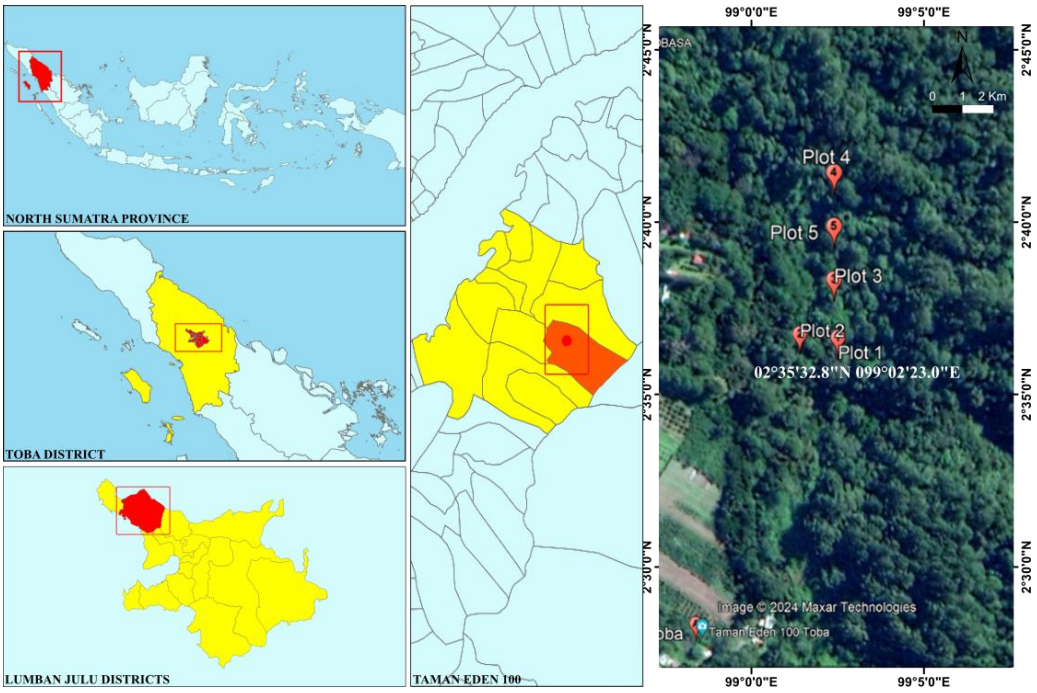

Figure 1. Map of orchids location in Taman Eden 100, Lumban Julu District, North Sumatra Province, Indonesia.

Research procedures

The research employed a descriptive–exploratory method using a purposive sampling technique. Sampling was conducted in the forest area of Taman Eden 100 from August to October 2023. Data collection was conducted using an exploration survey combined with purposive sampling. The exploration survey involved systematically traversing the entire study area to locate and document the occurrence of orchid species across different habitat types. Areas with relatively high orchid abundance were intentionally selected as representative sampling sites. Within these selected locations, 5 sampling

plots, each measuring 20×20 m were established to represent the variation in orchid habitats encountered during the survey. Each plot was surveyed to record orchid species composition, the number of individuals, and habitat characteristics, including the associated vegetation and environmental conditions. The use of standardized plots enabled consistent data collection and provided representative information on the orchid species composition, species diversity, and the physical environmental conditions supporting orchid habitats. The selection of observation sites was based on the presence of natural orchid populations, vegetation heterogeneity, canopy cover, humidity level, and accessibility of the study area.

Each orchid species encountered within the sampling plots was recorded by counting the number of individuals, documenting the species name (when identifiable in the field), and noting its habitat type. In addition, all species were photographed to support subsequent identification and verification. Representative specimens of each species were collected as voucher specimens while preserving their diagnostic morphological characteristics to facilitate taxonomic identification. The collected specimens were subsequently identified at the Plant Taxonomy Laboratory, Universitas Sumatera Utara, based on both vegetative and reproductive morphological characteristics. Species identification was performed using relevant taxonomic references and orchid identification keys, and the resulting scientific names were assigned to all orchid species recorded during the study.

Data analysis

The findings from the observations will be subjected to descriptive analysis and computation of various indices such as importance value index (INP), species relative density, diversity index, and morphological relationship. The Index of Diversity will be assessed through the application of the Shannon-Wiener diversity index (Magurran, 2004). The Shannon-Wiener diversity index is an analysis used to determine the level of species diversity found with the following formula:

Relative density

Frequency is the number of sample plots discovery of one type from a number sample plot created. The formula used in determining frequency is as follows.

$$KR = \frac{\text{Absolute density of a species}}{\text{Absolute density of all species}} \text{ x } 100\%$$

$$FR = \frac{\text{Absolute frequency of a type}}{\text{Absolute frequency of all types}} \text{ x } 100\%$$

Relative dominance

A vegetation analysis parameter that indicates the degree to which a species occupies or dominates a plant community based on its total basal area. A higher relative dominance value indicates a greater structural contribution of the species within the community.

The formula for calculating relative dominance is:

$$RD = (\Sigma BAi / \Sigma BAtotal) \times 100\%$$

Important Value Index (INP)

The dominant species in a plant community will have the highest Importance Value Index (INP) value among other types. The formula used to calculate the Index Important Value (INP) is:

$$INP = \text{Relative density} + \text{Relative frequency}$$

The diversity index (H')

Diversity index of the orchids found from the family *Orchidaceae* was calculated using the following formula.

$$H' = -(\sum pi \ln pi), \text{ where } Pi = (ni/N)$$

Description:

H' = shannon–Wiener species diversity index;
∑ = the summation of all species included in the analysis;
Pi = the number of individuals of the i-th species (ni) to the total individuals (N):(ni/N);
Ln = the natural logarithm;
Ni = the number of individuals of each species;
N = the total number of individuals.

Based on the condition of fauna diversity, the Shannon-Wiener (H') diversity index criteria according to Odum (1993) are divided into four: H'> 3.0 means very high diversity; H' of 1.6'3.0 means high diversity; H' of 1.0'1.5 means moderate diversity; H'<1 means low diversity.

Environmental parameters, including air temperature, relative humidity, soil pH and were analyzed descriptively to characterize the habitat conditions at each sampling site. These environmental variables were subsequently interpreted in relation to orchid species composition, abundance, and habitat type to examine the influence of habitat conditions on orchid occurrence and distribution. The analysis aimed to identify ecological patterns between environmental factors and the diversity and distribution of orchid species within the study area, thereby providing a better understanding of the environmental conditions that support orchid growth and habitat suitability.

RESULTS AND DISCUSSION

Orchid composition found in the Taman Eden 100, North Sumatra Province, Indonesia

A total of 77 orchid species were recorded in Taman Eden 100, North Sumatra Province (Table 1). The orchid flora comprised both epiphytic and terrestrial species, reflecting the high orchid diversity of the study area. The abundance of orchids varied considerably among species, ranging from one to 178 species.

Among the recorded orchids, *Thelasis micrantha* was the most abundant species, with 178 species, followed by *Coelogyne cuprea* (161 species), *Oberonia lotsyana* (151 species), *Liparis lacerata* (123 species), *Thrixspermum centipeda* (92 species), *Bulbophyllum mirum* and *Plocoglottis javanica* (82 species each), *Calanthe callosa* (81 species), *Paphiopedilum tonsum* (79 species), and *Podochilus microphyllum* (74 species). In contrast, *Bulbophyllum odoratum* was represented by only a single species, whereas *Appendicula alba*, *Callostylis rigida*, *Grammatophyllum speciosum*, *Podochilus muciratum*, and *Trichoglottis pusilla* each consisted of only two species.

The distribution of orchid species differed among the five sampling plots (Figure 1). Plot 1 contained the highest species richness, with 25 species, followed by Plots 2 and 3, each with 19 species, whereas Plots 4 and 5 each supported only six species. Plot 1 consisted of *Bulbophyllum adelphidium*, *Agrostophyllum bicuspidatum*, *Calanthe chrysoglossoides*, *Calanthe corymbose*, *Callostylis rigida*, *Ceratostylis ampullacea*, *Coelogyne brachygyne*, *Coelogyne cuprea*, *Cymbidium dayanum*, *Cymbidium lancifolium*, *Dendrobium acuminatissimum*, *Dendrobium kuyperi*, *Dendrobium mutabile*, *Eria bicristata*, *Mycaranthes tjadasmalangensis*, *Flickingeria convexa*, *Liparis elegens*, *Liparis rhedii*, *Neuwiedia zollingeri*, *Plocoglottis javanica*, *Renanthera angustifolia*, *Spathoglottis aurea*, *Trichoglottis pusilla*, *Trichotosia cystosepala*, and *Calanthe speciosa*.

Plot 2 comprised *Bulbophyllum longivagans*, *Paphiopedilum tonsum*, *Agrostophyllum laxum*, *Appendicula alba*, *Arundina graminifolia*, *Bulbophyllum biflorum*, *Bulbophyllum micholitzianum*, *Coelogyne dayana*, *Cymbidium ensifolium*, *Dendrobium capitellatum*, *Dendrochilum brevilabrum*, *Eria flavescens*, *Grammatophyllum speciosum*, *Liparis lacerata*, *Macodes petola*, *Nervilia aragoana*, *Oberonia lotsyana*, *Calanthe callosa*, and *Coelogyne imbricata*.

Plot 3 contained *Schoenorchis sumatrana*, *Agrostophyllum majus*, *Appendicula reflexa*, *Ascidieria longifolia*, *Bulbophyllum lobii*, *Bulbophyllum mirum*, *Bulbophyllum odoratum*, *Calanthe triplicate*, *Coelogyne modesta*, *Cymbidium haematodes*, *Dendrobium rhombeum*, *Liparis latifolia*, *Calanthe flava*, *Podochilus microphyllum*, *Podochilus muciratum*, *Trichotosia ferox*, *Thrixspermum centipeda*, *Thrixspermum gombakense*, and *Thrixspermum pensile*.

Plot 4 consisted of *Trichoglottis adnata*, *Appendicula torta*, *Bulbophyllum virescens*, *Coelogyne salmonicolor*, *Dilochia wallichii*, and

Eria hyacinthoides. Although only six species were recorded, the plot supported several orchid taxa with moderate to relatively high abundance, including *Coelogyne salmonicolor* (54 species).

Plot 5 contained *Trichoglottis simplex*, *Liparis terrestris*, *Plocoglottis plicata*, *Spathoglottis plicata*, *Thelasis micrantha*, and *Trichotosia velutina*. Despite having the same species richness as Plot 4, this plot was notable for the occurrence of *Thelasis micrantha*, the most abundant orchid species in the study area, indicating that the environmental conditions of this plot are particularly favorable for this species.

Overall, orchid diversity in Taman Eden 100 was characterized by substantial variation in both species richness and abundance among sampling plots. Plots 1–3 supported more diverse orchid assemblages, whereas Plots 4 and 5 contained fewer species but still harbored several locally abundant taxa. These findings indicate pronounced spatial heterogeneity in orchid community composition across the study area, likely reflecting differences in habitat characteristics and microenvironmental conditions.

The level of orchid diversity in the Taman Eden 100 was carried out by calculating Relative Density, Relative Frequency, Relative Dominance and Species diversity index. The calculation results can be seen in Table 1.

Table 1. Diversity index, Importance Value Index (INP), and growth habit of orchid species found in Taman Eden 100, North Sumatra, Indonesia.

No.	Type of orchid	Number of species	Growth	KR (%)	FR (%)	DR (%)	INP (%)	H'
1.	*Agrostophyllum bicuspidatum*	24	Epiphyte	1.06	1.95	0.31	3.33	0.021
2.	*Agrostophyllum laxum*	12	Epiphyte	0.53	0.81	1.62	2.96	0.012
3.	*Agrostophyllum majus*	25	Epiphyte	1.10	1.79	5.98	8.86	0.022
4.	*Anoectochilus longicalcuratus*	31	Terrestrial	1.38	0.98	0.09	2.45	0.026
5.	*Appendicula alba*	2	Epiphyte	0.11	0.33	0.04	0.48	0.003
6.	*Appendicula reflexa*	12	Epiphyte	0.53	0.81	0.22	1.57	0.012
7.	*Appendicula torta*	8	Epiphyte	0.35	0.98	0.10	1.43	0.009
8.	*Arundina graminifolia*	5	Terrestrial	0.22	0.33	0.06	0.61	0.006
9.	*Ascidieria longifolia*	24	Epiphyte	1.06	1.63	0.27	2.96	0.021
10.	*Bulbophyllum adelphidium*	25	Epiphyte	1.11	1.46	0.37	2.94	0.022
11.	*Bulbophyllum biflorum*	8	Epiphyte	0.35	0.81	0.04	1.21	0.009
12.	*Bulbophyllum lobii*	12	Epiphyte	0.53	1.14	0.12	1.79	0.012
13.	*Bulbophyllum longivagans*	19	Epiphyte	0.84	1.14	0.16	2.14	0.017
14.	*Bulbophyllum micholitzianum*	37	Epiphyte	1.64	1.30	0.27	3.21	0.029
15.	*Bulbophyllum mirum*	82	Epiphyte	3.63	2.28	0.18	6.09	0.052
16.	*Bulbophyllum odoratum*	1	Epiphyte	0.04	0.16	0.01	0.22	0.001
17.	*Bulbophyllum virescens*	13	Epiphyte	0.58	0.98	0.25	1.80	0.013
18.	*Calanthe chrysoglossoides*	5	Terrestrial	0.22	0.65	0.00	0.87	0.006
19.	*Calanthe speciosa*	25	Terrestrial	1.11	0.81	0.01	1.93	0.022
20.	*Calanthe triplicate*	13	Terrestrial	0.58	0.98	0.51	2.06	0.013
21.	*Callostylis rigida*	2	Epiphyte	0.09	0.16	0.01	0.27	0.003
22.	*Ceratostylis ampullacea*	19	Epiphyte	0.84	1.79	0.25	2.88	0.017
23.	*Coelogyne brachygyne*	40	Epiphyte	1.77	1.63	0.55	3.95	0.031
24.	*Coelogyne cuprea*	161	Epiphyte	7.14	2.93	3.05	13.11	0.082
25.	*Coelogyne dayana*	15	Epiphyte	0.66	1.63	0.22	2.51	0.014
26.	*Coelogyne modesta*	4	Epiphyte	0.18	0.65	0.01	0.84	0.005
27.	*Coelogyne salmonicolor*	54	Epiphyte	2.39	2.28	1.14	5.81	0.039
28.	*Cymbidium dayanum*	14	Epiphyte	0.62	1.46	0.79	2.87	0.014
29.	*Cymbidium ensifolium*	45	Terrestrial	1.99	1.79	1.06	4.84	0.034
30.	*Cymbidium haematodes*	24	Terrestrial	1.06	1.63	0.51	3.20	0.021
31.	*Cymbidium lancifolium*	29	Terrestrial	1.29	1.30	0.13	2.72	0.024

No.	Type of orchid	Number of species	Growth	KR (%)	FR (%)	DR (%)	INP (%)	H'
32.	*Dendrobium capitellatum*	6	Epiphyte	0.27	0.49	0.01	0.77	0.007
33.	*Dendrobium acuminatissimum*	19	Epiphyte	0.84	1.46	2.76	5.07	0.017
34.	*Dendrobium kuyperi*	4	Epiphyte	0.18	0.65	0.03	0.86	0.005
35.	*Dendrobium mutabile*	36	Epiphyte	1.60	1.79	4.25	7.63	0.029
36.	*Dendrobium rhombeum*	8	Epiphyte	0.35	0.65	0.07	1.08	0.009
37.	*Dendrochilum brevilabrum*	38	Epiphyte	1.68	1.95	11.49	15.12	0.030
38.	*Dilochia wallichii*	12	Terrestrial	0.53	0.98	3.05	4.55	0.012
39.	*Eria bicristata*	17	Epiphyte	0.75	1.30	0.48	2.53	0.016
40.	*Eria flavescens*	34	Epiphyte	1.51	1.79	1.23	4.53	0.027
41.	*Eria hyacinthoides*	15	Epiphyte	0.66	1.14	0.46	2.26	0.014
42.	*Flickingeria convexa*	25	Epiphyte	1.11	1.63	0.64	3.37	0.022
43.	*Grammatophyllum speciosum*	2	Epiphyte	0.09	0.16	0.45	0.70	0.003
44.	*Liparis elegens*	16	Terrestrial	0.71	1.46	0.34	2.51	0.015
45.	*Liparis lacerate*	123	Terrestrial	5.45	2.44	2.17	10.06	0.069
46.	*Liparis latifolia*	29	Terrestrial	1.29	2.11	1.14	4.54	0.024
47.	*Liparis rhedii*	25	Terrestrial	1.11	1.63	0.28	3.02	0.022
48.	*Liparis terrestris*	17	Terrestrial	0.75	1.14	0.10	2.00	0.016
49.	*Macodes petola*	17	Terrestrial	0.75	1.30	0.03	2.08	0.016
50.	*Mycaranthes tjadasmalangensis*	23	Epiphyte	1.02	1.14	2.72	4.88	0.020
51.	*Mycaranthes reinwardtii*	22	Epiphyte	0.98	1.63	3.75	6.35	0.020
52.	*Nervilia aragoana*	18	Terrestrial	0.80	0.65	0.04	1.49	0.017
53.	*Neuwiedia zollingeri*	34	Terrestrial	1.51	1.30	1.90	4.71	0.027
54.	*Oberonia lotsyana*	151	Epiphyte	6.69	3.25	0.56	10.51	0.079
55.	*Paphiopedilum tonsum*	79	Terrestrial	3.50	2.76	1.66	7.93	0.051
56.	*Calanthe callosa*	81	Terrestrial	3.59	2.60	9.16	15.35	0.052
57.	*Calanthe corymbose*	8	Terrestrial	0.35	0.81	0.31	1.48	0.009
58.	*Calanthe flava*	29	Terrestrial	1.29	1.30	2.57	5.16	0.024
59.	*Coelogyne imbricata*	3	Epiphyte	0.13	0.33	0.04	0.50	0.024
60.	*Plocoglottis javanica*	82	Terrestrial	3.63	2.44	1.07	7.14	0.052
61.	*Plocoglottis plicata*	8	Terrestrial	0.35	0.81	0.22	1.39	0.009
62.	*Podochilus microphyllum*	74	Epiphyte	3.28	1.63	2.48	7.39	0.049
63.	*Podochilus muciratum*	2	Epiphyte	0.09	0.33	0.13	0.55	0.003
64.	*Renanthera angustifolia*	4	Epiphyte	0.18	0.49	0.28	0.95	0.005
65.	*Schoenorchis sumatrana*	7	Epiphyte	0.31	0.65	0.10	1.06	0.008
66.	*Spathoglottis aurea*	12	Terrestrial	0.53	0.98	1.06	2.56	0.012
67.	*Spathoglottis plicata*	18	Terrestrial	0.80	1.14	1.86	3.79	0.017
68.	*Thelasis micrantha*	178	Epiphyte	7.89	2.76	2.33	12.99	0.087
69.	*Trichoglottis adnata*	8	Epiphyte	0.35	0.81	0.25	1.42	0.009
70.	*Trichoglottis pusilla*	2	Epiphyte	0.09	0.16	0.06	0.31	0.003
71.	*Trichoglottis simplex*	30	Epiphyte	1.33	1.46	0.92	3.71	0.025
72.	*Trichotosia cystosepala*	3	Epiphyte	0.13	0.33	1.38	1.84	0.004
73.	*Trichotosia ferox*	15	Epiphyte	0.66	1.46	13.24	15.37	0.014
74.	*Trichotosia velutina*	5	Epiphyte	0.22	0.65	0.37	1.24	0.006
75.	*Thrixspermum centipeda*	92	Epiphyte	4.08	2.93	1.06	8.06	0.057
76.	*Thrixspermum gombakense*	19	Epiphyte	0.84	1.30	1.44	3.58	0.017
77.	*Thrixspermum pensile*	16	Epiphyte	0.71	1.30	0.21	2.22	0.021

Orchids abiotic environmental data

Orchid growth is strongly influenced by environmental conditions that support optimal growth and development. Environmental parameters observed in orchid habitats at Taman Eden 100 included temperature, humidity, soil pH, altitude, and geographical coordinates. The results of the physical environmental conditions measured at each observation plot are presented in Table 2.

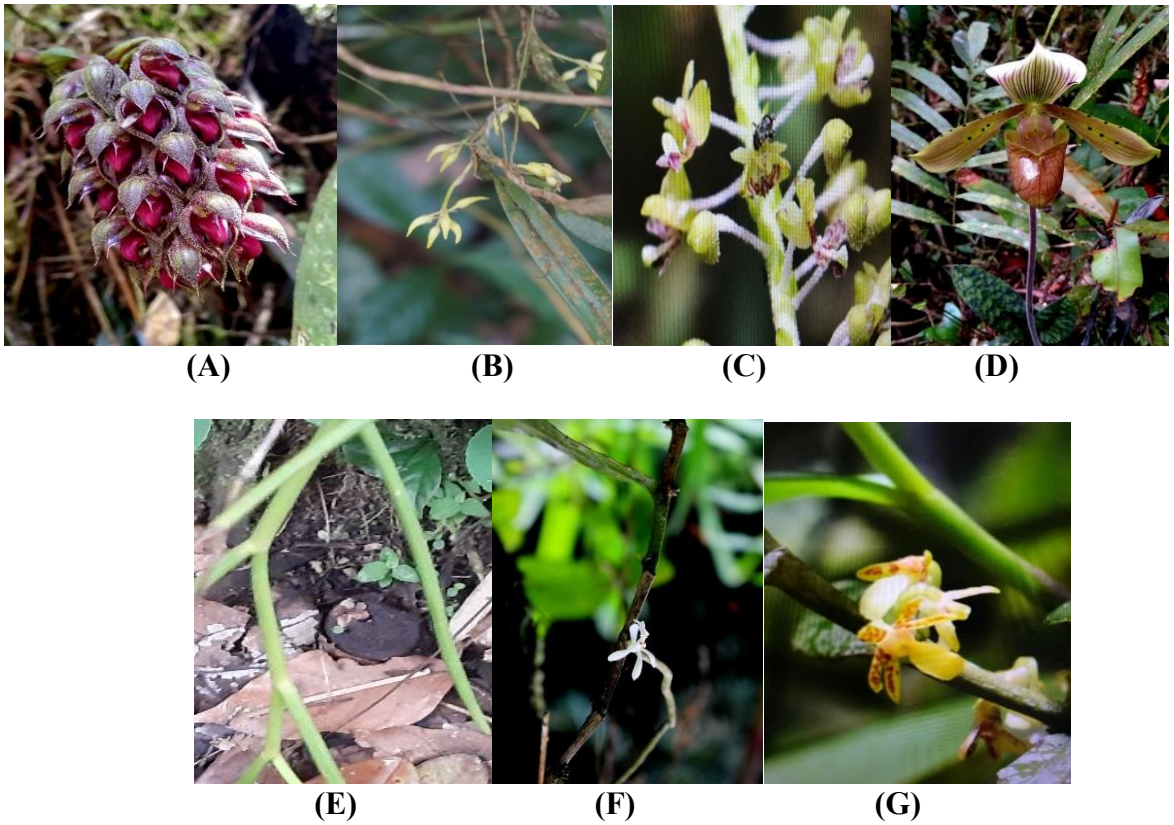

Figure 2. Some of the types of orchids found in the Taman Eden 100, North Sumatra Province, Indonesia: *A. Bulbophyllum adelphidium*; *B. Bulbophyllum longivagans*; *C. Mycaranthes tjadasmalangensis*; *D. Paphiopedilum tonsum*; *E. Schoenorchis sumatrana*; *F. Trichoglottis adnata*; *G. Trichoglottis simplex*. Photo taken by: Arif Syahrizal (2023).

Table 2. Physical environmental conditions of orchid habitats at Taman Eden 100

Plot	Temperature (°C)	Humidity (%)	Soil pH	Coordinates	Altitude (m asl)
Plot 1	21	96	6.7	02°39'32.8"S, 99°02'23.0"E	1200
Plot 2	23	94	6.8	02°35'32.8"S, 99°02'23.0"E	1261
Plot 3	22	95	6.5	02°35'34.8"S, 99°02'23.0"E	1300
Plot 4	25	97	6.7	02°35'36.8"S, 99°02'23.0"E	1320
Plot 5	27	97	6.8	02°35'35.8"S, 99°02'23.0"E	1350

The physical environmental conditions recorded across the five sampling plots at Taman Eden 100 showed relatively similar characteristics, indicating that all plots provided suitable habitats for orchid growth (Table 2). Air temperature ranged from 21°C to 27°C, with the lowest temperature recorded in Plot 1 and the highest in Plot 5. Relative humidity remained consistently high, ranging from 94% to 97%, reflecting the moist microclimatic conditions typical of montane tropical forests. Soil pH varied only slightly among the plots, ranging from 6.5 to 6.8, indicating slightly acidic soil conditions that are generally favorable for orchid establishment and nutrient availability. The sampling sites were located at elevations between 1,200 and 1,350 m above sea level, representing a montane environment with relatively stable climatic conditions. Geographical coordinates confirmed that all sampling plots were distributed within the Taman Eden 100 conservation area.

Overall, the observed environmental conditions suggest that the study area provides a favorable habitat for orchid diversity. The combination of cool temperatures, high humidity, slightly acidic soils, and montane elevation creates environmental conditions that

support orchid growth and survival, although local variations in these factors may contribute to differences in species composition and abundance among the sampling plots.

The orchid composition recorded in Taman Eden 100, North Sumatra Province, Indonesia, consisted of 77 species representing both epiphytic and terrestrial orchids. Epiphytic orchids were more dominant than terrestrial orchids, indicating that the forest vegetation provides suitable substrates and favorable microhabitats for orchid establishment and growth. Species with the highest abundance included *Thelasis micrantha* (178 species), *Coelogyne cuprea* (129 species), *Oberonia lotsyana* (85 species), *Thrixspermum centipeda* (61 species), *Bulbophyllum mirum* (48 species), and *Calanthe callosa* (46 species), whereas several species were represented by only one or two species, reflecting considerable variation in species abundance across the study area.

The recorded orchids exhibited diverse ecological characteristics corresponding to their growth forms. Epiphytic species typically possessed aerial roots covered with velamen tissue, an adaptation that enhances water absorption and moisture retention under fluctuating forest conditions. In contrast, terrestrial orchids, including *Calanthe triplicata*, *Liparis terrestris*, and *Paphiopedilum tonsum*, were commonly found on moist forest floors with abundant organic matter. Despite differences in habitat preference, all recorded species shared the characteristic orchid floral morphology, including three sepals, three petals with a modified labellum, a fused column, and pollinia, which are associated with the specialized pollination systems that distinguish members of the Orchidaceae.

Species from the genus *Bulbophyllum* were widely distributed in the study area, particularly *Bulbophyllum mirum* and *Bulbophyllum micholitzianum*, indicating their adaptability to humid forest environments. Likewise, *Coelogyne cuprea* showed a relatively high Important Value Index (INP = 13.11%), suggesting that this species has strong ecological dominance within the orchid community. Meanwhile, *Trichotosia ferox* and *Dendrochilum brevilabrum* exhibited high dominance values, reflecting their successful adaptation to local habitat conditions. The diversity of orchid species found in this study demonstrates that the study area still supports favorable environmental conditions for orchid growth, particularly in terms of humidity, canopy cover, and host tree availability for epiphytic species.

Environmental conditions in the Taman Eden 100 generally support orchid growth, particularly due to the relatively cool temperature, high humidity, and slightly acidic soil conditions. The temperature range recorded across the observation plots (21-27°C) indicates a favorable microclimate for both epiphytic and terrestrial orchids. Most orchid species are known to grow optimally under moderate temperatures and humid environments because these conditions help maintain water availability and support physiological processes such as photosynthesis and transpiration. High humidity levels (94-97%) in the study area likely contributed to the dominance of epiphytic orchids, especially species belonging to *Bulbophyllum*, *Coelogyne*, *Oberonia*, and *Thelasis*. Epiphytic orchids depend heavily on atmospheric moisture because they grow attached to host trees rather than directly in soil. Under cooler temperatures and humid conditions, the velamen tissue on orchid roots can absorb and retain water more efficiently, thereby reducing the risk of desiccation.

In addition, the altitudinal gradient of 1200-1350 m asl may influence orchid distribution patterns in the study area. Higher elevation areas generally provide lower temperatures and more stable humidity, creating suitable habitats for montane orchid species. This environmental condition may explain the relatively high abundance of species such as *Coelogyne cuprea*, *Thelasis micrantha*, and *Calanthe callosa*, which are commonly associated with moist tropical forest ecosystems. The

slightly acidic soil pH (6.5-6.8) also supports nutrient availability and root development for terrestrial orchids. Such conditions are considered favorable for orchid establishment because organic matter decomposition occurs effectively, supplying nutrients required for growth. Overall, the interaction between temperature, humidity, elevation, and soil acidity creates a microenvironment that supports high orchid diversity in the Taman Eden 100. This location's temperature and humidity conditions are within the normal range of growth of orchids. Lestari & Santoso (2011) stated that orchids could live in an air temperature range of 22-32^{0}C and air humidity ranging from 60-80%. Arobaya et al. (2022) and Bisri & Syahrorini (2024) also revealed that orchids lives at an air temperature of 25-28^{0}C and an air humidity of 65-70%. Yulia & Budiharta (2011) stated that orchids live in an air temperature range of 28-30^{0}C and air humidity ranging from 60-80%.

Research conducted in Taman Eden 100 showed that the most abundant orchid species was *Thelasis micrantha*, with 178 species and an Important Value Index (INP) of 12.99. The high abundance of this species is likely related to the environmental conditions recorded during the study, particularly the presence of large host trees, high humidity, moderate temperature, and dense forest canopy that support epiphytic orchid growth. The high abundance of this species is likely related to its adaptation to humid forest microhabitats and the availability of suitable host-tree substrates (de la Rosa-Manzano et al., 2014; Rasmussen & Rasmussen, 2018). Large host trees with rough bark surfaces can retain moisture and organic matter, thereby providing favorable attachment sites and nutrient accumulation for epiphytic orchids. In addition, stable humidity and shaded environmental conditions measured in the study plots may support the growth and survival of this species. The association of *T. micrantha* with mycorrhizal fungi and suitable pollinators may also contribute to its successful establishment and reproduction within the ecosystem.

In contrast, *Bulbophyllum odoratum* was the least recorded species, with only one individual and an INP of 0.22. The low abundance of this species may indicate that it has more specific habitat requirements or lower tolerance to environmental disturbance. Orchid species with narrow ecological preferences are generally more vulnerable to habitat degradation, forest disturbance, and microclimatic changes (Besi et al., 2023; Pica et al., 2024; Mirioba et al., 2024). Differences in canopy structure, humidity, and substrate availability among sampling plots may have influenced the limited occurrence of *B. odoratum*. Previous studies also reported that habitat degradation, climatic changes, and illegal collection continue to threaten orchid populations globally (Fay, 2018; Gale et al., 2018; Saavedra & Pitogo, 2021). Logged forests often show lower orchid density compared with relatively undisturbed secondary forests, especially for epiphytic orchids dependent on mature host trees (Besi et al., 2023; Taylor et al., 2022). The study further revealed high orchid diversity in Taman Eden 100, with 77 orchid species identified during field exploration. Several orchid species recorded in this study have restricted natural distributions in Indonesia, particularly on the island of Sumatra. According to *Plants of the World Online* (POWO), *Paphiopedilum tonsum* and *Trichoglottis adnata* are distributed only in Sumatra, *Schoenorchis sumatrana* occurs in the Malay Peninsula and Sumatra, while *Mycaranthes tjadasmalangensis* is found in Sumatra and Java. These species are therefore native to Sumatra but cannot be considered endemic to Taman Eden 100, as their natural distributions extend beyond the study area.

The high orchid richness recorded in this study is likely associated with favorable environmental conditions measured during field observations. The study area showed relatively cool temperatures, high air humidity, and dense vegetation cover, all of which are important

environmental factors for orchid growth and distribution. These environmental conditions create suitable microhabitats for both epiphytic and terrestrial orchids. In addition, the presence of mature forest vegetation and varied topography may increase habitat heterogeneity and provide diverse ecological niches for orchid species. However, the influence of pollinators on orchid abundance was not directly measured in this study. Therefore, it can only be suggested that the availability of pollinators may contribute to orchid reproduction and population persistence in the area.

The percentage of epiphytic orchids recorded in this study was higher than terrestrial orchids, with 51 epiphytic species (66%) and 26 terrestrial species (34%) (Table 1). This pattern is closely related to the environmental characteristics of Taman Eden 100, which is dominated by tropical forest vegetation with abundant mature trees suitable for epiphytic orchid attachment. Large trees provide multiple vertical microhabitats with differences in light intensity, humidity, and bark texture that support epiphytic orchid diversity (Ai et al., 2023; Fardhani et al., 2020; Wang et al., 2017). During field observations, most epiphytic orchids were found attached to tree trunks and branches in humid and shaded areas, indicating the importance of canopy structure and host-tree availability in determining orchid distribution. Similar findings were reported by Krömer & Batke (2025) and Nurfadilah (2015), who stated that epiphytic orchids are major contributors to plant diversity in tropical forest ecosystems.

Conversely, terrestrial orchids were less abundant because they are more dependent on shaded forest floors, stable soil moisture, and suitable mycorrhizal associations. Open or disturbed habitats generally provide less favorable conditions for terrestrial orchid establishment (Crain et al., 2025; Melinda et al., 2022). Environmental measurements in several open plots showed higher light intensity and lower humidity, conditions that may reduce terrestrial orchid occurrence. In addition, terrestrial orchids have complex ecological relationships involving pollinators and mycorrhizal fungi, making them more sensitive to habitat disturbance and environmental changes (Kolanowska, 2023; Shefferson et al., 2020; Nurfadilah et al., 2016). The findings of this study indicate that Taman Eden 100 plays an important role in supporting orchid diversity through the availability of relatively intact forest habitat, suitable microclimatic conditions, and diverse host trees. Nevertheless, conservation efforts remain essential because orchid populations are highly sensitive to deforestation, habitat degradation, and illegal collection. Documentation of habitat conditions and environmental factors associated with orchid occurrence is therefore important to support future conservation and management programs.

CONCLUSION

In conclusion, the orchid exploration conducted in the Taman Eden 100 area documented a high diversity of orchid taxa consisting of epiphytic and terrestrial orchids distributed across various habitat conditions. The study recorded numerous orchid genera, including *Agrostophyllum*, *Bulbophyllum*, *Coelogyne*, *Dendrobium*, *Liparis*, *Phaius*, *Trichotosia*, and *Thrixspermum*, indicating that the environmental conditions of Taman Eden 100 support orchid growth and distribution.

The presence of orchids in humid habitats with suitable temperature, light intensity, and canopy cover demonstrates the ecological importance of the area as a natural orchid habitat and biodiversity refuge. Several species recorded in this study are considered notable or locally recorded species, such as *Bulbophyllum adelphidium*, *Bulbophyllum longivagans*, *Paphiopedilum tonsum*, *Schoenorchis sumatrana*, *Trichoglottis adnata*, and *Trichoglottis simplex.* The findings of this study contribute scientifically to orchid biodiversity data in North Sumatra, particularly in the Taman Eden 100 area, and provide important baseline

information for future ecological, taxonomic, and conservation studies. Furthermore, the results emphasize the importance of both in-situ and ex-situ conservation strategies to maintain orchid diversity and habitat sustainability in the region.

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